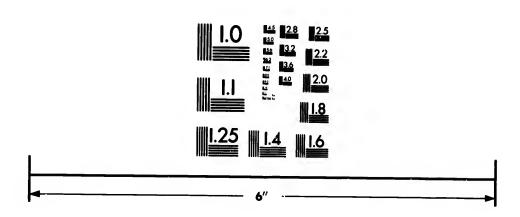


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INTERN

THE

International Scientific Series

VOL. XLI.

ANII

I HAVE recently learnt from the publishers of the 'International Scientific Series' that they have made arrangements with Sir John Lubbock to bring out in the same series a work of his on Ants and Bees. Necessarily therefore, the material to be dealt with in his work wil to a large extent overlap that which is presented by m chapters on the same insects; but after consulting with the publishers, and also with Sir John Lubbock, it ha seemed to me undesirable to omit these chapters of account of the circumstances here stated. For, on the one hand, the facts will not lose their value from bein twice told; and on the other, it is desirable that th present member of the Series should form in itself, far as its Author can make it, a complete résumé of all th more important facts of Animal Intelligence.

GEOR

20

KEGAN PAUL.

ANIMAL INTELLIGENCE

 $\mathbf{B}\mathbf{Y}$

GEORGE J. ROMANES, M.A. LL.D. F.R.S.

ZOOLOGICAL SECRETARY OF THE LINNEAN SOCIETY

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PREFACE.

WHEN I first began to collect materials for this work it was my intention to divide the book into two parts. Of these I intended the first to be concerned only with the facts of animal intelligence, while the second was to have treated of these facts in their relation to the theory of Descent. Finding, however, as I proceeded, that the material was too considerable in amount to admit of being comprised within the limits of a single volume, I have made arrangements with the publishers of the 'International Scientific Series' to bring out the second division of the work as a separate treatise, under the title 'Mental Evolution.' This treatise I hope to get ready for press within a year or two.

My object in the work as a whole is twofold. First, I have thought it desirable that there should be something resembling a text-book of the facts of Comparative Psychology, to which men of science, and also metaphysicians, may turn whenever they may have occasion to acquaint themselves with the particular level of intelligence to which this or that species of animal attains. Hitherto the endeavour of assigning these levels has been almost exclusively in the hands of popular writers; and as these have, for the most part, merely strung together, with discrimination more or less inadequate, innumerable anec-

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dotes of the display of animal intelligence, their books are valueless as works of reference. So much, indeed, is this the case, that Comparative Psychology has been virtually excluded from the hierarchy of the sciences. If we except the methodical researches of a few distinguished naturalists, it would appear that the phenomena of mind in animals, having constituted so much and so long the theme of unscientific authors, are now considered wellnigh unworthy of serious treatment by scientific methods. But it is surely needless to point out that the phenomena which constitute the subject-matter of Comparative Psychology, even if we regard them merely as facts in Nature, have at least as great a claim to accurate classification as those phenomena of structure which constitute the subject-matter of Comparative Anatomy. Leaving aside, therefore, the reflection that within the last twenty years the facts of animal intelligence have suddenly acquired a new and profound importance, from the proved probability of their genetic continuity with those of human intelligence, it would remain true that their systematic arrangement is a worthy object of scientific endeavour. then, has been my first object, which, otherwise stated, amounts merely to passing the animal kingdom in review in order to give a trustworthy account of the grade of psychological development which is presented by each group. Such is the scope of the present treatise.

My second, and much more important object, is that of considering the facts of animal intelligence in their relation to the theory of Descent. With the exception of Mr. Darwin's admirable chapters on the mental powers and moral sense, and Mr. Spencer's great work on the Principles of Psychology, there has hitherto been no earnest attempt at tracing the principles which have been probably concerned in the genesis of Mind. Yet there is

not a doubt th o subject of legree of inte iew of furthe his work. It olume, while ets of Compar urpose the la eatise on Mer ave just said, se is prelimina nphasise this resented only entually to be ayed is of som esent work is ject of supply: inciples, it ma on the works nembered that t of animal psy nthesis, I may entific intentio posal may inci necdote.

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not a doubt that, for the present generation at all events, o subject of scientific inquiry can present a higher egree of interest; and therefore it is mainly with the riew of furthering this inquiry that I have undertaken his work. It will thus be apparent that the present olume, while complete in itself as a statement of the ong the hets of Comparative Psychology, has for its more ultimate ed well-surpose the laying of a firm foundation for my future reatise on Mental Evolution. But although, from what I enomenate ave just said, it will be apparent that the present treative Psyse is preliminary to a more important one, I desire to Nature, in phasise this statement, lest the critics, in being now cation as the subresented only with a groundwork on which the picture is the subag aside, ayed is of somewhat too commonplace a kind. If the ayed is of somewhat too commonplace a kind. If the esent work is read without reference to its ultimate coursed a ject of supplying facts for the subsequent deduction of robability inciples, it may well seem but a small improvement intellin intelli-on the works of the anecdote-mongers. But if it is r. This, t of animal psychology for the purposes of a subsequent se stated, inthesis, I may fairly claim to receive credit for a sound in review entific intention, even where the only methods at my grade of posal may incidentally seem to minister to a mere love by each enecdote.

It remains to add a few words on the principles which is that of ave laid down for my own guidance in the selection and heir rela-ingement of facts. Considering it desirable to cast as eption of e a net as possible, I have fished the seas of popular al powers rature as well as the rivers of scientific writing. The k on the less multitude of alleged facts which I have thus been been no ged to read, I have found, as may well be imagined, nave been essively tedious; and as they are for the most part ret there is ed by wholly unknown observers, the labour of reading

them would have been useless without some trustworth third, to tabu principles of selection. The first and most obvious principle nknown obserthat occurred to me was to regard only those facts which hey have even stood upon the authority of observers well known as composervations n petent; but I soon found that this principle constitute his principle much too close a mesh. Where one of my objects was to y selection of determine the upper limit of intelligence reached by the hich present and that class, order, or species of animals, I usually found be unconscious that the most remarkable instances of the display of interest as good a ligence were recorded by persons bearing names more less unknown to fame. This, of course, is what we might rver, and I have antecedently expect, as it is obvious that the chances much as the latt always be greatly against the more intelligent individua among animals happening to fall under the observation the more intelligent individuals among men. Therefore soon found that I had to choose between neglecting all t more important part of the evidence—and consequently most cases feeling sure that I had fixed the upper lin of intelligence too low—or supplementing the principle looking to authority alone with some other principles selection, which, while embracing the enormous class alleged facts recorded by unknown observers, might felt to meet the requirements of a reasonably critic I therefore adopted the following principles a filter to this class of facts. First, never to accept an alleg n. For it is a fact without the authority of some name. Second, in case of the name being unknown, and the alleged fact and of with refe sufficient importance to be entertained, carefully to deferent kind of sider whether, from all the circumstances of the case en in our diag recorded, there was any considerable opportunity for melosophically ning through observation; this principle generally demanded that alleged fact, or action on the part of the animal, should affinity of a particularly marked and unmistakable kind, look allelism is exc to the end which the action is said to have accomplish broad outlines.

ents which sta always seekin en able to sub those of othe So much, th en guided in t ent of the fac ending order, the selected e ychology which d, in some cas son of my e tural groups th ngdom were cl

principle inknown observers, with the view of ascertaining whether next which hey have ever been corroborated by similar or analogous observations made by other and independent observers. Institute his principle I have found to be of great use in guiding the y selection of instances, for where statements of fact and by the hich present nothing intrinsically improbable are found ally found be unconsciously confirmed by different observers, they are of interest which stand on the single authority of a known observer which stand on the single authority of a known observer, and I have found the former to be at least as abundances much as the latter. Moreover, by getting into the habit always seeking for corroborative cases, I have frequently servation of other observers as well or better known.

So much, then, for the principles by which I have equently en guided in the selection of facts. As to the arrange-upper line ent of the facts, I have taken the animal kingdom in principles ent of the facts, I have taken the animal kingdom in principles the selected evidence at my disposal permitted of the ous class ychology which is distinctive of each class, or order, and, in some cases, family, genus, or even species. The ably critical son of my entering into greater detail with some inciples a tural groups than with others scarcely requires explanational alleg in a series of with reference to Psychology inleged fact and of with reference to Anatomy, we should have a very ully to complete the facts of the case of t

the purpose of definite arrangement to take the anima adividual case kingdom in the order presented by zoological classifica onnection tha tion, it would be absurd to restrict an inquiry into Anima uoted a small Psychology by any considerations of the apparently disceived, that all proportionate length and minute subdivision with which he contrary, no it is necessary to treat some of the groups. Anatomically nation and su an ant or a bee does not require more consideration than express quotation beetle or a fly; but psychologically there is need for use in guiding great a difference of treatment as there is in the robre I hope that very dissimilar case of a monkey and a man.

Throughout the work my aim has been to arrive greer flow. definite principles rather than to chronicle mere incal In all cases dents—an aim which will become more apparent when fact, which the work as a whole shall have been completed. Therefore imerous, I h it is that in the present volume I have endeavoured, arbatim. Only far as the nature and circumstances of the inquiry would ven by an aut permit, to suppress anecdote. Nevertheless, although limit of a cor have nowhere introduced anecdotes for their own sake, resented it in r have found it unavoidable not to devote much the large And here I l part of the present essay to their narration. Hence, with Mr. Darwin, the double purpose of limiting the introduction of ane enerous manner dotes as much as possible, and of not repeating mo well as with than I could help anecdotes already published, I have difficulty, bu all cases, where I could do so without detriment to my disposal main object, given the preference to facts which has telligence which been communicated to me by friends and correspondent ars, together And here I may fitly take the opportunity of expression apter on Inst my thanks and obligations to the latter, who in astonis e Origin of Spring numbers have poured in their communications during compression to several years from all quarters of the globe. I make the pre of hitherto statement because I desire to explain to all my correct I shall hav pondents who may read this book, that I am not the legely than in t sensible of their kindness because its bounty has reduced it impossible for me to send acknowledgments gent's Park, London

rve to swell t

he animal individual cases. However, I should like to add in this classification that it does not follow, because I have only uoted a small percentage of the letters which I have rejected, that all of the remainder have been useless. On with which he contrary, many of these have served to convey infortationically lation and suggestions which, even if not reserved for the press quotation in my forthcoming work, have been of seed for a see in guiding my judgment on particular points. Therefore I hope that the publication of these remarks may erve to swell the stream of communications into a yet of arrive a greef flow.

In all cases where I have occasion to quote statements rent where I fact, which in the present treatise are necessarily. Therefore unerous, I have made a point of trying to quote avoured, rbatim. Only where I have found that the account quiry would ven by an author or a correspondent might profitably although lmit of a considerable degree of condensation have I own sake, resented it in my own words.

And here I have to express my very special obligations Mr. Darwin, who not only assisted me in the most enerous manner with his immense stores of information, ating most well as with his valuable judgment on sundry points difficulty, but has also been kind enough to place ment to make the difficulty, but has also been kind enough to place my disposal all the notes and clippings on animal telligence which he has been collecting for the last forty expression apter on 'Instinct.' This chapter, on being re-cast for in astonia to compression that the original draft constitutes a rich I make the present of hitherto unpublished material. In my second my correspondent of the letter of the present one, and it is needless to add

ty has regilar Letters may be addressed to me directly at 18 Cornwall Terrace, edgments gent's Park, London, N.W.

that in all cases where I do draw upon it I shall be careful to state the source to which I am indebted.

The above was written when I sent this work to the publishers several months ago, and I have thought it best to leave the concluding paragraph as it originally stood. But in making this explanation, I cannot allude to the calamity which has since occurred without paying my tribute, not alone to the memory of the greates genius of our age, but still more, and much more, to the memory of a friend so inexpressibly noble, kind, and generous, that even my immense admiration of the troduction naturalist was surpassed by my loving veneration for the man.

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INTRODUCTION.

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38 EFORE we begin to consider the phenomena of mind roughout the animal kingdom it is desirable that we ould understand, as far as possible, what it is that we actly mean by mind. Now, by mind we may mean two ery different things, according as we contemplate it in ir own individual selves, or in other organisms. e contemplate our own mind, we have an immediate gnizance of a certain flow of thoughts or feelings, which e the most ultimate things, and indeed the only things, which we are cognisant. But if we contemplate mind other persons or organisms, we have no such immeate cognizance of thoughts or feelings. In such cases e can only infer the existence and the nature of oughts and feelings from the activities of the organisms hich appear to exhibit them. Thus it is that we may ave a subjective analysis of mind and an objective halvsis of mind—the difference between the two consting in this, that in our subjective analysis we are stricted to the limits of a single isolated mind which e call our own, and within the territory of which we we immediate cognizance of all the processes that are bing on, or at any rate of all the processes that fall ithin the scope of our introspection. But in our obctive analysis of other or foreign minds we have no ch immediate cognizance; all our knowledge of their erations is derived, as it were, through the medium of nbassadors—these ambassadors being the activities of e organism. Hence it is evident that in our study of simal intelligence we are wholly restricted to the obctive method. Starting from what I know subjectively of the operations of my own individual mind, and the activities which in my own organism they prompt, proceed by analogy to infer from the observable activities of other organisms what are the mental operations that underlie them.

Now, in this mode of procedure what is the kind of activities which may be regarded as indicative of mind I certainly do not so regard the flowing of a river or th blowing of the wind. Why? First, because the object are too remote in kind from my own organism to admit my drawing any reasonable analogy between them an it; and, secondly, because the activities which they pre sent are of invariably the same kind under the same cir cumstances; they afford no evidence of feeling or purpos In other words, two conditions require to be satisfied before we even begin to imagine that observable activities ar indicative of mind: first, the activities must be displaye by a living organism; and secondly, they must be of kind to suggest the presence of two elements which w recognise as the distinctive characteristics of mind such—consciousness and choice.

So far, then, the case seems simple enough. Wherever we see a living organism apparently exerting intention choice, we might infer that it is conscious choice, an therefore that the organism has a mind. But further reflection shows us that this is just what we cannot do for although it is true that there is no mind without th power of conscious choice, it is not true that all apparen choice is due to mind. In our own organisms, for in stance, we find a great many adaptive movements per formed without choice or even consciousness coming int play at all—such, for instance, as in the beating of ou hearts. And not only so, but physiological experiment and pathological lesions prove that in our own and i other organisms the mechanism of the nervous system sufficient, without the intervention of consciousness, produce muscular movements of a highly co-ordinate an apparently intentional character. Thus, for instance, if man has his back broken in such a way as to sever the nervous connection between his brain and lower extremi

es, on pinching enly away from nconscious of t he lower nervebring about t at requiring to ental operation ection of appa eflex Action, ar e limits of our herefore, in vi ent, leading to tentional, it cle say in the case hich appears to tion of the refl

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es, on pinching or tickling his feet they are drawn sudenly away from the irritation, although the man is quite nconscious of the adaptive movement of his muscles; he lower nerve-centres of the spinal cord are competent bring about this movement of adaptive response withat requiring to be directed by the brain. ental operation of the lower nerve-centres in the proaction of apparently intentional movements is called eflex Action, and the cases of its occurrence, even within e limits of our own organism, are literally numberless. herefore, in view of such non-mental nervous adjustent, leading to movements which are only in appearance tentional, it clearly becomes a matter of great difficulty say in the case of the lower animals whether any action fied befor hich appears to indicate intelligent choice is not really tion of the reflex kind.

On this whole subject of mind-like and yet not truly ental action I shall have much to say in my subsequent eatise, where I shall be concerned among other things th tracing the probable genesis of mind from nonental antecedents. But here it is sufficient merely to Wherever ake this general statement of the fact, that even within intentions e experience supplied by our own organisms adaptive hoice, and evements of a highly complex and therefore apparently ut furthe rposive character may be performed without any real rpose, or even consciousness of their performance. It as becomes evident that before we can predicate the re existence of mind in the lower animals, we need that the contract of mind than that which ns, for in me yet more definite criterion of mind than that which ments per supplied by the adaptive actions of a living organism, oming interesting of out the characteristic ch wn and intimate.

Objectively considered, the only distinction between aptive movements due to reflex action and adaptive dinate and vements due to mental perception, consists in the stance, if mer depending on inherited mechanisms within the sever the vous system being so constructed as to effect particular er extremitative movements in response to particular stimula-

tions, while the latter are independent of any such it is impossible herited adjustment of special mechanisms to the envance for innegencies of special circumstances. Reflex actions underly during the herited adjustment of special mechanisms to the envance for inner gencies of special circumstances. Reflex actions underly during the the influence of their appropriate stimuli may be constructed to the actions of a machine under the manipulations of an operator; when certain springs of actions are touched by certain stimuli, the whole machine thrown into appropriate movement; there is no room to the choice, there is no room for uncertainty; but as surely any of these inherited mechanisms are affected by the stimulus with reference to which it has been constructed to act, so surely will it act in precisely the same way as all the purposal always has acted. But the case with conscious mental adjustment is quite different. For, without at prest going into the question concerning the relation of be addents. I make any manipulation of the sense of being the necessary result or correlative of a character of physical sequences due to a physical stimulation, it is sense of being the necessary result or correlative of a character of reflex adjustments. All, that in an objective sense we can mean by a mental adjustment is an adjustment of a kind that has not be a may not the definitely fixed by heredity as the only adjustment processes, or there no alternative of adjustment, the case, in an animal condition.

It is then adaptive action by a living organism of the particular of a procession of the particular or and parti action.

It is, then, adaptive action by a living organism ce, we are in a cases where the inherited machinery of the nervous system conscious me does not furnish data for our prevision of what the additerefore our creative action must necessarily be—it is only here that ental action, no recognise the objective evidence of mind. The criterian of course to of mind, therefore, which I propose, and to which I shotisfactory, sind adhere throughout the present volume, is as follows: It on inference Does the organism learn to make new adjustments, or into out, as a modify old ones, in accordance with the results of its of iterion available individual experience? If it does so, the fact cannot and is logically due merely to reflex action in the sense above describe the case of the

ganised animal

ny such i it is impossible that heredity can have provided in

to the elevance for innovations upon, or alterations of, its machitions underly during the lifetime of a particular individual.

ay be consider this he manipaterion of mind more carefully, and then it will be so factor own that as here stated the criterion is not rigidly exmachine asive, either, on the one hand, of a possibly mental no room as surely arrely of a possibly non-mental element in apparently as surely resely, of a possibly non-mental element in apparently cted by the ental adjustments. But, nevertheless, the criterion is construct a best that is available, and, as it will be found sufficient ne way as a all the purposes of the present work, its more minute ious men alysis had better be deferred till I shall have to treat of t at press e probable evolution of mind from non-mental anion of be redents. I may, however, here explain that in my use
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ical in the per limit of non-mental action; I shall never regard it
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it is clear that the per limit of development to become amenable to the test in the constant estion, it has probably begun to dawn as nascent subnts. All, ctivity. In other words, because a lowly organised by a men imal does not learn by its own individual experience, has not be may not therefore conclude that in performing its estment putural or ancestral adaptations to appropriate stimuli n. For we assist a six of the mind-element, is wholly absent; we in an anim in only say that this element, if present, reveals no one of reflidence of the fact. But, on the other hand, if a lowly

ganised animal does learn by its own individual experiorganism ce, we are in possession of the best available evidence conscious memory leading to intentional adaptation. at the adaptation entry that ental action, not to the lower limit of mental. Of course to the sceptic this criterion may appear untisfactory, since it depends, not on direct knowledge, as follows: It on inference. Here, however, it seems enough to ental out, as already observed, that it is the best test of its of

higher, and even in that of men other than the scept adequate in the himself. For all objections which could apply to the under exhibition of this criterion of mind in the animal kingdom would apply with equal force to the evidence of any mind other than that of the individual objector. This is obvious the equestion of because, as I have already observed, the only evidence who can have of objective mind is that which is furnished to sot profound a objective activities; and as the subjective mind can never direct feeling the mental processes which there accompanies the objective activities, it is clearly impossible to satisfant on may choose to doubt the validity of inference that in any case other than his own mental processes even of the most extravagant form. Common sense, how the even of the most extravagant form. Common sense, how the even of the most extravagant form. Common sense, how the even of the most extravagant form. Common sense, how the even of the most extravagant form. Common sense, how the even of the most extravagant form. Common sense, how the even of the most extravagant form. Common sense, how the even of the most extravagant form. Common sense, how the even of the most extravagant form. Common sense, how the even of the most extravagant form. Common sense, how the even of the most extravagant form. Common sense, how the same in the securities of organisms and their activities is granted—without which indies the form of the processes will always and without question conclude that the howing itself activities of organisms other than our own, when analogous the same to have the same to those activities of our own which we know to be accompanied by certain mental states, are in them accompanie to the same than the securities of our own which we know to be accompanied by certain mental states, are in them accompanies and their activities of organisms and there are in them accompanies to the same than the securities of organisms of the remaining that the total control of the profound that the cl by analogous mental states.

The theory of animal automatism, therefore, which is as always been usually attributed to Descartes (although it is not quit is organism reclear how far this great philosopher really entertained the erves respond theory), can never be accepted by common sense; and ever as a philosophical speculation it will be seen, from what he proximity of as a philosophical speculation it will be seen, from what he proximity of no evidence of its interest in the standard property of the expression of fear or affection by a dog in the standard property of the expression of similar emotion is at the dog's a corresponding mental states is held to be inadequate in the actions the one case, it must in consistency be held similarly of course it in the standard property of the evidence of the expression of similar emotions at the actions the one case, it must in consistency be held similarly of course it in the standard property of the evidence of the expression of similar emotions at the actions the one case, it must in consistency be held similarly of course it in the expression of similar emotions at the actions the one case, it must in consistency be held similarly of course it in the expression of similar emotions at the actions the one case, it must in consistency be held similarly of course it in the expression of similar emotions.

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the scept adequate in the other. And likewise, of course, with all to the use her exhibitions of mental life.

to the use ther exhibitions of mental life.

It is quite true, however, that since the days of Desmind other tes—or rather, we might say, since the days of Joule—resonance we have defined aspect, seeing that it now runs straight into the constraint of the constraint into the cost profound and insoluble problem that has ever been resented to human thought—viz. the relation of body to ind in view of the doctrine of the conservation of energy, shall subsequently have occasion to consider this problem ith the close attention that it demands; but in the resent volume, which has to deal only with the phenomena of mind as such, I expressly pass the problem aside that phile is one reserved for separate treatment. Here I desire of idealism seems, how the same category, with reference to this prosenter guid lem, as the mind of man; and that we cannot without ross inconsistency ignore or question the evidence of other or indicated in the former, while we accept precisely the same not while the other of the other of

the other And this proof, as I have endeavoured to show, is in all—common ases and in its last analysis the fact of a living organism de that the howing itself able to learn by its own individual experianalogout ace. Wherever we find an animal able to do this, we be accompanied as the same right to predicate mind as existing in such ecompanies a animal that we have to predicate it as existing in any uman being other than ourselves. For instance, a dog e, which is as always been accustomed to eat a piece of meat when is organism requires nourishment, and when his olfactory retained the erves respond to the particular stimulus occasioned by and ever the proximity of the food. So far, it may be said, there me what has no evidence of mind; the whole series of events compossible to rised in the stimulations and muscular movements may be due to reflex action alone. But now suppose that by a a dog in the stimulations and the receiver a certain verbal and muscular movements may be a dog in the stimulations and muscular movements may be a dog in the stimulations and muscular movements may be a dog in the stimulations and muscular movements may be a dog in the stimulations and muscular movements may be a dog in the stimulations are the stimulations and muscular movements may be a dog in the stimulations are the stimulations and muscular movements may be a dog in the stimulations are the stimulations and muscular movements may be a dog in the stimulations and muscular movements may be a dog in the stimulations are the stimulations and muscular movements may be a dog in the stimulations are stimulations. But now suppose that by a dog in the stimulations are the stimu s of neuropeat when he is hungry until he receives a certain verbal ar emotion gnal: then we have exactly the same kind of evidence vidence that the dog's actions are prompted by mind as we have dequate is pat the actions of a man are so prompted. Now we find d similar of course it may be said that we have no evidence of prompting

that the lower down we go in the animal kingdom, the hose which as more we observe reflex action, or non-mental adjustment to predominate over volitional action, or mental adjust of which these ment. That is to say, the lower down we go in the igns. But we animal kingdom, the less capacity do we find for changing achieve movements in correspondence with changes are sufficiently conditions; it becomes more and more hopeless to teach animals—that is, to establish associations of ideas; and the reason of this, of course, is that ideas or mental unit he whole organizations the structure of mind. through the structure of mind.

It is not my object in the present work to enter upon the notion of the operations of mind, as this will require the reat prepond to be done as fully as possible in my next work. Never the less, a few words must here be said with regard to the main divisions of mental operation, in order to define the closely the meanings which I shall attach to certain term and analogy by relating to these divisions, and the use of which I cannot hat the inference of the present work to enter upon the view of the reat prepond sychology of a hing from that are in the less than the present work to enter upon the prepond sychology of a hing from the rule that the less than the prepond sychology of a hing from the prepond sy

relating to these divisions, and the use of which I cannot hat the inference avoid.

The terms sensation, perception, emotion, and volition of a dog or a model not here be considered. I shall use them in the array it goes, a cordinary psychological significations; and although shall subsequently have to analyse each of the organic of the erence available the no occasion in the present volume to enter upon the subject. I may, however, point out one general contained hat of sympathic sideration to which I shall throughout adhere. Taking there is no other in the processes which we observe in animals are trustworthy, a summan to bruth that we are justified in inferring particular mental state that the external indications of mental state that we are justified in inferring particular mental state unimal kingdo from particular bodily actions, it follows that in containing analogy as sistency we must everywhere apply the same criteria.

For instance, if we find a dog or a monkey exhibiting the inferring and the inferring analogy and the inferring particular mental state unimal series.

It may not be a dog or a monkey exhibition to the inferring particular mental state unimal series.

For instance, if we find a dog or a monkey exhibiting. It may no marked expressions of affection, sympathy, jealousy, rag that if we have &c., few persons are sceptical enough to doubt that the ing of the and complete analogy which these expressions afford without the real si

in either case; but this is the side issue which concerns the general hink the more relation of body and mind, and has nothing to do with the guarant known facts of of inferring the presence of mind in particular cases.

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that when

ental state nimal kingdom downwards from man, still, as it is the at in contonly analogy available, I shall follow it throughout the riteria.

gdom, the hose which are manifested by man, sufficiently prove ljustment he existence of mental states analogous to those in man tal adjust f which these expressions are the outward and visible go in the igns. But when we find an ant or a bee apparently rehanging whibiting by its actions these same emotions, few persons a changer re sufficiently non-sceptical not to doubt whether the ses to teach utward and visible signs are here trustworthy as evidence ideas; and f analogous or corresponding inward and mental states. ental unit the whole organisation of such a creature is so different to descent from that of a man that it becomes questionable how ar analogy drawn from the activities of the insect is a afe guide to the inferring of mental states—particularly enter upon a view of the fact that in many respects, such as in the vill requirement preponderance of 'instinct' over 'reason,' the sychology of an insect is demonstrably a widely different gard to the hing from that of a man. Now it is, of course, perfectly to define the true that the less the resemblance the less is the value of the resemblance, and therefore that the inference of an ant or a bee feeling sympathy or against not so valid as is the similar inference in the case. age is not so valid as is the similar inference in the case age is not so valid as is the similar inference in the case of a dog or a monkey. Still it is an inference, and, so m in the ar as it goes, a valid one—being, in fact, the only insert there available. That is to say, if we observe an ant or organic of the apparently exhibiting sympathy or rage, we must either conclude that some psychological state resembling that of sympathy or rage is present, or else refuse to hink about the subject at all; from the observable facts here is no other inference open. Therefore, having full of mental state and brute psychology as we recede through the ental state onimal kingdom downwards from man, still, as it is the

nimal series. exhibiting It may not however, be superfluous to point out outsy, rage that if we have full regard to this progressive weakened that the ing of the analogy, we must feel less and less certain afford with of the real similarity of the mental states compared; the generation that when we get down as low as the insects, I the guarante think the most we can confidently assert is that the known facts of human psychology furnish the best available pattern of the probable facts of insect psychology. Just as the theologians tell us—and logically enough that if there is a Divine Mind, the best, and indeed only, bodies, which is conception we can form of it is that which is formed on wherent in the the analogy, however imperfect, supplied by the human chanism, but as mind; so with 'inverted anthropomorphism' we must and the Divine apply a similar consideration with a similar conclusion to the animal mind. The mental states of an insect may exclude the su be widely different from those of a man, and yet most betain from an probably the nearest conception that we can form of their true nature is that which we form by assimilating them well-known w to the pattern of the only mental states with which we lifferent ways; are actually acquainted. And this consideration, it is hall pass on needless to point out, has a special validity to the evolutionist, inasmuch as upon his theory there must be a lways be looke psychological, no less than a physiological, continuity extending throughout the length and breadth of the tinets, and so animal kingdom.

In these preliminary remarks only one other point requires brief consideration, and this has reference to the distinction between what in popular phraseology is called 'Instinct' and 'Reason.' I shall not here enter upon any elaborate analysis of a distinction which is undoubtedly valid, but shall confine my remarks to explaining the sense in which I shall everywhere use these terms.

Few words in our language have been subject to a greater variety of meanings than the word instinct. In mpose is one popular phraseology, descended from the Middle Ages, many writers all the mental faculties of the animal are termed instinctive, in contradistinction to those of man, which are termed rational. But unless we commit ourselves to an obvious reasoning in a circle, we must avoid assuming that all actions of animals are instinctive, and then arguing that because they are instinctive, therefore they differ from the rational actions of man. The question whether or not really lies in what is here assumed, and we can only nind-elementanswer it by examining in what essential respect instinct conscious adapt differs from reason.

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Without co ve have to cor eatures of inst boint to obser nvolves mente hat serves to Reflex action, a nuscular adap tinctive action t the element ction in the se m, of course, uaded that if n the terms ess in our ide it is most d mental as dist loubt it is ofte natter, and h Again, Addison says:—

I look upon instinct as upon the principle of gravitation in eed only, bodies, which is not to be explained by any known qualities ormed on inherent in the bodies themselves, nor from any laws of me-the human chanism, but as an immediate impression from the first Mover, we must and the Divine energy acting in the creatures.

clusion to This mode of 'looking upon instinct' is merely to sect may exclude the subject from the sphere of inquiry, and so to yet most betain from any attempt at definition.

Innumerable other opinions might be quoted from

which we different ways; but as this is not an historical work, I ion, it is hall pass on at once to the manner in which science the evo- coks upon it, or, at least, the manner in which it will nust be allways be looked upon throughout the present work.

continuity Without concerning ourselves with the organization, the of the tincts, and so without reference to the theory of evolution, eatures of instinct as it now exists. The most important her point boint to observe in the first instance is that instinct nce to the nvolves mental operations; for this is the only point y is called hat serves to distinguish instinctive action from reflex. nter upon Reflex action, as already explained, is non-mental neuroh is un-muscular adaptation to appropriate stimuli; but inks to ex- tinctive action is this and something more; there is in use these at the element of mind. Such, at least, is instinctive ction in the sense that I shall always allude to it. I pject to a m, of course, aware that the limitation which I thus finct. In prose is one which is ignored, or not recognised, by dle Ages, many writers even among psychologists; but I am perunded that if we are to have any approach to definiteness in, which in the terms which we employ—not to say of clearness in our ideas concerning the things of which we speak assuming—it is most desirable to restrict the word instinct to and then mental as distinguished from non-mental activity. No defore they loubt it is often difficult, or even impossible, to decide question whether or not a given action implies the presence of the can only mind-element—i.e., conscious as distinguished from unt instinct conscious adaptation; but this is altogether a separate natter, and has nothing to do with the question of

ychology.

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defining instinct in a manner which shall be formally rational, does exclusive, on the one hand of reflex action, and on the tivity; the ne other of reason. As Virchow truly observes, it is difficult in a same in kind. cult or impossible to draw the line between instinctive their complexi and reflex action; but at least the difficulty may be or the rise of narrowed down to deciding in particular cases whether both in the an or not an action falls into this or that category of definition; there is no reason why the difficulty should arise consciousness on account of any ambiguity of the definitions themselves. Therefore I endeavour to draw as sharply as possible the letermine. In the which in theory should be taken to separate instinctive from reflex action; and this line, as I have body, and it or already said, is constituted by the boundary of non-mental of experience; or unconscious adjustment, with adjustment in which instinctive in there is concerned consciousness or mind there is concerned consciousness or mind.

Having thus, I hope, made it clear that the difficulty afterwards because of drawing a distinction between reflex and instinctive opposition to actions as a class is one thing, and that the difficulty of new-born child actions as a class is one thing, and that the difficulty of new-born child assigning particular actions to one or the other of our my definition, categories is another thing, we may next perceive that the sciousness become difficulty is obviated by the distinction which I breast, suckin have imposed, and that the latter only arises from the fact action. There that on the objective side there is no distinction impossible. The former difficulty is obviated by the distinction advances grad tion which I have drawn, simply because the distinction the undefined is itself a definite one. In particular cases of adjustive cannot be assigned action we may not always be able to affirm whether control to the other spices of their performance is present or absent that sciousness of their performance is present or absent; but We see that I have already said, this does not affect the validity of instinct can be our definition; all we can say of such cases is that if the viz., in present performance in question is attended with consciousness it is instinctive, and if not it is reflex.

And the difficulty of assigning particular actions to one or other of these two categories arises, as I have said merely because on the objective side, or the side of the nervous system, there is no distinction to be drawn Whether or not a neural process is accompanied by a mental process, it is in itself the same. The advent and development of consciousness, although progressively converting reflex action into instinctive, and instinctive into

instinctive, in

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The term various as tho

¹ I.e., ancestra had occasion to c the young child v own individual ex buted to any prod have seen that it

have said ide of the be drawn by a ment and deively connctive into

formally rational, does this exclusively in the sphere of subjecd on the fivity; the nervous processes engaged are throughout the it is diffisame in kind, and differ only in the relative degrees of nstinctive their complexity. Therefore, as the dawn of consciousness y may be or the rise of the mind-element is gradual and undefined, whether both in the animal kingdom and in the growing child, it of definities but necessary that in the early morning, as it were, of buld arise consciousness any distinction between the mental and the nemselves, non-mental should be obscure, and generally impossible to essible the determine. Thus, for instance, a child at birth does not parate in close its eyes upon the near approach of a threatening is I have body, and it only learns to do so by degrees as the result on-mental of experience; at first, therefore, the action of closing the in which eyelids in order to protect the eyes may be said to be instinctive, in that it involves the mind-element: 1 yet it difficulty afterwards becomes a reflex which asserts itself even in instinctive opposition to the will. And, conversely, sucking in a fficulty of new-born child, or a child in utero, is, in accordance with my definition, a reflex action; yet in later life, when converted the sciousness becomes more developed and the child seeks the breast, sucking may properly be called an instinctive action. Therefore it is that, as in the ascending scale of objective complexity the mind-element arises and advances gradually, many particular cases which occupy the undefined boundary between reflex action and instinct cannot be assigned with confidence either to the one region or to the other.

We see then the point, and the only point, wherein

walidity of instinct can be consistently separated from reflex action; hat if the viz., in presenting a mental constituent. Next we must iousness it consider wherein instinct may be separated from reason. And for this purpose we may best begin by considering ons to one what we mean by reason.

The term 'reason' is used in significations almost as various as those which are applied to 'instinct.' Some-

¹ I.e., ancestral as well as individual. If the race had not always had occasion to close the eyelids to protect the eyes, it is certain that the young child would not so quickly learn to do so in virtue of its own individual experience alone; and as the action cannot be attributed to any process of conscious inference, it is not rational; but we have seen that it is not originally reflex; therefore it is instinctive

times it stands for all the distinctively human faculties ion, and the re taken collectively, and in antithesis to the mental faculties in kind as those of the brute; while at other times it is taken to mean the

distinctively human faculties of intellect.

Dr. Johnson defines it as 'the power by which man deduces one proposition from another, and proceeds from premises to consequences.' This definition presupposes language, and therefore ignores all cases of inference not thrown into the formal shape of predication. Yet even in than the princ man the majority of inferences drawn by the mind never emerge as articulate propositions; so that although, aftere, however, we shall have occasion fully to observe in my subsequent work, there is much profound philosophy in identifying aculties are a reason with speech as they were identified in the term Logos, yet for purposes of careful definition so to identify intellect with language is clearly a mistake.

More correctly, the word reason is used to signify the power of perceiving analogies or ratios, and is in this sense equivalent to the term 'ratiocination,' or the faculty of deducing inferences from a perceived equivalency of Such is the only use of the word that is strictly legitimate, and it is thus that I shall use it throughout the present treatise. This faculty, however, of balancing relations, drawing inferences, and so of forecasting probabilities, admits of numberless degrees; and as in the designation of its lower manifestations it sounds somewhat unusual to employ the word reason, I shall in ith sufficient these cases frequently substitute the word intelligence Where we find, for instance, that an oyster profits by individual experience, or is able to perceive new relations and suitably to act upon the result of its perceptions, I think it sounds less unusual to speak of the oyster as displaying intelligence than as displaying reason. On this ption of wha account I shall use the former term to signify the lower degrees of the ratiocinative faculty; and thus in my usage it will be opposed to such terms as instinct, reflex action, &c., in the same manner as the term reason is so opposed This is a point which, for the sake of clearness, I desire the reader to retain in his memory. I shall always speak of intelligence and intellect in antithesis to instinct, emo-

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We have se ons, and that ex action; we is distinguis hough not con ho defines in re induced, ng, to the per re necessary b the continu ay convenien aid, is accura ction is adapt nction between onveyed by th Philosophy of ken in pursua kewise defect ortant differen stinctive action ie same speci ay more accu ental action

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faculties ion, and the rest, as implying mental faculties the same al faculties in kind as those which in ourselves we call rational.

Now it is notorious that no distinct line can be drawn etween instinct and reason. Whether we look to the hich man rowing child or to the ascending scale of animal life, we eeds from and that instinct shades into reason by imperceptible resupposes legrees, or, as Pope expresses it, that these principles are rence not for ever separate, yet for ever near.' Nor is this other et even in han the principles of evolution would lead us to expect, ind never is I shall afterwards have abundant occasion to show. Here, however, we are only concerned with drawing what istinction we can between instinct and reason as these aculties are actually presented to our observation. And his in a general way it is not difficult to do.

We have seen that instinct involves 'mental operaons, and that by this feature it is distinguished from resignify the exaction; we have now to consider the features by which is in this is distinguished from reason. These are accurately, the faculty hough not completely, conveyed by Sir Benjamin Brodie, valency of the defines instinct as 'a principle by which animals d that is re induced, independently of experience and reasonall use it mg, to the performances of certain voluntary acts, which re necessary to their preservation as individuals, or rees; and and continuance of the species, or in some other its sounds aid, is accurate as far as it goes, but it does not state ith sufficient generality and terseness that all instinctive ction is adaptive; nor does it clearly bring out the disprofits by an accurate and reason which is thus well an accurate and reason which is thus well and relation. so of fore to the continuance of the species, or in some other w relations onveyed by the definition of Hartmann, who says in his eptions, I Philosophy of the Unconscious, that instinct is action ster as distribution of what the end is.' This definition, however, is kewise defective in that it omits another of the imortant differentiæ of instinct—namely, the uniformity of stinctive action as performed by different individuals of so opposed as, I desire actual action (whether in animals or human beings),

¹ Psychological Researches, p. 187.

directed towards the accomplishing of adaptive movement antecedent to individual experience, without necessar knowledge of the relation between the means employed and the ends attained, but similarly performed under th same appropriate circumstances by all the individuals the same species. Now in every one of these respects with the exception of containing a mental constituent and ecies, and wh in being concerned in adaptive action, instinct differs from For reason, besides involving a mental conne subordinate stituent, and besides being concerned in adaptive action stinctive action is always subsequent to individual experience, never act reumstances but upon a definite and often laboriously acquired know ring the life ledge of the relation between means and ends, and is ver tions are perfar from being always similarly performed under the sam appropriate circumstances by all the individuals of the very coccurred experience. same species.

Thus the distinction between instinct and reason i both more definite and more manifold than is that between Nevertheless, in particula instinct and reflex action. cases there is as much difficulty in classifying certain actions as instinctive or rational, as there is in cases when the question lies between instinct and reflex action. the explanation of this is, as already observed, that instin passes into reason by imperceptible degrees; so the actions in the main instinctive are very common tempered with what Pierre Huber calls 'a little dose judgment or reason,' and vice versa. But here, again, the difficulty which attaches to the classification of particular actions has no reference to the validity of the distinction between the two classes of actions; these are definite an precise, whatever difficulty there may be in applying the to particular cases.

Another point of difference between instinct an reason may be noticed which, although not of invariable is of very general applicability. It will have bee observed, from what has already been said, that the essential respect in which instinct differs from reason con sists in the amount of conscious deliberation which the two processes respectively involve. Instinctive actions a actions which, owing to their frequent repetition, become

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Thus, then, veral definitio Reflex actio ent, due to stem, which is curring stimul an adaptive t Instinct is re

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movement habitual in the course of generations that all the habitual in the course of generations that all the necessary dividuals of the same species automatically perform the me actions under the stimulus supplied by the same propriate circumstances. Rational actions, on the other nd, are actions which are required to meet circumstances comparatively rare occurrence in the life-history of the ecies, and which therefore can only be performed by an tentional effort of adaptation. Consequently there arises e subordinate distinction to which I allude, viz., that stinctive actions are only performed under particular never actions are only performed under particular reumstances which have been frequently experienced iried know and is very tions are performed under varied circumstances, and and is vertions are performed under varied circumstances, and er the same ree to meet novel exigencies which may never before als of the ve occurred even in the life-history of the individual.

Thus, then, upon the whole, we may lay down our

d reason veral definitions in their most complete form. at between Reflex action is non-mental neuro-muscular adjustparticular ent, due to the inherited mechanism of the nervous ing certain stem, which is formed to respond to particular and often cases where curring stimuli, by giving rise to particular movements

an adaptive though not of an intentional kind.

Instinct is reflex action into which there is imported s; so the element of consciousness. The term is therefore a neric one, comprising all those faculties of mind which ttle dose concerned in conscious and adaptive action, antecedent individual experience, without necessary knowledge of e relation between means employed and ends attained, t similarly performed under similar and frequently rerring circumstances by all the individuals of the same ecies.

Reason or intelligence is the faculty which is concerned the intentional adaptation of means to ends. It therere implies the conscious knowledge of the relation beeen means employed and ends attained, and may be ercised in adaptation to circumstances novel alike to e experience of the individual and to that of the species.

CHAPTER I.

APPLICATION OF THE FOREGOING PRINCIPLES TO THE LOWEST ANIMALS.

Protozoa.

No one can have watched the movements of certa Infusoria without feeling it difficult to believe that the little animals are not actuated by some amount of intel gence. Even if the manner in which they avoid collision be attributed entirely to repulsions set up in the current which by their movements they create, any such mechani explanation certainly cannot apply to the small creature seeking one another for the purposes of prey, reproducti or, as it sometimes seems, of mere sport. There is common and well-known rotifer whose body is of a c shape, provided with a very active tail, which is armed its extremity with strong forceps. I have seen a sm specimen of this rotifer seize a much larger one with forceps, and attach itself by this means to the side of t cup. The large rotifer at once became very active, swinging about with its burden until it came to a piece weed, it took firm hold of the weed with its own force and began the most extraordinary series of movemen which were obviously directed towards ridding itself of t encumbrance. It dashed from side to side in all direction with a vigour and suddenness which were highly astonis ing, so that it seemed as if the animalcule would eith break its forceps or wrench its tail from its body. movements could possibly be better suited to jerk off t offending object, for the energy with which the jerks we given, now in one direction and now in another, were, as of the watchhave said, most surprising. But not less surprising This is certain

d: for although host jerked to n to be still at st have involve portion to the nutes, till eve lently away. succeed a seco ire scene was h animals as c depend upon a ald be sufficien ermination to But, without e be present, k of proving s t until an anir dual experience derivable from t movements, refore, I need sundry micro ilar to the abo roscopical orga ntelligence as -mental adjus ting to the lo ent person, wh te them in ful H. J. Carte tory,' and in h inct are to be zopoda. lf to the wate ed when away ch it has been n the sawdust

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tenacity with

tenacity with which the smaller rotifer retained its d; for although one might think that it was being host jerked to pieces, after each bout of jerking it was n to be still attached. This trial of strength, which st have involved an immense expenditure of energy in portion to the size of the animals, lasted for several nutes, till eventually the small rotifer was thrown lently away. It then returned to the conflict, but did 3 TO THE succeed a second time in establishing its hold. ire scene was as like intelligent action on the part of h animals as could well be imagined, so that if we were depend upon appearances alone, this one observation ald be sufficient to induce me to attribute conscious

ermination to these microscopical organisms.

But, without denying that conscious determination may e be present, or involving ourselves in the impossible k of proving such a negative, we may properly affirm t until an animalcule shows itself to be teachable by inidual experience, we have no sufficient evidence derived all creature derivable from any number of such apparently intellit movements, that conscious determination is present. erefore, I need not wait to quote the observations of sundry microscopists who detail facts more or less ilar to the above, with expressions of their belief that roscopical organisms display a certain degree of instinct ntelligence as distinguished from mechanical, or wholly -mental adjustment. But there are some observations ting to the lowest of all animals, and made by a comto a piece ent person, which are so remarkable that I shall have to own force te them in full. These observations are recorded by movemen H. J. Carter, F.R.S., in the 'Annals of Natural titself of tory, and in his opinion prove that the beginnings of all direction inct are to be found so low down in the scale as the zopoda. He says:—'Even Athealium will confine would either to the water of the watch-glass in which it may be ed when away from sawdust and chips of wood among jerk off the ch it has been living; but if the watch-glass be placed he jerks we in the sawdust, it will very soon make its way over the er, were, as of the watch-glass and get to it.'

urprising This is certainly a remarkable observation; for it seems

of certa e that the nt of intell oid collisid the currer ı mechani

eproductid There is is of a c is armed een a sm one with e side of t y active, a

hly astonis s body. 1

to show that the rhizopod distinguishes the presence the sawdust outside the watch-glass, and crawls over brim of the latter in order to get into more conger quarters, while it is contented with the water in the wat glass so long as there is no sawdust outside. But to ceed:

On one occasion, while investigating the nature of s large, transparent, spore-like elliptical cells (fungal?) w protoplasm was rotating, while it was at the same time char with triangular grains of starch, I observed some actinophor rhizopods creeping about them, which had similarly sha grains of starch in their interior; and having determined nature of these grains in both by the addition of iodin cleansed the glasses, and placed under the microscope a portion of the sediment from the basin containing these cells actinophryans for further examination, when A observed on the spore-like cells had become ruptured, and that a portion its protoplasm, charged with the triangular starch-grains, slightly protruding through the crevice. It then struck that the actinophryans had obtained their starch-grains f this source; and while looking at the ruptured cell, an nophrys made its appearance, and creeping round the cell last arrived at the crevice, from which it extricated one of grains of starch mentioned, and then crept off to a good tance. Presently, however, it returned to the same cell; although there were now no more starch-grains protruding, actinophrys managed again to extract one from the inte through the crevice. All this was repeated several time showing that the actinophrys instinctively knew that those nutritious grains, that they were contained in this cell, that, although each time after incepting a grain it went a to some distance, it knew how to find its way back to the again which furnished this nutriment.

On another occasion I saw an actinophrys station is close to a ripe spore-cell of pythium, which was situated u a filament of Spirogyra crassa; and as the young cili monadic germs issued forth, one after another, from the de cent spore-cell, the actinophrys remained by it and can every one of them, even to the last, when it retired to anotheribing to the part of the field, as if instinctively conscious that there

nothing more to be got at the old place.

But by far the greatest feat of this kind that ever present itself to me was the catching of a young acineta by an

ggish amœba, a ce as follows:-

In the evening king through a n placed aside: on a stalked an ich an amæba y are in quest of æba, like alme les of the acine raging an appe prised to find the und itself round e that frequentl ere there is a n interpretation. thout poisonous t ready to make ce so quickly, a nts of the non-, à priori, that h an agile littl d unrelaxing in el inceptions of m for nutrition ovarian aperti rse-like, in its ent, and crept t this was such the sequel disc ht yet escape, o host, I watche tale ended by ts, and thus in oming broken d

With regard ly, I think, be stive of somet mulation, they v rudiment of

¹ H. J. Carter, F.

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ever presen reta by an

ggish amæba, as the former left its parent; and this took ce as follows :-

In the evening of the 2nd of June, 1858, in Bombay, while re congetaking through a microscope at some Euglenæ, &c., which had n the water placed aside for examination in a watch-glass, my eye fell But to poon a stalked and triangular acineta (A. mystacina?), around ich an amæba was creeping and lingering, as they do when by are in quest of food. But knowing the antipathy that the wba, like almost every other infusorian, has to the tenles of the acineta, I concluded that the amæba was not entime charging an appetite for its whiskered companion, when I was actinophore prised to find that it crept up the stem of the acineta, and und itself round its body. This mark of affection, too much e that frequently evinced at the other end of the scale, even ere there is a mind for its control, did not long remain witht interpretation. There was a young acineta, tender, and these cells thout poisonous tentacles (for they are not developed at birth), served one at ready to make its exit from the parent, an exit which takes t a portion ce so quickly, and is followed by such rapid bounding move-th-grains, that who would venture to en struck 7, à priori, that a dull, heavy, sluggish amæba could catch h-grains fresh an agile little thing? But the amæba are as unerring d unrelaxing in their grasp as they are unrelenting in their and the cell sel inceptions of the living and the dead, when they serve sed one of the for nutrition; and thus the amaba, placing itself round to a good to ovarian aperture of the acineta, received the young one, ame cell; a resclike, in its fatal lap, incepted it, descended from the rotruding, rent, and crept off. Being unable to conceive at the time t this was such an act of atrocity on the part of the amæba several time the sequel disclosed, and thinking that the young acineta hat those we ght yet escape, or pass into some other form in the body of host, I watched the amæba for some time afterwards, until tale ended by the young acineta becoming divided into two rts, and thus in their respective digestive spaces ultimately oming broken down and digested.1

With regard to these remarkable observations it can ly, I think, be said that although certainly very sugom the de stive of something more than mechanical response to it and cau mulation, they are not sufficiently so to justify us in red to anotheribing to these lowest members of the zoological scale nat there rudiment of truly mental action. The subject, how-

¹ H. J. Carter, F.R.S., Annals of Natural History, 3rd Series, 1863,

ever, is here full of difficulty, and not the least so account of the amaba not only having no nerve system, but no observable organs of any kind; so th although we may suppose that the adaptive movement described by Mr. Carter were non-mental, it still remain wonderful that these movements should be exhibited such apparently unorganised creatures, seeing that as the remoteness of the end attained, no less than t complex refinement of the stimulus to which the adaptive response was due, the movements in questi rival the most elaborate of non-mental adjustments el where performed by the most highly organised of nervo systems.

$C\alpha lenterata.$

Dr. Eimer attributes 'voluntary action' to the Medu and indeed draws a sharp distinction between what considers their 'involuntary' and 'voluntary' movemen In this distinction, however, I do not at all concur; although I am well acquainted with the difference i tween the active and slow rhythm upon which the tinction is founded, I see no evidence whatever supposing that the difference involves any psychologic The active swimming is produced by stim lation, and is no doubt calculated to lead to the escape the organism; but this fact certainly does not carry beyond the ordinary possibilities of reflex action. even when, as in some species is constantly the car bouts of active swimming appear to arise spontaneous or without observable stimulation, the fact is to be tributed to a liberation of overplus ganglionic energ or to some unobservable stimulation; it does not just the supposition of any psychical element being co cerned.1

M'Crady gives an interesting account of a medu which carries its larvæ on the inner sides of its bel shaped body. The manubrium, or mobile digestive cavi

the animal, de mmit of the co Nov tongue. be moved firs the bell, in o les of the belle nutrient fluid ntained. I cit the higher an instinct; but ly-fish, it is u n ever have p erefore we n ult of natural

Some species ht, crowding is ively if moved cause certain se crowd into t dusæ is there tion which has der to bring th ul Bert has fo pecially the y e same fact with t in none of dence of a p ocess.

Some of the o some of the ggestive of pu ere is no adequ ofit by individu th our canon, t hibiting truly e study of refl terest—so mud em as typical

¹ For an account of the natural movements of the Medusæ and effects of stimulation upon them, see Croonian Lecture in Phil. True 1875, and also Phil. Trans. 1877 and 1879.

¹ See Croonian L

least so no nerve d; so the movemen till remai xhibited that as s than t rhich the in questi ments el of nervo

en what $\mathbf{movemen}$ concur; ference b ch the di hatever 1 y the cas ontaneous s to be a

a medu

in *Phil. Tra*i

the animal, depends, as in the other Medusæ, from the mmit of the concave surface of the bell, like a clapper tongue. Now M'Crady observed this depending organ be moved first to one side and then to the other side the bell, in order to give suck to the larvæ on the es of the bell—the larvæ dipping their long noses into e nutrient fluids which that organ of the parent's body ntained. I cite this case, because if it occurred in one the higher animals it would probably be called a case instinct; but as it occurs in so low an animal as a ly-fish, it is unreasonable to suppose that intelligence n ever have played any part in originating the action. erefore we may set it down as the uncompounded sult of natural selection.

Some species of medusæ—notably Sarsia—seek the he Medus ht, crowding into the path of a beam, and following it ively if moved. They derive advantage from so doing, cause certain small crustacea on which they feed likese crowd into the light. The seeking of light by these dusæ is therefore doubtless of the nature of a reflex tion which has been developed by natural selection in eler to bring the animals into contact with their prey. sychologic ul Bert has found that Daphnia pulex seeks the light by stime specially the yellow ray), and Engelmann has observed the escape esame fact with regard to certain protoplasmic organisms. ot carry at in none of these or other such cases is there any etion. At idence of a psychical element being concerned in the ocess.

Echinodermata.

Some of the natural movements of these animals, as not justific o some of their movements under stimulation, are very being configuration of purpose; but I have satisfied myself that ere is no adequate evidence of the animals being able to ofit by individual experience, and therefore, in accordance th our canon, that there is no adequate evidence of their of its bell hibiting truly mental phenomena. On the other hand, e study of reflex action in these organisms is full of edusæ and terest—so much so that in my next work I shall take em as typical organisms in this connection.

¹ See Croonian Lecture, 1881, in forthcoming issue of Phil. Trans.

Annelida.

Mr. Darwin has now in the press a highly interesting work on the habits of earth-worms. It appears from 1 observations that the manner in which these animals dra down leaves, &c., into their burrows is strongly indicati of instinctive action, if not of intelligent purpose—seeing that they always lay hold of the part of the leaf (ev though an exotic one) by the traction of which the le will offer least resistance to being drawn down. But this work will so shortly be published, I shall not forest ecause as a grany of the facts which it has to state, nor should I y ndeed, it is like to venture an opinion as to how far these facts, who nimals where considered altogether, would justify any inference to lon and reproduced to the state of the truly mental element as existing in these animals.

Of the land leeches in Ceylon, Sir E. Tennent give resent any cor an account which likewise seems to be speak intelligent heless, in the as occurring in annelids. He says:—

In moving, the land leeches have the power of planting of viz., the Cep extremity on the earth and raising the other perpendicularly anglia, and, watch for their victim. Such is their vigilance and instinct nent of intellig that on the approach of a passer-by to a spot which they infer om in ascend they may be seen amongst the grass and fallen leaves on thrustworthy ev edge of a native path, poised erect, and preparing for the attack on man and horse. On descrying their prey they vance rapidly by semicircular strides, fixing one end firmly at arching the other forwards, till by successive advances they lay hold of the traveller's foot, when they disengage themselv from the ground and ascend his dress in search of an aperture or Dicquemase In these encounters the individuals in the rear of sserts that oyste party of travellers in the jungle invariably fare worst, as the a, open their s leeches, once warned of their approach, congregate with simpsters taken from gular celerity.1

¹ Natural History of Ceylon, p. 481.

SHALL treat nimal function ense organs an ointing to the ained by the lo

Even the he foirs, where the ime, and are ot but, and then li he water. 1

The following

¹ This fact is p. 454, and is now chools' of France great for the new hells, they are fir exposure to the a respect is complet where they arrive

interestin rs from imals dra y indicati ose-seeir leaf (eve

ich the le n. But a

ces they ca ${f e}$ themselve

CHAPTER II.

MOLLUSCA.

SHALL treat of the Mollusca before the Articulata, not forestatecause as a group their intelligence is not so high. nould I yendeed, it is not to be expected that the class of facts, when himals wherein the 'vegetative' functions of nutri-erence to on and reproduction predominate so largely over the nimal functions of sensation, locomotion, &c., should nnent giveresent any considerable degree of intelligence. Neverintelligent heless, in the only division of the group which has ense organs and powers of locomotion highly developed planting of viz., the Cephalopoda—we meet with large cephalic ndicularly anglia, and, it would appear, with no small developand instinct nent of intelligence. Taking, however, the sub-kingthe they infer lom in ascending order, I shall first present all the
rustworthy evidence that I have been able to collect,
ointing to the highest level of intelligence that is atained by the lower members.

The following is quoted from Mr. Darwin's MS.:—

The following is quoted from Mr. Darwin's MS.:—

Even the headless oyster seems to profit from experience, an apertur or Dicquemase ('Journal de Physique,' vol. xxviii. p. 244) he rear of sserts that oysters taken from a depth never uncovered by the car, open their shells, lose the water within, and perish; but the with single years taken from the same place and depth, if kept in reserving where they are occasionally left uncovered for a short voirs, where they are occasionally left uncovered for a short ime, and are otherwise incommoded, learn to keep their shells but, and then live for a much longer time when taken out of he water.1

¹ This fact is also stated by Bingley, Animal Biography, vol. iii. p. 454, and is now turned to practical account in the so-called 'Oysterschools' of France. The distance from the coast to Paris being too great for the newly dredged oysters to travel without opening their shells, they are first taught in the schools to bear a longer and longer exposure to the air without gaping, and when their education in this respect is completed they are sent on their journey to the metropolis, where they arrive with closed shells, and in a healthy condition.

Some evidence of intelligence seems to be displayed elease them, the by the razor-fish. For the animals dislike salt, so that when this is sprinkled above their burrows in the sand they come to the surface and quit their habitations. if the animal is once seized when it comes to the surfact and afterwards allowed to retire into its burrow, n amount of salt will force it again to come to the surface.

With regard to snails, L. Agassiz writes: 'Quiconque a eu l'occasion d'observer les amours des limaçons, ne saurait mettre en doute la séduction déployée dans le mouvements et les allures qui préparent et accomplissent

le double embrassement de ces hermaphrodites.' 2

Again, Mr. Darwin's MS. quotes from Mr. W. White a curious exhibition of intelligence in a snail, which does not seem to have admitted of mal-observation. \mathbf{T} his gentleman 'fixed a land-shell mouth uppermost in a chink of rock; in a short time the snail protruded itself to its utmost length, and, attaching its foot vertically above, tried to pull the shell out in a straight line. Not succeeding, it rested for a few minutes and then stretched out its body on the right side and pulled its utmost, but Resting again, it protruded its foot on the left side, pulled with its full force, and freed the shell. exertion of force in three directions, which seems so geometrically suitable, must have been intentional.'

If it is objected that snail shells must frequently be liable to be impeded by obstacles, and therefore that this display of manœuvring on the part of their occupants is to be regarded as a reflex, I may remark that here again we have one of those incessantly recurring cases where it is difficult to draw the line between intelligence and nonintelligence. For, granting that the action is to a certain extent mechanical, we must still recognise that the animal while executing it must have remembered each of the two directions in which it had pulled ineffectually before it began to pull in the third direction; and it is improbable that snail shells are so frequently caught in positions from which a pull in only one direction will

¹ Bingley, *loc. cit.*, vol. iii. p. 449.

special instin irections at rig

The only oth pparent displa ble one which n the authority retation which evond anything hail intelligen pon the observ herefore quote

These animals nanent attachme rms me that he ne of which was fter a short tin eared, and was t djoining well-st had deserted it our hours it retu its successful me track, and

In this case ands on the ar b definite a kir uently we are he return of th ent, and their ocked garden he interpretati e look closely ouble accident to render th n the other ha nmediately sh nquestionably s home, and h eding. There

² De l'Espèce et de la Classe, &c., 1869, p. 106. ⁸ A Londoner's Walk to Edinburgh, p. 155 (1856).

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ons. Bu he surface urrow, n surface. $\mathbf{mplissent}$

V. White ine.

ell. This seems so ial.'

displayed elease them, that natural selection would have developed special instinct to try pulling successively in three the sand irections at right angles to one another.

The only other instance that I have met with of the pparent display of intelligence in snails is the remarkble one which Mr. Darwin gives in his 'Descent of Man,' n the authority of Mr. Lonsdale. Although the inter-Quiconque retation which is assigned to the fact seems to me to go acons, ne eyond anything that we should have reason to expect of e dans le hail intelligence, I cannot ignore a fact which stands pon the observation of so good an authority, and shall herefore quote it in Mr. Darwin's words:—

These animals appear also susceptible of some degree of perthich does animals appear also susceptible of some degree of polyanethich does anent attachment: an accurate observer, Mr. Lonsdale, informs me that he placed a pair of land-snails (*Helix pomatia*), nost in a ne of which was weakly, into a small and ill-provided garden. Iter a short time the strong and healthy individual disapvertically eared, and was traced by its track of slime over a wall into an including well-stocked garden. Mr. Lonsdale concluded that Not djoining well-stocked garden. Mr. Lonsdale concluded that stretched had deserted its sickly mate; but after an absence of twenty-most, but our hours it returned, and apparently communicated the result a the left its successful exploration, for both then started along the left ell. This

In this case the fact must be accepted, seeing that it ands on the authority of an accurate observer, and is of uently be definite a kind as not to admit of mistake. Consethat this wently we are shut up to the alternative of supposing pants is to the return of the healthy snail to its mate a mere acciagain we lent, and their both going over the wall into the wellhere it is tocked garden another mere accident, or acquiescing in and non-ne interpretation which Mr. Darwin assigns. a certain e look closely into the matter, the chances against the that the ouble accident in question are certainly so considerable d each of s to render the former supposition almost impossible. ffectually in the other hand, there is evidence to prove, as I shall and it is immediately show, that a not distantly allied animal is eaught in inquestionably able to remember a particular locality as ction will shome, and habitually to return to this locality after eding. Therefore, in view of this analogous and cor-

¹ Descent of Man, pp. 262-3.

roborative case, the improbability of the snail remembering distorted and income for twenty-four hours the position of its mate is very lints. . . . much reduced; while the subsequent communication, i I noticed sign it took place, would only require to have been of the pit in the chal nature of 'follow me,' which, as we shall repeatedly find sides of which there were is a degree of communicative ability which many inverted buted, there we brated animals possess. Therefore, in view of these considerations, I incline to Mr. Darwin's opinion that the fact smooth surface of can only be explained by supposing them due to intelligent they could be. gence on the part of the snails. Thus considered, these to my mind, to facts are no doubt very remarkable; for they would appear to indicate not merely accurate memory of direction and locality for twenty-four hours, but also no small degree was a pedestal of something akin to 'permanent attachment,' and sympa standing up abothetic desire that another should share in the good thing much that a tap which one has found.1

The case to which I have just alluded as proving beyond all doubt that some Gasteropoda are able to retail a very precise and accurate memory of locality, is that of the common limpet.

Mr. J. Clarke Hawkshaw publishes in the Journal of the Linnæan Society the following account of the habit in question:—

The holes in the chalk in which the limpets are often to be found are, I believe, excavated in a great measure by rasping from the lingual teeth, though I doubt whether the object is to form a cavity to shelter in, though the cavities, when formed may be of use for that purpose. It must be of the greatest importance to a limpet that, in order that it may insure a firm adherence to the rock, its shell should fit the rock accurately: when the shell does fit the rock accurately, a small amount of muscular contraction of the animal would cause the shell to adhere so firmly to a smooth surface as to be practically immoveable without fracture. As the shells cannot be adapted daily to different forms of surface, the limpets generally return to the same place of attachment. I am sure this is the case with many; for I found shells perfectly adjusted to the unever surfaces of flints, the growth of the shells being in some parts

hole. A limpet covered blocks b the smooth frac llearing had tak to the uneven su The cleared surf cavities, where t shelter in; yet i the top of the fli

It appears some extent we that limpets, one particular direction and I us in regarding unquestionably

Coming no that if a larger observation of much the mos Unfortunately, hitherto been count is all th the psychology

According

¹ The facts, however, in order to sustain such conclusions, of course require corroboration, and it is therefore to be regretted that Mr. Lonsdale did not experimentally repeat the conditions.

te is very lints. . . .

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by rasping object is to en formed reatest im ure a firm ccurately amount of shell to ad tically im-

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nembering distorted and indented to suit inequalities in the surface of the

en of the pit in the chalk. On one surface of a large block, over all edly find there were two flat fragments of a fossil shell about these content the facts to intellipte the smooth surface of the pieces of shell they were packed as closely as they could be. I noticed another case, which almost amounts, o my mind, to a proof that they prefer a smooth surface to a nole. A limpet had formed a clearing on one of the sea-weed-covered blocks before referred to. In the midst of this clearing was a pedestal of flint rather more than one inch in diameter, standing up above the surface of the chalk; it projected so much that a tap from my hammer broke it off. On the top of the smooth fractured surface of this flint the occupant of the clearing had taken up its abode. The shell was closely adapted clearing had taken up its abode. The shell was closely adapted to the uneven surface, which it would only fit in one position. The cleared surface was in a hollow with several small natural is that of cavities, where the limpet could have found a pit ready made to shelter in; yet it preferred, after each excursion, to climb up to Journal of the top of the flint, the most exposed point in all its domain.

It appears certain from these observations, which to some extent were anticipated by those of Mr. F. C. Lukis,² often to be that limpets, after every browsing excursion, return to one particular spot or home; and the precise memory of direction and locality implied by this fact seems to justify us in regarding these actions of the animal as of a nature unquestionably intelligent.

> Coming now to the cephalopoda, there is no doubt that if a larger sphere of opportunity permitted, adequate observation of these animals would prove them to be much the most intelligent members of the sub-kingdom. Unfortunately, however, this sphere of opportunity has hitherto been very limited. The following meagre account is all that I have been able to gather concerning the psychology of these interesting animals.

According to Schneider, the Cephalopoda show un-

Journal Linn. Soc. vol. xiv. p. 406 et seq.

² Mag. Nat. Hist. 1831, vol. iv. p. 346. * Thieresche Wille, § 78.

mistakable evidence of consciousness and intelligence This observer had an opportunity of watching them for long time in the zoological station at Naples; and h says that they appeared to recognise their keeper after they had for some time received their food from him Hollmann narrates that an octopus, which had had struggle with a lobster, followed the latter into an adjacen tank, to which it had been removed for safety, and then destroyed it. In order to do this the octopus had to climb up a vertical partition above the surface of the water and descend the other side.1 According Schneider, the Cephalopoda have an abstract idea water, seeking to return to it when removed, even though they do not see it. But this probably arises from the sense of discomfort due to exposure of their skin to the air; and if we can call it an 'idea,' it is doubtless share by all other aquatic Mollusca when exposed to air.

¹ Leben der Cephalopoden, s. 21.

VITHIN the last he habits and i nsiderably ext itome of our comparative hapter is consti ons and experin ort period nam debted for this ates, Belt, Mü r John Lubbo inducted their orld and on w rprising that difference; for ected, that diff abits and inte lese numerous show clearly bints of agree nsidered may eal with them becial sense; motions: Pow indry species; telligence of v

Taking first number of exp passing throu telligencehem for s; and h eper afte from hin had had n adjacen and there us had to ce of the ording t idea d en though

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CHAPTER III.

ANTS.

VITHIN the last ten or twelve years our information on he habits and intelligence of these insects has been so msiderably extended, that in here rendering a condensed bitome of our knowledge in this most interesting branch comparative psychology, it will be found that the napter is constituted principally of a statement of observaons and experiments which have been conducted during the ort period named. The observers to whom we are mainly debted for this large increase of our knowledge are Messrs. ates, Belt, Müller, Moggridge, Lincecum, MacCook, and r John Lubbock. From the fact that these naturalists inducted their observations in different parts of the orld and on widely different species of ants, it is not irprising that their results should present many points difference; for this only shows, as we might have exected, that different species of ants differ considerably in abits and intelligence. Therefore, in now drawing all lese numerous observations to a focus, I shall endeavour show clearly their points of difference as well as their pints of agreement; and in order that the facts to be insidered may be arranged in some kind of order, I shall eal with them under the following heads:—Powers of ecial sense; Sense of direction; Powers of memory; motions; Powers of communication; Habits general in indry species; Habits peculiar to certain species; General telligence of various species.

Powers of Special Sense.

Taking first the sense of sight, Sir John Lubbock made number of experiments on the influence of light coloured passing through various tints of stained glass, with the

The ants which he observed great following results. dislike the presence of light within their nests, hurrying about in search of the darkest corners when light is a mitted. The experiments showed that the dislike is mud greater in the case of some colours than in that of other Thus under a slip of red glass there were congregated one occasion 890 ants, under green 544, under yellow 49 and under violet only 5. To our eyes the violet is as opage as the red, more so than the green, and much more than the yellow. Yet, as the numbers show, the ants h scarcely any tendency to congregate under it: there we nearly as many under the same area of the uncoverportion of the nest as under that shaded by the viole glass. It is curious that the coloured glasses appear to a on the ants in a graduated series, which corresponds wi the order of their influence on a photographic plate. periments were therefore made to test whether it mig not be the actinic rays that were so particularly distasted to the ants; but with negative results. Placing viole glass above red produces the same effect as red gla alone. Obviously, therefore, the ants avoid the viole glass because they dislike the rays which it transmit and do not prefer the other colours because they like the rays which they transmit. Sodium, barium, strontium and lithium flames were also tried, but not with so mu effect as the coloured glass.

It has just been observed that the relative dislike which Sir John Lubbock's ants showed to lights of different colour seems to be determined by the position of the colour the spectrum—there being a regular gradation of intolerance shown from the red to the violet end. As these and dislike light, the question suggests itself that the reast of their graduated intolerance to light of different colour may be due to their eyes not being so much affected the rays of low as by those of high refrangibility. In the connection it would be interesting to ascertain whether ants of the genus Atta show a similarly graduated intolerance to the light in different parts of the spectrum; the both Moggridge and MacCook record of this genus that not only does not shun the light, but seeks it—coming

glass sides of amp. Possible the reverse of the case of the As regards he insects. Turnistling, &c., we ghtest influence the sensitive flat any evidence man ears.

Lastly, as regard that on being strong seent on without devidently per wever, they reter doing this further notice ubt on my mind wave about an ented pencil wa

That ants tra entioned by Hu nse for their po eviously found wer of tracking ends, by drawi ting the scent a ts arrived at the out in various ail on the other oceeded on th d systematic lly corroborate ints are conce ese experimen is the nest, I

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glass sides of their artificial nests to enjoy the light of ght is at hts of different colours would be found in this genus to ke is much the reverse of that which Sir John Tall the case of the British species.

As regards hearing, Sir John Lubbock found that nds of various kinds do not produce any effect upon insects. Tuning-forks and violin notes, shouting, s as opaque insects. Tuning-forks and violin notes, shouting, the more sistling, &c., were all equally inefficient in producing the ants has these influence upon the animals; and experiments h sensitive flames, microphone, telephone, &c., failed to uncovered ld any evidence of ants emitting sounds inaudible to man ears.

Lastly, as regards the sense of smell, Sir John Lubbock ponds without that on bringing a camel's-hair brush steeped in plate. Explored steeped in steeped in steeped in plate. nt on without taking any notice, but others stopped. distastef devidently perceiving the smell, turned back. Soon, wever, they returned, and passed the scented pencil. sered glaster doing this two or three times, they generally took further notice of the scent. This experiment left no ubt on my mind." In other cases the ants were observed wave about and throw back their antennæ when the

That ants track one another by scent was long ago entioned by Huber, and also that they depend on this ase for their power of finding supplies which have been eviously found by other ants. Huber proved their wer of tracking a path previously pursued by their ends, by drawing his finger across the trail, so oblites these and ting the scent at that point, and observing that when the the reast strived at that point they became confused and ran cent colour out in various directions till they again came upon the affected bail on the other side of the interrupted space, when they ty. In the occeeded on their way as before. The more numerous in whetherd systematic experiments of Sir John Lubbock have lly corroborated Huber's observations, so far as these ectrum; pints are concerned. Thus, to give only one or two of enus that see experiments; in the accompanying woodcut (Fig. 1) is the nest, B a board, n f g slips of paper, h and m

similar slides of glass, on one of which, h, there was plan pupæ, while the other, m, was left empty. Sir John L

bock watched two particular (marked) a proceeding from A to h and back aga carrying the pupæ on h to the nest Whenever an ant came out of A upon B transposed the slips f and g. Therefore the angle below n there was a choice p sented to the ant of taking the unscent pathway leading to the full glass h, or t scented pathway leading to the empty gl m. The two marked ants, knowing the way, always took the right turn at t angle; but the stranger ants, being guid

only by scent, for the most part took the wrong turn the angle, so going to the empty glass m. For out of 1 stranger ants only 21 went to h, while the remaining l went to m. Still the fact that all the stranger ants not follow the erroneous scent-trail to m, may be taken indicate that they are also assisted in finding treasure the sense of sight, though in a lesser degree. Therefore Sir John Lubbock concludes that in finding treasure 'th are guided in some cases by sight, while in others the track one another by scent.'

As further evidence showing how much more ants pend upon scent than upon sight in finding their way, following experiment may be quoted. In the accompan ing woodcut (Fig. 2) the line marked 1, 2, 3 represen the edge of a paper bridge leading to the nest; At the edge of a paper bridge leading to the nest; At top of a pencil which is standing perpendicularly up and and forward a board, represented by the general black surface; ject first stood the top of the same pencil when moved a distance wards the nest a few inches from its first position A. On the true between the of this pencil were placed some pupe. Sir John Lurry repeated efficiently bock, after contriving this arrangement, marked an arch, as it were and put it upon the pupe on the top of the pencil erefore the and After she had made two journeys carrying pupe from the pencil to the nest (the tracks she pursued being represented by the two thick white lines), while she was in the periment. 'S nest he moved the pencil to its position at B. The this and 4) on a

hite line repres its endeavours few inches fro urney to the s

was place

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he nest upon B Cherefore choice p unscent ss h, or t empty gl owing the urn at t eing guid ong turn r out of l naining l

be taken treasure Therefo asure 'th others th

ore ants d eir way, t accompan represer

nest; Atl

hite line represents the course then pursued by the ant its endeavours to find the pencil, which was shifted only few inches from A to B. That is, 'the ants on their urney to the shifted object travelled very often back-

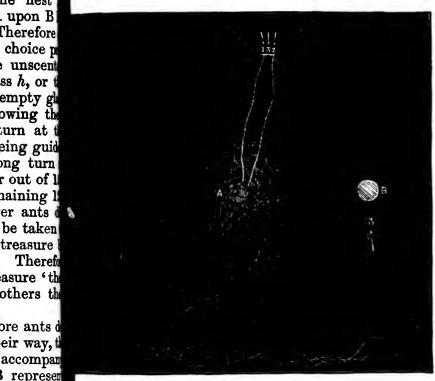


Fig. 2.

ularly up rds and forwards and round the spot where the coveted surface; ject first stood. Then they would retrace their steps distance wards the nest, wander hither and thither from side to on the tree between the nest and the point A, and only after John Lucy repeated efforts around the original site of the larvæ ked an arch, as it were, accidentally the object desired at B.' the penderefore the ants were clearly not guided by the sight per from the the pencil.

eing represent the same thing is well shown by another form of was in the periment. Some food was placed at the point a (Figs. The thin and 4) on a board measuring 20 inches by 12 inches,

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between

and so arranged that the ants in going straight from it en to x, and the nest would reach the board at the point b, and after two look for passing under the paper ter twenty-five tunnel c, would proceed andering.

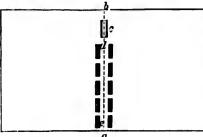


Fig. 3. to a. The board was the riment, which twisted as shown in Fig. 4. 'The bricks and tunnel being terest as shown arranged exactly in the entheir sense.

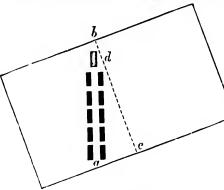


Fig. 4.

along the old path to e.' Keeping the board steady,

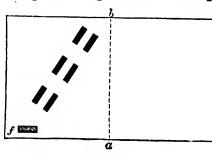


Fig. 5.

food were then moved wards the right-hand corner of the board—i.e. over a d tance of 8 inches (Fig. 6). The ant now first went to

And, as evid five pairs uch more de wooden bricks, each ey place upon inches in length and I

inches in height. Whending their withey got to know the on any other way they went qui culties, it is de straight along the line to te yet one for same direction as home of direction fore, but the box we shall presonant formation which line de was now of the F. niger we have the many of the many side them. The change ece of board, I however, did not at thich had been

discompose the and vice versâ,

but instead of going

as before, through t

tunnel and between

the rows of bricks

a, they walked exact

moving the brick path

to the left-hand corner the board where the for was next placed (Fig.

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the ant first go to the

position of the food at

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The bricks a

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As evidence nse of direct lduce Sir John ı ants—leavin es and wasps e first accusto nd fro to food ot quite accust as upon a brid

t from it en to x, and not finding the food at either place, set to b, and after to look for it at random, and was only successful the papeter twenty-five minutes' ald proces indering.

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And, as evidence how uch more dependence ey place upon scent in ht. Whending their way than

know the on any other of their rent qui ties, it is desirable to the line of their rent qui terest as showing that terest as showing that the hen their sense of smell is made to contradict their nse of direction, they follow the former, notwithstanding, we shall presently see, the wonderful accuracy of the formation which is supplied to them by the latter. 'If, hen F. niger were carrying off larvæ placed in a cup on a ece of board, I turned the board round so that the side hich had been turned towards the nest was away from it, and vice versâ, the ants always returned over the same ack on the board, and, in consequence, directly away om home. If I moved my board to the other side of my tificial nest, the result was the same. Evidently they of bricks laked exact. There can be little doubt that ants have a sense of steady, but the steady are so well able to distinguish sugary sub-

steady, he ste, as they are so well able to distinguish sugary sub-rick paths ances; and it is unquestionable that in their antennæ nd corner hey possess highly elaborated organs of touch.

Sense of Direction.

As evidence of the accuracy and importance of the coto the conse of direction in the Hymenoptera, we must here duce Sir John Lubbock's highly interesting experiments a ants—leaving his experiments in this connection on best and wasps to be considered in the next chapter. bricks a le first accustomed some ants (Lasius niger) to go to an moved of the first accustomed to the way, he watched when an ant as upon a bridge which could be rotated, and while she As evidence of the accuracy and importance of the

was passing along it, he turned it round, so that end b w at c, and c at b. 'In most cases the ant immediate turned round also; but even if she went on to b or c, the case might be, as soon as she came to the end of the bridge she turned round.' Next, between the nest at speriments already the food he placed a hat-box twelve inches in diameteration of the sta and seven inches high, cutting two small holes, so the egeneral fact the ants in passing from the nest to the food had to pa in at one hole and out at the other. The box was fixed a more or les upon a central pivot, so as to admit of being rotated easi inple proof that without much friction or disturbance. When the antship is of considera well learnt their way, the box was turned half round sture of this in soon as an ant had entered it, 'but in every case these, precisely id ant turned too, thus retaining her direction.' Lasth Sir John took a disk of white paper, which he place repetition, as in the stead of the hat-box between the nest and the faced by lapse food. When an ant was on the disk making toward atures of insectthe food, he gently drew the disk to the other side of the food, so that the ant was conveyed by the moving surfain the same direction as that in which she was going, by beyond the point to which she intended to go. Und these circumstances 'the ant did not turn round, but we on' to the further edge of the disk, when she seemed good deal surprised at finding where she was.'

These experiments seem to show that the mysterion 'sense of direction,' and consequent faculty of 'homing are in ants, at all events, due to a process of registering found his gard and, where desirable, immediately counteracting any change of direction, even when such change is gently made by wholly closed chamber in which the animal is moving, an portant additional not by any muscular movements of the animal itself. An tis. It seems that the fact that drawing the moving surface along in the drawing that Sir John no wholly closed chamber in which the animal is moving, an same direction of advance as that which the insect pursuing does not affect the movements of the latter experiment with seems conclusively to show that the power of registration rts the box, the arrival of the latter experiment with the power of registration rts the box, the arrival of the latter experiment with the power of registration rts the box, the arrival of the latter experiment with the power of registration rts the box, the arrival of the latter experiment with the power of registration rts the box, the arrival of the latter experiment with the power of registration rts the box, the arrival of the latter experiment with the power of registration rts the box, the arrival of the latter experiment with the power of registration rts the box, the arrival of the latter experiment with the power of registration rts the box, the arrival of the latter experiment with the power of registration rts the box, the arrival of the latter experiment with the power of registration rts the box, the arrival of the latter experiment with the power of registration rts the box, the arrival of the latter experiment with the power of registration rts the box, the arrival of the latter experiment with the power of registration rts the box, the arrival of the latter experiment with the power of registration rts the box of the latter experiment with the power of registration rts the latter experiment with the power of registration registrati has reference only to lateral movements of the travelling ting changes in the surface; it has no reference to variations in the velocit the hat-box is cove of advance along the line in which the animal is proved, we can under gressing.1

While this MS. is passing through the press Sir John Lubbock

me powers of m ore of food or la hus, a new fact treat of the in hough to refer ts, Sir John L sects by a rep easure, if that With regard pear that any

Little need

d another paper rection in which t light being the sou oved when it is m

periment with the

llowing observa-

the leaf-cuttin

their paths he

Powers of Memory.

Little need here be said to prove that ants display end of the pme powers of memory; for many of the observations and nest an experiments already detailed constitute a sufficient demondiameteration of the statement that they do. Thus, for instance, es, so the ne general fact that whenever an ant finds her way to a had to partore of food or larvæ, she will return to it again and again was fixed a more or less direct line from her nest, constitutes a more or less direct line from her nest, constitutes mple proof that the ant remembers the way to the store. It is of considerable interest, however, to note that the ature of this insect-memory appears to be, as far as it case the case side of the treat of the intelligence of bees; but meanwhile it is ing surface hough to refer to the fact that in his experiments on going, by Sir John Lubbock found it necessary to teach the O. Und sects by a repetition of several lessons their way to

easure, if that way was long or unusual.

With regard to the duration of memory, it does not opear that any experiments have been made; but the mysterior compared the leaf-cutting and may here be stated. In June 1859 the leaf-cutting and invaded by these and, and following any change their paths he found their nest about a hundred yards

made by ad another paper before the Linnman Society, which contains some loving, an portant additional matter concerning the sense of direction in tself. An its lit seems that in the experiment above described, the hat-box is not provided with a cover or lid, i.e. was not a 'closed chamber,' in the latter rection in which they observe the light to fall upon them. For in the latter experiment with the uncovered hat-box, if the source of light andle) is moved round together with the rotating table which superstration travelling the box, the ants continue their way without making compensating changes in their direction of advance. The same thing happens he velocity the hat-box is covered, so as to make of it a dark chamber. Direction light being the source of their information that their ground is being oved, we can understand why they do not know that it is being oved when it is moved in the direction of their advance, as in the oved when it is moved in the direction of their advance, as in the periment with the paper slip.

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Lubbock ha

distant. He poured down their burrows a pint of commo o considerable brown carbolic acid, mixed with four buckets of water eem probable, The marauding parties were at once drawn off from the he ants remember. The marauding parties were at once drawn off from the he ants remem garden to meet the danger at home, and the whole form beriod of twelve carium was disorganised, the ants running up and down as improbable again in the utmost perplexity. Next day he found the Thierstaaten,' busily employed bringing up the ant-food from the observants from burrows, and carrying it to newly formed ones a few yam habited streed distant. These, however, turned out to be only intended as temporary repositories; for in a few days both the observant to obtate as temporary repositories; for in a few days both the observant be supposed all the ants to have died. Subsequently, how can only be ever, he found that they had migrated to a new site, about the supposed all the ants to have died. Subsequently, how can only be ever, he found that they had migrated to a new site, about the supposed and there established the subsequently in a new nest. Twelve months later the antarkable facts. themselves in a new nest. Twelve months later the an markable facts, again invaded his garden, and again he treated them to emarkable facts strong dose of carbolic acid. The ants, as on the previous It has been occasion, were at once withdrawn from the garden, as hat all the ants two days afterwards he found 'all the survivors at work one another as one track that led directly to the old nest of the year before nother nest, experiences and the survivors at work one another as one track that led directly to the old nest of the year before nother nest, experiences and the survivors at work one another as one track that led directly to the old nest of the year before nother nest, experiences and the survivors at work one another as one track that led directly to the old nest of the year before nother nest, experiences and the survivors at work one another as one track that led directly to the old nest of the year before nother nest, experiences and the survivors at work one another as one track that led directly to the old nest of the year before nother nest, experiences and the survivors at work one another as one track that led directly to the old nest of the year before nother nest, experiences and the survivors at work on the previous states and the survivors at work on the previous states are not the survivors at work on the previous states and the survivors at work on the survivors at work of the survivors at where they were busily employed in making fresh expecies, is known vations. Many were bringing along pieces of ant-fow haltreated or purfrom the nest most recently deluged with carbolic acid emoved an ant that which had been similarly deluged a year before, a companions for a from which all the carbolic acid had long ago disappear lised as a frient of the carried the undeveloped white pupe and largitizens after the lit was a wholesale and entire migration; and the next described as a first the next deep which he had last poured the carbolic acid full. the nest down which he had last poured the carbolic at eating and full was entirely deserted. Mr. Belt adds: 'I afterwards for hem as follows. that when much disturbed, and many of the ants destroys way from the r the survivors migrate to a new locality. I do not do nonths, and fou that some of the leading minds in this formicarium receives han a year the lected the nest of the year before, and directed the eated this exp migration to it.

Now, I do not insist that the facts necessarily point ion accorded t this conclusion; for it may have been that the leaders pparently, how the migration simply stumbled upon the old and vac considering nest by accident, and finding it already prepared as a make a nest, it forthwith proceeded to transfer the food and pupe to e all personall Still, as the two nests were separated from one another stonishing that

ith the same

f common considerable a distance, this hypothesis does not of common of considerable a distance, this hypothesis does not of water seem probable, and the only other one open to us is that from the he ants remembered the site of their former home for a cole form seriod of twelve months. And this conclusion is rendered and down sess improbable from a statement of Karl Vogt in his bound there are ants from a certain nest used to go through certain a few yard phabited streets to a chemist's shop 600 mètres distant, y intende to obtain access to a vessel filled with syrup. As the theoretical transfer of the supposed that this vessel was found in success that he essive working seasons by as many successive accidents, and the site, about your store from season to season.

I shall now pass on to consider a class of highly re-

restablished I shall now pass on to consider a class of highly reserving the markable facts, perhaps the most remarkable of the many emarkable facts connected with ant psychology.

It has been known since the observations of Huber arden, as hat all the ants of the same nest or community recognise at work one another as friends, while an ant introduced from nother nest, even though it be an ant of the same fresh expecies, is known at once to be a foreigner, and is usually fant-food altreated or put to death. Huber found that when he colic acid emoved an ant from a nest and kept it away from its before, as ompanions for a period of four months it was still recognisappeare ised as a friend, and caressed by its previous fellowand larvitizens after the manner in which ants show friendship, the next disc, by stroking antennæ. Sir John Lubbock, after recarbolic as wards four way from the nest for a still longer period than four onot dot and a year the animal was recognised as before. He relief the same invariable difference between the receptivity point in accorded to a foreigner and a native—no matter, rily point ion accorded to a foreigner and a native—no matter,

pparently, how long the native had been absent.

Considering the enormous number of ants that go to the last a nest, it seems astonishing enough that they should be all personally known to one another, and still more another stonishing that they should be able to recognise members.

of their community after so prolonged an absence. Think ere thus so ce ing that the facts could only be explained, either by a friends had the ants in the same nest having a peculiar smell, or be resent in that of all the members of the same community having a partemarkable fact ticular pass-word or gesture-sign, Sir John Lubbock with the view of testing this theory, separated some ant and they are very from a nest while still in the condition of pupæ, and when they emerged from that state as perfect insects transferred them back to the nest from which they had been taken as pupæ. Of course in this case the ants in the nest could never have seen those which had been removed, for a larval ant is as unlike the mature insecta a grub is unlike a beetle; neither can it be supposed that a larva, hatched out away from the nest, should retain when a perfect insect, any smell belonging to its parer nest-more especially as it had been hatched out b ants in another nest; 1 nor, lastly, is it reasonable imagine that the animal, while still a larval grub, can have been taught any gesture-signal used as a pass-word by the matured animals. Yet, although all these possible hypo theses seem to be thus fully excluded by the condition of the experiment, the result showed unequivocally that the ants recognised their transformed larvæ as native-bor members of their community.

Lastly, Sir John Lubbock tried the experiment going still further back in the life-history of the ant before separating them from the nest. For in September he divided a nest into two halves, each having a queen At this season there were neither larvæ nor eggs. The troduced these following April both the queens began to lay eggs, and cause this hear August—i.e. nearly a year after the original partitioning ther that could of the nest—he took some of the ants newly hatched from the pupe in one division, and placed them in the other division, and vice versâ. In all cases these ants were r ceived by the members of the other half of the dividement made by nest as friends, although if a stranger were introduced in either half it was invariably killed. Yet the ants which

These observa

ough the resul ith had been bro ter they had be at the ants, har hen they came t in the highest possible. In the lutely never see me days after ar e nest; and yet sed as belonging It seems to me

ents that the re dual; that their t is individually mmunity.

At the same ti en when intoxic eir own nest eve rysalis by strang t effected by me

We must, th bject that the lected is as

It ought her us recognising ed by the limi cognised their absence of fou

Under this h enormous mas ants recognising

It is to be noted that although ants will attack stranger an introduced from other nests, they will carefully tend stranger lar similarly introduced.

Lubbock

condition

f the ant

e. Think ere thus so certainly recognised by their kindred ants her by a friends had never, even in the state of an egg, been nell, or be resent in that division of the nest before. On this highly ing a par markable fact Sir John Lubbock says:—

These observations seem to me conclusive as far as they go, some antend they are very surprising. In my experiments of last year, upæ, and ough the results were similar, still the ants experimented ith had been brought up in the nest, and were only removed they had become pupe. It might therefore be argued at the ants, having nursed them as larve, recognised them had been they came to maturity; and though this would certainly in the highest degree improbable, it could not be said to be appossible. In the present case, however, the old ants had above posed the lutely never seen the young ones until the moment when, uld retain me days after arriving at maturity, they were introduced into its parent e nest; and yet in all ten cases they were undoubtedly recog-ed out be sed as belonging to the community.

sonable to like the stable of the community.

It seems to me, therefore, to be established by these experients that the recognition of ants is not personal and indicated by the dual; that their harmony is not due to the fact that each it is individually acquainted with every other member of the mmunity.

mmunity.

At the same time, the fact that they recognise their friends ocally the en when intoxicated, and that they know the young born in native-bon eir own nest even when they have been brought out of the rysalis by strangers, seems to indicate that the recognition is eriment teffected by means of any sign or pass-word.

We must, therefore, conclude with reference to this September bject that the mode whereby recognition is undoubtedly a queen fected is as yet wholly unintelligible; and I have troduced these facts under the heading of memory only cause this heading is not more inappropriate than any her that could be devised for their reception.

It ought here to be added also that the power of the other community is not considered to this section.

the other us recognising members of their community is not conits were reflect by the limits of blood-relationship, for in an experi-the divides ent made by Forel it was shown that Amazon ants oduced in cognised their own slaves almost instantaneously after ants which absence of four months.

Under this heading I may also adduce the evidence as stranger and enormous masses, or, as we might say, a whole nation tranger land enormous masses, or, as we might say, a whole nation ants recognising each other as belonging to the same nationality. New nests often spring up as offshoots from the every ant the older ones, and thus a nation of towns gradual ike a little tig spreads to an immense circumference around the original ach stranger v Forel describes a colony of F. exsecta which comprised more than two hundred nests, and covered space of nearly two hundred square mètres. 'All th members of such a colony, even those from the further most nest, recognise each other and admit no stranger.'

Similarly, MacCook describes an 'ant town' in the Alleghany Mountains of North America ('Trans. Ame Entom. Soc., Nov. 1877) which was inhabited by F. exse toides. It consists of 1,600 to 1,700 nests, which rise cones to a height of from two to five feet. The groun below is riddled in every direction with subterrane passages of communication. The inhabitants are all on the most friendly terms, so that if any one nest is injured

is repaired by their united forces.

It remains to be added in connection with this subjection that the recognition is not automatically invariable, b when 'ants are removed from a nest in the pupa stat tended by strangers, and then restored, some at least their relatives are certainly puzzled, and in many cas doubt their claims to consanguinity. I say some, became while strangers under the circumstances would have be immediately attacked, these ants were in every ca amicably received by the majority of the colony, and it w sometimes several hours before they came across one w did not recognise them.'

It may also be added that Lasius flavus behave towards strangers quite differently and much more hi pitably than is the case with L. niger. The strang shows no alarm, but, on the contrary, will voluntar enter the strange nest, and she is there received wi kindness; although from the attention she excites, the numerous communications which take place between her and her new friends, Sir John was 'satisfied that the knew she was not one of themselves. . . . Very different the behaviour of L. niger under similar circumstances. tried the same experiment with them. There was communications with the antennæ, there was no cleaning

The pugna rell and gene pecial instance enderer emoti ion among obs ubbock it was lay marked si y caressing me olicitude for fr bund that the nented are ap ffection and of re in these sp he sterner pass

He tried b eneath an antoad made any anions. He t esult on variou ifficulty are a hat their comp e could give hen ants are evote themsel heir friends in iends take no heir own comp seem somewh: llow-creatures arry them about urther experin how that chlor moved to the ver into the sur

ecta which

covered 'All th

hoots from out every ant which the stranger approached flew at her gradually ike a little tigress. I tried this experiment four times; he original ach stranger was killed and borne off to the nest.'

Emotions.

The pugnacity, valour, and rapacity of ants are too tranger. The pugnacity, valour, and rapacity of ants are too vell and generally known to require the narration of pecial instances of their display. With regard to the enderer emotions, however, there is a difference of opinion among observers. Before the researches of Sir John and rise is subject to the prevalent view that these insects display marked signs of affection towards one another, both a prevalent view that these insects display marked signs of affection towards one another, both a prevalent view that these insects display marked signs of affection towards one another, both a province of their antennæ, and by showing conditions that the species of ants on which he has experimented are apparently deficient both in feelings of a ffection and of sympathy—or, at least, that such feelings ariable, in these species much less strongly developed than

re in these species much less strongly developed than pupa state he sterner passions.

He tried burying some specimens of Lasius niger eneath an ant-road; but none of the ants traversing the oad made any attempt to release their imprisoned comanions. He tried the same experiment with the same every care esult on various other species. Even when the friends in fifficulty are actually in sight, it by no means follows hat their companions will assist them. Of this, he says, e could give almost any number of instances. Thus, e could give almost any number of instances. Thus, de could give almost any number of instances. Thus, when ants are entangled in honey, their companions when her friends in distress; and when partly drowned, their voluntaries take no notice. When chloroformed or intoxicated heir own companions either do not heed them, or else excites, are seem somewhat puzzled at finding their intoxicated ellow-creatures in such a condition, take them up, and arry them about for a time in a somewhat aimless manner. The different further experiments, however, on a larger scale, went to now that chloroformed ants were treated as dead, i.e. there was a moved to the edge of the parade-board and dropped no cleaning their intoxicated were into the surrounding most of water; while intoxicated no cleaning yer into the surrounding moat of water; while intoxicated

ants were generally carried into the nest, if they were an belonging to that community; if not, they were throw overboard. This care shown towards intoxicated friend appears to indicate a dim sense of sympathy toward afflicted individuals; but that this emotion or instituted on the case of these species extend to health individuals in distress seems to be proved, not only by the experiments of burying already described, but also by the following:—

On Sept. 2, therefore, I put two ants from one of my nest of F. fusca into a bottle, the end of which was tied up wit muslin as described, and laid it down close to the nest. In second bottle I put two ants from another nest of the same species. The ants which were at liberty took no notice of the bottle containing their imprisoned friends. The strangers in t other bottle, on the contrary, excited them considerably. whole day one, two, or more ants stood sentry, as it were, ow the bottle. In the evening no less than twelve were collected round it, a larger number than usually came out of the nest any one time. The whole of the next two days, in the same way, there were more or less ants round the bottle containing the strangers; while, as far as we could see, no notice whatev was taken of the friends. On the 9th the ants had eat through the muslin, and effected an entrance. We did n chance to be on the spot at the moment; but as I found tw ants lying dead, one in the bottle and one just outside, I thin there can be no doubt that the strangers were put to deal The friends throughout were quite neglected.

Sept. 21.—I then repeated the experiment, putting the ants from another nest in a bottle as before. The same see was repeated. The friends were neglected. On the oth hand, some of the ants were always watching over the bott containing the strangers, and biting at the muslin which precede them. The next morning at 6 A.M. I found five an thus occupied. One had caught hold of the leg of one of the strangers, which had unwarily been allowed to protrude through the meshes of the muslin. They worked and watched, thou not, as far as I could see, with any system, till 7.30 in the evening, when they effected an entrance, and immediately a tacked the strangers.

Sept. 24.—I repeated the same experiment with the same sion of humane nest. Again the ants came and sat over the bottle containing the habit of the strangers, while no notice was taken of the friends.

The next moound the bottle As in the former he leg, and was ay the ants clus hough not system ened all the follow

On repeating formica rufescen and showed no significant to surminavery [i.e. by the lents on F. fuscentred is a strong

We must n neral conclusi e tenderer eme with the spec be certainly esently see. I en the hard-he seem not alto utilated friends althy friends oxicated friend served, a dim s eserve the life the communit ns of Latreille tilated compar ich he has him hen of F. fuscacked and inju parated by Sir ne by. 'She e ked her up te It would nessed this so sion of human

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were any ound the bottle containing the strangers, none near the friends. As in the former case, one of the ants had seized a stranger by he leg, and was trying to drag her through the muslin. All ay the ants clustered round the bottle, and bit perseveringly, or instinct hough not systematically, at the muslin. The same thing hapened all the following day.

On repeating these experiments with another species (viz., lormica rufescens) the ants took no notice of either bottle, and showed no sign either of affection or hatred. One is almost muted to surmise that the spirit of these ants is broken by The next morning again, when I got up, I found five ants

mpted to surmise that the spirit of these ants is broken by of my nest every [i.e. by the habit of keeping slaves]. But the experients on F. fusca seem to show that in these curious insects

nest. In atred is a stronger passion than affection.

We must not, however, too readily assent to this neral conclusion, that ants as a whole are deficient in e tenderer emotions; for although the case is doubtless with the species which Sir John examined, it appears be certainly otherwise with other species, as we shall esently see. But first it may be well to point out that containing en the hard-hearted species with which Sir John had to esently see. But first it may be well to point out that seem not altogether devoid of sympathy with sick or had eate utilated friends, although they appear to be so towards We did me althy friends in distress. Thus the care shown to found two toxicated friends seems to indicate, if not, as already side, I thing served, a dim sense of sympathy, at least an instinct to to death serve the life of an ailing citizen for the future benefit the community. Sir John also quotes some observans of Latreille showing that ants display sympathy with the other tilated companions; and, lastly, mentions an instance or the bottle ich he has himself observed of the same thing. A spewhich prepare of F. fusca congenitally destitute of antennæ was nd five an acked and injured by an ant of another species. When f one of the parated by Sir John, another ant of her own species rude through he by. 'She examined the poor sufferer carefully, then thed, though ked her up tenderly, and carried her away into the ked her up tenderly, and carried her away into the It would have been difficult for any one who nessed this scene to have denied to this ant the posth the same sion of humane feelings.' Moggridge is also of opinion le containing t the habit of throwing sick and apparently dead ants into the water, is 'in part to be rid of them, and partly perhaps, with a view to effecting a possible cure; for have seen one ant carry another down the twig which formed their path to the surface of the water, and, after dipping it in for a minute, carry it laboriously up again and lay it in the sun to dry and recover.'

But that some species of ants display marked sign of what we may call sympathy even towards healthy companions in distress, is proved by the following observation of Mr. Belt. He writes:

One day, watching a small column of these ants (id Eciton humata), I placed a little stone on one of them to s cure it. The next that approached, as soon as it discovered in situation, ran backwards in an agitated manner, and soon con municated the intelligence to the others. They rushed to the rescue; some bit at the stone and tried to move it, others seize the prisoner by the legs and tugged with such force that thought the legs would be pulled off, but they persevered unt they got the captive free. I next covered one up with a pin of clay, leaving only the ends of its antennæ projecting. It w soon discovered by its fellows, which set to work immediate and by biting off pieces of the clay soon liberated it. time I found a very few of them passing along at intervals. confined one of these under a piece of clay at a little distant from the line, with his head projecting. Several ants passed but at last one discovered it and tried to pull it out, but could It immediately set off at a great rate, and I thought had deserted its comrade, but it had only gone for assistant for in a short time about a dozen ants came hurrying up, e dently fully informed of the circumstances of the case, for the made directly for their imprisoned comrade and soon set hi I do not see how this action could be instinctive. It w sympathetic help, such as man only among the higher ma malia shows. The excitement and ardour with which the carried on their unflagging exertions for the rescue of the comrade could not have been greater if they had been hum beings.

This observation seems unequivocal as proving fellof feeling and sympathy, so far as we can trace any analog between the emotions of the higher animals and those

That sects. abits, and dep peration, shoul ently altruist tecedently ex the fittest. notions, or in loped in some hently see, also is connection Mr. Belt abov we shall subs ganised instin nong ants, and elfare of the in e same remark inea, which en rescuing bu scribed by Mr ainted with I se in which he buried comrade

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Huber, Kirby anklin, and other as more or the same commutera, are able other by some wever, on which that degree ce of the conclusion only one instants, and even the simply track

¹ See I ² Intro

¹ The Naturalist in Nicaragua, 1874, p. 26.

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ts passed i t, but cou I thought r assistano ying up, et ase, for the oon set hi ctive. It w cue of the

sects. That insects with such highly organised social abits, and depending so greatly on the principles of coperation, should manifest emotions or instincts of an inciently altruistic character, is no more than we should tecedently expect on the general principle of survival the fittest. Our only surprise should be that these notions, or instincts, should appear to be so feebly deloped in some species of ants, and, as we shall subsehently see, also of bees. But it may be worth while in is connection to point out that the valuable observation Mr. Belt above quoted refers to the species of ant which, we shall subsequently find, presents the most highly scovered it ganised instincts of co-operation that are to be met with soon companies, and therefore the greatest dependence of the elfare of the individual on that of the community. And e same remark is applicable to our native species, F. saninea, which the Rev. W. W. F. White has repeatedly
en rescuing buried companions very much in the manner
scribed by Mr. Belt; and he does not appear to be acainted with Mr. Belt's observations. He figures one
to Another se in which he saw three ants co-operating to dig out
intervals.

Powers of Communication.

Huber, Kirby and Spence, Dugardin, Burmeister, anklin, and other observers have all expressed themves as more or less strongly of the opinion that members the same community of ants, and other social Hymentera, are able to communicate information to one higher man other by some system of language or signs. which the wever, on which their opinion rests have not been stated th that degree of caution and detail which the acceptbeen humage of the conclusion requires. Thus, Kirby and Spence re only one instance of supposed communication between ving fello ts, 2 and even this one is inconclusive, as the facts de-any analog and those and those ts simply tracked one another by scent; while Huber

¹ See *Leisure Hour*, 1880, p. 390.

² Introduction to Entomology, vol. ii. p. 524.

merely deals in general statements as to contact antennæ, without narrating any particulars of his observations. Therefore, until within the last few years there was really no sufficient evidence to sustain the general opinion that ants are able to communicate with on another; but the observations which I shall now detain must be regarded as fully substantiating that general opinion by facts as abundant and conclusive as the most critical among us can desire. I shall first narrate in hown words the more important of Sir John Lubbock experiments in this connection:—

I took three tapes, each about 2 feet 6 inches long, a arranged them parallel to one another and about 6 inch apart. An end of each I attached to one of the nests (F. nige and at the other end I placed a glass. In the glass at the of one tape I placed a considerable number (300 to 600) larvæ. In the second I put two or three larvæ only, in third none at all. The object of the last was to see wheth many ants would come to the glasses under such circumstant by mere accident, and I may at once say that scarcely a did so. I then took two ants, and placed one of them to glass with many larvæ, the other to that with two or the Each of them took a larva and carried it to the nest, returni for another, and so on. After each journey I put another larva in the glass with only two or three larvæ, to replace the which had been removed. Now, if several ants came under above circumstances as a mere matter of accident, or acc panying one another by chance, or if they simply saw the lar which were being brought, and consequently concluded the they might themselves find a larva in the same place, then numbers going to the two glasses ought to be approximate equal. In each case the number of journeys made by the would be nearly the same; consequently, if it was a matter scent, the two glasses would be in the same position. It wo be impossible for an ant, seeing another in the act of bring a larva, to judge for itself whether there were few or many left behind. On the other hand, if the strangers were broug then it would be curious to see whether more were brought to the glass with many larvæthan to that which only contain two or three. I should also mention that every stranger imprisoned until the end of the experiment.

The results of these experiments were that during that they my bus in itself) sh

hours the a merous larvæ ile during ar ited the glass friends; and the glass who is see were existed to the first, have been them, these me power of wæ are to be for this inter-

One case of app ad had an ant (ch she was occu ht I imprisoned out at 6.15, wl ving to go to Lo en I returned a mined them car this time no oth inute she came made straight thirds of the others hesitated returned home. again went hon nds' stay in the nds. They all v about two-third he previous day though she had she seemed t after she had w larvæ. Now, ir brought out l her, and there that they my

ontact (hours the ants which had access to a glass containing s observa merous larvæ brought 257 friends to their assistance: ears ther ile during an interval $5\frac{1}{2}$ hours longer those which ne genera ited the glass with only two or three larvæ brought only with on friends; and, as already mentioned, no single ant came now detail the glass which contained no larvæ. Now, as all the t gener sses were exposed to similar conditions, and as the s the mos ds to the first two must, in the first instance at all rate in h ents, have been equally scented by the passage of ants Lubbock er them, these results look very conclusive as proving ne power of definite communication, not only that væ are to be found, but even where the largest store is es long, a

> be met with. To this interesting account Sir John Lubbock adds,-

One case of apparent communication struck me very much. ad had an ant (F. niger) under observation one day, during ch she was occupied in carrying off larvæ to her nest. At ircumstano ht I imprisoned her in a small bottle; in the morning I let out at 6.15, when she immediately resumed her occupation. ving to go to London, I imprisoned her again at 9 o'clock. en I returned at 4.40 I put her again to the larvæ. She mined them carefully, and went home without taking one. this time no other ants were out of the nest. In less than inute she came out again with eight friends, and the little b made straight for the heap of larvæ. When they had gone thirds of the way I again imprisoned the marked ant; others hesitated a few minutes, and then with curious quickreturned home. At 5.15 I put her again to the larvæ. again went home without a larva, but after only a few nds' stay in the nest, came out with no less than thirteen hds. They all went towards the larvæ, but when they had about two-thirds of the way, although the marked ant had he previous day passed over the ground about 150 times, though she had just gone straight from the larvæ to the , she seemed to have forgotten her way, and considered; after she had wandered about for half an hour, I put her to were brou larvæ. Now, in this case, the twenty-one ants must have nly contain brought out by my marked one, for they came exactly her, and there were no other ants out. Moreover, it would that they must have been told, because (which is very bus in itself) she did not in either case bring a larva, and

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consequently it cannot have been the mere sight of a lar which had induced them to follow her.

Further experiments proved, as we might have pected, that although an ant is able to communicate her friends in the nest that she has found treasure some where outside, she is not able to describe to them its m cise locality. Thus, having exposed larvæ and placed ant upon them as before, Sir John watched every time came out of the nest with friends to assist her, but inst of allowing her to pilot the way, he took her up carried her to the larvæ, allowing her to return with larva upon her own feet. Under these circumstances friends, although evidently coming out with the intent of finding some treasure, were never able to find it; wandered about in various directions for a while, and the returned to the nest. Thus, during two hours brought out in her successive journeys altogether no than 120 ants, of which number only 5 in their ungui wanderings happened to find the sought-for treas This result seems to prove, as we might have expect that the communication is of the nature of some amounting to no more than a 'follow me.' Other exp ments confirmed this result, and also brought out fact that 'some species act much more in association t others—Formica fusca, for instance, much less t Lasius niger.' Thus Sir John Lubbock placed some ho before a marked specimen of the former species; although she visited and revisited the honey during entire day, she brought out no friends to share it; although in her journeys to and from the nest she happe to pass and repass many other individuals, they took notice of each other.

The obvious objection to these experiments, that ant observing a friend bringing home food or a p might infer, without being told, that by accompany the friend on the return journey she 'might participate the good things,' has been partly met by the fact alrestated, viz., that there is so very marked a difference the result if, on experimenting on two ants, one had an to a large treasure and the other only to a small one.

ied the experi he ant which fo move it towa the nest for ven friends. at she outrar me out relucta ly half awake eandering abo ng for a time me to the nest me out with ei an the first par e same manne e nest. Mean I the while be oceeded to di st, and calling his experiment t species, alw hn remarks, 't ought out frier booty to show unication... ere brought out ppty-handed to duced to follow conclude, there

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In order to a unicating ants sound, Sir Joh wus six small ud on one of the ree ants to the d, I imprisoned g three ants at me. If, then, und, there oug

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put this matter beyond question, Sir John Lubbock ied the experiment of pinning down a dead fly, so that he ant which found it was unable, with all her tugging, move it towards the nest. At length she went back the nest for assistance, and returned accompanied by ven friends. So great was her excitement, however, at she outran these friends, 'who seemed to have me out reluctantly, as if they had been asleep, and were hly half awake; and they failed to find the fly, slowly eandering about for twenty minutes. After again tugng for a time at the fly, the first ant returned a second me to the nest for assistance, and in less than a minute me out with eight friends. They were even less energetic an the first party, and having lost sight of their guide in e same manner as happened before, they all returned to e nest. Meanwhile several of the first party, which had I the while been meandering about, found the fly, and oceeded to dismember it, carrying the trophy to the est, and calling out more friends in the ordinary way. his experiment was repeated several times and on differt species, always with the same result. Now, as Sir hn remarks, 'the two cases (i.e. those in which the ant ought out friends to her assistance even when she had b booty to show) surely indicate a distinct power of comunication. . . . It is impossible to doubt that the friends ere brought out by the first and; and as she returned npty-handed to the nest, the others cannot have been duced to follow her by merely observing her proceedings. conclude, therefore, that they possess the power of retesting their friends to come and help them.

In order to ascertain whether the signs which comunicating ants make to one another are made by means sound, Sir John Lubbock placed near a nest of *Lasius* wus six small upright pillars of wood about $1\frac{1}{2}$ inch high, d on one of these he put a drop of honey. 'I then put ree ants to the honey, and when each had sufficiently d, I imprisoned her, and put another; thus always keepg three ants at the honey, but not allowing them to go me. If, then, they could summon their friends by und, there ought soon to be many ants at the honey.' The result showed that the ants were not able thus to to one another from a distance.

As additional proof of the general fact that at events some ants have the power of communicating info mation to one another, it will be enough here to quote exceedingly interesting observation of the distinguish The quotations are taken from geologist Hague. his letters written to Mr. Darwin, and published $Nature: ^{1}$ —

On the mantelshelf of our sitting-room my wife has t habit of keeping fresh flowers. A vase stands at each end, a near the middle a small tumbler, usually filled with viole Some time ago I noticed a pile of very small red ants on the w above the left-hand vase, passing upward and downward tween the mantelshelf and a small hole near the ceiling, at point where a picture nail had been driven. The ants, wh first observed, were not very numerous, but gradually increase in number, until on some days the little creatures formed almost unbroken procession, issuing from the hole at the m descending the wall, climbing the vase directly below the m satisfying their desire for water or perfume, and then returning The other vase and tumbler were not visited at that time.

As I was just then recovering from a long illness it he pened that I was confined to the house, and spent my days in room where the operations of these insects attracted my atte Their presence caused me some annoyance, but I knew no effective means of getting rid of them. For several days succession I frequently brushed the ants in great numbers for the wall down to the floor; but as they were not killed then sult was that they soon formed a colony in the wall at the b of the mantel, ascending thence to the shelf, so that before la the vase was attacked from above and below.

One day I observed a number of ants, perhaps thirty forty, on the shelf at the foot of the vase. Thinking to k them, I struck them lightly with the end of my finger, killing some and disabling the rest. The effect of this was immedia and unexpected. As soon as those ants which were approach til it found itse ing arrived near to where their fellows lay dead and suffering they turned and fled with all possible haste. In half an holde circuits about the wall above the mantelshelf was cleared of ants.

During the space of an hour or two the colony from belowinging them in

ontinued to asce he shelf, at whic nable to see the urned about w. aring advanced helf, when, exter hey seemed to p heir suffering co he others, expres error. An hour he lower colony

I killed one o y finger, but les hat as soon as ar ot where one h reat disturbance eed.

A curious ar at when such reaching, the tw irsue its own w e spot where th at example.

For some days all, either above Then a few ar

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Occasionally a lose all self-pos d elevating th other interval

¹ Vol. vii. pp. 443-4.

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thus to commontinued to ascend until reaching the lower bevelled edge of he shelf, at which point the more timid individuals, although nable to see the vase, somehow became aware of trouble, and urned about without further investigation, while the more aring advanced hesitatingly just to the upper edge of the helf, when, extending their antennæ and stretching their necks, hey seemed to peep cautiously over the edge until beholding heir suffering companions, when they too turned and followed he others, expressing by their behaviour great excitement and error. An hour or two later, the path or trail leading from he lower colony to the vase was almost entirely free from ants.

I killed one or two ants on their path, striking them with ach end, a by finger, but leaving no visible trace. The effect of this was with violet hat as soon as an ant ascending towards the shelf reached the son the way bot where one had been killed, it gave signs immediately of the ceat disturbance, and returned directly at the highest possible ceiling, at beed.

A curious and invariable feature of their behaviour was ally increase at when such an ant, returning in fright, met another approaching, the two would always communicate, but each would at the manuscript its own way, the second ant continuing its journey to low the manuscript where the first had turned about, and then following

For some days after this there were no ants visible on the

lness it hat all, either above or below the shelf.

Then a few ants from the lower colony began to reappear, ed my attent instead of visiting the vase which had been the scene of the out I knew saster, they avoided it altogether, and following the lower veral days ont edge of the shelf to the tumbler standing near the middle, umbers from ade their attack upon that. I repeated the same experiment killed the received with precisely the same result. Killing or maining a few lat the base of the turns t before later, the others on approaching, and even before arriving at the pper surface of the shelf where their mutilated companions

ps thirty a gre visible, gave signs of intense emotion, some running away iking to king the mediately, and others advancing to where they could survey effeld and then hastening away precipitately.

Occasionally an ant would advance towards the tumbler re approach till it found itself among the dead and dying; then it seemed lose all self-possession, running hither and thither, making half an how de circuits about the scene of the trouble, stopping at times decircuits about the scene of the trouble, stopping at times d elevating the antennæ with a movement suggestive of y from belowinging them in despair, and finally taking flight. After this other interval of several days passed, during which no ants

appeared. Now, three months later, the lower colony has been note. entirely abandoned. Occasionally, however, especially when haviour of the a fresh and fragrant violets have been placed on the shelf, a few sion some of the 'prospectors' descend from the upper nail-hole, rarely, almost the upper edge never, approaching the vase from which they were first driven away, but seeking to satisfy their desire at the tumbler. To turn back these stragglers and keep them out of sight for number of days, sometimes for a fortnight, it is sufficient to kill one or two ants on the trail which they follow descending the wall. This I have recently done as high up as I can reach three or four feet above the mantel. The moment this spot reached, an ant turns abruptly and makes for home, and in little while there is not an ant visible on the wall.

In a subsequent volume of 'Nature' (viii. p. 244 Mr. Darwin publishes another letter which he received from Mr. Hague upon the same subject. It seems that Mr. Mog gridge suggested to Mr. Darwin that, as he and others ha observed ants to be repelled by the mere scent of a finge drawn across their path, the observation of Mr. Hagu might really resolve itself into a dislike on the part of the ants to cross a line over which a finger had been draw and have nothing to do with intelligent terror inspired the sight of their slaughtered companions. The following is Mr. Hague's reply to Mr. Darwin's request for further experiments to test this point:—

Acting on Mr. M——'s suggestion, I first tried making simple finger-marks on their path (the mantel is of marble), and foun just the results which he describes in his note as observed himself at Mentone, that is, no marked symptoms of fear, but dislike to the spot, and an effort to avoid it by going around or by turning back and only crossing it again after an interv of time. I then killed several ants on the path, using a smooth stone or piece of ivory, instead of my finger, to crush them. this case the ants approaching all turned back as before, a with much greater exhibition of fear than when the simple finger-mark was made. This I did repeatedly. The final r sult was the same as obtained last winter. They persisted coming for a week or two, during which I continued to ki them, and then they disappeared, and we have seen none sing It would appear from this that while the taint of the hand sufficient to turn them back, the killing of their fellows with stone or other material produces the effect described in my fir

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With this qu f the chapter; reviously ment ng the general icating with or ngs abundant bund implicate

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Swarming. warming of ar egards some o he winged ma hous numbers, r August for he nest are v umber, and the ace of the ne loud of all the o a considera everal hours, ower, and it ffected. he ground, wl prey, in their r, on account tarvation.

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aking simp), and foun observed b

y has been note. This was made clear to me at that time, from the behaviour of the ants the first day I killed any, for on that occahelf, a few sion some of them approaching the vase from below, on reaching the upper edge of the mantel, peeped over, and drew back on seeing what had happened about the vase, then turned away a little, and after a moment tried again at another and another sight for a coint along the edge, with the same result in the end. More-wer, those that found themselves among the dead and dying descending the vent from one writhing ant to another in great haste and exitement, exhibiting the signs of fright which I described.

I hardly hope that any will return again, but if they do, and in a line give me an opportunity, I shall endeavour to act further on the suggestion.

with this quotation I shall conclude the present division feived from the chapter; for, looking to all the other observations to Mr. Mog reviously mentioned, there can be no question concerning the general fact that ants have the power of communicating with one another. And under subsequent headings abundant additional evidence on this point will be part of the power of the power

Habits General in Sundry Species.

Swarming.—The precise facts with regard to the warming of ants are not yet certainly established. As egards some of the facts, however, there is no doubt. he winged males and females first quit the nest in enorhous numbers, and choose some fine afternoon in July r August for their wedding flight. The entrances to g around the nest are widened by the workers and increased in an intervaluable, and there is a great commotion on the suring a smoot ace of the nest. The swarm takes place as a thick
h them. I loud of all the male and female insects, rising together
before, at the sample everal hours, usually circling round some tree or
the final reveral hours, usually circling round some tree or
ower, and it is during the flight that fertilisation is
represented to kind on the swarm returns to he ground, when the males perish, either from falling prey, in their shelterless condition, to birds or spiders, the hand prey, in their shelterless condition, to birds or spiders, the shelterless with the hand prey, in their shelterless condition, to birds or spiders, or neutrons of their own drawation. The workers, or neuter ants, of their own

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colony have lost all interest in them from the moment their return, and trouble themselves no more about them for they well know that the males have now fulfilled their vocation.' The great majority of the fertilised female share the same fate as the males. But a small proportion find concealment in holes, which they either dig for them selves, or happen to find ready made, and there found new colony. The first thing they do is to pull off their now useless wings, by scratching and twisting them, on after the other, with the clawed ends of their feet. then lay their eggs, and become the queens of ne colonies.

Forel says that no fertilised female ever returns to he original home; but that the workers keep back a certain number of females which are fertilised before the swarming takes place; in this case the workers pull off the wing of the fertilised females. The majority of observers, how ever, maintain that some of the females composing the swarm return to their native home to become mother where they had been children. Probably both statement A writer in the 'Groniger Deekblad' for are correct. June 16, 1877, observes that, looking to the injuriou effects of in-breeding, the facts as related by Forel are less probable than those related by other observers, and that, they actually occur, the females fertilised before flight an probably kept by the ants as a sort of 'reserve corps t which the workers resort only in case of need, and if the fail to secure any returning queens.

Nursing.—The eggs will not develop into larvæ un The nursing is effected by licking the less nursed. surface of the eggs, which under the influence of this process increase in size, or grow. In about a fortnight during which time the workers carry the eggs from highe to lower levels of the nest, and vice versa, according to the circumstances of heat, moisture, &c., the larvæ are hatche out, and require no less careful nursing than the eggs The workers feed them by placing mouths together and re gurgitating food stored up in the crop or proventriculu into the intestinal tract of the young. The latter show their hunger by 'stretching out their little brown heads

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Great care is also taken by the workers in cleaning the larvæ, as well as in carrying them up and down the chambers of the nest for warmth or shelter.

When fully grown the larvæ spin cocoons, and are then oupæ, or the 'ants' eggs' of bird-fanciers. These require no food, but still need incessant attention with reference warmth, moisture, and cleanliness. When the time off their arrives for their emergence as perfect insects, the workers hem, on the hrough the walls of the latter. It is noticeable that in s of new loing this the workers do not keep to any exact time, but free them sometimes earlier and sometimes later, in arns to he accordance with their rate of development. 'The little a certain thin skip like a little skip little skip like a little skip like a little skip lit thin skin, like a little shirt, which has to be pulled off.
When we see how neatly and gently this is done, and low the young creature is then washed, brushed, and ed, we are involuntarily reminded of the mother than the mother than the mother than the same and the mother than the same and the same and the same are involuntarily reminded of the same and the same are involuntarily reminded of the same and the same are involuntarily reminded of e mother dutside the nest, and may be seen heaped together there or a long time. Some species carry them far away from he nest, or turn them into building materials for the welling.' 1

Education.—The young ant does not appear to come nto the world with a full instinctive knowledge of all its uties as a member of a social community. It is led about he nest, and 'trained to a knowledge of domestic duties, specially in the case of the larvæ.' Later on the young larvæ un ints are taught to distinguish between friends and foes. cking the Nen an ants' nest is attacked by foreign ants, the young the ness never join in the fight, but confine themselves to the maying the puper; and that the knowledge of hereditary fortnight emoving the pupæ; and that the knowledge of hereditary nemies is not wholly instinctive in ants is proved by the sllowing experiment, which we owe to Forel. He put oung ants belonging to three different species into a glass ase with pupæ of six other species—all the species being aturally hostile to one another. The young ants did ot quarrel, but worked together to tend the pupe. ventriculus ot quarrel, but worked together to tend the pupæ. When atter shows he latter hatched out, an artificial colony was formed of

Büchner, Geistesleben der Thiere, pp. 66-7.

a number of naturally hostile species all living together after the manner of the 'happy families' of the showmen.

Habit of keeping Aphides.—It is well known that various species of ants keep aphides, as men keep milch cows, to supply a nutritious secretion. Huber first observed this fact, and noticed that the ants collected the eggs of the aphides and treated them exactly as they treated their own, guarding and tending them with the utmost care. When these eggs hatch out the aphides are usually kept and fed by the ants, to whom they yield a sweet honey-like fluid, which they eject from the abdomen upon being stroked on this region by the antennæ of the ants. Mr. Darwin, who has watched the latter process, observes with regard to it,—

I removed all the ants from a group of about a dozen aphide on a dock plant, and prevented their attendance during several hours. After this interval, I felt sure that the aphides would want to excrete. I watched them for some time through a lens, but not one excreted; I then tickled them with a hair in the same manner, as well as I could, as the ants do with their antennæ; but not one excreted. Afterwards I allowed an an to visit them, and it immediately seemed, by its eager way of running about, to be well aware what a rich flock it had dis covered; it then began to play with its antennæ on the abdo men, first of one aphis and then of another; and each, as soon as it felt the antenne, immediately lifted up its abdomen and excreted a limpid drop of sweet juice, which was eagerly de voured by the ant. Even quite young aphides behaved in this manner, showing that the action was instinctive, and not the result of experience.

The facts also show that the yielding of the secretical to the ants is, as it were, a voluntary act on the part of the aphides, or, perhaps more correctly, that the instinct to yield it has been developed in such a relation to the requirements of the ants, that the peculiar stimulation supplied by the antennæ of the latter is necessary to start the act of secretion; for in the absence of this particular stimulation the aphides will never excrete until compelled to do so by the superabundance of the accumulating secretion. The question, therefore, directly arises how, on evolutionary

principles, su tainly difficul instinct, so be aphides, to w any advantag 'Although th an action for each tries to a and 'as the se convenience t probably they ants.'

Some ants tunnels, to th Forel saw a tu and down agai safe covered w ally such cove enclose the ste The latter are which, however function of sta really confined these chambers while large en saw such a p about a centim of a tree, and ants. Huber

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principles, such a class of facts is to be met; for it is certainly difficult to understand the manner in which this instinct, so beneficial to the ants, can have arisen in the aphides, to which it does not appear, at first sight, to offer any advantages. Mr. Darwin meets the difficulty thus: 'Although there is no evidence that any animal performs an action for the exclusive good of another species, yet each tries to take advantage of the instincts of others;' and 'as the secretion is extremely viscid, it is no doubt a convenience to the aphides to have it removed; therefore probably they do not excrete solely for the good of the ants.'

Some ants which keep aphides build covered ways, or tunnels, to the trees or shrubs where the aphides live. Forel saw a tunnel of this kind which was taken up a wall and down again on the other side, in order to secure a safe covered way from the nest to the aphides. Occasionally such covered ways, or tubes, are continued so as to enclose the stems of the plants on which the aphides live. The latter are thus imprisoned by the walls of the tube, which, however, expand where they take on this additional function of stabling the aphides, so that these insects are really confined in tolerably large chambers. The doors of these chambers are too small to allow the aphides to escape, while large enough for the ants to pass in and out. Forel saw such a prison or stable shaped like a cocoon, and about a centimètre long, which was hanging on the branch of a tree, and contained aphides carefully tended by the ants. Huber records similar observations.

Sir John Lubbock has made an interesting addition to our knowledge respecting this habit as practised by a certain species of ant (*Lasius flavus*), which departs in a very remarkable manner from the habit as practised by other species. He says: 'The ants took the greatest care of these eggs, carrying them off to the lower chambers with the utmost haste when the nest was disturbed.' But the most interesting of Sir John Lubbock's observations in this connection is new, and reveals an astonishing

¹ Origin of Species, 6th ed. pp. 207-8.

amount of method shown by the ants in farming their aphides. He says:—

When my eggs hatched I naturally thought that the aphides belonged to one of the species usually found on the roots of plants in the nests of Lasius flavus. To my surprise, however, the young creatures made the best of their way out of the nest, and, indeed, were sometimes brought out by the ants themselves. In vain I tried them with roots of grass, &c.; they wandered uneasily about, and eventually died. Moreover, they did not in any way resemble the subterranean species. In 1878 I again attempted to rear these young aphides; but though I hatched a great many eggs, I did not succeed. This year, however, I have been more fortunate. The eggs commenced to hatch the first week in March. Near one of my nests of Lasius tlavus, in which I had placed some of the eggs in question, was a glass containing living specimens of several species of plants commonly found on or around ants' nests. To this some of the young aphides were brought by the ants. Shortly after wards I observed on a plant of daisy, in the axils of the leaves, some small aphides, very much resembling those from my nest, though we had not actually traced them continuously. seemed thriving, and remained stationary on the daisy. Moreover, whether they had sprung from the black eggs or not, the ants evidently valued them, for they built up a wall of earth round and over them. So things remained throughout the summer, but on October 9 I found that the aphides had laid some eggs exactly resembling those found in the ants' nests; and on examining daisy plants from outside, I found on many of them similar aphides, and more or less of the same eggs.

I confess these observations surprised me very much. The statements of Huber have not, indeed, attracted so much notice as many of the other interesting facts which he has recorded; because if aphides are kept by ants in their nests, it seems only natural that their eggs should also occur. The above case, however, is much more remarkable. Here are aphides, not living in the ants' nests, but outside, on the leaf-stalks of plants. The eggs are laid early in October on the food-plant of the insect. They are of no direct use to the ants, yet they are not left where they are laid, where they would be exposed to the severity of the weather and to innumerable dangers, but brought into their nests by the ants, and tended by them with the utmost care through the long winter months until the following March, when the young ones are brought out and again placed

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The follow Geistesleben Performance of Lubbock observ

The author i ngs at Karlsrul nder the title, ' wo equally stro arden at Katto about five or gularly every y illions of aphi brouts, and thu ee. As I per ction of the aph b in the March ean and wash e the latter, with sult was that th is leaves and yo hides until the y was of short rprising numbe unk of the tree ok more closely. any troops of an estem to the to ves had been p eks the evil wa grass plot, an ony for the cou s colony; but t m distant branc

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on the young shoots of the daisy. This seems to me a most remarkable case of prudence. Our ants may not perhaps lay up food for the winter, but they do more, for they keep during ix months the eggs which will enable them to procure food during the following summer.

The following, which is taken from Büchner's Geistesleben der Thiere' is perhaps a still more striking performance of the same kind as that which Sir John Lubbock observed:—

The author is debtor to Herr Nottebohm, Inspector of Buildngs at Karlsruhe, who related the following on May 24, 1876, nder the title, 'Ants as Founders of Aphides' Colonies: '—' Of wo equally strong young weeping ashes, which I planted in my arden at Kattowitz, in Upper Silesia, one succeeded well, and about five or six years showed full foliage, while the other egularly every year was covered, when it began to bud, with fillions of aphides, which destroyed the young leaves and brouts, and thus completely delayed the development of the ee. As I perceived that the only reason for this was the tion of the aphides, I determined to destroy them utterly. o in the March of the following year I took the trouble to ean and wash every bough, sprig, and bud before the bursting the latter, with the greatest care, by means of a syringe. The sult was that the tree developed perfectly healthy and vigoris leaves and young shoots, and remained quite free from the hides until the end of May or the beginning of June. My y was of short duration. One fine sunny morning I saw a rprising number of ants running quickly up and down the unk of the tree; this aroused my attention, and led me to bk more closely. To my great astonishment I then saw that any troops of ants were busied in carrying single aphides up e stem to the top, and that in this way many of the lower ives had been planted with colonies of aphides. After some eks the evil was as great as ever. The tree stood alone on e grass plot, and offered the only situation for an aphides' ony for the countless ants there present. I had destroyed s colony; but the ants replanted it by bringing new colonists m distant branches, and setting them on the young leaves.

Again-

MacCook noticed, of the mound-making ants, that of the Loc. cit. p. 121.

workers returning to the nest from the tree on which the milk ing was going on, a far smaller number had distended abdomen than among those descending the tree itself. A closer investi gation showed that at the roots of the trees, at the outlets the subterranean galleries, a number of ants were assembled which were fed by the returning ants after the fashion alread described in feeding the larvæ, and which were distinguished by the observer as 'pensioners.' MacCook often observed the same fact later, among, with others, the already describe Pennsylvanian wood-ant. Distinguished individuals in the body-guard of the queen were fed in like fashion. MacCooki inclined to think that the reason of this proceeding is to found in the 'division of labour' so general in the ant reput lic, and that the members of the community which are en ployed in building and working within the nest, leave to the others the care of providing food for themselves as well as fi the younger and helpless members; they thus have a claim receive from time to time a reciprocal toll of gratitude, an take it, as is shown very clearly, in a way demanded by the welfare of the community.1

Aphides are not the only insects which ants employs cows, several other insects which yield sweet secretion being similarly utilised in various parts of the world Thus, gall insects and cocci are kept in just the same was aphides; but MacCook observed that where aphide and cocci are kept by the same ants, they are kept is separate chambers, or stalls. The same observer so caterpillars of the genus Lycena kept by ants for the same of a sweet secretion which they supply.

Habit of making Slaves.—This habit, or instinct obtains among at least three species of ant, viz., Forming rufescens, F. sanguinea, and strongylognathus. It was originally observed by P. Huber in the first-named species. Here the species enslaved is F. fusca, which is appropriate coloured black. The slave-making ants attack a nest F. fusca in a body; there is a great fight with must slaughter, and, if victorious, the slave-makers carry off the pupe of the vanquished nest in order to hatch them of as slaves. Mr. Darwin gives an account of a battle which he himself observed.²

¹ Loc. cit. p. 123.

When the he young slav egard their ma ttempt to esca nasters in defe hemselves wit he work that o the species v l. sanguinea t ousehold slave est, and so ar hey are then heir black colo nd much large y this species foraging, sla hasters; and w he masters car n the other has the slaves, w much larger ales and fertil e workers, or pturing slaves e whole com The ma aves. to feed their aves that dete der of things t asters in their thout a slave od, and also wi work; but th any died of hu d she at once tended to the 1

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² Origin of Species, 6th ed. p. 218.

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When the pupe hatch out in the nest of their captors, he young slaves begin their life of work, and seem to egard their master's home as their own; for they never ttempt to escape, and they fight no less keenly than their nasters in defence of the nest. F. sanguinea content hemselves with fewer slaves than do F. rufescens; and he work that devolves upon the slaves differs according o the species which has enslaved them. In the nests of r. sanguinea the comparatively few captives are kept as ousehold slaves; they never either enter or leave the est, and so are never seen unless the nest is opened. they are then very conspicuous from the contrast which heir black colour and small size present to the red colour nd much larger size of F. rufescens. As the slaves are y this species kept strictly indoors, all the outdoor work f foraging, slave-capturing, &c., is performed by the hasters; and when for any reason a nest has to migrate. he masters carry their slaves in their jaws. F. rufescens, n the other hand, assigns a much larger share of labour the slaves, which, as we have already seen, are present secretion much larger numbers to take it. In this species the lales and fertile females do no work of any kind; and same was the workers, or sterile females, though most energetic in a pturing slaves, do no other kind of work. Therefore he whole community is absolutely dependent upon its The masters are not able to make their own nests to feed their own larvæ. When they migrate, it is the aves that determine the migration, and, reversing the der of things that obtains in F. sanguinea, carry their asters in their jaws. Huber shut up thirty masters thout a slave and with abundance of their favourite od, and also with their own larvæ and pupæ as a stimulus work; but they could not feed even themselves, and any died of hunger. He then introduced a single slave. d she at once set to work, fed the surviving masters, tended to the larvæ, and made some cells.

In order to confirm this observation, Lespès placed a ece of sugar near a nest of slave-makers. It was soon and by one of the slaves, which gorged itself and rerned to the nest. Other slaves then came out and did

Then some of the masters came out, and, by pulling the legs of the feeding slaves, reminded them the eaving the nest they were neglecting their duty. The slaves then immedial Scotch fir diately began to serve their masters with the sugar. For excended together also has confirmed all these observations of Huber. Indeed and, according in the case of *F. rufescens*, the structure of the animalian Switzerland in such as to render self-feeding physically impossible. In Mr. Darwin long and narrow jaws, adapted to pierce the head of a Desiring to assence on the self-feeding used for feeding, unless nguish the puliquid food is poured into them by the mouth of a slave ake into slave. This fact shows of how ancient an origin the instinct of mr. flava, slave-making must be; it has altered in an importantithout a seven manner a structure which could not have been so altered prior to the establishment of the instinct in question.

Mr. Darwin thus sums up the differences in the office of the slaves in the nests of F. sanguinea and F. rufescer

respectively:—

The latter does not build its own nest, does not determined own migrations, does not collect food for itself or for its fellow and cannot even feed itself; it is absolutely dependent on itsu merous slaves. Formica sanguinea, on the other hand, possess much fewer slaves, and in the early part of the summer extreme few; the masters determine when and where a new nest shi be formed, and when they migrate, the masters carry the slave Both in Switzerland and England the slaves seem to have t exclusive care of the larvæ, and the masters alone go on slav making expeditions. In Switzerland the slaves and master work together, making and bringing materials for the new both, but chiefly the slaves, tend and milk, as it may be called their aphides; and thus both collect food for the community. England the masters alone usually leave the nest to colle building materials and food for themselves, their slaves larvæ. So that the masters in this country receive much service from their slaves than they do in Switzerland.

Mr. Darwin further observes that 'this difference the usual habits of the masters and slaves in the countries probably depends merely on the slaves bei captured in greater numbers in Switzerland than in En land; and records that he has observed in a communi of the English species having an unusually large stock slaves that 'a few slaves mingled with their maste

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As ants which y off pupe of o ossible that suc be developed, a red would then k they could. ch had seized th to capture wor ecting pupæ, ori ngthened and pose of raising s arried out to a anguinea, which h the same spec ease and modify on to be of use ctly dependent

Ants do not a make slaves; them that eaving the nest, and marched along the same road to a en immedall Scotch fir tree, twenty-five yards distant, which they gar. Fore, scended together, probably in search of aphides or cocci. r. Indeed and, according to Huber, the principal office of the slaves animal in Switzerland is to search for aphides.

sible. It Mr. Darwin also made the following observation:—ead of a Desiring to ascertain whether F. sanguinea could disng, unless nguish the pupæ of F. fusca, which they habitually of a slave ake into slaves, and which are an unwarlike species, instinct of m F. flava, which they rarely capture, and never important ithout a severe fight, he found it was evident that so altered ey did at once distinguish them; ' for while 'they gerly and instantly seized the pupe of F. fusca, they the office ere much terrified when they came across the pupæ, or rufescent en the earth from the nest, of F. flava, and quickly ran ay; but in about a quarter of an hour, shortly after e little yellow ants had crawled away (from their nest ving been disturbed by Mr. Darwin), they took heart nt on its med carried off the pupæ.

Concerning the origin of this remarkable instinct,

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As ants which are not slave-makers will, as I have seen, Bry off pupe of other species if scattered near their nests, it ossible that such pupe originally stored as food might bebe developed, and the foreign ants thus unintentionally red would then follow their proper instincts, and do what k they could. If their presence proved useful to the species ch had seized them—if it were more advantageous to the speto capture workers than to procreate them—the habit of ecting pupe, originally for food, might by natural selection be ngthened and rendered permanent for the very different pose of raising slaves. When the instinct was once acquired, arried out to a much less extent even than in our British anguinea, which, as we have seen, is less aided by its slaves in the true the same species in Switzerland, natural selection might slaves being lease and modify the instinct, always supposing such modifihan in Equation to be of use to the species, until an ant was found as communicately dependent on its slave as is the Formica rufescens.

> Ants do not appear to be the only animals of which make slaves; for there seems to be at least one case

in which these wonderful insects enslave insects of another species, which therefore may be said to stand to the an in the relation of beasts of burden. The case to which allude is one that is recorded in Perty's 'Intellectual Li of Animals' (2nd ed. p. 329), and is as follows:—

According to Audubon certain leaf-bugs are used as slave by the ants in the Brazilian forests. When these ants wants bring home the leaves which they have bitten off the truthey do it by means of a column of these bugs, which go pairs, kept in order on either side by accompanying ants. The compel stragglers to re-enter the ranks, and laggards to keep by biting them. After the work is done the bugs are shup within the colony and scantily fed.

Wars.—On the wars of ants a great deal might be sa as the facts of interest in this connection are very nun rous; but for the sake of brevity I shall confine myself

giving only a somewhat meagre account.

One great cause of war is the plundering of ants' ne by the slave-making species. Observers all agree that t plundering is effected by a united march of the wh army composing a nest of the slave-making speci directed against some particular nest of the species wh they enslave. According to Lespès and Forel, single sco or small companies are first sent out from the nest to plore in various directions for a suitable nest to atta These scouts afterwards serve as guides to the maraud excursion. Forel saw several of these scouts of the spe F. rufescens or Amazon carefully inspecting a nest F. fusca which they had found, investigating especial the entrances. These are purposely made difficult to by their architects, and it not unfrequently happens t after all precautions and inspections on the part of invaders, an expedition fails on account of not finding city gates.

When the scouts have been successful in discovering suitable nest to plunder, and have completed their stegical investigations of the locality to their satisfact they return straight to their own nest or fortress. It has then seen them walking about on the surface of the nest for a long time, as if in consultation, or making

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heir minds. Then some of them entered the nest, soon fter which hosts of warriors streamed out of the entrances. of another and ran about tapping each other with their heads and to the an antenne. They then formed into column and set out to pillage the nest of the slave ants. The following is the count which Lespès gives of such expeditions:—

They only take place towards the end of the summer and in utumn. At this time the winged members of the slave species ants want F. fusca and F. cunicularia) have left the nest, and the ff the tree Amazons will not take the trouble to bring back useless convincing ants. The the afternoon at about three or four o'clock. At first no order to ke to ke s perceptible in their movements, but when they are all gathered together they form a regular column, which then moves forward quickly, and each day in a different direction. They march closely pressed together, and the foremost always appear be seeking for something on the ground. They are each moment overtaken by others, so that the head of the column is ne myself continually growing. They are in fact seeking the traces of the ants which they propose to plunder, and it is scent that guides hem. They snuff over the ground like hounds following the ree that the track of a wild animal, and when they have found it they blunge headlong forward, and the whole column rushes on being specified. The smallest armies I saw consisted of several hundred individuals, but I have also seen some four times as large. They then form columns which may be five mètres long, and as much as fifty centimètres wide. After a march, which often a nest to the state of the second results are the second results. lasts a full hour, the column arrives at the nest of the slave species. The F. cunicularia, which are the strongest, offer e maraudic keen opposition, but without much result. The Amazons soon of the species within the nest, to come out again a moment later, while the assailed ants at the same time rush out in masses. During the whole time attention is directed solely to the larvæ and pupæ, which the Amazons steal while the others try to save as many as possible. They know very well that the Amazons cannot climb, so they fly with their precious burdens to the surrounding bushes or plants, whereto their enemies cannot the finding to take away from them as much of their booty as possible. to take away from them as much of their booty as possible. discovering But the latter do not trouble themselves much about them, and hasten on home. On their return they do not follow the shortstatistical strong, but exactly the one by which they came, finding their way back by smell. Arrived at their nest, they immediately

hand over their booty to the slaves, and trouble themselves m more about it. A few days afterwards the stolen pupe a nymphæ emerge, without memory of their childhood, and immediately and without compulsion take part in all tasks.

According to Büchner's account,1-

From time to time the army makes a short halt, partly let the rearguard close up, partly because different opinion arise as to the direction of the host, or because the place a which they are is unknown to them. Forel several times say the army completely lose its way—an incident only once of served by Huber. Forel puts the number of warriors in sud an army at from one hundred to more than two thousand. speed is on an average a mètre per minute, but varies mud according to circumstances, and is naturally least when return ing laden with booty. If the distance be very great, sud bodily fatigue may at last be felt that the whole attack on the hostile nest is given up, and a retreat is begun; Forel once say this happen after they had passed over a distance of two hun dred and forty yards. Sometimes it seems as though, on coming within sight of the hostile nest, a kind of discouragement tool possession of them, and prevented their making the attack. the nest cannot at once be found, the whole army halts, and some divisions are sent forward to search for it, and these are gradually seen returning towards the centre. Forel also say such an army only searching the first day, advancing zigzag and with frequent halts, whereas on the following day it were forward to its aim swiftly and without delay, having found or It seems that a single ant, even if it knows the way and the place, is not able alone to lead a large army, but that considerable number must be employed in this duty. Mistak as to the road occur with special ease during the return journey because the several ants are laden with booty and cannot readily understand each other. Individual ants are then seen to wande about in every direction often for a long time, until they at last reach a spot known to them, and then advance swiftly to their goal. Many never come back at all. These mistakes easily occur when the robbers which have passed into a hostile nest d not come out again at the same holes whereby they entered, but by others at some distance—for instance, by a subterrane canal. Coming out thus in a strange neighbourhood, they do not know which way to take, and only some chance to find the right road during their aimless wanderings about, and recognise and

blow it by smell ver happen to in rray. Other spe etter how to man mazons. The lac hey are, and only heir way. If the rge to be all tak as to complete ive no regular le pedition, altera ring that event ve previously co d the undecide llow immediatel ps on the head i ssion does not ac ves by their ow llowing.

One day Forel the *F. fusca* seeing able to find the robbers penetre hole, the invasid an entrance mazon army grate minutes later the hole. Not a summs united output the robbers of the r

A marauding fibarbis, a sub-six place as followed that it had reached ickly than it had ledly, and sent a in body and the anthirty seconds elf in a mass on renecessary as wered the approarer the dome to be a they penetrate

¹ Geistesleben der Thiere, pp. 145-9.

nselves no pupæ 🕡 and imme

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attack. I halts, and d these ar el also sav ing zigzag lay it went g found out ws the war but that

ement took

Mistake rn journer nnot readily n to wande they at las cognise and

bllow it by smell. On the other hand, such mistakes scarcely ver happen to individuals in an unladen train, kept in good rray. Other species of ants (F. fusca, rufa, sanguinea) know etter how to manage under such circumstances than do the mazons. The laden ones lay down their loads, first find where hey are, and only take them up again after they have found heir way. If the booty seized in the nest first attacked is too rge to be all taken at once, the robbers return once, or oftener, as to complete their work. The ants, as already said, eve no regular leaders nor chiefs, yet it is certain that in each pedition, alteration of road, or other change, the decision uring that event comes from a small knot of individuals, which ries much ve previously come to an understanding, and carry the rest d the undecided along with them. These do not always the return and the undecided along with them. These do not always great, such the low immediately, but only after they have received several ps on the head from the members of the 'ring.' The processor does not advance until the leaders have convinced them. el once sar ssion does not advance until the leaders have convinced themtwo hun lives by their own eyesight that the main part of the army is lowing.

> One day Forel saw some Amazons on the surface of a nest the F. fusca seeking and sounding in all directions, without ing able to find the entrance. At last one of them found a ry little hole, hardly as large as a pin's head, through which e robbers penetrated. But since, owing to the smallness of e hole, the invasion went on slowly, the search was continued, d an entrance was found further off, through which the mazon army gradually disappeared. All was quiet. e minutes later Forel saw a booty-laden column emerge from th hole. Not a single ant was without a load. The two

lumns united outside and retreated together.

A marauding excursion of the Amazons against the F. fibarbis, a sub-species of the F. fusca, or small black ants, k place as follows:—The vanguard of the robber army found at it had reached the neighbourhood of the hostile nest more ickly than it had expected; for it halted suddenly and detakes easily seedly, and sent a number of messengers which brought up the stile nest described and the rearguard with incredible speed. In less entered, by the described army had closed up, and hurled ibterranea elf in a mass on the dome of the hostile nest. This was the they do not be recessary as the *rufibarbes* during the short halt had disned the right rered the approach of the enemy, and had utilised the time to ver the dome with defenders. An indescribable struggle lowed, but the superior numbers of the Amazons overcame, d they penetrated into the nest, while the defenders poured by thousands out of the same holes, with their larvæ and puper ast turned home in their jaws, and escaped to the nearest plants and bushes the running over the heaps of their assailants. These looked of the heaps of their assailants. But the run he expedition. barbes, furious at their proceedings, pursued them, and expedition. deavoured to get away from them the few pupe they had of they are once on tained, by trying to seize the Amazons' legs and to snatch away ome shallow we the pupe. The Amazon lets its jaws slip slowly along the hen march over captive pupa, as far as the head of its opponent, and pierces all alf of them aw if it does not, as generally happens, draw back. But it often manages to seize the pupa at the instant at which the Amazu lets it go and flies with it. This is managed yet more easily when a comrade holds the robber by the legs, and compels it loose its prey in order to guard itself against its assailan Sometimes the robbers seize empty cocoons and carry the away, but they leave them on the road when they have di covered their mistake. In the above case the strength of rufibarbes proved at last so great that the rearguard of the treating army was seriously pressed, and was obliged to give its booty. A number of the Amazons also were overpower and killed, but not without the rufibarbes also losing man people. None the less did some individuals, as though desp rate, rush into the thickest hosts of the enemy, penetrate again into the nest, and carried off several pupe by sheer a dacity and skill. Most of them left their prey to go to help of their comrades when assailed by the ruftbarbes. I minutes after the commencement of the retreat all the Amazo had left the nest, and, being swifter than their opponents, the were only pursued for about halfway back. Their attack h failed on account of a short delay!

On another occasion observed by Forel, in which save fertile Amazons also took part and killed many enemies, nest was thoroughly ravished, but the retreat was also in case very much disturbed and harassed by the superior number of the enemy. There were many slain on both sides. spite of the above-mentioned unanimity different opinions and the members of an expedition sometimes hinder its conduct, following observation seems to show:—An advancing colu divided after it had gone about ten yards from the nest. H turned back, while the other half went on, but after some ti hesitated and also turned back. Arrived at home, it for those which had formerly turned back putting themselves motion in a new direction. The newly returned followed the and the reunited army, after various wheelings, halts, &c.,

vind, nor dust, rey. They only gain to bring fre

The following pitome of Fore

The most term $\mathbf{n} \mathbf{t}$ (F. sanguine omes into collision ursions. It is n pacity, but surp the most intelli istance, poured he slave species 1 enerally regarded upæ, earth, build est, and took all trances thereint eir only object, hts under similar ceived, but at o

On another hts was on its v arrived Forel d made a brea

The sanguine fend themselves hen they saw t e main army, w ut once united, t tter gathered tog mazons closed up rried them on to hese were overtl

mpels it s assailar carry the ey have di

hich seven enemies, rior numbe inions amou conduct, ncing colum nest. H er some 🕍 themselves ollowed the

and pupal ast turned home again by a long way round. The whole busibushes hess looked like a promenade. But apparently different parties looked of had different nests in view, while others were entirely against the rule he expedition. Yet perhaps it was only a march for exercise.

Outer obstacles do not, as a rule, hinder the Amazons when

hey are once on the march. Forel saw them wade through natch away ome shallow water, although many were drowned in it, and hen march over a dusty high road, although the wind blew alf of them away. As they returned, booty-laden, neither but it often wind, nor dust, nor water could make them lay down their new only got back with great trouble, and turned back more easily gain to bring fresh booty, although many lost their lives.

> The following is also quoted from Büchner's excellent pitome of Forel's observations in this connection:—

The most terrible enemy of the Amazons is the sanguine angth of the first (F. sanguinea), which also keeps slaves, and thereby often omes into collision with the Amazons on their marauding expressions. It is not equal to it in bodily strength or fighting apacity, but surpasses it in intelligence; according to Forel it the most intelligent of all the species of ants. If Forel, for ough desproyed out the contents of a sack filled with a nest of the slave species near an Amazon nest, the Amazons apparently enerally regarded the tumbled together heap of ants, larvæ, apæ, earth, building materials, &c., as the dome of a hostile est, and took all imaginable but useless pains to find out the attack have a track have a similar circumstances did not allow themselves to be exceived, but at once ransacked the whole heap. The most terrible enemy of the Amazons is the sanguine eceived, but at once ransacked the whole heap.

On another occasion, while a procession of Amazon also in the ats was on its way to plunder a nest of F. fusca, before arrived Forel poured out a sack-full of sanguine ants, That and made a break in the nest:—

The sanguine ants pressed in, while the fusca came out to fend themselves. At this moment the first Amazons arrived. hen they saw the sanguine ants they drew back and awaited e main army, which appeared much disturbed at the news. ut once united, the bold robbers rushed at their foes. The bme, it four ter gathered together and beat back the first attack, but the mazons closed up their ranks and made a second assault, which rried them on to the dome and into the midst of the enemy. halts, &c., hese were overthrown, as well as a number of F. pratensis,

which Forel at this moment poured out on the nest. The con querors delayed for a moment on the dome after their victory and then entered the nest to bring out a little of the valuable booty. A few Amazons which were mad with anger did no return with the main army, but went on slaughtering blind among the conquered and the fugitives of the three special

fusca, pratensis, and sanyuinea.

The ravished ruftbarbes once became so desperate at the overthrow that they followed the robbers to their own new and the latter had some trouble in defending it. The ruftbark let themselves be killed in hundreds, and really seemed though they courted death. A small number of the Amazon goody. also sank under the bites of their enemies. The nest contained slaves of the rufibarbis species, which on this emergency fough actively against their own race. There were also slaves the species fusca, so that the nest included three different species of ants.

The same nest is often revisited many times on the same day or at different periods, until either there is no more to stell or the plundered folk have hit upon better mode of defend A column which was in the act of going back to such a plus dered nest turned when halfway there, and halted, apparent of the army, and had learned that the nest was exhausted de prisoners by on no other ground than because it had met the rearguage robbers then went off to a rufibarbis nest which was i the neighbourhood, and killed half the inhabitants while plundering the nest. The surviving rufibarbes return after the robbery and brought up new progeny; but thirte days later the Amazons again reaped a rich harvest fro the same nest. The Amazon army often severs itself into to separate divisions when there is not enough for both to at the same spot. Sometimes one division finds something and the other nothing, and they then reunite. If any obstact be placed in their way they try to overcome it, in doing while some leave the main army, lose themselves, and only find the way home again with difficulty. Forel has tried to establish the normal frequency of expeditions, and found that a color watched by himself for a space of thirty days sent out no le than forty-four marauding excursions. Of these about eight rather less timing and-twenty were completely, nine partially, and the remaindrate useless, to stop not at all successful. He four times saw the army divide in two. Half the expeditions were levelled against the rufibard etuosity of the half against the fusce. On an average a successful expedition fusca or a rufib

yould bring back n the whole, th olony during a housand!

The internec mong the Amaz hey tear each of five or six indi en rolling over ble to distinguis en are also kno

The mode of ecies of slave fferent:-

They march in inforcements, an wly. Between n continually n continually in hich arrives at the nazons, but co maissances, wh and a regular s e that of the An ms a complete r d this with man going nearer. besieged, until the attack. Thi of object the ma t. A special t h of the besiege re gives rise t nes. By this mea have all the defe ind. This is th

The conr victory valuable er did nor ng blindly e specie

e at their own nest rufibarba seemed a e Amazon t containe ncy fough o slaves rent specie

ich was i self into to both to s something any obstac doing which aly find the to establis hat a color

rould bring back to the colony a thousand pupe or larve. In the whole, the number of future slaves stolen by a strong plony during a favourable summer may be reckoned at forty housand!

The internecine battles which occasionally break out mong the Amazons themselves are naturally the most cruel. hey tear each other to pieces with incredible fury, and knots five or six individuals which have pierced each other may be en rolling over each other on the ground, it being imposble to distinguish between friend and foe. Civil wars among en are also known to be the most embittered and the most cody.

The mode of attack practised by the other best known ecies of slave-making ant, sanguinea, is somewhat fferent:-

They march in small troops which, in case of need, summon inforcements, and therefore as a rule only reach their goal one to stead one to stead of defend on continually backwards and forwards. The first troop such a plus hich arrives at the hostile nest does not rush at it, as do the mazons, but contents itself with making provisional remainssances, wherein some of the assailants are generally deprisoners by the enemy, which have time to bethink there. The and a regular siege of the nest begins. A sudden invasion and a regular siege of the nest begins. A sudden invasion, itants while that of the Amazons, is never seen. The besieging army ms a complete ring round the hostile nest, and the besiegers but thirted definition that the desired desir besieged, until they feel themselves strong enough to advance the attack. This attack scarcely ever fails, and has for its ef object the mastering of the entrances and outlets of the t. A special troop guards each opening, and only allows h of the besieged to pass out as carry no pupe. This manvre gives rise to a number of comical and characteristic nes. By this means the sanguine ants in a few minutes manage have all the defenders out of the nests and the pupe left about eight rather less timid fuscæ try, even at the last moment when he remained suscless, to stop up or barricade the entrances. The sanguine y divide in side ont indeed possess the terrible weapons and the warlike he rufibarher etuosity of the Amazons, but they are stronger and large ul expedition fusca or a rufibarbis fights with a sanguine ant for the possession of a pupa, it is generally very soon overcome. While the main part of the army is penetrating into the nest to steel other out of the the pupe, some divisions pursue the fugitives, to take away from them the few pupe which may chance to have been saved They drive them even out of the cricket-holes in which the same specie have meanwhile taken refuge. In short, it is a razzia, or sweet rous, and soon ing burglary, as complete as can be imagined. In the retrest in mates. But the robbers in no wise hurry themselves, for they know that turned back against they are threatened by no danger and no loss, and the completione after the other. emptying of a large and distant nest often takes several days and there put d accomplishing. The ants which have been so thoroughly robbe scarcely every return to their former abode.

It must be admitted that a human army, robbing a foreign town or fortress, could not behave better or more prudently.

Huber gives the following account of a battle wage by sanguine ants:—

At ten, in a July morning, he noticed a small band of the emerge from their nest, and march rapidly towards a nest negroes, around which it dispersed. A number of the blad rushed out, gave battle, and succeeded in defeating their vaders, and in making several of them prisoners. Upon the the remainder of the attacking force waited for a reinforcement When this came up, they still declined further proceeding and sent more aides-de-camp to their own nest. The result these messages was a much larger reinforcement; but even the pirates appeared to shun the combat. At last, the negret marched out from their nest in a phalanx of about two square, and a number of skirmishes began, which soon ended a general mêlée. Long before the event seemed certain, negroes carried off their pupe to the most distant part of nest; and when, after a longer encounter, they appeared to the further resistance vain, they retreated, attempting to take them their young. In this, however, they were prevented, the invaders obtained possession of their nest and the box When they had done this, they put in a garrison, and occur the night and the succeeding day in carrying off their spoil

Büchner says—

Battles between ants of the same species often end wit lasting alliance, especially when the number of the worker both sides is comparatively small. The wise little animals u such circumstances discover, much more quickly and better men, that they can only destroy each other by fighting, union would benefit both parties. Sometimes they drived

a table a piece acervorum, and were they carrie ashion at the ed eelers convinced nercilessly let it waited a momen urned back to allen on the floo ng ant. The la only stretching i everal times re ame result. La glass case, and

At other tin eedless cruelty

They slowly p ess by wounds, e he other, then t till it, or pull it ition to some ou et some compa ictors, which on get rid of the hem.

The following Mind in Anima

The doors are heir important d olobopsis trunce ngs of which w eir thick cylin ops up the mo yrmecina Latre the slave-mak ach of the little

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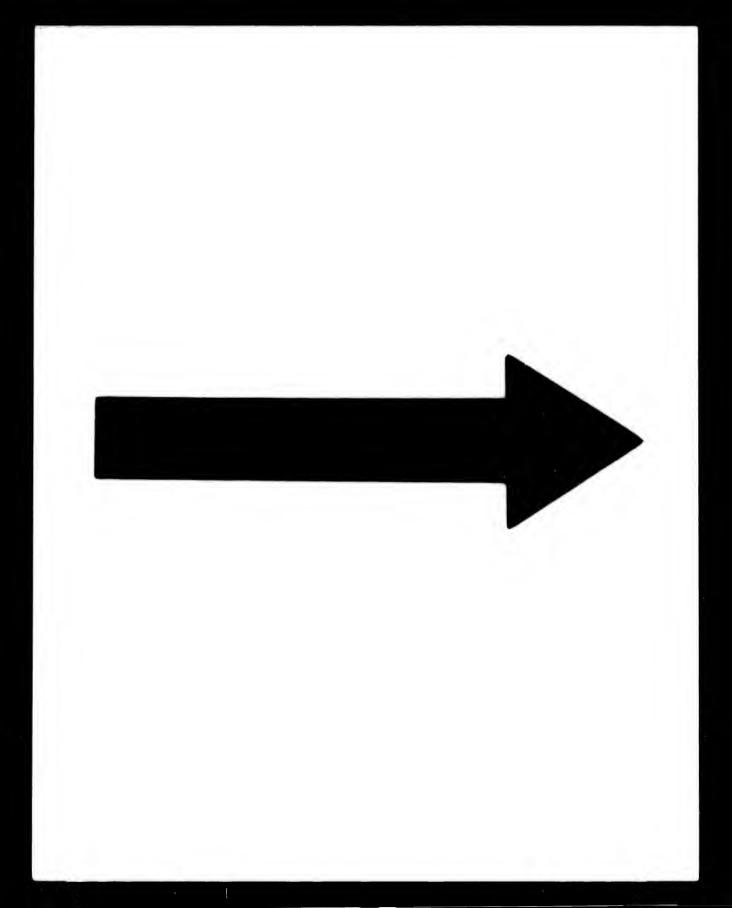
other out of their nests in a quite friendly way. Forel laid on a table a piece of bark with a nest of the gentle Leptothorax accrvorum, and then put on it the contents of another nest of the same species. The last comers were by far the more numerous, or sweet the same species. The last comers were by far the more numerous, and soon possessed themselves of the nest, driving out the inmates. But the latter did not know whither to go, and turned back again. They were then seized by their opponents one after the other, carried away as far as possible from the nest, and there put down. The oftener they came back the further were they carried away. One of the carriers arrived in this lashion at the edge of the table, and after it had by means of its ashion at the edge of the table, and after it had by means of its. ng a foreign eelers convinced itself that it had reached the end of the world, rudently. Percilessly let its burden drop into the fathomless abyss. waited a moment to see if it had attained its object, and then turned back to the nest. Forel picked up the ant which had allen on the floor, and put it down right in front of the returnand of the mg ant. The latter repeated the same manœuvre as at first, ds a nest only stretching its neck further over the edge of the table. He f the black everal times reiterated his experiment, and always with the ng their same result. Later the two colonies were shut up together in Upon the glass case, and gradually learned to agree.

At other times, however, warlike ants show great and heedless cruelty to one another:—

They slowly pull from their victim, that is rendered defenceess by wounds, exhaustion, or terror, first one feeler and then he other, then the legs one after another, until they at last ill it, or pull it in a completely mutilated and helpless conlition to some out-of-the-way spot where it perishes miserably. Tet some compassionate hearts are to be found among the ictors, which only pull the conquered to a distant place in order b get rid of them, and there let them go without injuring

The following account is also taken from Büchner's Mind in Animals, p. 87:—

The doors are often guarded by special sentries, which fulfil heir important duty in various ways. Forel saw a nest of the colobopsis truncata, the two or three very small round openhgs of which were watched by soldiers, arranged so that heir thick cylindrical heads stopped them up, just as a cork and better tops up the mouth of a bottle. The same observer saw the fighting, I syrmecina Latreillei defend themselves against the invasions hey drive the slave-making Strongylognathus, by placing a worker at ach of the little openings of the nest, which quite stops up



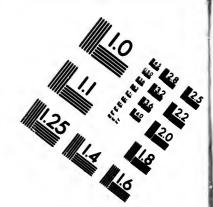
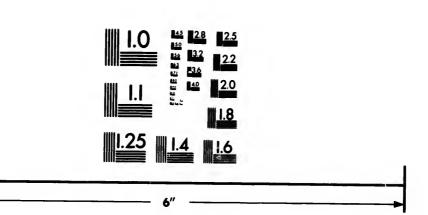


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the opening either with its head or abdomen. The Campo notus species also defend their nests by stretching their heads in front of the openings, drawing back the antennæ. Each approaching enemy thus receives a sharp blow or bite delivered with the whole weight of the body. MacCook noticed in the nest of the soon to be described Pennsylvanian mound-building anta the employment of special sentries, which lay watching within the nest entrances, and sprang out at the first sight of danger to attack the enemy; and it was wonderful to see with what swiftness the news of such an alarm spread through the nest and how the inhabitants came out en masse to meet the enemy The Lasius species defend their large, strong, and very extensive nests against hostile attack or sieges with equal courage and skill, while other timid species seek to fly as speedily as possible with their larvæ, pupæ, and fruitful queens. There is, as Ford tells us, a regular barricade fight. Passage after passage i stopped and defended to the uttermost, so that the assailant can only advance step and step. Unless the latter are in a enormous majority, the struggle may last a very long time wit these tactics. During this time, other workers are busy preparing subterranean passages backwards for eventual flight Generally such passages are already made, and during a fight new dome of the *Lasius* may be seen rising at a distance, it me being difficult for them to make this with the help of their ex tended subterranean passages and communications.

The F. exsecta or pressilabris fights in a peculiar way, which due to care of their small and very tender bodies. It avoids single combats, and always fights in closed ranks. Only whe it thinks victory secure does it spring on its enemy's back. Bu its chief strength lies in the fact that many together alway attack a foe. They nail down their opponent by seizing its lea and holding them firmly to the ground, while a comrade spring on the back of the defenceless creature and tries to bite through its neck. But if threatened the holders sometimes take flight and so it happens that in battles between the exsector and the much stronger pratenses not a few of the latter are seen running about with a small enemy clutching their shoulders, and making violent efforts to tear the neck of its foe. If the bearer is the lilities may hav seized with cramp, the nervous cord has been injured. On the other hand, if an exsecta is seized by the back by a pratensis

is at once lost.

The tactics of the turf ants resemble those of the tacting train, leathere or four of them seizing an opponent and pulling off he resting train, leathere or four of them seizing an opponent and pulling off he resting train, leathere or four of them seizing an opponent and pulling off he resting train, leather the off the Lasius species there lower down

hiefly directed a ve uniting in t articularly well omes to the wo ared by most ar orel one day por ont of a tree tru he siege at one e nests connecte ere at once seen atenses were obl well as their pu their nests to b

Battles, howe ving warlike a ts likewise at le importance lue which the ien supplies ar us Moggridge By far the mo

ve witnessed wer o different colon gular contests a bara, when one t belonging to longed though, over their proper In the case of the ting, the strife ay—but A. bar week after weel watching the pro one nest of bar y six days, from I cannot of cou m that wheneve s, or as nearly a ar and spoliatio An active train

hiefly directed against the legs of its enemies, three, four, or ve uniting in the effort. They understand barricade fighting articularly well in their large well-built dwellings, and if it bmes to the worst fly by subterranean passages. They are ared by most ants on account of their numerical superiority. orel one day poured the contents of ten nests of pratenses in ont of a tree trunk inhabited by Lasius fuliginosus (jet ant). he siege at once began; but the jet ants called in help from e nests connected with their colony, and thick black columns ere at once seen coming out from the surrounding trees. atenses were obliged to fly, and left behind them a mass of dead well as their pupæ, which last were carried off by the victors their nests to be eaten.

Battles, however, are not confined to species of ants ving warlike and slave-making habits. The agricultural ts likewise at times wage fierce wars with one another. he importance of seeds to these ants, and the consequent lue which they set upon them, induce the animals, en supplies are scarce, to plunder each other's nests. ius Moggridge says, —

By far the most savage and prolonged contests which I ve witnessed were those in which the combatants belong to o different colonies of the same species. gular contests are those which are waged for seeds by A. bara, when one colony plunders the stores of an adjacent t belonging to the same species, the weaker nest making longed though, for the most part, inefficient attempts to s back. But over their property.

In the case of the other species of ant which I have watched ting, the strife would last but a short time—a few hours or rade spring lay—but A. barbara will carry on the battle day after day week after week. I was able to devote a good deal of time vatching the progress of a predatory war of this kind, waged one nest of barbara against another, and which lasted for y six days, from January 18 to March 4!

I cannot of course declare positively that no cessation of earer is the tilities may have taken place during the time, but I can m that whenever I visited the spot—and I did so on twelve s, or as nearly as possible twice a week—the scene was one ar and spoliation such as that which I shall now describe.

the exsects An active train of ants, nearly resembling an ordinary lling off he vesting train, led from the entrance of one nest to that of us species ther lower down the slope, and fifteen feet distant; but on

delivered the nest ding ant ng within of danger with what the nest he enemy y extensive ourage and as possible

Campo

eir heads

Each

is, as Fore passage i e assailant r are in a g time with e busy pre tual flight ng a fight tance, it no

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us species

closer examination it appeared that though the great mass seed-bearers were travelling towards the upper nest, some fer were going in the opposite direction and making for the lower Besides this, at intervals, combats might be seen taking place one ant seizing the free end of a seed carried by another, an endeavouring to wrench it away, and then frequently, as neither would let go, the stronger ant would drag seed and opponen towards its nest. At times other ants would interfere and sei one of the combatants and endeavour to drag it away, this ofte resulting in terrible mutilations, and especially in the loss of the abdomen, which would be torn off while the jaws of the victi retained their indomitable bull-dog grip upon the seed. The the victor might be seen dragging away his prize, while its a versary, though now little more than a head and legs, offered vigorous though of course ineffectual resistance. I frequent observed that the ants during these conflicts would endeavo to seize one another's antennæ, and that if this were effected the ant thus assaulted would instantly release his hold, when of seed or adversary, and appear utterly discomfited. No do the antennæ are their most sensitive parts, and injuries inflic on these organs cause the greatest pain.

It was not until I had watched this scene for some days to I apprehended its true meaning, and discovered that the antithe upper nest were robbing the granaries of the lower, where the latter tried to recover the stolen seeds both by fight for them and by stealing seeds in their turn from the nof their oppressors. The thieves, however, were evident the stronger, and streams of ants laden with seeds arm safely at the upper nest, while close observation showed the very few seeds were successfully carried on the reverse jour

into the lower and plundered nest.

Thus when I fixed my attention on one of these robbeds surreptitiously making its exit with the seed from the this nest, and having overcome the opposition and dangers met on its way, reaching, after a journey which took six minutes accomplish, the entrance to its own home, I saw that it violently deprived of its burden by a guard of ants stationed that apparently for the purpose, one of whom instantly started and carried the seed all the way back again to the upper metals.

This I saw repeated several times.

After March 4 I never saw any acts of hostility between ests, though the robbed nest was not abandoned another case of the same kind, however, where the structure lasted thirty-one days, the robbed nest was at length complete.

bandoned, and rith one single patted roots of ave been long ne of the seed ermination.

No doubt so retematic raids in be little doubt as of the same ason and date. tive on many detely closed; an ong, enfeebled is her ants were se

The agricult ss pugnacious acCook says:—

A young comm nt prosperity th found in the unp want-city was c rds of a long-e ought would pro riculturals seem bund their formid allowed. He the se observation, a o had elapsed bet v had made war at numbers, and zens. The youn n their adversa y were overwhel ny of their assail ng pairs over a sp the ground was pnists aimed alto , which they acc riors, on the con omens of their was revisited, locked togeth

bandoned, and on opening it I found all the granaries empty ith one single exception, and this one was pierced by the patted roots of grasses and other plants, and must therefore ave been long neglected by the ants. Strangely enough, not ne of the seeds in this deserted granary showed traces of ermination.

No doubt some very pressing need is the cause of these stematic raids in search of accumulations of seeds, and there In be little doubt that the requirements of distinct colonies of ats of the same species are often different even at the same ason and date. Thus these warring colonies of ants were tive on many days when the majority of the nests were cometely closed; and I have even seen these robbers staggering ong, enfeebled by the cold, and in wind and rain, when all her ants were safe below ground.

The agricultural ants of Texas do not appear to be ss pugnacious than their European congeners. acCook says:—

A young community has sometimes to struggle into permant prosperity through many perils. The following example me days the found in the unpublished Lincecum manuscripts. One day a want-city was observed to be located within ten or twelve rds of a long-established nest, a distance that the doctor by fight ought would prove too near for peaceable possession—for the riculturals seem to pre-empt a certain range of territory bund their formicary as their own, within which no intrusion seeds arrivallowed. He therefore concluded to keep these nests under showed to be observation, and visited them frequently. Only a day or overse journ to had elapsed before he found that the inhabitants of the old y had made war upon the new. They had surrounded it in y had made war upon the new. They had surrounded it in set robbeds at numbers, and were entering, dragging out and killing the mather this izens. The young colonists, who seemed to be of less size in their adversaries, fought bravely, and, notwithstanding by were overwhelmed by superior numbers, killed and maimed mained in their assailants. The parties were scattered in strugstationed the grains over a space ten or fifteen feet around the city gate, if the ground was strewed with many dead bodies. The new onists aimed altogether at cutting off the legs of their larger as which they accomplished with much success. The old-gifty s, which they accomplished with much success. The old-city stility between the contrary, gnawed and clipped off the heads and bandoned lomens of their enemies. Two days afterward the battle-e the structure of the structure of the complete of the theorem of their enemies. Two days afterward the battle-e the structure of their enemies. Two days afterward the battle-e the structure of their enemies.

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of decapitated bodies and severed heads were strewed over the

ground.

Another example, which is given in the published paper, quite similar, and had like result. In forty-eight hours the distance between the nests was about 20 feet. While the young colonists remains in concealment they were not disturbed, but as soon as the began to clear away their open disk war was declared.

MacCook, however, says that 'these ants are not alway so jealous of territorial encroachment, or at least mu have different standards of rights.' For he observed man cases of nests situated within twenty, and even ten fe of one another, without a battle ever occurring between members of the two communities. Therefore, without questioning the accuracy of Lincecum's observations which, indeed, present no scope for inaccuracy—he add 'That neighbouring ants, like neighbouring nations civilised men, will fall out and wage war Lincecum's amples show. Perhaps we should be quite as unsuccess in case of these ants as of our human congeners, show we seek a sufficient reason for these wars, or satisfactor cause for these differences in dealing with neighbor which appear from the comparison of Lincecum's observ tions with mine.'

In connection with the wars of these ants, the folloging quotations may also be made from the same author:

The erratic ants do not appear to be held as common a mies by the agriculturals, and they are even permitted establish their formicaries within the limits of the open discontines, however, the diminutive hillocks which mark tentrance to an erratic ant-nest multiply beyond the limit of agriculturals' forbearance. But they do not declare war, resort to any personal violence. Nevertheless, they get rist them, oddly enough, by a regular system of vexatious obstrations. They suddenly conclude that there is urgent demotions. They suddenly conclude that there is urgent demotions for improving their public domain. Forthwith they sally for in large numbers, fall eagerly to work gathering the little blaballs which are thrown up by the earth-worms in great quantite everywhere in the prairie soil, which they bring and heap up the paved disk until all the erratic ant-nests are covered!

deposit more be y neighbours to sly against this avalanche of the e obstructions as le to keep the grainst destiny, an etly evacuate the triumph of the l opposition.

Lastly, MacCo

agement which ramorium cæ eet and Penn rly three weeks he same speci t, friends were ently by contac Habit of keep s display the cu dry kinds of otl ends, are of no have been reg These 'pets ir nowhere else pet' is pecul gridge found n beetle movi he harvesting he scarce and v Kraatz C. attee, hts belonging t biting the san er than a grain h had been pre s of several spe he best terms v arm weather, ar e allowing the ng migrations

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the follo e author: common e permitted he open di ich markt e limit of are war, hey get rid tious obstr ey sally for overed! 1 ains are tal

deposit more balls upon and around the domiciles of their y neighbours than elsewhere. The erratics struggle vigorly against this Pompeian treatment; they bore through avalanche of balls, only to find barriers laid in their way. e obstructions at length become so serious that it is impose to keep the galleries open. The dwarfs cease to contend inst destiny, and, gathering together their household stores, etly evacuate the premises of the inhospitable giants. triumph of the policy of obstruction, a bloodless but effecopposition.

Lastly, MacCook records the history of an interesting agement which he witnessed between two nests of framorium cæspitum. It took place between Broad eet and Penn Square in Philadelphia, and lasted for rly three weeks. Although all the combatants belonged he same species, however great the confusion of the t, friends were always distinguished from foes—apently by contact of antennæ.

Habit of keeping Domestic Pets.—Many species of s display the curious habit of keeping in their nests dry kinds of other insects, which, so far as observation ends, are of no benefit to the ants, and which therehave been regarded by observers as mere domestic These 'pets' are for the most part species which or nowhere else except in ants' nests, and each species pet' is peculiar to certain species of ants. gridge found 'a large number of a minute shining on beetle moving about among the seeds' in the nests he harvesting ant of the south of Europe, 'belonging he scarce and very restricted genus Colnocera, called Kraatz C. attee, on account of its inhabiting the nests nts belonging to the genus Atta.' He also observed biting the same nests a minute cricket 'scarcely gent demonstrate than a grain of wheat' (Gryllus myrmecophilus), th had been previously observed by Paolo Savi in the he little by s of several species of ants in Tuscany, where it lived reat quantithe he best terms with its hosts, playing round the nests nd heap warm weather, and retiring into them in stormy weather, e allowing the ants to carry it from place to place Again, Mr. Bates observes that ng migrations.

'some of the most anomalous forms of coleopterous inserare those which live solely in the nests of ants.' John Lubbock also, and other observers whom we not wait to cite, mention similar facts. The Rev. White says that altogether 40 distinct species of Coleopter most of which he has in his own collection, are known to inhabit the nests of various species of ants, and occur nowhere else.

As in all these cases the ants live on amicable ten with their guests, and in some cases even bestow labs upon them (as in carrying them from one nest to anothe during migration), it is evident that these insects are nonly tolerated, but fostered by the ants. Moreover, as seems absurd to credit ants with any mere fancy or caps such as that of keeping pets, we can only conclude these insects, like the aphides, are of some use to the hosts, although we are not yet in a position to surme what this use can be.

Habits of Sleep and Cleanliness.—It is probable tall species of ants enjoy periods of true sleep alternativith those of activity; but actual observations on tsubject have only been made on two or three spectime following is MacCook's account of these habits in harvesting ant of Texas:—

The observation upon the ants now before me begu 8 o'clock; at 11 P.M. the cluster had nearly dissolved, on few being asleep. To illustrate the soundness of this sle take the quill pen with which I write, and apply the fe end of it to an ant who is sleeping upon the soil. chosen a little oval depression in the surface, and lies abdomen upon the raised edge, and face toward the lamp. legs are drawn up close to the body. She is perfectly still gently draw the feather tip along the body, stroking 'with fur,' if I may so say. There is no motion. Again and this action is repeated, the stroke gradually being made her although always quite gentle. Still there is no change. strokes are now directed upon the head, with the same re Now the tip is applied to the neck, the point at which the is united to the pro-thorax, with a waving motion intend produce a sensation of tickling. The ant remains motion After continuing these experiments for several minut

ouse the sleeper t her head, the the light, and scribed. This ep. The above mnolence as obs ants for near ill, and even th lians without by tails which have dual just put ur Thus, I have s er awaking. Ι curately express nt of the huma th the peculiar ders; the tongu etched with the companies the y tennæ have a ge n, which seemed athing. I also d setting down o nost a rhythmic The length of ti vary according e large head-sold ve a more sluggis ep is longer and ermined. The 1 creatures under taking sleep ot ong and over the les. Again, new their desire to ge wsy comrades a rk in the galler ster, and present atment is invaria like jostlings wl slightest display n under these ci

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ouse the sleeper by a sharp touch of the quill. She stretches t her head, then her legs, which she also shakes, steps nearer the light, and begins to cleanse herself in the manner already scribed. This act invariably follows the waking of ants from ep. The above description applies to the general habit of mnolence as observed upon the two named species of harvestants for nearly four months. I have often applied the ill, and even the point of a lead pencil, to the sleeping Flolians without breaking their slumber. There are some other tails which have not appeared in the behaviour of the indidual just put under observation.

Thus, I have several times seen the ants (Crudelis) yawning er awaking. I use this word for lack of one which more curately expresses the behaviour. The action is very like at of the human animal; the mandibles are thrown open th the peculiar muscular strain which is familiar to all ders; the tongue also is sometimes thrust out, and the limbs etched with the appearance, at least, of that tension which companies the yawn in the genus homo. During sleep the tennæ have a gentle, quivering, apparently involuntary mon, which seemed to me, at times, to have the regularity of eathing. I also often noted an occasional regular lifting up d setting down of the fore-feet, one leg after another, with nost a rhythmic motion.

The length of time during which sleep is prolonged appears vary according to circumstances and, perhaps, organism. e large head-soldiers of the Floridian harvesters appear to ve a more sluggish nature than the smaller workers. Their ep is longer and heavier. The former fact the watch readily ermined. The latter appeared from the greater stolidity of creatures under disturbance. While the ants of one group taking sleep others may be busy at work, and these stalk ong and over the sleepers, jostling them quite vigorously at les. Again, new members occasionally join the group, and, their desire to get close up to the heat and light, crowd their bwsy comrades aside. I have seen ants who had been at rk in the galleries drop their pellets, push thus into the ster, and presently be apparently sound asleep. This rough atment is invariably received with perfect good humour, as like jostlings when the ants are awake. I have never seen slightest display of anger or attempt to resent disturbance the same remain under these circumstances, so peculiarly calculated to exthe utmost irritation in men. But of course some of the epers are aroused. They change position a little, or give themselves a brief combing, and then resume their nap, unle indeed, they are satisfied. In watching these movements it we quite evident that the Florida soldiers were far less easily deturbed than their smaller fellows. They slept on stolidly whe all the others were in agitation around them. Moreover, the very appearance, particularly when awaking out of sleep, in cated the greater sluggishness of their temperament in the respect.

The ordinary duration of sleep MacCook takes to about three hours.

Ants, like many other insects, are in the habit cleaning themselves, being, like them, provided by natu with combs and brushes, &c., for the purpose. But, unli other insects, several species of ants are also in the hab of assisting each other in the performance of their tolk. The author last quoted gives the following account of the process in the genus Atta:—

We take a couple; the cleanser has begun at the face, whi is licked thoroughly, even the mandibles being cared for, the being held apart for convenient manipulation. From the the cleanser passes to the thorax, thence to the haunch, and along the first leg, along the second and third in the sa manner, around to the abdomen, and thence up the other side the ant to the head. A third ant approaches and joins in friendly task, but soon abandons the field to the origin cleanser. The attitude of the cleansed all this while is one intense satisfaction, quite resembling that of a family dog wh one is scratching the back of his neck. The insect stretch out her limbs, and, as her friend takes them successively in hand, yields them limp and supple to her manipulation; rolls gently over upon her side, even quite over upon her bad and with all her limbs relaxed presents a perfect picture of m cular surrender and ease. The pleasure which the creature take in being thus 'combed' and 'sponged' is really enjoyal to the observer. I have seen an ant kneel down before another and thrust forward the head, drooping, quite under the fa and lie there motionless, thus expressing, as plainly as sign language could, her desire to be cleansed. I at once und stood the gesture, and so did the supplicated ant, for she once went to work. If analogies in nature-studies were not apt to be misleading, one might venture to suggest that

ect friends are hmetonian Turki The acrobatic sl amusement, and ly shown one mo cary was taken f lled, and placed ore an open-grate oughout the nest ity. A tuft of g rered with them, ned round and nnasts performin various positions, rth pairs of legs, ir heads with the lick the abdome one case a triple cribed. The clea side and a hind at full length, w bw, and reache sant process. posture on the pa nost agility.

Similarly, Bate ther genus of

Here and there and then another its comrades, who ween the jaws andly wipe.

Habits of Pla work, or, at lea cies, at any rat ulged in.

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ect friends are thus in possession of a modified sort of metonian Turkish bath.

The acrobatic skill of these ants, which has often furnished amusement, and which I shall yet further illustrate, was ly shown one morning in these offices of ablution. The forcary was taken from the study, where the air had become lled, and placed in an adjoining chamber upon the hearth, fore an open-grate fire. The genial warmth was soon diffused oughout the nest, and aroused its occupants to unusual acity. A tuft of grass in the centre of the box was presently ered with them. They climbed to the very top of the spires, ned round and round, hanging by their paws, not unlike masts performing upon a turning-bar. They hung or clung various positions, grasping the grass blade with the third and rth pairs of legs, which were spread out at length, cleansing ir heads with the fore-legs or bending underneath to comb lick the abdomen. Among these ants were several pairs, one case a triplet, engaged in the cleansing operation just cribed. The cleanser clung to the grass, having a fore-leg on side and a hind leg on the other side of the stem, stretched at full length, while the cleansed hung in a like position bw, and reached over and up, submitting herself to the asant process. As the progress of the act required a change osture on the part of both insects, it was made with the nost agility.

joins in Similarly, Bates thus describes the cleansing process in the original ther genus of ants (*Ecitons*):—

Here and there an ant was seen stretching forth first one and then another, to be brushed and washed by one or more its comrades, who performed the task by passing the limb ween the jaws and tongue, finishing by giving the antennæ andly wipe.

Habits of Play and Leisure.—The life of ants is not work, or, at least, is not so in all species; for in some cies, at any rate, periods of recreation are habitually ulged in.

Büchner ('Geistesleben der Thiere,' p. 163) gives the owing abstract of Huber's celebrated observations in

s connection:—

It was of the *pratensis* that Huber wrote the observations ching its gymnastic sports which became so famous. He

saw these ants on a fine day assembled on the surface of the tion. When the nest, and behaving in a way that he could only explain nest, and behaving in a way that he could only explain in the lorest. I simulating festival sports or other games. They raised the columns, at these selves on their hind legs, embraced each other with their for legs, seized each other by the antennæ, feet, or mandibles, and left, to wrestled—but all in friendliest fashion. They then let go, reader after each other, and played hide-and-seek. When one were brushing included in the colors in the ring, and tumbled the love-quoted passive size of the colors of the colors of the colors of the colors of the colors.

over like ninepins. This account of Huber's found its way into many popul imple indulgence books, but in spite of its clearness won little credence from reading public. 'I found it hard to believe Huber's c' vation, writes Forel, 'in spite of its exactness, until I m had seen the same.' A colony of the pratensis several ta gave him the opportunity when he approached it careful The players caught each other by the feet or jaws, rolled of each other on the ground like boys playing, pulled each of inside the entrances of their nest, only to come out again, and All this was done without bad temper, or any spurting ades. This hal poison, and it was clear that all the rivalry was friendly. least breath from the side of the observer was enough to put ments, thus beco end to the games. 'I understand,' continues Forel, 'that natural selection affair must seem marvellous to those who have not seen especially when we remember that sexual attraction can be play no part.'

MacCook also gives an account of habits of play as dulged in among ants of the other Hemisphere:—

At one formicary half a dozen or more young queens w out at the same time. They would climb up a large pel near the gate, face the wind, and assume a rampant post Several having ascended the stone at one time, there ensure hey usually depos They nipped little playful passage-at-arms as to position. other gently with the mandibles, and chased one another fivral ant upon the favourite spots. They, however, never nipped the work chaviour towards These latter evidently kept a watch upon the sportive pasight of this. cesses, occasionally saluted them with their antennæ in viturals of anoth usual way, or touched them at the abdomen, but appared ery soon after the allowed them full liberty of action.

As to leisure, Bates writes:—

The life of these Ecitons is not all work, for I frequently them very leisurely employed in a way that looked like

in the forest. bove-quoted pas hese hours of re he effective perfe oking at them, erely in play wa

Funereal Ho been stated that ery careful in d pecies of ants, nt are thus rela

There is nothing he life-history of unereal habits. bserved are quite ead, and for the ppear to treat wit ent of giving the hem. The latter, ew home, a numbe nd began carrying he next day this

¹ Loc. cit.

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1 Loc. cit.

face of the ation. When this happened the place was always a sunny nook raised the columns, at these times, were in their ordinary relative positions; but instead of pressing forward eagerly and plundering right and left, they seemed to have been all smitten with a main let go, a were brushing their antennæ with their fore-feet; but the men one were brushing their antennæ with their fore-feet; but the men one wireless sight was their cleaning each other. [Here fellows the irollest sight was their cleaning each other. [Here follows the bove-quoted passage. The actions of these ants looked like nany popul simple indulgence in idle amusement. It is probable that ence from these hours of relaxation and cleaning may be indispensable to uber's c's he effective performance of their harder burdens; but whilst ntil I m king at them, the conclusion that the ants were engaged erely in play was irresistible.1

Funereal Habits.—In another connection it has already been stated that Sir John Lubbock found his ants to be again, and very careful in disposing of the dead bodies of their commy spurting ades. This habit seems to be pretty general among many riendly. I pecies of ants, and is no doubt due to sanitary requireugh to put ments, thus becoming developed as a beneficial instinct by orel, 'that natural selection. The funereal habits of the agricultural not seen ant are thus related by MacCook: 2 —

There is nothing which is apt to awaken deeper interest in he life-history of ants than what may properly be called their of play as Junereal habits. All species whose manners I have closely bserved are quite alike in their mode of caring for their own lead, and for the dry carcasses of aliens. The former they queens we ppear to treat with some degree of reverence, at least to the extense pet ent of giving them a sort of sepulture without feeding upon a pant posts hem. The latter, after having exhausted the juices of the body, hey usually deposit together in some spot removed from the private of the segriculture of the segretaries, of the agriculture of the segriculture y nipped est. I did not see any of the 'cemeteries' of the agriculanother it was and upon the field, nor, indeed, observe any of their the work chaviour towards the dead, but my artificial nests gave me some sportive pasight of this. In the first colony had been placed eight agritennæ in ulturals of another nest, which were literally cut to pieces. Tery soon after the ants were comfortably established in their ew home, a number of them laid hold upon these disjecta membra, and began carrying them back and forth around the formicarium. the next day this continued, and several of their own number

² Loc. cit. p. 337.

who had died were being treated in like manner. Back and forth, up and down, into every corner of the box the bearers wandered, the very embodiment of restlessness. For four days this conduct continued without any intermission. No sooner would a body or fragment thereof be dropped by one bearer than another would take it up and begin the restless circuit, The difficulty, I easily understood, was that there was no point to be found far enough removed from the living-rooms of the insects in which to inter these dead. Their desire to have their dead buried out of their sight was strong enough to keep them on this ceaseless round, apparently under the continuous influence of the hope that something might turn up to give them a more satisfactory burial-ground. It does not appear greatly to the credit of their wisdom that they were so long discovering that they were limited to a space beyond their power to enlarge. When, however, this fact was finally recognised they gave their habit its utmost bent, and began to deposit the carcasses in the extreme corner of the flat, as distant as possible from the galleries on the terrace above. Here a little hollow was made in the earth, quite up against the glass, wherein a number of bodies were laid. Portions of bodies were thrust into the chinks formed in the dry sod. This flat became the permanent charnel-house of the colony, and here, in corners, crevices, and holes, for the most part out of sight, but not always so, the dead were deposited. But the living never seemed quite reconciled to their presence. Occasionally, restless resurrectionists would disentomb the dead, shift them to another spot, or start them once more upon their unquiet wanderings. Even after the establishment of this cemetery, the creatures did not seem able to lay away their newly deceased comrades-for there were occasional deaths in the formicary—without first indulging in this funereal promenade.

In the formicaries established in glass jars, both of barbatw and crudelis, the same behaviour appeared. So great was the desire to get the dead outside the nest, that the bearers would climb up the smooth surface of the glass to the very top of the jar, laboriously carrying with them a dead ant. This was sever work, which was rarely undertaken except under the influence of this funereal enthusiasm. The jar was very smooth and quite high. Falls were frequent, but patiently the little 'undertaker' would follow the impulse of her instinct, and try and try again. Finally, as in the large box, the fact of a necessity seemed to dawn upon the ants, and a portion of the surface opposite from the entrance to the galleries, and close up against the glass, was

used as burial-g refuse of the no that her artific same way.

An interest guinea was rela colony of these s adjoining her r that a number of fusca, were dep These were pro from recent raid of one species, a red slave-maker their black serv in groups, but considerable dis pointing here as ocial hymenopt arry their distin to the gates of t nto its mother d

It will be of an ave been the roceeding here is a very braining among om the pen of ion seems to be carcely have braiton, and this f'soldier ants, he place where

I saw a large etermined to war five that starte stance off, in what about five minual into rank, warey arrived at the its. In a few m

used as burial-ground and sort of kitchen-midden, where all the refuse of the nest was deposited. Mrs. Treat has informed me that her artificial nests of *crudelis* behaved in precisely the same way.

An interesting fact in the funereal habits of Formica sanquinea was related to me by this lady. A visit was paid to a large colony of these slave-makers, which is established on the grounds adjoining her residence at Vineland, New Jersey. I noticed that a number of carcasses of one of the slave species, Formica fusca, were deposited together quite near the gates of the nest. These were probably chiefly the dry bodies of ants brought in from recent raids. It was noticed that the dead ants were all of one species, and thereupon Mrs. Treat informed me that the red slave-makers never deposited their dead with those of their black servitors, but always laid them by themselves, not in groups, but separately, and were careful to take them a considerable distance from the nest. One can hardly resist pointing here another likeness between the customs of these locial hymenopters and those of human beings, certain of whom arry their distinctions of race, condition, or religious caste, even to the gates of the cemetery in which the poor body moulders nto its mother dust!

It will be observed that none of these accounts furnish evidence of ants burying their dead, as Pliny asserts to have been the case with ants in the south of Europe. In the Proceedings of the Linnæan Society, however (1861), here is a very definite account of such a practice as bearining among the ants of Sydney; and although it is from the pen of an observer not well known, the observation seems to have been one about which there could carcely have been a mistake. The observer was Mrs. Intton, and this is her account. Having killed a number f'soldier ants,' and returning half an hour afterwards to be place where the dead bodies were lying, she says:

I saw a large number of ants surrounding the dead ones. I etermined to watch their proceedings closely. I followed four five that started off from the rest towards a hillock a short stance off, in which was an ants' nest. This they entered, and about five minutes they reappeared, followed by others. All ll into rank, walking regularly and slowly two by two, until ey arrived at the spot where lay the dead bodies of the soldier ats. In a few minutes two of the ants advanced and took up

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the dead body of one of their comrades; then two others, and so on, until all were ready to march. First walked two ants bearing a body, then two without a burden; then two others with another dead ant, and so on, until the line was extended to about forty pairs, and the procession now moved slowly onwards, followed by an irregular body of about two hundred ants Occasionally the two laden ants stopped, and laying down the dead ant, it was taken up by the two walking unburdened behind them, and thus, by occasionally relieving each other, ther arrived at a sandy spot near the sea. The body of ants now commenced digging with their jaws a number of holes in the ground, into each of which a dead ant was laid, where they now laboured on until they had filled up the ants' graves. did not quite finish the remarkable circumstances attending this funeral of the ants. Some six or seven of the anti had attempted to run off without performing their share of the task of digging; these were caught and brought back, when they were at once attacked by the body of ants and killed upon the spot. A single grave was quickly dug, and they were all dropped into it.

The Rev. W. Farren White also, in his papers on antipublished in the 'Leisure Hour' (1880), after alluding to the above case, corroborates it by some interesting observations of his own. He says:—

Several of the little sextons I observed with dead in the mandibles, and one in the act of burying a corpse. . . I should mention that the dead are not interred without considerable difficulty, in consequence of the sides of the trays being almost perpendicular. The work of the sextons continued untino dead bodies remained upon the surface of the nest, but alwere interred in the extramural cemeteries. Afterwards I removed the trays, and turned the contents of the formicarium upside down, and then I placed six trays on the surface of the earth, two of which I filled with sugar for food. All six we used freely as cemeteries, being crowded with the corpses the little people and their young, the larvæ which had perishe in the disruption of their home.

I have noticed in one of my formicaria a subterraneal cemetery, where I have seen some ants burying their dead by placing earth above them. One ant was evidently much affected and tried to exhume the bodies, but the united exertions of the yellow sextons were more than sufficient to neutralise the effort of the disconsolate mourner. The cemetery was now converted

into a large together with covered in.

Leaf-cutt otes).—The

thus describe

They movitself on the sulike jaws a new then takes the detaches the p ground, where another relay of the piece it has the colony, the and bare, looking the herbage.

Each ant over its head, s very conspicuo home-returnin side of the re train keeps to is a double tr When the leav smaller kind o pieces of leaf leaves seem to as we shall pr workers never t hey occasional purpose of obta he nest they n uently, as if i ircular pieces he nest, and so

From his con ludes—and his into a large vault, the chamber where the dead were placed, together with the passage which led to it, being completely covered in.

Habits Peculiar to Certain Species.

Leaf-cutting Ants of the Amazon (Œcodoma cephalotes).—The mode of working practised by these ants is thus described by Mr. Bates:—

They mount a tree in multitudes. . . . Each one places itself on the surface of a leaf, and cuts with its sharp scissor-like jaws a nearly semicircular incision on the upper side; it then takes the edge between its jaws, and by a sharp jerk detaches the piece. Sometimes they let the leaf drop to the ground, where a little heap accumulates, until carried off by another relay of workers; but generally each marches off with the piece it has operated on, and as all take the same road to the colony, the path they follow becomes in a short time smooth and bare, looking like the impression of a cart-wheel through the herbage.

Each ant carries its semicircular piece of leaf upright over its head, so that the home-returning train is rendered very conspicuous. Nearer observation shows that this home-returning or ladened train of workers keeps to one side of the road, while the outgoing or empty-handed train keeps to the other side; so that on every road there is a double train of ants going in opposite directions. When the leaves arrive at the nest they are received by a smaller kind of workers, whose duty it is to cut up the pieces of leaf into still smaller fragments, whereby the leaves seem to be better fitted for the purpose to which, as we shall presently see, they are put. These smaller workers never take any part in the outdoor labours; but they occasionally leave the nest, apparently for the sole burpose of obtaining air and exercise, for when they leave the nest they merely run about doing nothing, and frequently, as if in mere sport, mount some of the semicircular pieces of leaf which the carrier ants are taking to the nest, and so get a ride home.

From his continued observation of these ants, Bates conludes—and his opinion has been corroborated by that

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ubterraneat heir dead h luch affected rtions of the ise the effor w converte both of Belt and Müller—that the object of all this labour is highly interesting and remarkable. The leaves when gathered do not themselves appear to be of any service to the ants as food; but when cut into small fragments and stored away in the nests, they become suited as a nidus for the growth of a minute kind of fungus on which the ants feed. We may therefore call these insects the 'gardening ants,' inasmuch as all their labour is given to the rearing of nutritious vegetables on artificially prepared soil. They are not particular as to the material which they collect and store up for soil, provided that it is a material on which the fungus will grow. Thus they are very partial to the inside white rind of oranges, and will carry off the flowers of certain shrubs while leaving the leaves untouched. But, to quote again from Bates,—

They are very particular about the ventilation of their underground chambers, and have numerous holes leading up to the surface from them. These they open out or close up, apparently to keep up a regular degree of temperature below. The great care they take that the pieces of leaves they carry into the nest should be neither too dry nor too damp, is also consistent with the idea that the object is the growth of a fungus that requires particular conditions of temperature and moisture to ensure its vigorous growth. If a sudden shower should come on, the ants do not carry the wet pieces into the burrows, but throw them down near the entrances. Should the weather clear up again, these pieces are picked up when nearly dried and taken inside: should the rain, however, continue, they get sodden down into the ground, and are left there. On the contrary, in dry and hot weather, when the leaves would get dried up before they could be conveyed to the nest, the ants, when in exposed situations, do not go out at all during the hot hours, but bring in their leafy burdens in the cool of the day and during the night. As soon as the pieces of leaves are carried in they must be cut up by the small class of workers into little pieces. Some of the ants make mistakes, and carry in unsuitable leaves Thus grass is always rejected by them, but I have seen some ants, perhaps young ones, carrying leaves of grass; but after and to clamber o while these pieces are always brought out again and thrown uddle. I now away. I can imagine a young ant getting a severe ear-wigging ts with their b from one of the major-domos for its stupidity.

When a nest is disturbed and the masses of ant-food spread

about, the ants under shelter a I found the nex its, that the a food. When also carry with ions.

In Büchne lished an inter which was con orf of Wieder Dr. America. t would be qui hort grass with ite off the grass nches, and thro which is finally assing to and f f the road is 1 hillions thickly heir green banı iant green snak his picture is all re swaying back

This observe dvance of a co sult which he

I wished to s their way. \mathbf{I} arrow road, so t ad on their hea ameter, oblique ghtly on the gre he first comers uld, and then eight on their e other side car er the bough t

about, the ants are in great concern to carry every morsel of it labour under shelter again; and sometimes, when I had dug into a nest, found the next day all the earth thrown out filled with little s when pits, that the ants had dug into it to get out the covered-up rvice to ood. When they migrate from one part to another, they nts and also carry with them all the ant-food from their old habitaa nidus nich the ions. In Büchner's 'Geistesleben der Thiere' there is pubects the given to

ished an interesting description of the habits of these ants, which was communicated to the author by Dr. Fr. Ellenorf of Wiedenbrück, who has lived many years in Central America. Dr. Ellendorf says that-

t would be quite impossible for them to creep even through hort grass with loads on their heads for miles. They therefore bite off the grass close to the ground for a breadth of about five nches, and throw it on one side. Thus a road is constructed, which is finally made quite smooth and even by the continual assing to and fro of millions upon millions night and day. . . If the road is looked down upon from a height with these hillions thickly pressed together, and all moving along with heir green bannerets over their heads, it looks as though a iant green snake were gliding slowly along the ground; and his picture is all the more striking in that all these bannerets re swaying backwards and forwards.1

This observer made the experiment of interrupting the dvance of a column of these ants, with the interesting esult which he describes:—

I wished to see how they would manage if I put an obstacle their way. Thick high grass stood on either side of their arrow road, so that they could not pass through it with the ad on their heads. I placed a dry branch, nearly a foot in ameter, obliquely across their path, and pressed it down so ghtly on the ground that they could not creep underneath. The first comers crawled beneath the branch as far as they ied in they hald, and then tried to climb over, but failed owing to the ittle pieces eight on their heads. Meanwhile the unloaded ants from able leaves the other side came on, and when these succeeded in climbing seen some ver the bough there was such a crush that the unladen ants but after and to clamber over the laden, and the result was a terrible nd thrown uddle. I now walked along the train, and found that all the ear-wigging ts with their bannerets on their heads were standing still,

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¹ Loc. cit. p. 97.

thickly pressed together, awaiting the word of command from the front. When I turned back to the obstacle, I saw with astonishment that the loads had been laid aside by more than a foot's length of the column, one imitating the other. And now work began on both sides of the branch, and in about had an hour a tunnel was made beneath it. Each ant then took we its burden again, and the march was resumed in the most perfect order.

A migration of these ants is thus described by the same observer:—

The road led towards a cocoa plantation, and here I so discovered the building which I afterwards visited daily. As again went thither one day I was met, at a considerable di tance from the nest, by a closely pressed column coming then and all the ants laden with leaves, beetles, pupæ, butterfin &c.; the nearer I came to the nest, the greater was the activity. It was soon plain to me that the ants were in the act of leaving their dwelling, and I walked along the tri to discover the new abode. They had gone for some distant along the old road, and had then made a new one through the grass to a cooler place, lying rather higher. The grass on the new road was all bitten off close to the ground, and thousan were busy carrying the path on to the new building. new home itself was an unusual stir of life. There were sorts of labourers-architects, builders, carpenters, sapper A number were busy digging a hole in the groun and they carried out little pellets of earth and laid the together on end to make a wall. Others drew along little twi straws, and grass-stalks, and put them near the place of built ing. I was anxious to know why they had quitted their home, and when the departure was complete, I dug it up wi a spade. At a depth of about a foot and a half I found seve tunnels of a large marmot species, the terror of cocoa planter because in making their passages they gnaw off the thick roots of the cocoa plants. The interior of the ant-hill had parently fallen in through these mines. Unfortunately I unable to follow further the progress of the new building, for was obliged to leave the next day for San Juan del Sur. Wh I returned at the end of a week the building was finished, the whole colony was again busy with the leaves of the con plants.

Harvesting Ants (Atta).—The ants which, so far as

bresent know habits to be d most part to c number of spe our quarters ave been de These consist luring summe onsumption. hese insects to outh of Europ tudied them in ho made some so occur scatte alestine, wher her classical v

Mr. Moggrid server, found abits of the Erious direction ay be from twe ch consists of af-cutting ant atgoing row a ming row are I eds. The road t-fields, and to come dispersed asses. The foll quote from Mo

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¹ Harvesting And ment, 1874.

² Journal Linn & Agricultural An Trans. Ent. Soc

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nand from present known, practise the peculiar and distinctive saw with habits to be described under this division belong for the ore than most part to one genus, Atta, which, however, comprises a her. An number of species distributed in localised areas over all the about har four quarters of the globe. Hitherto nineteen species en took we have been detected as having the habits in question.

These consist of gathering nutritious seeds of grasses These consist of gathering nutritious seeds of grasses uring summer, and storing them in granaries for winter onsumption. We owe our present knowledge concerning hese insects to Mr. Moggridge, who studied them in the outh of Europe, Dr. Lincecum,² and Mr. MacCook,³ who tudied them in Texas, and Colonel Sykes⁴ and Dr. Jerdon,⁵ ho made some observations upon them in India. They also occur scattered over a great part of Europe and in butterflis alestine, where they were clearly known to Solomon and er was the ther classical writers of antiquity, whose claim to accuwere in the classical writers of antiquity, whose claim to accute observation, although long disputed (owing to the
uthority of Huber), has now been complete. uthority of Huber), has now been amply vindicated.

Mr. Moggridge, who was a careful and industrious berver, found the following points of interest in the ad thousand abits of the European harvesters. From the nest in the rious directions there proceed outgoing trains, which here were a better the ground the ground and the statement of the ground the ground and the statement of the statement o tgoing row are empty-handed, while those in the inming row are laden. But here the burdens are grass eds. The roads terminate in the foraging ground, or t-fields, and the insects composing the columns there come dispersed by hundreds among the seed-yielding asses. The following is their method of collecting seeds;

quote from Moggridge:—

² Journal Linn Soc., vol. vi. p. 29, 1862.

¹ Harvesting Ants and Trap-door Spiders, London, 1873 and Supment, 1874.

³ Agricultural Ant of Texas, Philadelphia, 1880

⁴ Trans. Ent. Soc. Lond., i. 103, 1836.

⁵ Madras Journ. Lit. Sc. 1851.

For this see Moggridge, loc. cit. pp. 6-10, where, besides Prov. iv. B, and xxx. 25, quotations are given from Horace, Virgil, Plautus, I others.

It is not a little surprising to see that the ants bring in m only seeds of large size and fallen grain, but also green capsula the torn stalks of which show that they have been fresh gathered from the plant. The manner in which they accomplish this feat is as follows. An ant ascends the stem of a fruiting plant of shepherd's-purse (Capsella bursa-pastoris), let us 81 and selects a well-filled but green pod about midway up stem, those below being ready to shed their seeds at a tour Then, seizing it in its jaws, and fixing its hind legs firmly as pivot, it contrives to turn round and round, and so strain fibres of the fruit-stalk that at length they snap. It then scends to the stem, patiently backing and turning upwar again as often as the clumsy and disproportionate burd becomes wedged between the thickly set stalks, and joins line of its companions on their way to the nest. In this manu capsules of chickweed (Stellaria media) and entire calyces, or taining the nutlets of calamint, are gathered; two ants sometimes combine their efforts, when one stations itself m the base of the peduncle and gnaws it at the point of great tension, while the other hauls upon and twists it. I ha never seen a capsule severed from its stalk by cutting alor and the mandibles of this ant are perhaps incompetent to form such a task. I have occasionally seen ants engaged cutting the capsules of certain plants, drop them, and allow companions below to carry them away; and this correspon with the curious account given by Ælian of the manner which the spikelets of corn are severed and thrown down the people below,' τῷ δήμῳ τῷ κάτω.

The recognition of the principle of the division labour which the latter observation supplies, is furth proved by the following quotation from the same auth A dead grasshopper which was being carried into the nest was—

Too large to pass through the door, so they tried to dismemit. Failing in this, several ants drew the wings and legs as back as possible, while others gnawed through the must where the strain was greatest. They succeeded at last in pulling it in.

The same thing is strikingly shown by the follow quotation from Lespès:—

If the road from the place where they are gathering

rvest to the n eir provisions ces, and let of m depôt to de

Büchner (le erences to th

The subterrant ver. The Rev Sa-ubas have ar Parahyba, adon, in order k. Bates tells a, the ants bor water escaped Para Botanica everything he conferent and their galleries Bates when he than seventy nean passages of

The recognition of the recogniti

Instead of de down on the to obttom, where a arried them to this hurrying ou ope, and rushing he same thing the leaf-cutting

tly throwing do the carriers g various speciallowing state are thus record

Herr Gredler's omed for some r rvest to the nest is very long, they make regular depôts for pir provisions under large leaves, stones, or other suitable ces, and let certain workers have the duty of carrying them m depôt to depôt.

Büchner (loc. cit. p. 101) also makes the following erences to the statements of previous observers:—

The subterranean workers of this remarkable genus are very ver. The Rev. H. Clark reports from Rio de Janeiro, that Sa-ubas have made a regular tunnel under the bed of the er Parahyba, which is there as broad as the Thames at don, in order to reach a storehouse which is on the opposite k. Bates tells us that close to the Magoary rice-mills, near a, the ants bored through the dam of a large reservoir, and water escaped before the mischief could be remedied. In Para Botanical Gardens an enterprising French gardener everything he could to drive the Sa-ubas away. He lit fires he chief entrances of their nests, and blew sulphur vapour their galleries by means of bellows. But how astonished Bates when he saw the vapour come out at no less a dise than seventy yards! Such an extension have the subnean passages of the Sa-ubus.

The recognition of the principle of the division of ur, which is shown by the above observations, is further borated by the following quotation from Belt:—

Between the old burrows and the new one was a steep Instead of descending this with their burdens, they cast down on the top of the slope, whence they rolled down to ottom, where another relay of labourers picked them up arried them to the new burrow. It was amusing to watch nts hurrying out with bundles of food, dropping them over ope, and rushing back immediately for more.

he same thing has been observed, as already stated, he leaf-cutting ants—those engaged in cutting fretly throwing down the fragments of leaf which they at last in the carriers below. The prevalence of this habit g various species of ants therefore renders credible ollowing statements of Vincent Gredler of Botzen, are thus recorded in 'der Zool. Gart.,' xv. p. 434:—

> Herr Gredler's monastery one of the monks had been omed for some months to put food regularly on his window-

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sill for ants coming up from the garden. In consequence Herr Gredler's communications he took it into his head to the bait for the ants, pounded sugar, into an old inkstand, hung this up by a string to the cross-piece of his window, left it hanging freely. A few ants were in with the These soon found their road out over the string with their grant of sugar, and so their way back to their friends. Before long procession was arranged on the new road from the window along the string to the spot where the sugar was, and so this went on for two days, nothing fresh occurring. But one the procession stopped at the old feeding-place on the wind sill, and took the food thence, without going up to the pend sugar-jar. Closer observation revealed that about a doze the rogues were in the jar above, and were busily and unwa ingly carrying the grains of sugar to the edge of the pot, throwing them over to their comrades down below.

Many other instances of the division of labour me be given besides these, and those to be mentioned be after in other connections throughout the course of present chapter; but enough has been said to show the principle is unquestionably acted upon by superies of ants.

That ants are liable to make mistakes, and, whent do, that they profit by experience, is shown by the foll ing experiment made by Moggridge; and many other stances might be given were it desirable:—

It sometimes happens that an ant has manifestly made selection, and is told on its return that what it has bro home with much pains is no better than rubbish, and is he out of the nest, and forced to throw its burden away. In to try whether these creatures were not fallible like mortals, I one day took out with me a little packet of green white porcelain beads, and scattered these in the path of vesting train. They had scarcely lain a minute on the before one of the largest workers seized upon a bead, and some difficulty clipped it with its mandibles and trotted by a great pace to the nest. I waited for a little while, my tion being divided between the other ants who were vain deavouring to remove the beads, and the entrance down the worker had disappeared, and then left the spot. return in an hour's time, I found the ants passing unconcer by and over the beads which lay where I had strewed the

parently undiat they had for their accusto

When the ored in regulated of its 'h rried on belov e surface, when e wind.

It is a rema

y the seed, w t far enough es not germin e nests and a amined, he on rmination. M m November tober, March, covered, thoug germination. which the ant ir sprouting. mth or the in seeds, for we often at but a ground; and ds is not impai ng plants from He also says,--By a fortunate s will germinate prevented from only that the st bt sufficient of its

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I discovered in a discovered in which they

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oparently undiminished quantities; and I conclude from this lat they had found out their mistake, and had wisely returned their accustomed occupations.

When the grain is thus taken into the nest, it is

When the grain is thus taken into the nest, it is ored in regular granaries, but not until it has been deded of its 'husks' or 'chaff.' The denuding process is rried on below ground, and the chaff is brought up to e surface, where it is laid in heaps to be blown away by e wind.

It is a remarkable thing, and one not yet understood, by the seed, when thus stored in subterranean chambers t far enough below the surface to favour germination, es not germinate. Moggridge says that out of twentye nests and among many thousands of seeds that he amined, he only found twenty-seven cases of incipient rmination. Moreover, all these cases occurred in months m November to February, while in the nests opened in tober, March, April, and May, no sprouted seeds were covered, though these are the months highly favourable germination. He is at a loss to suggest the treatment which the ants expose the seeds in order to prevent 'Apparently it is not that moisture or ir sprouting. mth or the influence of atmospheric air is denied to seeds, for we find them in damp soil in genial weather, l often at but a trifling distance below the surface of ground;' and he has proved that the vitality of the ds is not impaired, for he succeeded in raising crops of ng plants from seeds removed from the granaries. He also says,—

By a fortunate chance I have been able to prove that the swill germinate in an undisturbed granary when the ants prevented from obtaining access to it: and this goes to show only that the structure and nature of the granary chamber of sufficient of itself to prevent germination, but also that the ence of the ants is essential to secure the dormant condition he seeds.

I discovered in two places portions of distinct nests of Atta ctor which had been isolated owing to the destruction of the pw wall behind which they lay, and then the granaries well up and literally choked with growing seeds, though the hin which they lay completely enclosed and concealed them

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until by chance I laid them bare. In one case I knew that destruction of the wall had only taken place ten days before,

that the seeds had sprouted in the interval.

My experiments also tend to confirm this, and to favoure belief that the non-germination of the seeds is due to so direct influence voluntarily exercised by the ants, and merely to the conditions found in the nest, or to acid vapowhich in certain cases are given off by the ants themselves.

These experiments consisted in confining a land number of harvesting ants with their queen and larvate a glass test-tube partly filled with damp soil and variateds, the whole being closed with a cork in the most of the test-tube. Under these circumstances the set all sprouted, showing that mere confinement in an atmosphere of exhalations from the ants did not prevent gen nation. Another series of experiments, undertaken att suggestion of Mr. Darwin, on the effects of an atmosphere of formic acid, showed that although this vapour was a injurious to the seeds, it did not prevent their incipal germination. Therefore it yet remains to be ascertain why the seeds do not germinate in the granaries of tants.

But in whatever way the ants manage to prevent g mination, it is certain that they are aware of t importance in this connection of keeping the seeds dry as possible; for Moggridge repeatedly observed t when the seeds which had been stored proved over-mother the ants again took them out and spread them in the to dry, to be again brought into the nest after a sufficient exposure.

Lastly, he also repeatedly observed the most surprisand interesting fact that when, as we have seen was a sionally the case, the seeds did begin to germinate interests, the ants knew the most effective method of preventing the germination from proceeding; for he for that in these cases the ants gnawed off the tips of tradicles. This fact deserves to be considered as one the most remarkable among the many remarkable facts ant-psychology.

Passing on now to the harvesting or agricultural

f Texas, atter nsect by Mr. ho sent an y whom they 1861. Fiv roceedings of hiladelphia fi 877 Mr. Mac(bits of these sults of his ges.² These atory of thos asons to be d be accepted a ses they are epitome of t The ants cle e form of a ameter, by car at may be gro ickly grown lo ks is highly co miniature the nerican backy ared of herba s of the surf l into the ho iformly flat su tion of multi come hard and eway of the a hollow cone From the dis ds or avenues k itself, and grass, branch ntually taper

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f Texas, attention was first called to the habits of this asect by Mr. Buckley in 1860, and by Dr. Lincecum, ho sent an account of his observations to Mr. Darwin. whom they were communicated to the Linnæan Society 1861. Five years later a paper was published in the roceedings of the Academy of Natural Sciences of hiladelphia from the MS. of Dr. Lincecum. Lastly, in 877 Mr. MacCook went to Texas expressly to study the bits of these insects, and he has recently embodied the sults of his observations in a book of three hundred ges.² These observations are for the most part confiratory of those of Lincecum, and for this as well as for asons to be deduced from the work itself, they deserve be accepted as trustworthy, notwithstanding that in some ses they are provokingly incomplete. The following is epitome of these observations.

The ants clear away all the herbage above their nest in e form of a perfect circle, or 'disk,' 15 or 20 feet in ameter, by carefully felling every stalk of grass or weed at may be growing thereon. As the nests are placed in ickly grown localities, the effect of these bald or shaven ks is highly conspicuous and peculiar, exactly resembling miniature the clearings which the settlers make in the nerican backwoods. The disk, however, is not merely ared of herbage, but also carefully levelled, all inequalis of the surface being reduced by building pellets of l into the hollows to an extent sufficient to make a iformly flat surface. The action of rain and the constant tion of multitudes of ants cause this flat surface to come hard and smooth. In the centre of the disk is the leway of the nest. This may be either a simple hole a hollow cone.

From the disk in various directions there radiate antds or avenues, which are cleared and smoothed like the k itself, and which course through the thick surroundgrass, branching and narrowing as they go till they attually taper away. These roads are usually three or r in number before they begin to branch, but may be

Proc. Phil. Acad. Nat. Sci., xii. p. 445.

Agricultural Ant of Texas (Lippincott & Co., Philadelphia, 1880).

as many as seven. They are usually two to three inches porter dodges wide at their origin, but in large nests may be as much a MacCook found no road longer than sixty feet, but Lincecum describes one of three hundred feet. these hard and level roads there is always passing, during the daytime of the harvesting season, a constant stream of ants-those going from the nest being empty-handed and those returning to it being laden with seeds. course the incoming ants, converging from all quarter upon the road, and therefore increasing in numbers as the approach the nest, require greater space for free locomo tion; while the outgoing ants, diverging as they get further from home, also require greater proportional space the less their distance from the nest: hence the gradul swelling in the width of the roads as they approach the nests.

The manner of collecting the seeds in the jungle su rounding the roads is thus described by MacCook:—

At last a satisfactory seed is found. It is simply lifted from the ground, or, as often happens, has to be pulled out of the soil into which it has been tightly pressed by the rain or passing feet. Now follows a movement which at first thought to be a testing of the seed, and which, indeed, may partially that; but finally I concluded that it was the adjusting of the burden for safe and convenient carriage. The ant pul at the seed-husk with its mandibles, turning and pinching 'feeling' it on all sides. If this does not satisfy, and common it does not, the body is raised by stiffening out the legs, t abdomen is curved underneath, and the apex applied to the see I suppose this to be simply a mechanical action for the better adjusting of the load. Now the worker starts homeward. has not lost itself in the mazes of the grass forest. directly towards the road with an unerring judgment. are many obstacles to overcome. Pebbles, pellets of earth, of wood, obtruding rootlets, or bent-down spears of grass blood up or hinder the way. These were scarcely noticed when ant was empty-handed. But they are troublesome barriers a that she is burdened with a seed quite as thick, twice as wi and half as long as herself. It is most interesting to see skill, strength, and rapidity with which the little harve swings her treasure over or around, or pushes it beneath the obstacles. Now the seed has caught against the herbage as

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ree inches porter dodges under a too narrow opening. She backs out and as much a tries another passage. Now the sharp points of the husk are entangled in the grass. She jerks or pulls the burden loose, and et. Along hurries on. The road is reached, and progress is comparatively ng, during easy. Holding the grain in her mandibles well above the surface, she breaks into what I may describe with suffiant stream cient accuracy as 'a trot,' and with little further interruption ty-handed reaches the disk and disappears within the gate. There are variations from this behaviour, more or less marked, according Il quarter to the nature of the grounds, the seeds, and (I suppose) the indipers as the viduality of the harvesters; but the mode of ingathering the ree locomo rop is substantially as above. Each ant operated independently. Once only did I see anything like an effort to extend sympathy and aid. A worker minor seeming to have difficulty in testing br adjusting a large seed of buffalo-grass, was assisted (apbarently) by one worker major, and then by another, after which she went on her way.

But these ants do not confine their harvesting operaions to gathering fallen seeds; they will, like the ants of Europe, also cut seeds from the stalk.

In order to test the disposition of *crudelis* to garner the eeds from the stem, bunches of millet were obtained from the North, and stalks eighteen inches high, crowned by the boll of lose-set seeds, were stuck in the mound of an active formicary. The ants mounted the stems and set to work vigorously to ecure the seeds, clusters of twenty or more being engaged at nce upon one head. The seeds were carried off and stored within the nest. This experiment proved pretty conclusively hat in the seeding season crudelis does not wait for the seeds o drop, but harvests them from the plant.

The 'granaries' into which the seeds are brought are ept distinct from the 'nurseries' for the pupæ. alls, floor, and roof are so hard and smooth, that MacCook hinks the insects must practise upon them 'some rude nason's craft.'

He traced these granaries to a depth of four feet elow the surface of the ground, and believes, from the tatements of a native peasant, that they, or at least the ting to see prmicaries, extend to a depth of fifteen feet.

As regards the care that the ants take of the gathered rain, Lincecum describes the same habit as Moggridge herbage as and Sykes describe—viz., the sunning of wet seeds to

dry. MacCook, however, neglected to make any experiments on this subject. Neither has he been able to throw any light upon the question as to why the stored seeds do not germinate, and is doubtful whether the habit of gnawing the radicle of sprouting seeds, which prevails in the European species, is likewise practised by the American. On two other points of importance MacCook's observations are also incomplete. One of these has reference to an alleged statement, which he is disposed to believe, that when some ants in a community have been killed by poison, the survivors avoid the poison: he, however, made no experiments to test this statement.

The other main point on which his observations are defective has reference to a remarkable statement made by Lincecum in the most emphatic terms. ment is that upon the surface of their disk the antisow the seeds of a certain plant, called ant-rice, for the purpose of subsequently reaping a harvest of the grain There is no doubt that the ant-disks do very often support this peculiar kind of grass, and that the ants an particularly fond of its seed; but whether the plant actually sown in these situations by the insects, or grown there on account of these situations being more oper than the general surface of the ground—this question MacCook has failed to answer, or even to further. We are therefore, still left with Dr. Lincecum's emphatic assurance that he has witnessed the fact. His account is the the seed of the ant-rice, which is a biennial plant, is som in time for the autumnal rains to bring up. At the be ginning of November a green row or ring of ant-ria about four inches wide, is seen springing up round the cumference of the disk. In the vicinity of this circular ring the ants do not permit a single spire of any other grass or weed to remain a day, but leave the aristida, ant-rice, untouched until it ripens, which occurs in Junea the next year. After the maturing and harvesting of the seed, the dry stubble is cut away and removed from the pavement or disk, which is thus left unencumbered until the ensuing autumn, when the same species of grass again appears as before, and so on. Lincecum says he has see

the process and adds,—

There can of grain-beari In farmer-like fully divested growing. We stubble cut avenumbered ureappears with cultural attents on year after when the antianimals.

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the process go on year after year on the same ant-farms, and adds,—

There can be no doubt of the fact that the particular species of grain-bearing grass mentioned above is intentionally planted. In farmer-like manner the ground upon which it stands is carefully divested of all other grasses and weeds during the time it is growing. When it is ripe the grain is taken care of, the dry stubble cut away and carried off, the paved area being left unencumbered until the ensuing autumn, when the same 'ant-rice' reappears within the same circle, and receives the same agricultural attention as was bestowed upon the previous crop—and so on year after year, as I know to be the case, in all situations when the ant's settlements are protected from graminivorous animals.

In a second letter Dr. Lincecum, in reply to an inquiry from Mr. Darwin whether he supposed that the ants plant seeds for the ensuing crop, says:—

I have not the slightest doubt of it. And my conclusions have not been arrived at from hasty or careless observation, nor from seeing the ants do something that looked a little like it, and then guessing at the results. I have at all seasons watched the same ant-cities during the last twelve years, and I know that what I stated in my former letter is true. I visited the same cities yesterday, and found the crop of ant-rice growing inely, and exhibiting also the signs of high cultivation, and not blade of any other kind of grass or weed was to be seen within twelve inches of the circular row of ant-rice.—(Journ. Linn. Soc., vol. vi. p. 30-1.)

Now, MacCook found the ant-rice growing as described, but only on some nests. Why it does not grow upon all he nests he does not understand. So far, then, as his beervations go, they confirm those of Dr. Lincecum; but he does 'not believe that the ants deliberately sow a crop is Lincecum asserts;' he thinks 'that they have for some eason found it to their advantage to permit the aristida o grow upon their disks, while they clear off all other herbage;' but finally concludes 'that there is nothing increasonable, nor beyond the probable capacity of the mmet intellect, in the supposition that the crop is actually own. Simply, it is the Scotch verdict—"Not proven."

The following facts with regard to 'modes of mining' are worth quoting from MacCook:—

In sinking the galleries the difficulty of carrying is not great in a moist or tough soil, which permits the ant to obtain goodly-sized pellets for portage. But when the soil is light and dry, so that it crumbles into dust as it is bitten off, the difficulty is greatly increased. It would be a very tedious task indeed to take out the diggings grain by grain. This difficulty the worker overcomes by balling the small particles against the surface of the gallery, the under side of the head, or within and against the mandibles. The fore-feet are used for this purpose. being pressed against the side face, turned under, and pushed upward with a motion similar to that of a man putting his hand upon his mouth. The abdomen is then swung underneath the body and the apex pressed against the little heap of grains of dirt massed against the under side of the mandibles, or be tween that and the smooth under surface of the head. Thus the dust is compressed into a ball which is of sufficient size to justify deportation.

The same operation is observed in the side-galleries, when the ants work very frequently upon their sides or backs, precisely as I have seen colliers do in Pennsylvania coal-mines.

The following is likewise worth quoting from the same author:—

Seeds are evidently not the only food of our agriculturals When the ants at disk No. 2 had broken through the slight mud-sediment that sealed up their gate, as described above they exhibited a peculiar behaviour. Instead of heading for the roads and pressing along them, they distributed themselve at once over the entire disk, radiating from the gate to a points in the circumference, from which they penetrated the jungle of grass beyond. In a moment a large number wer returning across the roads, out of the grass, over the pavement toward the entrance. They bore in their mandibles object which I presently found to be the males and females of white ants (Termes flavipes), which were filling the air, during an after the rain, in marriage flight. They had probably swarms just before the shower. The agriculturals were under green excitement, and hurried forth and back at the top of the speed. The number of ants bearing termites was soon so great that the vestibule became choked, and a mass of struggling anthood was piled up around the gate. A stream of eag insects continually poured out of the door, pushing their w

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through the crowd that vainly but persistently endeavoured to get in with their burdens. The outcoming ants had the advantage, and succeeded in jostling through the quivering rosette of antennæ, legs, heads, and abdomens. Occasionally a worker gained an entrance by dint of sheer physical force and perseverance. Again and again would the crowd rush from all sides upon the gate, only to be pushed back by the issuing throng. In the meanwhile quite a heap of termites, a good handful at least, had been accumulated at one side of the gate, the ants having evidently dropped them, in despair of entrance, and hurried off to garner more.

In due time the pressure upon the vestibule diminished, the laden workers entered more freely, and in the end this heap was transferred to the interior. The rapidity with which the ants were distributed to all parts of their roads, after the first opening of the gates, was truly surprising. I was greatly puzzled, at the first, to know what the cause of such a rush might be. The whole behaviour was such as to carry the conviction that they knew accurately what effect the rain would have, had calculated upon it, and were acting in accordance with previous experience. I had no doubt at the time, and have none now, that the capturing of insects beaten down by the rain is one of the well-established customs of these ants. I saw a few other insects taken in, and one milliped, but chiefly the white ants.

That very afternoon I found in a formicary which I then opened several large colonies, or parts of one colony of termites, nested within the limits of the disk and quite at home. The next day numbers of the winged white ants were found stored within the granaries of a large formicary. There is no reason to doubt that these insects were intended for food, in accordance with the quite universal habit of the *Formicariæ*.

A curious habit has been noticed by most observers to occur in many species of ant, and it is one on which Mr. MacCook has a good deal to say. The habit in question consists in the ants transporting one another from place to place. The carrying ant seizes her comrade by the middle, and hurries along with it held aloft—the ant which is carried remaining quite motionless with all her legs drawn together. Huber supposed the process to be one enjoyable to both the insects concerned, and to be performed by mutual understanding and consent; but MacCook, in common with most other observers, supposes that it is

merely a rough and primitive way of communicating t_0 fellow-workers the locality where their services are required. He says:—

Keeping these facts in mind, we have a key to the solution of the press-gang operations which Lincecum observed among the agriculturals, and which have been fully described in other species. In the absence of any common head or directory, and of all executive officers, a change of location or any other concerted movement must be carried forward by the willing cooperation of individuals. At first sight, the act of seizing and carrying off workers does not appear like an appeal to free-will. It is indeed coercive, so far as the first act goes. But, in point of fact, the coercion ceases the moment the captive is set down within the precincts of the new movement. The carrier-ant has depended upon securing her consent and co-operation by thus bringing her within the circle of activity for which her service is sought. As a rule, no doubt, the deported ant at once yields to the influence around her, and drops into the current of fresh enterprise, in which she moves with as entire freedom and as independently as any other worker. But she is apparently under no restraint, and if she so please, may return to her former haunts.

Certain Ants of Africa.—Livingstone says of certain ants of Africa:—

They have established themselves on the plain where water stands so long annually as to allow the lotus and other aqueous plants to come to maturity. When all the ant-horizon is submerged a foot deep, they manage to exist by ascending to little houses built of black tenaceous loam on stalks of grass, and placed higher than the line of inundation. This must have been the result of experience, for, if they had waited till the water actually invaded their terrestrial habitations, they would not have been able to procure materials for their aërial quarters unless they dived down to the bottom for every mouthful of clay.¹

The Tree Ant of India and New South Wales.—These ants are remarkable from their habit of forming nests only in trees. According to Col. Sykes' account, the shape of the nest is more or less globular, and about ten inches in diameter. It is formed entirely of cow-dung, which the

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nsects collect from the ground beneath, and work into he form of thin scales. These are then built together in n imbricated manner, like tiles or slates upon the roof of a house, the upper or outer scale, however, being one unproken sheet, which covers the whole nest like a skull-cap. Below this the scales are placed one upon another in a ravy or scalloped manner, so that numerous little arched intrances are left, and yet, owing to the imbricated nanner in which the scales are arranged, the interior of he nest is perfectly protected from rain. This interior onsists of a number of irregular cells, the walls of which reformed by the same process as the exterior.

In New South Wales there is another species of ant hich also frequents trees, but builds within the stem and ranches. In the report of Captain Cook's expedition its abits are thus described:—'Their habitations are the sides of the branches of a tree, which they contrive to cavate, by working out the pith almost to the extremity the slenderest twig; the tree at the same time flourishing as if it had no such inmate.' On breaking one of the anches the ants swarm out in legions. Some of our ative species also have the habit of excavating the inrior of trees, though not on so extensive a scale.

Honey-making Ant (Myrmecocystus mexicanus).—
his ant is found in Texas and New Mexico. Capt. W.
Fleeson has observed its habits, and his observations
we been communicated to the Californian Academy of
hiences, and also, by Mr. Henry Edwards, to Mr. Darwin.
he following are the chief points of interest in Capt.
heeson's results:—

The community appears to consist of three distinct kinds of ts, probably of two separate genera, whose offices in the neral order of the nest would seem to be entirely apart from the other, and who perform the labour allotted to them with the least encroachment upon the duties of their fellows. less three kinds are—

I. Yellow workers; nurses and feeders of II.

II. Yellow honey-makers; sole function to secrete a kind of honey in their large globose abdomens, on which the other ants are supposed to feed. They never quit the nest, and are fed and tended by I.

III. Black workers, guards, and purveyors; surround the nest as guards or sentinels, in a manner present to be described, and also forage for the food require for I. They are much larger and stronger insection than either I. or II., and are provided with vertical formidable mandibles.

The nest is placed in sandy soil in the neighbourhout of shrubs and flowers, is a perfect square, and occupi about four or five square feet of ground, the surface which is kept almost unbroken. But the boundaries the nest are rendered conspicuous by the guard of bla workers (III.), which continuously parade round three its sides in a close double line of defence, moving opposite directions. In the accompanying diagram the sentry path is represented by the thick black lines. The always face the same points of the compass, and direction in which the sentries march is one column for south-west to south-east, and the other column from south east to south-west-each column, however, moving regular order round three sides of a square. The south side of the encampment is left unguarded; but if enemy approaches on this or any other side, a number the guards leave their stations, and sally forth to face foe-raising themselves on their hind tarsi on meetingt enemy, and moving their large mandibles in defian Spiders, wasps, beetles, and other insects, if they vent too near the nest, are torn to pieces by the guard in most merciless manner, and the dead body of the quished is speedily removed from the neighbourhood of nest—the guard then marching back to resume the places in the line of defence, their object in destroi other insects being the defence of their encampment, not the obtaining of food.

The object of leaving the southern side of the squencampment open is as follows. While some of the blue workers are engaged on duty as guard, another and lar division are engaged on duty as purveyors. These and leave the quadrangle by its open or southerns along the dotted line marked a to the central point The incoming line is composed of individuals each bear

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burden of fragments of flowers or aromatic leaves. These are all deposited in the centre of the quadrangle. Along the other diagonal e there is a no less incessantly noving double line of yellow workers (I.), whose office it to convey the supplies deposited by the black workers t c to b, which is the gateway of the fortress. It is reparkable that no black ant is ever seen upon the line e,

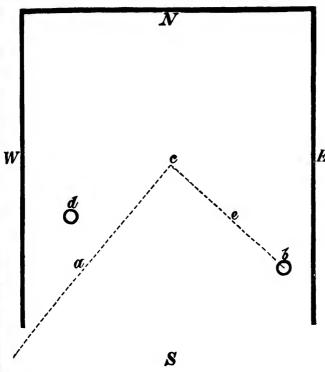


Fig. 7.

I no yellow one upon the line a; each keeps his own arate station, and follows his own particular duty with teadfastness and apparent adherence to discipline that most astonishing. The hole at d seems to be a venting shaft; it is never used as a gateway.

Section of the nest reveals, besides galleries, a small mber about three feet below the surface, across which pread, like a spider's web, a network of squares spun the insects, the squares being about \(\frac{1}{4}\) inch across, and

walls of the chamber. In each one of the squares, supported by the web, sits one of the honey-making ants (II.) Here these honey makers live in perpetual confinement and receive a constant supply of flowers, pollen, &c., which is continually being brought them by (I.), and which, by a process analogous to that performed by the bee, the

convert into honey.

Such is an epitome of the only account that the work has yet received of the habits and economy of this wonderful insect, whose instincts of military organization seer to be not less wonderful than those of the Ecitons, though in this case they are developed with reference to defend and not to aggression. It is especially noteworthy that the black and yellow workers are believed to belong the two separate genera; for if this is the case, it is the only one I can recall of two distinct species co-morating for common end; for even the nearest parallel which we find supplied in other species of ants maintaining aphides, not quite the same thing, seeing that the aphides a merely passive agents, like Class II., of the honey-making ant, and not actively co-operating members of the community, like Class I.

Ecitons.—We have next to consider the habits of a wonderful 'foraging,' or, as it might be more appropriate called, the military and of the Amazon. These insets which belong to several species of the same genus, as been carefully watched by Belt, Bates, and other naturalists. The following facts must therefore be accepted

fully established.

Eciton legionis moves in enormous armies, and ever thing that these insects do is done with the most perfinstinct of military organization. The army marches the form of a rather broad and regular column, hundred of yards in length. The object of the march is the capt and plunder of other insects, &c., for food, and as well-organised host advances, its devastating legions all other terrestrial life at defiance. From the maccolumn there are sent out smaller lateral columns, composing individuals of which play the part of sent

anching off th the utmo , under ever here there is and is com the prey fou ves to man ck to the ma the scouts to the main co ched a detac rements. In gle ants to veyed back t ny insects in ere they are twig by their ne terminal r mediate captu murderous h ils that are ta t out in answ nediately take ve there, the smaller colu ning, one on plies that are h of these out posing one of ction as the n er line all ru her are empty r burdens in for fresh burd all laden with ther ants, &c. e are also con duals of small , which seem er leave their

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anching off in various directions, and searching about th the utmost activity for insects, grubs, &c., over every g, under every fallen leaf, and in every nook and cranny here there is any chance of finding prey. When their and is completed, they return into the main column. the prey found is sufficiently small for the scouts themves to manage, it is immediately seized, and carried ck to the main column; but if the amount is too large the scouts to deal with alone, messengers are sent back the main column, whence there is immediately disched a detachment large enough to cope with the reirements. Insects which when killed are too large for gle ants to carry, are torn in pieces, and the pieces iveyed back to the main army by different individuals. my insects in trying to escape run up bushes and shrubs, ere they are pursued from branch to branch and twig twig by their remorseless enemies, until on arriving at he terminal ramification they must either submit to mediate capture by their pursuers, or drop down amid murderous hosts beneath. As already stated, all the ils that are taken by the scouts or by the detachments tout in answer to their demands for assistance, are nediately taken back to the main column. When they ive there, they are taken to the rear of that column by smaller columns of carriers, which are constantly ning, one on either side of the main column, with the plies that are constantly pouring in from both sides. h of these outside columns is a double line, the ants posing one of the two lines all running in the same ction as the main army, and the ants composing the er line all running in the opposite direction. per are empty-handed carriers, which having deposited r burdens in the rear, are again advancing to the for fresh burdens. Those composing the other line all laden with the mangled remains of insects, pupæ ther ants, &c. On either side of the main column e are also constantly running up and down a few induals of smaller size and lighter colour than the other , which seem to play the part of officers; for they er leave their stations, and while running up and

down the outsides of the column, they every now a again stop to touch antennæ with some member of rank and file, as if to give instructions. When the scool discover a wasp's nest in a tree, a strong force is sent from the main army, the nest is pulled to pieces, and the larvæ carried to the rear of the army, while the was fly around defenceless against the invading multitude Or, if the nest of any other species of ant is found similarly strong force, or perhaps the whole army is flected towards it, and with the utmost energy the im merable insects set to work to sink shafts and dig min till the whole nest is rifled of its contents. mining operations the ants work with an extraordina display of organized co-operation; for those low down the shafts do not lose time by carrying up the earth whi they excavate, but pass on the pellets to those above; the ants on the surface, when they receive the pelle carry them, 'with an appearance of forethought that or staggered' Mr. Bates, only just far enough to ensure they shall not roll back again into the shaft, and, a depositing them, immediately hurry back for m But there is not a rigid division of labour, although work 'seems to be performed by intelligent co-operation amongst a host of eager little creatures;' for some them act 'sometimes as carriers of pellets, and at and as miners, and all shortly afterwards assume the offer conveyors of the spoil.' Again, as showing the insti of co-operation, the following may also be quoted to Bates's account:—

On the following morning no trace of ants could be so near the place where I had seen them the preceding day, were there signs of insects of any description in the thin but at the distance of eighty or one hundred yards, I upon the same army, engaged evidently on a razzia of a sim kind to that of the previous evening; but requiring other sources of their instinct, owing to the nature of the grown They were eagerly occupied on the face of an inclined but light earth in excavating mines, whence, from a depth of or ten inches, they were extracting the bodies of a bulky so of ant of the genus Formica. It was curious to see them on ing round the orifices of the mines, some assisting their

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des to lift out the bodies of the Formicæ, and others tearing em in pieces, on account of their weight being too great for a ngle Eciton; a number of carriers seizing each a fragment, ad carrying it off down the slope.

These Ecitons have no fixed nest themselves, but live, it were, on a perpetual campaign. At night, however, ey call a halt and pitch a camp. For this purpose they sually select a piece of broken ground, in the interstices which they temporarily store their plunder. In the orning the army is again on the march, and before an our or two has passed not a single ant is to be seen here the countless multitudes had previously covered to ground.

Another and larger species of Eciton (E. humata) into sometimes in dense armies, and sometimes in lumns, according to the kind of prey of which they are search. When in columns they are seeking for the sts of a certain species of ant which have their young holes of rotten logs. These Ecitons when seeking for ese nests hunt about, like those just described, in lumns, which branch off in various directions. When a len log is reached, the column spreads over it, searched through all the holes and cracks. Mr. Belt says of em:—

The workers are of various sizes, and the smallest are here use, for they squeeze themselves into the narrowest holes, I search out their prey in the furthest ramifications of the sts. When a nest of the *Hypoclinea* is attacked, the ants shout, carrying the larvæ and pupæ in their jaws, but are mediately despoiled of them by the Ecitons, which are rung about in every direction with great swiftness. Whenever your come across a *Hypoclinea* carrying a larva or pupa, they te it from it so quickly, that I could never ascertain exactly wit was done.

As soon as an Eciton gets hold of its prey, it rushes off back ng the advancing column, which is composed of two sets, hurrying forward, the other returning laden with their ity, but all and always in the greatest haste and apparent rry. About the nest which they are harrying, all appears in fusion, Ecitons running here and there and everywhere in greatest haste and disorder; but the result of all this ap-

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parent confusion is that scarcely a single Hypoclinea gets aw with a pupa or larva. I never saw the Ecitons injure the Hypoclineas themselves, they were always contented with a spoiling them of their young.

The columns of this species 'are composed almost entirely of workers of different sizes;' but, as in the species previously mentioned, 'at intervals of two of three yards there are larger and lighter coloured in viduals that often stop, and sometimes run a little back ward, stopping and touching some of the ants with the antennæ,' and looking 'like officers giving orders and of recting the march of the column.'

Concerning the other habits of this species, the san

author writes:—

The eyes in the Ecitons are very small, in some of species imperfect, and in others entirely absent; in this th differ greatly from the Pseudomyrma ants, which hunt sing and which have the eyes greatly developed. The imperfect of eyesight in the Ecitons is an advantage to the communi and to their particular mode of hunting. It keeps them gether, and prevents individual ants from starting off alm after objects that, if their eyesight was better, they might cover at a distance; the Ecitons and most other ants followed each other by scent, and, I believe, they can communicated presence of danger, of booty, or other intelligence, to a distant by the different intensity or qualities of the odours given off. one day saw a column of Eciton hamata running along the fi of a nearly perpendicular tramway cutting, the side of whi was about six feet high. At one point I noticed a sort assembly of about a dozen individuals that appeared in cons Suddenly one ant left the conclave, and ran with gre speed up the perpendicular face of the cutting without stopping It was followed by others, which, however, did not keep strain on like the first, but ran a short way, then returned, then an followed a little further than the first time. They were dently scenting the trail of the pioneer, and making it manently recognisable. These ants followed the exact taken by the first one, although it was far out of sight. Wh ever it had made a slight détour they did so likewise. I scrap with my knife a small portion of the clay on the trail, and ants were completely at fault for a time which way to Those ascending and those descending stopped at the scrap ortion, and ma gain, when all bwn it with th e cutting, the g. In a very unicated to the arch for their hts in this res ove on from or ounds around ore than four me across the ere and there ards and forwa enormous leng individuals.

ree hundred y They make the metimes under llows. A nest en at one side. ass, like a grea aching to the bked like brov ust have been a indreds of thou re outside, som d dissected bod this living nest the mass, kept terials. Down oty passed witl ecentre of the ts holding larva the crowding k-coloured wor ny still large y go about hol

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ortion, and made short circuits until they hit the scented trail gain, when all their hesitation vanished, and they ran up and own it with the greatest confidence. On gaining the top of he cutting, the ants entered some brushwood suitable for huntosed almost g. In a very short space of time the information was comunicated to the ants below, and a dense column rushed up to arch for their prey. The Ecitons are singular amongst the hts in this respect, that they have no fixed habitations, but ove on from one place to another, as they exhaust the hunting ounds around them. I think Eciton hamata does not stay ore than four or five days in one place. I have sometimes me across the migratory columns; they may easily be known. tere and there one of the light-coloured officers moves backards and forwards directing the columns. Such a column is enormous length, and contains many thousands if not millions individuals. I have sometimes followed them up for two or ree hundred yards without getting to the end.

They make their temporary habitations in hollow trees, and metimes underneath large fallen trucks that offer suitable llows. A nest that I came across in the latter situation was en at one side. The ants were clustered together in a dense ass, like a great swarm of bees, hanging from the roof but sching to the ground below. Their innumerable long legs oked like brown threads binding together the mass, which ust have been at least a cubic yard in bulk, and contained ndreds of thousands of individuals, although many columns ere outside, some bringing in the pupe of ants, others the legs d dissected bodies of various insects. I was surprised to see this living nest tubular passages leading down to the centre the mass, kept open just as if it had been formed of inorganic terials. Down these holes the ants who were bringing in oty passed with their prey. I thrust a long stick down to ecentre of the cluster, and brought out clinging to it many ts holding larvæ and pupæ, which probably were kept warm the crowding together of the ants. Besides the common k-coloured workers and light-coloured officers, I saw here ny still larger individuals with enormous jaws. y go about holding wide open in a threatening manner.

It was this ant which, as previously stated, showed npathy and fellow-feeling with companions in diffilties.

The habits of E. drepanophora are closely similar those of the species already described; and, indeed, except in matters of detail, all the species of Ecitons have much the same habits. Mr. Bates records an interesting observation which he made on one of the moving column of this species. He says: 'When I interfered with the column or abstracted an individual from it, news of the disturbance was quickly communicated to a distance of several yards to the rear, and the column at that point commenced retreating.' The main column is in this species narrower, viz., 'from four to six deep,' but extend to a great length, viz., half a mile or more. It was this species of Eciton that the same naturalist describes as enjoying periods of leisure and recreation in the 'sunn nooks of the forest.'

Next we have to consider E. prædator, of which the same observer writes:—

This is a small dark reddish species, very similar to common red stinging ant of England. It differs from all other Ecitons in its habit of hunting, not in columns, but in dea phalanxes consisting of myriads of individuals, and was first m with at Ega, where it is very common. Nothing in inse movements is more striking than the rapid march of the large and compact bodies. Wherever they pass, all the rest the animal world is thrown into a state of alarm. They street along the ground and climb to the summits of all the low trees, searching every leaf to its apex, and whenever they counter a mass of decaying vegetable matter, where boots plentiful, they concentrate, like other Ecitons, all their for upon it, the dense phalanx of shining and quickly-moving bodies, as it spreads over the surface, looking like a flood dark-red liquid. They soon penetrate every part of the a fused heap, and then, gathering together again in marchi order, onward they move. All soft-bodied and inactive inse fall an easy prey to them, and, like other Ecitons, they to their victims in pieces for facility of carriage. A phalant this species, when passing over a tract of smooth ground, or pies a space of from four to six square yards; on examini the ants closely they are seen to move, not all together in straightforward direction, but in variously spreading contigu columns, now separating a little from the general mass, m reuniting with it. The margins of the phalanx spread out times like a cloud of skirmishers from the flanks of an art I was never able to find the hive of this species.

Lastly, the and their hal we have hith

The armies could learn, w them gradually foragers pushes these covered otting log, or crevices in sear sionally, for a of earth are tal ing, and are fi mentioned fear covered roads to cement the numbers, build arcades, and co them and fit i cemented struc vision of labou blind species. monstrously le hamata and E. from the smallworking comm Whenever I mthe ants under minors remaine heads issued for heads and snap rage and defian

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Lastly, there are two species of Eciton totally blind, and their habits differ from those of the species which we have hitherto considered. Bates writes of them:—

The armies of E. vastator and E. erratica move, as far as I could learn, wholly under covered roads, the ants constructing them gradually but rapidly as they advance. The column of foragers pushes forward step by step, under the protection of these covered passages, through the thickets, and on reaching a rotting log, or other promising hunting-ground, pour into the crevices in search of booty. I have traced their arcades, occasionally, for a distance of one or two hundred yards; the grains of earth are taken from the soil over which the column is passing, and are fitted together without cement. It is this lastmentioned feature that distinguishes them from the similar covered roads made by termites, who use their glutinous saliva to cement the grains together. The blind Ecitons, working in numbers, build up simultaneously the sides of their convex arcades, and contrive, in a surprising manner, to approximate them and fit in the key-stones without letting the loose uncemented structure fall to pieces. There was a very clear division of labour between the two classes of neuters in these blind species. The large-headed class, although not possessing monstrously lengthened jaws like the worker-majors in E. hamata and E. drepanophora, are rigidly defined in structure from the small-headed class, and act as soldiers, defending the working community (like soldier termites) against all comers. Whenever I made a breach in one of their covered ways, all the ants underneath were set in commotion, but the workerminors remained behind to repair the damage, whilst the largeheads issued forth in a most menacing manner, rearing their heads and snapping their jaws with an expression of the fiercest rage and defiance.

Annornia arcens.—This is the so-called 'driver' or marching' ant of West Africa, which in habits and intelligence closely resembles the military ants of the other hemisphere. I shall therefore not wait again to describe these habits in detail. Like the Ecitons, the marching ing contigues ants of Africa have no fixed nest, but make temporary halts ral mass, much in the shade of hollow trees, overhanging rocks, &c. spread out. They march in large armies, and, like the Ecitons, always in the form of a long close column; but in this case the relative position of the carriers of spoil and larvæ is reversed, for while these occupy the middle place the soldiers and officers march on either side. These have large heads armed with powerful jaws, and never take part in carrying; their function is to maintain order, act as scouts, and attack prey. The habits of these antiresemble most closely those of the blind Ecitons in that they very frequently, and indeed generally, build covered ways; they do so apparently in order to protect themselves from the heat of the African sun. Their line of march is therefore marked by a continuous arch or tunnel, which is always being constructed by the van of the column The structure is made of earth moulded together by saliva, and is very quickly built. But it is only built in places where the line of march is exposed to the sunlight; at night, or in the shadow of trees or long grass, is not made. If their camp is flooded by a tropical rain storm, the ants congregate in a close mass, with the younger ants in the centre; they thus form a floating island.

It is remarkable that ants of different hemisphered should manifest so close a similarity with respect to all these wonderful habits. The Chasseur ants of Trinidad and, according to Madame Merian, the ants of visitation of Cayenne, also display habits of the same kind.

General Intelligence of Various Species.

Many of the foregoing facts display an astonishing degree of intelligence as obtaining among ants; for I think that however much latitude we may be inclined to allow to 'blind instinct' in the way of imitating actions elsewhere due to conscious purpose, some at least of these foregoing facts can only be fairly reconciled with the view that the insects know what they are doing and why they are doing But as I am myself well aware of the difficulty that conceivable di arises in all such cases of drawing the line between pur- not been pre poseless instinct and purposive intelligence, I have thought porizontal room it desirable to reserve for this concluding division of the therefore inac present chapter several isolated facts which have been observed among sundry species of ants, and which do not wood c p. con

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seem to admit of being reasonably comprised under the category of instinctive action, if by the latter we mean action pursued without knowledge of the relation between the means adopted and the ends attained.

It will be remembered that our test of instinctive as distinguished from truly intelligent action is simply whether all individuals of a species perform similar adaptive movements under the stimulus supplied by similar and habitual circumstances, or whether they manifest individual and peculiar adaptive movements to meet the exigencies of novel and peculiar circumstances. The importance of this distinction may be rendered manifest by the following illustrations.

We have already seen that the ants which Sir John Lubbock observed display many and complex instincts, which together might seem to justify us in anticipating that animals which present such wonderful instincts must also present sufficient general intelligence to meet simple though novel exigencies by such simple adaptations as the unfamiliar circumstances require. Yet experiments which

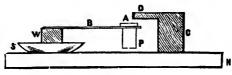


Fig. 8.

he made in this connection seem to show that such is not nishing den the case, but that these ants, with all their wealth of for I think instinctive endowments, are utterly destitute of intellito allow to gent resources; they have abundance of common and detailed knowledge (supposing the adaptations to be made consciously) how to act under certain complex though familiar circumstances, but appear quite unable to originate any adaptive action to obviate even the simplest conceivable difficulty, if this is of a kind which they have not been previously accustomed to meet. Thus, on a horizontal rod B supported in a saucer of water s, and therefore inaccessible to the ants from beneath, he placed to meet a block of the do not seed to be constructed so that the portion p should touch ich do not rood c D. constructed so that the portion D should touch

the larvæ at A. When the ants had made a number of journeys over CDA and back again, he raised the block CD so that there was an interval $\frac{3}{10}$ of an inch between the end of the block D and the larvæ at A.

The ants kept on coming, and tried hard to reach down from D to A, which was only just out of their reach. . . . After a while they all gave up their efforts and went away, losing their prize in spite of most earnest efforts, because it did not occur to them to drop 130 of an inch. At the moment when the separation was made there were fifteen ants on the larvæ. These could, of course, have returned if one had stood still and allowed the others to get on its back. This however, did not occur to them; nor did they think of letting themselves drop from the bottom of the paper (P) on to the nest. Two or three, indeed, fell down, I have no doubt by accident; but the remainder wandered about, until at length most of them got into the water.

In another experiment he interposed a light straw bridge on the way between the nest and the larvæ, and when the ants had well learnt the way, he drew the bridge a short distance towards the nest, so that a small chasm was made in the road. The ants tried hard and ineffectually to reach across it, but it did not occur to them to push the straw into its original position.

The following experiment is still more illustrative of the absence of intelligence, because the adjustive action required would not demand the exercise of such high powers of imagination and abstraction as would have been required for the moving forwards of the paper drawbridge:

To test their intelligence I made the following experiments: I suspended some honey over a nest of Lasius flavus at a height of about $\frac{1}{2}$ an inch, and accessible only by a paper bridge more than 10 feet long. Under the glass I then placed a small heap of earth. The ants soon swarmed over the earth on to the glass, and began feeding on the honey. I then removed a little of the earth, so that there was an interval of about $\frac{1}{3}$ of an inch between the glass and the earth; but though the distance was so small, they would not jump down but preferred to go round by the long bridge. They tried in vain to stretch up from the earth to the glass, which, however, was just out of their reach, though they could touch it with

their antenne up a little, the of eacth they we the food. This they gave up a round by the p weeks, but the bridge.

Another : in placing a another stick the ground a placed some this cell were The larvæ. though the a to take this s leap, but all 7 feet.' Sir an inch, so tl with their an to go the lon therefore, he ranged them cally. He al cell containin to go the lo could not hav though even ing up the fir so as to touc

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their antennæ; but it did not occur to them to heap the earth up a little, though if they had moved only half a dozen particles of earth they would have recured for themselves direct access to the food. This, however, never occurred to them. At length they gave up all attempts to reach up to the glass, and went round by the paper bridge. I left the arrangement for several weeks, but they continued to go round by the long paper bridge.

Another and somewhat similar experiment consisted in placing an upright stick A, supporting at an angle another stick B, which nearly but not quite touched the ground at c. At the end of the stick B there were olaced some larvæ in a horizontal glass cell at D. Into this cell were also placed a number of ants along with the larvæ. The drop from D to C was only \frac{1}{2} an inch; 'still, though the ants reached over and showed a great anxiety to take this short cut home, they none of them faced the leap, but all went round by the sticks, a distance of nearly 7 feet.' Sir John then reduced the interruption to 2 of an inch, so that the ants could even touch the glass cell with their antennæ; yet all day long the ants continued to go the long way round rather than face the drop. Next, therefore, he took still longer sticks and tapes, and arranged them as before, only horizontally instead of vertically. He also placed some fine earth under the glass cell containing the larvæ. The ants as before continued to go the long way round (16 feet), though the drop could not have hurt either themselves or the larvæ, and though even this drop might have been obviated by heaping up the fine earth into a little mound & of an inch high, so as to touch the glass cell.

It is desirable, however, here to state that all species of ants do not show this aversion to allowing themselves to drop through short distances; for Moggridge describes the harvesting ants of Europe as seeming rather to enjoy acrobatic performances of this kind; and the same fact is recorded by Belt of the leaf-cutting ants of the Amazons. Dr. Bastian, in his work on 'Brain as an Organ of Mind,' suggests that the 'seeming lack of intelligence betrayed by our English ants, from their disinclination to take a small leap, may be due simply to their defective sight'

(pp. 241-2). But even this consideration does not extenuate the stupidity of the ants which failed to heap up the fine earth to reach the glass cell which they were able to touch with their antennæ.

That the species of ants on which Sir John Lubbock experimented were not, however, quite destitute of intelligence is proved by the result of the following experiment:—

I put some provisions in a shallow box with a glass top and a single hole in one side; I then put some specimens of Lasiu niger to the food, and soon a stream of ants was at work busily carrying supplies off to the nest. When they had got to know their way thoroughly, and from thirty to forty were so occupied I poured some fine mould in front of the hole, so as to cover it to a depth of about \(\frac{1}{2} \) an inch. I then took out the ants which were actually in the box. As soon as the ants had recovered from the shock of this unexpected proceeding on my part, they began to run all round and about the box, looking for some other place of entrance. Finding none, however, they began digging down into the earth just over the hole, carrying off the grains of earth one by one and depositing them without any order all round at a distance of from $\frac{1}{2}$ to 6 inches, until the had excavated down to the doorway, when they again began carrying off the food as before.

This experiment was several times repeated on L. niger and on L. flavus, always with the same result.

Thus, then, we may conclude that the reasoning power of these ants, although shown by the first experiments to be almost nil, is shown by this experiment to be not quite nil; for the attempt to meet the exigencies of the case by first going round the box to seek another entrance, before taking the labour to remove the earth from the known entrance, implies a certain rudimentary degree of adaptive capacity which belongs to the category of the rational.

Another point of considerable interest, as bearing on the general intelligence of ants, is one that was brought out as the result of a laborious series of hourly observations, extending without intermission from 6.30 A.M. to 10 P.M. for a period of three months. The object of these observations was to ascertain whether the principle of the

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bearing on as brought ly observa-.30 A.M. to ct of these iple of the ivision of labour is practised by the ants. The result of hese observations was to show that during the winterme, when the ants are not active, certain individuals are old off to forage for supplies, and that when any casualty vertakes these individuals, others are told off to supply heir places. Thus, in the words of Sir John Lubbock's nalysis of his lengthy tables,—

The feeders at the beginning of the experiment were those nown to us as Nos. 5, 6, and 7. On the 22nd of November a iend, registered as No. 8, came to the honey, and again on the 1th December; but with these two exceptions the whole of he supplies were carried in by Nos. 5 and 6, with a little help om No. 7. Thinking now it might be alleged that possibly these ere merely unusually active or greedy individuals, I imrisoned No. 6 when she came out to feed on the 5th. As will e seen from the table, no other ant had been out to the honey or some days; and it could therefore hardly be accidental that n that very evening another ant (then registered as No. 9) ame out for food. This ant, as will be seen from the table, hen took the place of No. 6 (No. 5 being imprisoned). On the Ith January No. 9 took in all the supplies, again with a little elp from No. 7. So matters continued until the 17th, when I pprisoned No. 9, and then again, i.e. on the 19th, another ant N_0 , 10) came out for the food, aided, on and after the 22nd, vanother (No.11). This seems to me very curious. From the 1st Tovember to the 5th January, with two or three casual excepons, the whole of the supplies were carried in by three ants, ne of whom, however, did comparatively little. The other two re imprisoned, and then, but not till then, a fresh ant appears h the scene. She carries in the food for a week, and then she eing imprisoned, two others undertake the task. On the ther hand, in nest 1, when the first foragers were not imrisoned, they continued during the whole time to carry in he necessary supplies.

The facts, therefore, certainly seem to indicate that ertain ants are told off as foragers, and that during inter, when but little food is required, two or three such pragers are sufficient to provide it.

Although Sir John Lubbock's ants showed such meagre esources of intelligent adjustment, other species of ants, hich we have already had occasion to consider, appear to e as remarkable in this respect as they are in respect of

their instinctive adjustments. Unfortunately observation on this subject are very sparse, but such as they are the hold out a strong inducement for any one who has the opportunity to experiment with the view of testing the intelligence of those species in connection with which the following observations have been made.

Réaumur states that ants will make no attempt to enter a inhabited beehive to get at the contained honey, knowing that the bees will slaughter them if they do so. But if the hive i uninhabited, or the bees all dead, the ants will swarm into the hive as long as any honey is to be found there.

P. Huber records that a wall which had been parts erected by ants was observed by him—

As though it were intended to support the still unfinished arched roof of a large room, which was being built from the opposite side. But the workers which had begun the arch had given it too low an elevation for the wall on which it was rest, and if it had been continued on the same lines it would have met the partition wall halfway up, and this was to avoided. I had just made this criticism to myself, when a new arrival, after looking at the work, came to the same conclusion For it began at once to destroy what had been done, and heighten the wall on which it was supported, and to make new arch with the materials of the old one under my very eye When the ants begin an undertaking it seems exactly as if a idea slowly ripened into execution in their minds. Thus if on of them finds two stalks lying crosswise on the nest, which make possible the formation of a room, or some little rafters which suggest the walls and the corners, it first observes the various parts accurately, and then quickly and neatly heaps little peller of earth in the interspaces and alongside the stalks. It bring from every side materials that seem appropriate, and some times takes such from the uncompleted works of its companion so much is it urged on by the idea which it has once conceived and by the desire to execute it. It goes and comes and turn back again, until its plan is recognisable by the others.

Ebrard, in his 'Etudes de Mœurs' (p. 3), gives the following remarkable instance of the display of intelligence of F. fusca:—

The earth was damp and the workers were in full swing

was a const om their und ellets of earth tention I fixe ere being built ad made consi uld be plainly mained an inte fill in. Here e earth still to llars, buttress ts are wont to not customar ur ants, how moment they on turned inst rrow leaves of arest, and wei ex just bent de e bend was to eak. To prev se of the leaf u e space require ey heaped dam the leaf, until d thus attaine of the material

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bservation was a constant coming and going of ants, coming forth by are the community that the community that the contract of the contract my that the contract of the contract my testing the stention I fixed my gaze on the largest of the rooms which which the ere being built, wherein several ants were busy. The work ad made considerable progress; but although a projection uld be plainly seen along the upper edge of the wall, there mained an interspace of about twelve or fifteen millimetres fill in. Here would have been the place, in order to support e earth still to be brought in, to have had recourse to those llars, buttresses, or fragments of dried leaves, which many hts are wont to use in building. But the use of this expedient not customary with the ants I was observing (F. fusca). ur ants, however, were sufficient for the occasion. moment they seemed inclined to leave their work, but on turned instead to a grass-plant growing near, the long rrow leaves of which ran close together. They chose the arest, and weighted its distal end with damp earth, until its ex just bent down to the space to be covered. Unfortunately bend was too close to the extremity, and it threatened to leak. To prevent this misfortune, the ants gnawed at the se of the leaf until it bent along its whole length and covered e space required. But as this did not seem to be quite enough, ley heaped damp earth between the base of the plant and that the leaf, until the latter was sufficiently bent. After they d thus attained their object, they heaped on the buttressing of the materials required for building the arched roof.

The characteristic trait of the building of ants, says Forel, the almost complete absence of an unchangeable model, culiar to each species, such as is found in wasps, bees, and The ants know how to suit their indeed little perfect hers. ork to circumstances, and to take advantage of each situation. esides, each works for itself and on a given plan, and is only casionally aided by others when these understand its plan. aturally many collisions occur, and some destroy that which hers have made. This also gives the key to understanding e labyrinth of the dwelling. For the rest, it is always those prkers which have discovered the most advantageous method, which have shown the most patience, which win over to their an the majority of their comrades and at last the whole colony, though not without many fights for supremacy. But if one cceeds in obtaining a second to follow it, and this second aws the others after it, the first is soon lost again in the owd.

uld never hav Espinas also observed ('Thierischen Gesellschafte preparing pas German translation, 1879, p. 371) that each single The e larvæ. made its own plan and followed it until a comrade, whi tted of the sir had caught the idea, joined it, and then they worked ants, and the fter a few day:

gether in the execution of the same plan. Moggridge says of the harvesters of Europe,-

I have observed on more than one occasion that when digging into an ants' nest I have thrown out an elater lan the ants would cluster round it and direct it towards so small opening in the soil, which it would quickly enlarge disappear down. At other times, however, the ants would no notice of the elater, and it is my belief that the attention paid to it on former occasions were purely selfish, and they intended to avail themselves of the tunnel thus ma down into the soil, with the view of reopening communication with the galleries and granaries concealed below, the approach to which had been covered up. I have frequently watched ants make use of these passages mined by the elater on the occasions.

And again, as showing apparently intelligent adaptati of their usual habits to altered circumstances, he gives account of the behaviour of these ants when a gm crowd of them were confined by him in a glass jar or taining earth. He says:—

On the following morning the openings were ten in number and the greatly increased heaps of excavated earth showed they must probably have been at work all night. of work done in this short time was truly surprising, for must be remembered that, eighteen hours before, the earth sented a perfectly level surface, and the larvæ and ants, n housed below, found themselves prisoners in a strange plan bounded by glass walls, and with no exit possible.

It seems to me that the ants displayed extraordinary inte gence in having thus at a moment's notice devised a plan which the superabundant number of workers could be ployed at one time without coming in one another's way. soil contained in the jar was of course less than a tenth part that comprised within the limits of an ordinary nest, while number of workers was probably more than a third of the to number belonging to the colony. If therefore but one or entrances had been pierced in the soil, the workers would been for ever running against one another, and a great num

Concerning otation may acCook. Aft nny places v es on to say

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mained open.

ite tree that s he sapling had mmunity, and til too old to ent was very s micary was b e spring ran b ere in commun en made in the re quite appa hat seemed an ciated it with the young tree

He also giv nich indeed, edible. I an pear very d thor himself him by his g m words:—

While studyi make a night e farmer's story tain plants ar d vain search t the countrym the cutting ung peach tree sellschafter ch single a mrade, whe cy worked

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ordinary intelessed a plant could be ere's way. The atenth part nest, while the but one or the swould have a great numbers.

uld never have got below to help in the all-important task preparing passages and chambers for the accommodation of e larvæ. These numerous and funnel-shaped entrances adtted of the simultaneous descent and ascent of large numbers ants, and the work progressed with proportionate rapidity. fter a few days only there entrances, and eventually only one, mained open.

Concerning the harvesting ant of Texas, the following notation may be made, under the present head, from acCook. After remarking that these ants always select nny places wherein to build their nests, or disks, he sees on to say that within a few paces of his tent—

A nest was made which was partly shaded by a small mestite tree that stood just beyond the margin of the clearing. he sapling had probably grown up after the location of the mmunity, and for some reason had been permitted to remain til too old to kill off. The shadow thrown upon the paveent was very slight; nevertheless, fifteen feet distant a new rmicary was being established. The path from the ranch to e spring ran between this new hill and the old one, and ants ere in communication between the two. An opening had en made in the ground, and the beginnings of a new formicary ere quite apparent. This is the only instance observed of hat seemed an attempt at colonising or removing, and I asciated it with the presence of the small but growing shadow the young tree.

He also gives us a still more remarkable observation, nich indeed, I must candidly say, does not appear to me edible. I am, therefore, glad to add that it does not pear very distinctly from the account whether the thor himself made the observation, or had it narrated him by his guide. But here is the observation in his m words:—

While studying the habits of the cutting ant I was tempted make a night visit to a farm some distance from camp, by a farmer's story of depredations made by these insects upon tain plants and vegetables. A long, dark tramp, a blind d vain search among the fields, compelled us at last to call the countryman from his bed. He led us directly to one the cutting ants' nests, which was overshadowed by a ung peach tree. 'There they be, sir,' cried he triumphantly.

They were agriculturals! So also were the other nests show The reason for this confounding of the two ants on the part the people hereabouts, and the reason for the 'cutting' operation of our harvesters, will be explained farther on. It is only point here to say that the farmer affirmed that the ants un the peach tree had stripped off the first tender leaves last spin so that scarcely one had been left upon the limbs. I am vinced that the reason for this onslaught was the desire to be of the obnoxious shade, and open the formicary to the full of the sun.

From this account it is not very clear whether writer himself saw evidence of the former denudation the tree, and if so whether there was any indication other than the word of the farmer, that the denudati had been effected by the ants. To make this conclusion credible the best conceivable evidence would be require and this, unfortunately, is just what we find wanting Somewhat the same remarks may be made on the following ing quotation from the same writer, though in this a his view is to some extent supported by an observation Moggridge, as well as by that of Ebrard already quoted:

Here I observed what appeared to be a new mode of operations. The workers, in several cases, left the point at whi they had begun a cutting, ascended the blade, and passed far out toward the point as possible. The blade was thus be downward, and as the ant swayed up and down it real seemed that she was taking advantage of the leverage the gained, and was bringing the augmented force to bear upont fracture. In two or three cases there appeared to be a divisi of labour; that is to say, while the cutter at the roots kept with her work, another ant climbed the grass blade and appli the power at the opposite end of the lever. This position m have been quite accidental, but it certainly had the appearant of a voluntary co-operation. I was sorry not to be able to tablish this last inference by a series of observations, as facts were only observed in this one nest.

The observation of Moggridge, to which I have allud as in some measure rendering support to the foregoing as follows. Speaking of European harvesters which kept in an artificial nest for the purposes of close obse vation, he says:--

I was also i herwise could eration of ren lleries, belong d which was r d of the root, ain was great

And again, Two ants son elf near the ba eatest tension, have occasional certain plants, carry them aw

Lastly, the gether serve t m Bingley, 1 New South V $_{
m d}$ others-

green as a sts of various s ese nests are o nding down sev a man's hand, form a purse. animal juice. no opportuni their strength ltitudes were e s to prevent th leaves were be ive artificers, v hey were drive re employed sp ld have though heir strength.

This remark the followin nnent:--

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have allude foregoing, ers which he f close obse I was also in this way able to see for myself much that I herwise could not have seen. Thus I was able to watch the eration of removing roots which had pierced through their lleries, belonging to seedling plants growing on the surface, d which was performed by two ants, one pulling at the free d of the root, and the other gnawing at its fibres where the ain was greatest, until at length it gave way.

And again,-

Two ants sometimes combine their efforts, when one stations elf near the base of the peduncle, and gnaws it at the point of eatest tension, while the other hauls upon and twists it. . . . have occasionally seen ants engaged in cutting the capsules certain plants, drop them, and allow their companions below carry them away.

Lastly, the statements of these three observers taken gether serve to render credible the following quotation m Bingley, who says that in Captain Cook's expedition New South Wales ants were seen by Sir Joseph Banks dothers—

green as a leaf, which live upon trees and build their sts of various sizes, between that of a man's head and his fist. ese nests are of a very curious structure: they are formed by ding down several of the leaves, each of which is as broad a man's hand, and gluing the points of them together so as form a purse. The viscous matter used for this purpose is animal juice. . . . Their method of bending down leaves we I no opportunity to observe; but we saw thousands uniting their strength to hold them in this position, while other busy ltitudes were employed within, in applying this gluten, that s to prevent their returning back. To satisfy ourselves that leaves were bent and held down by the efforts of these dimitive artificers, we disturbed them in their work; and as soon they were driven from their station, the leaves on which they re employed sprang up with a force much greater than we ld have thought them able to conquer by any combination heir strength.

This remarkable fact also seems to be corroborated the following independent observation of Sir E. nent:—

¹ Animal Biography, 'Ants.'

The most formidable of all is the great red ant, or Dimin It is particularly abundant in gardens and on fruit-trees; constructs its dwellings by gluing the leaves of such species are suitable from their shape and pliancy into hollow balls, at these it lines with a kind of transparent paper, like that man factured by the wasp. I have watched them at the interest operation of forming these dwellings;—a line of ants stands on the edge of one leaf bring another into contact with it, a hold both together with their mandibles till their companion within attach them firmly by means of their adhesive paper, assistants outside moving along as the work proceeds. If it necessary to draw closer a leaf too distant to be laid hold of the immediate workers, they form a chain by depending a from the other till the object is reached, when it is at lend brought into contact, and made fast by cement.

I shall now pass on to the remarkable observation of municated to Kirby by Colonel Sykes, F.R.S., and whis thus narrated by Kirby in his 'History, Habits, Instincts of Animals:'—

When resident at Poona, the dessert, consisting of fm cakes, and various preserves, always remained upon a small table, in a verandah of the dining-room. To guard agai inroads, the legs of the table were immersed in four basins with water; it was removed an inch from the wall, and keep off dust from open windows, was covered with a tabled At first the ants did not attempt to cross the water, but as strait was very narrow, from an inch to an inch and a half, the sweets very tempting, they appear, at length, to have but all risks, to have committed themselves to the deep, to h scrambled across the channel, and to have reached the of their desires, for hundreds were found every morning revell in enjoyment: daily vengeance was executed upon them out lessening their numbers; at last the legs of the table w painted, just above the water, with a circle of turpentine. at first seemed to prove an effectual barrier, and for some the sweets were unmolested, after which they were again tacked by these resolute plunderers; but how they got them seemed totally unaccountable, till Colonel Sykes, who passed the table, was surprised to see an ant drop from the about a foot above the table, upon the cloth that covered another and another succeeded. So that though the turpent and the distance from the wall appeared effectual barriers,

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Colonel Sy ent, standing questioned. splayed by proboration, nich the stat re, add the etermined manich so far le

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hich was visit oth soaked in me down th oth, they tur the overhan op clear of the e ants which e nature of t bm a distance their jaws a bacco-cloth t hich the ants This interes uckart's is, entical one m eury, and c blished it i he Cardinal sr order to prev

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isting of fru pon a small guard again our basins fil e wall, and ith a tabled rater, but ast and a half, , to have bran e deep, to be hed the obje orning revell pon them w **f** the table π arpentine. I d for some di were again w they got Sykes, who of \mathbf{p} from the π hat covered n the turpent al barriers,

e resources of the animal, when determined to carry its point, ere not exhausted, and by ascending the wall to a certain ight, with a slight effort against it, in falling it managed to nd in safety upon the table.

Colonel Sykes was a good observer, so that this stateent, standing upon his authority, ought not, perhaps, to questioned. But in all cases of remarkable intelligence splayed by animals, we naturally and properly desire proboration, however good the authority may be on hich the statement of such cases may rest. I will, therere, add the following instances of the ingenious and termined manner in which ants overcome obstacles, and hich so far lend confirmation to the above account.

Professor Leuckart placed round the trunk of a tree, hich was visited by ants as a pasture for aphides, a broad oth soaked in tobacco-water. When the ants returning me down the trunk of the tree arrived at the soaked oth, they turned round, went up the tree again to some the overhanging branches, and allowed themselves to op clear of the obnoxious barrier. On the other hand, e ants which desired to mount the tree first examined e nature of the barrier, then turned back and procured om a distance little pellets of earth, which they carried their jaws and deposited one after another upon the bacco-cloth till a road of earth was made across it, over hich the ants passed to and fro with impunity.

This interesting, and indeed surprising observation of euckart's is, in turn, a corroboration of an almost entical one made more than a century ago by Cardinal eury, and communicated by him to Réaumur, who blished it in his 'l'Histoire des Insectes' (1734). The Cardinal smeared the trunk of a tree with birdlime order to prevent the ants from ascending it; but the sects overcame the obstacle by making a road of earth, all stones, &c., as in the case just mentioned. In other instance the Cardinal saw a number of ants make bridge across a vessel of water surrounding the bottom an orange-tree tub. They did so by conveying a mber of little pieces of wood, the choice of which aterial instead of earth or stones, as in the previous case,

seems to betoken no small knowledge of practical engineering.

Büchner, after quoting these cases, proceeds to

(loc. cit., p. 120),—

The ants behaved in yet more ingenious fashion under following very similar circumstances. Herr G. Theuerkan the painter (Wasserthorstr. 49, Berlin), writes to the authorstr. November 18, 1875: 'A maple tree standing on the ground of the manufacturer, Vollbaum, of Elbing (now of Dantze swarmed with aphides and ants. In order to check the m chief, the proprietor smeared about a foot width of the ground round the tree with tar. The first ants who wanted to cro But what did the next? They turns naturally stuck fast. back to the tree and carried down aphides, which they stuck down on the tar one after another until they had made a bridge on which they could cross the tarring without danger. The about named merchant, Vollbaum, is the guarantor of this stor which I received from his own mouth on the very spot where it occurred.

Büchner also gives the following case on the authority of Karl Vogt (loc. cit., p. 128). An apiary of a friend with invaded by ants:—

To make this impossible for the future, the four legs of the beehive-stand were put into small, shallow bowls filled with water, as is often done with food in ant-infested places. ants soon found a way out of this, or rather a way into the beloved honey, and that over an iron staple with which stand was attached to a neighbouring wall. The staple w removed, but the ants did not allow themselves to be defeated They climbed into some linden trees standing near, the branch of which hung over the stand, and then dropped upon it for the branches, doing just the same as their comrades do will respect to food surrounded by water, when they drop upon from the ceiling of the room. In order to make this important sible, the boughs were cut away. But once more the an were found in the stand, and closer investigation show that one of the bowls was dried up, and that a crowd of an had gathered in it. But they found themselves puzzled how go on with their robbery, for the leg did not, by chance, rest the bottom of the bowl, but was about half an inch from The ants were seen rapidly touching each other with the antennæ, or carrying on a consultation, until at last a rath arger ant cam
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The same ble observati orf:—

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The same author publishes the following very remarkble observation, quoted from a letter to him by Dr. Ellenorf:—

It is a hard matter to protect any eatables from these reatures, let the custody be ever so close. The legs of cupoards and tables in or on which eatables are kept are placed in essels of water. I myself did this, but I none the less found housands of ants in the cupboard next morning. It was a uzzle to me how they crossed the water, but the puzzle was oon solved; for I found a straw in one of the saucers, which y obliquely across the edge of the pan and touched the leg the press: this they had used for a bridge. Hundreds were rowned in the water, apparently because disorder had reigned first, those coming down with booty meeting those going up. ut now there was perfect order; the descending stream used ne side of the straw, the ascending the other. I now pushed he straw about an inch away from the cupboard leg; a terrible In a moment the leg immediately over the ater was covered with hundreds of ants, feeling for the bridge every direction with their antennæ, running back again and ming in ever larger swarms, as though they had communicated their comrades within the cupboard the fearful misfortune hat had taken place. Meanwhile the new-comers continued run along the straw, and not finding the leg of the cupboard he greatest perplexity arose. They hurried round the edge of he pan, and soon found out where the fault lay. With united rces they quickly pulled and pushed at the straw, until it gain came into contact with the wood, and the communication as again restored.

This observation is strikingly, though unconsciously, onfirmed by a recent writer in the *Leisure Hour* (1880, p. 718-19), who having been much troubled by small red at in the tropics swarming over his provisions, placed he latter in a meat-safe detached from the wall and tanding on four legs, each of which was placed in a little in vessel containing water. Eight or ten days afterwards

he found his provisions in the safe swarming with ants a before, and on investigating their mode of access to then found—

Proceeding along the whitewashed wall a string of antigoing and coming from the outer door to a height of four fee on my wall, and corresponding with that of the safe; and look ing between it and the wall, I discovered the secret—the bride which these persevering little insects had made. It consisted a broken bit of straw, which rested with one end on a mi buttress fixed to the wall, and the other on the overhanging projecting top of the safe, which came within an inch and a ha of the wall. So they must have carried the straw up from the floor, and resting their end of it on the support they had m pared, let it fall until its other end reached the safe, and the crossed and completed the structure, for it was fastened at but ends with the mortar composed of their saliva and fine early Ruthlessly I destroyed the bridge, and moving the safe fartle from the wall, managed to prevent their inroads for that seaso at least. Since then I have frequently seen short bridges, com posed entirely of the concrete or mortar which the white an use to cover up their workings, extending from a damp earth wall to anything not more than three-quarters of an in from it.

Of the Ecitons Mr. Belt says:—

I shall relate two more instances of the use of a reasoning faculty in these ants. I once saw a wide column trying to particular along a crumbling, nearly perpendicular slope. They would have got very slowly over it, and many of them would have fallen, but a number having secured their hold, and reaching to each other, remained stationary, and over them the main column passed. Another time they were crossing a watercome along a small branch, not thicker than a goose-quill. The widened this natural bridge to three times its width by number of ants clinging to it and to each other on each side over which the column passed three or four deep; where excepting for this expedient they would have had to pass ow in single file, and treble the time would have been consumed Can it be contended that such insects are not able to determine by reasoning powers which is the best way of doing a thing?

Another observer, writing from the same part of the world to Büchner, gives a still more wonderful account the ingenuity of Ecitons in crossing water. This observe

s Herr H. who lived in engineer, driver ants in ander date I

On both s ach other, st he others by rigantic man he ant-state They look afte ither to the r f the march gain. While n unceasingly natives call t orwards, read The crossing o ng point. ind trees, the ide, and after over these brid with marvello f no natural b along the ban Each hore. water, and mo ones even furt and to their co water is cover large to be hel breaks itself of eft on the bar and work at This is repeate often heard de year 1859 I ha

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s Herr H. Kreplin, of Heidemühl (Station Ducherom), who lived for nearly twenty years in South America as n engineer, and had often the opportunity of seeing the river ants in the forests there.' He writes to Büchner, ander date May 10, 1876, as follows:—

On both sides of the train, at about 10 mm. distance from ach other, stronger ants are to be seen, distinguishable from nd on a much he others by their foxy colour and very thick heads with verhanging a figantic mandibles. These 'thickheads' play the same *rôle* in the ant-state for which they are cast in cultured communities. We up from the They look after the order of the march, and allow none to turn they had presither to the right or left. The least confusion in the regularity safe, and the of the march makes them turn round and put things straight safe, and the of the march makes them turn round and put things straight stened at but spain. While the procession of the brown workers streams on different at one procession of the brown workers streams on the safe farth natives call these thickheads, run constantly backwards and for that season to the bridges, con the crossing of streams by these creatures is the most interesting point. If the watercourse be narrow, the thickheads soon find trees, the branches of which meet on the bank on either rs of an interesting and after a short halt the column set themselves in motion over these bridges, rearranging themselves in the parrow train over these bridges, rearranging themselves in the narrow train with marvellous quickness on reaching the further side. But f no natural bridge be available for the passage, they travel of a reasoning along the bank of the river until they arrive at a flat sandy shore. Each ant now seizes a bit of dry wood, pulls it into the They would water, and mounts thereupon. The hinder rows push the front ones even further out, holding on to the wood with their feet and to their comrades with their jaws. In a short time the water is covered with ants, and when the raft has grown too arge to be held together by the small creatures' strength, a part breaks itself off and begins the journey across, while the ants left on the bank busily pull their bits of wood into the water, and work at enlarging the ferry-boat until it again breaks. This is repeated as long as an ant remains on shore. I had often heard described this method of crossing rivers, but in the year 1859 I had the opportunity of seeing it for myself.

> It is remarkable that the military or driving ants of Africa exhibit precisely similar devices for the bridging of streams, namely, by forming a chain of individuals over which the others pass. By means of similar chains they also let themselves down from trees. It must be observed,

however, that these and all the above observations, being independently made and separately recorded, serve to corroborate one another so strongly that we can entertain no reasonable doubt concerning the wonderful facts which they convey.

I shall now bring these numerous instances to a close with a quotation from Mr. Belt, which reveals in the most unequivocal manner surprising powers of observation and rational action on the part of the leaf-cutting ants of South America, whose general habits we have already considered:—

A nest was made near one of our tramways, and to get to the trees the ants had to cross the rails, over which the waggom were continually passing and repassing. Every time they came along a number of ants were crushed to death. They persevered in crossing for some time, but at last set to work and tunnelled underneath each rail. One day, when the waggom were not running, I stopped up the tunnels with stones; but although great numbers carrying leaves were thus cut off from the nest, they would not cross the rails, but set to work making fresh tunnels underneath them.

Anatomy and Physiology of Nerve-centres and Sense-organs.

The foregoing facts concerning the intelligence of ants fully justifies Mr. Darwin's observation that 'the brain of an ant is one of the most marvellous atoms of matter in the world, perhaps more so than the brain of a man.' It may therefore be interesting in this particular case to depart from the lines otherwise laid down throughout the present work, and to devote a short section to the anatomy and physiology of this nerve-centre with its appended organs of sense.

The brain of an ant, then, is proportionally larger than that of any other insect. (See Titus Graber, 'Insects,' vol. i. p. 255.) In structure, also, the brain of an ant is in advance of that of other insects, its nearest analogue being the brain of a bee. The superiority of development is particularly remarkable with reference to the 'stalked bodies' of Dujardin; and these are largest in neuter

workers, whi community.

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larger than nsects,' vol. n ant is in logue being lopment is ne 'stalked in neuter workers, which are the most intelligent members of the community.

Injury of the brain causes, as in higher animals, tetanic spasms and involuntary reflex movements, followed

by stupefaction.

An ant, whose brain has been perforated by the pointed mandibles of an amazon, remains as though nailed to its place; a shudder runs from time to time through its body, and one of ts legs is lifted at regular intervals. It occasionally makes a short and quick step, as though driven by an unseen spring, but, like that of an automaton, aimless and objectless. If it is bulled, it makes a movement of avoidance, but falls back into ts stupefied condition as soon as it is released. It is no longer capable of action consciously directed to a given object; it neither tries to escape, nor to attack, nor to go back to its home, nor to rejoin its companions, nor to walk away; it feels heither heat nor cold, it knows neither fear nor desire for food. It is merely an automatic and reflex machine, and is exactly imilar to one of those pigeons from which Flourens removed he hemispheres of the cerebrum. Just in the same way behaves he body of an ant from which the head has been taken away. In the numerous fights between amazons and other ants, countess cases have been observed of slight injury to the brain, which have caused the most remarkable phenomena. Many of he wounded were seized with a mad rage, and flung themelves at every one that came in their way, whether friend or be. Others assumed an appearance of indifference, and walked erenely about in the midst of the fighting. Others exhibited sudden failure of strength; but they still recognised their nemies, approached them, and tried to bite them in cold lood, in a way quite foreign to the behaviour of healthy ants. They were also often observed to run round and round in a ircle, the motion resembling the manège, or riding-school ction of mammals, when one of the crura cerebri has been emoved.

If an ant is cut in half through the thorax, so that the great erve ganglia of the pro-thorax remain untouched, the behaviour f the head shows that intelligence also remains untouched. Into its mutilated in this way try to go forwards with their two emaining legs, and beg with their antennæ for their comanions' aid. If one of these latter lets itself be stopped, then the observe a lively interchange of thanks and sympathy expressed by the actively moving antennæ. Forel placed near to

each other two such mutilated bodies of the *F. rufibarbis*. The conversed with each other in the above-described way, and appeared each to beg for help. But when he put in some similarly mutilated ants of a hostile species, *F. sanguinea*, the picture was changed; war broke out between these cripples just in the same way and with the same fury as between perfect ants. 1

The antennæ appear to be the most important of the sense-organs, as their removal produces an extraordinary disturbance in the intelligence of the animal. An antismutilated can no longer find its way or recognise companions, and therefore is unable to distinguish between friends and foes. It is also unable to find food, ceases the engage in any labour, and loses all its regard for larger remaining permanently quiet and almost motionless. It somewhat similar disturbance, or rather destruction, of the mental faculties is observable as a result of the same mutilation in the case of bees.²

¹ Büchner, Geistesleben der Thiere, English translation, p. 49.

² While this work is passing through the press, an interesting Essay has been published by Mr. MacCook on the Honey-making Am I am not here able to refer to this Essay at greater length, but have done so in a review in *Nature* (March 2, 1882.)—G. J. R.

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CHAPTER IV.

BEES AND WASPS.

RRANGING this chapter under the same general headings the one on ants, we shall consider first—

Powers of Special Sense.

Bees and wasps have much greater powers of sight han ants. They not only perceive objects at a greater istance, but are also able to distinguish their colours. his was proved by Sir John Lubbock, who placed honey a slips of paper similarly formed, but of different colours; hen a bee had repeatedly visited a slip of one colour (A), e transposed the slips during the absence of the bee; on s return the insect did not fly to slip B, although this now ccupied the position which had been previously occupied y slip A, but again visited slip A, although this now occuied the position which had been previously occupied by lip B. Therefore, as these experiments were again and gain repeated both on bees and wasps with uniform relits, there can be no question that the insects by their rst visits to slip A established an association between he colour of A and the honey upon it, such that, when hey again returned and found B in the place of A, they ere guided by their memory of the colour rather than y their memory of the position. It was thus shown that he insects could distinguish green, red, yellow, and blue. hese experiments also brought out the further fact that oth bees and wasps exhibit a marked preference for some olours over others. Thus, in a series of black, white, ellow, orange, green, blue, and red slips, two or three ees paid twenty-one visits to the orange and yellow, and ply four to all the other slips. The slips were then moved, As regards scent, Sir John found that on putting a fed drops of eau de Cologne at the entrance of a beehing immediately a number (about 15) came out to see what was the matter. Other scents had a similar effect; but on repetition several times the bees became accustome

to the scent, and no longer came out.

As in ants, so in bees, Sir John's experiments failed yield any evidence of a sense of hearing. But in this connection we must not forget the well-known fact, first observe by Huber, that the queen bee will answer by a certain soun the peculiar piping of a pupa queen; and again, by making a certain cry or humming noise, will strike consternation suddenly on all the bees in the hive—these remaining is a long time motionless as if stupefied.

Sense of Direction.

The following are Sir John Lubbock's observation upon this subject in the case of bees and wasps:—

Every one has heard of a 'bee-line.' It would be no be correct to speak of a wasp-line. On August 6 I marked wasp, the nest of which was round the corner of the house, that her direct way home was not out at the window by which she had entered, but in the opposite direction, across the rout to a window which was closed. I watched her for some house during which time she constantly went to the wrong window and lost much time in buzzing about at it. For ten consecutive days this wasp paid numerous visits, coming in at the open window, and always trying, though always unsuccessfully, the return to her nest in the 'wasp-line' of the closed window-buzzing about that window for hours at a time, though eventually on finding it closed she returned and went round through the open window by which she always entered:

This observation shows how strong must be the instinging a wasp to take the shortest way home, and how must the insect depends upon its sense of direction in so doing It also shows how long a time it requires to learn by individual experience the properties of a previously unknown

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bstance such as glass. But to this latter point we shall esently have occasion to return.

Next we must adduce evidence to show that in wayding the 'sense of direction' in bees appears to largely supplemented by observation of particular

jects

Sir John Lubbock observes: 'I never found bees to turn if brought any considerable distance at once. By king them, however, some twenty yards each time they me to the honey, I at length trained them to come to y room; that is to say, bees require to learn their way tle by little before they can return to a store of honey hich they may have been fortunate enough to find; their neral sense of direction is not in itself a sufficient ide. This, at least, is the case where, as in the experients in question, the bees are carried from the hive to e store of honey (here a distance of less than 200 ds): possibly if they had found the honey by themves flying towards it, and so probably taking note of jects by the way, one journey might have proved suffint to teach them the way. But, whether or not this uld have been the case, the fact that when carried they uired also to be taught the way piece by piece, is consive proof that their sense of direction alone is not ficient to enable them to traverse a route of 200 yards econd time.

The same result is brought out by other experiments ducted on a different plan, though not apparently h this object. 'My room is square, with two windows the south-west side, where the hive was placed, and on the south-east.' Besides the ordinary entrance m outside, the hive had a small postern door opening the room.

6.50 a bee came out through the little postern door. After she had fed, she evidently did not know her way home; so I put her back.

7.10 she came out again. I again fed her and put her

back.

10.15 she came out a third time; and again I had to put her back.

At 10.55 she came out again, and still did not remember to door. Though I was satisfied that she really wishes to return, and was not voluntarily remaining outside still, to make the matter clear, I turned her out a side window into the garden, when she at one returned to the hive.

At 11.15 she came out again; and again I had to show her the way back.

At 11.20 she came out again; and again I had to show her the way back (this makes five times); when, however, At 11.30 she came out again after feeding, she returned straight

to the hive.

At 11.40 she came out, fed, and returned straight to the hive. At 11.50 she came out, fed, and returned straight to the hive she then stayed in for some time.

At 12.30 she came out again, but seemed to have forgottent way back; after some time, however, she found to door and went in.

Again:—August 24 at 7.20 a bee came through the posern: I fed her; and though she was not frightened or disturbed when she had finished her meal she flew to the window and he evidently lost her way; so at 8 o'clock I in pity put her had myself.

August 29.—A bee came out to the honey at 10.10; at 10.1 she flew to the window, and remained buzzing about till 11.1 when, being satisfied that she could not find her way, I pher in.

Nay, even those who seemed to know the postern, if take near the other window, flew to it, and seemed to have be themselves.

This cost me a great many bees. Those which got into a room by accident continually died on the floor near a window.

These observations show that even when a bee is a carried from the hive to the honey, but herself flies to her sense of direction is not alone sufficient to enable to find the way back to the hive—or, rather, to the uncustomed entrance to the hive from which she had conout. Probably if the side window had been open, the would have returned to the hive round the corner of thouse, and through the entrance to which she was maccustomed. But as it was she had to learn, by five

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ix journeys, the way between the postern entrance and he food.

But the following observation on a wasp is in this conection the most conclusive.

A marked wasp visited honey exposed in the room efore mentioned. 'The next morning she came-

- t 7.25, and fed till 7.28, when she began flying about the room and even into the next; so I thought it well to put her out of the window, when she flew straight away to her nest. My room, as already mentioned, had windows on two sides; and the nest was in the direction of a closed window, so that the wasp had to go out of her way in going out through the open one.
- t 7.45 she came back. I had moved the glass containing the honey about two yards; and though it stood conspicuously, the wasp seemed to have much difficulty in finding it. Again she flew to the window in the direction of her nest, and I had to put her out, which I did at 8.2.
- y put her but 8.15 she returned to the honey almost straight. 8.21, she flew again to the closed window, and apparently could not find her way; so at 8.35 I put her out again. It seems obvious from this that wasps have a sense of direction, and do not find their way merely by sight.
 - $_{
 m tt}$ 8.50 back to honey, and 8.54 again to wrong window; but finding it closed, she took two or three turns round the room, and then flew out through the open window.
 - t 9.24 back to the honey; and 9.27 away, first, however, paying a visit to the wrong window, but without alighting.

t 9.36 back to the honey, and 9.39 away, but, as before, going first to wrong window.

She was away therefore 9 minutes. 9.509.53 away, this time straight.,, 11 ,, 10 10. 7 10.19 10.22,, ,, " 10.3510.3913 ,, " 10.47 10.509 11. 4 11. 7 14 " " 11.21 11.24" 11.34 11.3710 ,, "

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&c., &c., the way being now clearly well learnt.

But that the sense of direction is of much service to bees in finding the locality of their hives seems to be indicated by the following observation thus narrated, of the authority of the authors themselves, by Messrs. Kith and Spence:—

In vain, during my stay at St. Nicholas, I sallied out a every outlet to try to gain some idea of the extent and form of the town. Trees, trees, still met me, and intercepted the view in every direction; and I defy any inhabitant bee of the rural metropolis, after once quitting its hive, ever to gain glimpse of it again until nearly perpendicularly over it. In bees, therefore, must be led to their abodes by instinct, to

The observation, however, is not so conclusive as it authors suppose; for there is nothing to show that the bees did not take note of particular objects on their acustomed routes, and so learn these routes by stages. It would be worth while in this connection to try the effect of hooding the eyes of a bee, or, if this were deemed to disturbing an experiment, removing the hive bodily to distance from its accustomed site, and observing whether the bees start away boldly as before for long flights, the learn their new routes by stages.

In this connection I may quote the following.

Mr. John Topham, of Marlborough House, Torqui

writing to 'Nature,' 1 says:-

On October 29, 1873, I removed a hive of bees in garden, after it was quite dark, for a distance of 12 yards for the place in which it had stood for several months; between its original situation and the new one there was bushy evergreen tree, so that all sight of its former place.

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obstructed to a person looking from the new situation of the hive.

Notwithstanding this change, the bees every day flew to the locality where they formerly lived, and continued flying around the site of what had been their home until, as night came on, they many of them sank upon the grass exhausted and chilled by the cold. Numbers, however, returned alive to their new position, after having looked in vain for their hive in its old place. At night I picked the exhausted bees up, and having restored warmth to them (by leaving them for a time on my coat-sleeve), I returned them to their companions.

Here was an illustration that the faculty of memory was superior to that of observation; but that was not all. Nearly every bee which I picked up during the 23 days through which his effort of memory lasted was an old one, as was easily deduced from observing the worn edges of the wings; showing hat whilst the young insects were quick in receiving new impressions and in correcting errors, the nervous system of the ld bees continued acting in the direction which early habit had ffected. So true it is that one touch of nature makes the vhole world kin.'

A closely similar observation has been told me by a riend, Mr. George Turner. He found that when he emoved a beehive only a yard or two from its accusomed site, the bees, on returning home, flew in swarms round the latter, and for a long time were unable to find he hive. And several other similar cases might be dduced. Lastly, Thompson says:—

It is highly remarkable that they [bees] know their hive hore from its locality than from its appearance, for if it be repoved during their absence and a similar one be substituted, hey enter the strange one. If the position of a hive be changed, he bees for the first day take no distant flight till they have horoughly scrutinised every object in its neighbourhood.

On the other hand, the writer of the article on 'Bees' a the 'Encyclopædia Britannica' says that in certain parts of France it is the habit of bee-keepers to place a number of hives upon a boat, which, in charge of a man, floats lowly down a river. The bees are thus continuously hanging their pasture-ground, and yet do not lose their becomotive hives.

Passions of Animals, p. 53.

It may be here worth while to add, parenthetically, at the only authentic observation with which I am acquainted concerning the distance that bees are accustomed to forage, the following statement of Prof. Hugh Blackburn Writing from Glasgow University to 'Nature,' he say that bees are found in a certain peach-house every spring at the time of blossom, although, so far as he can ascertain, the beehives nearest to the peach-house in question are his own, and these are at a distance of ten miles.

On the whole, then, and in the absence of further experiments, we must conclude it to be probable that the sense of direction with which hymenopterous insects are, as shown by some of Sir John Lubbock's experiments, upquestionably endowed, is of no small use to them in finding their way from home to food and vice versâ; although it appears certain, from other of his experiments, that this sense of direction is not in all cases a sufficient guide, and therefore requires to be supplemented by the definite observation of landmarks.

But the most conclusive evidence on this latter point is afforded by a highly interesting observation of Markets and the sand-wasps at Santurem, which may here be suitably introduced, as the insects are not distantly allied. He describes these animals as always taking a few turn in the air round the hole they had made in the sand before leaving to seek for flies in the forest, apparently order to mark well the position of the burrow, so that of their return they might find it without difficulty. This observation has been since confirmed in a striking manner by Mr. Belt, who found that the sand-wasp takes the most precise bearings of an object the position of which she desires to remember. This observation is so interesting that it deserves to be rendered in extenso:—

A specimen of *Polistes carnifex* (i.e. the sand-wasp notice by Mr. Bates) was hunting about for caterpillars in my gards. I found one about an inch long, and held it out towards it at the point of a stick. It seized it immediately, and comments biting it from head to tail, soon reducing the soft body to a major pulp. It rolled up about one-half of it into a ball, and property in the soft body to a major pulp.

ared to carry it fine-leaved clin b take note of o do this, it ho mall circles in f lant. I though nother look at he other half o hust have left it he nest, for it r ne circle around n a leaf, and ra illar was lying he one on which nissed it, and coming out agai he same spot ag mall seed-pods, narks that I ha rasp seemed als own to them, a ragment of cate ny on the outsi rom the object ame process wa ircling round it lighted near the arprised at its p p the search; imes, and seeme rings. At last nd as there was ff to its nest, w uch an action hinking mind; ntly constructed nan.

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-wasp notice n my gardentowards it of ad commences ody to a mast ball, and pre-

ared to carry it off. Being at the time amidst a thick mass of fine-leaved climbing plant, it proceeded, before flying away, take note of the place where it was leaving the other half. o do this, it hovered in front of it for a few seconds, then took mall circles in front of it, then larger ones round the whole lant. I thought it had gone, but it returned again, and had nother look at the opening in the dense foliage down which he other half of the caterpillar lay. It then flew away, but nust have left its burden for distribution with its comrades at he nest, for it returned in less than two minutes, and making ne circle around the bush, descended to the opening, alighted n a leaf, and ran inside. The green remnant of the caterillar was lying on another leaf inside, but not connected with he one on which the wasp alighted, so that in running in it nissed it, and soon got hopelessly lost in the thick foliage. oming out again, it took another circle, and pounced down on he same spot again, as soon as it came opposite to it. mall seed-pods, which here grew close together, formed the harks that I had myself taken to note the place, and these the vasp seemed also to have taken as its guide, for it flew directly lown to them, and ran inside; but the small leaf on which the ragment of caterpillar lay not being directly connected with ny on the outside, it again missed it, and again got far away rom the object of its search. It then flew out again, and the ame process was repeated again and again. Always when in ircling round it came in sight of the seed-pods down it pounced, lighted near them, and recommenced its quest on foot. I was urprised at its perseverance, and thought it would have given p the search; but not so, it returned at least half-a-dozen imes, and seemed to get angry, hurrying about with buzzing vings. At last it stumbled across its prey, seized it eagerly, nd as there was nothing more to come back for, flew straight If to its nest, without taking any further note of the locality. such an action is not the result of blind instinct, but of a hinking mind; and it is wonderful to see an insect so differ-Intly constructed using a mental process similar to that of nan.

Memory.

We may here first allude to an observation of Sir ohn Lubbock already quoted in another connexion (see 147). It is here evident that the wasp, after finding the store of honey in the room, and after finding he window closed in the 'wasp-line' direction to its nest,

required three repeated lessons from Sir John before she learnt that the window on the other side of the room, and away from the direction of her nest, afforded no obstacle to her exit. Having learnt this, the fourth time she came she again flew to the closed window as before, and then, as if but dimly remembering that there was another opening somewhere that offered no such mysterious resistance to her passage, 'she took two or three turns round the room, and then flew out through the open window.' Having now taken the bearings of all the room upon her own wings, and having again found the difference between the two windows in respect of resistance, although in all other respects so much alike, the next time she came she made in the first instance as it were an experimental flight towards the closed window, but clearly had the alternative of going to the open one in her memory: for on finding the window closed as before, she did not alight, but flew straight from the closed to the open window. The same thing happened once again, but now, with the distinction between the two windows thus fully learnt, and with it the perception that in this case 'the short est cut was the longest way round,' she never again flew to the closed window; in the forty successive visits which she paid through the remainder of that day, and the hundred visits or so which she made during the two following days she seems to have uniformly flown to the open window.

As evidence of forgetfulness, it will be enough to refet to the case of another wasp which, under precisely similar circumstances to those just detailed, learnt her way out of the open window one day, having made fifty passage through it in five hours. Yet Sir John remarks,—

It struck me as curious that on the following day this was seemed by no means so sure of her way, but over and over again went to the closed window.

It is further of interest to note, as showing the similarity of the memory displayed by these insects with that of the higher animals, that there are considerable individual differences to be found in the degree of its manifestation.

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In this respect they certainly differ considerably. Some of the bees which came out of the little postern door (already described) were able to find their way back after it had been shown to them a few times. Others were much more stupid; thus one bee came out on the 9th, 10th, 11th, 12th, 14th, 15th, 16th, 17th, 18th, and 19th, and came to the honey; but though I repeatedly put her back through the postern, she was never able to find her way for herself.

I often found that if bees which were brought to honey did not return at once, still they would do so a day or two afterwards. For instance, on July 11, 1874, a hot thundery day, and when the bees were much out of humour, I brought twelve bees to some honey; only one came back, and that one only twice; but on the following day several of them returned.

This latter observation is important, as proving that bees can remember for at least a whole day the locality where they have found honey only once before, and that they so far think about their past experiences as to return to that locality when foraging.

As the association of ideas by contiguity is the principle which forms the basis of all psychology, it is desirable to consider still more attentively this the earliest manifestation that we have of it in the memory of the Hymenoptera. That it is not exercised with exclusive reference to *locality* is proved by the following observation of Sir John Lubbock:—

I kept a specimen of *Polistes Gallica* for no less than nine nonths.¹ . . . I had no difficulty in inducing her to feed on ny hand; but at first she was shy and nervous. She kept her ting in constant readiness. . . . Gradually she became quite sed to me, and when I took her on my hand apparently exected to be fed. She even allowed me to stroke her without ny appearance of fear, and for some months I never saw her ting.

One other observation which goes to prove that other hings besides locality are noted and remembered by ees may here be quoted. Sir John placed a bee in bell jar, the closed end of which he held towards a sindow. The bee buzzed about at that end trying to

^{1 &#}x27;Three months' in the Journal of the Linnæan Society, but Sir

make for the open air. He then showed her the way out of the open end of the jar, and after having thus learns it, she was able to find the way out herself. This seems to show that the bee, like the wasp on the closed window. pane, was able to appreciate and to remember the differ. ence between the quality of glass as resisting and air & permeable, although to her sense of vision the difference must have been very slight. In other words, the been must have remembered that by first flying away from the window, round the edge of the jar, and then towards the window, she could surmount the transparent obstacle: and this implies a somewhat different act of memory from that of associating a particular object—such as honeywith a particular locality. It is noteworthy that a fly under similar circumstances did not require to be taught to find its way out of the jar, but spontaneously found its own way out. This, however, may be explained by the fact that flies do not always direct their flight towards windows and therefore the escape of this one was probably not du to any act of intelligence.

While upon the subject of memory in the Hymenoptera, it is indispensable that we should again refer to the observation of Messrs. Belt and Bates already alluded to a pages 150-51. For it is from that observation rendered evident that these sand-wasps took definite pains, as it were, to teach themselves the localities to which they desired to return. Mr. Bates further observed that after thus taking a careful mental note of the place, they would return to it without a moment's hesitation after an absence of an hour. The observation of Mr. Belt, already quoted in extenso, proves that these mental notes may be taken with the utmost minuteness, so that even in the most intricate places the insect, on its return, is perfectly con-

With regard to the duration of memory, Stickner relates a case in which some bees took possession of a hollow place beneath a roof, and having been then removed into a hive, continued for several years to return and occupy the same hole with their successive swarms.

fident that it has not made a mistake.

¹ See Kirby and Spence vol. ii. p. 591.

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y, Stickney session of a en then rers to return e swarms.¹ Similarly Huber relates an observation of his own showing the duration of memory in bees. One autumn he put some honey in a window, which the bees visited in large numbers. During the winter the honey was taken away and the shutters shut. When they were again opened in the spring the bees returned, although there was no honey in the window.

These two cases amply prove that the memory of bees comparable with that of ants, which, as we have seen from analogous facts, also extends at least over a period

of many months.

Emotions.

Sir John Lubbock's experiments on this head go to how that the social sympathies of bees are even less developed than he found them to be in certain species of ants. Thus he says:—

I have already mentioned with reference to the attachment which bees have been said to show for one another, that though have repeatedly seen them lick a bee which had smeared herelf in honey, I never observed them show the slightest attenion to any of their comrades who had been drowned in water. Far, indeed, from having been able to discover any evidence of ffection among them, they appear to be thoroughly callous and tterly indifferent to one another. As already mentioned, it was necessary for me occasionally to kill a bee; but I never ound that the others took the slightest notice. Thus on the 11th of October I crushed a bee close to one which was feeding in fact, so close that their wings touched; yet the survivor ook no notice whatever of the death of her sister, but went on feeding with every appearance of composure and enjoyment, just as if nothing had happened. When the pressure was removed, she remained by the side of the corpse without the lightest appearance of apprehension, sorrow, or recognition. It was, of course, impossible for her to understand my reason or killing her companion; yet neither did she feel the slightest emotion at her sister's death, nor did she show any alarm lest he same fate should befall her also. In a second case exactly he same occurred. Again, I have several times, while a bee as been feeding, held a second bee by the leg close to her; the prisoner, of course, struggled to escape, and buzzed as loudly as he could; yet the selfish eater took no notice whatever. So

far, therefore, from being at all affectionate, I doubt whether bees are in the least fond of one another.

Réaumur, however ('Insects,' vol. v., p. 265), narrates a case in which a hive-bee was partly drowned and so rendered insensible; the others in the hive carefully licked and otherwise tended her till she recovered. This seems to show that bees, like ants, are more apt to have their sympathies aroused by the sight of ailing or injured companions than by that of healthy companions in distress; but Sir John Lubbock's observations above quoted go to prove that even in this case display of sympathy is certainly not the rule.

Powers of Communication.

Huber says that when one wasp finds a store of hone, it returns to its nest, and brings off in a short time, hundred other wasps; and this statement is confirmed by Dujardin, who witnessed a somewhat similar performance in the case of bees—the individual which first found a concealed store informing other individuals of the fact, and so on till numberless individuals had found it.

Although the systematic experiments of Sir John Lubbock have not tended to confirm these observation with regard to bees and wasps, we must not too readily allow his negative results to discredit these positive observation —more especially as we have seen that his *later* experiments have fully confirmed the opinion of these previous authors with respect to ants. His experiments on bea and wasps consisted in exposing honey in a hidden situal tion, marking a bee or wasp that came to it, and observing whether it afterwards brought any companions to share the booty. He found that although the same insec would return over and over again, strangers came rarely that their visits could only be attributed to according dental and independent discovery. Only if the hone were in an exposed situation, where the insects could one another feeding, would one follow the other to the food.

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¹ Letter to M

² Vol. xii., pp

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he conclusion to which these experiments in themselves might lead, because the very able observer F. Müller states an observation of his own which must be considered as alone sufficient to prove that bees are able to communicate information to one another:

Once (he says1) I assisted at a curious contest, which took place between the queen and the other bees in one of my hives, which throws some light on the intellectual faculties of these animals. A set of forty-seven cells have been filled, eight on a newly completed comb, thirty-five on the following, and four around the first cell of a new comb. When the queen had aid eggs in all the cells of the two older combs she went several imes round their circumference (as she always does, in order to ascertain whether she has not forgotten any cell), and then prepared to retreat into the lower part of the breeding-room. But as she had overlooked the four cells of the new comb, the workers ran impatiently from this part to the queen, pushing her, in an odd manner, with their heads, as they did also other workers they met with. In consequence the queen began again to go around on the two older combs; but as she did not find any cell wanting an egg she tried to descend, but everywhere he was pushed back by the workers. This contest lasted for a ather long while, till the queen escaped without having combleted her work. Thus the workers knew how to advise the queen that something was as yet to be done, but they knew not how to show her where it had to be done.

Again, Mr. Josiah Emery, writing to 'Nature,' with eference to Sir John Lubbock's experiments, says that the aculty of communication which bees possess is so well nd generally known to the 'bee-hunters' of America, hat the recognised method of finding a bees' nest is to ct upon the faculty in question:—

Going to a field or wood at a distance from tame bees, with their box of honey they gather up from the flowers and Imprison one or more bees, and after they have become suffiliently gorged, let them out to return to their home with their asily gotten load. Waiting patiently a longer or shorter time, ccording to the distance of the bee-tree, the hunter scarcely ver fails to see the bee or bees return accompanied with other bees, which are in like manner imprisoned till they in turn are

² Vol. xii., pp. 25-6.

¹ Letter to Mr. Darwin, published in *Nature*, vol. x., p. 102

filled, when one or more are let out at places distant from each other, and the direction in each case in which the bee flies noted, and thus, by a kind of triangulation, the position of the bee-tree proximately ascertained.

Those who have stored honey in their houses understand very well how important it is to prevent a single bee from discovering its location. Such discovery is sure to be followed by a general onslaught from the hive unless all means of access in prevented. It is possible that our American are more intelligent than European bees, but hardly probable; and I certainly shall not ask an Englishman to admit it. Those in American who are in the habit of playing first, second, and third fiddle to instinct will probably attribute this seeming intelligence to that principle.

According to De Fravière, bees have a number of different notes or tones which they emit from the stigmata of the thorax and abdomen, and by which they communicate information. He says:—

As soon as a bee arrives with important news, it is at one surrounded, emits two or three shrill notes, and taps a comrade with its long, flexible, and very slender feelers, or antenna. The friend passes on the news in similar fashion, and the intelligence soon traverses the whole hive. If it is of an agreeable kind—if, for instance, it concerns the discovery of a store of sugar or of honey, or of a flowering meadow—all remains orderly. But, on the other hand, great excitement arises if the news presages some threatened danger, or if strange animals are threatening invasion of the hive. It seems that such intelligence is conveyed first to the queen, as the most important person in the state.

This account, which is quoted from Büchner, no doubt bears indications of imaginative colouring; but if the observation as to the emission of sounds is correct—and, as we shall see, this point is well confirmed by other observers—it is most likely concerned in communicating by tone a general idea of good or harm: probably in the former case it acts as a sign, 'follow me;' and in the latter as a signal of danger. Büchner further says that, according to Landois, if a saucer of honey is placed before a hive, a few bees come out, which emit a cry of tut, tut, tut. This note is rather shrill, and resembles the cry of

an attacked b out of the hive Again,—

The best we sessed by bees take away the hour afterward of the communication about over the and the side of leave the little they meet their touch the other impression from and convey the the other parts spreads to the opeople. Then

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Apparently ingly fine scent it may seem, to the members of thousands of been trance strang when they wand to unite in one them with some certain extent object. It is all bees smell of some

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an attacked bee. Hereupon a large number of bees come out of the hive to collect the offered honey.

Again,—

The best way to observe the power of communication possessed by bees by means of their interchange of touches, is to take away the queen from a hive. In a little time, about an hour afterwards, the sad event will be noticed by a small part of the community, and these will stop working and run hastily about over the comb. But this only concerns part of the hive, and the side of a single comb. The excited bees, however, soon leave the little circle in which they at first revolved, and when they meet their comrades they cross their antennæ and lightly touch the others with them. The bees which have received some impression from this touch now become uneasy in their turn, and convey their uneasiness and distress in the same way to the other parts of the dwelling. The disorder increases rapidly, spreads to the other side of the comb, and at last to all the people. Then arises the general confusion before described.

Huber tested this communication by the antennæ by a striking experiment. He divided a hive into two quite separate parts by a partition wall, whereupon great excitement arose in the division in which there was no queen, and this was only quieted when some workers began to build royal cells.

He then divided a hive in similar fashion by a trellis, through which the bees could pass their feelers. In this case all remained quiet, and no attempt was made to build royal cells: the queen could also be clearly seen crossing her antennæ with the workers on the other side of the trellis.

Apparently the feelers are also connected with the exceedingly fine scent of the bees, which enables them, wonderful as it may seem, to distinguish friend and foe, and to recognise the members of their own hive among the thousands and thousands of bees swarming around, and to drive back from the entrance stranger or robber bees. The bee-masters, therefore, when they want two separate colonies or the members of them to unite in one hive, sprinkle water over the bees, or stupefy them with some fumigating substance, so as to make them to a certain extent insensible to smell, in order to attain their object. It is always possible to unite colonies by making the bees smell of some strong-smelling stuff, such as musk.

Lastly, under the present heading I shall quote one other observation, for which I am also indebted to

1 Loc. cit.

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Büchner's very admirable collection of facts relating to the psychology of Hymenoptera:—

Herr L. Brofft relates, in 'der Zoologische Garten' (XVIII. Year, No. 1, p. 67), that a poor and a rich hive stood next each other on his father's bee-stand, and the latter suddenly lost its queen. Before the owner had come to a decision thereupon the bees of the two hives came to a mutual understanding as to the condition of their two states. The dwellers in the queenless hive, with their stores of provisions, went over into the less populous or poorer hive, after they had assured themselves, by many influential deputations, as to the state of the interior of the poor hive, and, as appeared, especially as to the presence of an egg-laying queen!

General Habits.

The active life of bees is divided between collecting food and rearing young. We shall therefore consider

these two functions separately.

The food collected consists of two kinds, honey (which although stored in the 'crop' for the purpose of carriage from the flowers to the cells, appears to be but the condensed nectar of flowers) and so-called 'bee-bread.' This consists of the pollen of flowers, which is worked into a kind of paste by the bees and stored in their cells till it is required to serve as food for their larvæ. It is then partly digested by the nurses with honey, so that a sort of chyle is formed. It is observable that in each flight the 'carrier bees' collect only one kind of pollen, so that it is possible for the 'house bees' (which, by the way, are the younger bees left at home to discharge domestic duties with only a small proportion of older ones, left probably to direct the more inexperienced young) to sort it for storage in different cells. In the result there are several different kinds of bee-bread, some being more stimulating or nutritious than others. The most nutritious has the effect. when given to any female larva, of developing that larva into a queen or fertile female. This fact is well known to the bees, who only feed a small number of larvæ in this manner, and the larvæ which they select so to feed they place in larger or 'royal' cells, with an obvious fore mowledge of mimal will growne queen is a lways raise sevene, other larva

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nowledge of the increased dimensions to which the nimal will grow under the influence of this food. Only ne queen is required for a single hive; but the bees lways raise several, so that if any mishap should occur to ne, other larvæ may be ready to fall back upon.

Besides honey and bee-bread two other substances are ound in beehives. These are propolis and beeswax. the former is a kind of sticky resin collected for the most art from coniferous trees. This is used as mortar in uilding, &c. It adheres so strongly to the legs of the ee which has gathered it, that it can only be detached v the help of comrades. For this purpose the loaded ee presents her legs to her fellow-workers, who clean it f with their jaws, and while it is still ductile, apply it bund the inside of the hive. According to Huber, who hade this observation, the propolis is applied also to the sides of the cells. The workers first planed the surfaces ith their mandibles, and one of them then pulled out a aread of propolis from the heap deposited by the carrier es, severed it by a sudden throwing back of the head, d returned with it to the cell which it had previously en planing. It then laid the thread between the two alls which it had planed; but, proving too long, a pertion the thread was bitten off. The properly measured portion as then forced into the angle of the cell by the fore-feet d mandibles. The thread, now converted into a narrow blon, was next found to be too broad. It was therefore awed down to the proper width. Other bees then cometed the work which this one had begun, till all the walls the cells were framed with bands of propolis. The obt of the propolis here seems to be that of giving strength the cells.

The wax is a secretion which proceeds from between e segments of the abdomen. Having ingested a large eal of honey, the bees hang in a thick cluster from the of their hive in order to secrete the wax. When it gins to exude, the bees, assisted by their companions, bit off into heaps, and when a sufficient quantity of the terial has been thus collected, the work begins of buildthe cells. As the cells are used both for storing food and rearing young, I shall consider them later on. Now we have to pass to the labours incidental to propagation.

All the eggs are laid by one queen, who requires during this season a large amount of nourishment, so much indeed, that ten or twelve working bees (i.e. sterile females are set apart as her feeders. Leaving the 'royal cell' she walks over the nursery-combs attended by a retinuof workers, and drops a single egg into each open cell It is a highly remarkable fact that the queen is able to control the sex of the eggs which she lays, and only deposits drone or male eggs in the drone cells, and worker or female eggs in the worker cells—the cells DIA pared for the reception of drone larvæ being larger than those required for the worker larvæ. Young queens la more worker eggs than old queens, and when a queen from increasing age or any other cause, lays too large proportion of drone eggs, she is expelled from the conmunity or put to death. It is remarkable, also, under these circumstances, that the queen herself seems to know that she has become useless, for she loses her propensit to attack other queens, and so does not run the risk making the hive virtually queenless. There is nown doubt at all that the determining cause of an egg tun ing out male or female is that which Dzierzon has show namely, the absence or presence of fertilisation—unfert lised eggs always developing into males, and fertilise ones into females. The manner, therefore, in which queen controls the sex of her eggs must depend on som power that she has of controlling their fertilisation.

The eggs hatch out into larvæ, which require constant attention from the workers, who feed them with the chip or bee-bread already mentioned. In three weeks from the time that the egg is deposited, the white worm-like larva has passed through its last metamorphosis. When it has emancipated itself its nurses assemble round it wash and caress it, as well as to supply it with for They then clean out the cell which it has left.

When so large a number of the larvæ hatch out as overcrowd the hive, it is the function of the queen to be forth a swarm. Meanwhile several larval queens have be

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n course of development, and matters are so arranged by he foresight of the bees, that one or more young queens re ready to emerge at a time when otherwise the hive ould be left queenless. But the young queen or queens, lthough perfectly formed, must not escape from their oval prison-houses until the swarm has fairly taken place; he worker bees will even strengthen the coverings of hese prison-houses if, owing to bad weather or other auses, swarming is delayed. The prisoner queens, hich are fed through a small hole in the roof of their ells, now continually give vent to a plaintive cry, called v the bee-keepers 'piping,' and this is answered by the nother queen. The tones of the piping vary. eason why the young queens are kept such close risoners till after the departure of the mother queen ith her swarm, is simply that the mother queen would estroy all the younger ones, could she get the chance. v stinging them. The workers, therefore, never allow he old queen to approach the prisons of the younger nes. They establish a guard all round these prisons or by cells, and beat off the old queen whenever she ideavours to approach. But if the swarming season is ver, or anything should prevent a further swarm from eing sent out, the worker bees offer no further resistance the jealousy of the mother queen, but allow her in cold lood to sting to death all the young queens in their nursery risons. As soon as the old queen leaves with a swarm, le young queens are liberated in succession, but at tervals of a few days; for if they were all liberated at ice they would fall upon and destroy one another. Each ung queen as it is liberated goes off with another farm, and those which remain unliberated are as carefully parded from the liberated sister queen as they were eviously guarded from the mother queen. When the ason is too late for swarming the remaining young teens are liberated simultaneously, and are then allowed fight to the death, the survivor being received as vereign.

The bees, far from seeking to prevent these battles, appear excite the combatants against each other, surrounding and

bringing them back to the charge when they are disposed to recede from each other; and when either of the queens shows a disposition to approach her antagonist, all the bees forming the cluster instantly give way to allow her full liberty of attack. The first use which the conquering queen makes of her victory is to secure herself against fresh dangers by destroying all he future rivals in the royal cells; while the other bees, which are spectators of the carnage, share in the spoil, greedily devouring any food which may be found at the bottom of the cells, and even sucking the fluid from the abdomen of the pupe before they toss out the carcasses. I

Similarly, when a strange queen is put into a hive already provided with a queen—

A circle of bees instinctively crowd around the invader, not however, to attack her—for a worker never assaults a queenbut to respectfully prevent her escape, in order that a combat may take place between her and their reigning monarch. The lawful possessor then advances towards the part of the combater the invader has established herself, the attendant workers clear a space for the encounter, and, without interfering, wait the result. A fearful encounter then ensues, in which one is stung to death, the survivor mounting the throne. Although the workers of a de facto monarch will not fight for her defense yet, if they perceive a strange queen attempting to enter the hive, they will surround her, and hold her until she is starved to death; but such is their respect for royalty that they never attempt to sting her.²

All these facts display a wonderful amount of apparently sagacious purpose on the part of the worker although they may not seem to reflect much credit on the intelligence of the queens. But in this connection wo must remember the observation of F. Huber, who so two queens, which were the only ones left in the him engaged in mortal combat; and when an opportunity arose for each to sting the other simultaneously, the simultaneously released each other's grasp, as if in home of a situation that might have ended in leaving the him queenless. This, then, is the calamity to avert which

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Art. 'Bees,' Encycl. Brit.

² Dr. Kemp, Indications of Instinct.

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he instincts both of workers and queens are directed. and that these instincts are controlled by intelligence is aggested, if not proved, by the adaptations which they how to special circumstances. Thus, for instance, F. Huber smoked a hive so that the queen and older bees ffected their escape, and took up their quarters a short listance away. The bees which remained behind set bout constructing three royal cells for the purpose of earing a new queen. Huber now carried back the old meen and ensconced her in the hive. Immediately the ees set about carrying away all the food from the royal ells, in order to prevent the larvæ contained therein from leveloping into queens. Again, if a strange queen is preented to a hive already provided with one, the workers do ot wait for their own queen to destroy the pretender, but hemselves sting or smother her to death. When, on the ther hand, a queen is presented to a hive which is withut one, the bees adopt her, although it is often necessary or the bee-master to protect her for a day or two in a rellis cage, until her subjects have become acquainted ith her. When a hive is queenless, the bees stop all ork, become restless, and make a dull complaining noise. his, however, is only the case if there is likewise a total bsence of royal pupæ, and of ordinary pupæ under three ays of age—i.e. the age during which it is possible to ear an ordinary larva into a queen.

As soon as the queen has been fertilised, and the ervices of the drones therefore no longer required, the orker bees fall upon their unfortunate and defenceless rothers to kill them, either by direct stinging or by prowing them out of the hive to perish in the cold. The rones' cells are then torn down, and any remaining drone ggs or pupæ destroyed. Generally all the drones—which may number more than a thousand—are slaughtered in the course of a single day. Evidently the object of this passacre is that of getting rid of useless mouths; but here is a more difficult question as to why these useless touths ever came into existence. It has been suggested that the enormous disproportion between the present number of males and the single fertile female refers to

a time before the social instincts became so complex of consolidated, and when, therefore, bees lived in lesse communities. Probably this is the explanation, although I think we might still have expected that before this period in their evolution had arrived bees might have de veloped a compensating instinct, either not to allow the queen to lay so many drone eggs, or else to massacre the drones while still in the larval state. But here we must remember that among the wasps the males do work (chief) domestic work, for which they are fed by their foraging sisters); so it is possible that in the hive-bee the drope were originally useful members of the community, and that they have lost their primitively useful instincts. By whatever the explanation, it is very curious that here among the animals which are justly regarded as exhibiting the highest perfection of instinct, we meet with perhan the most flagrant instance in the animal kingdom It is the more remarkable that instinct unperfected. the drone-killing instinct should not have been better de veloped in the direction of killing the drones at the mor profitable time—namely, in their larval or oval statefrom the fact that in many respects it seems to have been advanced to a high degree of discriminative refinement Thus, to quote Büchner,—

That the massacre of the drones is not performed entirely from an instinctive impulse, but in full consciousness of the object to be gained, is proved by the circumstance that it carried out the more completely and mercilessly the more for tile the queen shows herself to be. But in cases where this fertility is subject to serious doubt, or when the queen has been fertilised too late or not at all, and therefore only lays drong eggs, or when the queen is barren, and new queens, to be for tilised later, have to be brought up from working-bee larva then all or some of the drones are left alive, in the clear pre vision that their services will be required later. . . . This win calculation of consequences is further exemplified in that some times the massacre of the drones takes place before the time a swarming, as, for instance, when long-continued unfavourable weather succeeds a favourable beginning of spring, and make arlier times, o the bees anxious for their own welfare. If, however, the embled bees in weather breaks, and work again becomes possible, so that the rub-slaying in

hees take courag prepare them in is distinguished that the bees the drone larvæ, sav tion. Not less circumstances w rate climate to a ecting lasts long but at a later pe

But the ph more difficult i bees. For, un vear to year, th with the excep his season of destroy all the pinion of som icence of the I o understand l case is to be ex idual females winter cannot b of grubs; and, nunity is so so rhat advantage he whole hum: vere to perish ace would pro before the ${f end}$ o nd other 'usel with regard to efore, and I or ion to the fact roblem present nstinct as exh as suggested

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hees take courage anew, they then bring up new drones, and prepare them in time for the swarming. This killing of drones is distinguished from the regular drone massacre by the fact that the bees then only kill the developed drones, and leave the drone larvæ, save when absolute hunger compels their destruction. Not less can it be regarded as a prudent calculation of circumstances when the bees of a hive, brought from our temperate climate to a more southern country, where the time of colecting lasts longer, do not kill the drones in August, as usual, but at a later period, suitable to the new conditions

But the philosophy of drone-killing is, I think, even more difficult in the case of the wasps than in that of the bees. For, unlike the bees, whose communities live from year to year, the wasps all perish at the end of autumn, with the exception of a very few fertilised females. his season of universal calamity approaches, the workers lestroy all the larval grubs—a proceeding which, in the ppinion of some writers, strikingly exemplifies the beneficence of the Deity! Now, it does not appear to me easy o understand how the presence of such an instinct in this case is to be explained. For, on the one hand, the indiridual females which are destined to live through the winter cannot be conspicuously benefited by this slaughter of grubs; and, on the other hand, the rest of the comnunity is so soon about to perish, that one fails to see of what advantage it can be to it to get rid of the grubs. If he whole human race, with the exception of a few women, rere to perish periodically once in a thousand years, the ace would profit nothing by destroying, a few months efore the end of each millennium, all sick persons, lunatics, nd other 'useless mouths.' I have not seen this difficulty with regard to the massacring instinct in wasps mentioned before, and I only mention it now in order to draw attenion to the fact that there seems to be a more puzzling problem presented here than in the case of the analogous nstinct as exhibited by bees. The only solution which as suggested itself to my mind is the possibility that in arlier times, or in other climates, wasps may have re-embled bees in living through the winter, and that the e, so that the rub-slaying instinct is in them a survival of one which

was then, as in the case of the bees now, a clearly beneficial instinct.

For some days before swarming begins, there is a great excitement and buzzing in the hive, the temperature of which rises from 92° to 104°. Scouts having been previously sent out to explore for suitable quarters wherein to plant the new colony, these now act as guides. The swarm leaves the hive with their queen. The bees which remain behind busy themselves in rearing out the pupe, which soon arriving at maturity, also quit the hive in successive swarms. According to Büchner, 'secondary swarms with young queens send out no scouts, but fly at random through the air. They clearly lack the experience and prudence of the older bees.' And, regarding the behaviour of the scouts sent out by primary swarms, this author says:—

M. de Fravière had the opportunity of observing the manner in which such an examination is carried on, and with what prodence and accuracy. He placed an empty beehive, made in a new style, in front of his house, so that he could exactly watch from his own window what went on inside and out without disturb ance to himself or to the bees. A single bee came and examined the building, flying all round it and touching it. It then k itself down on the board, and walked carefully and thorough over the interior, touching it continually with its antennæ so a to subject it on all sides to a thorough investigation. The result of its examination must have been satisfactory, for after it had gone away it returned accompanied by a crowd of some fifty friends, which now together went through the same pw cess as their guide. This new trial must also have had a god result, for soon a whole swarm came, evidently from a distant spot, and took possession. Still more remarkable is the behaviour of the scouts when they take possession of a satis factory hive or box for an imminent or approaching swarm Although it is not yet inhabited they regard it as their property watch it and guard it against stranger bees or other assailant and busy themselves earnestly in the most careful cleansing it, so far as this cleansing is impossible to the setter up of the hive. Such a taking possession sometimes occurs eight day before the entrance of the swarm.

Wars.—As with ants, so with bees, the great cause

war is plund numberless of a large measu their labour in of other hives. in concert. only in indivi in plundering stealth. 'The into the hive fectly consciou belonging to t full consciousn are successful leads other me them; thus it velop maraudii in concert to r precipitates its and if successi first of all sear whereby they d hive with ease. successful, the hat the robbe n their own we When tates.' he invaders k inding that all but very often heir conquero heir cells, and hive of their mptied, the n esistance is off n this way a wh iebold observ $Polistes\ gallic$ f the defender nemies to a

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war is plunder; and facts now well substantiated by numberless observers concerning 'robber-bees' indicate a large measure of intelligence. These aim at lessening their labour in collecting honey by plundering the store of other hives. The robberies may be conducted singly or in concert. When the thieving propensity is developed only in individual cases, the thieves cannot rely on force in plundering a foreign state, and so resort to cautious stealth. 'They show by their whole behaviour-creeping into the hive with careful vigilance—that they are perfeetly conscious of their bad conduct; whereas the workers belonging to the hive fly in quickly and openly, and in full consciousness of their right.' If such solitary burglars are successful in obtaining plunder, their bad example leads other members of their own community to imitate them; thus it is that the whole bee-nation may develop marauding habits, and when they do this they act in concert to rob by force. In this case an army of bees precipitates itself upon the foreign hive, a battle ensues, and if successful in overcoming resistance, the invaders first of all search out the queen-bee and put her to death, whereby they disorganise their enemies and plunder the hive with ease. It is observed that when this policy is once successful, the spirit of aggrandisement is encouraged, so hat the robber-bees 'find more pleasure in robbery than n their own work, and become at last formidable robberstates.' When an invaded hive is fairly overcome by he invaders killing the queen, the owners of the hive, inding that all is lost, not only abandon further resistance, but very often reverse their policy and join the ranks of heir conquerors. They assist in the tearing down of heir cells, and in the conveyance of the honey to the live of their invaders. 'When the assailed hive is emptied, the next ones are attacked, and if no effective esistance is offered, are robbed in similar fashion, so that n this way a whole bee-stand may be gradually destroyed. biebold observed the same facts in the case of wasps Polistes gallica). If, however, the battle turns in favour of the defenders, they pursue the flying legions of their nemies to a distance from their home. It sometimes happens that the plundered hive offers no resistance at all, owing to the robbers having visited the same flowers as the robbed, and so probably (having much the same smell) not being recognised as belonging to a different community. The thieves, when they find such to be the case, may become so bold as to stop the bees that are returning to the hive with their loads, of which they deprive them at the entrance of the hive. This is done by a process which one observer, Weygandt,¹ calls 'milking,' and it seems that the milking bee attains the double advantage of securing the honey from the milked one and disarming suspicion of the other bees by contracting its smell and entering the hive loaded, into which it is admitted without opposition to continue its plunder.

Sometimes robber-bees attack their victims in the fields at a distance from the hives. This sort of high way robbery is generally conducted by a gang of four of five robber-bees which set upon a single honest bee, hold him by the legs, and pinch him until he unfolds his tongue, which is sucked in succession by his assailants.

who then suffer him to depart in peace.'

It is strange that hive-bees of dishonest temperaments seem able to coax or wheedle humble-bees into the voluntary yielding of honey. 'Humble-bees have been known to permit hive-bees to take the whole honey that they have collected, and to go on gathering more, and handing it over, for three weeks, although they refuse to part with it, or seek refuge in flight, when wasps make similar overtures.' 2

Besides theft and plunder, there are other causes of warfare among bees, which, however, are only apparent in their effects. Thus, for some undiscernible reason, dues are not infrequent, which generally end in the death of one or both combatants. At other times, equally without apparent reason, civil war breaks out in a hive, which is sometimes attended with much slaughter.

Architecture.—Coming now to the construction of the cells and combs, there is no doubt that here we meet with

¹ The Bec, 1877, No. 1.

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² Dr. Lindley Kemp, Indications of Instinct.

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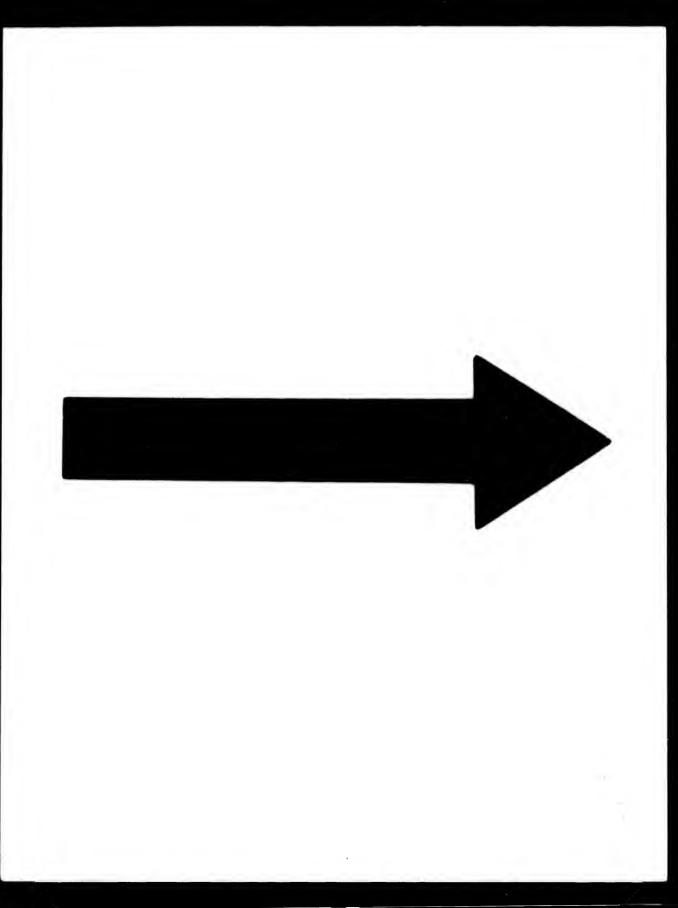
the most astonishing products of instinct that are presented in the animal kingdom. A great deal has been written on the practical exhibition of high mathematical principles which bees display in constructing their combs in the form that secures the utmost capacity for storage of honey with the smallest expenditure of building material. The shortest and clearest statement of the subject that I have met with is the following, which has been given by Dr. Reid:—

There are only three possible figures of the cells which can make them all equal and similar, without any useless interstices. These are the equilateral triangle, the square, and the regular hexagon. Mathematicians know that there is not a fourth way possible in which a plane may be cut into little spaces that shall be equal, similar, and regular, without useless spaces. Of the three figures, the hexagon is the most proper for convenience and strength. Bees, as if they knew this, make their cells regular hexagons.

Again, it has been demonstrated that, by making the bottoms of the cells to consist of three planes meeting in a point, there is a saving of material and labour in no way inconsiderable. The bees, as if acquainted with these principles of solid geometry, follow them most accurately. It is a curious mathematical problem, at what precise angle the three planes which compose the bottom of a cell ought to meet, in order to make the greatest possible saving, or the least expense of material and abour. This is one of the problems which belong to the higher parts of mathematics. It has accordingly been resolved by ome mathematicians, particularly by the ingenious Maclaurin, by a fluctionary calculation, which is to be found in the Transactions of the Royal Society of London. He has determined precisely the angle required, and he found, by the most exact mensuration the subject would admit, that it is the very angle n which the three planes in the bottom of the cell of a honeyomb do actually meet. 1

Marvellous as these facts undoubtedly are, they may now be regarded as having been satisfactorily explained. Long ago Buffon sought to account for the hexagonal orm of the cells by an hypothesis of mutual pressure. Supposing the bees to have a tendency to build tubular

¹ Handcock on Instinct, p. 18.



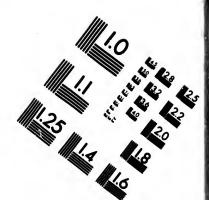
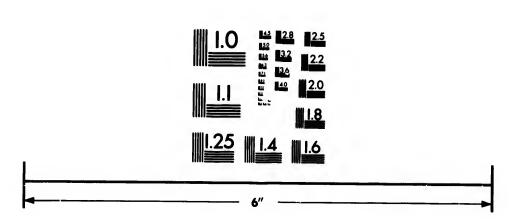


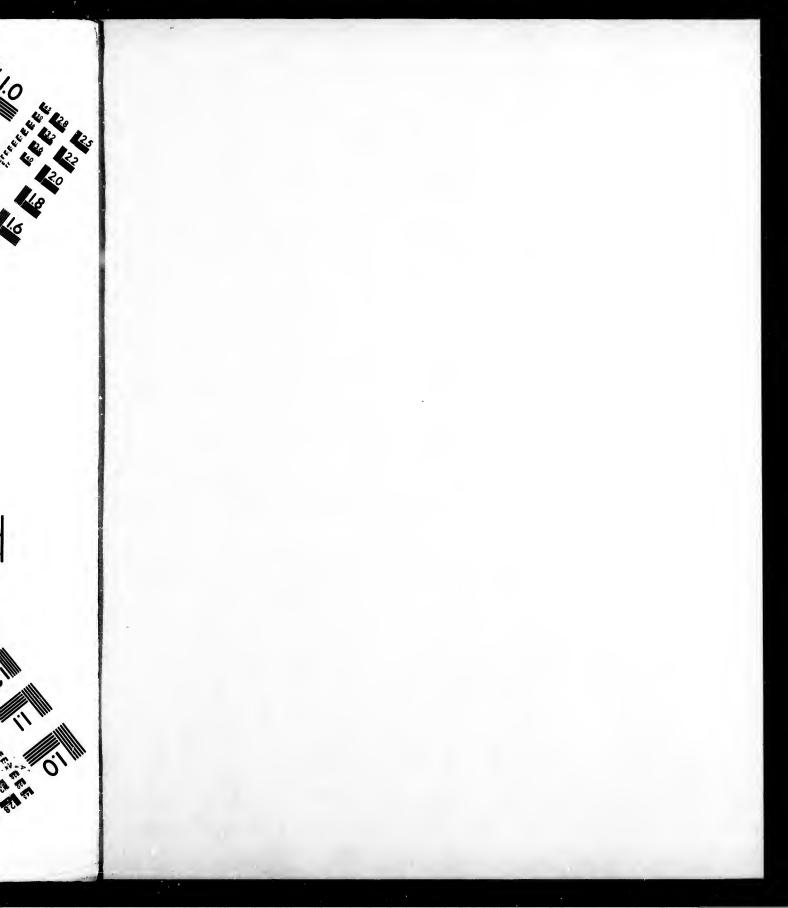
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cells, if a greater number of bees were to build in a given space than could admit of all the parallel tubes being completed, tubes with flat sides and sharp angles might result, and if the mutual pressure were exactly equal in all directions, these sides and angles would assume the form of hexagons. This hypothesis of Buffon was sustained by such physical analogies as the blowing of a crowd of soalbubbles in a cup, the swelling of moistened peas in a confined space, &c. The hypothesis, however, as thus presented was clearly inadequate; for no reason is assigned why the mutual pressure, even if conceded to exist, should always be so exactly equal in all directions as to convert all the cylinders into perfect hexagons—even the analogy of the soan-bubbles and the moistened peas failing as pointed out by Brougham and others, to sustain it, seeing that as a matter of fact bubbles and peas under circumstances of mutual pressure do not assume the form of hexagons, but, on the contrary, forms which are conspicuously irregular. Moreover, the hypothesis fails to account for the particular prismatic shape presented by the cell base. Therefore it is not surprising that this hypothesis should have gained but small acceptance. Kirby and Spence dispose of it thus:—'He (Buffon) gravels tells us that the boasted hexagonal cells of the bee are produced by the reciprocal pressure of the cylindrical bodies of these insects against each other!!' The double note of admiration here may be taken to express the feelings with which this hypothesis of Buffon was regarded by all the more sober-minded naturalists. turns out to have been not very wide of the mark. Ask often the case with the gropings of a great mind, the idea contains the true principle of the explanation, although it fails as an explanation from not being in a position to take sufficient cognizance of all the facts. Safer it is for lesser minds to restrain their notes of exclamation while considering the theories of a greater; however crude of absurd the latter may appear, the place of their birth renders it not impossible that some day they may prove to have been prophetic of truth revealed by fuller know

¹ Introd. Ent., ii., p. 465.

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ledge. Usually in such cases the final explanation is eventually reached by the working of a yet greater mind, and in this case the undivided credit of solving the problem is to be assigned to the genius of Darwin.

Mr. Waterhouse pointed out 'that the form of the cell stands in close relation to the presence of adjoining cells.'

Starting from this fact, Mr. Darwin says,—

Let us look to the great principle of gradation, and see whether Nature does not reveal to us her method of work. At one end of a short series we have humble-bees, which use their old cocoons to hold honey, sometimes adding to them short tubes of wax, and likewise making separate and very irregular rounded cells of wax. At the other end of the series we have the cells of the hive-bee, placed in a double layer. . . . In the series between the extreme perfection of the cells of the hivebee and the simplicity of those of the humble-bee we have the cells of the Mexican Melipona domestica, carefully described and figured by Pierre Huber. . . . It forms a nearly regular waxen comb of cylindrical cells, in which the young are hatched, and, in addition, some large cells of wax for holding honey. These latter cells are nearly spherical and of nearly equal sizes, and are aggregated into an irregular mass. But the important thing to notice is, that these cells are always made at that degree of nearness to each other that they would have intersected or broken into each other if the spheres had been completed; but this is never permitted, the bees building perfectly flat cells of wax between the spheres which thus tend to intersect. Hence each cell consists of an outer spherical portion; and of two, three, or more flat surfaces, according as the cell adjoins two, three, or more other cells. When one cell rests on three other tells, which, from the spheres being nearly of the same size, is very frequently and necessarily the case, the three flat surfaces re united into a pyramid; and this pyramid, as Huber has emarked, is manifestly a gross imitation of the three-sided yramidal base of the cell of the hive-bee. . . .

Reflecting on this case, it occurred to me that if the Meliona had made its spheres at some given distance from each ther, and had made them of equal sizes, and had arranged them ymmetrically in a double layer, the resulting structure would ave been as perfect as the comb of the hive-bee. Accordingly wrote to Prof. Miller of Cambridge, and this geometer has indly read over the following statement, drawn up from his

of formation, and tells me that it is strictly correct.

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This statement having fully borne out his theory, Mr. Darwin continues:—

Hence we may safely conclude that, if we could slightly modify the instincts already possessed by the Melipona, and in themselves not very wonderful, this bee would make a structure is wonderfully perfect as that of the hive-bee. We must suppose the Melipona to have the power of forming her cells truly spherical, and of equal sizes; and this would not be very surprising, seeing that she already does so to a certain extent, and seeing what perfectly cylindrical burrows many insects make in wood, apparently by turning round on a fixed point. suppose the Melipona to arrange her cells in level layers, as she already does her cylindrical cells; and we must further suppose —and this is the greatest difficulty—that she can somehow judge accurately at what distance to stand from her fellow-labourers when several are making their spheres; but she is already so far able to judge of distance that she always describes her spheres so as to intersect to a certain extent; and then she unites the points of intersection by perfectly flat surfaces. By such modifications of instinct, which in themselves are not very wonderful—hardly more wonderful than those which guide a bird to make its nest,—I believe that the hive-bee has acquired through natural selection her inimitable architectural powers.

Mr. Darwin next tested this theory by the experiment of introducing into beehives plates of wax, and observing that the bees worked upon these plates just as the theory required. That is to say, they made their cells by excavating a number of little circular pits at equal distances from one another, so that by the time the pits had acquired the width of an ordinary cell, the sides of the pits intersected. As soon as this occurred the bees ceased to excavate, and instead began to build up flat walls of war on the lines of intersection. Other experiments with very thin plates of vermilion-coloured wax showed that the bees all worked at about the same rate, and on opposite sides of the plates, so that the common bottoms of any two opposite pits were flat. These flat bottoms 'were situated, as far as the eye could judge, exactly along the planes of imaginary intersection between the basins of the opposite sides of the ridge of wax;' so that if the

Origin of Species, 'Cell-making Instinct.'

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experiment d observing s the theory cells by exual distances pits had acs of the pits es ceased to walls of wax nts with very ed that the l on opposite toms of any ttoms 'were ly along the ne basins on plate of wax had been thick enough to admit of the opposite basins being deepened (and widened) into cells, the mutual intersection of adjacent as well as opposite bottoms would have given rise, as in the first experiment with the thick plate of wax, to the pyramidal bottoms. Experiments with the vermilion wax also showed, as Huber had previously stated, that a number of individual bees work by turns at the same cell; for by covering parts of growing cells with vermilion wax, Mr. Darwin-

Invariably found that the colour was most delicately diffused by the bees—as delicately as a painter could have done it with his brush—by atoms of the coloured wax having been taken from the spot on which it had been placed, and worked into the growing edges of the cells all round.

Such, omitting details, is the substance of Mr. Darwin's theory. In summary he concludes,—

The work of construction seems to be a sort of balance struck between many bees, all instinctively standing at the same relative distance from each other, all trying to sweep equal spheres, and then building up, or leaving ungnawed, the planes of intersection between these spheres.

This theory, while serving as a full and simple explanation of all the facts, has, as we have seen, been so fully substantiated by observation and experiment, that it deserves to be regarded as raised to the rank of a completed demonstration. It differs from the theory of Buffon in two important particulars: it embraces all the facts, and supplies a cause adequate to explain them. This cause is natural selection, which converts the random pressure in Buffon's theory into a precisely regulated principle. Random pressure alone could never produce he beautifully symmetrical form of the hexagonal cell with the pyramidal bottom; but it could and must have produced the intersection of cylindrical cells among posibly many extinct species of bees, such as the Melipona. Whenever this intersection occurred in crowded nests, it nust clearly have been of great benefit in securing that if the conomy of precious wax; for in every case where a flat rall of partition between two adjacent cells did duty instead of a double cylindrical wall of separate cells, there wax should have been saved. Thus we can see how natural selection would have worked towards the developing of an instinct to excavate cells near enough together to produce intersection; and once begun, there is no reason why this instinct should not have been perfected by the same agency, till we meet with its ideal perfection in the hive-bee. For as Mr. Darwin observes.—

With respect to the formation of wax, it is known that bees are often hard pressed to get sufficient nectar; and I am informed by Mr. Tegetmeier that it has been experimentally proved that from twelve to fifteen pounds of dry sugar are consumed by a hive of bees for the secretion of a pound of wax; & that a prodigious quantity of fluid nectar must be collected and consumed by the bees in a hive for the secretion of the war necessary for the construction of their combs. Moreover, many bees have to remain idle for many days during the process of secretion. . . . Hence it would continually be more and more advantageous to our humble-bees if they were to make their cells more and more regular, nearer together, and aggregated into a mass, like the cells of Melipona; for in this case a large part of the bounding surface of each cell would serve to bound the adjoining cell, and much labour and wax would be saved Again, from the same cause, it would be advantageous to the Melipona if she were to make her cells closer together, and more regular in every way than at present; for then, as we have seen, the spherical surfaces would wholly disappear and be replaced by plane surfaces; and the Melipona would make comb as perfect as that of the hive-bee. Beyond this stage of perfection in architecture, natural selection could not lead; for the comb of the hive-bee, as far as we can see, is absolutely perfect in economising labour and wax.

The problem, then, as to the origin and perfection of the cell-making instinct appears thus to have been fully and finally solved. I shall now adduce a few facts to show that while the general instinct of building hexagonal cells has doubtless been acquired by natural selection in the way just explained, it is nevertheless an instinct not wholly of a blind or mechanical kind, but is constantly under the control of intelligent purpose. Thus Mr. Darwin observes,—

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Again, H had already I did not arran design of her undesirable of it, pulled dow it to the first exactly follow Büchner.—

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known that ; and I am perimentally gar are cond of wax; so collected and of the wax reover, many he process of ore and more o make their gregated into e a large part to bound the ald be saved. tageous to the together, and then, as we sappear and be would make a this stage of not lead; for is absolutely

perfection of ve been fully a facts to show he kangonal selection in instinct not is constantly as Mr. Darwin

It was really curious to note in cases of difficulty, as when two pieces of comb met at an angle, how often the bees would pull down and rebuild in different ways the same cell, sometimes recurring to a shape which they had at first rejected.

Again, Huber saw a bee building upon the wax which had already been put together by her comrades. But she did not arrange it properly, or in a way to continue the design of her predecessors, so that her building made an undesirable corner with theirs. 'Another bee perceived it, pulled down the bad work before our eyes, and gave it to the first in the requisite order, so that it might exactly follow the original direction.' Similarly, to quote Büchner,—

All the cells have not the same shape, as would be the case I the bees in building worked according to a perfectly instinctive and unchangeable plan. There are very manifold changes and irregularities. Almost in every comb irregular and unfinished ells are to be found, especially where the several divisions of a omb come together. The small architects do not begin their omb from a single centre, but begin building from many different points, so as to progress as rapidly as possible, and so that he greatest number may work simultaneously; they therefore build from above downwards, in the shape of flat truncated ones or hanging pyramids, and these several portions are afterwards united together during the winter building. At these ines of junction it is impossible to avoid irregular cells between he pressed together or unnaturally lengthened ones. The ame is true more or less of the passage cells, which are made bunite the large cells of the so-called drone wax with the maller ones of the working bees, and which are generally aced in two or three rows. The cells also which they usually hild from the combs to the glass walls of their hives, in order hold them up, show somewhat irregular forms. Finally, in aces where special conditions of the situation do not otherise permit, it may be observed that the bees, far from clinging stinately to their plan, very well understand how to accompolate themselves to circumstances not only in cell-building, talso in making their combs. F. Huber tried to mislead fir instinct, or rather to put to the proof their reason and verness in every possible way, but they always emerged triphant from the ordeal. For instance, he put bees in a hive

¹ Origin of Species, p. 225

the floor and roof of which were made of glass, that is of a body which the bees use very unwillingly for the attachment of the combs, on account of its smoothness. Thus the possibility of building as usual from above downwards, and also from below upwards, was taken away from them; they had no point of support save the perpendicular walls of their dwelling. There thereupon built on one of these walls a regular stratum if cells, from which, building sideways, they tried to carry the comb to the opposite side of the hive. To prevent this Huber covered that side also with glass. But what way out of the difficulty was found by the clever insects? Instead of building further in the projected direction, they bent the comb round at the extreme point, and carried it at a right angle towards one of the inner sides of the hive which was not covered with glass and there fastened it. The form and dimensions of the cells must necessarily have been altered thereby, and the arrange ment of their work at the angle must have been quite different from the usual. They made the cells of the convex side » much broader than those of the concave that they had diameter two or three times as great, and yet they managed join them properly with the others. They also did not wait bend the comb until they came to the glass itself, but recovnised the difficulty beforehand, which had been interposed in Huber while they were building with a view to overcome the first difficulty.

SPECIAL HABITS.

The Mason-Bec.—This insect closes the roof of it larval cell with a kind of mortar, which sets as hard a stone. A little hole, closed only with soft mud, is, however, left in one part of the roof as a door of exit forth matured insect. It is said that when a mason-bee find an old and deserted nest, it saves itself the trouble of making a new one—utilising the ready-made nest after having well cleaned it. In Algiers the mason-bees have been observed in this way to utilise empty snail-shell According to Blanchard, some individuals avoid the labor of making their own nests or houses for their young, by possessing themselves of their neighbours' houses either the possession that the posses

¹ Mind in Animals, pp. 252-3.

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cording to circumstances, possesses itself of old nests. cleanses and improves them, and thereby shows that it can fully appreciate the immediate position? Can one believe that no kind of reflection is here necessary?'

The Tapestry-Bee.—The so-called tapestry-bee digs holes for her larvæ three or four inches deep in the earth. and lines the walls and floor of the chamber with petals of the poppy laid perfectly smooth. Several layers of petals are used, and when the eggs are introduced the chamber s closed by drawing all the leaves together at the top. Loose earth is then piled over the whole structure in order to conceal it. The so-called rose-bee (Megachile centur-

ularis) displays very similar habits.1

The Carpenter-Bee.—This was first observed and decribed by Réaumur.² It makes a long cylindrical tube in the wood of beams, palings, &c. This it divides into a number of successive chambers by partitions made of gglutinated saw-dust built across the tube at right ngles to its axis. In each chamber there is deposited a ingle egg, together with a store of pollen for the nourishpent of the future larva. The larvæ hatch out in sucession and in the order of their age—i.e. the dates at hich they were deposited. To provide for this, the bee ores a hole from the lower cell to the exterior, so that ach larva, when ready to escape from its chamber, finds n open way from the tube. The larvæ have to cut their wn way out through the walls of their respective chambers, nd it is remarkable that they always cut through the wall hat faces the tubular passage left by the parent; they ever bore their way out in the opposite direction, which, ere they to do so, would entail the destruction of all the ther and immature larvæ.

The Carding-Bee.—This insect surrounds its nest ith a layer of wax, and then with a thick covering of oss. For this purpose a number of bees co-operate, d in order to save time each bee does not find and carry s own moss, but, with a division of labour similar to that

ography, vol. iii., pp. 272–5. ² Mém. sur les Insectes, tom. vi., p. 39.

¹ For a complete account of these habits see Bingley, Animal

which we have already noticed in the case of certain anta, a row of bees is formed, and the bits of moss passed from one to another along the line. There is a long passage to the nest, through which the moss has to be passed, and it is said that at the mouth of the tunnel a guard is stationed to drive away ants or other intruders.

Wasps.—These usually construct their nests of wood. dust, which they scrape off the weather-worn surfaces of boards, palings, &c., and work into a kind of paper with their saliva. If they happen to find any real paper, ther perceive that it so much resembles the product of their own manufacture that they utilise it forthwith. The wasps do not require any special cells or chambers for the storage of honey, as they do not lay up any supply for the winter. The cells which they construct are therefore used exclusively for the rearing of larvæ. In form these cells are sometimes cylindrical or globular, but more usually hexagonal, like those of the hive-bee. Although the mode of building is different from that employed by the bees, there can be little doubt that if it were as care fully investigated Mr. Darwin's theory of transition from the cylindrical to the hexagonal form would be found to apply here also, seeing that both forms so frequently occur in the same nest.

The Mason-Wasp.—The habits of this insect are described by Mr. Bates. It constructs its nest of clay. Each pellet that the insect brings it lays on the top of its nest wall, and then spreads it out with its jaws, and treads it smooth with its feet. The nest, which is suspended on the branch of a tree, is then stocked with spiders and insects paralysed by stinging. The victims, not being wholly deprived of life, keep fresh until required as food of the developing larvæ.

The Butcher-Wasps.—These also paralyse their pres in a similar manner, and for a similar purpose. Falm removed from a so-called sphex-wasp a killed grass hopper, which it was conveying to its nest and ha momentarily laid down at the mouth of the burrow-s these insects always do on returning with prey, in order to see that nothing has intruded into the burrow during lingle bee took

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yse their pret rpose. Fabre killed grass nest and had their absence. Fabre car.led the dead or paralysed grasshopper to a considerable distance from the hole. On coming out the insect searched about until it found its prey. It then again carried it to the mouth of its burrow, and again laid it down while it once more went in to see that all was right at home. Again Fabre removed the grasshopper, and so on for forty times in succession—the sphex never omitting to go through its fixed routine of examining the interior of its burrow every time that it brought the prey to its mouth.

Mr. Mivart, in his 'Lessons from Nature,' points to the instinct of this animal in the stinging of the ganglion of its prey as one that cannot be explained on Mr. Darwin's theory concerning the origin of instincts. In my next work, which will have to deal with this theory, I shall consider Mr. Mivart's difficulty, and also the difficulty first pointed out by Mr. Darwin himself as to why neuter insects, separated as they appear to be from the possibility of communicating by heredity any instinctive acquirements of the individual to the species, should present any instincts at all.

General Intelligence.

Beginning with Sir John Lubbock's observations on his head, I shall first quote his statements with regard to way-finding: ---

I have found, he says, that some bees are much more inteligent in this respect than others. A bee which I had fed everal times, and which had flown about in the room, found its way out of the glass in a quarter of an hour, and when put in a econd time came out at once. Another bee, when I closed the ostern door, used to come round to the honey through an pen window.

Bees seem to me much less clever in finding things than I ad expected. One day (April 14, 1872), when a number of hem were very busy on some barberries, I put a saucer with ome honey between two bunches of flowers; these were rene burrow—see peatedly visited, and were so close that there was hardly room prey, in order or the saucer between them, yet from 9.30 to 3.30 not a burrow during ingle bee took any notice of the honey. At 3.30 I put some

honey on one of the bunches of flowers, and it was eagerly sucked by the bees; two kept continually returning till past

live in the evening.

One day when I came home in the afternoon I found that at least a hundred bees had got into my room through the postern and were on the window, yet not one was attracted by an open jar of honey which stood in a shady corner about 3 feet 6 inches from the window.

One day (29th April, 1872) I placed a saucer of honey close to some forget-me-nots, on which bees were numerous and busy; yet from 10 A.M. till 6 only one bee went to the honer.

I put some honey in a hollow in the garden wall opposite the hives at 10.30 (this wall is about five feet high and for feet from the hives); yet the bees did not find it during the

whole day.

On the 30th March, 1873, a fine sunshiny day, when the bees were very active, I placed a glass containing honey at 9 in the morning on the wall in front of the hives; but not a single bee went to the honey the whole day. On April 20 I tried the same experiment, with the same result.

September 19.—At 9.30 I placed some honey in a glass about four feet from and just in front of the hive; but during

the whole day not a bee observed it.

As it then occurred to me that it might be suggested that there was something about this honey which rendered it unst tractive to the bees, on a following day I placed it again on the top of the wall for three hours, during which not a single be came, and then moved it close to the alighting-board of the hive. It remained unnoticed for a quarter of an hour, what two bees observed it; and others soon followed in considerable numbers. . . . On the whole, wasps seem to me more clever if finding their way than bees. I tried wasps with the glass mentioned on p. 124 [i.e. the bell-jar], but they had no difficulty in finding their way out.

We shall now conclude this résumé of Sir John Lubbock's observations by quoting two other passage bearing on the general intelligence of bees and wasps:-

The following fact struck me as rather remarkable. It wasp already mentioned at the foot of p. 135 one day smeared her wings with syrup, so that she could not fly. When the happened to a bee, it was only necessary to carry her to the alighting-board, when she was soon cleaned by her comrade But I did not know where this wasp's nest was, and therefore

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could not pursue a similar course with her. At first, then, I was afraid that she was doomed. I thought, however, that I would wash her, fully expecting, indeed, to terrify her so much that she would not return again. I therefore caught her, put her in a bottle half full of water, and shook her up well till the honey was washed off. I then transferred her to a dry bottle and put her in the sun. When she was dry I let her out, and she at once flew to her nest. To my surprise, in thirteen minutes she returned, as if nothing had happened, and continued her visits to the honey all the afternoon.

This experiment interested me so much that I repeated it with another marked wasp, this time, however, keeping the wasp in the water till she was quite motionless and insensible. When taken out of the water she soon recovered; I fed her; she went quietly away to her nest as usual, and returned after the usual absence. The next morning this wasp was the first

to visit the honey.

I was not able to watch any of the above-mentioned wasps for more than a few days; but I kept a specimen of Polistes Gallica for no less than nine months.

This is the wasp which has already been alluded to under the heading 'Memory;' but it is evident that the capacity which the insect displayed of becoming tamed implies no small degree of general intelligence; its hereditary instincts were conspicuously modified by the individual experiences incidental to its domestication.

The remaining passages that deserve quotation are the following :---

It is sometimes said of bees that those of one hive all know one another, and immediately recognise and attack any intruder from another hive. At first sight this certainly implies a great deal of intelligence. It is, however, possible that the bees of particular hives have a particular smell. Thus Langshaft, in his interesting 'Treatise on the Honey-Bee,' says: 'Members of different colonies appear to recognise their hive companions by the sense of smell; and I believe that if colonies are sprinkled with scented syrup, they may generally be safely mixed. Moreover, a bee returning to its own hive with a load of treasure is a very different creature from a hungry marauder; and it is said that a bee, if laden with honey, is allowed to enter any y her comrade hive with impunity.' Mr. Langshaft continues, 'There is an is, and therefore hir of roguery about a thieving bee which, to the expert, is as characteristic as are the motions of a pickpocket to a skilful policeman. Its sneaking look, and nervous, guilty agitation, once seen, can never be mistaken.' It is, at any rate, natural the a bee which enters a wrong hive by accident should be much surprised and alarmed, and would thus probably betray herself.

On the whole, then, I do not attach much importance to their recognition of one another as an indication of intelligence.

Since their extreme eagerness for honey may be attributed rather to their anxiety for the common weal than to their desire for personal gratification, it cannot fairly be imputed as greed. ness; still the following scene, one which most of us have witnessed, is incompatible surely with much intelligence. fate of their unfortunate companions does not in the least deter others who approach the tempting lure from madly alighting on the bodies of the dying and dead, to share the same miserable No one can understand the extent of their infatuation until he has seen a confectioner's shop assailed by myriads of hungry bees. I have seen thousands strained out from the syrup in which they had perished; thousands more alighting even upon the boiling sweets, the floor covered and windows darkened with bees, some crawling, others flying, and others still, so completely besmeared as to be able neither to crawl nor fly, not one in ten able to carry home its ill-gotten spoils, and yet the air filled with new hosts of thoughtless comers.

Passing on now to the statements of other observers. Huber first noticed the remarkable fact that when beehives are attacked by the death's-head moth the bess close the entrance of their hive with wax and propolis to keep out the marauder. The barricade, which is built immediately behind the gateway, completely stops it in —only a small hole being left large enough to admit bee, and therefore of course too small to admit the moth Huber specially states that it was not until the beehive had been repeatedly attacked and robbed by the death's head moth, that the bees closed the entrance of their hive with wax and propolis. Pure instinct would have induced the bees to provide against the first attack. Huber also observed that a wall built in 1804 against the death's head hawk-moth was destroyed in 1805. In the latter year there were no death's-head moths, nor were any seen during the following. But in the autumn of 1807 a large number again appeared, and the bees at once protected themselves stroyed agai

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Again, Huber (loc. cit., tom. ii., p. 280) gives a case of apparent exercise of reason, or power of inference from a particular case to other and general cases. A piece of comb fell down and was fixed in its new position by wax. The bees then strengthened the attachments of all the other combs, clearly because they inferred that they too might be in danger of falling. This is a very remarkable case, and leads Huber to exclaim, 'I admit that I was unable to avoid a feeling of astonishment in the presence of a fact from which the purest reason seemed to shine out.'

A closely similar, and therefore corroborative case of an even more remarkable kind is thus narrated in Watson's Reasoning Power of Animals' (p. 448):—

Dr. Brown, in his book on the bee, gives another illustration of the reasoning power of bees, observed by a friend of his. A centre comb in a hive, being overburdened with honey, had parted from its fastenings, and was pressing against another comb, so as to prevent the passage of the bees between them. This accident excited great bustle in the colony, and as soon as heir proceedings could be observed, it was found that they had constructed two horizontal beams between the two combs, and had removed enough of the honey and wax above them to admit the passage of a bee, while the detached comb had been secured by another beam, and fastened to the window with spare wax. But what was most remarkable was, that, when the comb was hus fixed, they removed the horizontal beams first constructed, is being of no further use. The whole occupation took about en days.

Again, Mr. Darwin's MS. quotes from Sir B. Brodie's Psychological Inquiries' (1854, p. 88) the following case, which is analogous to the above, except that the supports equired had to be made in a vertical instead of in a portional direction:—

On one occasion, when a large portion of the honeycomb ad been broken off, they pursued another course. The fragent had somehow become fixed in the middle of the hive, and he bees immediately began to erect a new structure of comb on he floor, so placed as to form a pillar supporting the fragment, and preventing its further descent. They then filled up the space above, joining the comb which had become detached to that from which it had been separated, and they concluded their labours by removing the newly constructed comb below, thus proving that they had intended it to answer a merely tem. porary purpose.

Similarly, Dr. Dzierzon, an experienced keeper of bees, and the observer who first discovered the fact of their parthenogenesis, makes the general remark,—

The cleverness of the bees in repairing perfectly injuries to their cells and combs, in supporting on pillars pieces of their building accidentally knocked down by a hasty push, in fastening them with rivets, and bringing everything again into proper unity, making hanging bridges, chains, and ladders, compels our astonishment.

Lastly, as still further corroboration of such facts, I shall quote the following from Jesse's 'Gleanings: '1_

Bees show great ingenuity in obviating the inconvenience they experience from the slipperiness of glass, and certainly beyond what we can conceive that mere instinct would enable them to do. I am in the habit of putting small glass globes on the top of my straw hives, for the purpose of having them filled with honey; and I have invariably found that before the bees commence the construction of combs, they place a great number of spots of wax at regular distances from each other, which serve as so many footstools on the slippery glass, each be resting on one of these with its middle pair of legs, while the fore claws were hooked with the hind ones of the bee next above him; thus forming a ladder, by means of which the workers were enabled to reach the top, and begin to make their combs there.

Herr Kleine, in his pamphlet on Italian Bees and Beekeeping (Berlin, 1855), says that on substituting during the absence of the bees a hive filled with empty comb for their own hive, the returning bees exhibit the utmost perplexity. As the substituted hive stands in the example previously occupied by their own hive, the returning bees fly into it without observing the change. But finding only empty combs inside, 'they stop, do not know

¹ Vol. i., pp. 22-3 (3rd ed.).

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where they are, come out of the hole again without depositing their loads, fly off, look most carefully round the stand to assure themselves that they have made no mistake, and go in once more when convinced that they are at the right place. The same thing is repeated over and over again, until the bees at last bow to the incomprehensible and unavoidable, lay down their loads, and set to work at those tasks made necessary by the new circumstances of the hive. But as all the newly arriving bees behave in similar fashion, the disturbance lasts till late in the evening, and the uncertainty and anxiety of the bees is so great that the bee-master cannot contemplate it without deep sympathy.' Under such circumstances the bees take quickly to a substituted queen; 'for the feeling of the first comers that they have no right to the new dwelling, having, as they suppose, made some inexplicable mistake which they cannot remedy, prevents them from feeling any hostility to the new queen which they find; they probably consider themselves as merely on sufferance, and feel that they should be grateful that no action is taken against them for their illegal entry, as generally happens in bee-experience.' Hence the writer adopts this device when he desires to exchange or substitute queens.

Büchner, after alluding to this case, supplements it

with the following:—

The wind threw down from the stand of a bee-master—a friend of the author's, whose name will soon become known a straw beehive, the inmates of which were surprised in full work, and no small disorder in the interior was the result. The owner repaired the hive, put the loose comb back in its place, and replaced it in such a manner that the wind could not again atch it, hoping that the accident would have no further results. But when he examined the hive a few days later, he found that the bees had left their old home in the lurch, and had tried to in the examinater other hives, clearly because they could no longer trust the weather, and feared that the terrible accident might again beall them.

> Dr. Erasmus Darwin, in his 'Zoonomia,' asserts that bees, when transported to Barbadoes, where there is no

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winter, cease to lay up honey. In contradiction to this statement, however, Kirby and Spence say, 'It is known to every naturalist acquainted with the fact, that many different species of bees store up honey in the hottest climates, and that there is no authentic instance on record of the hive-bees altering in any age or climate their

peculiar operations.

On the other hand, more recent observation has shown that Dr. Darwin's statement is probably correct. For according to a note in Nature, European bees, when transported to Australia, retain their industrious habits only for the first two or three years. After that time ther gradually cease to collect honey till they become wholly idle. In a subsequent number of the same periodical (p. 411) a correspondent writes that the same fact is observable with bees transported to California, but is obviated by abstracting honey as the bees collect it.

There seems to be no doubt that bees and wasps are able to distinguish between persons, and even to recognise those whom they are accustomed to see, and to regard as friends. Bee-masters who attend much to their bees, so as to give the insects a good chance of knowing them, are generally of the opinion that the insects do know them, as shown by the comparatively sparing use of their stings. Again, many instances might be quoted such as that given by Guerinzius,2 who allowed a species of wasp native to Natal to build in the doorposts of his house, and who observed that although he often interfered with the nest, he was only once stung, and this by young wasp; while no Caffre could venture to approach the door, much less to pass through it.3 This powerd distinguishing between persons indicates a higher order of intelligence than we might have expected to meet with among insects; and, according to Bingley, bees will not only learn to distinguish persons, but even lend them selves to tuition by those whom they know. For he says

¹ Vol. xvii., p. 373.

² See Brehm, *Thierleben*, ix., p. 252.

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³ An exactly similar case is recorded by Stodmann in his Travels Surinam, ii, p. 286.

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n in his Travels

Mr. Wildman, whose remarks on the management of hees are well known, possessed a secret by which he could at any time cause a hive of bees to swarm upon his head. shoulders, or body, in a most surprising manner. He has heen seen to drink a glass of wine with the bees all over his head and face more than an inch deep; several fell into the glass, but did not sting him. He could even act the part of a general with them, by marshalling them in battle array on a large table. Then he divided them into regiments, battalions, and companies, according to military discipline, waiting only for his word of command. The moment he uttered the word march! they began to march in a very regular manner in rank and file, like soldiers. To these, his Lilliputians, he also taught so much politeness that they never attempted to sting any of the numerous company which, at different times, resorted to admire this singular spectacle."

Huber's observation, since amply confirmed, of bees biting holes through the base of corollas in order to get at the honey which the length of the corollas prevent them from reaching in the ordinary way, also seems to indicate a rational adjustment to unusual circumstances. For the bees do not resort to this expedient until they find from trial that they cannot reach the nectar from above; but having once ascertained this, they forthwith proceed to pierce the bottoms of all the flowers of the same species. From an interesting account by Mr. Francis Darwin (unfortunately too long to quote) it appears that, even when the nectar may be reached from above, bees may still resort to the expedient of biting

brough corollas in order to save time.

In connection with biting holes in corollas I may quote in observation communicated to me by a correspondent, for J. Clarke Jervoise. Speaking of a humble-bee, he ays: 'I watched him into the flower of a foxglove, and, then out of sight, I closed the lips of the flower with my inger and thumb. He did not hesitate a moment, but ut his way out at the further end as if he had been erved the same trick before. I never did it.'

¹ Nature, ix., p. 189.

Bees are highly particular in the matter of keeping their hives pure, and their sanitary arrangements often exhibit intelligence of a high order.

The following is quoted from Büchner (loc. cit., p.

248):—

Impure air within the hive is that which the bees must above all things fear and avoid, for with the pressure together of so many individuals in a comparatively small space, it would not only be directly harmful to individual bees, but would produce among them dangerous diseases. They therefore also never void their excrements within, but always outside the hive While this is very easy to do in summer, it is, on the contrart very difficult in the winter, when the bees sit close together and generally motionless in the upper part of the hive, and when, from impure air and foul evaporations, as well as from bad and insufficient food, dysentery-like diseases break out among them, and often carry off the whole community in a brief space of time. In such cases they utilise the first fine day to relieve themselves, and in the spring they take a long general cleansing flight. But they also know how to take advantage of special circumstances so as to perform the process of purification in the way least harmful to the hive. Herr Heinrich Lehr, of Darmstadt, a bee-keeping friend of the author, has sent the following communication:—During an epidemic of dysentery in winter, from which most of his hives suffered (as the bees were no longer able to retain their excrements), one hive suffered less than the others. Exact investigation showed that this hive was soiled all over at the back with the excrement of the bees, and that the inmates had here made a kind of drain. On this spot a little opening had been made by the falling off of the covering clay, which led directly to the upper part of the hive, where the bees were accustomed to sit together during the winter. This excellent opportunity, whereby they could reach in the shortest way an otherwise difficult object, and one rendered complicated by circumstances, did not escape them.

It sometimes happens that mice, slugs, &c., enter a beehive. They are then killed and covered with a coating of propolis. Réaumur says 1 that he once sawa snail enter a hive in this way. The hard shell was an effective protection against the stings of the bees, so the insects smeared round the edges of the shell with wax and

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¹ See Kirby and Spence, vol. ii., p. 229.

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s, &c., enter vered with a he once sawa shell was an e bees, so the with wax and

resin, fastening down the animal to the wall of the hive, so that it died of starvation or want of air. If the encasing of an animal (such as a mouse) with propolis is not sufficient to prevent its putrefaction, the bees gnaw away all the putrescible parts of the carcass and carry them out of the hive, leaving only the skeleton behind. The dead bodies of their companions are also carried out of the hive and deposited at a distance. There is no question about this fact (which it will be remembered is analogous to that already mentioned in the case of ants); according to Büchner, however, bees not only remove their dead, but also, occasionally at least, bury them. But as he gives very inadequate evidence in support of this assertion, we may safely set it aside as insufficiently proven.

Büchner, however, gives an admirable summary, and makes some judicious remarks on the well-known and highly remarkable habit which bees practise for the obvious purpose of ventilating their hives. As this account gives all the facts in a brief compass, I cannot do

better than quote it:-

Very interesting, and closely connected with this characteristic of cleanliness, is the conduct of the so-called ventilatingbees, which have to take care that in summer or hot weather the air necessary for respiration of the bees in the interior of the hive is renewed, and the too high temperature cooled down. The latter precaution is necessary, not only on account of the bees working within the hive, to whom, as already said, a temperature risen beyond a certain point would be intolerable, but also to guard against the melting or softening of the wax. The bees charged with the care of the ventilation divide themselves ato rows and stages in regular order through all parts of the live, and by swift fanning of their wings send little currents of ir in such fashion that a powerful stream or change of air asses through all parts of the hive. Other bees stand at the bouth of the hive, which fan in the same way and considerably ccelerate the wind from within. The current of air thus caused so strong that little bits of paper hung in front of the mouth re rapidly moved, and that, according to F. Huber, a lighted patch is extinguished. The wind can be distinctly felt if the and be held in front.

The motion of the wings of the ventilating bees is so rapid hat it is scarcely perceptible, and Huber saw some bees working

their wings in this way for five-and-twenty minutes. When they are tired they are relieved by others. According to Jesse, the bees in very hot weather, in spite of all their efforts, are unable to sufficiently lower the temperature, and prevent the melting of some of the wax; they then get into a condition of great excitement, and it is dangerous to approach them. In such a case they also try to mend matters by a number leaving the hive and settling in large masses on its surface, so as to protect it as much as possible from the scorching rays of the sun.

Although the described plan of ventilation is remarkable enough in itself, it is yet more remarkable in that it is clearly only the result of bee-keeping, and is evoked by this misfortune. For there could be no need of such ventilation for bees in a state of nature, whose dwellings in hollow trees and clefts of rocks leave nothing to be desired as to roominess and airines, while in the narrow artificial hive this need at once comes out strongly. In fact, the fanning of the bees almost entirely ceased when Huber brought them into large hives five feet high, in which there was plenty of air. It follows, therefore, that the fanning and ventilating can have absolutely nothing to do with an inborn tendency or instinct, but have been gradually evoked by necessity, thought, and experience.

As the following observation on the cautious sagacity of wasps is, so far as I am aware, new, and as it certainly does not admit of mal-observation, I introduce it on the authority of a correspondent, the Rev. Mr. J. W. Mossman, who writes from Tarrington Rectory, Wragby. He found an apple in his orchard which had fallen from a tree in apparently good condition; but on taking it up observed that it was little more than a shell filled with wasps. Giving the apple a shake, he saw a wasp slowly emerging from a single small aperture in the rind:—

This aperture was sufficient, and only just sufficient, to admit of the ingress or egress of a single wasp. The circumstance which struck me as very remarkable was this—that the wasp did not make its way through the aperture with its head first as I should have expected, but with its tail, darting out its sting to its utmost extent, and brandishing it furiously. In this manner it came out of the apple backwards. Then, finding itself in the open air upon the outer surface of the apple, it turned round, and without any attempt to molest me, flew off in the usual way. The moment this first wasp had emerged, the sting

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and tail of another was seen protruding. This, too, I watched with much interest, and exactly the same process was repeated as in the case of the first. I held the apple in my hand until some ten or a dozen wasps had made their exit in the same identical manner in each individual case. I then threw down the apple, inside of which, however, there were still apparently a good many wasps.

It seemed to me at the time, and I have always felt since, that the wasps coming out of the apple backwards, brandishing their stings as a defensive weapon against possible enemies, whom of course they were not able to see, was an evidence of what would be called thought and reflection in the case of human beings. It seems to me that these wasps must have reflected that if they came out of the narrow aperture in the apple, which was their only possible means of ready egress, in the usual manner, head first, they might be taken at a disadvantage by a possible enemy, and destroyed in detail. They, therefore, with great prudence and foresight, came out of the apple backwards, protecting themselves by means of their chief offensive and defensive weapons, their stings, which, according to their formal method of locomotion, would have been useless to them s long as they were making their exit.

With regard to the tactics displayed by hunting wasps may quote the following cases:—

Mr. Seth Green, writing to the New York World of May 4, says that one morning when he was watching a spider's est, a wasp alighted within an inch or two of the nest, on the de opposite the opening. Creeping noiselessly around towards be entrance of the nest the wasp stopped a little short of it, nd for a moment remained perfectly quiet; then reaching out be of his antennæ he wriggled it before the opening and withlew it. This overture had the desired effect, for the boss of e nest, as large a spider as one ordinarily sees, came out to what was wrong and to set it to rights. No sooner had the ider emerged to that point at which he was at the worst dis-Ivantage than the wasp, with a quick movement, thrust his ing into the body of his foe, killing him easily and almost inantly. The experiment was repeated on the part of the wasp, en, finding itself and when there was no response from the inside he became apple, it turned tisfied, probably, that he held the fort. At all events, he proeded to enter the nest and slaughter the young spiders, which nerged, the sting are afterwards lugged off one at a time.

Mr. Henry Cecil writes as follows (Nature, vol. xviii., p. 311):—

I was sitting one summer's afternoon at an open window (my bedroom) looking into a garden, when I was surprised to observe a large and rare species of spider run across the window. sill in a crouching attitude. It struck me the spider was evidently alarmed, or it would not have so fearlessly approached It hastened to conceal itself under the projecting ledge of the window-sill inside the room, and had hardly done so when a very fine large hunting wasp buzzed in at the open window and flew about the room, evidently in search of something Finding nothing, the wasp returned to the open window and settled on the window-sill, running backwards and forwards as a dog does when looking or searching for a lost scent. It soon alighted on the track of the poor spider, and in a moment it discovered its hiding-place, darted down on it, and no doubt inflicted a wound with its sting. The spider rushed off again and this time took refuge under the bed, trying to conceal itself under the framework or planks which supported the mattres. The same scene occurred here; the wasp now appeared to follow the spider by sight, but ran backwards and forwards in large circles like a hound. The moment the trail of the spider was found the wasp followed all the turns it had made till it came on it again. The poor spider was chased from hiding-place to hiding-place, out of the bedroom, across a passage, and into the middle of another large room, where it finally succumbed to the repeated stings inflicted by the wasp. Rolling itself up into a ball the wasp then took possession of its prey, and after ascertaining it could make no resistance, tucked it up under it very long hind legs, just as a hawk or eagle carries off its quarr when I interposed and secured both for my collection.

Mr. Belt, in his work already frequently quoted, gives the following account of a struggle which not unfrequently occurs between wasps and ants for the sweet secretion of 'frog-hoppers:'—

Similarly as, on the savannahs, I had observed a waspatending the honey-glands of the bull's-horn acacia along with the ants; so at Santo Domingo another wasp, belonging to quit a different genus (Nectarina), attended some of the clusters of frog-hoppers, and for the possession of others a constant skin mishing was going on. The wasp stroked the young hopper and sipped up the honey when it was exuded, just like the analysis.

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When an ant came up to a cluster of leaf-hoppers attended by a wasp, the latter would not attempt to grapple with its rival on the leaf, but would fly off and hover over the ant; then when its little foe was well exposed, it would dart at it and strike it to the ground. The action was so quick that I could not determine whether it struck with its fore-feet or its jaws; but I think it was with the feet. I often saw a wasp trying to clear a leaf from ants that were already in full possession of a cluster of leaf-hoppers. It would sometimes have to strike three or four times at an ant before it made it quit its hold and fall. At other times one ant after the other would be struck off with great celerity and ease, and I fancied that some wasps were much cleverer than others. In those cases where it sucreeded in clearing the leaf, it was never left long in peace; for fresh relays of ants were continually arriving, and generally tired the wasp out. It would never wait for an ant to get near t, doubtless knowing well that if its little rival once fastened on its leg, it would be a difficult matter to get rid of it again. If a wasp first obtained possession, it was able to keep it; for he first ants that came up were only pioneers, and by knocking hese off, it prevented them from returning and scenting the rail to communicate the intelligence to others.

Dr. Erasmus Darwin records an observation 'Zooomia,' i., p. 183) which, from having since been so widely moted, deserves to be called classical. He saw a wasp pon the ground endeavouring to remove a large fly which as too heavy for it to carry off. The wasp cut off the ead and abdomen, and flew away with the thorax alone. he wind, however, catching the wings of this portion hade it still too unwieldy for the wasp to guide. It herefore again alighted, and nipped off first one wing nd then the other, when it was able to fly off with its boty without further difficulty.

This observation has since been amply confirmed.

hall quote some of the confirmatory cases.

Mr. R. S. Newall, F.R.S., in Nature, vol. xxi., p. 494,

Many years ago I was examining an apple tree, when a wasp ighted on a leaf which formed a caterpillar's nest neatly rolled The wasp examined both ends, and finding them closed, it on clipped a hole in the leaf at one end of the nest about oneist like the ant with of an inch in diameter. It then went to the other end and made a noise which frightened the caterpillar, which came rushing out of the hole. It was immediately seized by the wasp, who finding it too large to carry off at once, cut it in two and went off with his game. I waited a little and saw the wasp come back for the other half, with which it also flew away.

Again, Büchner (loc. cit., p. 297) gives the following account in the words of his informant, Herr H. Löwenfels, who himself witnessed the incident:—

I here found a robber-wasp busied in lifting from the ground a large fly which it had apparently killed. It succeeded indeed in its attempt, but had scarcely raised its prey a few inches above the ground when the wind caught the wings of the dead fly, and they began to act like a sail. The wasp was clearly unable to resist this action, and was blown a little distance in the direction of the wind, whereupon it let itself fall to the ground with its prize. It now made no more attempts to fly, but with eager industry pulled off with its teeth the fly's wings which hindered it in its object. When this was quite done it seized the fly, which was heavier than itself, and flew off with it untroubled on its journey through the air at a height of about five feet.

Büchner also records the two following remarkable observations, which from being so similar corroborate one another. The first is received from Herr Albert Schlüte, who writing from Texas says that he there saw a cicade pursued by a large hornet, which threw itself upon its prey and seemed to sting it to death:—

The murderer walked over its prey, which was considerable larger than itself, grasped its body with its feet, spread out it wings, and tried to fly away with it. Its strength was no sufficient, and after many efforts it gave up the attempt. Had a minute went by; sitting astride on the corpse and motionles—only the wings occasionally jerking—it seems to reflect, as indeed not in vain. A mulberry tree stood close by, really only a trunk—for the top had been broken off, clearly by the last flood—of about ten or twelve feet high. The hornet saw the trunk, dragged its prey to ilsomely to the foot of it, and then to the top. Arrived thereat, it rested for a moment, graspits victim firmly, and flew off with it to the prairies. That while it was unable to raise off the ground it could now carry easl once high in the air.

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The other instance is as follows:—
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Th. Meenan ('Proc. of the Acad. of Nat.,' Philadelphia, Jan. 22, 1878) observed a very similar case with Vespa maculata. He saw one of these wasps try in vain to raise from the ground a grasshopper it had killed. When all its efforts proved to be m vain, it pulled its prey to a maple tree, about thirty feet off, mounted it with its prize, and flew away from it. 'This,' adds the writer, 'was more than instinct. It was reflection and judgment, and the judgment was proved to be correct.'

Depriving bees of their antennæ has the effect of producing an even more marked bewilderment than results from this operation in the case of ants. A queen thus mutilated by Huber ran about in confusion, dropping her eggs at random, and appeared unable to take with precision the food that was offered her. She showed no resentment to a similarly mutilated stranger queen that was introduced: the workers also heeded not the mutilated stranger; but when an unmutilated stranger was introduced they fell upon her. When the mutilated queen was allowed to escape, none of the workers followed.

CHAPTER V.

TERMITES.

THE habits of the Termites, or so-called White Ants have not been so closely studied as they deserve. Our chief knowledge concerning them is derived from the observations of Jobson, in his 'History of Gambia,' Bastian, in 'The Nations of Eastern Asia;' Forsteal, Lespès, König, Sparman, Hugen, Quatrefages, Fritz Müller, and most of all, Smeathman, in 'Philosophical Transactions, vol. lxxi. In Africa these insects raise their hills to a height of between ten and twenty feet, and construct them of earth, stones, pieces of wood, &c., glued to gether by a sticky saliva. The hills are in the form of a cone, and so strong that it is said the buffaloes are in the habit of using them as watch-towers on which to post sentries, and that they will even support the weight of an elephant, The growth of these gigantic mounds is gradual, increase ing with the increase of the population. From the mound in all directions there radiate subterranean tunnels, which may be as much as a foot in width, and which serve as Besides these tunnels there are a number of other subterranean tubes, which serve the purpose of drainage to carry off the floods of water to which the nest is exposed during tropical showers. Büchner calculated that a pyramid built by man on a scale proportional to his size would only equal one of these nests if it attained to the height of 3,000 feet. The following is this authors description of the internal structure:—

These internal arrangements are so various and so complicated that pages of description might be written there upon. There are myriads of rooms, cells, nurseries, provision

chambers, g subterranean smooth inclir herent, and v ing, sheltered stately royal royal pair re and outlets a vice can pass the egg-laying three thousan The queen, therein. Rou enlarged in pr at least a yard cells for the e cells for the w chambers for t rous store-roo meal, seeds, fr ziech-Beta, the common room. the meeting ar chambers of th serves for purp

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chambers, guard-rooms, passages, corridors, vaults, bridges, subterranean streets and canals, tunnels, arched ways, steps, smooth inclines, domes, &c., &c., all arranged on a definite. coherent, and well-considered plan. In the middle of the building, sheltered as far as possible from outside dangers, lies the stately royal dwelling, resembling an arched oven, in which the royal pair reside, or rather are imprisoned; for the entrances and outlets are so small, that although the workers on service can pass easily in and out, the queen cannot; for during the egg-laying her body swells out to an enormous size, two or three thousand times the size and weight of an ordinary worker. The queen, therefore, never leaves her dwelling, and dies therein. Round the palace, which is at first small, but is later enlarged in proportion as the queen increases in size until it is at least a yard long and half a yard high, lie the nurseries, or cells for the eggs and larvæ; next these the servants' rooms, or cells for the workers which wait on the queen; then special chambers for the soldiers on guard, and, between these, numerous store-rooms, filled with gums, resins, dried plant-juices, meal, seeds, fruits, worked-up wood, &c. According to Bettziech-Beta, there is always in the midst of the nest a large common room, which is used either for popular assemblies or as the meeting and starting point of the countless passages and chambers of the nest. Others are of the opinion that this space serves for purposes of ventilation.

Above and below the royal cell are the rooms of the workers and soldiers which are specially charged with the care and defence of the royal pair. They communicate with each other, as well as with the nursery-cells and store-rooms, by means of galleries and passages which, as already said, open into the common room in the middle under the dome. This room is surrounded by high, boldly projected arched ways, which lose hemselves further out in the walls of the countless rooms and alleries. Many roofs outside and in protect this room and the surrounding chambers from rain, which, as already said, is frained away by countless subterranean canals, made of clay and of a diameter of ten or twelve centimetres. also, under the layer of clay covering the whole building, broad spirally winding passages running from below to the highest points, which communicate with the passages of the nterior, and apparently, as they mainly consist of smooth inlines, serve for carrying provisions to the higher parts of the

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¹ Loc. cit., p. 189.

The termites, like many species of true ants, are divided into two distinct castes, the workers and the soldiers. If a breach is made in the walls of the dome the soldiers rush out to meet the enemy, and fight desperately with any enemy that they may find. Here, again, I cannot do better than quote Büchner's epitome of facts:—

If the assailant withdraws beyond their reach and inflicts no further injury, they retire within their dwelling in the course of half an hour, as though they had come to the conclusion that the enemy who had done the mischief had fled. Scarcely have the soldiers disappeared when crowds of workers appear in the breach, each with a quantity of ready-made mortar in its As soon as they arrive they stick this mortar round the open place, and direct the whole operation with such swift ness and facility that in spite of their great number they never hinder each other, nor are obliged to stop. During this spectacle of apparent restlessness and confusion the observer is agreeably surprised to see arising a regular wall, filling up the gap. During the time that the workers are thus busied the soldiers remain within the nest, with the exception of a few, which walk about apparently idly, never touching the mortan among the hundreds and thousands of workers. Nevertheless one of them stands on guard close to the wall which is being It turns gently each way in turn, lifting its head at in tervals of one or two minutes to strike the building with it heavy mandibles, making the before-mentioned crackling noise This signal is immediately answered by a loud rustling from the interior of the nest and from all the subterranean passages and holes. There is no doubt that this noise arises from the workers, for as often as the sign is given they work with in creased energy and speed. A renewal of the attack instantaneously changes the scene. 'At the first stroke,' says Smeathman, 'the workers run into the many tunnels and passages which run through the building, and this happens so quickly that they seem regularly to vanish. In a few seconds they are all gone, and in their stead appear the soldiers once more, as numerous and as pugnacious as before. If they find no enemy, they turn back slowly into the interior of the hill and immediately the mortar-laden workers again appear, and among them a few soldiers, which behave just as on the first occasion. So one can have the pleasure of seeing them work and fight in turn, as often as one chooses; and it will be found

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Similar facts have been observed by Fritz Müller of

the South American species.

The Termites, being like the Ecitons blind, like them make all their expeditions under the protection of covered ways. These are underground tunnels in all cases where circumstances permit, but on arriving at a rock or other impenetrable obstruction, they build a tubular passage upon the surface. According to Büchner,—

They can even carry their viaducts through the air, and that in such bold arches that it is difficult to understand how they were projected. In order to reach a sack of meal which was well protected below, they broke through the roof of the room in which it was, and built a straight tube from the breach they had made down to the sack. As soon as they tried to carry off their booty to a safe place, they became convinced that it was impossible to pull it up the straight road. In order to meet this difficulty, they adopted the principle of the smooth incline, the use of which we have already seen in the interior of their nests, and built close to the first tube a second, which wound spirally within, like the famous clock tower of Venice. It was now an easy task to carry their booty up this road and so away. . . . Either from the desire to remain undiscovered, or from their liking for darkness, they have the remarkable habit of destroying and gnawing everything from within outwards, and of leaving the outside shell standing, so that from the outside appearance the dangerous state of the inside is not perceptible. If, for instance, they have destroyed a table or other piece of household furniture, in which they always manage from the ground upwards to hit exactly the places on which the feet of the article rest, the table looks perfectly uninjured outside, and people are quite astonished when it breaks down under the slightest pressure. The whole inside is eaten away, and only the thinnest shell is left standing. If fruits are lying on the table, they also are eaten out from the exact spot on which they rest on the surface of the table.

In similar fashion things consisting wholly of wood, such as wooden ships, trees, &c., are destroyed by them so that they finally break in with out any one having noticed the mischief. Yet it is said that they go so prudently to work in their de-

struction that the main beams, the sudden breakage of which would threaten the whole building and themselves therewith. are either spared, or else so fastened together again with a cement made out of clay and earth that their strength is greater than ever! (1) Hagen also states that they never cut right through the corks which stop up stored bottles of wine, but leave a very thin layer, which is sufficient to prevent the out. flow of the wine and the consequent destruction of the workers The same author relates that in order to reach a box of wax lights they made a covered road from the ground up to the second story of a house.1

It is needless to give a special description of any of the other habits of these insects, such as their swarming breeding, &c., for they all more or less closely resemble the analogous habits of ants and bees. It is very remarkable that insects of two distinct orders should both manifest such closely similar social habits of such high complexity, and it rather surprises me that more has not been made of this point by writers opposed to the principles of evolution. Of course if the point were raised, the argument in answer would require to be, either that the similar instincts were derived from common and very remote progenitors (in which case the fact would form by far the most remarkable instance of the permanency of instincts among changing species), or more probably, that similar causes operating in the two orders have produced similar effects—complex and otherwise unique though these effects undoubtedly are.

In connection with the theory of evolution I may conclude this chapter with the following quotation from Smeathman, as it shows how natural relation may develop for the benefit of the species instincts which are detrimental to the individual. Speaking of the soldiers he

says:-

I was always amused at the pugnacity displayed when, in making a hole in the earthy cemented archway of their covered roads, a host of these little fellows mounted the breach to cover the retreat of the workers. The edges of the rupture bristled with their armed heads as the courageous warriors ranged

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Geisteslehen der Thiere, pp. 194 and 199-200.

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themselves in compact line around them. They attacked fiercely any intruding object, and as fast as their front ranks were destroyed, others filled up their places. When the jaws closed in the flesh, they suffered themselves to be torn in pieces rather than loosen their hold. It might be said that this instinct is rather a cause of their ruin than a protection when a colony is attacked by the well-known enemy of termites, the ant-bear; but it is the soldiers only which attach themselves to the long worm-like tongue of this animal, and the workers, on whom the prosperity of the young brood immediately depends, are left for the most part unharmed. I always found, on thrusting my finger into a mixed crowd of termites, that the soldiers only fastened upon it. Thus the fighting caste do in the end serve to protect the species by sacrificing themselves to its good I

1 Phil. Trans., loo. oit

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CHAPTER VI.

SPIDERS AND SCORPIONS.

Emotions.

THE emotional life of spiders, so far as we can observe it as expressed in their actions, seems to be divided between sexual passion (including maternal affection) and the sterner feelings incidental to their fiercely predatory But the emotions, although apparently few and habits. simple in character, are exceedingly strong in force. In many species the male spider in conducting his courtship has to incur an amount of personal danger at the hands (and jaws) of his terrific spouse, which might well daunt the courage of a Leander. Ridiculously small and weak in build, the males of these species can only conduct the rites of marriage with their enormous and voracious brides by a process of active manœuvring, which if unsuccessful is certain to cost them their lives. Yet their sexual emotions are so strong that, as proved by the continuance of the species, no amount of personal risk is sufficient to deter them from giving these emotions full play. There is no other case in the animal kingdom where courtship is attended with any approach to the gravity of danger that is here observable. Among many animals the males have to meet a certain amount of inconvenience from the coquetry or disinclination of the females; but here the coquetry and disinclination has passed into the hungry determination of a ferocious giantess. The ease, therefore because unique, is of interest from an evolutionary point We can see a direct advantage to species from the danger incurred by males on account of mutual jealousy; for this, giving rise to what Mr. Darwin has

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called 'the law of battle,' must obviously be a constant source of the creation and the maintenance of specific proficiency: the law of battle determines that only the strongest and most courageous males shall breed. But the benefit to species is not so obvious where the danger of courtship arises from the side of the female. Still, that there must be some benefit is obvious, seeing that the whole structure of the male, if we take that of the female as the original type, has been greatly modified with reference to this danger: had the latter been wholly useless, either it would not have been allowed to arise, or the species must have become extinct. The only suggestion can make to meet this aberrant case is that the courage and determination required of the male, besides being no doubt of use to him in other relations in life, may be of benefit to the species by instilling these qualities into the psychology both of his male and female descendants.

The courage and rapacity of spiders as a class are too well and generally known to require special illustration. One instance, however, may be quoted to show the strength of their maternal emotions. Bonnet threw a spider with her bag of eggs into the pit of an ant-lion. The latter seized the eggs and tore them away from the spider; but although Bonnet forced her out of the pit, she returned, and chose to be dragged in and buried alive rather than

leave her charge.

The only other point that occurs to me with reference to the emotions of spiders is the somewhat remarkable one concerning their apparent fondness of music. The testimony is so varied and abundant on this matter that we can scarcely doubt the truth of the facts. These simply are that spiders—or at any rate some species or individuals -approach a sounding musical instrument, 'especially when the music is tender and not too loud.' They usually approach as near as possible, often letting themselves down from the ceiling of the room by a line of web, and remain Should the music suspended above the instrument. become loud, they often again retreat. Professor C. Reclain, during a concert at Leipsic, saw a spider descend in this way from one of the chandeliers while a violin solo

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was being played; but as soon as the orchestra began to sound it quickly ran back again. Similar observations have been published by Rabigot, Simonius, von Hartmann and others.

A highly probable explanation of these facts has recently been given by Mr. C. V. Boys, which relieves us of the necessity of imputing to animals so low in the scale any rudiment of æsthetic emotion as aroused by musical tones. As the observation is an interesting one, I shall quote it in extenso:—

Having made some observations on the garden spider which are I believe new, I send a short account of them, in the hope that they may be of interest to the readers of *Nature*.

Last autumn, while watching some spiders spinning their beautiful geometrical webs, it occurred to me to try what effect a tuning-fork would have upon them. On sounding an A fork and lightly touching with it any leaf or other support of the web, or any portion of the web itself, I found that the spider, if at the centre of the web, rapidly slues round so as to face the direction of the fork, feeling with its fore-feet along which radial thread the vibration travels. Having become satisfied on this point, it next darts along that thread till it reaches either the fork itself or a junction of two or more threads, the right one of which it instantly determines as before. If the fork is not removed when the spider has arrived it seems to have the same charm as any fly; for the spider seizes it, embraces it, and runs about on the legs of the fork as often as it is made to sound, never seeming to learn by experience that other things may buzz besides its natural food.

If the spider is not at the centre of the web at the time that the fork is applied, it cannot tell which way to go until it has been to the centre to ascertain which radial thread is vibrating unless of course it should happen to be on that particular thread, or on a stretched supporting thread in contact with the

fork.

If, when a spider has been enticed to the edge of the web the fork is withdrawn, and then gradually brought near, the spider is aware of its presence and of its direction, and reaches out as far as possible in the direction of the fork; but if a sounding fork is gradually brought near a spider that has not been disturbed, but which is waiting as usual in the middle of

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¹ Body and Mind, p. 275.

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the web, then, instead of reaching out towards the fork, the spider instantly drops—at the end of a thread, of course. If under these conditions the fork is made to touch any part of the web, the spider is aware of the fact, and climbs the thread and reaches the fork with marvellous rapidity. The spider never leaves the centre of the web without a thread along which to travel back. If after enticing a spider out we cut this thread with a pair of scissors, the spider seems to be unable to get back without doing considerable damage to the web, generally gumming together the sticky parallel threads in groups of three and four.

By means of a tuning-fork a spider may be made to eat what it would otherwise avoid. I took a fly that had been drowned in paraffin and put it into a spider's web, and then attracted the spider by touching the fly with a fork. When the spider had come to the conclusion that it was not suitable food, and was leaving it, I touched the fly again. This had the same effect as before, and as often as the spider began to leave the fly I again touched it, and by this means compelled the spider to eat a large portion of the fly.

The few house-spiders that I have found do not seem to appreciate the tuning-fork, but retreat into their hiding-places as when frightened; yet the supposed fondness of spiders for musicmust surely have some connection with these observations; and when they come out to listen, is it not that they cannot tell

which way to proceed?

The few observations that I have made are necessarily imperfect, but I send them, as they afford a method which might lead a naturalist to notice habits otherwise difficult to observe, and so to arrive at conclusions which I in my ignorance of natural history must leave to others.

General Habits.

Coming now to general habits, our attention is claimed by the only general habit that is of interest—namely, that of web-building. The instinct of constructing nets for the capture of prey occurs in no other class of animals, while in spiders it not only attains to an extraordinary legree of perfection (so that, in the opinion of some geometers, the instinct is not less wonderful in this repect than is that displayed by the hive-bee in the con-

¹ Nature, xxiii., pp. 149-50.

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struction of its cells), but also ramifies into a number of diverse directions. Thus we have, in different species. wide open networks spread between the branches of bushes. &c., closely woven textures in the corners of buildings. earth tubes lined with silk, the strong muslin-like snare of the Mygale, which, as first noticed by Madame Merian. and since confirmed by Bates,2 is able to retain a struggling humming-bird while this most beautiful animal in creation is being devoured by the most repulsive; and many other varieties might be mentioned. It may at first sight appear somewhat remarkable that this instinct of spreading snares should on the one hand occur only in one class of the animal kingdom, while on the other hand, in the class where it does occur, it should attain such extreme perfection, and run into so much variety. But we must here remember that the development of the instirct obviously depends upon the presence of a web-secreting apparatus which is a comparatively rare anatomical feature. In caterpillars, which are not predaceous, the web is used only for the purposes of protection and locomotion; and it is easy to see that the spreading of snares would here be of no use to the animals. But in spiders, of course, the case is otherwise. Once granting the power of forming a web, and it is evident that there is much potential service to which this power may be put with reference to the voncious habits of the animal; and therefore it is not to be wondered that both the anatomical structures and their correlated instincts should attain to extreme perfection in sundry lines of development. The origin of the webbuilding structure was probably due to the use of the web for purposes of locomotion or of cocoon-spinning, as we see it still so used in the same way that it is used by caterpillars for descending from heights, and in the case of the gossamer spider for travelling immense distances through the air. As the anatomical structures in question differ very greatly in the case of spiders and in that of caterpillars, we may wonder why analogous if not homolo-

Naturalist on the Amazon, p. 83.

² For many other confirmations see Sir E. Tennent, Nat. Hist. Ceylon, pp. 468-69.

gous structures should never have been developed in the case of any other animal having predaceous habitsespecially, perhaps, in that of the imago form of predaceous insects. It is easy to see how, if there were any original tendency to secrete a viscid substance in the neighbourhood of the anus, this might be utilised in descending from low elevations (as certain kinds of slugs use their viscid slime as threads whereby to let themselves down from low branches to the ground); and so we can understand how natural selection might thus have the material supplied out of which to develop such highly specialised organs as the spinnerets of a spider. But if we are inclined to wonder why this should not have happened among other animals, we must remember that any expectation that it should rests on negative grounds; we have no reason to suppose that in any other case the initial tendency to secrete a viscid substance was present. One inference, however, in the case of spiders seems perfeetly valid. As this comparatively rare faculty of webpinning occurs so generally throughout the class, it must have had its earliest origin very far back in the history of hat class, though probably not so far back as to include he common progenitors of the spiders and the scorpions, seeing that the latter do not spin webs.

I shall now give a few details on the manner in which piders' webs are made. Without going into the anamy of the subject further than to observe that a pider's 'thread' is a composite structure made up of a number of finer threads, which leave their respective pinneret-holes in an almost fluid condition, and immeditely harden by exposure to the air, I shall begin at once o describe the method of construction.

The so-called 'geometric spider' constructs her web y first laying down the radiating and unadhesive rays, and then, beginning from the centre, spins a spiral line of nadhesive web, like that of the rays which it intersects. his line, in being woven through the radii in a spiral com centre to circumference, serves as a scaffolding for the pider to walk over, and also keeps the rays properly retched. She next spins another spiral line, but this

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time from the circumference to near the centre, and formed of web, covered with a viscid secretion to retain prey. Lastly, she constructs her lair to hide and watch for prey, at some distance from the web but connected with it by means of a line of communication or telegraph, the vibrations of which inform her of the struggling of an insect in the net.¹

According to Thompson,-

The web of the garden spider—the most ingenious and Der. fect contrivance that can be imagined—is usually fixed in perpendicular or somewhat oblique direction in an opening between the leaves of some plant or shrub; and as it is obvious that round its whole extent lines will be required to which those ends of radii that are farthest from the centre can be attached, the construction of those exterior lines is the spider's first operation. It seems careless about the shape of the area they are to enclose, well aware that it can as readily inscribe circle in a triangle as a square; and in this respect it is guided by the distance or proximity of the points to which it can attach them. It spares no pains, however, to strengthen and keep them in a proper degree of tension. With the former view it com. poses each line of five or six or even of more threads glued together; and with the latter it fixes to them from different points a numerous and intricate apparatus of smaller threads; and having thus completed the foundation of its snare, it proceeds to fill up the outline. Attaching a thread to one of the main lines, it walks along it, guiding it with one of its hind legs, that it may not touch in any part and be prematurely glued, and crosses over to the opposite side, where, by applying its spinner. it firmly fixes it. To the middle of this diagonal thread, which is to form the centre of its net, it fixes a second, which in like manner it conveys and fastens to another part of the lines in cluding the area. The work now proceeds rapidly. During the preliminary operations it sometimes rests, as though its plan required meditation; but no sooner are the marginal lines the net firmly stretched, and two or three radii spun from it centre, than it continues its labour so quickly and unremittingly that the eye can scarcely follow its progress. The radii, to the number of about twenty, giving the net the appearance of wheel, are speedily finished. It then proceeds to the central quickly turns itself round, pulls each thread with its feet ascertain its strength, breaking any one that seems defective, and

replacing it the centre, f half a line fi each separat last serve as to keep the 1 concentric ci construct. thread to the towards the from its body stepping acro legs, it glues radius to whi it has filled u to the centre about two lin around the si centre, and bi the radii, which have thus pro cular opening, and watches fo ment formed u house.1

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¹ Kirby, vol. ii., p. 298.

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replacing it by another. Next it glues, immediately round the centre, five or six small concentric circles, distant about half a line from each other, and then four or five larger ones, each separated by the space of half an inch or more. These last serve as a sort of temporary scaffolding to walk over, and to keep the radii properly stretched while it glues to them the concentric circles that are to remain, which it now proceeds to construct. Placing itself at the circumference, and fastening its thread to the end of one of the radii, it walks up that one, towards the centre, to such a distance as to draw the thread from its body of a sufficient length to meet the next. Then stepping across and conducting the thread with one of its hind legs, it glues it with its spinners to the point in the adjoining radius to which it is to be fixed. This process it repeats until it has filled up nearly the whole space from the circumference to the centre with concentric circles, distant from each other about two lines. It always, however, leaves a vacant interval around the smallest first spun circles that are nearest to the centre, and bites away the small cotton-like tuft that united all the radii, which being held now together by the circular threads have thus probably their elasticity increased; and in the circular opening, resulting from this procedure, it takes its station and watches for its prey, or occasionally retires to a little apartment formed under some leaf, which it also uses as a slaughterhouse.1

According to Büchner,—

The long main threads, with the help of which the spider begins and attaches its web, are always the thickest and strongst; while the others, forming the web itself, are considerably weaker. Injuries to the web at any spot the spider very mickly repairs, but without keeping to the original plan, and without taking more trouble than is absolutely necessary. lost spiders' webs, therefore, if closely looked into are found to e somewhat irregular. When a storm threatens, the spider, thich is very economical with its valuable spinning material, pins no web, for it knows that the storm will tear it in pieces nd waste its pains, and it also does not mend a web which as been torn. If it is seen spinning or mending, on the other and, fine weather may be generally reckoned on. . . . The merged young at first spin a very irregular web, and only adually learn to make a larger and finer one, so that here, as verywhere else, practice and experience play a great part. . .

¹ Thompson, Passions of Animals, p. 145.

The position must also offer favourable opposite points for the attachment of the web itself. People have often puzzled their brains, wondering how spiders, without being able to fly, had managed first to stretch their web through the air between two opposite points. But the little creature succeeds in accomplish. ing this difficult task in the most various and ingenious wavs. It either, when the distance is not too great, throws a moist viscid pellet, joined to a thread, which will stick where it touches; or hangs itself by a thread in the air and lets itself be driven by the wind to the spot; or crawls there, letting out a thread as it goes, and then pulls it taut when arrived at the desired place; or floats a number of threads in the air and waits till the wind has thrown them here or there. or radial threads which fasten the web possess such a high degree of elasticity, that they tighten themselves between two distant points to which the spider has crawled, without it being necessary for the latter to pull them towards itself. When the little artist has once got a single thread at its disposition, it strengthens this until it is sufficiently strong for it to run backwards and forwards thereupon, and to spin therefrom the web.1

Special Habits.

Water-spider.—The water-spider (Argyroneta aquatica), as is well known, displays the curious instinct of building her nest below the surface of water, and constructing it on the principle of a diving-bell. The animal usually selects still waters for this purpose, and makes her nest in the form of an oval hollow, lined with web, and held secure by a number of threads passing in various directions and fastened to the surrounding plants. In this oval bell, which is open below, she watches for prey, and, according to Kirby, passes the winter after having closed the opening. The air needful for respiration the spider carries from the surface of the water. To do this she swims upon her back in order to entangle an airbubble upon the hairy surface of her abdomen. With this bubble she descends, 'like a globe of quicksilver,' to the opening of her nest, where she liberates it and returns for more.

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¹ Loc. cit., p. 316 et seq.

² Hist. Habits and Inst. of Animals, vol. ii., p. 296.

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The Vagrant or Wolf Spider.—This insect catches its prey by stealthily stalking it until within distance near enough to admit of a sudden dart being successful in effecting capture. Some species, before making the final dart (e.g. Salticus scenicus), fix a line of web upon the surface over which they are creeping, so that whether their station is vertical or horizontal with reference to the prey, they can leap fearlessly, the thread in any case preventing their fall. Dr. H. F. Hutchinson says that he has seen this spider crawling over a looking-glass stalking its own reflection.¹

The following is quoted from Büchner:—

Less idyllic than the water-spider is our native huntingspider (Dolomedes fimbriata), which belongs to those species which spin no web, but hunt their victims like animals of prey. As the Argyroneta is the discoverer of the diving-bell, so may this be regarded as the discoverer or first builder of a floating raft. It is not content with hunting insects on land, but follows them on the water, on the surface of which it runs about with ease. It, however, needs a place to rest on, and makes it by rolling together dry leaves and such like bodies, binding them into a firm whole with its silken threads. On this raft-like vessel it floats at the mercy of wind and waves; and if an unlucky water-insect comes for an instant to the surface of the water to breathe, the spider darts at it with lightning speed, and carries it back to its raft to devour at its ease. Thus everywhere in nature are battle, craft, and ingenuity, all following the merciless law of egoism, in order to maintain their own lives and to destroy those of others!

Trap-door Spiders.—These display the curious instinct of providing their nests with trap-doors. The nest consists of a tube excavated in the earth to the depth of half a foot or more. In all save one species the tube is unbranched; it is always lined with silk, which is continuous with the lining of the trap-door or doors, of which it forms the hinge. In the species which constructs a branching tube, the branch is always single, more or less straight, takes origin at a point situated a few inches from the orifice of the main tube, is directed upwards at an acute

¹ Nature, vol. xx., p. 581.

² Loc. cit., p. 323.

angle with that tube, and terminates blindly just below the surface of the soil. At its point of junction with or departure from the main tube it is provided with a trapdoor resembling that which closes the orifice of the main tube, and of such a size and arrangement that when closed against the opening of the branch tube it just fills that opening; while when turned outwards, so as to uncork this opening, it just fills the diameter of the main tube: the latter, therefore, is in this species provided with two trap-doors, one at the surface of the soil, and the other at the fork of the branched tube.

Each species of trap-door spider is very constant in building a particular kind of trap-door; but among the different species there are four several kinds of trap-doors to be distinguished. 1st. The single-door cork nest, wherein the trap-door is a thick structure, and fits into the tube like a cork into a bottle. 2nd. The single-door wafer nest, wherein the trap-door is as thin as a piece of paper. 3rd The double-door unbranched nest, wherein there is a second trap-door situated a few inches below the first one. And 4th, the double-door branched nest already described. In all cases the trap-doors open outwards, and when the nest is placed, as it usually is, on a sloping bank, the trap-door opens upwards; hence there is no fear of its gaping, for gravity is on the side of holding it shut.

The object of the trap-door is to conceal the nest, and for this purpose it is always made so closely to resemble the general surface of the ground on which it occurs, that even a practised eye finds it difficult to detect the structure when closed. In order to make the resemblance to the surrounding objects as perfect as possible, the spider either constructs the surface of its door of a portion of leaf, or weaves moss, grass, &c., into the texture. Moggridge says, 1—

Thus, for example, in one case where I had cut out a little clod of mossy earth, about two inches thick and three square on the surface, containing the top of the tube and the moss covered cork door of N. cæmentaria, I found, on revisiting the

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¹ Harvesting Ants and Trap-door Spiders, p. 120.

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place six days later, that a new door had been made, and that the spider had mounted up to fetch moss from the undisturbed bank above, planting it in the earth which formed the crown of the door. Here the moss actually called the eye to the trap, which lay in the little plain of brown earth made by my digging.

If an enemy should detect the trap-door and endeavour to open it, the spider frequently seizes hold of its internal surface, and, applying her legs to the walls of the tube, forcibly holds the trap-door shut. In the double trap-door species it is surmised that the second trap-door serves as an inner barrier of defence, behind which the spider retires when obliged to abandon the first one. In the branched tube species (which, so far as at present known, only occurs in the south of Europe) it is surmised that the spider, when it finds that an enemy is about to gain entrance at the first trap-door, runs into the branch tube and draws up behind it the second trap-door. The surface of this trap-door, being overlaid with silk like the walls of the tube, is then invisible; so that the enemy no doubt passes down the main tube to find it empty, without observing the lateral branch in which the spider is concealed behind the closed door.

As showing that these animals are to no small extent able to adapt their dwellings to unusual circumstances, I shall here quote the following from Moggridge (loc. cit.,

p. 122):—

Certain nests which were furnished with two doors of the cork type were observed by Mr. S. S. Saunders in the Ionian Islands. The door at the surface of these nests was normal in position and structure, but the lower one was placed at the very bottom of the nest, and inverted, so that, though apparently intended to open downwards, it was permanently closed by the surrounding earth. The presence of a carefully constructed door in a situation which forbade the possibility of its ever being opened seemed, indeed, something difficult to account for. However, it occurred to Mr. Saunders that, as these nests were found in the cultivated ground round the roots of olive trees, they may occasionally have got turned topsy-turvy when the soil was broken up. The spider then, finding her door buried below in the ground and the bottom of the tube at the surface,

would have either to seek new quarters or to adapt the nest to its altered position, and make an opening and door at the exposed end. In order to try whether one of these spiders would do this, Mr. Saunders placed a nest, with its occupant inside, upside down in a flower-pot. After the lapse of ten days a new door was made, exactly as he had conjectured it would be, and the nest presented two doors like those which he had found at first.

The most remarkable fact connected with these animals, if we regard their peculiar instinct from the standpoint of the descent theory, is the wide range of their geographical distribution. In all quarters of the globe species of trap-door spiders are found occurring in more or less localised areas; and as it is improbable that so peculiar an instinct should have arisen independently in more than one line of descent, we can only conclude that the wide dispersion of the species presenting it has been subsequent to the origin and perfecting of the instinct. This conclusion of course necessitates the supposition that the instinct must be one of enormous antiquity: and in this connection it is worthy of remark that we seem to have independent evidence to show that such is the case. It is a principle of evolution that the earlier any structure or instinct appears in the development of the race, the sooner will it appear in the development of the individual; and read by the light of this principle we should conclude, quite apart from all considerations as to the wide geographical distribution of trap-door spiders, that their instincts—as, indeed, is the case with the characteristic instincts of many other species of spidersmust be of immense age. Thus, again to quote Moggridge,-

It seems to be the rule with spiders generally that the offspring should leave the nest and construct dwellings for themselves when very young.

Mr. Blackwall, speaking of British spiders, says:—'Complicated as the processes are by which these symmetrical nets are produced, nevertheless young spiders, acting under the influence of instinctive impulse, display, even in their first attempts to fabricate them, as consummate skill as the most experienced individuals.'

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says:—'Comnmetrical nets ing under the in their first ll as the most Again, Mr. F. Pollock¹ relates of the young of *Epeira aurelia*, which he observed in Madeira, that when seven weeks old they made a web the size of a penny, and that these nets have the same beautiful symmetry as those of the full-grown spider.

And, speaking of trap-door spiders, Moggridge says,---

I cannot help thinking that these very small nests, built as they are by minute spiders probably not very long hatched from the egg, must rank among the most marvellous structures of this kind with which we are acquainted. That so young and weak a creature should be able to excavate a tube in the earth many times its own length, and know how to make a perfect miniature of the nest of its parents, seems to be a fact which has scarcely a parallel in nature.²

Regarding the steps whereby the instinct of building trap-doors probably arose, Büchner quotes Moggridge thus:—

To show, lastly, how various are the transitional forms and gradations so important in deciding upon the gradual origin of the forms of nests, Moggridge also alludes to the similar buildings made by other genera of spiders. Lycosa Narbonensis, a spider of Southern France much resembling the Apuleian tarantula, and belonging to the family of the wolf spiders, makes cylindrical holes in the earth, about one inch wide and three or four inches deep, in a perpendicular direction; when they have attained this depth they run further horizontally, and end in a three-cornered room, from one to two inches broad, the floor of which is covered with the remnants of dead insects. The whole nest is lined within with a thick silken material, and has at its opening—closed by no door—an aboveground chimney-shaped extension, made of leaves, needles, moss, wood, &c., woven together with spider threads. These chimneys show various differences in their manner of building, and are intended chiefly, according to Moggridge, to prevent the sand blown about by the violent sea-winds from penetrating into the nests. During winter the opening is wholly and continuously woven over, and it is very well possible, or probable, that the process of reopening such a warm covering in the spring,

^{&#}x27; 'The History and Habits of Epeira aurelia,' in Annals and Mag. of Nat. Hist. for June 1865.

² Harvesting Ants and Trap-door Spiders, p. 126. This admirable work, with its appendix, contains a very full account of the whole conomy of the interesting animals with which it is concerned.

after this opening was three-quarters completed, and was large enough to let the spider pass out, may have long ago awaked in the brain of some species of spider the idea of making a permanent and moveable door. But from this to the practical construction of so perfect a door as we have learned to know, and even to the building of the exceedingly complicated nest of the N. Manderstjernæ, through all the gradations which we already know, and which doubtless exist in far greater number, is no great or impossible step.

General Intelligence.

Coming now to the general intelligence of spiders, I think there can be no reasonable doubt, from the force of concurrent testimony, that they are able to distinguish between persons, and approach those whom they have found to be friendly, while shunning strangers. This power of discrimination, it will be remembered, also occurs among bees and wasps, and therefore its presence in spiders is not antecedently improbable. I myself know a lady who has 'tamed' spiders to recognise her, so that they come out to be fed when she enters the room where they are kept; and stories of the taming of spiders by prisoners are abundant. The following anecdote recorded by Büchner is in this connection worth quoting:—

Dr. Moschkau, of Gohlis, near Leipsic, writes as follows to the author, on August 28, 1876:—'In Oderwitz (?), where I lived in 1873 and 1874, I noticed one day in a half-dark corner of the antercom a tolerably respectable spider's web, in which a well-fed cross-spider had made its home, and sat at the nestopening early and late, watching for some flying or creeping food. I was accidentally several times a witness of the craft with which it caught its victim and rendered it harmless, and it soon became a regular duty to carry it flies several times during a day, which I laid down before its door with a pair of pincers. At first this feeding seemed to arouse small confidence, the pincers perhaps being in fault, for it let many of the flies escape again, or only seized them when it knew that they were within reach of its abode. After a while, however, the spider came each time and took the flies out of the pincers and spun them over. The latter business was sometimes done so superficially, when I gave flies very quickly one after the other, that some of the to escape. it seemed to very ravence began teaking it back again. The first tinforgive me, ship was desmy offered fithird day it

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s as follows to tz (?), where I alf-dark corner web, in which sat at the nestng or creeping ss of the craft harmless, and several times with a pair of nall confidence, ny of the flies that they were ever, the spider ncers and spun done so super the other, that some of the already ensnared flies found time and opportunity to escape. This game was carried on by me for some weeks, as it see ned to me curious. But one day when the spider seemed very ravenous, and regularly flew at each fly offered to it, I began testing it. As soon as it had got hold of the fly I pulled it back again with the pincers. It took this exceedingly ill. The first time, as I finally left the fly with it, it managed to forgive me, but when I later took a fly right away, our friendship was destroyed for ever. On the following day it treated my offered flies with contempt, and would not move, and on the third day it had disappeared.

Jesse relates the following anecdote, which seems to display on the part of a spider somewhat remote adaptation of means to novel circumstances. He confined a spider with her eggs under a glass upon a marble mantel-piece. Having surrounded the eggs with web,—

She next proceeded to fix one of her threads to the upper part of the glass which confined her, and carried it to the further end of the piece of grass, and in a short time had succeeded in raising it up and fixing it perpendicularly, working her threads from the sides of the glass to the top and sides of the piece of grass. Her motive in doing this was obvious. She not only rendered the object of her care more secure than it would have been had it remained flat on the marble, but she was probably aware that the cold from the marble would chill her eggs, and prevent their arriving at maturity: she therefore raised them from it in the manner I have described.²

Mr. Belt gives the following account of the intelligence which certain species of South American spiders display in escaping from the terrible hosts of the Eciton ants:—

Many of the spiders would escape by hanging suspended by a thread of silk from the branches, safe from the foes that swarmed both above and below.

I noticed that spiders generally were most intelligent in exaping, and did not, like the cockroaches and other insects, take shelter in the first hiding-place they found, only to be driven out again, or perhaps caught by the advancing army of arts. I have often seen large spiders making off many yards in advance, and apparently determined to put a good distance

¹ Loc. cit., p. 319.

² Gleanings, vol. i., p. 103.

between themselves and the foe. I once saw one of the false spiders, or harvest-men (*Phalangidæ*), standing in the midst of an army of ants, and with the greatest circumspection and coolness lifting, one after the other, its long legs, which supported its body above their reach. Sometimes as many as five out of its eight legs would be lifted at once, and whenever an ant approached one of those on which it stood, there was always a clear space within reach to put down another, so as to be able to hold up the threatened one out of danger. 1

Mr. L. A. Morgan, writing to 'Nature' (Jan. 22, 1880). gives an account of a spider conveying a large insect from the part of the web where it was caught to the 'larder' by the following means. The spider first went two or three times backwards and forwards between the head of the insect and the main strand of the web. After this he went about cutting all the threads around the insect till the latter hung by the head strands alone. The spider then fixed a thread to the tail end, and by this dragged the carcass as far on its way to the larder as the head strands would permit. As soon as these were taut, he made the tail rope fast, went back to the head rope and cut it; then he attached himself to the head and pulled the body towards the larder, until the tail rope was taut. In this way, by alternately cutting the head and tail ropes and dragging the insect bit by bit, he conveyed it safely to the larder.

But the practical acquaintance with mechanical principles which this observation displays is perhaps not so remarkable as that which is sometimes shown by spiders when they find that a widely spread web is not tightly enough stretched, and as a consequence is to an inconvenient extent swayed about by the wind. Under such circumstances these animals have been observed to suspend to their webs small stones or other heavy objects, the weight of which serves to steady the whole system. Gleditsch saw a spider so circumstanced let itself down to the ground by means of a thread, seize a small stone, remount, and fasten the stone to the lower part of its web, at a height sufficient to enable animals and men to walk

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¹ Naturalist in Nicaragua, p. 19.

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heavy objects, whole systemitself down to nall stone, reart of its web, I men to walk beneath it. After alluding to this case, Büchner observes (loc. cit., p. 318),—

But a similar observation was made by Professor E. H. Weber, the famous anatomist and physiologist, and was published many years ago in Müller's Journal. A spider had stretched its web between two posts standing opposite each other, and had fastened it to a plant below for the third point. But as the attachment below was often broken by the garden work, by passers-by, and in other ways, the little animal extricated itself from the difficulty by spinning its web round a little stone, and fastened this to the lower part of its web, swinging freely, and so to draw the web down by its weight instead of fastening it in this direction by a connecting thread. (Vergl. Psycho., 1866, p. 76) also made a similar observation. But the most interesting observation on this head is related by J. G. Wood ('Glimpses into Petland'), and repeated by Watson (loc. cit., p. 455). One of my friends, says Wood, was accustomed to grant shelter to a number of garden spiders under a large verandah, and to watch their habits. One day a sharp storm broke out, and the wind raged so furiously through the garden that the spiders suffered damage from it, although sheltered by the verandah. The mainyards of one of these webs, as the sailors would call them, were broken, so that the web was blown hither and thither, like a slack sail in a storm. The spider made no fresh threads, but tried to help itself in another way. It let itself down to the ground by a thread, and crawled to a place where lay some splintered pieces of a wooden fence thrown down by the storm. It fastened a thread to one of the bits of wood, turned back with it, and hung it with a strong thread to the lower part of its nest, about five feet from the The performance was a wonderful one, for the weight of the wood sufficed to keep the nest tolerably firm, while it was yet light enough to yield to the wind, and so prevent further injury. The piece of wood was about two and a half inches long, and as thick as a goose-quill. On the following day a careless servant knocked her head against the wood, and it fell down. But in the course of a few hours the spider had found it and brought it back to its place. When the storm ceased, the spider mended her web, broke the supporting thread in two, and let the wood fall to the ground!

If so well-observed a fact requires any further confirmation, I may adduce the following account, which is of the more value as corroborative evidence from the writer

not appearing to be aware that the fact had been observed before. This writer is Dr. John Topham, whom the late Dr. Sharpey, F.R.S., assured me is a competent observer, and who publishes the account in 'Nature' (xi. 18):—

A spider constructed its web in an angle of my garden, the sides of which were attached by long threads to shrubs at the height of nearly three feet from the gravel path beneath. Being much exposed to the wind, the equinoctial gales of this autumn destroyed the web several times.

The ingenious spider now adopted the contrivance here represented. It secured a conical fragment of gravel with its larger end upwards by two cords, one attached to each of its opposite sides, to the apex of its wedge-shaped web, and left it suspended as a moveable weight to be opposed to the effect of such gusts of air as had destroyed the webs previously occupying the same situation.

The spider must have descended to the gravel path for this special object, and having attached threads to a stone suited to its purpose, must have afterwards raised this by fixing itself upon the web, and pulling the weight up to a height of more than two feet from the ground, where it hung suspended by elastic cords. The excellence of the contrivance is too evident to require further comment.

An almost precisely analogous case, with a sketch, is published by another observer in 'Land and Water,' Dec. 12, 1877.

Scorpions.

Before quitting the Arachnida I must allude to some recent correspondence on the alleged tendency of the scorpion to commit suicide when surrounded by fire. This alleged tendency has long been recognised in popular fables, and has been used by Byron as a poetical metaphor in certain well-known lines. But until the publication of the correspondence to which I allude, no one supposed the tendency in question to have any existence in fact. This correspondence took place in 'Nature' (vol. xi.), and as the subject is an interesting one, I shall reproduce the more important contributions to it in extenso. It was opened by Mr. W. G. Biddie as follows:—

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reference to the common black scorpion of Southern India, which was observed by me some years ago in Madras.

One morning a servant brought to me a large specimen of this scorpion, which, having stayed out too long in its nocturnal rambles, had apparently got bewildered at daybreak, and been unable to find its way home. To keep it safe the creature was at once put into a glazed entomological case. Having a few leisure minutes in the course of the forenoon I thought I would see how my prisoner was getting on, and to have a better view of it the case was placed in a window in the rays of the hot sun. The light and heat seemed to irritate it very much, and this recalled to my mind a story which I had read somewhere that a scorpion, on being surrounded with fire, had committed suicide. I hesitated about subjecting my pet to such a terrible ordeal, but taking a common botanical lens, I focussed the rays of the sun on its back. The moment this was done it began to run hurriedly about the case, hissing and spitting in a very fierce way. This experiment was repeated some four or five times with like results, but on trying it once again, the scorpion turned up its tail and plunged the sting, quick as lightning, into its own back. The infliction of the wound was followed by a sudden escape of fluid, and a friend standing by me called out, See, it has stung itself: it is dead; and sure enough in less than half a minute life was quite extinct. I have written this brief note to show (1) that animals may commit suicide; (2) that the poison of certain animals may be destructive to themselves.

The following corroborative evidence on the subject was then supplied by Dr. Allen Thomson, F.R.S. ('Nature,' vol. xx., p. 577):—

Doubts having been expressed at various times, even by larned naturalists, as to the reality of the suicide or self-destruction of the scorpion by means of its own poison, and these doubts having been again stated in 'Nature,' vol. xx., p. 553, by Mr. B. F. Hutchinson, of Peshawur, as the result of his own observations, I think it may be useful to give an articulate account of the phenomenon as it has been related to me by an eye-witness, which removes all possible doubt as to its occurrence under certain circumstances.

While residing many years ago, during the summer months, at the baths of Sulla in Italy, in a somewhat damp locality, my informant together with the rest of the family was much innoyed by the frequent intrusion of small black scorpions into

the house, and their being secreted among the bedclothes, in shoes, and other articles of dress. It thus became necessary to be constantly on the watch for these troublesome creatures, and to take means for their removal and destruction. Having been informed by the natives of the place that the scorpion would destroy itself if exposed to a sudden light, my informant and her friends soon became adepts in catching the scorpions and disposing of them in the manner suggested. This consisted in confining the animal under an inverted drinking-glass or tumbler. below which a card was inserted when the capture was made, and then, waiting till dark, suddenly bringing the light of a candle near to the glass in which the animal was confined. No sooner was this done than the scorpion invariably showed signs of great excitement, running round and round the interior of the tumbler with reckless velocity for a number of times. This state having lasted for a minute or more, the animal suddenly became quiet, and turning its tail on the hinder part of its body over its back, brought its recurved sting down upon the middle of the head, and piercing it forcibly, in a few seconds became quite motionless, and in fact quite dead. This observation was repeated very frequently; in truth, it was adopted as the best plan of getting rid of the animals. The young people were in the habit of handling the scorpions with impunity immediately after they were so killed, and of preserving many of them as curiosities.

In this narrative the following circumstances are worthy of attention:—

(1) The effect of light in producing the excitement amounting to despair, which causes the animal to commit self-destruction;

(2) The suddenness of the operation of the poison, which is probably inserted by the puncture of the head into the upper cerebral ganglion; and

(3) The completeness of the fatal symptoms at once induced.

I am aware that the phenomena now described have been observed by others, and they appear to have been familiarly known to the inhabitants of the district in which the animals are found. Sufficient confirmation of the facts is also to be found in the narratives of 'G. Biddie' and 'M. L.' contained in 'Nature,' vol. ix., pp. 29-47, and it will be observed that the circumstances leading the animal to self-destruction in these instances were somewhat similar to those narrated by my informant. It is abundantly clear, therefore, that the view taken

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by Mr. Hutchinson, viz., that the 'popular idea regarding scorpionic suicide is a delusion based on an impossibility,' is wholly untenable; indeed, the recurved direction of the sting, which he refers to as creating the impossibility of the animal destroying itself, actually facilitates the operation of inflicting the wound. I suppose Mr. Hutchinson, arguing from the analogy of bees or wasps, imagined that the sting would be bent forwards upon the body, whereas the wound of the scorpion is invariably inflicted by a recurvation of the tail over the back of the animal.

It will be perceived that these observations were not made by Dr. Allen Thomson himself, and that there are certain inherent discrepancies in the account which he has published—such, for instance, as the reason given for trying and repeating the experiment, the method being clearly a cumbersome one to employ if the only object were that of 'disposing of' the animals. Nevertheless, as Dr. Thomson is a high authority, and as I learn from him that he is satisfied regarding the capability and veracity of his informant, I have not felt justified in suppressing his evidence. Still I think that so remarkable a fact unquestionably demands further corroboration before we should be justified in accepting it unreservedly. For if it is a fact, it stands as a unique case of an instinct detrimental alike to the individual and to the species.

CHAPTER VII.

REMAINING ARTICULATA.

THE Hymenoptera being so much the most intelligent order, not merely of insects, but of Invertebrata, and the Arachnida having been now considered, very little space need be occupied with the remaining classes of the Articulata.

Coleoptera.

Sir John Lubbock, in his first paper on Bees and Wasps, quotes the following case from Kirby and Spence, with the remarks which I append:—

The first of these anecdotes refers to a beetle (Ateuchus pilularius) which, having made for the reception of its eggs a pellet of dung too heavy for it to move, repaired to an adjoining heap, and soon returned with three of his companions. 'All four now applied their united strength to the pellet, and at length succeeded in pushing it out; which being done, the three assistant beetles left the spot and returned to their own quarters.' This observation rests on the authority of an anonymous German artist; and though we are assured that he was a 'man of strict veracity,' I am not aware that any similar fact has been recorded by any other observer.

Catesby, however, says:—

I have attentively admired their industry, and their mutual assisting of each other in rolling these globular balls from the place where they made them, to that of their interment, which is usually a distance of some yards, more or less. This thereform back foremost, by raising their hind parts and pushing away the ball with their hind feet. Two or three of them are sometimes engaged in trundling one ball, which from meeting with impediments, on account of the unevenness of the ground is sometimes deserted by them. It is, however, attempted by others with success, unless it happen to roll into some deep hollow or ditch, where they are accustomed to leave it; but

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they continue their work by rolling off the next ball that comes in their way. None of them seem to know their own balls, but an equal care for the whole appears to affect all the community. They form these pellets while the dung remains moist, and leave them to harden in the sun before they attempt to roll them. In their rolling of them from place to place, both they and the balls may frequently be seen tumbling about over the little eminences that are in their way. They are not, however, easily discouraged, and by repeating their attempts usually surmount the difficulties.

Büchner speaks of the fact that dung-beetles co-operate in their work as one that is well established, but gives no authorities or references.² A friend of my own, however, informs me that she has witnessed the fact; and in view of analogous observations made on other species of Coleoptera, I see no reason to doubt this one. Some of these observations I may here append.

Herr Gollitz writes to Büchner thus:—

Last summer, in the month of July, I was one day in my field, and found there a mound of fresh earth like a molehill, on which a striped black and red beetle, with long legs, and about the size of a hornet, was busy taking away the earth from a hole that led like a pit into the mound, and levelling the place. After I had watched this beetle for some time, I noticed a second beetle of the same kind, which brought a little lump of earth from the interior to the opening of the hole, and then disappeared again in the mound; every four or five minutes pellet came out of the hole, and was carried away by the firstnamed beetle. After I had watched these proceedings for about alf an hour, the beetle which had been working underground ame out and ran to its comrade. Both put their heads together, nd clearly held a conversation, for immediately afterwards they hanged work. The one which had been working outside went to the mound, the other took the outside labour, and all went a vigorously. I watched the affair still for a little longer, and ent away with the notion that these insects could understand ich other just like men. Klingelhöffer, of Darmstadt (in rehm, loc. cit., ix., p. 86), says:—A golden running beetle came pacockchafer lying on its back in the garden, intending to eat but was unable to master it; it ran to the next bush, and

er, attempted by into some deep to leave it; but 2 Loc. cit., p. 344.

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¹ Quoted by Bingley, Animal Biography, vol. iii., p. 118.

returned with a friend, whereupon the two overpowered the cockchafer, and pulled it off to their hiding-place.

Similarly, there is no doubt that the burying beetles (Nicrophorus) co-operate.

Several of them unite together to bury under the ground, as food and shelter for their young, some dead animal, such as a mouse, a toad, a mole, a bird, &c. The burial is performed because the corpse, if left above ground, would either dry up, or grow rotten, or be eaten by other animals. In all these cases the young would perish, whereas the dead body lying in the earth and withdrawn from the outer air lasts very well. The burying beetles go to work in a very well-considered fashion for they scrape away the earth lying under the body, so that it sinks of itself deeper and deeper. When it is deep enough down it is covered over from above. If the situation is stony, the beetles with united forces and great efforts drag the corpse to some place more suitable for burying. They work so diligently that a mouse, for instance, is buried within three hours. But they often work on for days, so as to bury the body as deeply as possible. From large carcasses, such as those of horses, sheep, &c., they only bury pieces as large as they can manage.1

Lastly, Clarville gives a case of a burying beetle which wanted to carry away a dead mouse, but, finding it too heavy for its unaided strength, went off, like the beetles previously mentioned, and brought four others to its assistance.²

A friend of Gleditsch fastened a dead toad, which he desired to dry, upon the top of an upright stick. The burying beetles were attracted by the smell, and finding that they could not reach the toad, they undermined the stick, so causing it to fall with the toad, which was the buried safe out of harm's way.³

A converse exemplification of beetle-intelligence is given by G. Berkeley. He saw a beetle carrying a deal spider up a heath plant, and hanging it upon a twig of the heath in so secure a position, that when the insect had left it Mr. Berkeley found that a sharp shake of the heather would not bring the dead spider down. As the burying

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¹ Büchner, loc. cit., p. 344.

Quoted in Strauss, Insects, s. 389.
 Kirby and Spence, lov. cit., pp. 321-2.

⁴ Life and Recollections, vol. ii., p. 356.

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heetle preserves its treasure by hiding it out of sight below ground, so this beetle no doubt secured the same end but by other means; 'seeing,' as Mr. Berkeley observes, 'that if it did not hang up its prey, it might fall into the hands of other hunters, it took all possible pains to find out the hest store-room for it.'

The above instances of beetle-intelligence lead me to credit the following, which has been communicated to me by Dr. Garraway, of Faversham. On a bank of moss in the Black Forest he saw a beetle alight with a caterpillar which it was carrying, and proceed to excavate a cylindrical hole in the peat, about an inch and a half deep, into which, when completed, it dropped the caterpillar, and then flew away through the pines. 'I was struck,' says my correspondent, 'with the creature's folly in leaving the whole meovered, as every curious wayfaring insect would doubtless be tempted to enter therein. However, in about a minute the beetle returned, this time carrying a small pebble, of which there were none in the immediate vicinity, and having carefully fitted this into the aperture, fled way into space.'

Earwig.

I must devote a short division of this chapter to the arwig. M. Geer describes a regular process of incubation spractised by the mother insect. He placed one with ereggs in a box, and scattered the eggs on the floor of he latter. The earwig, however, carried them one by one ato a certain part of the box, and then remained contantly sitting upon the heap without ever quitting it for moment. When the eggs were hatched, the young earigs kept close to their mother, following her about everyhere, and often running under her abdomen, just as nickens run under a hen. I

A young lady, who objects to her name being published, forms me that her two younger sisters (children) are in e habit of feeding every morning with sugar an earwig, hich they call 'Tom,' and which crawls up a certain rtain regularly every day at the same hour, with the parent expectation of getting its breakfast.

¹ Quoted by Bingley, loc. cit., vol. iii., pp. 150-51.

sembles analogous instances which have been mentioned in the case of spiders.

Dipterous Insects.

The gad-fly, whose eggs are hatched out in the intestines of the horse, exhibits a singular refinement of instinct in depositing them upon those parts of the horse which the animal is most likely to lick. For, according to Bingley and other writers, 'the inside of the knee is the part on which these flies principally deposit their eggs; and next to this they fix them upon the sides, and the back part of the shoulder; but almost always in places liable to be licked by the tongue.' The female fly deposits her eggs while on the wing, or at least scarcely appears to settle when she extends her ovidepositor to touch the horse. She lays only a single egg at a time—flying away a short distance after having deposited one in order to prepare another, and so on.

The following anecdote, which I quote from Jesse, seems to indicate no small degree of intelligence on the part of the common house-fly—intelligence, for instance, the same both in kind and degree as that which was displayed by Sir John Lubbock's pet wasp already mentioned:

Slingsby, the celebrated opera dancer, resided in the large house in Cross-deep, Twickenham, next to Sir Wathen Waller's looking down the river. He was fond of the study of natural history, and particularly of insects, and he once tried to tame some house-flies, and preserve them in a state of activity through the winter. For this purpose, quite at the latter end of autum and when they were becoming almost helpless, he selected for from off his breakfast-table, put them upon a large handful cotton, and placed it in one corner of the window nearest Not long afterwards the weather became so w that all flies disappeared except these four, which constant left their bed of cotton at his breakfast-time, came and fed the table, and then returned to their home. This continu for a short time, when three of them became lifeless in the shelter, and only one came down. This one Slingsby 🛚 trained to feed upon his thumb-nail, by placing on it some mo sugar mixed with a little butter. Although there had been intervals several days of sharp frost, the fly never missed take his daily meal in this way till after Christmas, when, his

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preserver having invited a friend to dine and sleep at his house, the fly, the next morning, perched upon the thumb of the visitor, who, being ignorant that it was a pet of his host's, clapped his hand upon it, and thus put an end to Mr. Slingsby's experiment.1

Crustacea.

There is no doubt that these are an intelligent group of animals, although I have been able to collect but wonderfully little information upon the subject. Moseley, F.R.S., in his very interesting work, 'Notes by a Naturalist on the Challenger, says (p. 70):—

In the tropics one becomes accustomed to watch the habits of various species of crabs, which there live so commonly an aërial life. The more I have seen of them, the more have I been astonished at their sagacity.

And again (pp. 48-9):—

A rock crab (Grapsus stringosus) was very abundant, running about all over the rocks, and making off into clefts on one's approach. I was astonished at the keen and long sight of this crab. I noticed some made off at full speed to their hidingplaces at the instant that my head showed above a rock fifty

At Still Bay, on the sandy beach of which a heavy surf was breaking, I encountered a sand crab (*Ecypoda ippeus*), which was walking about, and got between it and its hole in the dry sand above the beach. The crab was a large one, at least three inches in breadth of its carapace. . . . With its curious columnlike eyes erect, the crab bolted down towards the surf as the only escape, and as it saw a great wave rushing up the shelving shore, dug itself tight into the sand, and held on to prevent the undertide from carrying it into the sea. As soon as the wave had retreated, it made off full speed for the shore. I gave chase, and whenever a wave approached, the crab repeated the manœuvre. I once touched it with my hand whilst it was buried and blinded by the sandy water, but the surf compelled came and fed to me to retreat, and I could not snatch hold of it for fear of its This continue powerful claws. At last I chased it, hard pressed, into the surf in a hurry, and being unable to get proper hold in time, it was washed into the sea. The crab evidently dreaded going on it some moi anto the sea. . . . They soon die when kept a short time be-

Gleanings, vol. ii., pp. 165-6.

The land crabs of the West Indies and North America descend from their mountain home in May and June, to deposit their spawn in the sea. They travel in such swarms that the roads and woods are covered with them. They migrate in a straight line, and rather than allow themselves to be deflected from it, 'they scale the houses, and surmount every other obstacle that lies in their way' (Kirby). They travel chiefly by night, and when they arrive at the sea-shore they 'bathe three or four different times,' and then 'commit their eggs to the waves.' They return to the mountains by the same route, but only the

most vigorous survive the double journey.

Prof. Alex. Agassiz details some interesting observations on the behaviour of young hermit crabs reared by himself 'from very young stages,' when first presented with shells of mollusks. 'A number of shells, some of them empty, others with the animal living, were placed in a glass dish with the young crabs. Scarcely had the shells reached the bottom before the crabs made a rush for the shells turned them round and round, invariably at the mouth, and soon a couple of the crabs decided to venture in which they did with remarkable alacrity.' The crabs which obtained for their share the shells still inhabited by living mollusks, 'remained riding round upon the mouth of their future dwelling, and, on the death of the mollusk, which generally occurred soon after in captivity, commenced at once to tear out the animal, and having eaten him, proceeded to take its place within the shell."

There is a species of small crustacean (Podocerus capillatus) described by Mr. Bates, which builds a nest to contain its eggs. The nest is in the form of a hollow cone, built upon seaweed, and composed of fine thread-like material closely interlaced. 'These nests,' says Mr. Bates, 'are evidently used as a place of refuge and security in which the parent protects and keeps her brood of your until they are old enough to be independent of the

mother's care.'

Dr. Erasmus Darwin tells us, on the authority of a friend on whose competency as an observer he relied, the the common crab during the moulting season stations a

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¹ American Journ. Sc. and Art, vol. x., Oct. 1875.

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sentinel an unmoulted or hard-shelled individual, to prevent marine enemies from injuring moulted individuals in their unprotected state. While thus mounting guard the hard-shelled crab is much more courageous than at other times, when he has only his own safety to consider. But these observations require to be corroborated.

In 'Nature' (xv., p. 415) there is a notice of a lobster (Homarus marinus) in the Rothesay Aquarium which attacked a flounder that was confined in the same tank with him, and having devoured a portion of his victim, buried the rest beneath a heap of shingle, on which he 'mounted guard.' 'Five times within two hours was the fish unearthed, and as often did the lobster shovel the gravel over it with his huge claws, each time ascending the pile and turning his bold defensive front to his companions.'

The following is quoted from Mr. Darwin's 'Descent of

Man'(pp. 270-1):

A trustworthy naturalist, Mr. Gardner, whilst watching a shore-crab (Gelasimus) making its burrow, threw some shells towards the hole. One rolled in, and three other shells remained within a few inches of the mouth. In about five minutes the crab brought out the shell which had fallen in, and carried it away to the distance of a foot; it then saw the three other shells lying near, and evidently thinking that they might likewise roll in, carried them to the spot where it had laid the first. It would, I think, be difficult to distinguish this act from one performed by man by the aid of reason.

Mr. Darwin also alludes to the curious instinctive habits of the large shore-crab (Birgus latro), which feeds on fallen cocoa-nuts ' by tearing off the husk fibre by fibre; and it always begins at that end where the three eye-like depressions are situated. It then breaks through one of these eyes by hammering with its heavy front pincers, and turning round, extracts the albuminous core with its narrow posterior pincers.'

Remarkable cases occur of commensalism between certain crabs and sea-anemones, and they betoken much intelligence. Thus Professor Möbius says in his 'Beiträge zur Meeresfauna der Insel Mauritius' (1880) that there are two crabs belonging to different genera which have the habit of firmly grasping a sea-anemone in each claw and carrying them about, presumably to secure some benefit to themselves. The more familiar case of the species of anemone which lives on the shells tenanted by hermit crabs is of special interest to us on account of a remarkable observation published by Mr. Gosse, F.R.S. (Zoologist, June, 1859). He found that on his detaching the anemone (Adamsia) from the shell, the hermit crab always took it up in its claws and held it against the shell 'for the space of ten minutes at a time, until fairly attached by a good strong base.' It was said by the late Dr. Robert Ball that when the common Sagartia parasitica is attached to a stone and a hermit crab is placed in its vicinity, the anemone will leave the stone and attach itself to the hermit's shell (Critic, March 24, 1860).

Intelligence of Larvæ of Certain Insects.

I shall now allude to some of the more interesting facts touching the psychology of insects when in their immature or larval state. This is an interesting topic from the point of view which we occupy as evolutionists, because a caterpillar is really a locomotive and self-feeding embryo, whose entire mental constitution is destined to undergo a metamorphosis no less complete and profound than that which is also destined to take place in its corporeal structure. Yet although the caterpillar has an embryo psychology, its instincts and even intelligence often seem to be higher or more elaborated than is the case with the imago form. Where such is the case the explanation of course must be that it is of more importance to the species that the larval form should be in a certain measure intelligent than that the image form should be so. Every larva is a potential imago, or breeding individual; therefore its life is of no less value to the species during its larval than during its adult existence; and if certain instincts or grades of intelligence are of more use to it during the former than during the latter period, of course natural selection would determine the unusual event which we seem here in some cases to see-namely, that the

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I may most fitly begin under this heading with the remarkable instincts of the so-called 'ant-lion,' which is the larva of a neuropterous insect, the common Myrmeleon (M. formicarium). I quote the following account of its habits from Thompson's 'Passions of Animals' (p. 258):—

The devices of the ant-lion are still more extraordinary if possible. He forms, with astonishing labour and perseverance, a pit in the shape of a funnel, in a dry sandy soil, under some old wall or other spot protected from the wind. His pit being finished, he buries himself among the sand at the bottom, leaving only his horns visible, and thus waits patiently for his prey. When an ant or any other small insect happens to walk on the edge of the hollow, it forces down some of the particles of sand, which gives the ant-lion notice of its presence. He immediately throws up the sand which covers his head to overwhelm the ant, and with its returning force brings it to the bottom. This he continues to do till the insect is overcome and falls between his horns. Every endeavour to escape, when once the incautious ant has stepped within the verge of the pit, is vain, for in all its attempts to climb the side the deceptive sand slips from under its feet, and every struggle precipitates it still lower. When within reach its enemy plunges the points of its jaws into its body, and having sucked out all its juices, throws out the empty skin to some distance.

According to Bingley, if the ant-lion, while excavating its pitfall,—

Comes to a stone of some moderate size, it does not desert the work on this account, but goes on, intending to remove that impediment the last. When the pit is finished, it crawls backward up the side of the place where the stone is; and, getting its tail under it, takes great pains and time to get it on a true poise, and then begins to crawl backward with it up the edge to the top of the pit, to get it out of the way. It is a common thing to see an ant-lion labouring in this manner at a stone four times as big as its own body; and as it can only move backwards, and the poise is difficult to keep, especially up a slope of such crumbling matter as sand, which moulders away from under its feet, and necessarily alters the position of its body, the stone very frequently rolls down, when near the verge, quite to the bottom. In this case the animal attacks it again

Common

in the same way, and is often not discouraged by five or six miscarriages, but continues its struggle so long that it at length gets over the verge of the place. When it has done this, it does not leave it there, lest it should roll in again; but is always at the pains of pushing it further on, till it has removed it to a necessary distance from the edge of the pit.

Passing on now to the intelligence of caterpillars, Mr. G. B. Buckton, F.R.S., writing from Haslemere, says:—

Many caterpillars of *Pieris rapæ* have, during this autumn, fed below my windows. On searching for suitable positions for passing into chrysalides, some eight or ten individuals, in their direct march upwards, encountered the plate-glass panes of my windows; on these they appeared to be unable to stand. Accordingly in every case they made silken ladders, some of them five feet long, each ladder being formed of a single continuous thread, woven in elegant loops from side to side. . . . The reasoning, however, seems to be but narrow, for one ladder was constructed parallel to the window-frame for nearly three feet, on which secure footing could be had by simply diverting the track two inches.²

In this case it appears clear that we have to do with instinct, and not with reason. No doubt it is the congenital habit of these caterpillars to overcome impediments in this way; but the instinct is one of sufficient interest to be here stated.

The following is quoted from Kirby and Spence:-

A caterpillar described by Bonnet, which, from being confined in a box, was unable to obtain a supply of the bark with which its ordinary instinct directs it to make its cocoon, substituted pieces of paper that were given to it, tied them together with silk, and constructed a very passable cocoon with them. In another instance the same naturalist having opened several cocoons of a moth (Noctura verbasci), which are composed of a mixture of grains of earth and silk, just after being finished, the larvæ did not repair the injury in the same manner. Some employed both earth and silk; others contented themselves with spinning a silken veil before the opening.³

The same authorities state, as result of their own observation, that the—

¹ Animal Biography, vol. iii., pp. 244-5.
² Nature, vii., p. 49.
⁸ Intr. to Ent., ii., p. 475.

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Common cabbage caterpillar, which, when building web under stone or wooden surfaces, previously covers a space with a web to form a base for supporting its dependent pupa, when building a web beneath a muslin surface dispenses with this base altogether: it perceives that the woven texture of the muslin forms facilities for attaching the threads of the cocoon securely enough to support the weight of the cocoon without the necessity of making the usual square inch or so of basal support.

The instincts of the larva of the *Tinea* moth are thus described by Réaumur:—

It feeds upon the elm, using the leaves both as food and To do this it only eats the parenchyma of the leaf, preserving the upper and under epidermal membranes, between which it then insinuates itself as it progressively devours the parenchyma. It, however, carefully avoids separating these membranes where they unite at the extreme edge of the leaf. which is designed to form 'one of the seams of its coat.' 'The cavity when thus excavated between the two epidermal membranes is then lined with silk, made cylindrical in shape, cut off at the two ends and all along the side remote from the 'seam,' and then the two epidermal membranes sewn together along the side where they have had to be cut in order to separate them from the tree. The larva now has a coat exactly fitting its body, and open at each end. By the one opening it feeds, and by the other discharges its excrement, 'having on one side a nicely jointed seam—that which is commonly applied to its back composed of the natural marginal junction of the membranes of the leaf.'

Réaumur cut off the edge of a newly finished coat, so as to expose the body of the larva at that point. The animal did not set about making a new coat ab initio, as we might expect that it would on the popular supposition that a train of instinctive actions is always as mechanical as the running down of a set of cog-wheels, and that wherever a novel element is introduced the machinery must be thrown out of gear, so that it cannot meet a new emergency of however simple a character, and must therefore re-start the whole process over again from the beginning. In this case the larva sewed up the rent; and not only so, but 'the seissors having cut off one of the projections intended to enter into the construction of

first designed for the tail.'

Another remarkable case of the variation of instinct in the Lepidoptera is stated by Bonnet. There are usually, he says, two generations of the Angoumois moth: the first appear in early summer, and lay their eggs upon the ears of wheat in the fields; the second appear later in the summer, or in the autumn, and these lay their eggs upon wheat in the granaries; from these eggs there comes the first generation of next year's moths. This is a highly remarkable case—supposing the facts to be as Bonnet states; for it seems that the early summer moths, although born in the granaries, immediately fly to the unreaped fields to lay their eggs in the standing corn, while the autumn moths never attempt to leave the granaries, but lay their eggs upon the stored wheat.

Westwood says that-

A species of Tasmanian caterpillar (Noctua Ewingii) swarms over the land in enormous companies, which regularly begin to march at four o'clock in the morning, and as regularly halt at midday. Liparis chrysorrhaca, a kind of caterpillar, spins for the winter a common web, in which several hundred individuals find a common shelter.²

According to Kirby and Spence,-

The larva of the ichneumon, while feeding upon its caterpillar host, spares the walls of the intestines until it is time for it to escape, when, the life of the caterpillar being no longer necessary

to its development, it perforates these walls.3

The larvæ Theda isocrates live in a group of seven or eight in the fruit of pomegranate. In consequence of their excavations within the fruit, the latter is apt to fall; and to prevent its doing so the larvæ throw out a thread of attachment wherewith to secure the fruit to the branch, so that if the stalk withers, this thread serves to suspend the fruit.⁴

The caterpillar of the Bombyx moth, which is a native of France, exhibits very wonderful instincts. The larva is gregarious in its habits, each society (family) consisting of perhaps

³ Introd. Ent., Letter xi.

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¹ Euvres, ix., p. 370. ² Trans. Ent. Soc., vol. ii.

⁴ Westwood, Trans. Ent. Soc., vol. ii., p. 1.

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600 or 800 individuals. When young they have no fixed habitation, but encamp sometimes in one place, and sometimes in another, under the shelter of their web; but when they have attained two-thirds of their growth, they weave for themselves a common tent. About sunset the regiment leaves its quarters.

At their head is a chief, by whose movements their procession is regulated. When he stops all stop, and proceed when he proceeds; three or four of his immediate followers succeed in the same line, the head of the second touching the tail of the first; then comes an equal series of pairs, next of threes, and so on, as far as fifteen or twenty. The whole procession moves regularly on with an even pace, each file treading in the steps of those that precede it. If the leader, arriving at a particular point, pursues a different direction, all march to that point before they turn.

The following additional facts concerning these remarkable habits may be quoted. I take them from the account published by Mr. Davis in 'Loudoun's Magazine of Natural History:'—

The caterpillars, he observed, were Bombyces, and were seen crossing a road in single file, each so close to its predecessor that the line was quite continuous, 'moving like a living cord.' The number of caterpillars was 154, and the length of the line 27 feet. When Mr. Davis removed one from the line the caterpillar immediately in front suddenly stood still, then the next, and next, and so on to the leader. Similarly, those behind the point of interruption successively halted. After a pause of a few moments, the first caterpillar behind the break in the line endeavoured to fill up the vacant space, and so recover contact or communication, which after a time it succeeded in doing, when the information that the line was again closed was passed forward in some way from caterpillar to caterpillar till it reached the leader, when the whole line was again put in motion. The individual which had been abstracted remained rolled up and motionless; but on being placed near the moving column it immediately unrolled, and made every attempt to get readmitted into the procession. After many endeavours it succeeded, the one below falling into the rear of the interloper. On repeating the experiment by removing a caterpillar fifty from the head of the procession, Mr. Davis found that it took just thirty seconds by his watch for information of the fact to reach All the same results followed as in the previous

¹ Kirby and Spence, Entomology, Letter xvi.

case. It was observable that the animals were guided neither by sight nor smell while endeavouring to close up the interrupted line; for the caterpillar next behind the interruption, on whom the duty of closing up devolved, 'turned right and left, and often in a wrong direction, when within half an inch of the one immediately before him; when he at last touched the object of his search, the fact was communicated again by signal; and in thirty seconds the whole line was in rapid march.' This gentleman adds that the object of the march was the search for new pasture. The caterpillars feed on the Eucalyptus, and when they have completely stripped one tree of its leaves, they all congregate on the trunk, and proceed as described to another tree.

De Villiers 1 gives an account of his observations on the manner in which these caterpillars (Cnethocampii pitzocampa) are able to pass information, which does not quite agree with the above observation of Mr. Davis. For he says that, in a train of 600 caterpillars, interference by him in any part of the train was communicated through the whole series instantaneously—all the 600 caterpillars stopping immediately and with one consent like a single organism.

According to Kirby and Spence there is a kind of caterpillar (*Pieris cratægi*) which lives in little colonies of ten or twelve in common chambers lined with silk. In one part they make of the same material a little bag or pocket, which is used by the community or household as a water-closet. When full of excrement the caterpillars empty it by turning out the pellets with their feet.²

Only two other instances of noteworthy intelligence as exhibited by larvæ have fallen within my reading. One of these is mentioned by Réaumur, who says that the larvæ of *Hemerobius chrysops* chase aphides, and having killed them, clothe themselves in their skins; and the other case is the very remarkable one mentioned in his newly published work by W. MacLachlan, F.R.S., of caddis-worms adjusting the specific gravity of their tubes to suit that of the water in which they live, by attaching heavy or light material to them according as they requiresinking or flotation.

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Phil. Frags.

¹ Trans. Ent. Soc. France, vol. i., p. 201.

² Introduction to Entomology, Letter xxvi.

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CHAPTER VIII.

FISH.

ALTHOUGH we here pass into the sub-kingdom of animals the intelligence of which immeasurably surpasses that of the other sub-kingdoms, it is remarkable that these lowest representatives of the higher group are psychologically inferior to some of the higher members of the lower groups. Neither in its instincts nor in general intelligence can any fish be compared with an ant or a bee—a fact which hows how slightly a psychological classification of animals depends upon zoological affinity, or even morphological oranisation. For although a highly competent authority, namely Van Baer, has said that a bee is as highly organised n animal as a fish, though on a different type, no one would be found to assert that an ant or a bee is so much more lighly organised than a fish as its higher intelligence ould require, supposing degrees of intelligence to stand n necessary relation to degree of organic development. and this consideration is not materially altered if, instead fregarding the whole organism, we look to the nervous There is no doubt that the cerebral hemivstem alone. pheres of a fish, although small as compared with these gans in the higher Vertebrata, are, bulk for bulk, formous as compared with the esophageal ganglia or brain' of an insect; while the disproportion becomes ill greater if the cerebral hemispheres of a fish are comared with their supposed analogues in the brain of an pt, viz., the pedunculated and convoluted lobes which rmount the cephalic ganglion. But here the relative pallness of the ant as a whole must be taken into con-

Phil. Frags., translated by Huxley, Taylor's Mag., 1853, p. 196.

sideration, and also the fact that its brain is relatively much more massive as well as more highly organised than that which occurs in any other order of invertebrated animals, except, perhaps, the octopus and his allies. Therefore, although the brain of a fish is formed upon a type which by increase of size and complexity is destined in function far to eclipse all other types of nerve-centre, we have to observe that in its lowest stage of evolution as presented to science in the fishes, this type is functionally inferior to the invertebrate type, where this reaches its highest stage of evolution in the Hymenoptera.

Emotions.

Fish display emotions of fear, pugnacity; social, sexual, and parental feelings; anger, jealousy, play, and curiosity. So far the class of emotions is the same as that with which we have met in ants, and corresponds with that which is distinctive of the psychology of a child about four months old. I have not, however, any evidence of sympathy, which would be required to make the list of emotions identical; but sympathy may nevertheless be present.

Fear and pugnacity are too apparent in fish to require special proof. The social or gregarious feelings are strongly shown by the numberless species which swim in shoals the sexual feelings are proved by courtships, and the parental by those species which build nests and guant their young. Schneider saw several species of fish at the Naples Aquarium protecting their eggs. In one case the male mounted guard over a rock where the eggs were deposited, and swam with open mouth against intrudent The following accounts of the nidification of certain species of fish show that the parental instincts are not unlike those which obtain in birds, and are comparable in points strength with the same instincts as they occur in ant bees, and spiders.

Agassiz remarks ¹ that while examining the marine product of the Sargasso Sea, Mr. Mansfield picked up and brought him a round mass of sargassum, about the size of the two

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¹ Silliman's American Journal, Feb. 1872.

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fists placed together. The whole consisted, to all appearance, of nothing but gulf-weed, the branches and leaves of which were. however, evidently knit together, and not merely balled into a roundish mass. The elastic threads which held the gulf-weed together were beaded at intervals, sometimes two or three beads being close together, or a branch of them hanging from the cluster of threads. This nest was full of eggs scattered throughout the mass, and not placed together in a cavity. It was evidently the work of the Chironectes. This rocking fish-cradle is carried along as an undying arbour, affording at the same time protection and afterwards food for its living freight. It is suggested that the fish must have used their peculiar pectoral fins when constructing this elaborate nest.

The well-known tinker or ten-spined stickleback (Gasterosteus pungitius) is one of our indigenous fish which constructs a nest. On May 1, 1864, a male was placed in a well-established aquarium of moderate size, to which, after three days, two ripe females were added. Their presence at once roused him into activity, and he soon began to build a nest of bits of dirt and dead fibre, and of growing confervoid filaments, upon a jutting point of rock among some interlacing branches of Muriophyllum spicatum—all the time, however, frequently interrupting his labours to pay his addresses to the females. This was done in most vigorous fashion, he swimming, by a series of little jerks, near and about the female, even pushing against her with open mouth, but usually not biting. After a little equetting she responds and follows him, swimming just above him as he leads the way to the nest. When there, the male commences to flirt—he seems unaware of its situation, will not win to the right spot, and the female, after a few ineffectual ttempts to find the proper passage into it, turns tail to swim way, but is then viciously pursued by the male. When he ist courts the female, if she, not being ready, does not soon espond, he seems quickly to lose his temper, and, attacking her with great apparent fury, drives her to seek shelter in some are not unlike revice or dark corner. The coquetting of the male near the lest, which seems due to the fact that he really has not quite y occur in anterinished it, at length terminates by his pushing his head well pto the entrance of the nest, while the female closely follows im, placing herself above him, and apparently much excited. e marine product sals he withdraws she passes into the nest, and pushes quite p and brought brough it, after a very brief delay, during which she deposits size of the two er ova. The male now fertilises the eggs, and drives the female

¹ Ransom, Ann. and Mag. Nat. Hist., 1865, xvi., p. 449.

away to a safe distance; then, after patting down the nest, he proceeds in search of another female. The nest is built and the ova deposited in about twenty-four hours. The male continued to watch it day and night, and during the light hours he also

continually added to the nest.

The marine afteen-spined stickleback (Gasterosteus spinachia) affords another instance of nest-constructing fishes. The places selected for their nests are usually harbours, or some sheltered spots to where pure sea water reaches. The fish either find growing, or even collect some of the softer kinds of green or red seaweed, and join them with so much of the coralline tufts (Janiæ) growing on the rock as will serve the purpose of afford. ing firmness to the structure, and constitute a pear-shaped mass five or six inches long, and about as stout as a man's fist. A thread, which is elastic and resembles silk, is employed for the purpose of binding the materials together: under a magnifier it appears to consist of several strands connected by a gluer substance, which hardens by exposure to the water.1

M. Carbonnier, who has studied the habits of the Chinese butterfly-fish (Macropodus) in his private aquarium in Paris. where he had some in confinement, observed that the male constructs a nest of froth of considerable size, 15 to 18 centimetres horizontal diameter, and 10 to 12 high. He prepares the bubbles in the air (which he sucks in and then expels). strengthening them with mucous matter from his mouth, and brings them into the nest. Sometimes the buccal secretion will fail him, whereupon he goes to the bottom in search of confervæ, which he sucks and bites for a little in order to stime late the act of secretion. The nest prepared, the female is induced to enter. Not less curious is the way in which the male brings the eggs from the bottom into the nest. He appears unable to carry them up in his mouth; instead of this, he first swallows an abundant supply of air, then descending, he place himself beneath the eggs, and suddenly, by a violent contraction of the muscles in the interior of his mouth and pharynx, he ex hales the air which he had accumulated by the gills. This air, finely divided by the lamellæ and fringes of the gills escapes in the form of two jets of veritable gaseous powder which envelopes the eggs and raises them to the surface. this manœuvre the Macropodus entirely disappeared in a kin of air-mist, and when this had dissipated he reappeared with

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Quoted from Francis Day, F.L.S., Instincts and Emotions of Fig. Journ. Linn. Soc., vol. xv., pp. 36-7, where see for other cases of new building among fish.

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Again, in detailing Mr. Baker's observations on the three-spined stickleback, published in the Philosophical Transactions, this author says:—

It has been remarked that after the deposition of the eggs the nest was opened more to the action of the water, and the vibratory motion of the body of the male fish, hovering over its surface, caused a current of water to be propelled across the surface of the ova, which action was repeated almost continuously. After about ten days the nest was destroyed and the materials removed; and now were seen the minute fry fluttering upwards here and there, by a movement half swimming, half leaping, and then falling rapidly again upon or between the clear pebbles of the shingle bottom. This arose from their having the remainder of the yelk still attached to their body. which, acting as a weight, caused them to sink the moment the swimming effort had ceased. Around, across, and in every direction the male fish, as the guardian, continually moved. Now his labours became more arduous, and his vigilance was taxed to the utmost extreme, for the other fish (two tench and a gold carp), some twenty times larger than himself, as scon as they perceived the young fry in motion, continuously used their utmost endeavours to snap them up. The courage of the little stickleback was now put to its severest test; but, nothing daunted, he drove them all off, seizing their fins and striking with all his strength at their heads and at their eyes. His care of the young brood when encumbered with the yelk was very extraordinary; and as this was gradually absorbed and they gained strength, their attempts to swim carried them to a greater distance from the parent fish; his vigilance, however, seemed everywhere, and if they rose by the action of their fins above a certain height from the shingle bottom, or flitted beyond a given distance from the nest, they were immediately seized in his mouth, brought back, and gently puffed or jetted into their place again. The same care of the young, bringing them back to their nest up till about the sixth day after hatching, has been remarked by Dr. Ransom in the ten-spined stickleback (G. pungitius).

The well-known habit of the lophobranchiate fish, of

Follow

incubating their eggs in their pouches, also displays highly elaborated parental feeling. M. Risso says that when the young of the pipe-fish are hatched out, the parents show them marked attachment, and that the pouch then serves them as a place of shelter or retreat from danger.²

M. Carbonnier has recorded how the male of the curiously grotesque telescope-fish, a variety of *Carassius auratus* (Linn.), acts as accoucheur to the female. Three males pursued one female which was heavy with spawn, and rolled her like a ball upon the ground for a distance of several metres, and continued this process without rest or relaxation for two days, until the exhausted female, who had been unable to recover her equilibrium for a moment, had at last evacuated all her ova.³

That adult fish are capable of feeling affection for one another would seem to be well established: thus Jesse relates how he once captured a female pike (*Esox lucius*) during the breeding season, and that nothing could drive away the male from the spot at which he had perceived his partner slowly disappear, and whom he had followed to the edge of the water.

Mr. Arderon 4 gave an account of how he tamed a dace, which would lie close to the glass watching its master; and subsequently how he kept two ruffs (Acerina cernua) in an aquarium, where they became very much attached to one another. He gave one away, when the other became so miserable that it would not eat, and this continued for nearly three weeks. Fearing his remaining fish might die, he sent for its former companion, and on the two meeting they became quite happy again. Jesse gives a similar account of two gold carp.

Anger is strikingly shown by many fish, and notoriously by sticklebacks when their territory is invaded by a neighbour. These animals display a strange instinct of appropriating to themselves a certain part of the tank in which they may be confined, and furiously attacking any other stickleback which may presume to cross the imaginary frontier. Uunder such circumstances of provocation I have seen the whole animal change colour, and, darting at

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¹ Kaup, Catal. Lopho. Fish in Brit. Mus. 1856, p. i.

² Yarrell, *Brit. Fishes*, 2nd ed. ii. p. 436.

Compt. Rend., Nov. 4, 1872, p. 1127.
 Phil. Trans. Royal Society, 1747.

⁵ F. Day, loc. cit.

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the trespasser, show rage and fury in every movement. Of course, here, as elsewhere, it is impossible to be sure how far apparent expression of an emotion is due to the presence of that mental state which we recognise as the emotion in ourselves; but still the best guide we have to follow is that of apparent expression.

Following this principle, we are also entitled to attribute to fish the emotions conducive to play; for nothing can well be more expressive of sportive glee than many of their movements. As for jealousy, the fights of many male fish for the possession of females constitutes evidence of emotion which would be called by this name in the higher animals. Schneider, in his recent work already often quoted, says that he has observed a male fish (Labrus) show jealousy only towards other individual males of his own species—chasing these away from the neighbourhood of his female, but not objecting to the approach of fish of other species.

Curiosity is shown by the readiness, or even eagerness, with which fish will approach to examine any unfamiliar object. So much is this the case that fishermen, like

hunters, sometimes trade upon this faculty:—

And the fisher, with his lamp And spear, about the low rocks damp Crept, and struck the fish which came To worship the delusive flame.1

Stephenson, the engineer, on sinking lighted lanterns in the water, also found that fish were attracted to them.²

Special Habits.

As curious instances of special instincts in fish we may notice the well-known habit of the angler (Lophius piscator), which conceals itself in mud and seaweed, while waving in the water certain filaments with which it is provided above its snout. Other fish, attracted by these moving objects, approach, and are thereupon seized by the

Shelley, Lines written in the Bay of Lerici. ² See Smiles, Lives of Engineers, vol. iii., p. 69.

angler. We must also allude to the Chelmon rostratus, which shoots its prey by means of a drop of water projected from the mouth with considerable force and unerring aim. The mark thus shot at is always some small object, such as a fly, at rest above the surface of the water, so that when suddenly hit it falls into the water. This remarkable instinct can only, I think, have originated as a primordially intentional adjustment, and as such shows a high degree of intelligence on the part of these fishes an cestors. Moreover, the wonderful co-ordination of sight and muscular movements required to judge the distance, to make due allowance for refraction, and to aim correctly, shows that the existing representatives are not unworthy of their ancestors.

Several species of fish in different parts of the world have the habit of quitting pools which are about to dry up, and taking excursions across country in search of more abundant water. Eels have this habit, and perform their migrations by night. Dr. Hancock, in the 'Zoological Journal, gives an account of a species of *Doras*, the individuals of which are about a foot in length, and travel by night in large shoals, or 'droves,' when thus searching for water. A strong serrated arm constitutes the first ray of the pectoral fin; and, using this as a kind of foot, the animal pushes itself forward by means of its tail, thus moving nearly as fast as a man can walk. Another migrating fish (*Hydrargzra*) was found by thousands in the fresh waters of Carolina by Bosc. It travels by leaps, and, according to Bosc, always directs itself towards the nearest water, although he purposely placed them so that they could not see it.

But perhaps the strangest among this class of habits is that of the climbing perch (*Perca scandens*), first discovered by Daldorff in Tranquebar; for this animal not only creeps over land, but even climbs the fan palm in search of certain Crustacea which form its food. In climbing it uses its open gill-covers as hands wherewith to suspend itself, while it deflects its tail laterally upwards so as to bring to bear upon the bark certain little spines with

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¹ See 'On the Jaculator-Fish,' by Schlosser, Phil. Trans. 1764.

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which its anal fin is provided; it then pushes itself upwards by straightening the tail, while it closes the gill-covers not to prevent progress, and so on. Sir E. Tennent, however, without disputing the evidence that these fish do climb trees, says,—

The probability is, as suggested by Buchanan, that the ascent which was witnessed by Daldorff was accidental, and ought not to be regarded as the habit of the animal.¹

A great number of species of fish perform migrations. In relation to intelligence, the most interesting of these is the migration of salmon, which annually leave the sea to spawn in rivers, though there is some doubt whether the same individuals spawn every year. There is no doubt, however, that the same individuals frequently, though not invariably, revisit the same rivers for their successive spawnings. This fact may be due either to the remembrance of locality, similar to that which is unquestionably manifested by birds, or to the salmon not swimming far along the coast during other seasons of the year, and therefore in the spawning season when seeking a river happening to hit upon the same one. The latter hypothesis is one which Mr. Herbert Spencer tells me he is inclined to adopt, and, being a salmon-fisher, he has paid attention to the subject. He informs me of an observation by a friend of his own, who saw a salmon, when about to spawn, swimming along the coast-line, and all round a boathouse, apparently seeking any stream that it might first encounter.

The distances up rivers to which salmon will swim in the spawning season is no less surprising than the energy with which they perform the feat, and the determination with which they overcome all obstacles. They reach Bohemia by the Elbe, Switzerland by the Rhine, and, which is much more wonderful, the Cordilleras of America by the Maragnon.

They employ only three months in ascending to the sources of the Maragnon (a journey of 3,000 miles), the current of which is remarkably rapid, which is at the rate of nearly forty

¹ Natural History of Ceylon, p. 351.

miles a day; in a smooth stream or lake their progress would increase in a fourfold ratio. Their tail is a very powerful organ, and its muscles have wonderful energy; by placing it in their mouths they make of it a very elastic spring, for letting it go with violence they raise themselves in the air to the height of from twelve to fifteen feet, and so clear the cataract that impedes their course: if they fail in their first attempt, they continue their efforts till they have accomplished it.

General Intelligence.

With reference to the general intelligence of fish, allusion may first be made to their marked increase of wariness in waters which are much fished. This shows no small degree of intelligence, for the caution is proved to be the result of observation by the fact that young trout under such circumstances are less wary than old ones. Moreover, many fish will abandon old haunts when much disturbed. Again, according to Kirby, the carp thrusts itself into the mud in order that the net may pass over it, or, if the bottom be stony, makes great leaps to clear it.

At the Andaman Islands fish are captured by the convicts by means of weirs fixed across the openings of creeks. After existing a week or so, it is observed that captures invariably cease; and it is believed that such is due to barnacles, &c., clustering on to the wood of which they are composed. It does not seem improbable that the fish have learned to avoid a locality out of terror at those which enter but do not again return.

Lacepède³ relates that some fish, which had been kept for many years in a basin of the Tuileries, would come when called by their names. Probably it was the sound of the voice and not the articulate words to which they responded; for Lacepède also relates that in many parts of Germany trout, carp, and tench were summoned to their food by the sound of a bell; and the same thing has been recorded of various fish in various localities, notably by Sir Joseph Banks, who used to collect his fish by sounding a bell.⁴

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¹ Kirby, Hist. Habits and Instincts of Animals, vol. i. p. 119.

² F. Day, loc. cit. ² Hist. des Poiss., Introd., cxxx. ⁴ For sundry other similar cases see Mr. Day's excellent paper already quoted.

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In 'Nature' (vol. xi., p. 48) Mr. Mitchell gives the following instance of intelligence on the part of a small perch. Having one day disturbed its nest full of young fry, Mr. Mitchell next day went to look for the nest; 'but we searched in vain for the fish and her young. At length, a few yards further up stream, we discovered the parent guarding her fry with jealous care in a cavity scooped out of the coarse sand. . . . This is the first and only instance that has come under my notice of a fish watching over her young, and conveying them, when threatened with danger, to some other place.'

In 'Nature' (December 19, 1878) there is also published a communication which was made by Mr. J. Faraday to the Manchester Anglers' Association, concerning a skate which he observed in the aquarium of that town:—

A morsel of food thrown into the tank fell directly in an angle formed by the glass front and the bottom. The skate, a large example, made several vain attempts to seize the food, owing to its mouth being on the underside of its head and the food being close to the glass. He lay quite still for a while as though thinking, then suddenly raised himself into a slanting posture, the head inclined upwards, and the under surface of the body towards the food, when he waved his broad expanse of fins, thus creating an upward current or wave in the water, which lifted the food from its position and carried it straight to his mouth.

It will be observed, however, that this observation is practically worthless, from the observer having neglected to repeat the conditions in order to show that the movements of the fish were not, in their adaptation to these circumstances, purely accidental. Therefore I should not have alluded to this observation, had I not found that it has been quoted by several writers as a remarkable display of intelligence on the part of the fish.

I must not take leave of this class without making some allusion to the alleged habits of the so-called 'pilot-fish,' and also to those of 'thresher' and 'sword-fish.' I class these widely different habits together because they are alike in being dubious; different observers give different accounts, and therefore, until more information is

forthcoming, we must suspend our judgment with regard to the habits in question. The following describes what these habits are believed by many observers to be.

Captain Richards, R.N., says that he saw a blue shark following a bait which was thrown out to him from the ship. The shark, which was attended by four pilot-fish. repeatedly approached the bait; but every time he did so one of the latter rushed in and prevented him. After a time the shark swam away; but when he had gone a considerable distance, he turned back again, swam quickly after the vessel, and before the pilot-fish could overtake him, seized the bait and was caught. While hoisting him on board, one of the pilots was seen to cling to his side until above water, when it dropped off. All the pilots then swam about for a time, as if searching for their friend, 'with every apparent mark of anxiety and distress." Colonel Smith fully corroborates this observation; but Mr. Geoffrey, on the other hand, saw a pilot-fish take great pains to bring a shark to the bait.2 Probably the truth is that the pilot-fish attend the shark in order to obtain the crumbs that fall from his feasts, and that the cases in which they appear to prevent his taking the bait are without any psychological significance.

With regard to the alleged co-operation of the threshing and sword-fish in the destruction of whales, all that can be said is that the statements, although antecedently improbable, are sufficient in number not to be ignored. Mr. Day appears to accept the evidence as adequate, and

gives the following cases:-

Captain Arn, in a voyage to Memel in the Baltic, gives the following interesting narrative:—One morning during a calm, when near the Hebrides, all hands were called up at 2 A.M. to witness a battle between several of the fish called threshers or fox-sharks (*Alopecias vulpes*), and some sword-fish on one side, and an enormous whale on the other. It was in the mildle of the summer; and the weather being clear, and the fish close to the vessel, we had a fine opportunity of witnessing the centest. As soon as the whale's back appeared above the water, the

² F. Day, loc. cit.

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¹ Cuv., Anim. Kingd. x. p. 636.

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altic, gives the during a calm, up at 2 A.M. to ed threshers or h on one side, the mildle of he fish close to ng the contest. The water, the

threshers springing several yards into the air descended with great violence upon the object of their rancour, and inflicted upon him the most severe slaps with their long tails, the sounds of which resembled the reports of muskets fired at a distance. The sword-fish in their turn attacked the distressed whale, stabbing from below: and thus beset on all sides and wounded, when the poor creature appeared, the water around him was dyed with blood. In this manner they continued tormenting and wounding him for many hours, until we lost sight of him; and I have no doubt they in the end completed his destruction.

The master of a fishing-boat has recently observed that the thresher-shark serves out the whales, the sea sometimes being all blood. One whale, attacked by these fish, once took refuge under his vessel, where it lay an hour and a half without moving a fin. He also remarked having seen the threshers jump out of the water as high as the mast-head and down upon the whale, while the sword-fish was wounding him from beneath the two

sorts of fish evidently acting in concert.

CHAPTER IX.

BATRACHIANS AND REPTILES.

On the intelligence of frogs and toads very little has to be said. Frogs seem to have definite ideas of locality; for several of my correspondents inform me that they have known cases in which these animals, after having been removed for a distance of 200 or 300 yards from their habitual haunts, returned to them again and again. This, however, may I think perhaps be due to these haunts having a moistness which the animals are able to perceive at a great distance. But be this as it may, certainly the distance at which frogs are able to perceive moisture is surprising. Thus, for instance, Warden gives a case in which a pond containing a number of frogs dried up, and the frogs thereupon made straight for the nearest water, although this was at a distance of eight kilometres.

A curious special instinct is met with in the toad Bufo obstetricans, from which it derives its name; for the male here performs the function of an accoucheur to the female, by severing from her body the gelatinous cord by which

the ova are attached.

Another special instinct or habit manifested by toads is described by M. Duchemin in a paper before the Academy of Sciences at Paris.² The habit consists in the killing of carp by squatting on the head of the fish and forcing the fore-feet into its eyes. Probably this habit arises from sexual excitement on the part of the toads.

I have one case, communicated to me by a correspondent, of a frog which learnt to know her voice, and to come when called. As fish will sometimes do the same

² April 11, 1870.

thing, the quote:—

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¹ Account of the United States, vol. ii., p. 9.

thing, the account is sufficiently credible for me to quote:—

I used to open the gate in the railings round the pond, and call out 'Tommy' (the name I had given it), and the frog would jump out from the bushes, dive into the water, and swim across to me—get on my hand sometimes. When I called 'Tommy,' it would nearly always come, whatever the time of day, though it was only fed after breakfast; but it seemed quite tame.

A very similar case is recorded by Mr. Pennent ¹ of a toad which was domesticated for thirty-six years, and knew all his friends.

There is no doubt that frogs are able to appreciate coming changes of weather, and to adapt their movements in anticipation of them; but these facts show delicate sensibility rather than remarkable intelligence.

The following observation of Edward, the Scottish naturalist, however, shows considerable powers of observation on the part of frogs. After describing the great noise made by a number of frogs on a moonlight night, he says:—

Presently, when the whole of the vocalists had reached their highest notes, they became hushed in an instant. I was amazed at this, and began to wonder at the sudden termination of the concert. But, looking about, I observed a brown owl drop down, with the silence of death, on to the top of a low dyke close by the orchestra.²

Reptiles.

Like the other cold-blooded Vertebrata, the reptiles are characterised by a sluggishness and low development of mental power which is to some extent proverbial. Nevertheless, that some members of the class present vivid emotions is not to be questioned. Thus, to quote from Thompson:—

The common guana (*Lacerta iguana*) is naturally extremely gentle and harmless. Its appearance, however, is much against

² Smiles, Life of Edwards, p. 124.

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¹ See Bingley, Animal Biography, vol. ii., p. 406.

it, especially when agitated by fear or anger. Its eyes then seem on fire; it hisses like a serpent, swells out the pouch under its throat, lashes about its long tail, erects the scales on its back, and extending its wide jaws, holds its head, covered over with tubercles, in a menacing attitude. The male, during the spring of the year, exhibits great attachment towards the Throwing aside his usual gentleness of character, he defends her even with fury, attacking with undaunted courage every animal that seems inclined to injure her; and at this time. though his bite is by no means poisonous, he fastens so firmly. that it is necessary either to kill him or to beat him with great violence on the nose, in order to make him quit his hold.

Several species of snake incubate their eggs and show parental affection for their young when they are hatched out; but neither in these nor in any other of their emotions do the reptiles appear to rise much above the level of fish. The case, however, which I shall afterwards quote, of the tame snakes kept by Mr. and Mrs. Mann, seems to show a somewhat higher degree of emotional development than could be pointed to as occurring in any lower Vertebrata. Moreover, according to Pliny. so much affection subsists between the male and female asp, that when the one is killed the other seeks to avenge its death; and this statement is so far confirmed—or rather, its origin explained—by Sir Emerson Tennent that he says when a cobra is killed, its mate is often found on the same spot a day or two afterwards.

Passing on to the general intelligence of reptiles, we shall find that this also, although low as compared with the intelligence of birds and mammals, is conspicuously

higher than that of fish or batrachians.

Taking first the case of special instincts, Mr. W. F. Barrett, in a letter to Mr. Darwin, bearing the date May 6, 1873, and contained among the MSS. already alluded to, gives an account of cutting open with a penknife the egg of an alligator just about to hatch. The young animal, although blind, 'instantly laid hold of the finger, and attempted to bite.' Similarly, Dr. Davy, in his 'Account of Ceylon, gives an interesting observation of his own on a young crocodile, which he cut out of the egg,

¹ Passions of Animals, p. 229.

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and which, as soon as it escaped, started off in a direct line for a neighbouring stream. Dr. Davy placed his stick before it to try to make the little animal deviate from its course; but it stoutly resisted the opposition, and raised itself into a posture of offence, just as an older animal would have done.

Humboldt made exactly the same observation with regard to young turtles, and he remarks that as the young normally quit the egg at night, they cannot see the water which they seek, and must therefore be guided to it by discerning the direction in which the air is most humid. He adds that experiments were made which consisted in putting the newly hatched animals into bags, carrying them to some distance from the shore, and liberating them with their tails turned towards the water. It was invariably found that the young animals immediately faced round, and took without hesitation the shortest way to the water.

Scarcely less remarkable than the instincts of the young turtles are those of the old ones. Their watchful timidity at the time of laying their eggs is thus described

by Bates:—

Great precautions are obliged to be taken to avoid disturbing the sensitive turtles, who, previous to crawling ashore to lay, assemble in great shoals off the sand-bank. The men during this time take care not to show themselves, and warn off any fisherman who wishes to pass near the place. Their fires are made in a deep hollow near the borders of the forest, so that the smoke may not be visible. The passage of a boat through the shallow waters where the animals are congregated, or the sight of a man or a fire on the sand-bank, would prevent the turtles from leaving the water that night to lay their eggs; and if the causes of alarm were repeated once or twice they would forsake the praia for some other quieter place. . . . I rose from my hammock by daylight, shivering with cold—a praia, on account of the great radiation of heat in the night from the sand, being towards the dawn the coldest place that can be found in this climate. Cardozo and the men were already up watching the The sentinels had erected for this purpose a stage about fifty feet high, on a tall tree near their station, the ascent to which was by a roughly made ladder of woody lianas. They are enabled, by observing the turtles from this watch-tower, to ascertain

the date of successive deposits of eggs, and thus guide the commandante in fixing the time for the general invitation to the Ega people. The turtles lay their eggs by night, leaving the water, when nothing disturbs them, in vast crowds, and crawl. ing to the central and highest part of the praia. These places are, of course, the last to go under water when, in unusually wet seasons, the river rises before the eggs are hatched by the heat of the sand. One could almost believe, from this, that the animals used forethought in choosing a place; but it is simply one of those many instances in animals where unconscious habit has the same result as conscious prevision. The hours between midnight and dawn are the busiest. The turtles excavate with their broad webbed paws deep holes in the fine sand: the first comer, in each case, making a pit about three feet deep, laying its eggs (about 120 in number) and covering them with sand; the next making its deposit at the top of that of its predecessor, and so on until every pit is full. The whole body of turtles frequenting a praia does not finish laying in less than fourteen or fifteen days, even when there is no interrup. When all have done, the area (called by the Brazilians taboleiro) over which they have excavated is distinguishable from the rest of the praia only by signs of the sand having been a little disturbed.1

The same naturalist says of the alligator,—

These little incidents show the timidity and cowardice (? prudence and caution) of the alligator. He never attacks man when his intended victim is on his guard; but he is cunning enough to know when this may be done with impunity. Of this we had proof a few days afterwards, &c.²

Of the alligator, Jesse writes: 3—

But a most singular instance of attachment between two animals, whose natures and habits were most opposite, was related to me by a person on whose veracity I can place the greatest reliance. He had resided for nine years in the American States, where he superintended the execution of some extensive works for the American Government. One of these works consisted in the erection of a beacon in a swamp in one of the rivers,

¹ Naturalist on the Amazon, pp. 285-6.

3 Gleanings, vol. i., pp. 163-4.

where he ca perfectly tan scrambling u and docility. friendship w before the fir himself down go to sleep. but he always only instance a fox, which fox resented s and thus calle the fox he did much severity fined the fox klligator was which he sho hut up in a b me frosty nigl ot, I believe, nd showing a Numenbach n wo instances h nowing their derable alacri

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² *Ibid.* The astonishing facts relating to the migration of turtles in the laying season will be treated under the general heading 'Migration' in my forthcoming work.

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where he caught a young alligator. This animal he made so perfectly tame that it followed him about the house like a dog, scrambling up the stairs after him, and showing much affection and docility. Its great favourite, however, was a cat, and the friendship was mutual. When the cat was reposing herself before the fire (this was at New York), the alligator would lay himself down, place his head upon the cat, and in this attitude go to sleep. If the cat was absent the alligator was restless; but he always appeared happy when the cat was near him. The only instance in which he showed any ferocity was in attacking a fox, which was tied up in the yard. Probably, however, the for resented some playful advances which the other had made, and thus called forth the anger of the alligator. In attacking the fox he did not make use of his mouth, but beat him with so much severity with his tail, that, had not the chain which confined the fox broken, he would probably have killed him. alligator was fed on raw flesh, and sometimes with milk, for which he showed a great fondness. In cold weather he was but up in a box, with wool in it; but, having been forgotten me frosty night, he was found dead in the morning. ot I believe, a solitary instance of amphibia becoming tame, nd showing a fondness for those who have been kind to them. Blumenbach mentions that crocodiles have been tamed; and wo instances have occurred under my own observation of toads nowing their benefactors, and coming to meet them with conderable alacrity.

With regard to the higher intelligence of reptiles, I

ay quote the following instances.

Three or four different correspondents tell me of cases hich they have themselves observed, of snakes and roises unmistakably distinguishing persons. In one of ese cases the tortoise would come to the call of the voured person, and when it came would manifest its ection by tapping the boot of this person with its mouth; ut it would not answer anyone else.' A separation of me weeks did not affect the memory of this tortoise for friend.'

I The tortoise which has gained such immortal celebrity by having an under the observation of the author of the Natural History of wine, likewise distinguished persons in this way. For 'whenever good old lady came in sight, who had waited on it for more than ty years, it always hobbled with www. ward alacrity towards its factress, whilst to strangers it was altogether inattentive.'

The following interesting observation on the intelligence of snakes shows, not only that these animals are well able to distinguish persons, and that they remember their friends for a period of at least six weeks, but also that they possess an intensity of amiable emotion scarcely to be expected in this class. Clearly the snakes in question were not only perfectly tame, but entertained a remarkable affection for those who tended and petted them. The facts were communicated to me by Mr. Walter Severn, the well-known artist, who was a friend of Mr. and Mrs. Mann the gentleman and his wife to whom the snakes belonged Mr. and Mrs. Mann having got into trouble with the neighbours on account of the fear and dislike which their pets occasioned, legal proceedings were instituted, and s the matter came before the public. Mr. Severn the wrote a letter to the Times, in order to show that the animals were harmless. From this letter the following an extract:—

I happen to know the gentleman and lady against whom complaint has been made because of the snakes they keep, as I should like to give a short account of my first visit to them,

Mr. M., after we had talked for a little time, asked if I h any fear of snakes; and after a timid 'No, not very,' from me, produced out of a cupboard a large boa-constrictor, a pythological and several small snakes, which at once made themselves home on the writing-table among pens, ink, and books. In at first a good deal startled, especially when the two large sna coiled round and round my friend, and began to notice me wi their bright eyes and forked tongues; but soon finding h tame they were, I ceased to feel frightened. After a short in Mr. M. expressed a wish to call Mrs. M., and left me with boa deposited on an arm-chair. I felt a little queer when animal began gradually to come near, but the entrance of host and hostess, followed by two charming little children. me at my ease again. After the first interchange of civility she and the children went at once to the boa, and, calling it the most endearing names, allowed it to twine itself most grant and allowed it to twine itself most grant gr fully round about them. I sat talking for a long time, lost wonder at the picture before me. Two beautiful little! with their charming mother sat before me with a boa-constin (as thick round as a small tree) twining playfully round lady's waist and neck, and forming a kind of turban round

head, expedition of the children and kissed in so. The and head conting it to nestle in the prettier the Mrs. M. who to pour out nicely, and eather with a staming acquation of the could make the taming acquation of the could make the taming acquation of the could make the cou

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head, expecting to be petted and made much of like a kitten. The children over and over again took its head in their hands and kissed its mouth, pushing aside its forked tongue in doing so. The animal seemed much pleased, but kept turning its head continually towards me with a curious gaze, until I allowed it to nestle its head for a moment up my sleeve. Nothing could be prettier than to see this splendid serpent coiled all round Mrs. M. while she moved about the room, and when she stood to pour out our coffee. He seemed to adjust his weight so nicely, and every coil with its beautiful marking was relieved by the black velvet dress of the lady. It was long before I could make up my mind to end the visit, and I returned soon after with a friend (a distinguished M.P.¹), to see my snake-taming acquaintance again. . . .

These (the snakes) seemed very obedient, and remained in

their cupboard when told to do so.

About a year ago Mr. and Mrs. M. were away for six weeks, and left the boa in charge of a keeper at the Zoo. The poor reptile moped, slept, and refused to be comforted, but when his master and mistress appeared he sprang upon them with delight, wiling himself round them, and showing every symptom of inense delight.²

The end of this python was remarkable and pathetic. Ir. Severn tells me that some years after he had published he above letter Mr. Mann was seized with an apoplectic t. His wife, being the only other person in the house at he time, ran out to fetch a doctor. She was absent about m minutes, and on returning found that the serpent uring her absence had crawled upstairs from the room elow into that where her husband was lying, and was retched beside him dead. Such being the fact, we are At to speculate whether the double seizure of the man nd the snake was a mere coincidence, or whether the ght of its stricken master, acting on the emotions of a ssibly not healthy animal, precipitated its death. Lookg to the extreme suddenness of the latter, as well as to e fact of the animal having pined so greatly for his iends while it was confined at the Zoological Gardens, think the probability rather points to the death of the

² The Times, July 25, 1872.

¹ This gentleman was Lord Arthur Russell.

animal having been accelerated by emotional shock. But

of course the question is an open one.

So much for the power of reptiles to establish such definite and complete associations as are required for the recognition of persons—associations, however, to which, as we have seen, frogs, and even insects may attain. As for other associations, a correspondent writes to me:—

I believe tortoises are able to establish a definite association between particular colours on a flat surface and food. Only the day before reading your article on animal intelligence I noticed the endeavours of a small tortoise to eat the *yellow* flowers of an inlaid writing-table, and I have often remarked the same recognition with regard to red.

Lord Monboddo relates the following anecdote of a serpent:—

I am well informed of a tame serpent in the East Indies, which belonged to the late Dr. Vigot, and was kept by him in the suburbs of Madras. This serpent was taken by the French, when they invested Madras in the late war, and was carried to Pondicherry in a close carriage. But from thence he found his way back again to his old quarters, which it seems he liked better, though Madras is distant from Pondicherry about one hundred miles. This information, he adds, I have from a lady who then was in India, and had seen the serpent often before his journey and after his return.

Considering the enormous distances over which turtle are able to find their way in the season of migration, this display of the homing faculty to so great a degree in a serpent is not to be regarded as incredible.

Mr. E. L. Layard, in his 'Rambles in Ceylon' say

of the cobra: 1-

I once watched one which had thrust its head through narrow aperture and swallowed one (i.e. a toad). With the encumbrance he could not withdraw himself. Finding this, he reluctantly disgorged the precious morsel, which began to more off. This was too much for snake philosophy to bear, and the toad was again seized; and again, after violent efforts to escap was the snake compelled to part with it. This time, however a lesson had been learnt, and the toad was seized by one lequithdrawn, and then swallowed in triumph.

Mr. E.

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Mr. Penns quently lie at He fixes his e not escape; it that a passer-l present. lown again, The snake con ixed on the so hat a person a ioise without omes lower, a aready dis his fascinating ranch of a tr ons, and at th large snake res, gazing ste as so great th od when one and dead up a examination

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¹ See Annas. and Mag. of Nat. Hist., 2nd series, vol. ix., p. 333.

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, vol. ix., p. 333.

Mr. E. C. Buck, B.C.S., says in 'Nature' (vol. viii., p. 303):—

I have witnessed exactly a similar plan pursued by a large number of Ganges crocodiles, which had been lying or swimming about all day in front of my tent, at the mouth of a small stream which led from some large inland lakes to the Ganges. Towards dusk, at the same moment every one of them left the bank on which they were lying, or the deep water in which they were swimming, and formed a line across the stream, which was about twenty yards wide. They had to form a double line, as there was not room for all in a single line. They then swam slowly up the shallow stream, driving the fish before them, and I saw two or three fish caught before they disappeared.

An account of reptile psychology would be incomplete without some reference to the alleged facts of snakes charming other animals by 'fascination,' and being themselves charmed by the arts of music, &c. The testimony on both subjects is conflicting, and especially with regard to the fascination of other animals by snakes. Thus:—

Mr. Pennant says that this snake (rattle-snake) will frequently lie at the bottom of a tree on which a squirrel is scated. He fixes his eyes on the animal, and from that moment it cannot escape; it begins a doleful outcry, which is so well known that a passer-by, on hearing it, immediately knows that a snake s present. The squirrel runs up the tree a little way, comes lown again, then goes up, and afterwards comes still lower. The snake continues at the bottom of the tree with its eyes ixed on the squirrel, and his attention is so entirely taken up. hat a person accidentally approaching may make a considerable loise without so much as the snake turning about. The squirrel omes lower, and at last leaps down to the snake, whose mouth s already distended for its reception. Le Vaillant confirms his fascinating terror by a scene he witnessed. He saw on the much of a tree a species of shrike, trembling as if in convulions, and at the distance of nearly four feet, on another branch, large snake that was lying with outstretched neck and fiery yes, gazing steadily at the poor animal. The agony of the bird as so great that it was deprived of the power of moving away; d when one of the party killed the snake, it (i.e. the bird) was and dead upon the spot—and that entirely from fear; for, examination, it appeared not to have received the slightest ound. The same traveller adds that a short time afterwards

he observed a small mouse in similar agonising convulsions, about two yards from a snake, whose eyes were intently fixed upon it; and on frightening away the reptile, and taking up the mouse, it expired in his hand.¹

Many other observations, more or less similar, might be quoted; but, on the other hand, Sir Joseph Fayrer tells me that 'fascination is only fright;' and this appears to be the opinion of all persons who have had the opportunity of looking into the subject in a scientific manner. The truth probably is that small animals are occasionally much alarmed by the sight of a snake looking at them, and as a consequence of this more easily fall a prey. In some cases, it is likely enough, strong terror so unnerves the animal as to make it behave in the manner which the witnesses describe; in making half-palsied efforts to escape, it may actually fall or draw nearer to the object of its dread. Perhaps, therefore, Dr. Barton, of Philadelphia, is a little too severe on previous observers when he says that—

The report of this fascinating property has had its rise in nothing more than the fears and cries of birds and other animals in the protection of their nests. . . . The result of not a little attention has taught me that there is but one wonder in the business—the wonder that the story should ever have been believed by any man of understanding and observation.

But, be this as it may, it is certainly remarkable, as Sir J. Fayrer in his letter to me observes, 'how little fear some animals show until the moment that they are seized and struck.'

As for snake-charming, the facts seem to be that cobras and other serpents are attracted by the sound of a pipe to creep out of their hiding-places, when they are captured and tamed. It is certain that the fangs are not always drawn, and also that from the first moment of capture, before there has been time for any process of training, a real snake-charmer is able to make the reptile 'dance.' Thus, for instance, Sir E. Tennent publishes the following letter from Mr. Reyne. After describing all his

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¹ Thompson, *Passions of Animals*, p. 118; see also Bingley, *Anim Biography*, vol. ii., pp. 447-8.

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precautions to ensure that the snake-charmer had no tained snakes concealed about his person, Mr. Reyne proceeds to tell how he made the man accompany him to the jungle, where, attracted by the music of a pipe which the man played, a large cobra came from an ant-hill which Mr. Reyne knew it to occupy:—

On seeing the man it tried to escape, but he caught it by the tail and kept swinging it round until we reached the bungalow. He then made it dance, but before long it bit him above the knee. He immediately bandaged the leg above the bite and applied a snake-stone to the wound to extract the poison. He was in great pain for a few minutes, but after that it gradually went away, the stone falling off just before he was relieved.¹

Thus the only remarkable thing about the charming of a freshly caught snake seems to be that the charmer is able to make the animal 'dance'—for the fact of the snake approaching the unfamiliar sound of music is not in itself any more remarkable than a fish approaching the unfamiliar sight of a lantern. It does not, however, appear that this dancing is anything more than some series of gestures or movements which may be merely the expressions, more or less natural, of uneasiness or alarm. Anything else that charmed snakes may do is probably the result of training; for there is no doubt that cobras admit of being tamed, and even domesticated. Thus, for instance, Major Skinner, writing to Sir E. Tennent, says:—

In one family near Negombo, cobras are kept as protectors, in the place of dogs, by a wealthy man who has always large sums of money in his house. But this is not a solitary case of the kind. . . . The snakes glide about the house, a terror to the thieves, but never attempting to harm the inmates.²

Thus, on the whole, we may accept Dr. Davey's opinion—who had good opportunities for observation—that the snake-charmers control the cobras by working upon the well-known timidity and reluctance of these animals to use their fangs till they become virtually tame.

² Tennent, loc. cit., p. 299

¹ Natural History of Ceylon, p. 314.

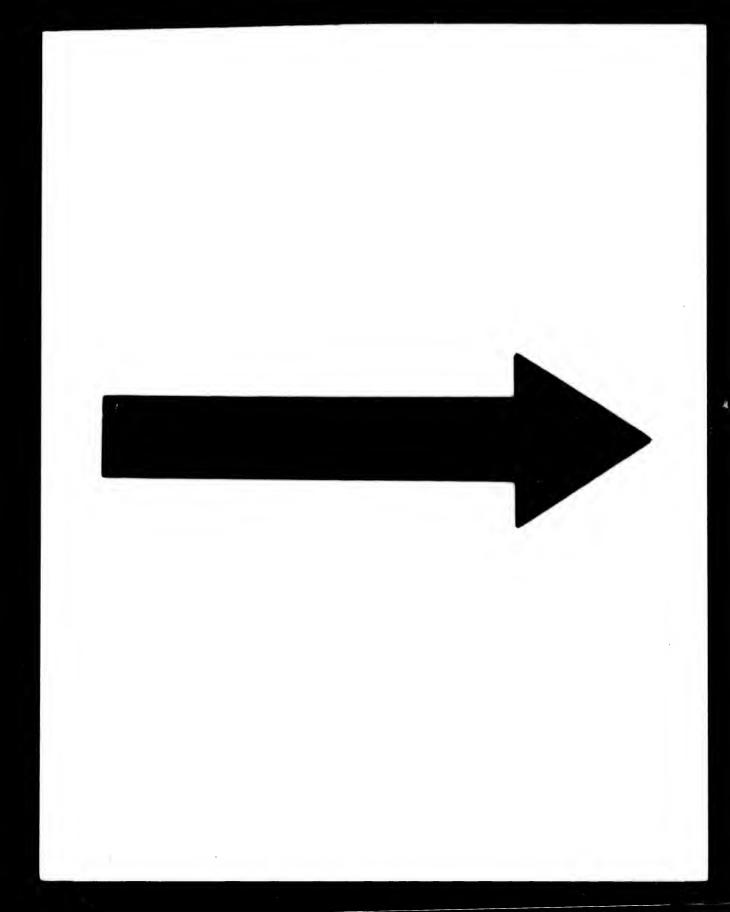
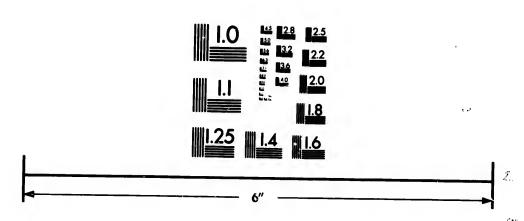


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CHAPTER X.

BIRDS.

ADEQUATELY to treat of the intelligence of birds a separate volume would be required; here it must be enough to deal with this class as I shall afterwards deal with the Mammalia—namely, by giving an outline sketch of the more prominent features of their psychology.

Memory.

The memory of birds is well developed. Thus, although we are much in the dark on the whole subject of migration —so much so that I reserve its discussion with all the problems that this presents for a separate chapter in my next work—we may at least conclude that the return of the same pair of swallows every year to the same nest must be due to the animals remembering the precise locality of their nests. Again, Buckland gives an account of a pigeon which remembered the voice of its mistress after an absence of eighteen months; but I have not been able to

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liberty, cau eye on his overtook an return.'

¹ Curiosities, &c., p. 126. Wilson also, in his American Ornithology, gives the following sufficiently credible account of the memory of a crow:-'A gentleman who resided on the Delaware, a few miles below Easton, had raised [reared] a crow, with whose tricks and society he used frequently to amuse himself. This crow lived long in the family, but at length disappeared, having, as was then supposed, been shot by some vagrant gunner, or destroyed by accident. About eleven months after this, as the gentleman one morning, in company with several others, was standing on the river shore, a number of crows happened to pass by; one of them left the flock, and flying directly towards the company, alighted on the gentleman's shoulder, and began to gabble away with great volubility, as one long-absent friend naturally enough does on meeting On recovering from his surprise the gentleman instantly recognised his old acquaintance, and endeavoured, by several civil but sly manœuvres, to lay hold of him; but the crow, not altogether relishing quite so much familiarity, having now had a taste of the sweets of

meet with satisfactory evidence of the memory of a bird

enduring for a longer time than this.

As it is a matter of interest in comparative psychology to trace as far as possible into detail the similarities of a mental faculty as it occurs in different groups of animals, and as the faculty of memory first admits of detailed study in the class which we are now considering, I shall here devote a paragraph to the facts concerning the exhibition of memory by birds where its mechanism best admits of being analysed; I refer to the learning of articulate phrases and tunes by talking and musical birds. The best observations in this connection with which I am acquainted are those of Dr. Samuel Wilks, F.R.S., and therefore I shall quote in extenso the portion of his paper which refers to the memory of parrots: other portions of this paper I shall have occasion to quote in my next work:—

When my parrot first came into my possession, several years ago, it was quite unlettered, and I therefore had an opportunity of observing the mode in which it acquired the accomplishment of speech. I was very much struck with its manner of learning, and the causes for its speaking on special occasions. first seemed to resemble very much the method of children in learning their lessons, and the second to be due to some association or suggestion—the usual provocative for set speeches at all periods of human life. A parrot is well known to imitate sounds in a most perfect manner, even to the tone of the voice. besides having a compass which no human being can approach, ranging from the gravest to the most acute note. My bird, though possessing a good vocabulary of words and sentences, can only retain them for a few months unless kept constantly in practice by the suggestive recurrence of some circumstance which causes their continual utterance. If forgotten, however, they are soon revived in the memory by again repeating them a few times, and much more speedily than any new sentence can be acquired. In beginning to teach the parrot a sentence, it has to be repeated many times, the bird all the while listening most attentively by turning the opening of the ear as close as possible to the speaker. After a few hours it is heard attempting

liberty, cautiously eluded all his attempts: and suddenly glancing his eye on his distant companions, mounted in the air after them, soon overtook and mingled with them, and was never afterwards seen to return.'

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to say the phrase, or, I should say, trying to learn it. It evidently has the phrase somewhere in store, for eventually this is uttered perfectly, but at first the attempts are very poor and ludicrous. If the sentence be composed of a few words, the first two or three are said over and over again, and then another and another word added, until the sentence is complete, the pronunciation at first being very imperfect, and then becoming gradually more complete, until the task is accomplished. Thus hour after hour will the bird be indefatigably working at the sentence, and not until some days have elapsed will it be perfect. The mode of acquiring it seems to me exactly what I have ob. served in a child learning a French phrase; two or three words are constantly repeated, and then others added, until the whole is known, the pronunciation becoming more perfect as the repetition goes on. I found also on whistling a popular air to my parrot that she picked it up in the same way, taking note by note until the whole twenty-five notes were complete. the mode of forgetting, or the way in which phrases and airs pass from its recollection, may be worth remarking. The last words or notes are first forgotten, so that soon the sentence remains unfinished or the air only half whistled through. The first words are the best fixed in the memory; these suggest others which stand next to them, and so on till the last, which have the least hold on the brain. These, however, as I have before mentioned, can be easily revived on repetition. also a very usual process in the human subject: for example, an Englishman speaking French will, in his own country, if no opportunity occur for conversation, apparently forget it; he no sooner, however, crosses the Channel and hears the language than it very soon comes back to him again. In trying to recall poems learned in childhood or in school days, although at that period hundreds of lines may have been known, it is found that in manhood we remember only the two or three first lines of the 'Iliad,' the 'Æneid,' or the 'Paradise Lost.'1

The following is communicated to me by Mr. Venn, of Cambridge, the well-known logician:—

I had a grey parrot, three or four years old, which had been taken from its nest in West Africa by those through whom I received it. It stood ordinarily by the window, where it could equally hear the front and back door bells. In the yard, by the back door, was a collie dog, who naturally barked violently at nearly all the comers that way. The parrot took to imitating the

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¹ Journal of Mental Science, July 1879.

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dog. After a time I was interested in observing the discriminative association between the back-door bell and the dog's bark in the parrot's mind. Even when the dog was not there, or for any other cause did not bark, the parrot would constantly bark when the back-door bell sounded, but never (that I could hear) when the front-door bell was heard.

This is but a trifle in the way of intelligence, but it struck me as an interesting analogous case to a law of association often

noticed by writers on human psychology.

The celebrated parrot that belonged to the Buffon family and of which the Comte de Buffon wrote, exhibited in a strange manner the association of its ideas. For he was frequently in the habit of asking himself for his own claw, and then never failed to comply with his own request by holding it out, in the same way as he did when asked for his claw by anybody else. This, however, probably arose, not, as Buffon or his sister Madame Nadault supposed, from the bird not knowing its own voice, but rather from the association between the words and the gesture:

According to Margrave, parrots sometimes chatter their phrases in their dreams, and this shows a striking similarity of psychical processes in the operations of memory

with those which occur in ourselves.

Similarly, Mr. Walter Pollock, writes me of his own parrot:—

In this parrot the sense of association is very strongly developed. If one word picked up at a former home comes into its head, and is uttered by it, it immediately follows this word up with all the other words and phrases picked up at the same place and period.

Lastly, parrots not only remember, but recollect; that is to say, they know when there is a missing link in a train of association, and purposely endeavour to pick it up. Thus, for instance, the late Lady Napier told me an interesting series of observations on this point which she had made upon an intelligent parrot of her own. They were of this kind. Taking such a phrase as 'Old Dan Tucker,' the bird would remember the beginning and the end, and try to recollect the middle. For it would say

very slowly, 'Old—old—old '(and then very quickly) 'Lucy Tucker.' Feeling that this was not right, it would try again as before, 'Old—old—old—old—old—old Bessy Tucker,' substituting one word after another in the place of the sought-for word 'Dan.' And that the process was one of truly seeking for the desired word was proved by the fact that if, while the bird was saying, 'Old—old—old—old,' any one threw in the word 'Dan,' he immediately supplied the 'Tucker.'

Emotions.

As regards emotions, it is among birds that we first meet with a conspicuous advance in the tenderer feelings of affection and sympathy. Those relating to the sexes and the care of progeny are in this class proverbial for their intensity, offering, in fact, a favourite type for the poet and moralist. The pining of the 'love-bird' for its absent mate, and the keen distress of a hen on losing her chickens, furnish abundant evidence of vivid feelings of the kind in question. Even the stupid-looking ostrich has heart enough to die for love, as was the case with a male in the Rotund of the Jardin des Plantes in Paris, who, having lost his wife, pined rapidly away. It is remarkable that in some species—notably pigeons—conjugal fidelity should be so strongly marked; for this shows, not only what may be called a refinement of sexual feeling, but also the presence of an abiding image in the mind's eve of the lover. For instance,—

Referring to the habits of the mandarin duck (a Chinese species) Mr. Bennett says that Mr. Beale's aviary afforded a singular corroboration of the fidelity of the birds in question. Of a pair in that gentleman's possession, the drake being one night purloined by some thieves, the unfortunate duck displayed the strongest marks of despair at her bereavement, retiring into a corner, and altogether neglecting food and drink, as well as the care of her person. In this condition she was courted by a drake who had lost his mate, but who met with no encouragement from the widow. On the stolen drake being subsequently recovered and restored to the aviary, the most extravagant demonstrations of joy were displayed by the fond couple; but this was not all, for, as if informed by his spouse of the gallant

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proposals made to her shortly before his arrival, the drake attacked the luckless bird who would have supplanted him, beat out his eyes, and inflicted so many injuries as to cause his death.

Similarly, to give an instance or two with regard to other birds, Jesse states the following as his own observation:—

A pair of swans had been inseparable companions for three years, during which time they had reared three broods of tygnets; last autumn the male was killed, and since that time the female has separated herself from all society with her own species; and, though at the time I am writing (the end of March) the breeding season for swans has far advanced, she remains in the same state of seclusion, resisting the addresses of a male swan, who has been making advances towards forming an acquaintance with her, either driving him away, or flying from him whenever he comes near her. How long she will continue in this state of widowhood I know not, but at present it is quite evident that she has not forgotten her former partner.

This reminds me of a circumstance which lately happened at Chalk Farm, near Hampton. A man, set to watch a field of peas which had been much preyed upon by pigeons, shot an old cock pigeon which had long been an inhabitant of the farm. His mate, around whom he had for many a year cooed, whom he had nourished from his own crop, and had assisted in rearing numerous young ones, immediately settled on the ground by his side, and showed her grief in the most expressive manner. The labourer took up the dead bird, and tied it to a short stake, thinking that it would frighten away the other depredators. In this situation, however, the widow did not forsake her decased husband, but continued, day after day, walking slowly round the stick. The kind-hearted wife of the bailiff of the farm at last heard of the circumstance, and immediately went to aford what relief she could to the poor bird. She told me that, on arriving at the spot, she found the hen bird much exhausted, and that she had made a circular beaten track round the dead pigeon, making now and then a little spring towards him. On the removal of the dead bird the hen returned to the dovecote.2

As evidence of the intensity of the maternal instinct,

² Gleanings, vol. i., pp. 112-13.

¹ Couch, Illustrations of Instinct, p. 165

even in the case of barren birds, I may quote the following from the naturalist Couch. I do so because, although the instance is a trivial one, and also one of frequent occurrence, it is interesting as showing that a deeply rooted instinct or emotion may assert itself powerfully even in the absence of what may be termed its natural stimulus or object:—

I was once witness to a curious instance of the yearning

for progeny in a diminutive bantam hen.

There was at this time a nest of the common hen in a secluded part of the garden, and the parent had been sitting on its eggs, till compelled by hunger she left them for a short time. This absence was fatal; for the bantam had in the meantime found its situation in a covered recess in the hedge, and I saw her creep into it with all the triumph of the discoverer of a The real mother now returned, and great was her agony at finding an intruder in her nest. The expression of her eye and the attitude of her head were emphatic of surprise at the impudence of the proceeding. But after many attempts to recover possession she was compelled to resign her rights, for the bantam was too resolute to be contended with; and though its body was not big enough to cover the whole of the eggs, and thus some of them were not hatched, yet in due season the pride of this audacious step-mother was gratified by strutting at the head of a company of robust chickens, which she passed off upon the feathered public as a brood of her own.

As evidence of sympathy I shall quote in extenso an interesting case which has been communicated to me by a young lady, who desires her name withheld. There are several more or less corroborative cases in the anecdote-books,² so that I have no doubt as to the substantial accuracy of the account:—

My grandfather had a Swan River gander, which had been reared near the house, and had consequently attached himself to the members of the family; so much so that, on seeing any of them at a distance, he would run to meet them with all possible demonstrations of delight.

But 'Swanny' was quite an outcast from his own tribe and as often as he made humble overtures to the other geese,

¹ Couch, Illustrations of Instinct, p. 232.

often was occasions and layin At last, An old gr more forti recognisin under his it well for in his bill, to the wate by her side his neck ov After cruis convenient before, lead he would p and if any il art-rut, Swa body, and ca

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² See especially Bingley, Animal Biography, vol. ii., pp. 327-29.

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often was he driven away with great contempt, and on such occasions he would frequently run to some of his human friends. and laying his head on their laps, seem to seek for sympathy. At last, however, he found a friend among his own species. An old grey goose, becoming blind, was also discarded by her more fortunate companions, and Swanny lost no opportunity of recognising this comrade in distress. He at once took her under his protection and led her about. When he considered it well for her to have a swim, he would gently take her neck in his bill, and thus lead her, sometimes a considerable distance, to the water's edge. Having fairly launched her, he kept close by her side, and guided her from dangerous places by arching his neck over hers, and so turning her in the right direction. After cruising about a sufficient time, he would guide her to a convenient landing-place, and taking her neck in his bill as before, lead her to terra firma again. When she had goslings, he would proudly convoy the whole party to the water-side; and if any ill-fated gosling got into difficulties in a hole or deep art-rut, Swanny with ready skill would put his bill under its ody, and carefully raise it to the level ground.

My grandfather had also another gander who attached himelf to him, and would follow him for hours through fields and anes, pausing when he stood still, and waddling gravely by his ide as he proceeded. This gander was not, like the other, disarded by his kind, but would leave them any time to walk with is master, and was exceedingly jealous of any one else who tried share this privilege, excepting only his mistress. On one casion, a gentleman venturing to place his hand on my grandther's arm, the gander flew at him, and beat him severely with swings, and it was with great difficulty that he was induced

let go.

The solicitude which most gregarious birds display hen one of their number is wounded or captured, nstitutes strong evidence of sympathy. rves,—

There is one trait in the character of the rook which is, I lieve, peculiar to that bird, and which does him no little dit; it is the distress which is exhibited when one of his ows has been killed or wounded by a gun while they have a feeding in a field or flying over it. Instead of being scared by by the report of the gun, leaving their wounded or dead panion to his fate, they show the greatest anxiety and pathy for him, uttering cries of distress, and plainly proving that they wish to render him assistance by hovering over him, or sometimes making a dart from the air close up to him, apparently to try and find out the reason why he did not follow them. . . . I have seen one of my labourers pick up a rook which he had shot at for the purpose of putting him up as a scarecrow in a field of wheat, and while the poor wounded bind was still fluttering in his hand, I have observed one of his com. panions make a wheel round in the air, and suddenly dart past him so as almost to touch him, perhaps with the last hope that he might still afford assistance to his unfortunate mate or com. panion. Even when the dead bird has been hung, in terrorem, to a stake in the field, he has been visited by some of his former friends, but as soon as they found that the case was hopeless, they have generally abandoned that field altogether.

When one considers the instinctive care with which rooks avoid any one carrying a gun, and which is so evident that I have often heard country people remark that a rook can smell gunpowder, one can more justly estimate the force of their love or friendship in thus continuing to hover round a person who has just destroyed one of their companions with an instrument the dangerous nature of which they seem fully capable of appre

ciating.1

The justice of these remarks may be better appreciated in the light of the following very remarkable observation as an introduction to which I have quoted them.

Edward, the naturalist, having shot a tern, which fel winged into the sea, its companions hovered around the floating bird, manifesting much apparent solicitude, terns and gulls always do under such circumstances. Ho far this apparent solicitude is real I have often speculate as in the analogous case of the crows—wondering wheth the emotions concerned were really those of sympathy mere curiosity. The following observation, however, seem to set this question at rest. Having begun to make pr parations for securing the wounded bird, Edward says: expected in a few moments to have it in my possession being not very far from the water's edge, and drifting shorewards with the wind.' He continues:—

While matters were in this position I beheld, to my ut astonishment and surprise, two of the unwounded terms to

¹ Gleanings, pp. 58-9.

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hold of their disabled comrade, one at each wing, lift him out of the water, and bear him out seawards. They were followed by two other birds. After being carried about six or seven yards, he was let gently down again, when he was taken up in a similar manner by the two who had been hitherto inactive. In this way they continued to carry him alternately, until they had conveyed him to a rock at a considerable distance, upon which they landed him in safety. Having recovered my self-possession, I made toward the rock, wishing to obtain the prize which had been so unceremoniously snatched from my grasp. I was observed, however, by the terns; and instead of four, I had in a short time a whole swarm about me. On my near approach to the rock I once more beheld two of them take hold of the wounded bird as they had done already, and bear him out to sea in triumph, far beyond my reach. This, had I been so inclined, l could no doubt have prevented. Under the circumstances. however, my feelings would not permit me; and I willingly allowed them to perform without molestation an act of mercy, and to exhibit an instance of affection which man himself need not be ashamed to imitate.1

According to Clavigero,² the inhabitants of Mexico utilise the sympathy of the wild pelican for the procuring of fish. First a pelican is caught and its wing broken. The bird is then tied to a tree, and being both in pain and captivity, it utters cries of distress. Other pelicans are attracted by the cries, and finding their friend in such a sorry case, their bowels of compassion become moved in a very literal sense; for they disgorge from their stomachs and pouches the fish which they have caught, and deposit them within reach of the captive. As soon as this is done the men, who have been lying in wait concealed, run to the spot, drive off the friendly pelicans, and secure their ish, leaving only a small quantity for the use of the aptive.

The parrot which belonged to the Buffon family showed such sympathy with a female servant to whom it was tached when the girl had a sore finger, which it dislayed by its never leaving her sick room, and groaning as itself in pain. As soon as the girl got better the bird

ain became cheerful.

Smiles, Life of Edward, p. 240. 2 History of Mexico, p. 220.

I shall conclude this brief demonstration of the keen sympathy which may exist in birds, by quoting the following very conclusive case in the words of its distinguished observer, Dr. Franklin: 1—

I have known two parrots, said he, which had lived together four years, when the female became weak, and her legs swelled. These were symptoms of gout, a disease to which all birds of this family are very subject in England. It became impossible for her to descend from the perch, or to take her food as formerly, but the male was most assiduous in carrying it to her in his beak. He continued feeding her in this manner during four months, but the infirmities of his companion increased from day to day, so that at last she was unable to support herself on the perch. She remained cowering down in the bottom of the cage, making, from time to time, ineffectual efforts to regain the perch. The male was always near her, and with all his strength aided the feeble attempts of his dear better half. Seizing the poor invalid by the beak, or the upper part of the wing, he tried to raise her, and renewed his efforts several times.

His constancy, his gestures, and his continued solicitude, all showed in this affectionate bird the most ardent desire to relieve the sufferings and assist the weakness of his companion.

But the scene became still more interesting when the female was dying. Her unhappy spouse moved around her incessantly, his attention and tender cares redoubled. He even tried to open her beak to give some nourishment. He ran to her, then returned with a troubled and agitated look. At intervals he uttered the most plaintive cries; then, with his eyes fixed on her, kept a mournful silence. At length his companion breathed her last; from that moment he pined away, and died in the course of a few weeks. ¹

The jealousy of birds is proverbial; and that they also manifest the kindred passion of emulation, no one can doubt who has heard them singing against one another Mr. Bold relates that a mule canary would always sing a his own image in a mirror, becoming more and more excited till he ended by flying in rage against his supposed rivil

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many,' the following graphic description of the exultation displayed by the bird when it baffled the imitative powers of its master. The bird was the same as that already mentioned under the head of 'Memory':—

Sometimes when only two or three were in the room, at quiet occupations instead of talking, she would utter at short intervals a series of strong squalls or cries in an interjectional style, each more strange and grotesque than the previous one. My father on these occasions sometimes amused himself by imitating these cries as she uttered them, which seemed to excite her ingenuity in the production of them to the uttermost. As a last resource she always had recourse to a very peculiar one, which completely baffled him; upon which, with a loud ha! ha! ha! she made a somersault round her perch, swinging with her head downwards, sprung from one part of the cage to another, and tossed a bit of wood she used as a toy over her head in the most exulting triumph, repeating at intervals the inimitable cry, followed by peals of ha! ha! ha! to the great amusement of all present.

Allied to emulation is resentment, of which the following, communicated to me by a correspondent, may be taken as an example. If space permitted I could give confirmatory cases:—

One day the cat and the parrot had a quarrel. I think the cat had upset Polly's food, or something of that kind; however, they seemed all right again. An hour or so after, Polly was standing on the edge of the table; she called out in a tone of extreme affection, 'Puss, puss, come then—come then, pussy.' Pussy went and looked up innocently enough. Polly with her beak seized a basin of milk standing by, and tipped the basin and all its contents over the cat; then chuckled diabolically, of course broke the basin, and half drowned the cat.

Several strange but mutually corroborative stories seem to show cherished vindictiveness on the part of storks. Thus, in Captain Brown's book there occurs an account of a tame stork which lived in the college yard at Tübingen,—

And in a neighbouring house was a nest, in which other storks, hat annually resorted to the place, used to hatch their eggs. At this nest, one day in autumn, a young collegian fired a shot,

by which the stork that was sitting on it was probably wounded, for it did not fly out of the nest for some weeks afterwards. It was able, however, to take its departure at the usual time with the rest of the storks. But in the ensuing spring a strange stork was observed on the roof of the college, which, by clapping his wings and other gestures, seemed to invite the tame stork to come to him; but, as the tame one's wings were clipped, he was unable to accept the invitation. After some days the strange stork appeared again, and came down into the yard, when the tame one went out to meet him, clapping his wings as if to bid him welcome, but was suddenly attacked by the visitor with great fury. Some of the neighbours protected the tame bird, and drove off the assailant, but he returned several times after wards, and incommoded the other through the whole summer The next spring, instead of one stork only, four storks came together into the yard, and fell upon the tame one; when all the poultry present—cocks, hens, geese, and ducks—flocked at once to his assistance, and rescued him from his enemies. In consequence of this serious attack, the people of the house took precaution for the tame stork's security, and he was no more molested that year. But in the beginning of the third spring came upwards of twenty storks, which rushed at once into the yard and killed the tame stork before either man or any other animal could afford him protection.

A similar occurrence took place on the premises of a farmer near Hamburg, who kept a tame stork, and, having caught another, thought to make it a companion for the one in his possession. But the two were no sooner brought together than the tame one fell upon the other, and beat him so severely that he made his escape from the place. About four months afterwards, however, the defeated stork returned with three others, who all made a combined attack upon the tame one and killed him.¹

The curiosity of birds is highly developed, so much so, indeed, that in this and other countries it is played upon by sportsmen and trappers. Unfamiliar objects being

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Watson, Reasoning Fower of Animals, pp. 375-76, where see also some curious cases of male storks slaying their females upon the latter hatching out eggs of other birds. He gives an exactly similar case as having occurred with the domestic cock; and in Bingley (bc. cit., vol. ii., p. 241) there is quoted from Dr. Percival another case of the same kind, in which a cock killed his hen as soon as she had hatched out a brood of young partridges from eggs which had been set to her.

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placed within sight, say of ducks, the birds approach to examine them, and fall into the snares which have been Similarly, in oceanic islands unfrequented by man, the birds fearlessly approach to examine the first human beings that they have seen.

That birds exhibit pride might be considered doubtful if we had to rely only on the evidence supplied by the display of the peacock, and the strutting of the turkeygobbler; for these actions, although so expressive of this emotion, may not really be due to it. But I think that the evident pleasure which is taken in achievement by talking birds can only be ascribed to the emotion in question. These birds regularly practise their art, and when a new phrase is perfected they show an unmistakable delight in displaying the result.

Play is exhibited by many species in various ways, and itseems to be this class of feelings in their most organised form which have led to the extraordinary instincts of the bower-birds of New South Wales. The 'playhouses' of the animals have been described by Mr. Gould in his 'History of the Birds of New South Wales.' Of course the play-instincts are here united with those of courtship, which are of such general occurrence among birds; but I think no one can read Mr. Gould's description of the bowers and the uses to which they are put without feeling that the love of sportive play must have been joined with the sexual instincts in producing the result. But, be this as it may, there can be no question that these bowers are highly interesting structures, as furnishing the most unexceptionable evidence of true æsthetic, if not artistic feeling on the part of the bird which constructs them; and, according to Mr. Herbert Spencer, the artistic feelings are physiologically allied with those of play. It is a matter of importance to obtain definite proof of an æsthetic sense n animals, because this constitutes the basis of Mr. Darwin's theory of sexual selection; but as he has treated the evidence on this subject in so exhaustive a manner, I shall ot enter upon so wide a field further than to point out hat the case of the bower-bird, even if it stood alone, s which had been set would be amply sufficient to carry the general conclusion

that some animals exhibit emotions of the beautiful. The following is Mr. Gould's description, in extenso, of the habits of the bird in question:—

The extraordinary bower-like structure, alluded to in my remarks on the genus, first came under my notice in the Sydney Museum, to which an example had been presented by Charles Cox, Esq. . . . On visiting the cedar bushes of the Liverpool range, I discovered several of these bowers or playing-houses on the ground, under the shelter of the branches of the overhang. ing trees, in the most retired part of the forest; they differed considerably in size, some being a third larger than others. The base consists of an extensive and rather convex platform of sticks firmly interwoven, on the centre of which the bower itself is built. This, like the platform on which it is placed, and with which it is interwoven, is formed of sticks and twigs, but of a more slender and flexible description, the tips of the twigs being so arranged as to curve inwards and nearly meet at the top; in the interior the materials are so placed that the forks of the e always presented outwards, by which arrangement not the slightest obstruction is offered to the passage of the The interest of this curious bower is much enhanced by the manner in which it is decorated with the most gaily coloured articles that can be collected, such as the blue tail-feathers of the Rose-hill and Pennantian parakeets, bleached bones and shells of snails, &c.; some of the feathers are inserted among the twigs, while others with the bones and shells are strewed near the entrances. The propensity of these birds to fly off with any attractive object is so well known to the natives that the always search the runs for any small missing article that ma have been accidentally dropped in the bush. I myself found atth entrance of one of them a small neatly worked stone tomahawka an inch and a half in length, together with some slips of blue cotton rag, which the birds had doubtless picked up at a desert encampment of the natives.

It has now been clearly ascertained that these curion bowers are merely sporting-places in which the sement, when the males display their finery, and exhibit many remarkable actions; and so inherent is this habit that the living examples, which have been from time time sent to this country, continue it even in captivity. Those belonging to the Zoological Society have constructed

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¹ See Darwin, Descent of Man, pp. 92, 381, 406, 413.

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their bowers, decorated and kept them in repair, for several years. In a letter from the late Mr. F. Strange, it is said:—

My aviary is now tenanted by a pair of satin-birds, which for the last two months have been constantly engaged in constructing bowers. Both sexes assist in their erection, but the male is the principal workman. At times the male will chase the female all over the aviary, then go to the bower, pick up a gay feather or a large leaf, utter a curious kind of note, set all his feathers erect, run round the bower, and become so excited that his eyes appear ready to start from his head, and he continues opening first one wing and then another, uttering a low whistling note, and, like the domestic cock, seems to be picking up something from the ground, until at last the female goes gently towards him, when after two turns round her, he suddenly makes a dash, and the scene ends.'

I have said that if this case stood alone it would constitute ample evidence that some animals possess emotions of the beautiful. But the case does not stand alone. Certain humming-birds, according to Mr. Gould, decorate the outsides of their nests 'with the utmost taste; they instinctively fasten thereon beautiful pieces of flat lichen. the larger pieces in the middle, and the smaller on the part attached to the branch. Now and then a pretty feather is intertwined or fastened to the outer sides, the stem being always so placed that the feather stands out beyond the surface.' Several other instances might be rendered of the display of artistic feeling in the architecture of birds; and, as Mr. Darwin so elaborately shows, there can scarcely be question that these animals take emotional pleasure in surveying beautiful plumage in the opposite sex, looking to the careful manner in which the males of many species display their fine colours to the females. Doubtless the evidence of æsthetic feeling is much stronger in the case of birds than it is in that of any other class; but if this feeling is accepted as a sufficient cause, through sexual selection, of natural decoration in the members of this class, we are justified in attributing to sexual selection, and so to æsthetic feeling, natural

Gould, Birds of Australia, vol. i., pp. 442-45.

decoration in other classes, at least as low down in the scale as the Articulata. But, as I have said, Mr. Darwin has dealt with this whole subject in so exhaustive a manner that it is needless for me to enter upon it further than to say in general terms, that whatever we may think of his theory of sexual selection, his researches have unquestionably proved the existence of an æsthetic sense in animals.

The same fact appears to be shown in another way by the fondness of song-birds for the music of their mates. There can be no doubt that male birds charm their females with their strains, and that this, in fact, is the reason why song in birds has become developed. Of course it may be said that the vocal utterances of birds are not always. or even generally, musical; but this does not affect the fact that birds find some æsthetic pleasure in the sounds which they emit; it only shows that the standard of æsthetic taste differs in different species of birds as it does in different races of men. Moreover, the pleasure which birds manifest in musical sounds is not always restricted to the sounds which they themselves produce. Parrots seem certainly to take delight in hearing a piano play or a girl sing; and the following instance, published by the musician John Lockman, reveals in a remarkable manner the power of distinguishing a particular air, and of preferring it above others. He was staying at the house of a Mr. Lee in Cheshire, whose daughter used to play; and whenever she played the air of 'Speri si' from Handel's opera of 'Admetus,' a pigeon would descend from an adjacent dovecot to the window of the room where she sat, 'and listen to the air apparently with the most pleasing emotions,' always returning to the dovecot immediately the air was finished. But it was only this one air that would induce the bird to behave in this way.

Special Habits.

Under this heading we shall have a number of facts to consider, which are more or less of a disconnected character.

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¹ Bingley, Animal Biography, vol. ii., p. 220.

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Taking first those special habits connected with the procuring of food, we may notice the instinct manifested by blackbirds and thrushes of conveying snails to considerable distances in order to hammer and break their shells against what may happen to be the nearest stone, and the still more clever though somewhat analogous instinct exhibited by certain gulls and crows of flying with shell-fish to a considerable height and letting them fall upon stones for the purpose of smashing their shells.2 Both these instincts manifest a high degree of intelligence. either on the part of the birds themselves, or on that of their ancestors; for neither of these instincts can be regarded as due to originally accidental adjustments favoured and improved by natural selection; they must at least originally have been intelligent actions purposely designed to secure the ends attained.

An interesting instinct is that of piracy, which in the animal kingdom reaches its highest or most systematic development among the birds. It is easy to see how it may be of more advantage to a species of strong bird that its members should become parasitic on the labours of other species than that they should forage for themselves, and so there is no difficulty in understanding the development of the plundering instinct by natural selection. We find all stages of this development among the sea-birds. Thus the gulls, although usually self-foragers, will, as I have often observed, congregate in enormous numbers where the guillemots have found a shoal of fish. Resting

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¹ For full information, see Buckland, Curiosities of Natural History, p. 183.

² of the crow (carrion and hooded), Edward says: 'He goes aloft with a crab, and lets it fall upon a stone or a rock chosen for the purpose. If it does not break, he seizes it again, goes up higher, lets it fall, and repeats his operation again and again until his object is accomplished. When a convenient stone is once met with, the birds resort to it for a long time. I myself know a pretty high rock, that has been used by successive generations of crows for about twenty years!' Also, as Handcock says, 'a friend of Dr. Darwin saw on the north coast of Ireland above a hundred crows preying upon mussels, which is not their natural food; each crow took a mussel up into the air, twenty or forty yards high, and let it fall on the stones, and thus breaking the shell, got possession of the animal. Ravens, we are told, often resort to the same contrivance.'

on or flying over the surface of the water, the gulls wait till a guillemot comes to the surface with a fish, and then wrest the latter from the beak of the former. In the robber-tern this instinct has proceeded further, so that the animal gains its subsistence entirely by plunder of other terns. I have often observed this process, and it is interesting that the common tern well knows the appearance of the robber; for no sooner does a robber-tern come up than the greatest consternation is excited among a flock of common terns, these flying about and screaming in a frantic manner. The white-headed eagle has also developed the plundering instinct in great perfection, as is shown by the following graphic account of Audubon:—

During spring and summer, the white-headed eagle, to procure sustenance, follows a different course, and one much less suited to a bird apparently so well able to supply itself without interfering with other plunderers. No sooner does the first hawk make its appearance along the Atlantic shore, or around the numerous and large rivers, than the eagle follows it, and, like a selfish oppressor, robs it of the hard-earned fruits of its labour. Perched on some tall summit, in view of the ocean or of some watercourse, he watches every motion of the osprey while on When the latter rises from the water, with a fish in its grasp, forth rushes the eagle in pursuit. He mounts above the fish-hawk, and threatens it by actions well understood; when the latter, fearing perhaps that its life is in danger, drops its prey. In an instant the eagle, accurately estimating the rapid descent of the fish, closes its wings, follows it with the swiftness of thought, and the next moment grasps it. The prize is carried off in silence to the woods, and assists in feeding the everhungry brood of the eagle.

The frigate pelican is likewise a professional thief, and attacks the boobies not only to make them drop the fish which they have newly caught, but also to disgorge those which are actually in their stomachs. The latter process is effected by strong punishment, which they continue until the unfortunate booby yields up its dinner. The punishment consists in stabbing the victim with its powerful beak. Catesby and Dampier have both observed and described these habits, and it seems from their account that the plunderer may either commit highway robbery in

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the air, or lie in wait for the boobies as they return to rest.

In antithesis to this habit of plundering other birds I may quote the following from 'Nature' (July 20, 1871), to show that the instinct of provident labour, so common among insects and rodents, is not altogether unrepresented in birds:—

The ant-eating woodpecker (Melanerpes formicivorus), a common Californian species, has the curious and peculiar habit of laying up provision against the inclement season. Small round holes are dug in the bark of the pine and oak, into each of which is inserted an acorn, and so tightly is it fitted or driven in, that it is with difficulty extricated. The bark of the pine trees, when thus filled, presents at a short distance the appearance of being studded with nails.

The following may also be quoted:—

It is the nature of this bird (guillemot), as well as of most of those birds which habitually dive to take their prey, to perform all their evolutions under water with the aid of their wings; but instead of dashing at once into the midst of the terrified group of small prey, by which only a few would be captured, it passes round and round them, and so drives them into a heap; and thus has an opportunity of snatching here one and there another as it finds it convenient to swallow them; and if any one pushes out to escape, it falls the first prey of the devourer. The manner in which this bird removes the egg of agull or hen to some secure place to be devoured, when compared with that in which a like conveyance is made by the parent for the safety of its future progeny, affords a striking manifestation of the difference between appetite and affection. When influenced by affection, the brittle treasure is removed without flaw or fracture, and is replaced with tender care; but the plunderer at once plunges his bill into its substance, and carries it off on its point.1

Speaking of the feeding habits of the lapwing, Jesse says:—

When the lapwing wants to procure food, it seeks for a worm's cast, and stamps the ground by the side of it with its feet. After doing this for a short time, the bird waits for the

¹ Couch, Illustrations of Instinct, pp. 192 93.

issue of the worm from its hole, which, alarmed at the shaking of the ground, endeavours to make its escape, when it is immediately seized, and becomes the prey of the ingenious bird. The lapwing also frequents the haunts of moles, which, when in pursuit of worms on which they feed, frighten them, and the worm, in attempting to escape, comes to the surface of the ground, when it is seized by the lapwing.

Again, -

A lady of Dr. E. Darwin's acquaintance saw a little bird repeatedly hop on a poppy stem, and shake the head with his bill, till many seeds were scattered, when it settled on the ground and picked up the seeds.²

It is a matter of common remark that in countries where vultures abound, these birds rapidly 'gather together where the carcass is, although before the death of their prey no bird was to be seen in the sky. The question has always been asked whether the vultures are guided to the carcass by their sense of smell or by that of sight; but this question is really no longer an open one. When Mr. Darwin was at Valparaiso he tried the following experiment. Having tied a number of condors in a long row. and having folded up a piece of meat in paper, he walked backwards and forwards in front of the row, carrying the meat at a distance of three yards from them, 'but no notice whatever was taken.' He then threw the meat upon the ground, within one yard of an old male bird: 'he looked at it for a moment with attention, but then regarded it no more.' With a stick he next pushed the meat right under the beak of the bird. Then for the first time the bird smelled it, and tore open the paper 'with fury, and at the same moment every bird in the long row began struggling and flapping its wings.'3 Thus there can be no doubt that vultures do not depend on their sense of smell for finding carrion at a distance. Nor is it mysterious why they should find it by their sense of sight. If over an area of many square miles there are a number of vultures flying as they do at a very high elevation, and if one of scend, the first the ser

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¹ Gleanings, &c., vol. i., p. 71.

² Ibid.

^{*} Voyage of a Naturalist, &c., p. 184.

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Coming now to special instincts relating to incubation and the care of offspring, a correspondent writes:—

Last spring I had a pair of canaries, in an ordinary breeding cage (with two small boxes for nests in a compartment at one end). In due course the first egg was laid, which I inspected through the little door made for that purpose. The next day I looked again; still only one egg, and so for four or five days. It being evident, from the appearance of the hen, that there were more eggs coming, and as she seemed in good health, I supposed she might have broken some; and I took out the box, and examined it carefully for the shells (but without pulling the nest to pieces), and found nothing, until towards the beginning of another week I went to take the one egg away, as the hen seemed preparing to sit upon it. There were two eggs! The next morning, to my surprise, she was sitting upon six eggs! She must therefore have buried four of them in the four corners of the box, and so deep that I had been unable to find them. At first I thought that she had done so merely from dislike at their being looked at, but on reflection it has occurred to me that she did it that all might be hatched at the same time (as they subsequently were); for she was perfectly tame, and would almost suffer herself to be handled when on her nest. birds never seem to conceal their eggs before sitting; but then (having more amusements than cage birds) they do not revisit their eggs after laying, until they have laid their number. whereas a caged bird, having nothing to divert her attention from her nest, often sits on it the greater part of the day.

I am not aware that this curious display of forethought on the part of a caged bird has been hitherto recorded, and seeing, as my correspondent points out, that it has reference to the changed conditions of life brought about by domestication, it may be said to constitute the first step in the development of a new instinct, which, if the conditions were of sufficiently long continuance, might lead to an important and permanent change of the ancestral instinct.

I have several interesting facts, also communicated to

me by correspondents, similarly relating to individual variations of the ancestral instinct of incubation in order to meet the requirements of a novel environment. Thus Mr. J. F. Fisher tells me that while he was a commander in the East India trade he always took a quantity of fowls to sea for food. The laying-boxes being in a confined space, the hens used to quarrel over their occupancy; and one of the hens adopted the habit of removing the 'nesteggs' which Mr. Fisher placed in one of the boxes to another box of the same kind not very far away. He watched the process through a chink of a door, and 'saw her curl her neck round the egg, thus forming a cup by which she lifted the egg,' and conveyed it to the other box. He adds:—

I can give no information as to the more recondite question why the egg was removed, or the fastidious preference of the one box over the other, or the inventive faculty that suggested the neck as a makeshift hand; but from the despatch with which she effected the removal of the egg in the case I saw, I have no doubt that this hen was the one which had performed the feat so often before.

The explanation of the preference shown for the one box over the other may, I think, be gathered from another part of my correspondent's letter, for he there mentions incidentally that the box in which he placed the nest-egg, and from which the hen removed it, was standing near a door which was usually open, and thus situated in a more exposed position than the other box. But be this as it may, considering that among domestic fowls the habit of conveying eggs is not usual, such isolated cases are interesting as showing how instincts may originate. Jesse gives an exactly similar case ('Gleanings,' vol. i., p. 149) of the Cape goose, which removed eggs from a nest attacked by rats, and another case of a wild duck doing the same.

In the same connection, and with the same remarks, I may quote the following case in which a fowl adopted the habit of conveying, not her eggs, but her young chickens. I quote it from Houzeau ('Journ.,' i., p. 332), who gives

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the observation on the authority of his brother as eyewitness. The fowl had found good feeding-ground on the further side of a stream four metres wide. She adopted the habit of flying across with her chickens upon her back, taking one chicken on each journey. She thus transferred her whole brood every morning, and brought them back in a similar way to their nest every evening. The habit of carrying young in this way is not natural to Grallinaceæ, and therefore this particular instance of its display can only be set down as an intelligent adjustment by a particular bird.

Similarly, a correspondent (Mr. J. Street) informs me of a case in which a pair of blackbirds, after having been disturbed by his gardener looking into their nest at their young, removed the latter to a distance of twenty yards, and deposited them in a more concealed place. Partridges are well known to do this, and similarly, according to hudubon, the goatsucker, when its nest is disturbed, removes its eggs to another place, the male and female

both transporting eggs in their beaks.1

Still more curiously, a case is recorded in 'Comptes Rendu' (1836) of a pair of nightingales whose nest was threatened by a flood, and who transported it to a safe place, the male and the female bearing the nest between them.

Now, it is easy to see that if any particular bird is intelligent enough, as in the cases quoted, to perform this djustive action of conveying young—whether to feeding-rounds, as in the case of the hen, or from sources of langer, as in the case of partridges, blackbirds, and goat-uckers—inheritance and natural selection might develop he originally intelligent adjustment into an instinct common to the species. And it so happens that this has ctually occurred in at least two species of birds—viz., he woodcock and wild duck, both of which have been reseatedly observed to fly with their young upon their backs and from their feeding-ground.

Couch gives some facts of interest relating to the mode escape practised by the water-rail, swan, and some other matic birds. This consists in sinking under water, with

¹ Orn. Biog., i., p. 276.

only the bill remaining above the surface for respiration. When the swan has young, she may sink the head quite under water in order to allow the young to mount on it, and so be carried through even rapid currents.

The same author remarks that—

Many birds will carefully remove the meetings of the young from the neighbourhood of their nests, in order not to attract the attention of enemies; for while we find that birds which make no secret of their nesting-places are careless in such matters, the woodpecker and the marsh-tit in particular are at pains to remove even the chips which are made in excavating the cavities where the nests are placed, and which might lead an observer to the sacred spot.

Similarly, Jesse observes:

The excrement of the young of many birds who build their nests without any pretensions to concealment, such as the swallow, crow, &c., may at all times be observed about or under the nest; while that of some of those birds whose nests are more industriously concealed is conveyed away in the mouths of the parent birds, who generally drop it at a distance of twenty or thirty yards from the nest. Were it not for this precaution, the excrement itself, from its accumulation, and commonly from it very colour, would point out the place where the young were concealed. When the young birds are ready to fly, or nearly so the old birds do not consider it any longer necessary to remove the excrement.

Sir H. Davy gives an account of a pair of eagles which he saw on Ben Nevis teaching their young ones to fly; an every one must have observed the same thing amon commoner species of birds. The experiments of Spalding however, have shown that flying is an instinctive faculty so that when he reared swallows from the nest and liberate them only after they were fully fledged, they flew well in mediately on being liberated. Therefore, the 'teachin to fly' by parent birds must be regarded as mere a couragement to develop instinctive powers, which in virtu of this encouragement are probably developed sooner the would otherwise be the case.

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The habit which many small birds display of mobbing carnivorous ones is probably due to a desire to drive off the enemy, and perhaps also to warn friends by the hubbub. It may therefore perhaps be regarded as a display of concerted action, of which, however, we shall have better evidence further on. I have seen a flock of common terns mob a pirate tern, which shows that this combined action may be directed as much against robbery as against murder. Couch says he has seen blackbirds mobbing a cat which was concealed in a bush, and here the motive would seem to be that of warning friends rather than that of driving away the enemy.

I have observed among the sea-gulls at the Zoological Gardens a curious habit, or mode of challenge. This consists in ostentatiously picking up a small twig or piece of wood, and throwing it down before the bird challenged, in the way that a glove used to be thrown down by the old hights. I observed this action performed repeatedly by several individuals of the glaucous and black-back species in the early spring-time of the year, and so it probably has some remote connection with the instinct of nestbuilding.

Nidification.

In connection with the habits and instincts peculiar to ertain species of birds, I may give a short account of the nore remarkable kinds of nidification that are met with in his class of animals. As the account must necessarily be rief, I shall only mention the more interesting of the sual types.

Petrels and puffins make their nests in burrows which bey excavate in the earth. The great sulphur mountain Guadaloupe is described by Wasser as 'all bored like a bbit warren with the holes that these imps (i.e. petrels) ers, which in virtue cavate.' In the case of the puffin it is the male that eloped sooner the best he work of burrowing. He throws himself upon back in the tunnel which he has made, and digs it offered on soll ager and longer with his broad bill, while casting out the mould with his webbed feet. The burrow when finished has several twists and turns in it, and is about ten feet deep. If a rabbit burrow is available, the puffin saves himself the trouble of digging by taking possession of the one already made. The kingfisher and land-martin also make their nests in burrows.

Certain auks lay their single egg on the bare rock while the stone curlew and goatsucker deposit theirs on the bare soil, returning, however, year after year to the same spot. Ostriches scrape holes in the sand to serve as extemporised nests for their eggs promiscuously dropped, which are then buried by a light coating of sand, and incubated during the day by the sunbeams, and at night by the male bird. Sometimes a number of female ostriches deposit their eggs in a common nest, and then take the duty of incubation by turns. Similarly, gulls, sandpipers, plovers, &c., place their eggs in shallow pits hollowed out of the soil. The kingfisher makes a bed of undigested fish-bones ejected as pellets from her stomach, and 'some of the swifts secrete from their salivary glands a fluid which rapidly hardens as it dries on exposure to the air into a substance resembling isinglass, and thus furnish the "edible birds' nests" that are the delight of the Chinese epicures.' 1

The house-martin builds its nest of clay, which it sticks upon the face of a wall, and renders more tenacious by working into it little bits of straw, splinters of wood, & According to Mr. Gilbert White:—

That this work may not, while it is soft and green, put itself down by its own weight, the provident architect has prudence and forbearance enough not to advance her work to fast; but by building only in the morning, and by dedicating the rest of the day to food and amusement, gives it sufficient time to dry and harden. About half an inch seems a sufficient layer for a day. Thus careful workmen, when they build may walls (informed at first perhaps by these little birds), raise by a moderate layer at a time, and then desist, lest the work should become top-heavy, and ruined by its own weight. By the method, in about ten or twelve days is formed a hemispherenest, with a small aperture towards the top, strong, compare

1 Newton, Encycl. Brit., art. 'Birds.'

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Other birds build in wood. The tomtit and the woodpecker excavate a hole in a tree, and carefully carry away the chips, so as not to give any indication of the whereabouts of their nests. Wilson says that the American woodpecker makes an excavation five feet in depth, of a tortuous form, to keep out wind and rain.

The orchard starling suspends its nest from the branches of a tree, and uses for its material tough kinds of grass, the blades of which it weaves together. Wilson found one of these blades to be thirteen inches long, and

to be woven in and out thirty-four times.

We may next notice the weaver (Ploceus textor) and tailor (Prinia, Orthotomus, and Sylvia). The former intertwines slender leaves of grass so as to produce a web sufficiently substantial for the protection of its young. The tailor-birds sew together leaves wherewith to make their nests, using for the purpose cotton and thread where they can find it, and natural vegetable fibres where they cannot obtain artificial. Colonel Sykes says that he has found the threads thus used for sewing knotted at the ends.¹

Forbes saw the tailor-bird of the East Indies constructing its nest, and observed it to choose a plant with large leaves, gather cotton which it regularly spun into a thread by means of its bill and claws, and then sew the leaves

together, using its beak as a needle, or rather awl.

This instinct is rendered particularly interesting to evolutionists from the fact that it is exhibited by three distinct genera. For, as the instinct is so peculiar and mique, it is not likely to have originated independently in the three genera, but must be regarded as almost certainly derived from a common ancestral type—thus showing that ministinct may be perpetuated unaltered after the differentiation of structure has proceeded beyond a specific distinction. The genus Sylvia inhabits Italy, the other two inhabit India. Sylvia uses for thread spiders' web col-

¹ Catalogue of Birds, &c., p. 16.

lected from the egg-pouches, which is stitched through holes made in the edges of leaves, presumably with the beak.

The baya bird of India hangs its pendulous dwelling from a projecting bough, twisting it with grass into a form somewhat resembling a bottle with a prolonged neck, the entrance being inverted, so as to baffle the approaches of its enemies, the tree snakes and other reptiles.'

Sir E. Tennent, from whom this account is taken, adds:—

The natives assert that the male bird carries fire-flies to the nest, and fastens them to its sides by particles of soft mud. Mr. Layard assures me that although he has never succeeded in finding the fire-fly, the nest of the male bird (for the female occupies another during incubation) invariably contains a patch of mud on each side of the perch.

Dr. Buchanan confirms the report of the natives here alluded to, and says:—

At night each of the habitations is lighted up by a fire-fly stuck on the top with a bit of clay. The nest consists of two rooms; sometimes there are three or four fire-flies, and their blaze in the little cells dazzles the eyes of the bats, which often kill the young of these birds.

While this work is passing through the press I meet with the following, which appears to refer to some independent, and therefore corroborative observation concerning the above-stated fact, and in any case is worth adding, on account of the observation concerning the rats, which, if trustworthy, would furnish a sufficient reason for the instinct of the birds. The extract is taken from a letter to 'Nature' (xxiv., p. 165), published by Mr. H. A. Severn:

I have been informed on safe authority that the Indian bottle-bird protects his nest at night by sticking several of these glow-beetles around the entrance by means of clay; and only a few days back an intimate friend of my own was watching three rats on a roof rafter of his bungalow when a glow-fly lodged very close to them; the rats immediately scampered off.

The Talegallus of Australia is, in the opinion of Gould,—Among the most important of the ornithological noveltia which the exploration of Western and Southern Australia has

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pinion of Gould, shological noveltie shern Australia ha unfolded to us, and this from the circumstance of its not hatching its own eggs, which, instead of being incubated in the usual way, are deposited in mounds of mixed sand and herbage, and there left for the heating of the mass to develop the young, which, when accomplished, force their way through the sides of the mound, and commence an active life from the moment they see the light of day.¹

Sir George Grey measured one of these mounds, and found it to be 'forty-five feet in circumference, and if rounded in proportion on the top (it being at the time unfinished) would have been full five feet high.' The heat round the eggs was taken to be 89°.

A curious aberration of the nest-building instinct is sometimes shown by certain birds—particularly the common wren—which consists in building a supernumerary nest. That is to say, after one nest is completed, another is begun and finished before the eggs are laid, and the first nest is not used, though sometimes it is used in preference to the second.

As showing at once the eccentricity which birds sometimes display in the choice of a site, and also the determination of certain birds to return to the same site in successive years, I may allude to the case published by Bingley, of a pair of swallows which built their nest upon the wings and body of a dead owl, which was hanging from the rafters of a barn, and so loosely as to sway about with every gust of wind. The owl with the nest upon it was placed as a curiosity in the museum of Sir Ashton Lever, and he directed that a shell should be hung upon the rafters in the place which had been previously occupied by the dead owl. Next year the swallows returned and constructed their new nest in the cavity of the shell.²

The following is quoted from Thompson's 'Passions of Animals,' p. 205:—

The sociable grosbeak of Africa is one of the few instances of birds living in community and uniting in constructing one

² Animal Biography, vol. ii., p. 204.

¹ Gould, *Birds of Australia*, vol. ii., p. 155, where see for further description.

huge nest for the whole society. L. Valiant's account has been fully confirmed by other travellers. He says: 'I observed on the way a tree with an enormous nest of these birds, which I have called republicans; and as soon as I arrived at my camp I despatched a few men with a waggon to bring it to me, that I might open and examine the hive. When it arrived, I cut it in pieces with a hatchet, and saw that the chief portion of the structure consisted of a mass of Boshman's grass, without any mixture. but so compact and firmly basketed together as to be impene. trable to the rain. This is the commencement of the structure. and each bird builds its particular nest under this canopy. But the nests are formed only beneath the eaves, the upper surface remaining void, without, however, being useless; for as it has a projecting rim, and is a little inclined, it serves to let the water run off, and preserves each little dwelling from the rain. Figure to yourself a huge irregular sloping roof, all the eaves of which are covered with nests, crowded one against another, and you will have a tolerably accurate idea of these singular edifices. Each individual nest is three or four inches in diameter, which is sufficient for the bird; but, as they are all in contact with one another around the eaves, they appear to the eye to form but one building, and are distinguishable from each other only by a little external aperture which serves as an entrance to the nest; and even this is sometimes common to three different nests, one of which is situated at the bottom and the other two at the This large nest, which was one of the most considerable I had anywhere seen in the course of my journey, contained 320 inhabited cells, which, supposing a male and female to each, would form a society of 640 individuals; but as these birds are polygamous, such a calculation would not be exact.'

The following is quoted from Couch ('Illustrations of Instinct,' p. 227 et seq.):—

Mr. Waterton says there is a peculiarity in the nidification of the domestic swan too singular to be passed over without notice. At the time it lays its first egg the nest which it has prepared is of very moderate size; but as incubation proceeds we see it increase vastly in height and breadth. Every soft material, such as pieces of grass and fragments of sedges, is laid hold of by the sitting swan as they float within her reach, and are added to the nest. This work of accumulation is performed by her during the entire period of incubation, be the weather wet or dry, settled or unsettled; and it is perfectly astonishing to see with what assiduity she plies her work of aggrandisement

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to a nest already sufficient in strength and size to answer every end. My swans generally form their nest on an island quite above the reach of a flood; and still the sitting bird never appears satisfied with the quantity of materials which are provided for her nest. I once gave her two huge bundles of oaten straw, and she performed her work of apparent supererogation by applying the whole of it to her nest, already very large, and not exposed to destruction had the weather become ever so rainy.

This same author continues:—

It is probable that this disposition to accumulation, in its general bearing, has reference to heat rather than the flood; but that the wild swan has a foresight regarding danger, and a quick perception as to the means of securing safety, appears from an instance mentioned by Captain Parry, in his Northern voyage. When everything was deeply involved in ice, the voyagers were obliged to pay much attention to discern whether they were travelling over water or land; but some birds, which formed their nest at no great distance from the ships, were under no mistake in so important a matter; and when the thaw took place it was seen that the nest was situated on an island in the lake.

The following cases are likewise taken from Couch (loc. cit., p. 225):—

This swan was eighteen or nineteen years old, had brought up many broods, and was highly valued by the neighbours. She exhibited, some eight or nine years past, one of the most remarkable powers of instinct ever recorded. She was sitting on four or five eggs, and was observed to be very busy in collecting weeds, grasses, &c., to raise her nest; a farming man was ordered to take down half a load of haulm, with which she most industriously raised her nest and the eggs two feet and a half; that very night there came down a tremendous fall of rain, which flooded all the malt-shops and did great damage. Man made no preparation, the bird did; instinct prevailed over reason. Her eggs were above, and only just above, the water.

During the early part of the summer of 1835, a pair of water-hens built their nest by the margin of the ornamental pond at Bell's Hill, a piece of water of considerable extent, and ordinarily fed by a spring from the height above, but into which the contents of another large pond can occasionally be admitted. This was done while the female was sitting; and as the nest had been built when the water level stood low, the sudden influx

of this large body of water from the second pond caused a rise of several inches, so as to threaten the speedy immersion and consequent destruction of the eggs. This the birds seem to have been aware of, and immediately took precautions against so imminent a danger; for when the gardener, upon whose veracity I can safely rely, seeing the sudden rise of the water. went to look after the nest, expecting to find it covered and the eggs destroyed, or at least forsaken by the hen, he observed. whilst at a distance, both birds busily engaged about the brink where the nest was placed; and when near enough he clearly perceived that they were adding, with all possible despatch, fresh materials to raise the fabric beyond the level of the increased contents of the pond; and that the eggs had by some means been removed from the nest by the birds, and were then deposited upon the grass about a foot or more from the margin of the water. He watched them for some time, and saw the nest rapidly increase in height; but I regret to add that he did not remain long enough, fearing he might create alarm, to witness the interesting act of replacing the eggs which must have been effected shortly after; for, upon his return in less than an hour, he found the hen quietly sitting upon them in the newly raised nest. In a few days afterwards the young were hatched. and, as usual, soon quitted the nest and took to the water with The nest was shown to me in situ shortly after, and I could then plainly discern the formation of the new with the older part of the fabric.

We must not conclude these remarks on nidification without alluding to Mr. Wallace's chapters on the 'Philosophy of Birds' Nests,' in his work on 'Natural Selection,' This writer is inclined to suppose that birds do not build their nests distinctive of their various species by the teachings of hereditary instinct, but by the young birds intelligently observing the construction of the nests in which they are hatched, and purposely imitating this construction when in the following season they have occasion to build zests of their own. With reference to this theory it is only needful to say that it is antecedently improbable, and not well substantiated by facts. It is antecedently improbable because, when any habit has been continued for a number of generations—especially when the habit is of a peculiar and detailed character—the probability is that it has become instinctive; we should have almost as

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A more valuable contribution to the 'Philosophy of Birds' Nests' is furnished by this able naturalist when he directs attention to a certain general correlation between the form of the nest and the colour of the female. For, on reviewing the birds of the world, he certainly makes good the proposition that, as a general rule, liable however to frequent exceptions, dull-coloured females sit on open nests, while those that are conspicuously coloured sit in domed nests. But Mr. Darwin, in a careful review of all the evidence, clearly shows that this interesting fact is to be attributed, not, as Mr. Wallace supposed, to the colour of the female having been determined through natural selection by the form of the nest, but to the reverse process of the form of the nest having been determined by the colour of the female.

Another general fact of interest connected with nidification must not be omitted. This is that the instincts of nidification, although not so variable as the theory of Mr. Wallace would require, are nevertheless highly plastic. The falcon, which usually builds on a cliff, has been known to lay its eggs on the ground in a marsh; the golden eagle sometimes builds in trees or on the ground; while the heron varies its site between trees, cliffs, and open fen.² Again, Audubon, in his 'Ornithological Biography,' gives many cases of conspicuous local variations in the nests of the same species in the northern and

See Descent of Man, p. 452 et seq.
 See Newton, Enoy. Brit., art. 'Birds.'

southern United States; and, as Mr. Wallace truly observes,—

Many facts have already been given which show that birds do adapt their nests to the situations in which they place them; and the adoption of eaves, chimneys, and boxes by swallows, wrens, and many other birds, shows that they are always ready to take advantage of changed conditions. It is probable, therefore, that a permanent change of climate would cause many birds to modify the form or materials of their abode, so as better to protect their young.¹

In America the change of habits in this respect undergone by the house-swallow has been accomplished within

the last three hundred years.

Closely connected, if not identical, with this fact is another, namely, that in some species which have been watched closely for a sufficient length of time, a steady improvement in the construction of nests has been observed. Thus C. G. Leroy, who filled the post of Ranger of Versailles about a century ago, and therefore had abundant opportunities of studying the habits of animals, wrote an essay on 'The Intelligence and Perfectibility of Animals from a Philosophical Point of View.' In this essay he has anticipated the American observer Wilson in noticing that the nests of young birds are distinctly inferior to those of older ones, both as regards their situation and construction. As we have here independent testimony of two good observers to a fact which in itself is not improbable, I think we may conclude that the nest-making instinct admits of being supplemented, at any rate in some birds, by the experience and intelligence of the individual. M. Pouchet has also recorded that he has found a decided improvement to have taken place in the nests of the swallows at Rouen during his own lifetime; and this accords with the anticipation of Leroy that if our observation extended over a sufficient length of time, and in a manner sufficiently close, we should find that the accumulation of intelligent improvements by individuals of successive generations would begin to tell upon the intoo l

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Natural Selection, pp. 232-3.

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Leroy also says that when swallows are hatched out too late to migrate with the older birds, the instinct of migration is not sufficiently imperative to induce them to undertake the journey by themselves. 'They perish, the victims of their ignorance, and of the tardy birth which made them unable to follow their parents.'

Cuckoo.

Perhaps the strangest of the special instincts manifested by birds is that of the cuckoo laying its eggs in the nests of other birds. As the subject is an important one from several points of view, I shall consider it at some length.

It must first be observed that the parasitic habit in question is not practised by all species of the genus—the American cuckoo, for instance, being well known to build its nest and rear its young in the ordinary manner. The Australian species, however, manifests the same instinct as the European. The first observer of the habit practised by the European cuckoo was the illustrious Jenner, who published his account in the 'Philosophical Transactions.' From this account the following is an extract:—

The cuckoo makes choice of the nests of a great variety of small birds. I have known its eggs entrusted to the care of the hedge-sparrow, water-wagtail, titlark, yellowhammer, green linnet, and winchat. Among these it generally selects the three former, but shows a much greater partiality to the hedge-sparrow than to any of the rest; therefore, for the purpose of avoiding confusion, this bird only, in the following account, will be considered as the foster-parent of the cuckoo, except in instances which are particularly specified.

When the hedge-sparrow has sat her usual time, and disengaged the young cuckoo and some of her own offspring from the shell,² her own young ones, and any of her eggs that remain unhatched, are soon turned out, the young cuckoo remaining

¹ Phil. Trans., vol. lxxviii., p. 221 et seq.

² The young cuckoo is generally hatched first.

possessor of the nest, and sole object of her future care. The young birds are not previously killed, nor are the eggs demolished, but all are left to perish together, either entangled about the bush which contains the nest, or lying on the ground under it.

On June 18, 1787, I examined the nest of a hedge-sparrow, which then contained a cuckoo's and three hedge-sparrow's eggs. On inspecting it the day following, I found the bird had hatched, but that the nest now contained a young cuckoo and only one young hedge-sparrow. The nest was placed so near the extremity of a hedge, that I could distinctly see what was going forward in it; and, to my astonishment, saw the young cuckoo, though so newly hatched, in the act of turning out the young hedge-

sparrow.

The mode of accomplishing this was very curious. The little animal, with the assistance of its rump and wings, contrived to get the bird upon its back, and making a lodgment for the burden by elevating its elbows, clambered backward with it up the side of the nest till it reached the top, when, retting for a moment, it threw off its load with a jerk, and quite disengaged it from the nest. It remained in this situation a short time. feeling about with the extremities of its wings, as if to be convinced whether this business was properly executed, and then dropped into the nest again. With these (the extremities of its wings) I have often seen it examine, as it were, an egg and nestling before it began its operations; and the sensibility which these parts appeared to possess seemed sufficiently to compensate the want of sight, which as yet it was destitute of. I afterwards put in an egg, and this by a similar process was conveyed to the edge of the nest and thrown out. These experiments I have since repeated several times in different nests, and have always found the young cuckoo disposed to act in the same manner. In climbing up the nest it sometimes drops its burden, and thus is foiled in its endeavours; but after a little respite the work is resumed, and goes on almost incessantly till it is effected. It is wonderful to see the extraordinary exertions of the young cuckoo, when it is two or three days old, if a bird be put into the nest with it that is too weighty for it to lift out. In this state it seems ever restless and uneasy. But this disposition for turning out its companions begins to decline from the time it is two or three till it is about twelve days old, when, as far as I have hitherto seen, it ceases. Indeed, the disposition for throwing out the egg appears to cease a few days sooner; for I have frequently seen the young cuckoo, after it had been hatched

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Had nature allowed the cuckoo to have stayed here as long as some other migrating birds, which produce a single set of young ones (as the swift or nightingale, for example), and had allowed her to have reared as large a number as any bird is capable of bringing up at one time, there might not have been sufficient to have answered her purpose; but by sending the cuckoo from one nest to another, she is reduced to the same state as the bird whose nest we daily rob of an egg, in which

case the stimulus for incubation is suspended.

A writer in 'Nature' (vol. v., p. 383; and vol. ix., p. 123), to whom Mr. Darwin refers in the latest edition of 'The Origin of Species' as an observer that Mr. Gould has found trustworthy, precisely confirms, from observations of his own, the above description of Jenner. So far, therefore, as the observations are common I shall not quote his statements; but the following additional matter is worth rendering:—

But what struck me most was this: the cuckoo was perfectly naked, without a vestige of a feather or even a hint of future feathers; its eyes were not yet opened, and its neck seemed too weak to support the weight of its head. The pipits (in whose nest the young cuckoo was parasitic) had well-developed quills on the wings and back, and had bright eyes partially open; yet they seemed quite helpless under the manipulations of the cuckoo, which looked a much less developed

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creature. The cuckoo's legs, however, seemed very muscular, and it appeared to feel about with its wings, which were absolutely featherless, as with hands—the 'spurious wing' (unusually large in proportion) looking like a spread-out thumb. The most singular thing of all was the direct purpose with which the blind little monster made for the open side of the nest, the only part where it could throw its burden down the bank. [The latter remark has reference to the position of the nest below a heather bush, on the declivity of a low abrupt bank, where the only chance of dislodging the young birds was to eject them over the side of the nest remote from its support upon the bank.] As the young cuckoo was blind, it must have known the part of the nest to choose by feeling from the inside that that part was unsupported.

Such being the facts, we have next to ask how they are to be explained on the principles of evolution. At first sight it seems that although the habit saves the bird which practises it much time and trouble, and so is clearly of benefit to the individual, it is not so clear how the instinct is of benefit to the species; for as cuckoos are not social birds, and therefore cannot in any way depend on mutual co-operation, it is difficult to see that this saving of time and trouble to the individual can be of any use to But Jenner seems to have hit the right cause in the concluding part of the above quotation. If it is an advantage that the cuckoo should migrate early, it clearly becomes an advantage, in order to admit of this, that the habit should be formed of leaving her eggs for other birds to incubate. At any rate, we have here a sufficiently probable explanation of the raison d'être of this curious instinct; and whether it is the true reason or the only reason, we are justified in setting down the instinct to the creating influence of natural selection.

Mr. Darwin, in his 'Origin of Species,' has some interesting remarks to make on this subject. First, he is informed by Dr. Merrell that the American cuckoo, although as a rule following the ordinary custom of birds in incubating her own eggs, nevertheless occasionally demosits them in the nests of other birds.

Now let us suppose that the ancient progenitor of our Eurocan cuckoo had the habits of the American cuckoo, and that she occasionally laid her egg in another bird's nest. If the old bird profited by this occasional habit through being able to migrate earlier, or through any other cause; or if the young were made more vigorous by advantage being taken of the mistaken instinct of another species than when reared by their own mother, encumbered as she could hardly fail to be by having eggs and young at the same time; ¹ then the old birds or the fostered young would gain an advantage.²

The instinct would seem to be a very old one, for there are two great changes of structure in the European cuckoo which are manifestly correlated with the instinct. Thus, the shape of the young bird's back has already been noted; and not less remarkable than this is the small size of the egg from which the young bird is hatched. For the egg of the cuckoo is not any larger than that of the skylark. although an adult cuckoo is four times the size of an adult skylark. And 'that the small size of the egg is a real case of adaptation (in order to deceive the small birds in whose nests it is laid), we may infer from the fact of the non-parasitic American cuckoo laying full-sized eggs, Yet, although the instinct in question is doubtless of high antiquity, there have been occasional instances observed in cuckoos of reversion to the ancestral instinct of nidification; for, according to Adolf Müller, 'the cuckoo occasion-

Allusion is here made to the fact that the cuckoo lays her eggs at intervals of two or three days, and therefore that if all were incubated by the mother, they would hatch out at different times—a state of things which actually obtains in the case of the American cuckoo, whose

nest contains eggs and young at the same time.

² It is worth while to observe, as bearing on this theory of the origin of this parasitic habit, that even non-parasitic birds occasionally deposit their eggs in nests of other birds. Thus, Professor A. Newton writes in his admirable essay on 'Birds' in the Encyclopædia Britannica, 'Certain it is that some birds, whether by mistake or stupidity, do not unfrequently lay their eggs in the nests of others. It is within the knowledge of many that pheasants' eggs and partridges' eggs are often land in the same nest; and it is within the knowledge of the writer that gulls' eggs have been found in the nests of eider-ducks, and vice versa; that a redstart and a pied flycatcher will lay their eggs in the same convenient hole—the forest being rather deficient in such accommodation: that an owl and a duck will resort to the same nest-hole, set up by the scheming woodman for his own advantage; and that the starling, which constantly dispossesses the green woodpecker, sometimes discovers that the rightful heir of the domicile has to be brought up by the intruding tenant.

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ally lays her eggs on the bare ground, sits on them, and feeds her young.'

In 'Nature' for November 18, 1869, Professor A. Newton, F.R.S., has published an article on a somewhat obscure point connected with the instincts of the cuckoo. He says that Dr. Baldamus has satisfied him, by an exhibition of sixteen specimens of cuckoos' eggs found in the nests of different species of birds, 'that the egg of the cuckoo is approximately coloured and marked like those of the bird in whose nest it is found,' for the purpose, no doubt, of deceiving the foster-parents. Professor Newton adds, however:—

Having said this much, and believing as I do the Doctor to be partly justified in the carefully worded enunciation of what he calls a 'law of nature,' I must now declare that it is only 'approximately,' and by no means universally true that the cuckoo's egg is coloured like those of the victims of her imposition, &c.

Still, when so great an authority as Professor Newton expresses himself satisfied that there is a marked tendency to such imitation, which in some cases leads to extraordinary variations in the colouring of the cuckoo's egg, the alleged fact becomes one which demands notice. The question, of course, immediately arises, How is it conceivable that the fact, if it is a fact, can be explained? We cannot imagine the cuckoo to be able consciously to colour her egg during its formation in order to imitate the eggs among which she is about to lay it; nor can we suppose that having laid an egg and observed its colouring, she then carries it to the nest of the bird whose eggs it most Professor Newton suggests another theory, resembles. which he seems to think sufficient, but which I confess seems to me little more satisfactory than the impossible theories just stated. He says:—

Only one explanation of the process can, to my mind, be offered. Every person who has studied the habits of birds with sufficient attention will be conversant with the tendency which certain of those habits have to become hereditary. It is, I am sure, no violent hypothesis to suppose that there is a very reasonable probability of each cuckoo most commonly placing

her eggs in the nest of the same bird, and of this habit being

transmitted to her posterity.

Now it will be seen that it requires but only an application to this case of the principle of 'natural selection,' or 'survival of the fittest,' to show that if my argument be sound, nothing can be more likely than that, in the course of time, that principle should operate so as to produce the facts asserted, the eggs which best imitated those of particular foster-parents having the best chance of duping the latter, and so of being hatched out.

Now, granting to this hypothesis the assumption that individual cuckoos have special predilections as to the species in whose nests they are to lay their eggs, and that some of these species require to be deceived by imitative colouring of the egg to prevent their tilting it out, there is still an enormous difficulty to be met. Supposing that one cuckoo out of a hundred happens to lay eggs sufficiently like those of the North African magpies (a species alluded to by Professor Newton) to deceive the latter into supposing the egg to be one of their own. This I cannot think is too small a proportion to assume, seeing that, ex hypothesi, the resemblance must be tolerably close, and that the egg of the magpie does not resemble the great majority of eggs of the cuckoo. Now, in order to sustain the theory, we must suppose that the particular cuckoo which happens to have the peculiarity of laying eggs 80 closely resembling those of the magpie, must also happen to have the peculiarity of desiring to lay its eggs in the nest of a magpie. The conjunction of these two peculiarities would, I should think, at a moderate estimate reduce the chances of an approximately coloured egg being laid in the appropriate nest to at least one thousand to one. But supposing the happy accident to have taken place, we have next to suppose that the peculiarity of laving these exceptionably coloured eggs is not only constant for the same individual cuckoo, but is inherited by innumerable generations of her progeny; and, what is much more difficult to grant, that the fancy for laying eggs in the nest of a magpie is similarly inherited. think, therefore, notwithstanding Professor Newton's strong opinion upon the subject, that the ingenious hypothesis

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Cuckoos are not the only birds which manifest the parasitic habit of laying their eggs in other birds' nests.

Some species of *Melothrus*, a widely distinct genus of American birds, allied to our starlings, have parasitic habits like those of the cuckoo; and the species present an interesting gradation in the perfection of their instincts. The sexes of Melothrus cadius are stated by an excellent observer, Mr. Hudson, sometimes to live promiscuously together in flocks and sometimes to pair. They either build a nest of their own, or seize on one belonging to some other bird, occasionally throwing out the nestlings of the stranger. They either lay their eggs in the nest thus appropriated, or oddly enough build one for themselves on the top of it. They usually sit on their own eggs and rear their own young; but Mr. Hudson says it is probable that they are occasionally parasitic, for he has seen the young of this species feeding old birds of a distinct kind and clamouring to be fed by them. The parasitic habits of another species of Melothrus, the M. Canariensis, are much more highly developed than those of the last, but are still far from perfect. This bird, as far as it is known, invariably lays its eggs in the nests of strangers, but it is remarkable that several together sometimes commence to build an irregular untidy nest of their own, placed in singularly ill-adapted situations, as on the leaves of a large thistle. They must, however, as far as Mr. Hudson has ascertained, complete a nest for themselves. They often lay so many eggs, from fifteen to twenty, in the same foster-nest, that few or none can possibly be hatched. They have, moreover, the extraordinary habit of pecking holes in the eggs, whether of their own species or of their foster-parents, which they find in the appropriated nests. They drop also many eggs on the bare

ground, which are thus wasted. A third species, the *M. precius* of North America, has acquired instincts as perfect as those of the cuckoo, for it never lays more than an egg in a foster-nest, so that the young bird is securely reared. Mr. Hudson is a strong disbeliever in evolution, but he appears to have been so much struck by the imperfect instincts of the *Melothrus Canariensis* that he quotes my words, and asks, 'Must we consider these habits not as especially endowed or created instincts, but as small consequences of one general law, namely transition?'

Such are all the facts and considerations which I have to present with reference to the curious instinct in question. It will be seen that—with one doubtful or not sufficiently investigated exception, viz., that of cuckoos adapting the colour of their eggs to that of the eggs of the foster-parents—there is nothing connected with these instincts that presents any difficulty to the theory of evolution. We may, perhaps, at first sight wonder why some counteracting instinct should not have been developed by the same agency in the birds which are liable to be thus duped; but here we must remember that the deposition of a parasitic egg is, comparatively speaking, an exceedingly rare event, and therefore not one that is likely to lead to the development of a special instinct to meet it.

General Intelligence.

Under this heading I shall here, as in the case of this heading elsewhere, string together all the instances which I have met with, and which I deem trustworthy, of the display of unusually high intelligence in the class, family, order, or species of animals under consideration—the object of this heading in all cases being that of supplying, by the facts mentioned beneath it, a general idea of the upper limit of intelligence which is distinctive of each group of animals.

That birds recognise their own images in mirrors as birds there can be no question. Houzeau, who records observations of his own in this connection with parrots,² adds that dogs are more difficult to deceive by mirrors in

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¹ Origin of Species, p. 215.

² Tom. i., p. 130.

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this way than birds, on account of their depending so much upon smell for their information. No doubt individual differences are to be met with in animals of both classes, and much depends on previous experience. Young dogs, or dogs which have never seen a mirror before, are not, as a rule, difficult to deceive, even though they have good noses. I myself had a setter with an excellent nose, who on many repeated occasions tried to fight his own image, till he found by experience that it was of no use. As to birds, I have seen canaries suppose their own images to be other canary birds, and also the reflection of a room to be another room—the birds flying against a large mirror and falling half stunned. I mention the latter circumstance because it afforded evidence of the superior intelligence of a linnet, which on the same occasion dashed itself against the mirror once, but never a second time, while the canaries did so repeatedly.

Mrs. Frankland, in 'Nature'(xxi., p. 82), gives the following account of a bullfinch paying more attention to a portrait of a bullfinch than to his own image in a mirror, which is certainly remarkable; and as the fact seems to have been observed repeatedly, it can scarcely be discredited:

The following is a curious instance of discrimination which I have observed in my bullfinch. He is in the habit of coming out of his cage in my room in the morning. In this room there is a mirror with a marble slab before it, and also a very cleverly executed water-colour drawing of a hen bullfinch, life size. The first thing that my bullfinch does on leaving his cage is to fly to the picture (perching on a vase just below it) and pipe his tune in the most insinuating manner, accompanied with much bowing to the portrait of the hen bullfinch. After having duly paid his addresses to it, he generally spends some time on the marble slab in front of the looking-glass, but without showing the slightest emotion at the sight of his own reflection, or courting it with a song. Whether this perfect coolness is due to the fact of the reflection being that of a cock bird, or whether (since he shows no desire to fight the reflected image) he is perfeetly well aware that he only sees himself, it is difficult to say.

That birds possess considerable powers of imagination, or forming mental pictures of absent objects, may be in-

ferred from the fact of their pining for absent mates, parrots calling for absent friends, &c. The same fact is further proved by birds dreaming, a faculty which has been noticed by Cuvier, Jerdon, Thompson, Bennet, Houzeau, Bechstein, Lindsay, and Darwin.¹

The facility with which birds lend themselves to the education of the show-man is certain evidence of considerable docility, or the power of forming novel associations

of ideas. Thus, according to Bingley,—

Some years ago the Sieur Roman exhibited in this country the wonderful performances of his birds. These were gold-finches, linnets, and canary birds. One appeared dead, and was held up by the tail or claw without exhibiting any signs of life. A second stood on its head, with its claws in the air, &c., &c.,

And many years ago there was exhibited a very puzzling automaton, which, although of very small size and quite isolated from any possibly mechanical connection with its designer, performed certain movements in any order that the fancy of the observers might dictate. The explanation turned out to be that within the mechanism of the figure there was a canary bird which had been taught to run in different directions at different words or tones of command, so by its weight starting the mechanism to perform the particular movement required.

The rapidity with which birds learn not to fly against newly erected telegraph wires, displays a large amount of observation and intelligence. The fact has been repeatedly

observed. For instance, Mr. Holden says:-

About twelve years ago I was residing on the coast of county Antrim, at the time the telegraph wires were set up along that charming road which skirts the sea between Larne and Cushendall. During the winter months large flocks of starlings always migrated over from Scotland, arriving in the early morning. The first winter after the wires were stretched along the coast I frequently found numbers of starlings lying dead or wounded on the road-side, they having evidently in their flight in the dusky morn struck against the telegraph wires, not

² Animal Biography, vol. ii., p. 173

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¹ See Birds of India, i., p. 21; Passions of Animals, p. 60; Fac. Men. des Ani., tom. ii., p. 183; Mind in Lower Animals, vol. ii., p. 96; and Descent of Man, p. 74.

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als, p. 60; Fac. Men. s, vol. ii., p. 96; and blown against them, as these accidents often occurred when there was but little wind. I found that the peasantry had come to the conclusion that these unusual deaths were due to the flash of the telegraph messages killing any starlings that happened to be perched on the wires when working. Strange to say that throughout the following and succeeding winters hardly a death caused among the starlings on their arrival. It would thus appear that the birds were deeply impressed, and understood the cause of the fatal accidents among their fellow-travellers the previous year, and hence carefully avoided the telegraph wires; not only so, but the young birds must also have acquired this knowledge and perpetuated it, a knowledge which they could not have acquired by experience or even instinct, unless the instinct was really inherited memory derived from the parents whose brains were first impressed by it.

Similar facts are given in Buckland's 'Curiosities of Natural History,' 2 and I have myself known of a case in Scotland where a telegraph was erected across a piece of moorland. During the first season some of the grouse were injured by flying against the wires, but never in any succeeding season. Why the young birds should avoid them without having had individual experience may, I think, be explained by the consideration that in birds which fly in flocks or coveys, it is the older ones that lead the way. This explanation would not, of course, apply to birds which fly singly; but I am not aware that any observations have gone to show that the young of such birds avoid the wires.

I quote the following exhibition of intelligence in an eagle from Menault:—

The following account of the patience with which a golden eagle submitted to surgical treatment, and the care which it showed in the gradual use of the healing limb, must suggest the idea that something very near to prudence and reason existed in the bird. This eagle was caught in a fox-trap set in the forest of Fontainebleau, and its claw had been terribly torn. An operation was performed on the limb by the conservators of the Zoological Gardens at Paris, which the noble bird bore with a rational patience. Though his head was left loose, he made no attempts to interfere with the agonising extraction of the

¹ Nature, xx., p. 266. ² Vol. i., p. 216. See also Descent of Man, p. 80.

splinters, or to disturb the arrangements of the annoying band. ages. He seemed really to understand the nature of the services rendered, and that they were for his good.¹

Speaking of the Urubu vultures, Mr. Bates says:-

They assemble in great numbers in the villages about the end of the wet season, and are then ravenous with hunger. My cook could not leave the open kitchen at the back of the house for a moment whilst the dinner was cooking, on account of their thievish propensities. Some of them were always loitering about, watching their opportunity, and the instant the kitchen was left unguarded, the bold marauders marched in and lifted the lids of the saucepans with their beaks to rob them of their contents. The boys of the village lie in wait, and shoot them with bow and arrow; and vultures have consequently acquired such a dread of these weapons, that they may be often kept off by hanging a bow from the rafters of the kitchen.²

Mrs. Lee, in her 'Anecdotes,' says that one day her gardener was struck by the strange conduct of a robin, which the man had often fed. The bird fluttered about him in so strange a manner—now coming close, then hurrying away, always in the same direction—that the gardener followed its retreating movements. The robin stopped near a flower-pot, and fluttered over it in great agitation. It was soon found that a nest had been formed in the pot, and contained several young. Close by was a snake, intent, doubtless, upon making a meal of the brood.

The following appeared in the 'Gardener's Chronicle' for Aug. 3, 1878, under the initials 'T. G.' I wrote to the editor requesting him to supply me with the name of his correspondent, and also to state whether he knew him to be a trustworthy man. In reply the editor said that he knew his correspondent to be trustworthy, and that his name is Thomas Guring:—

About thirty years ago the small market town in which I reside was skirted by an open common, upon which a number of geese were kept by cottagers. The number of the birds was very great. . . . Our corn market at that time was held in the street in front of the principal inn, and on the market day a good deal of corn was scattered from sample bags by millers. Somehow the geese found out about the spilling of corn, and they appear to have held a consultation upon the subject. . . .

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¹ Menault, Wonders of Instinct, p. 132.

² Nat. on Amazons, p. 177; Anecdotes, p. 135.

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p. 135.

From this time they never missed their opportunity, and the entry of the geese was always looked for and invariably took place. On the morning after the market, early, and always on the proper morning, fortnightly, in they came cackling and subbling in merry mood, and they never came on the wrong day. The corn, of course, was the attraction, but in what manner did they mark the time? One might have supposed that their perceptions were awakened on the market day by the smell of corn, or perhaps by the noise of the market traffic; but my story is not yet finished, and its sequel is against this view. It happened one year that a day of national humiliation was kept, and the day appointed was that on which our market should have been held. The market was postponed, and the geese for once were baffled. There was no corn to tickle their olfactory organs from afar, no traffic to appeal to their sense of hearing. I think our little town was as still as it usually is on Sundays. . . . The geese should have stopped away; but they knew their day, and came as usual. . . . I do not pretend to remember under what precise circumstances the habit of coming into the street was acquired. It may have been formed by degrees, and continued from year to year; but how the old hirds, who must have led the way, marked the time so as to ome in regularly and fortnightly, on a particular day of the week, I am at a loss to conceive.

Livingstone's 'Expedition to the Zambesi, 1865,' p. 209, gives a conclusive account of the bird called the honey-guide, which leads persons to bees' nests. 'They are quite as anxious to lure the stranger to the bees' hive as other birds are to draw him away from their own nests.' The object of the bird is to obtain the pupæ of the bees which are laid bare by the ravaging of the nest. The habits of this bird have long been known and described in books on popular natural history; but it is well that the facts have been observed by so trustworthy a man as Livingstone. He adds, 'How is it that members of this amily have learned that all men, white and black, are fond of honey?' We can only answer, by intelligent observation in the first instance, passing into individual and hereditary habit, and so eventually into a fixed instinct.

Brehm relates an instance of cautious sagacity in a ewit. He had placed some horsehair snares over its est, but the bird seeing them, pushed them aside with

her bill. Next day he set them thickly round the nest; but now the bird, instead of running as usual to the nest along the ground, alighted directly upon it. This shows a considerable appreciation of mechanical appliances, as does also the following.

Mrs. G. M. E. Campbell writes to me:-

At Ardglass, co. Down, Ireland, is a long tract of turf coming to the edge of the rocks overhanging the sea, where cattle and geese feed; at a barn on this tract there was a low enclosure, with a door fastening by a hook and staple to the side post: when the hook was out of the staple, the door fell open by its own weight. I one day saw a goose with a large troop of goslings coming off the turf to this door, which was secured by the hook being in the staple. The goose waited for a minute or two, as if for the door to be opened, and then turned round as if to go away, but what she did was to make a rush at the door, and making a dart with her beak at the point of the hook nearly threw it out of the staple; she repeated this manœuvre, and succeeded at the third attempt, the door fell open, and the goose led her troop in with a sound of triumphant chuckling How had the goose learned that the force of the rush was need. ful to give the hook a sufficient toss?

Mrs. K. Addison sends me the following instance of the use of signs on the part of an intelligent jackdaw. The bird was eighteen months old, and lived in some bushes in Mrs. Addison's garden. She writes:—

I generally made a practice of filling a large basin which stands under the trees every morning for Jack's bath. A few day ago I forgot this duty, and was reminded of the fact in a very singular manner. Another of my daily occupations is to open my dressing-room shutters about eleven o'clock of a morning. Now these said shuuters open almost on to the trees where Jack lives. The day I forgot his bath, when I opened the shutters I foun my little friend waiting just outside them, as though he knew that he should see me there; and when he did he placed himself immediately in front of me, and then shook himself and spread out his wings just as he always does in his bath. The action was so suggestive and so unmistakable, that I spoke just as would have done to a child—'Oh yes, Jack, of course you sha have some water.'

Mr. W. W. Nichols writes to 'Nature:'-

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re:'—

The Central Prison at Agra is the roosting-place of great numbers of the common blue pigeon; they fly out to the neighhouring country for food every morning, and return in the evening, when they drink at a tank just outside the prison walls. In this tank are a large number of fresh-water turtles, which lie in wait for the pigeons just under the surface of the water and at the edge of it. Any bird alighting to drink near one of these turtles has a good chance of having its head bitten off and eaten; and the headless bodies of pigeons have been picked up near the water, showing the fate which has sometimes befallen the birds. The pigeons, however, are aware of the danger, and have hit on the following plan to escape it. A pigeon comes in from its long flight, and, as it nears the tank, instead of flying down at once to the water's edge, will cross the tank at about twenty feet above its surface, and then fly back to the side from which it came, apparently selecting for alighting a safe spot which it had remarked as it flew over the bank; but even when such a spot has been selected the bird will not alight at the edge of the water, but on the bank about a yard from the water, and will then run down quickly to the water, take two or three hurried gulps of it, and then fly off to repeat the same process at another part of the tank till its thirst is satisfied. I had often watched the birds doing this, and could not account for their strange mode of drinking till told by my friend the superintendent of the prison, of the turtles which lay in ambush for the pigeons.

As a still more remarkable instance of the display of intelligence by a bird of this species, I shall quote the following observation of Commander R. H. Napier, also published in 'Nature' (viii., p. 324):—

A number of them (pouters) were feeding on a few oats that had been accidentally let fall while fixing the nose-bag on a horse standing at bait. Having finished all the grain at hand, a large 'pouter' rose, and flapping its wings furiously, flew directly at the horse's eyes, causing the animal to toss his head, and in doing so, of course shake out more corn. I saw this several times repeated—in fact, whenever the supply on hand had been exhausted. . . . Was not this something more than instinct?

The following display of intelligence on the part of smallows is communicated to me by Mr. Charles Wilson.

It can scarcely be attributed to accident, and does not admit of mal-observation. My informant says:—

Two swallows were building a nest in the verandah of a house in Victoria, but as their nest was resting partly on a bell-wire, it was by this means twice pulled down. They then began afresh, making a tunnel through the lower part of the nest, through which the wire was able to act without doing damage.

Another gentleman writes me of another use to which he has observed swallows put the artifice of building tunnels. Being molested by sparrows which desired to take forcible possession of their nest, a pair of swallows modified the entrance of the latter, so that instead of opening by a simple hole under the eaves of a house, it was carried on in the form of a tunnel.

Linnæus says that the martin, when it builds under the eaves of houses, sometimes is molested by sparrows taking possession of the nest. The pair of martins to which the nest belongs are not strong enough to dislodge the invaders; but they convoke their companions, some of whom guard the captives, whilst others bring clay, close up the entrance of the nest, and leave the sparrows to die miserably. This account has been to a large extent independently confirmed by Jesse, who seems not to have been acquainted with the statement of Linnæus. He writes:—

Swallows seem to entertain the recollection of injury, and to resent it when an opportunity offers. A pair of swallows built their nest under the ledge of a house at Hampton Court. It was no sooner completed than a couple of sparrows drove them from it, notwithstanding the swallows kept up a good resistance, and even brought others to assist them. The intruders were left in peaceable possession of the nest, till the two old birds were obliged to quit it to provide food for their young. They had no sooner departed than several swallows came and broke down the nest; and I saw the young sparrows lying dead on the ground. As soon as the nest was demolished, the swallows began to rebuild it.¹

The same author gives the following and somewhat similar case:—

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¹ Gleanings, vol. ii., p. 96.

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A pair of swallows built their nest against one of the firstfloor windows of an uninhabited house in Merrion Square, Dublin. A sparrow, however, took possession of it, and the swallows were repeatedly seen clinging to the nest, and endeavouring to gain an entrance to the abode they had erected with so much labour. All their efforts, however, were defeated by the sparrow, who never once quitted the nest. The perseverance of the swallows was at length exhausted: they took flight, but shortly afterwards returned, accompanied by a number of their congeners, each of them having a piece of dirt in its bill. By this means they succeeded in stopping up the hole, and the intruder was immured in total darkness. Soon afterwards the nest was taken down and exhibited to several persons, with the dead sparrow in it. In this case there appears to have been not only a reasoning faculty, but the birds must have been possessed of the power of communicating their resentment and their wishes to their friends, without whose aid they could not thus have avenged the injury they had sustained.1

That birds sometimes act in concert may also be gathered from the following observations recorded by Mr. Buck:—

I have constantly seen a flock of pelicans, when on the feed, form a line across a lake, and drive the fish before them up its whole length, just as fishermen would with a net.²

The following is extracted from Sir E. Tennent's 'Natural History of Ceylon,' and displays remarkable intelligence on the part of the crows in that island:—

One of these ingenious marauders, after vainly attitudinising in front of a chained watch-dog, that was lazily gnawing abone, and after fruitlessly endeavouring to divert his attention by dancing before him, with head awry and eye askance, at length flew away for a moment, and returned bringing a companion which perched itself on a branch a few yards in the rear. The crow's grimaces were now actively renewed, but with no better success, till its confederate, poising itself on its wings, descended with the utmost velocity, striking the dog upon the spine with all the force of its strong beak. The ruse was successful; the dog started with surprise and pain, but not quickly enough to seize his assailant, whilst the bone he had been gnawing was snatched away by the first crow the

¹ Ibid., p. 99. ² Nature, vol. xiii., p. 303.

instant his head was turned. Two well-authenticated instances of the recurrence of this device came within my knowledge at Colombo, and attest the sagacity and powers of communication and combination possessed by these astute and courageous birds.

This account, which would be difficult of credence if narrated by a less competent author, is strikingly confirmed by an independent observation on the crows of Japan, which has recently been published by Miss Bird, in whose words I shall render it. She writes:—

In the inn garden I saw a dog eating a piece of carrion in the presence of several of these covetous birds. They evidently said a great deal to each other on the subject, and now and then one or two of them tried to pull the meat away from him. which he resented. At last a big strong crow succeeded in tearing off a piece, with which he returned to the pine where the others were congregated, and after much earnest speech they all surrounded the dog, and the leading bird dexterously dropped the small piece of meat within reach of his mouth, when he immediately snapped at it, letting go the big piece unwisely for a second, on which two of the crows flew away with it to the pine, and with much fluttering and hilarity they all ate, or rather gorged it, the deceived dog looking vacant and bewildered for a moment, after which he sat under the tree and barked at them inanely. A gentleman told me that he saw a dog holding a piece of meat in like manner in the presence of three crows, which also vainly tried to tear it from him, and after a consultation they separated, two going as near as they dared to the meat, while the third gave the tail a bite sharp enough to make the dog turn round with a squeak, on which the other villains seized the meat, and the three fed triumphantly upon it on the top of a wall.

These two independent statements by competent observers of such similar exhibitions of intelligence by crows, justifies us in accepting the fact, remarkable though it be. As further corroboration, however, I shall quote still another independent and closely similar observation, which I find in a letter to me from Sir J. Clarke Jervoise, who says, while writing of rooks which he has observed in England:—

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¹ Unbeaten Tracks in Japan, vol. ii., pp. 149-50.

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A pheasant used to come very boldly and run off with large pieces of food, which he could only divide by shaking, and he was closely watched by the rooks for the pieces that flew out of his reach. He learned to run off into the shrubs, followed by the rooks, who pulled his tail to make him drop his food.

I shall next quote a highly interesting observation which seems to have been well made, and which displays remarkable intelligence on the part of the birds described. These are Turnstones, which, as their name implies, turn over stones, &c., in order to obtain as food the sundry small creatures concealed beneath. In this case the observer was Edward. Being concealed in a hollow, and unnoticed by the birds, he saw a pair trying to turn over the body of a stranded cod-fish, three and a half feet long, and buried in the sand to a depth of several inches. He thus describes what he saw:—

Having got fairly settled down in my pebbly observatory, I turned my undivided attention to the birds before me. They were boldly pushing at the fish with their bills, and then with their breasts. Their endeavours, however, were in vain: the object remained immovable. On this they both went round to the opposite side, and began to scrape away the sand from beneath the fish. After removing a considerable quantity, they again came back to the spot which they had left, and went once more to work with their bills and breasts, but with as little apparent success as formerly. Nothing daunted, however, they ran round a second time to the other side, and recommenced their trenching operations with a seeming determination not to be battled in their object, which evidently was to undermine the dead animal before them, in order that it might be the more easily overturned.

While they were thus employed, and after they had laboured in this manner at both sides alternately for nearly half an hour, they were joined by another of their own species, which came flying with rapidity from the neighbouring rocks. Its timely arrival was hailed with evident signs of joy. I was led to this conclusion from the gestures which they exhibited, and from a low but pleasant murmuring noise to which they gave utterance so soon as the new-comer made his appearance. Of their felings he seemed to be perfectly aware, and he made his reply to them in a similar strain. Their mutual congratulations being over, they all three set to work; and after labouring

vigorously for a few minutes in removing the sand, they came round to the other side, and putting their breasts simultaneously to the fish, they succeeded in raising it some inches from the sand, but were unable to turn it over. It went down again into its sandy bed, to the manifest disappointment of the three. Resting, however, for a space, and without leaving their respective positions, which were a little apart the one from the other, they resolved, it appears, to give the work another trial. Lowering themselves, with their breasts pressed close to the sand, they managed to push their bills underneath the fish. which they made to rise about the same height as before Afterwards, withdrawing their bills, but without losing the advantage which they had gained, they applied their breasts to the object. This they did with such force, and to such purpose, that at length it went over, and rolled several yards down a slight declivity. It was followed to some distance by the birds themselves before they could recover their bearing.1

I shall now bring this chapter to a close by presenting all the evidence that I have been able to collect with regard to the punishment of malefactors among rooks.

Goldsmith, who used constantly to observe a rookery from his window, says that the selection of a site for the building of a nest is a matter of much anxious deliberation on the part of a young crow couple; the male and female 'examining all the trees of a grove very attentively, and when they have fixed upon a branch that seems fit for their purpose, they continue to sit upon it, and observe it very sedulously for two or three days longer:'—

It often happens that the young couple have made choice of a place too near the mansion of an older pair, who do not choose to be incommoded by such troublesome neighbours; a quarrel, therefore, instantly ensues, in which the old ones are always victorious. The young couple, thus expelled, are obliged again to go through their fatigues—deliberating, examining and choosing; and, having taken care to keep their due distance the nest begins again, and their industry deserves commendation. But their activity is often too great in the beginning they soon grow weary of bringing the materials of their nest from distant places, and they very early perceive that stick may be provided nearer home, with less honesty indeed, but some degree of address. Away they go, therefore, to pilfer a fast as they can, and, whenever they see a nest unguarded, the

¹ Smiles, Life of Edward, pp. 244-6.

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take care to rob it of the very choicest sticks of which it is composed. But these thefts never go unpunished, and probably, upon complaint being made, there is a general punishment I have seen eight or ten rooks come upon such occasions, and, setting upon the new nest of the young couple, all at once tear it to pieces in a moment.

At length, however, the young pair find the necessity of going more regularly to work. While one flies to fetch the materials, the other sits upon the tree to guard it; and thus in the space of three or four days, with a skirmish now and then between, the pair have filled up a commodious nest, composed of sticks without, and of fibrous roots and long grass within. From the instant the female begins to lay, all hostilities are at an end; not one of the whole grove, that a little before treated her so rudely, will now venture to molest her, so that she brings forth her brood with perfect tranquillity. Such is the severity with which even native rooks are treated by each other; but if a foreign rook should attempt to make himself a denizen of their society, he would meet with no favour, the whole grove would at once be up in arms against him, and expel him without mercy.

Couch says ('Illustrations of Instinct,' p. 334 et seq.):— The wrong-doers being discovered, the punishment is appropriate to the offence; by the destruction of their dishonest work they are taught that they who build must find their own bricks or sticks, and not their neighbours', and that if they wish to live in the enjoyment of the advantages of the social condition, they must endeavour to conform their actions to the principles of the rookery of which they have been made members.

It is not known what enormities led to the institution of another tribunal of the same kind, called the Crow Court, but according to Dr. Edmonson, in his 'View of the Shetland Islands,' its proceedings are as authoritative and regular, and it is remarkable as occurring in a species (Corvus Cornice) so near akin to the rook. The Crow Court is a sort of general assembling of birds who, in their usual habits, are accustomed to live in pairs, scattered at great distances from each other; when they visit the south or west of England, as they do in severe winters, they are commonly solitary. In their summer haunts in the Shetland Islands, numbers meet together from different points nonesty indeed, but a particular hill or field; and on these occasions the assem-herefore, to pilfer a by is not complete, and does not begin its business for a day est unguarded, the rewo, till, all the deputies having arrived, a general clamour or croaking ensues, and the whole of the court, judges, barristers, ushers, audience, and all, fall upon the two or three prisoners at the bar, and beat them till they kill them. When this is accomplished the court breaks up and quietly disperses.

In the northern parts of Scotland (says Dr. Edmonson). and in the Faroe Islands, extraordinary meetings of crows are occasionally known to occur. They collect in great numbers. as if they had all been summoned for the occasion; a few of the flock sit with drooping heads, and others seem as grave as judges, while others again are exceedingly active and noisy; in the course of about one hour they disperse, and it is not uncommon, after they have flown away, to find one or two left dead on the spot. These meetings will sometimes continue for a day or two before the object, whatever it may be, is completed. Crows continue to arrive from all quarters during the session. As soon as they have all arrived, a very general noise ensues: and, shortly after, the whole fall upon one or two individuals. When the execution has been per and put them to death. formed, they quietly disperse.

Similarly, the Bishop of Carlisle writes in the 'Nineteenth Century' for July 1881:—

I have seen also a jackdaw in the midst of a congregation of rooks, apparently being tried for some misdemeanour. First Jack made a speech, which was answered by a general cawing of the rooks; this subsiding, Jack again took up his parable, and the rooks in their turn replied in chorus. After a time the business, whatever it was, appeared to be settled satisfactorily: if Jack was on his trial, as he seemed to be, he was honourably acquitted by acclamation; for he went to his home in the towers of Ely Cathedral, and the rooks also went their way.

Lastly, Major-General Sir George Le Grand Jacob, K.C.S.I., C.B., writes to me that while sitting in a verandah in India, he saw three or four crows come and perch on a neighbouring house. They then cawed continuously with such peculiar sound and vigour as to attract his attention. His account proceeds:—

Soon a gathering of crows from all quarters took place, until the roof of the guard-house was blackened by them. Thereupon a prodigious clatter ensued; it was plain that a 'palaver' was going forward. Some of its members, more eager than others skipping about, I became much interested, and narrowly watched the proceedings, all within a dozen yards of me. After much cawing and clamour, the whole group suddenly rose into the air

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and kept circling round half a dozen of their fellows, one of whom had been clearly told off for punishment, for the five repeatedly attacked it in quick succession, allowing no opportunity for their victim to escape, which he was trying to do, until they had cast him fluttering on the ground about thirty yards from my chair. Unfortunately I rushed forward to pick up the bird, prostrate but fluttering on the grass which was like a lawn before the building. I succeeded only in touching it, for it wriggled away from my grasp, and flew greatly crippled and close to the ground into the neighbouring bushes, where I lost sight of it. All the others, after circling round me and chattering, angrily as I thought, flew away, on my resuming my seat, in the direction taken by their victim.

[Since going to press I have seen, through the kindness of Mr. Seebohm, some specimens of cuckoo's eggs coloured in imitation of those belonging to the birds in the nests of which they are laid. There can be no question about the imitation, and I add this note to mitigate the criticism which I have passed upon Professor Newton's theory of the cause. For Mr. Seebohm has pointed out to me that the theory becomes more probable if we consider that a cuckoo reared in the nest of any particular bird is likely afterwards to choose a similar nest for the deposition of its own eggs. Whether or not the memory of a bird would thus act could only, of course, be certainly proved by experiment; but in view of the possibility that it may, Professor Newton's theory becomes more probable than it is if the selection of the appropriate nest is supposed to depend only on inheritance.

I must also add that Dr. Sclater has been kind enough to draw my attention to a remarkable description of a species of Bower-bird, published by Dr. Beccari in the Gardener's Chronicle for March 16, This species is called the Gardener Bower-bird (Amblyornis niornata), and inhabits New Guinea. The animal is about the size of a turtle-dove, and its bower—or rather hut—is built round the stem of a tree in the shape of a cone, with a space between the stem of the tree and the walls of the hut. The latter are composed of stems of an orchid with their leaves on—this particular plant being chosen by the birds apparently because its leaves remain long fresh. But the most extraordinary structure is the garden, which is thus described by Dr. Beccari:— Before the cottage there is a meadow of moss. This is brought to the spot and left free from grass, stones, or anything which would offend the eye. On this green turf flowers and fruits of pretty wour are placed, so as to form an elegant little garden. The greater part of the decoration is collected round the entrance to the nest, and it would appear that the husband offers these his daily gifts to his wife. The objects are very various, but always of a vivid colour. There were some fruits of a Garcinia like a small-sized apple. Others were the fruits of Gardencias of a deep yellow colour in the interior. I saw also small rosy fruits, probably of a Scitamineous plant, and beautiful rosy flowers of a new Vaccinium. There were also fungi and mottled insects placed on the turf. As soon as the objects are faded they are moved to the back of the hut.' There is a fine-coloured plate of this bird in its garden, published in the Birds of New Guinea, by Mr. Gould,

CHAPTER XI.

MAMMALS.

I shall devote this chapter to the psychology of all the Mammalia which present any features of psychological interest, with the exception of the rodents, the elephant, the dog and cat tribe among Carnivora, and the Primates—all of which I shall reserve for separate treatment.

Marsupials.

In the 'Transactions of the Linnean Society,' Major Mitchell gives an interesting account of the structure reared by a small Australian marsupial (Conilurus constructor) for the purposes of defence against the dingo dog. It consists of a large pile of dry sticks and brushwood, 'big enough to make two or three good cart-loads.' Each stick and fragment is closely intertwined or woven with the rest, so that the whole forms a solid, compact mass. In the middle of this large structure is the nest of the animal.

The marsupials are as low in the scale of mammalian intelligence as they are in that of mammalian structure; so that, except the above, I have met with no fact connected with the psychology of this group that is worth quoting, except, perhaps, the following, which appears to show deliberation and decision on the part of the kangaroo. Jesse writes:—

A gentleman who had resided for several years in New South Wales related the following circumstance, which he assured me he had frequently witnessed while hunting the kangaroo: it furnishes a strong proof of the affection of that animal for her young, even when her own life has been placed in the

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most imminent danger. He informed me that, when a female kangaroo has been hard pressed by dogs, he has seen her, while she has been making her bounds, put her fore-paws into her pouch, take a young one from it, and then throw it as far on one side as she possibly could out of the way of the dogs. But for this manœuvre her own life and that of her young one would have been sacrificed. By getting rid of the latter she has frequently effected her escape, and probably returned afterwards to seek for her offspring.

Cetaceans.

The following is quoted from Thompson:-

In 1811, says Mr. Scoresby, one of my harpooners struck a sucker, with the hope of leading to the capture of the mother. Presently she arose close to the 'fast boat,' and seizing the young one, dragged about 600 feet of line out of the boat with remarkable force and velocity. Again she rose to the surface, darted furiously to and fro, frequently stopped short or suddenly changed her direction, and gave every possible intimation of extreme agony. For a length of time she continued thus to act, though pursued closely by the boats; and, inspired with courage and resolution by her concern for her young, seemed regardless of the dangers which surrounded her. At length one of the boats approached so near that a harpoon was hove at her; it hit, but did not attach itself. A second harpoon was struck, but this also failed to penetrate; but a third was more successful, Still she did not attempt to escape, but allowed other boats to approach; so that in a few minutes three more harpoons were fastened, and in the course of an hour afterwards she was killed. 1

Mr. Saville Kent communicates an article to 'Nature' (vol. viii., p. 229) on 'Intellect of Porpoises.' He says:—

The keeper in charge of these interesting animals is now in the habit of summoning them to their meals by the call of a whistle; his approaching footsteps, even, cause great excitement in their movements. . . The curiosity attributed to these creatures, as illustrated by the experiences of Mr. Matthew Williams, receives ample confirmation from their habits and confinement. A new arrival is at once subjected to the most importunate attention, and, advancing from familiarity to con-

Passions of Animals, p. 154.

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ral years in New stance, which he hunting the kanion of that animal been placed in the tempt if disapproved of, soon becomes the object of attack and persecution. A few dog-fish (Acanthias and Mastelus), three or four feet long, now fell victims to their tyranny, the porpoises seizing them by their tails, and swimming off with and shaking them in a manner scarcely conducive to their comfort or dignified appearance, reminding the spectator of a large dog worrying a rat. . . . On one occasion I witnessed the two Cetacea acting evidently in concert against one of these unwieldy fish (skates), the latter swimming close to the top of the water, and seeking momentary respite from its relentless enemies by lifting its unfortunate caudal appendage high above its surface—the peculiar tail of the skate being the object of sport to the porpoises, which seized it in their mouths as a convenient handle whereby to pull the animal about, and worry it incessantly.

In a subsequent number of 'Nature' (vol. ix., p. 42)
Mr. C. Fox writes:—

Several years ago a herd of porpoises was scattered by a net which I had got made to enclose some of them. . . . The whole 'sculle' was much alarmed, and two were secured. I conclude that their companions retained a vivid remembrance of the sea-fight, as these *Cetacea*, although frequent visitants in this harbour (Falmouth) previously, and often watched for, were not seen in it again for two years or more.

Horse and Ass.

The horse is not so intelligent an animal as any of the larger Carnivora, while among herbivorous quadrupeds his sagacity is greatly exceeded by that of the elephant, and in a lesser degree by that of his congener the ass. On the other hand, his intelligence is a grade or two above that of perhaps any ruminant or other herbivorous quadruped.

The emotional life of this animal is remarkable, in that it appears to admit of undergoing a sudden transformation in the hands of the 'horse-tamer.' The celebrated results obtained by Rarey in this connection have since been repeated with more or less success by many persons in various parts of the world, and the 'method' appears to be in all cases essentially the same. The untamed and apparently untamable animal has its foreleg or legs strapped up, is cast on its side and allowed to

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hal as any of the s quadrupeds his elephant, and in the ass. On the r two above that rous quadruped. s remarkable, in a sudden transmer.' The celeconnection have success by many nd the 'method' The unsame. nal has its foree and allowed to struggle for a while. It is then subjected to various manipulations, which, without necessarily causing pain, make the animal feel its helplessness and the mastery of the operator. The extraordinary fact is that, after having once felt this, the spirit or emotional life of the animal undergoes a complete and sudden change, so that from having been 'wild' it becomes 'tame.' In some cases there are subsequent relapses, but these are easily checked. Even the truly 'wild' horse from the prairie admits of being completely subdued in a marvellously short time by the Gauchos, who employ an essentially similar method, although the struggle is here much more fierce and prolonged.1 The same may be said of the taming of wild elephants, although in this case the facts are not nearly so remarkable from a psychological point of view, seeing that the process of taming is so much more slow.

Another curious emotional feature in the horse is the liability of all the other mental faculties of the animal to become abandoned to that of terror. For I think I am right in saying that the horse is the only animal which, under the influence of fear, loses the possession of every other sense in one mad and mastering desire to run. With its entire mental life thus overwhelmed by the flood of a single emotion, the horse not only loses, as other animals lose, 'presence of mind,' or a due balance among the distinctively intellectual faculties, but even the avenues of special sense become stopped, so that the wholly demented animal may run headlong and at terrific speed against a stone wall. I have known a hare come to grief in a somewhat similar fashion when hotly pursued by a dog; this, however, was clearly owing to the hare looking behind instead of before, in a manner not, under the circumstances, unwise; but, as I have said, there is no animal except the horse whose whole psychology is thus liable to be completely dominated by a single emotion.

As for its other emotions, the horse is certainly an affectionate animal, pleased at being petted, jealous of

^{&#}x27; See Mr. Darwin's account in Naturalist's Voyage round the World, pp. 151-2.

companions receiving favour, greatly enjoying play with others of its kind, and also the sport of the hunting-field. Lastly, horses exhibit pride in a marked degree, as do also mules. Such animals, when well kept, are unmistakably pleased with gay trappings, so that 'in Spain, as a punishment for disobedience, it is usual to strip the animal of its gaudy coronal and bells, and to transfer them to another' (Thompson).

The memory of the horse is remarkably good, as almost every one must have had occasion to observe who has driven one over roads which the animal may have only once traversed a long time before. As showing the duration of memory I may quote the following letter to Mr. Darwin from the Rev. Rowland H. Wedgwood, which

I find among the MSS. of the former:—

I want to tell you of an instance of long memory in a horse. I have just driven my pony down from London here, and though she has not been here for eight years, she remembered her way quite well, and made a bolt for the stables where I used to keep her.

A few instances of the display of intelligence by members of the horse tribe may bring this section to a close.

Mr. W. J. Fleming writes me concerning a vicious horse he had which, while being groomed, frequently used to throw a ball of wood attached to his halter at the groom. He did so by flexing his fetlock and jamming the ball between the pastern and the leg, then throwing the ball

backwards 'with great force.'

I myself had a horse which was very clever at slipping his halter after he knew that the coachman was in bed. He would then draw out the two sticks in the pipe of the oat-bin, so as to let all the oats run down from the bin above upon the stable floor. Of course he must have observed that this was the manner in which the coachman obtained the oats, and desiring to obtain them, did what he had observed to be required. Similarly, on other occasions he used to turn the water-tap to obtain a drink, and pull the window cord to open the window on hot nights.

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The anecdote books contain several stories very much alike concerning horses spontaneously visiting blacksmiths' shops when they require shoeing, or feel their shoes uncomfortable. The appended account, vouched for as it is by a good authority, may be taken as corroborative of these stories. I quote the account from 'Nature' (May 19, 1881):—

The following instance of animal intelligence is sent to us by Dr. John Rae, F.R.S., who states that the Mr. William Sinclair mentioned is respectable and trustworthy. The anecdote is taken from the 'Orkney Herald' of May 11:-"A wellauthenticated and extraordinary case of the sagacity of the Shetland pony has just come under our notice. A year or two ago Mr. William Sinclair, pupil-teacher, Holm, imported one of these little animals from Shetland on which to ride to and from school, his residence being at a considerable distance from the school buildings. Up to that time the animal had been unshod, but some time afterwards Mr. Sinclair had it shod by Mr. Pratt, the parish blacksmith. The other day Mr. Pratt, whose smithy is a long distance from Mr. Sinclair's house, saw the pony, without halter or anything upon it, walking up to Thinking the animal had strayed from where he was working. home, he drove it off, throwing stones after the beast to make it run homewards. This had the desired effect for a short time; but Mr. Pratt had only got fairly at work once more in the smithy when the pony's head again made its appearance at the door. On proceeding a second time outside to drive the pony away, Mr. Pratt, with a blacksmith's instinct, took a look at the pony's feet, when he observed that one of its shoes had Having made a shoe he put it on, and then waited to see what the animal would do. For a moment it looked at the blacksmith as if asking whether he was done, then pawed once or twice to see if the newly-shod foot was comfortable, and finally gave a pleased neigh, erected its head, and started homewards at a brisk trot. The owner was also exceedingly surprised to find the animal at home completely shod the same evening, and it was only on calling at the smithy some days afterwards that he learned the full extent of his pony's sagacity.

In 'Nature,' also (vol. xx., p. 21), Mr. Claypole, of Antioch Cottage, Ohio, writes as follows:—

A friend of mine is employed on a farm near Toronto, Ontario, where a horse, belonging to the wife of the farmer is

never required to work, but is allowed to live the life of a gentleman, for the following reason. Some years ago the lady above mentioned fell off a plank bridge into a stream when the water was deep. The horse, which was feeding in a field close by, ran to the spot, and held her up with his teeth till assistance arrived, thus probably saving her life. Was this reason or instinct?

Mr. Strickland, also writing to 'Nature' (vol. xix., p. 410), says:—

A mare here had her first foal when she was ten or twelve years old. She was blind of one eye. The result was, she frequently trod upon the foal or knocked it over when it happened to be on the blind side of her, in consequence of which the foal died when it was three or four months old. The next year she had another foal, and we fully expected the result would be the same. But no; from the day it was born she never moved in the stall without looking round to see where the foal was, and she never trod upon it or injured it in any way. You see that reason did not teach her that she was killing her first foal; her care for the second was the result of memory, imagination, and thought after the foal was dead, and before the next one was born. The only difference that I can see between the reasoning power of men and animals is that the latter is applied only to the very limited space of providing for their bodily wants, whereas that of men embraces a vast amount of other objects besides this.

Houzeau (vol. ii., p. 207) says that the mules used in the tramways at New Orleans prove that they are able to count five; for they have to make five journeys from one end of the tramway to the other before they are released, and they make four of these journeys without showing that they expect to be released, but bray at the end of the fifth. This observation, however, requires to be confirmed, for unless carefully made we must suppose that the fact may be due to the mules seeing the ostler waiting to take them out.

Mr. Samuel Goodbehere, solicitor, writes me from Birmingham the following instance as having fallen under his own observation:—

We had a Welsh cob pony or Galloway about 14 hands high, who was occasionally kept in a shed (in a farmyard),

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y about 14 hands (in a farm**y**ard), partly closed at the front by a gate which was secured by a bolt inside and a drop latch outside. The pony (who was able to put his head and neck over the gate, but could not reach the outside latch) was constantly found loose in the yard, which was considered quite a mystery until it was solved one day by my observing the pony first pushing back the inside bolt, and then neighing until a donkey, who had the run of the yard and an adjoining paddock, came and pushed up the outside latch with his nose, thus letting the pony at liberty, when the two marched off together.

The following is the only instance that I have met with in any of the horse tribe of that degree of sagacity which leads to the intentional concealment of wrong-doing. In the case of elephants, dogs, and monkeys we find abundant evidence on this head, which therefore renders the following instance more antecedently credible, and, as it is also narrated on good authority, I do not hesitate to quote it.

Professor Niphon, of Washington University, St. Louis, U.S., says:—

A friend of mine living at Iowa City had a mule, whose ingenuity in getting into mischief was more than ordinarily remarkable. This animal had a great liking for the company of an oat-bin, and lost no opportunity, when the yard gate and barn door were open, to secure a mouthful of oats. Finally the mule was found in the barn in the morning, and for a long time it was found impossible to discover how he had come there. This went on for some time, until the animal was 'caught in the act.' It was found that he had learned how to open the gate, reaching over the fence to lift the latch, and that he then effectually mystified his masters by turning round and backing against it until it was latched. He then proceeded to the barn door, and pulling out the pin which held the door, it swung open of its own accord. From the intelligence which this animal displayed on many occasions, I am of the opinion that had not discovery of his trick prevented, it would soon have occurred to him to retrace his steps before daylight, in order to avoid the clubbing which the stable boys gave him in the It may be added that this animal had enjoyed no unusual educational advantages, and his owners found it to their interest to discourage his intellectual efforts as much as possible.

¹ Nature, vol. xx., p. 21.

Ruminants.

Concerning sympathy, Major-General Sir George Le Grand Jacob, C.B., &c., writes me of instances which he observed of doe ibexes raising with their heads the bucks which he shot, and supporting them during flight.

A vivid and intelligent class of emotions, in which sympathy and rational fear are blended, seem to be exhibited by cattle in slaughterhouses. Many years ago a pamphlet was written upon the subject, and more recently Mr. Robert Hamilton, F.C.S., without apparently knowing of this previous publication, wrote another pamphlet, conveying precisely similar statements. These are too long to quote in extenso; but from a letter which the latter gentleman writes to me I may make the following extract:—

The animal witnessing the process of killing, flaying, &c., repeated on one after another of its fellows, gets to comprehend to the full extent the dreadful ordeal, and as it mentally grasps the meaning of it all, the increasing horror depicted in its condition can be clearly seen. Of course some portray it much more vividly than others; the varying intelligence manifested in this respect is only another link which knits them in oneness with the human family.

Pride is well marked in sheep and cattle, as shown by the depressing effects produced on a 'bell-wether' or leading cow by transferring the bell to another member of the herd; and it is said that in Switzerland the beasts which on show days are provided with garlands, are evidently aware of the distinction thus placed upon them. With some amount of poetic exaggeration this fact is noted by Schiller, who says in 'Wilhelm Tell,'—

See with what pride your steer his garland wears; He knows himself the leader of the herd; But strip him of it, and he'd die of grief.

With regard to the general intelligence of ruminants I may first quote the following:—

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The buffalo of the Old World manifests sagacity very similar. As Sir J. E. Tennent informs us,—

The temper of the wild buffalo is morose and uncertain; and such is its strength and courage, that in the Hindu epic of the 'Ramayana' its onslaught is compared with that of the tiger. It is never quite safe to approach them if disturbed in their pasture, or alarmed from their repose in the shallow lakes. On such occasions they hurry into line, draw up in defensive array, with a few of the oldest bulls in advance; and, wheeling in circles, their horns clashing with a loud sound as they clank them together in their rapid evolutions, they prepare for attack: but generally, after a menacing display, the herd betake themselves to flight; then forming again at a safer distance, they halt as before, elevating their nostrils, and throwing back their heads to take a defiant survey of the intruders.²

When tamed this animal is used for sporting purposes in a manner which displays the spirit of curiosity of deer, hogs, and other animals. Thus, Sir J. E. Tennent continues:—

A bell is attached to its neck, and a box or basket with one side open is securely strapped on its back. This at night is lighted with flambeaux of wax, and the buffalo bearing it is slowly driven into the jungle. The huntsmen with their fowling-pieces keep close under the darkened side, and as it moves slowly onwards, the wild animals, startled by the sound and bewildered by the light, steal cautiously towards it in stupefied fascination. Even the snake, I am assured, will be attracted by this extraordinary object; and the leopard, too, falls a victim to curiosity.³

Livingstone says of the African buffalo, that he has known the animal, when pursued by hunters, to 'turn back to a point a few yards from its own trail, and then lie down in a hollow for the hunter to come up,'—a fact

³ Ibid., p. 56.

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¹ Thompson, Passions of Animals, p. 308

² Natural History of Ceylon, p. 54.

which displays a level of intelligence in this animal surpassing that which is met with in most Carnivora.

Livingstone also says:-

It is curious to observe the intelligence of game; in districts where they are much annoyed by fire-arms they keep out on the most open spots of country they can find, in order to have a widely extended range of vision, and a man armed is carefully shunned. . . . But here, where they are killed by the arrows of the Balonda, they select for safety the densest forest, where the arrow cannot be easily shot.²

Jesse, who had many opportunities of observing the fact, says:—

I have been much delighted with watching the manner in which some of the old bucks in Bushey Park continue to get the berries from the fine thorn trees there. They will raise themselves on their hind legs, give a spring, entangle their horns in the lower branches of the tree, give them one or two shakes, and they will then quietly pick them up.³

The same author elsewhere says:—

Few things, indeed, can show more forcibly the powerful instinct which is implanted in animals for their self-preservation than the means which they take to avoid danger. I saw an instance of this lately in a stag. It had been turned out before a pack of hounds, and, when somewhat pressed by them, I observed it twice to go amongst a flock of sheep, and in both cases to double back, evidently, I should imagine, with the intention of baffling the pursuit of the dogs. It would thus seem that the animal was aware of its being followed by the scent, and not by sight. If this be the case, it affords another proof that animals are possessed of something more than common instinct.

This author also says that he has 'frequently observed the buffalo at the Zoological Farm on Kingston Hill' display the following proof of intelligence. Being of a ferocious disposition, a strong iron ring was fixed through the septum of his nose, to which a chain about two feet long was attached. At the free end of the chain there was another ring about four inches in diameter. 'In grazing the buffalo must have put his feet on this ring,

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¹ Missionary Travels, p. 328.

³ Gleanings, &c., vol. i., p. 20.

² *Ibid.*, p. 280.

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feet on this ring,

id., p. 280. id., vol. ii., p. 20. and in raising his head the jerk would have produced considerable pain. In order to avoid this the animal has the sense to put his horn through the lower ring, and thus avoid the inconvenience he is put to. I have seen him do this in a very deliberate manner, putting his head on one side while he got his horn through the ring, and then shaking his head till the ring rested at the bottom of the horn.'

The following is quoted from Mrs. Lee's 'Anecdotes' (p. 366), and is rendered credible not only because her own observations are generally good, but also because we shall subsequently find unquestionable evidence of the display of similar intelligence by cats:—

A goat and her kids frequented a square in which I once lived, and were often fed by myself and servants—a circumstance which would have made no impression, had I not heard a thumping at the hall door, which arose from the buttings of the goat when the food was not forthcoming, and whose example was followed by the two little things. After a time this remained unheeded, and, to our great astonishment, one day the area bell used by the tradespeople, the wire of which passed by the side of one of the railings, was sounded. The cook answered it, but no one was there save the goat and kids, with their heads bent down towards the kitchen window. It was thought that some boy had rung for them; but they were watched, and the old goat was seen to hook one of her horns into the wire and pull it. This is too much like reason to be ascribed to mere instinct.

P. Wakefield, in his 'Instinct Displayed,' 2 gives two separate cases of an intelligent manœuvre performed by goats. On both occasions two goats met on a ridge of rock with a precipice on each side, and too narrow to admit of their passing one another. One of these cases occurred on the ramparts of Plymouth Citadel, and was witnessed by 'many persons;' the other took place at Ardenglass, in Ireland. 'In both these instances the minals looked at each other for some time, as if they were considering their situation, and deliberating what has best to be done in the emergency.' In each case one of the goats then 'knelt down with great caution, and

¹ *Ibid.*, pp. 226-7.

² Pp. 66 and 97.

crouched as close as it could lie, when the other walked over its back.' This manœuvre on the part of goats has also been recorded by other writers, and is not so incredible as it may at first sight appear, if we remember that in their wild state these animals must not unfrequently find themselves in this predicament.

Mr. W. Forster, writing from Australia, gives me the following account of the intelligence of a bull:—

A rather tame bull, bred of a milch cow, used to puzzle me by being found inside a paddock used for cultivation, and enclosed by a two-railed fence, of which the lower rail was unusually high. At last I saw the animal lie down close to the fence, and roll over on his back, with four legs in the air, by which proceeding he was inside the paddock. I never knew another beast perform this feat; and although it must have been often done in the presence of a number of cows, not one of them ever imitated it, though they would all have unquestionably followed the bull through an opening in the fence, or by the slip-rails.

Mr. G. S. Erb, writing from Salt Lake City, gives me an interesting account of the sagacity displayed by the wild deer of the United States in avoiding gun-traps, which, except for the cutting of the string, to which the teeth of the animal are not so well adapted, is strikingly similar to the sagacity which we shall see to be displayed in this respect by sundry species of Carnivora. He says:—

My method was this: I would fell or cut down a maple tree, the top of which they are very partial to; and as the ground was invariably covered with snow to the depth of 12 inches, food was scarce, and the deer would come and browse, probably from hearing the tree fall. I would place a loaded gun 20 fee from the top of the tree at which it was pointing; I would attach a line the size of an ordinary fish-line to a lever that pressed against the trigger; the other end of the line I would fasten to the tree-top. By this means the deer could not pas between the tree and the gun without getting shot, or at less shot at; but I never succeeded in killing one when my line was large as a fish-line, i.e. about one-sixteenth of an inch in thick ness. Commencing at the body of the tree on one side, the dee would eat all the tops to within 12 inches of the line, and the go around the gun and eat all on the other side, never touching

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the line. I tried this at least sixty times, always with the same result. Then I took a black linen thread, and had no difficulty in killing them, as it was so small and black that they could not distinguish it.

Pigs.

There can be no doubt that pigs exhibit a degree of intelligence which falls short only of that of the most intelligent Carnivora. The tricks taught the so-called learned pigs' would alone suffice to show this; while the marvellous skill with which swine sometimes open latches and fastenings of gates, &c., is only equalled by that of the cat. The following account of pigs in their wild state shows that they manifest the same kind of sagacious co-operation in facing an enemy as that which we have just seen to be manifested by the bison and the buffalo, although here it seems to be displayed in a manner still more organised:—

Wild swine associate in herds and defend themselves in common. Green relates that in the wilds of Vermont a person fell in with a large herd in a state of extraordinary restlessness; they hd formed a circle with their heads outwards, and the young ones placed in the middle. A wolf was using every artifice to map one, and on his return he found the herd scattered, but the wolf was dead and completely ripped up. Schmarda recounts an almost similar encounter between a herd of tame swine and a wolf, which he witnessed on the military positions of Croatia. He says that the swine, seeing two wolves, formed themselves into a wedge, and approached the wolves slowly, grunting and recting their bristles. One wolf fled, but the other leaped n to the trunk of a tree. As soon as the swine reached it hey surrounded it with one accord, when, suddenly and instanmeously, as the wolf attempted to leap over them, they got im down and destroyed him in a moment.

¹ Thompson, Passions of Animals, p. 308.

night, and in a few more weeks it also learnt to retrieve. Her scent was exceedingly good, and she stood well at partridges, black game, pheasants, snipes, and rabbits, but never pointed hares. She was more useful than a dog, and afterwards became the property of Sir Henry Mildmay. According to Youatt, Colonel Thornton also had a sow similarly trained. The same author says that a sow belonging to Mr. Craven had a litter of pigs, one of which. when old enough, was taken and roasted, then a second These were necessarily taken when the mother returned in the evening from the woods for supper. But the next time she came she was alone, and, 'as her owners were anxious to know what was become of her brood, she was watched on the following evening, and observed driving back her pigs at the extremity of the wood, with much earnest grunting, while she went off to the house, leaving them to wait for her return. It was evident that she had noticed the diminution of her family and had adopted this method to save those that re mained.'2

Mr. Stephen Harding sends me the following as a observation of his own:—

On the 15th ult. (Nov. 1879) I saw an intelligent sow pi about twelve months old, running in an orchard, going to a youn apple tree and shaking it, pricking up her ears at the sam time, as if to listen to hear the apples fall. She then picke the apples up and ate them. After they were all down she shook the tree again and listened, but as there were no more to fall she went away.

The proverbial indifference to dirt attributed to the pig seems scarcely to be justified; the worst that can be said is that the animal prefers cool mud to dry heat, and the filth which swine often exhibit in their sty is the fault of the farmers rather than of the animals. Of the quote from Thompson's 'Passions,'—

A washed sow in the hot season of our temperate clima and in almost every season of such a climate as that of Pale tine, 'returns to her wallowing in the mire' simply becaushe feels scorched, and blistered, and sickened under the ards sunshing is due to all the shelter

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sunshine; and hence, when she receives from man the aid which is due to her as a domesticated animal, she demands not dirtall the year through, nor any day at all, but shade in summer, shelter in winter, and a clean, dry bed in every season.

Cheiroptera.

Mr. Bates says of bats: 'The fact of their sucking the blood of persons sleeping is now well established; but it is only a few persons who are subject to this bloodletting.
... I am inclined to think many different kinds of bats have this propensity' ('Nat. on Amaz.,' p. 91). The particular species of bat, however, which has been most universally accredited with this habit, viz., the vampire, is perfectly harmless.

Mr. G. Clark ('A Brief Notice of the Fauna of Mauritius') gives an account of the intelligence displayed by a tame bat (*Pteropus vulgaris*). As soon as its master came into the room, it welcomed him with cries; and if not at once taken up to be petted, it climbed up his dress, rubbed its head against him, and licked his hands. If Mr. Clark took anything in his hand, the bat would carefully examine it by sight and smell, and when he sat down the bat would hang upon the back of his chair, following all his movements with its eyes.

Carnivora.

I shall here run together a few facts relating to the intelligence of carnivorous animals other than those to be

considered in subsequent chapters.

Seals.—In their wild state these animals have not much opportunity for the display of intelligence; but when tamed it is seen that the latter is considerable. They are then affectionate animals, liking to be petted, and showing attachment to their homes. The most emarkable species of the order from a psychological point of view are the so-called Pinnipeds, whose habits during the breeding season are so peculiar that I think it is sorth while to quote the best account that has hitherto

2 Ibid.

been published on the subject. This is the elaborate work of Mr. Joel Asaph Allen: 1—

From the time of the first arrivals in May up to the 1st of June, as late as the middle of this month if the weather be clear, is an interval in which everything seems quiet; very few seals are added to the pioneers. By the 1st of June, however, or thereabouts, the foggy, humid weather of summer sets in, and with it the bull-seals come up by hundreds and thousands, and locate themselves in advantageous positions for the reception of the females, which are from three weeks to a month later, as a rule. The labour of locating and maintaining a position in the rookery is really a serious business for those bulls which come in last, and for those that occupy the water-line, frequently resulting in death from severe wounds in combat sustained. It appears to be a well-understood principle among the able-bodied bulls that each one shall remain undisturbed on his ground, which is usually about ten feet square, provided he is strong enough to hold it against all comers; for the crowding in of fresh bulls often causes the removal of those who, though equally able. bodied at first, have exhausted themselves by fighting earlier. and are driven by the fresher animals back further and higher Some of these bulls show wonderful up on the rookery. strength and courage. I have marked one veteran, who was among the first to take up his position, and that one on the water-line, when at least fifty or sixty desperate battles were fought victoriously by him with nearly as many different seals who coveted his position; and when the fighting season was over (after the cows have mostly all hauled up) I saw him covered with scars and gashes, raw and bloody, an eye gouged out, but holding it bravely over his harem of fifteen or twenty cows, all huddled together on the same spot he had first chosen The fighting is mostly or entirely done with the mouth, the opponents seizing each other with the teeth and clenching the jaws; nothing but sheer strength can shake them loose, and that effort almost always leaves an ugly wound, the sharp caning tearing out deep gutters in the skin and blubber, or shredding the flippers into ribbon-strips. They usually approach ead other with averted heads and a great many false passes before either one or the other takes the initiative by gripping; the heads are darted out and back as quick as flash, their hoars roaring and shrill piping whistle never ceases, while their fa

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History of the North American Pinnipeds. The quotations at taken from pp. 348 to 361.

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bodies writhe and swell with exertion and rage, fur flying in air and blood streaming down—all combined make a picture fierce and savage enough, and, from its great novelty, exceedingly strange at first sight. In these battles the parties are always distinct, the offensive and the defensive; if the latter proves the weaker he withdraws from the position occupied, and is never followed by his conqueror, who complacently throws up one of his hind flippers, fans himself, as it were, to cool himself from the heat of the conflict, uttering a peculiar chuckle of satisfaction and contempt, with a sharp eye open for the next covetous bull or 'sea-catch' (native name for the bulls on the rookeries, especially those which are able to maintain their position).

All the bulls, from the very first, that have been able to hold their positions have not left them for an instant, night or day; nor do they do so until the end of the rutting season, which subsides entirely between the 1st and 10th of August, beginning shortly after the coming of the cows in June. Of necessity, therefore, this causes them to fast, to abstain entirely from food of any kind, or water for at least three months; and a few of them stay four months before going into the water for the first time after hauling up in May. This alone is remarkable enough, but it is simply wonderful when we come to associate the condition with unceasing activity, restlessness, and duty devolved upon the bulls as heads and fathers of large families. They do not stagnate like bears in caves; it is evidently accomplished or due to the absorption of their own fat, with which they are so liberally supplied when they take their positions on the breeding-ground, and which gradually diminishes while they remain on it.

They are noticed and received by the bulls on the water-line station with much attention; they are alternately coaxed and urged up on the rocks, and are immediately under the most jealous supervision; but owing to the covetous and ambitious nature of the bulls which occupy the stations reaching some way back from the water-line, the little cows have a rough-and-tumble time of it when they begin to arrive in small numbers at first; for no sooner is the pretty animal fairly established on the station of bull No. 1 who has installed her there, than he perhaps sees another one of her style down in the water from which she has just come, and in obedience to his polygamous feling, he devotes himself anew to coaxing the later arrival in the same winning manner so successful in her case, when bull

No. 2. seeing bull No. 1 off his guard, reaches out his long strong neck, and picks the unhappy but passive creature up by the scruff of hers, just as a cat does a kitten, and deposits her on his seraglio-ground; then bulls Nos. 3, 4, 5, and so on in the vicinity, seeing this high-handed operation, all assail one another, and especially bull No. 2, and have a tremendous fight perhaps for half a minute or so; and during this commotion the cow is generally moved or moves farther back from the water two or three stations more, where, when all gets quiet, she usually remains in peace. Her late lord and master, not having the exposure to such diverting temptation as had her first, gives her such care that she not only is unable to leave did she wish, but no other bull can seize upon her. This is only one instance of the many different trials and tribulations which both parties on the rookery subject themselves to before the harems are filled. Far back, fifteen or twenty stations deep from the water-line sometimes, but generally not more than, on an average, ten or fifteen, the cows crowd in at the close of the season for arriving, July 10 to 14, and then they are able to go about pretty much as they please, for the bulls have become greatly enfeebled by this constant fighting and excitement during the past two months, and are quite content with even only one or two partners.

I have found it difficult to ascertain the average number of cows to one bull on the rookery, but I think it will be nearly correct to assign to each male from twelve to fifteen females occupying the stations nearest the water, those back in the rear from five to nine. I have counted forty-five cows all under the charge of one bull, which had them penned up on a flat table rock near Kestaire Point; the bull was enabled to do this quite easily, as there was but one way to go to or come from this seraglio, and on this path the old Turk took his stand and guarded it well. At the rear of all these rookeries there is always a large number of able-bodied bulls, who wait patiently, but in vain, for families, most of them having had to fight as desperately for the privilege of being there as any of their more fortunately located neighbours, who are nearer the water than themselves; but the cows do not like to be in any outside position, when they are not in close company lying most quiet and content in the largest harems; and these large families pack the surface of the ground so thickly that there is hardly moving or turning room until the females cease to come up from the sea; but the inaction on the part of the bulls in the rear during the

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This courage is all the more noteworthy from the fact that, in regard to man, it is invariably of a defensive character. The seal, if it makes you turn when you attack it, never follows you much farther than the boundary of its station, and no aggravation will compel it to become offensive, as far as I have been

able to observe.

The apathy with which the young are treated by the old on the breeding-grounds is somewhat strange. I have never seen a cow caress or fondle her offspring, and should it stray but a short distance from the harem, it can be picked up and killed before the mother's eyes, without causing her to show the slightest concern. The same indifference is exhibited by the bull to all that takes place outside of the boundary of his seraglio. While the pups are, however, within the limits of his harem-ground he is a jealous and fearless protector; but if the little animals pass beyond this boundary, then they may be

carried off without the slightest attention in their behalf from their guardian.

Early in August (8th) the pups that are nearest the water on the rookeries essay swimming, but make slow and clumsy progress, floundering about, when over head in depth, in the most awkward manner, thrashing the water with their fore-flippers, not using the hinder ones. In a few seconds, or a minute at the most, the youngest is so wary that he crawls out upon the rocks or beach, and immediately takes a recuperative nap, repeating the lesson as quick as he awakes and is rested. They soon get familiar with the water and delight in it, swimming in endless evolutions, twisting, turning, diving; and when exhausted, they draw up on the beach again, shake themselves as young dogs do, either going to sleep on the spot, or having a lazy frolic among themselves.

In this matter of learning to swim, I have not seen any 'driving' of the young pups into the water by the old in order to teach them this process, as has been affirmed by writers on

the subject of seal life.

Otter.—The fact that otters admit of being taught to catch fish and bring them to their masters, shows no small degree of docility on the part of these animals. 'I have seen,' says Dr. Goldsmith, 'an otter go to a gentleman's pond at word of command, drive the fish into a corner, and, seizing upon the largest of the whole, bring it off in his mouth to his master.' And several other cases

of the same kind are given by Bingley.1

Weasel.—'Mdlle. de Faister described her tame weasel to Buffon as playing with her fingers like a kitten, jumping on her head and neck; and if she presented her hands at the distance of three feet, it jumped into them without ever missing. It distinguished her voice amidst twenty people, and sprang over everybody to get at her. She found it impossible to open a drawer or a box, or even to look at a paper, without his examining it also. If she took up a paper or book, and looked attentively at it, the weasel immediately ran upon her hand, and surveyed with an inquisitive air whatever she happened to hold.' ²

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¹ Animal Biography, vol. iii., pp. 301-2. ² Thompson, Passions in Animals, p. 337.

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1-2. 337. Polecat.—Professor Alison, in his article on 'Instinct,' in Todd's 'Cyclopædia of Anatomy,' quotes the following account from the 'Magazine of Natural History' (vol. iv., p. 206) touching a remarkable instinct manifested by polecats. 'I dug out five young polecats, comfortably embedded in dry, withered grass; and in a side hole, of proper dimensions for such a larder, I picked out forty large frogs and two toads, all alive, but merely capable of sprawling a little. On examination, I found that the whole number, toads and all, had been purposely and dexterously bitten through the brain.' The analogy of this instinct to that which has already been mentioned as having been much more recently observed by M. Fabre in the sphex insect is noteworthy.

Ferret.—I once kept a ferret as a domestic pet. He was a very large specimen, and my sister taught him a number of tricks, such as begging for food (which he did quite as well and patiently as any terrier), leaping over sticks, &c. He became a very affectionate animal, delighting much in being petted, and following like a dog when taken out for walk. He would, however, only follow those persons whom he well knew. That his memory was exceedingly good was shown by the fact that after an absence of many months, during which he was never required to beg, or to perform any of his tricks, he went through all his paces perfectly the first time that we again tried him.

I strongly suspect that ferrets dream, as I have frequently seen them when fast asleep moving their noses and twitching their claws as if in pursuit of rabbits. Another fact I may mention as bearing on the intelligence of these animals. On one occasion, while ferreting rabbits, I lost the ferret about a mile away from home. Some days afterwards the animal returned to his home. Similar cases have been communicated to me by several sporting friends, but certainly the return of a ferret under such circumstances is the exception, and not the rule.

Wolverine.—Amazing tales are told concerning the intelligence of this animal, which for the most part are certainly exaggerations. Still there is no doubt that the creature does display a degree of sagacious cunning unsur-

passed, if not unequalled, in the animal kingdom. This may be shown by the two following quotations from the statements of trustworthy writers. The first is a letter kindly sent me by Dr. J. Rae, F.R.S., in reply to my request for information concerning the intelligence of this animal:—

The narratives of most travellers in America tell wonderful stories of the glutton or wolverine, but I do not know that any of my experiences of this extremely acute animal indicate what I call reasoning powers. They are very suspicious, and can seldom or never be taken with poisoned bait, trap, or gun. The poisoned baits are usually found broken up, but not eaten by them; traps are destroyed or entered, but not where the trapper desired; and guns, except when concealed after the Eskimo

fashion by a covering of snow, are avoided.

In 1853, on the Arctic coast, when about to change our domicile from a tent to the warmer snow hut, my man had carried over about 100 lbs. or more of fine venison steaks to the snow houses about a quarter of a mile from our tents; and as there were at the time no traces either of foxes, wolves, or wolverines about, the meat was placed overnight in one of the huts, and the door left open. During the night two wolverines came, but, evidently dreading some trap or danger in the open door, would not enter that way, but cut a hole for themselves through the wall of the snow hut, and carried off all our fine steaks, a considerable quantity of which was picked up close to our house when the thaw took place in the spring, it having been hid in the snow, but completely spoilt for use, by a well-known filthy habit.

Dr. Rae has also drawn my attention to the following account contained in the Miscellaneous Publications of the Geological Survey of the United States.¹ The writer of this account is Captain Elliot Cones:—

To the trapper the wolverines are equally annoying. When they have discovered a line of marten traps they will never abandon the road, and must be killed before the trapping can be successfully carried on. Beginning at one end, they proceed from trap to trap along the whole line, pulling them successively to pieces, and taking out the baits from behind. When they can eat no more, they continue to steal the baits and câche

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¹ Vol. viii., Washington, 1877: 'A Monograph of the North American Mustelidæ.'

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If hungry they may devour two or three of the martens they find captured, the remainder being carried off and hidden in the snow at a considerable distance. The work of demoli-

tion goes on as fast as the traps can be renewed.

The propensity to steal and hide things is one of the strongest traits of the wolverine. To such an extent is it developed that the animal will often secrete articles of no possible use to itself. Besides the wanton destruction of marten traps, it will carry off the sticks and hide them at a distance, apparently in sheer malice. Mr. Ross, in the article above quoted, has given an amusing instance of the extreme of this propensity. The desire for accumulating property seems so deeply implanted in this animal, that, like tame ravens, it does not appear to care much what it steals so that it can exercise its favourite propensity to commit mischief. An instance occurred within my own knowledge, in which a hunter and his family having left their lodge unguarded during their absence, on their return found it completely gutted—the walls were there, but nothing else. Blankets, guns, kettles, axes, cans, knives, and all the other paraphernalia of a trapper's tent had vanished, and the tracks left by the beast showed who had been the thief. The family set to work, and by carefully following up all his paths recovered, with some trifling exceptions, the whole of the lost property.

At Peel's River, on one occasion, a very old carcajou discovered my marten road, on which I had nearly a hundred and fifty traps. I was in the habit of visiting the line about once a fortnight, but the beast fell into the way of coming oftener than I did, to my great annoyance and vexation. I determined to put a stop to his thieving and his life together, cost what it might. So I made six strong traps at as many different points, and also set three steel traps. For three weeks I tried my best to catch the beast without success; and my worst enemy would allow that I am no green hand in these matters. The animal carefully avoided the traps set for his own benefit, and seemed to be taking more delight than ever in demolishing my marten traps and eating the martens, scattering the poles in every direction, and câching what baits or martens he did not devour on the spot. As we had no poison in those days, I next set a gun on the bank of a little lake. The gun was concealed in some low bushes, but the bait was so placed that the carcajou must see it on his way up the bank. I blockaded my path to the gun with a small pine tree, which completely hid it. On my first visit afterwards I found that the beast had gone up to the bait and smelled it, but had left it untouched. He had next pulled up the pine tree that blocked the path, and gone around the gun and cut the line which connected the bait with the trigger, just behind the muzzle. Then he had gone back and pulled the bait away, and carried it out on the lake, where he lay down and devoured it at his leisure. There I found my string. I could scarcely believe that all this had been done designedly, for it seemed that faculties fully on a par with human reason would be required for such an exploit if done intentionally. fore rearranged things, tying the string where it had been But the result was exactly the same for three successive occasions, as I could plainly see by the footprints; and what is most singular of all, each time the brute was careful to cut the line a little back of where it had been tied before, as if actually reasoning with himself that even the knots might be some new device of mine, and therefore a source of hidden danger he would prudently avoid. I came to the conclusion that that carcajou ought to live, as he must be something at least human, if not worse. I gave it up, and abandoned the road for a period.

With so much for the tricks and the manners of the beast behind our backs, roaming at will in his vast solitudes, what of his actions in the presence of man? It is said that if one only stands still, even in full view of an approaching carcajou, he will come within fifty or sixty yards, provided he be to windward, before he takes the alarm. Even then, if he be not warned by sense of smell, he seems in doubt, and will gaze earnestly several times before he finally concludes to take himself off. On these and similar occasions he has a singular habit—one not shared, so far as I am aware, by any other beast whatever. He sits on his haunches and shades his eyes with one of his fore-paws, just as a human being would do in scrutinising a dim or distant object. The carcajou, then, in addition to his other and varied accomplishments, is a perfect sceptic—to use this word in its original signification. A sceptic, with the Greeks, was simply one who would shade his eyes to see more clearly.

Bears.—There is no doubt that the intelligence of these animals stands very high in the psychological scale, although the actual instances which I have met of the display of their intelligence are few. The tricks which

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intelligence of chological scale, ave met of the he tricks which are taught performing bears do not count for much as proof of high sagacity, as they for the most part consist in teaching the animals to assume unnatural positions, or display grotesque antics—performances which speak indeed for the general docility of the creatures, but scarcely for their high intelligence. Still even here it is worth while to remark that all species of bears would prohably not lend themselves to this kind of education, for the emotional temperament manifested by the different species is unquestionably diverse. Thus, making all allowances for exaggeration, it seems certain that the grizzly bear displays a courage and ferocity which are foreign to the disposition of the brown bear, and indeed to that of most other animals. The polar bear likewise displays much bravery under the influence of hunger or maternal feeling, although under other circumstances it usually deems discretion the better part of valour. following incident displays considerable intelligence on the part of this animal.

Scoresby, in his 'Account of the Arctic Regions,' gives

the instance to which I allude:—

The animal with two cubs was being pursued by a party of sailors over an ice-field. She urged her young to an increase of speed by running before them, turning round, and manifesting, by a peculiar action and voice, her anxiety for their progress; but finding that her pursuers were gaining upon them, she carried, or pushed, or pitched them alternately forward, until she effected their escape. In throwing them before her, the little creatures placed themselves across her path to receive the impulse; and when projected some yards in advance, they ran onwards until she overtook them, when they alternately adjusted themselves for a second throw.

As the polar bear is not exposed to any enemies except man, this method of escaping is not likely to be instinctive, but was probably an intelligent adaptation to the particular circumstances of the case.

Mr. S. J. Hutchinson writes me as follows with regard

to this same species:—

One Sunday, at the 'Zoo,' some one threw a bun to the bears, but it fell in the water in that quadrant-shaped pond you will

remember. The bun fell just at the angle, and the bear seemed disinclined to enter the water, but stood on the edge of the pond, and commenced stirring the water with its paw, so that it established a sort of rotatory current, which eventually brought the bun within reach. When one leg got tired it used the other, but in the same direction. I watched the whole performance with the greatest interest myself.

In corroboration of this most remarkable observation I quote the following from Mr. Darwin's 'Descent of Man' (p. 76), which is so precisely similar, that the fact of bears reaching the high level of intelligence which the fact implies can scarcely be doubted. 'A well-known entomologist, Mr. Westropp, informs me that he observed in Vienna a bear deliberately making with his paw a current in some water which was close to the bars of his cage, so as to draw a piece of floating bread within his reach.'

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CHAPTER XII.

RODENTS.

THE rodents, psychologically considered, are, of all orders in the animal kingdom, most remarkable for the differences presented by constituent species. For while the group contains many animals, such as the guinea-pig, whose instincts and intelligence cannot be said to rise above the lowest level that obtains among mammalian forms, it also contains other animals with instincts as remarkable as those of the squirrel, intelligence as considerable as that of the rat, and a psychological development as unique as that of the beaver. In no other group of animals do we meet with nearly so striking an exemplification of the truth that zoological or structural affinity is only related in a most loose and general way to psychological or mental similarity. Up to a certain point, however, even here we meet with an exemplification of what I may call a complementary truth, namely, that similarity of organisation and environment is in a general way related to similarity of instincts (though not necesarily of intelligence). This is obviously the case with the habit from which the order takes its name; for whether the instinct of gnawing is here the cause or the result of peculiar organisation, the instinct is unquestionably correlated with the peculiarity. And similarly, though less obviously, is this the case with the instinct of storing for winter consumption, which is more prevalent mong the rodents than in any other order of mammals ats, mice, squirrels, harvesters, beavers, &c., all maniesting it with remarkable vigour and persistency. Here e probably have a case of similar organisation and enronment determining the same instinct; for the latter is not of sufficiently general occurrence among all species of rodents to allow us to suppose that the species in which it does occur have derived it from a common ancestry.

Rabbit.

Rabbits are somewhat stupid animals, exhibiting but small resources under novel circumstances, although inheriting several clever instincts, such as that of rapidly deciding upon the alternative of flight or crouching, which is usually done with the best judgment. I have, however, often observed that the animal does not seem to have sense enough to regard the colour of the surface on which it crouches, so that if this happens to be inappropriate, the rabbit may become conspicuous, and so its crouching a source of danger. I have been particularly struck with the fact that black rabbits inherit the crouching instinct as strongly as do normally coloured ones, with the effect of rendering themselves highly conspicuous. This shows that the instinct is not necessarily correlated with the colour which alone renders the instinct useful, but that both have developed simultaneously and independently, and by natural selection. The fact also shows that the crouching of rabbits is purely instinctive, and not due to any conscious process of comparing their own colour with that of the surfaces on which they crouch. doubt the instinct began and was developed by natural selection placing a premium upon the better judgment of those individuals which know when best to seek safety in flight and when by crouching—protective colouring being added at the same time by the same agency.

Another fact, which every one who shoots must have observed, goes to show the stupidity of rabbits, or their inability to learn by experience. When alarmed they ru for their burrows, and when they reach them, instead of entering they very frequently squat down to watch th enemy. Now, although they well know the distance a which it is safe to allow a man with a gun to approach whit bolts excess of curiosity, or a mistaken feeling of security is self to be s being so near their homes, induces the animals to allow

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man to approach within easy shooting distance. Yet that in other respects rabbits can learn much by experience must be evident to all who are accustomed to shoot with ferrets. From burrows which have not been much ferreted, rabbits will bolt soon after the ferret is put in; but this is not the case where rabbits have had previous experience of the association between ferrets and sportsmen. Rather than bolt under such circumstances, and so face the known danger of the waiting gun, rabbits will often allow themselves to be torn with the ferrets' claws and mutilated by their teeth. This is the case, no matter how silently the sportsmen may conduct their operations; the mere fact of a ferret entering their burrows seems to be enough to assure the rabbits that sportsmen are waiting outside.

In its emotions the rabbit is for the most part a very timid animal, although the males fight severely with one another—having more strongly developed than any other animal the strange but effectual instinct of castrating their rivals. Moreover, even against other animals, rabbits will, when compelled to do so, stand upon the defensive. To show this I may quote a letter which several years ago I published in 'Nature:'

I have occasion just now to keep over thirty Himalayan abbits in an outhouse. A short time ago it was observed that some of these rabbits had been attacked and slightly bitten by natural ter judgment of to seek safety in the colouring being ause, found one rat dead, and another so much injured that it would scarcely run. Both rats were of an unusually large size, and their bodies were much mangled by the rabbits' teeth.

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w the distance a shift bolts and, seeing the sportsman, doubles back into its burrow, gun to approach sing of security is self to be slowly and painfully killed by the ferret rather than bolt a animals to allow billing image or idea in the mind of the animal.

It is evident that the show-fight instinct cannot have been developed in Himalayan rabbits by means of natural selection, but it is no less evident that if it ever arose in wild rabbits it would be preserved and intensified by such means.

The following observation of my own on a previously unnoticed instinct displayed by wild rabbits is, I think, of sufficient interest to render. Most people are aware that if a rabbit is shot near the mouth of its burrow, the animal will employ the last remnant of its life in struggling Having several times observed that wounded rabbits which had thus escaped appeared again several days afterwards above ground, lying dead a few feet from the mouth of the burrow, I wished to ascertain whether the wounded animals had themselves come out before dying, possibly for air, or had been taken out by their I therefore shot numerous rabbits while companions. they were sitting near their burrows, taking care that the distance between the gun and the animal should be such as to insure a speedy, though not an immediate death Having marked the burrows at which I shot rabbits in this manner I returned to them at intervals for a fortnight or more, and found that about one-half of the bodies appeared again on the surface in the way described That this reappearance above ground is not due to the victim's own exertions, I am now quite satisfied; for no only did two or three days generally elapse before the body thus showed itself—a period much too long for severely wounded rabbit to survive—but in a number of cases decomposition had set in. Indeed, on one occasion scarcely anything of the animal was left save the ski and bones. This was in a large warren.

It is a curious thing that I have hitherto been unable to get any bodies returned to the surface, of rabbit which I inserted into their burrows after death. I account for this by supposing that the stench of the decomposing carcass is not so intolerable to the other occupants of the burrow when it is near the orifice as it is when further in. Similarly, I find that there is not so good a chant of bodies being returned from an extensive warren intercommunicating holes, as there is from smaller was

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rens or blind holes; the reason probably being that in the one case the living inhabitants are free to vacate the offensive locality, while in the other case they are not so. Anyhow, there can be no reasonable doubt that the instinct of removing their dead has arisen in rabbits from the necessity of keeping their confined domiciles in a pure state.

Hare.

The hare is a more intelligent animal than the rabbit. Possibly its much greater powers of locomotion may be one cause of its mental superiority to its nearest congener. I have never myself observed a hare commit the mistake already mentioned in the case of the rabbit, viz., that of crouching for concealment upon an inappropriately coloured surface. But the best idea of the comparatively high intelligence of the hare will be gained by the following quotations. The first of these is taken from Loudoun's 'Magazine of Natural History' (vol. iv., p. 143):—

It is especially conscious of the scent left by its feet, and of the danger which threatens it in consequence; a reflection which implies as much knowledge of the habits of its enemies as of its own. When about to enter its seat for the purpose of rest, it leaps in various directions, and crosses and recrosses its path with repeated springs; and at last, by a leap of greater energy than it has yet used, it effects a lodgment in the selected spot, which is chosen rather to disarm suspicion than to protect it from injury. In the 'Manuel du Chasseur' some instances are quoted from an ancient volume on hunting by Jaques du Fouillouse. A hare intending to mislead its pursuers has been seen spontaneously to quit its seat and to proceed to a pond at the distance of nearly a mile, and having washed itself, push off again through a quantity of rushes. It has, too, been known, when pursued to fatigue by dogs, to thrust another hare from its seat and squat itself down in its place. This author has seen hares swim successively through two or three ponds, of which the smallest was eighty paces round. He has known it, after a long chase, to creep under the door of a sheep-house and rest among the cattle, and when the hounds were in pursuit, it would get into the middle of a flock of sheep and accompany them in all their motions round the field, refusing by any means to quit the shelter they afforded. The stratagem of its passing

forward on one side of a hedge and returning by the other, with only the breadth of the hedge between itself and its enemies, is of frequent occurrence, and it has even been known to select its seat close to the walls of a dog-kennel. This latter circumstance, however, is illustrative of the principles of reflection and reason. ing; for the fox, weasel, and polecat are to the hare more dangerous enemies than the hound; and the situations chosen were such as those ferocious creatures were not likely to approach. A gentleman was engaged in the amusement of coursing, when a hare, closely pressed, passed under a gate, while the dogs fol. lowed by leaping over it. The delay caused to her pursuers by this manœuvre seems to have taught a sudden and useful lesson to the persecuted creature; for as soon as the dogs had cleared the gate and overtaken her, she doubled and returned under the gate as before, the dogs again following and passing over it. And this flirtation continued backwards and forwards until the dogs were fairly tired of the amusement; when the hare, taking advantage of their fatigue, quietly stole away.

The following note, by Mr. Yarrell, is significant of a process of reasoning derived from observations of the course of nature, such as would do no discredit to a higher race of creatures:—

A harbour of great extent on our northern coast has an island near the middle of considerable size, the nearest point of which is a mile distant from the mainland at high water, and with which point there is frequent communication by a ferry. Early one morning in spring two hares were observed to come down from the hills of the mainland towards the sea-side; one of which from time to time left its companion, and proceeding to the very edge of the water, stopped there a minute or two. and then returned to its mate. The tide was rising, and after waiting some time, one of them, exactly at high water, took to the sea, and swam rapidly over, in a straight line, to the opposite projecting point of land. The observer on this occasion, who was near the spot, but remained unperceived by the hares, had no doubt they were of different sexes, and that it was the male (like another Leander) which swam across the water, as he had probably done many times before. It was remarkable that the hares had remained on the shore nearly half an hour; one of them occasionally examining, as it would seem, the state of the current, and ultimately taking to the sea at that precise period of the tide called slackwater, when the passage across could be effected without being carried by the force of the stream

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either above or below the desired point of landing. The other hare then cantered back to the hills. (Loudoun's 'Magazine of Natural History,' vol. v., p. 99.)

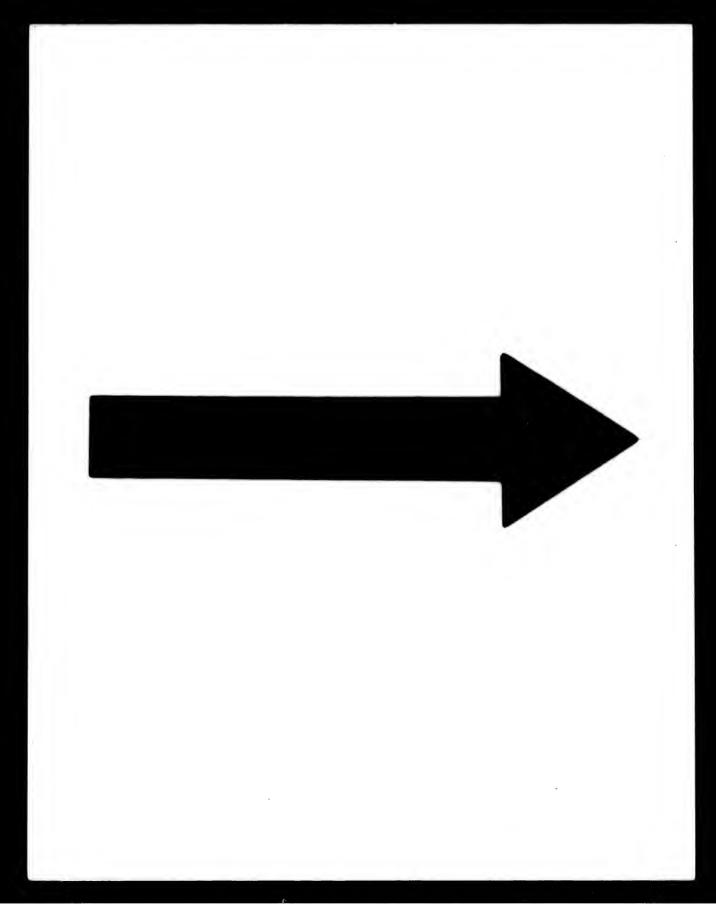
According to Couch ('Illustrations of Instinct,'p. 177)—

When followed by dogs, it will not run through a gate, though this is obviously the most ready passage; nor in crossing a hedge will it prefer a smooth and even part, but the roughest, where thorns and briars abound; and when it mounts an eminence it proceeds obliquely, and not straightforward. And whether we suppose these actions to proceed from a desire to avoid those places where traps may probably have been laid, or from knowing that his pursuers will exactly follow his footsteps, and he has resolved to lead them through as many obstacles as possible, in either case an estimation of causes and consequences is to be discovered.

It is a remarkable thing that both hares and rabbits should allow themselves to be overtaken in the open field by weasels. I have myself witnessed the process, and am at a loss to account for it. The hare or rabbit seems perfectly aware of the dangerous character of the weasel, and yet does not put forth its powers of escape. It merely toddles along with the weasel toddling behind, until tamely allowing itself to be overtaken. This anomalous case may perhaps be akin to the alleged phenomena of the fascination of birds and small rodents by snakes; but in any case there seems to have been here a remarkable failure of natural selection in doing duty to the instincts of these swift-footed animals.

We must not close this account of the intelligence of the hare genus without alluding to the classical case of Cowper's hares. The following abstract is taken from Tegg's edition of 'The Life and Works of William Cowper,' p. 633:—

Puss was ill three days, during which time I nursed him, kept him apart from his fellows, . . . and by constant care, &c., restored him to perfect health. No creature could be more grateful than my patient after his recovery, a sentiment which he most significantly expressed by licking my hand, first the back of it, then the palm, then every finger separately, then between all the fingers, as if anxious to leave no part of it un-



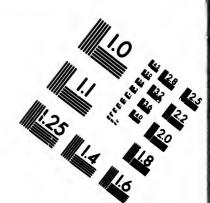
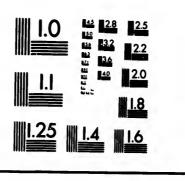


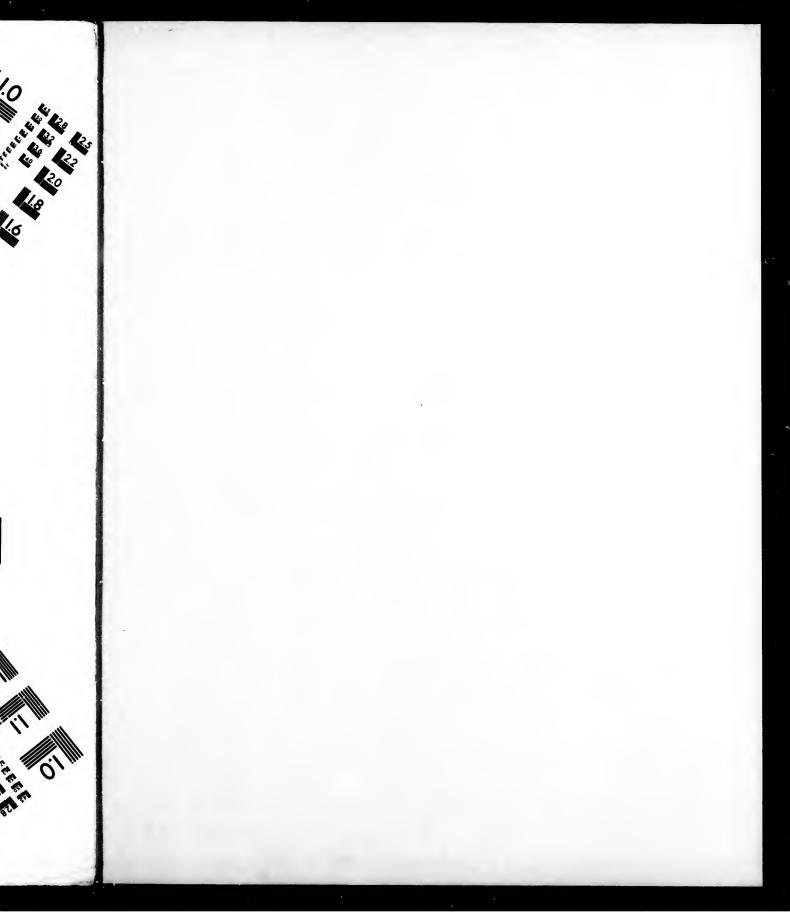
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saluted; a ceremony which he never performed but once again upon a similar occasion. Finding him extremely tractable, I made it my custom to carry him always after breakfast into the garden. . . . I had not long habituated him to this taste of liberty before he began to be impatient for the return of the time when he might enjoy it. He would invite me to the garden by drumming upon my knee, and by a look of such expression as it was not possible to misinterpret. If this rhetoric did not immediately succeed, he would take the skirt of my coat between his teeth and pull it with all his force. He seemed to be happier in human society than when shut up with his natural companions.

Rats and Mice.

Rats are well known to be highly intelligent animals. Unlike the hare or rabbit, their shyness seems to proceed from a wise caution rather than from timidity; for, when circumstances require, their boldness and courage in combat is surprising. Moreover, they never seem to lose their presence of mind; for, however great their danger, they seem always ready to take advantage of any favouring circumstances that may arise. Thus, when matched with so formidable an opponent as a ferret in a closed room, they have been known to display wonderful cunning in taking advantage of the light—keeping close under the window so as to throw the glare into the eyes of the enemy, darting forwards time after time to deliver a bite, and then as often retiring to their vantage-ground. But the emotions of rats do not appear to be of an entirely selfish character. There are so many accounts in the anecdote books of blind rats being led about by their seeing companions, that it is difficult to discredit an observation so frequently confirmed.² Moreover, rats have been frequently known to assist one another in defending themselves from dangerous enemies. Several observations of this kind are recorded by the trustworthy writer Mr. Rodwell, in his somewhat elaborate work upon this animal.

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¹ See Watson's Reasoning Power in Animals, and Quarterly Review. c. i., p. 135.

² See especially Jesse, Gleanings, &c., iii., p. 206; and Quarterly Review, c. i., p. 135.

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Again, as showing affection for human beings, I may quote the following:—'The mouse which had been tamed by Baron Trench in his prison having been taken from him, watched at the door and crept in when it was opened; being removed again, it refused all food, and died in three days.'

With regard to general intelligence, every one knows the extraordinary wariness of rats in relation to traps, which is only equalled in the animal kingdom by that of the fox and the wolverine. It has frequently been regarded as a wonderful display of intelligence on the part of rats that while gnawing through the woodwork of a ship, they always stop before they completely perforate the side; but, as Mr. Jesse suggests, this is probably due to their distaste of the salt water. No such disparaging explanation, however, is possible in some other instances of the display of rat-intelligence. Thus, the manner in which they transport eggs to their burrows has been too frequently observed to admit of doubt. Rodwell gives a case in which a number of eggs were carried from the top of a house to the bottom by two rats devoting themselves to each egg, and alternately passing it down to each other at every step of the staircase.2 Dr. Carpenter also received from an eye-witness a similar account of another instance. According to the article in the Quarterly Review, already mentioned, rats will not only convey eggs from the top of the house to the bottom, but from bottom to top. male rat places himself on his fore-paws, with his head downwards, and raising up his hind legs and catching the egg between them, pushes it up to the female, who stands on the step above, and secures it with her fore-paws till he jumps up to her; and this process is repeated from step to step till the top is reached.'

'The captain of a merchantman,' says Mr. Jesse, 'trading to the port of Boston, in Lincolnshire, had constantly missed eggs from his sea stock. He suspected that he was robbed by his crew, but not being able to dis-

¹ Thompson, Passions of Animals, p. 368.

² The Rat, its Natural History, p. 102. ³ Mrs. Lee, Ancedotes of Animals, p. 264.

cover the thief, he was determined to watch his storeroom. Accordingly, having laid in a fresh stock of eggs. he seated himself at night in a situation that commanded a view of his eggs. To his great astonishment he saw a number of rats approach; they formed a line from his egg baskets to their hole, and handed the eggs from one to another in their fore-paws.'1

Another device to which rats resort for the procuring of food is mentioned in all the anecdote books, and it seemed so interesting that I tried some direct experiments upon the subject. I shall first state the alleged facts in

the words of Watson:-

As to oil, rats have been known to get oil out of a narrownecked bottle in the following way:—One of them would place himself, on some convenient support, by the side of the bottle. and then, dipping his tail into the oil, would give it to another to lick. In this act there is something more than what we call instinct; there is reason and understanding.²

Jesse also gives the following account:—

A box containing some bottles of Florence oil was placed in a store-room which was seldom opened; the box had no lid to it. On going to the room one day for one of the bottles, the owner found that the pieces of bladder and cotton at the mouth of each bottle had disappeared, and that much of the contents of the bottles had been consumed. The circumstance having excited suspicion, a few bottles were refilled with oil, and the mouths of them secured as before. Next morning the coverings of the bottles had been removed, and some of the oil was gone. However, upon watching the room, which was done through a little window, some rats were seen to get into the box, and insert their tails into the necks of the bottles, and then withdrawing them, they licked off the oil which adhered to them.³

Lastly, Rodwell gives another case similar in all essential respects, save that the rat licked its own tail instead of presenting it to a companion.

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3 Loc. cit.

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¹ Jesse, Gleanings, &c., ii., p. 281.

² Reasoning Power in Animals, p. 293.

statements was a very simple one. I recorded it in 'Nature' as follows:—

It is, I believe, pretty generally supposed that rats and mice use their tails for feeding purposes when the food to be eaten is contained in vessels too narrow to admit the entire body of the animal. I am not aware, however, that the truth of this supposition has ever been actually tested by any trustworthy person, and so think the following simple experiments are worth publishing. Having obtained a couple of tall-shaped preserve bottles with rather short and narrow necks, I filled them to within three inches of the top with red currant jelly which had only half stiffened. I covered the bottles with bladder in the ordinary way, and then stood them in a place infested by rats. Next morning the bladder covering each of the bottles had a small hole gnawed through it, and the level of the jelly was reduced in both bottles to the same extent. Now, as this extent corresponded to about the length of a rat's tail if inserted at the hole in the bladder, and as this hole was not much more than just large enough to admit the root of this organ, I do not see that any further evidence is required to prove the manner in which the rats obtained the jelly, viz., by repeatedly introducing their tails into the viscid matter, and as repeatedly licking them clean. However, to put the question beyond doubt, I refilled the bottles to the extent of half an inch above the jelly level left by the rats, and having placed a circle of moist paper upon each of the jelly surfaces, covered the bottles with bladder as before. I now left the bottles in a place where there were no rats or mice, until a good crop of mould had grown upon one of the moistened pieces of paper. The bottle containing this crop of mould I then transferred to the place where the rats were numerous. Next morning the bladder had again been eaten through at one edge, and upon the mould there were numerous and distinct tracings of the rats' tails, resembling marks made with the top of a pen-holder. These tracings were evidently caused by the animals sweeping their tails about in a fruitless endeavour to find a hole in the circle of paper which covered the jelly.

With regard to mice, the Rev. W. North, rector of Ashdown, in Essex, placed a pot of honey in a closet, in which a quantity of plaster rubbish had been left by builders. The mice piled up the plaster in the form of a heap against the sides of the pot, in order to constitute an

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inclined plane whereby to reach the rim. A quantity of the rubbish had also been thrown into the pot, with the effect of raising the level of the honey that remained to near the rim of the pot; but, of course, the latter fact may have been due to accident, and not to design.1 case in which mal-observation does not seem to have been

likely.

Powelsen, a writer on Iceland, has related an account of the intelligence displayed by the mice of that country, which has given rise to a difference of competent opinion, and which perhaps can hardly yet be said to have been definitely settled. What Powelsen said is that the mice collect in parties of from six to ten, select a flat piece of dried cow-dung, pile berries or other food upon it, then with united strength drag it to the edge of any stream they wish to cross, launch it, embark, and range themselves round the central heap of provisions with their heads joined over it, and their tails hanging in the water, perhaps serving as rudders. Pennant afterwards gave credit to this account, observing that in a country where berries were scarce, the mice were compelled to cross streams for distant forages.² Dr. Hooker, however, in his 'Tour in Iceland,' concludes that the account is a pure fabrication. Dr. Henderson, therefore, determined on trying to arrive at the truth of the matter, with the following result: - 'I made a point of inquiring of different individuals as to the reality of the account, and am happy in being able to say that it is now established as an important fact in natural history by the testimony of two eyewitnesses of unquestionable veracity, the clergyman of Briamslack, and Madame Benedictson of Stickesholm, both of whom assured me that they had seen the expedition performed repeatedly. Madame Benedictson, in particular, recollected having spent a whole afternoon, in her younger days, at the margin of a small lake on which these skilful navigators had embarked, and amusing herself and her companions by driving them away from the sides of the lake as they approached them. I was also informed

¹ Jesse, Gleanings, iii., p. 176.

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² Introduction to Arctic Zoology, p. 70.

Dr. 1815, vol.

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d an account that country, etent opinion, to have been that the mice a flat piece of upon it, then of any stream 1 range themvith their heads in the water, fterwards gave country where pelled to cross however, in his count is a pure determined on er, with the folring of different t, and am happy hed as an imporony of two eyee clergyman of tickesholm, both n the expedition ictson, in partiafternoon, in her l lake on which d amusing herself ay from the sides was also informed that they make use of dried mushrooms as sacks, in which they convey their provisions to the river, and thence to their homes.'

Before leaving the mice and rats I may say a few words upon certain mouse- and rat-like animals which scarcely require a separate section for their consideration. Of the harvesting mouse Gilbert White says:—

One of their nests I procured this autumn, most artificially plaited and composed of blades of wheat, perfectly round, and about the size of a cricket-ball, with the aperture so ingeniously closed that there was no discovering to what part it belonged. It was so compact and well filled that it would roll across the table without being discomposed, though it contained eight little mice that were naked and blind. As the nest was perfectly full, how could the dam come at her litter respectively, so as to administer a teat to each? Perhaps she opens different places for that purpose, adjusting them again when the business is over; but she could not possibly be contained herself in the ball with the young ones, which, moreover, would be daily increasing in size. This wonderful procreamt cradle, an elegant instance of the efforts of instinct, was found in a wheat-field, suspended on the head of a thistle.

Pallas has described the provident habits of the so-called 'rat-hare' (Lagomys), which lays up a store of grass, or rather hay, for winter consumption. These animals, which occur in the Altai Mountains, live in holes or crevices of rock. About the middle of the month of August they collect grass, and spread it out to dry into hay. In September they form heaps or stacks of the hay, which may be as much as six feet high, and eight feet in diameter. It is stored in their chosen hole or crevice, protected from the rain.

The following is quoted from Thompson's 'Passions of Animals,' pp. 235-6:—

The life of the harvester rat is divided between eating and fighting. It seems to have no other passion than that of rage, which induces it to attack every animal that comes in its way, without in the least attending to the superior strength of its enemy. Ignorant of the art of saving itself by flight, rather

¹ Dr. Henderson, Journal of a Residence in Iceland in 1814 and 1815, vol. ii., p. 187.

than yield, it will allow itself to be beaten to pieces with a stick. If it seizes a man's hand, it must be killed before it will quit its hold. The magnitude of the horse terrifies it as little as the address of the dog, which last is fond of hunting it. When a harvester perceives a dog at a distance, it begins by emptying its cheek-pouches, if they happen to be filled with grain; it then blows them up so prodigiously, that the size of the head and neck greatly exceeds that of the rest of the body. It rears itself upon its hind legs, and thus darts upon the enemy. If it catches hold, it never quits it but with the loss of its life; but the dog generally seizes it behind, and strangles it. This ferocious disposition prevents it from being at peace with any animal what. ever. It even makes war against its own species. When two harvesters meet, they never fail to attack each other, and the stronger always devours the weaker. A combat between a male and a female commonly lasts longer than between two They begin by pursuing and biting each other, then each of them retires aside, as if to take breath. After a short interval they renew the combat, and continue to fight till one of them falls. The vanquished uniformly serves as a repast to the conqueror.

If we contrast the fearless disposition of the harvester with the timidity of the hare or rabbit, we observe that in respect of emotions, no less than in that of intelligence, the order Rodentia comprises the utmost extremes.

The so-called 'prairie-dog' is a kind of small rodent, which makes burrows in the ground, and a slight elevation above it. The animals being social in their habits, their warrens are called 'dog-towns.' Prof. Jillson, Ph.D., kept a pair in confinement (see 'American Naturalist,' vol. v., pp. 24-29), and found them to be intelligent and highly affectionate animals. These burrows he found to contain a 'granary,' or chambers set apart for the reception of stored food. With regard to the association said to exist between this animal and the owl and rattle-snake, Prof. Jillson says, 'I have seen many dog-towns, with owls and dogs standing on contiguous, and in some cases on the same mound, but never saw a snake in the vicinity.' The popular notion that the owl acts the part of sentry to the dog requires, to say the least, confirmation.

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Most remarkable among rodents for instinct and intelligence unquestionably stands the beaver. Indeed. there is no animal—not even excepting the ants and bees —where instinct has risen to a higher level of far-reaching adaptation to certain constant conditions of environment, or where faculties, undoubtedly instinctive, are more puzzlingly wrought up with faculties no less undoubtedly So much is this the case that, as we shall intelligent. presently see, it is really impossible by the closest study of the pyschology of this animal to distinguish the web of instinct from the woof of intelligence; the two principles seem here to have been so intimately woven together, that in the result, as expressed by certain particular actions, it cannot be determined how much we are to attribute to mechanical impulse, and how much to reasoned purpose.

Fortunately, the doubt that for many years shrouded the facts has been dispelled by the conscientious and laborious observations of the late Mr. Lewis H. Morgan, whose work throughout displays the judicious accuracy of a scientific mind. As this is much the most trustworthy, as well as the most exhaustive essay upon the subject, I shall mainly rely upon it for my statement of facts, and while presenting these I shall endeavour to point out the psychological explanation, or difficulty of explanation, to which they are severally open.

The beaver is a social animal, the male living with his single female and progeny in a separate burrow or 'lodge.' Several of these lodges, however, are usually built close together, so as to form a beaver colony. The young quit the lodge of their parents when they enter upon the summer of their third year, seek mates, and establish new lodges for themselves. As each litter numbers three or four, and breeding is annual, it follows that a beaver lodge never or rarely contains more than twelve individuals, while the number usually ranges from four to eight.

Every season, and particularly when a district becomes

*The American Beaver and his Works (Lippincott & Co., 1868).

entrances :--

overstocked, some of the beavers migrate. The Indians say that in their local migrations the old beavers go up stream, and the young down; assigning as a reason that in the struggle for existence greater advantages are afforded near the source than lower down a stream, and therefore that the old beavers appropriate the former. But although lodges may thus be vacated by the old beavers, they are not left tenantless; their lease is, as it were, transferred to another beaver couple. This process of transference of ownership goes on from generation to generation, so that the same lodges are continuously occupied for centuries.

These lodges, which are always constructed in or near water, are of three kinds—the island, bank, and lake lodge. The first are formed on small islands which may happen to occur in the ponds made by the beaver-dams. The floor of the lodge is a few inches above the level of the water, and into it there open two, or sometimes more

These are made with great skill, and in the most artistic manner. One is straight, or as nearly so as possible, with its floor, which is of course under water, an inclined plane, rising gradually from the bottom of the pond into the chamber; while the other is abrupt in its descent, and often sinuous in its The first we shall call the 'wood entrance,' from its evident design to facilitate the admission into the chamber of their wood cuttings, upon which they subsist during the season These cuttings, as will elsewhere be shown, are of such size and length that such an entrance is absolutely necessary for their free admission into the lodge. The other, which we shall call the 'beaver entrance,' is the ordinary run-way for their exit and return. It is usually abrupt, and often winding. In the lodge under consideration, the wood entrance descended from the outer run of the chamber entrance about ten feet to the bottom of the pond in a straight line, and upon an inclined plane; while the other, emerging from the line of the chamber at the side, descended quite abruptly to the bottom of the moat or trench, through which the beavers must pass, in open water, out into the pond. Both entrances were rudely arched, with a roof of interlaced sticks filled in with mud intermixed with vegetable fibre, and were extended to the bottom of the their the flupper while compadifficu

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Upon the floor of the lodge there is constructed a house of sticks, brushwood, and mud, in the form of a circular or oval chamber, the size of which varies with the age of the lodge; for by a continuous process of repair (which consists in removing the decayed sticks, &c., from the interior and working them up with new material upon the exterior) the whole lodge progressively increases in size: eventually in this way the interior chamber may attain a diameter of seven or eight feet.

The 'bank lodges' are of two kinds:-

One is situated upon the bank of the stream or pond, a few feet back from its edge, and entered by an underground passage from the bed of the stream, excavated through the natural earth up into the chamber. The other is situated upon the edge of the bank, a portion of it projecting over and resting upon the bed of the channel, so as to have the floor of the chamber rest upon the bank as upon solid ground, while the external wall on the pond side projects beyond it, and is built up from the bottom of the pond.

Lastly, the 'lake lodges' are constructed on the shores of lakes, which, being usually shelving and hard, require some further variation in the structure of the lodges. These, therefore, are of interest 'as illustrations of the capacity of the beavers to vary the mode of construction of their lodges in accordance with the changes of situation.' One-half or two-thirds of the lodge is in this case 'built out upon the lake for the obvious purpose of covering the entrance, as well as for its extension into deep water.'

All these forms of lodge are, historically regarded,

modified burrows.

The beaver is a burrowing animal. Indulging this propensity, he excavates chambers underground, and constructs artificial lodges upon its surface, both of which are indispensable to his security and happiness. The lodge is but a burrow above ground, covered with an artificial roof, and possesses some advantages over the latter as a place for rearing young.

There are reasons for believing that the burrow is the normal residence of the beavers, and that the lodge grew out of it, in the progress of their experience, by a process of natural suggestion. . . . In addition to the lodge, the same beavers who inhabit it have burrows in the banks surrounding the pond. They never risk their personal safety upon their lodge alone, which, being conspicuous to their enemies, is liable to attack. . . . As the entrances are always below the surface level of the pond, there are no external indications to mark the site of the burrow,

except occasionally a small pile of beaver-cuttings a foot or more high. These, the trappers affirm, are purposely left there by the beavers to keep the snow loose over the ends of their burrows during winter for the admission of air.

Mr. Morgan adds the very probable suggestion that this habit of piling up cuttings for purposes of ventilation may have constituted the origin of lodge-building.

It is but a step from such a surface-pile of sticks to a lodge, with its chamber above ground, and the previous burrow as its entrance from the pond. A burrow accidentally broken through at its upper end, and repaired with a covering of sticks and earth, would lead to a lodge above ground, and thus inaugurate a beaver lodge out of a broken burrow.

It is evidence of an important local variation of instinct, that in the Cascade Mountains the beavers live chiefly in burrows in the banks of streams, and rarely construct either lodges or dams. Dr. Newbury, in his report on the zoology of Oregon and California, says: 'We found the beavers in numbers, of which, when applied to beavers, I had no conception,' and yet 'we never saw their houses and seldom a dam.' Whether this local variation be due to a relapse from dam- and lodge-building instincts to the primitive burrowing instinct, or to a failure in the

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variation of inthe beavers live eams, and rarely Newbury, in his fornia, says: 'We, when applied to ve never saw their his local variation building instincts to a failure in the

full development of the newer instinct, is immaterial. Probably, I think, looking to the high antiquity of the building instinct, and also to its being occasionally manifested by the Californian beavers, their case is to be regarded as one of relapsing instinct.

In selecting the site of their lodges beavers display

much sagacity and forethought.

The severity of the climate in these high northern latitudes lays upon them the necessity of so locating their lodges as to be assured of water deep enough in their entrances, and also so protected in other respects, as not to freeze to the bottom; lotherwise they would perish with hunger, locked up in ice-bound habitations. To guard against this danger, the dam, also, must be sufficiently stable through the winter to maintain the water at a constant level; and this level, again, must be so adjusted with reference to the floor of the lodge as to enable them, at all times, to take in their cuttings from without as they are needed for food. When they leave their normal mode of life in the banks of the rivers, and undertake to live in dependence upon artificial ponds of their own formation, they are compelled to prevent the consequences of their acts at the peril of their lives.

On the upper Missouri, where the banks of the river are for miles together vertical, and rising from three to eight feet above its surface, the beavers resort to the device of making what are called 'beaver slides.' These are narrow inclined planes cut into the banks at intervals, the angle of inclination being 45° to 60°, so as to form a gradual descent from a point a few feet back from the edge of the bank to the level of the river. As Mr. Morgan observes, 'they furnish another conspicuous illustration of the fact that beavers possess a free intelligence, by means of which they are enabled to adapt themselves to the circumstances in which they are placed.'

fornia, says: 'We Coming now to the habits of these animals in connect, when applied to tion with the procuring and storing of food, it is first to ve never saw their be observed that 'the thick bark upon the trunks of large his local variation rees, and even upon those of medium size, is unsuitable

to a failure in the there a spring happens to rise in the bottom of the lake or pond.

for food; but the smaller limbs, the bark of which is tender and nutritious, afford the aliment which they Drefer.' To obtain this food, the animals, as is well known. fell the trees by gnawing a ring round their base. Two or three nights' successive work by a pair of beavers is enough to bring down a half-grown tree, 'each family being left to the undisturbed enjoyment of the fruits of their own toil and industry.' 'When the tree begins to crackle they desist from cutting, which they afterwards continue with caution until it begins to fall, when they plunge into the pond usually, and wait concealed for a time, as if fearful that the cracking noise of the tree-fall might attract some enemy to the place.' It is of much interest that the beavers when thus felling trees know how to regulate the direction of the fall; by gnawing chiefly on the side of the trunk remote from the water, they make the tree fall towards the water, with the obvious purpose of saving as much as possible the labour of subsequent transport. For as soon as a tree is down, the next work is to cut off the branches, or such as are from two to six inches in diameter; and then, when they have been cleared of their twigs, to divide them into lengths sufficient to admit of the beavers transporting them to their lodges. cutting into lengths is effected by making a number of semi-sections through the branch at more or less equal distances as it lies upon the ground, and then turning the branch half round and continuing the sections from the opposite side. 'To cut it (the branch) entirely through from the upper side would require an incision of such width as to involve a loss of labour.' The thicker the branch, the closer together are the sections made, and con sequently the shorter are the resulting portions—th reason, of course, being that the strength of the anima would not be sufficient to transport a thick piece of timber of the same length as a thin piece which it is only just able to manage.

In moving cuttings of this description they are quite in genious. They shove and roll them with their hips, using all their legs and tails as levers, moving sideways in the act. It this way they move the larger pieces from the more or le

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elevated ground on which the deciduous trees are found, over the uneven but generally descending surface to the pond. . . . After one of these cuttings has been transported to the water, a beaver, placing one end of it under his throat, pushes it before him to the place where it is to be sunk.

The sinking is no doubt partly effected by mere soaking; but there is also some evidence to show that the beavers have a method of anchoring down their supplies. Thus they have been observed towing pieces of brush to their lodges, and then, while holding the large end in their mouths, 'going down with it to the bottom, apparently to fix it in the mud bottom of the pond.' A brush-heap being thus formed, the cuttings from the felled trees are stuck through the brushwork, without which 'protection they would be liable to be floated off by the strong currents, and thus be lost to the beavers at the time when their lives might depend upon their safe custody.'

Lastly, as a method whereby the beavers can save themselves the trouble of cutting, transporting, and anchoring all at the same time, they are prone, when circumstances permit, to fell a tree growing near enough to their pond to admit of its branches being submerged in the water. The animals then well know that the branches and young shoots will remain preserved throughout the winter without any further trouble from them. But of course the supply of trees thus growing conveniently near a beaver-pond is too limited to last long.

We have next to consider the most wonderful, and I think the most psychologically puzzling structures that are presented as the works of any animal; I mean, of course, the dams and canals.

The object of the dam is that of forming an artificial pond, the use of which is to afford refuge to the animals as well as water connection with their lodges. Therefore the level of the pond must in all cases be higher than that of the lodge- and burrow-entrances, and it is usually maintained two or three feet above them.

As the dam is not an absolute necessity to the beaver for the maintenance of his life—his normal habitation being rather natural ponds and rivers, and the burrows in their banks—it is, in itself considered, a remarkable fact that he should have voluntarily transferred himself, by means of dams and ponds of his own construction, from a natural to an artificial mode of life.

In external appearance there are two distinct kinds of dams, although all are constructed on the same principle. One, the more common, is the 'stick dam,' which is composed of interlaced stick and pole work upon the lower face, with an embankment of earth mixed with the same materials on the upper face. The other is the 'solid-bank dam,' which differs from the former in having much more brush and mud worked into its construction, especially upon its surfaces; the result being that the whole formation looks like a solid bank of earth. In the first kind of dam the surplus water percolates through the structure along its entire length; but in the second kind the discharge takes place through a single furrow in the crest, which, remarkable though the fact unquestionably is, the beavers intentionally form for this purpose.

In the construction of the dam, stones are used here and there to give down-weight and solidity. These stones weigh from one to six pounds, and are carried by the beavers in the same way as they carry their mud—namely, by walking on their hind legs while holding their burden against the chest with their fore-paws. The solid dams are much firmer in their consistence than the stick dams; for while a horse might walk across the former, the weight of a man would be too great to be sustained by the latter. Each kind of dam is adapted to the locality in which it is built, the difference between the two kinds being due to the following cause. As a stream gains water and force in its descent, it develops banks, and also a broader and deeper channel. These banks assume a vertical form in the level areas where the soil is alluvial. Thus, an open stick-work dam could not in such places be led of from either bank; and even if it could, the force and depth of the stream would carry it away. Therefore in such places the beavers build their solid-bank dams, while in shallow and comparatively sluggish waters they content

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To give some idea of the proportions of a dam, I shall epitomise a number of measurements given by Mr. Morgan:—

					\mathbf{Feet}
Height of structure from bas				•	2 to 6
Difference in depth of water	above	and	below	dam	4 to 5
Width of base or section .					6 to 18
Length of slope, lower face					6 to 13
Length of slope, upper face	•	•	•	•	4 to 8

The only other measurement is that of length, and this, of course, varies with the width of water to be spanned. Where this width is considerable the length of a dam may be prodigious, as the following quotation will show:—

Some of the dams in this region are not less remarkable for their prodigious length, a statement of which, in fact, would scarcely be credited unless verified by actual measurement. The largest one yet mentioned measures 260 feet, but there are dams 400 and even 500 feet long.

There is a dam in two sections, situated upon a tributary of the main branch of the Esconauba River, about a mile and a half north-west of the Washington Main. measures 110 and the other 400 feet, with an interval of natural bank, worked here and there, of 1,000 feet. A solidbank dam, 20 feet in length, was first constructed across the channel of the stream, from bank to bank, with the usual opening for the surplus water, five feet wide. As the water rose and overflowed the bank on the left side, the dam was extended for 90 feet, until it reached ground high enough to confine the pond. This natural bank extended up the stream, and nearly parallel with it, for 1,000 feet, where the ground again subsided, and allowed the water in the upper part of the pond to flow out and around into the channel of the stream below the dam. To meet this emergency a second dam, 420 feet long, was constructed. For the greater part of its length it is low, but in some places it is two and a half and three feet high, and constructed of stick-work on the land, and with an earth embankment on its outer face. In effect, therefore, it is one structure 1,530 feet in length, of which 530 feet in two sections is artificial, and the remainder natural bank, but worked here and there where depressions in the ground required raising by artificial means.

It is truly an astonishing fact that animals should engage in such vast architectural labours with what appears to be the deliberate purpose of securing, by such very artificial means, the special benefits that arise from their high engineering skill. So astonishing, indeed. does this fact appear, that as sober-minded interpreters of fact we would fain look for some explanation which would not necessitate the inference that these actions are due to any intelligent appreciation, either of the benefits that arise from the labour, or of the hydrostatic principles to which this labour so clearly refers. Yet the more closely we look into the subject, the more impossible do we find it to account for the facts by any such easy method. Thus it seems perfectly certain that the beavers, properly and strictly speaking, understand the use of their dams in maintaining a certain level of water. For it is unquestionable that in the solid-bank dams, as already observed, a regular opening or trough is cut at one part of its crest to provide for the overflow; and now it has to be added that this opening is purposely widened or narrowed with reference to the amount of water in the stream at different times, so as to ensure the maintenance of a constant level in the pond. Similarly, though by different means, the same end is secured in the case of the stick dams. For 'in most of these dams the rapidity or slowness with which the surplus water is discharged is undoubtedly regulated by the beavers; otherwise the level of the pond would continually vary. There must be a constant tendency to enlarge the orifices through which the water passes,' when the stream is small, and vice versû; otherwise the lodges would be either inundated or have their sub-aquatic entrances exposed.\(^1\) Moreover, a very little consideration is enough to show that in stick dams the tendency to increased leakage from the effects of percolation, and to a settling down of the dam as its materials decay from underneath, must demand unceasing vigilance a it is f materi compe

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¹ In times of considerable 'freshet' the former case sometimes occurs; the beavers not being able to provide for a very considerable overflow through their dams, the latter become then wholly submerged. When again exposed, the animals take great pains in repairing the injuries sustained.

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inceasing vigier case sometimes a very considerable wholly submerged. in repairing the inlance and care to avert the consequences. And accordingly it is found that 'in the fall of the year a new supply of materials is placed upon the lower face of these dams to

compensate this waste from decay.'

Now, it is obvious that we have here presented a continual variation of conditions, imposed by continual variations in the amount of water coming down; and it is a matter of observation that these variations are met by the beavers in the only way that they can be met—namely, by regulating the amount of flow taking place through the dams. It will therefore be seen that we have here to consider a totally different case from that of the operation of pure instinct, however wonderful such operation may be. For the adaptations of pure instinct only have reference to conditions that are unchanging; so that if in this case we suppose pure instinct to account for all the facts, we must greatly modify our ideas of what pure instinct is taken to mean. Thus we must suppose that when the beavers find the level of their ponds rising or falling, the discomfort which they experience acts as a stimulus to cause them, without intelligent purpose, either to widen or to narrow the orifices in their dams as the case may be. And not only so, but the conditions of stimulation and response must be so nicely balanced that the animals widen or narrow these orifices with a more or less precise quantitative reference to the degree of discomfort, actual or prospective, which they experience. Now it seems to me that even thus far it is an extremely difficult thing to believe that the mechanism of pure or wholly unintelligent instinct could admit of sufficient refinement to meet so complex a case of compensating adaptation; and, as we shall immediately see, this difficulty increases still more as we contemplate additional facts relating to these structures.

Thus it sometimes happens that in large dams the pressure of the water which they keep back is so considerable that their stability is endangered. In such cases it has been observed by Mr. Morgan that, at a short distance beneath the main dam, another and lower dam is thrown across the stream, with the result of forming a shallow pond between the two. This pond isOf no apparent use for beaver occupation, but yet subserving the important purpose of setting back water to the depth of twelve or fifteen inches; and the small dam, by maintaining the water a foot deep below the great dam, diminishes to this extent the difference in level above and below, and neutralises to the same extent the pressure of the water in the pond above against the main structure.

'Whether,' adds Mr. Morgan, with commendable caution, 'the lower dam was constructed with this motive and for this object, or is explainable on some other hypothesis, I shall not venture an opinion.' But as, he further adds, 'I have also found the same precise work repeated below other large dams,' we are led to conclude that their correlation cannot at least be accidental; and as it is of so definite a character, there really seems no 'other hypothesis' open to us than that of its having reference to the stability of the main dam. Yet, if this is the case, it becomes in my opinion simply impossible to attribute the fact to the operation of pure instinct.

Again, Mr. Morgan observed one case in which, higher up stream than the main dam, there was constructed another dam, ninety-three feet long, and two and a half feet high at the centre:—

A dam at this point is apparently of no conceivable use to improve the lake for beaver occupation. It has one feature, also, in which it differs from other dams except those upon lake outlets, and that consists in its elevation, at all points, of about two feet above the level of the lake at ordinary stages of the water. In all other dams, except those upon lake outlets, and in most of the latter, the water stands quite near their crests, while in the one under consideration it stood about two feet below it. This fact suggests at least the inference, although it may have but little of probability to sustain it, that it was constructed with special reference to sudden rises of the lake in times of freshet, and that it was designed to hold this surplus water until it could be gradually discharged through the dam into the great space below. It would at least subserve this purpose very efficiently, and thus protect the dam below it from the effects of freshets. To ascribe the origin of this dam to such motives of intelligence is to invest this animal with a higher degree of sagacity than we have probable reason to

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As before, we have here to commend the caution displayed by the closing sentence; but, as useless dams are not found in other places, the inference clearly is that the dam in question, both as regards its exceptional position and exceptional height, can only be explained by supposing the structure to have been designed for the use which it unquestionably served. That is to say, if we do not entertain this explanation, there is no other to be suggested; and although in any ordinary or occasional instance of the display of animal intelligence in such a degree as this I should not hesitate to attribute the facts to accident, in the case of the beaver there are such a multitude of constantly recurring facts, all and only referable to a practical though not less extraordinary appreciation of hydrostatic principles, that the hypothesis of accident must here, I think, be laid aside. To substantiate this statement I shall detail the facts concerning the beavercanals.

As Mr. Morgan, who first discovered and described these astonishing structures, observes,—

Remarkable as the dam may still be considered, from its structure and objects, it scarcely surpasses, if it may be said to equal, these water-ways, here called canals, which are excavated through the low lands bordering their ponds for the purpose of reaching the hard wood, and for affording a channel for its transportation to their lodges. To conceive and execute such a design presupposes a more complicated and extended process of reasoning than that required for the construction of a dam, and, although a much simpler work to perform when the thought was fully developed, it was far less to have been expected from a mute animal.

These canals are developed in this way. One of the principal objects served by a dam thrown across a small stream, is that of flooding the low ground so as to obtain water connection with the first high ground upon which hard wood is to be found, such connection being convenient, or even necessary, for the purposes of transport.

Where the pond fails to accomplish this fully, and also where the banks are defined and mark the limits of the pond, the deficiency is supplied by the canals in question. On descending surfaces, as has elsewhere been stated, beavers roll and drag their short cuttings down into the ponds. But where the ground is low it is generally so uneven and rough as to render it extremely difficult, if not impossible, for the beavers to move them for any considerable distance by physical force. Hence the canal for floating them across the intervening level ground to the pond. The necessity for it is so apparent as to diminish our astonishment at its construction; and yet that the beaver should devise a canal to surmount this difficulty is not the less remarkable.

The canals, which are made by excavation, are usually from three to five feet wide, three feet deep, and perhaps hundreds of feet long—the length of course depending on the distance between the lodge and the wood supply. They are cut in the form of trenches, having perpendicular sides and abrupt ends. All roots of trees, under-brush, &c., are cleared away in their course, so as to afford an unobstructed passage. These canals are of such frequent occurrence that it is impossible to attribute them to accident; they are evidently made, at the cost of much labour, with the deliberate purpose of putting them to the use for which they are designed. In executing this purpose there is sometimes displayed a depth of engineering forethought over details of structure required by the circumstances of special localities, which is even more astonishing than the execution of the general idea. Thus it not unfrequently happens that when a canal has been run for a certain distance, a rise in the level of the ground renders it impossible to continue the structure further from the water supply or lodge-pond, without either incurring a great amount of labour in digging the canal with progressively deepening sides, or leaving the trench empty of water, and so useless. In such cases the beavers resort to various expedients, according to the nature of the ground.

Mr. Morgan gives an interesting sketch of one such case, where the canal is excavated through low ground for a distance of 450 feet, when it reaches the first rise of

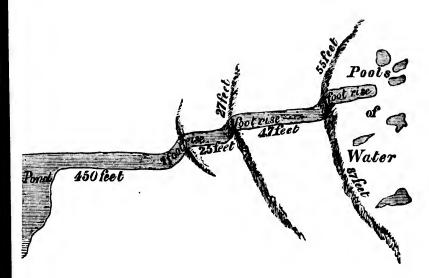
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trate it into the second reach of the canal. Beyond this larger dam there is another abrupt rise of a foot, and the canal is there continued for 47 feet more, where a third dam is built resembling the second in construction, only having a still wider span on either side of the canal (142 feet), so as to catch a still larger quantity of drainage water to supply the third or uppermost reach of the canal. We have, therefore, here presented, not only a perfect application of the principle of 'locks,' which are used in canals of human construction, but also the principle of collecting water to supply the reaches situated on the slope by means of elaborately constructed dams of wide

extent, and of the best form for the purpose. There is thus shown much too great a concurrence of engineering principles to the attainment of one object to admit of our attributing the facts to accident. On this structure Mr. Morgan observes:—

The crests of these dams where they cross the canals are depressed, or worn down, in the centre, by the constant passage of beavers over them while going to and fro and dragging their cuttings. This canal with its adjuncts of dams and its manifest objects is a remarkable work, transcending very much the ordinary estimates of the intelligence of the beaver. It served to bring the occupants of the pond into easy connection by water with the trees that supplied them with food, as well as to relieve them from the tedious and perhaps impossible task of transporting their cuttings 500 feet over uneven ground unassisted by any descent.

Again, in another case, also sketched by Mr. Morgan, another device is resorted to, and one which, having reference to the particular circumstances of the case, is the best that could have been adopted. Here the canal, proceeding from the pond to the woodland 150 feet distant, encounters at the woodland a rising slope covered with hard wood. Thereupon the canal bifurcates, and the two diverging branches or prongs are carried in opposite directions along the base of the woodland rise, one for a distance of 100 and the other for 115 feet. The level being throughout the same, the water from the pond supplies the two branch-canals as well as the trunk. Both branches end with abrupt vertical faces. Now the object of these branches is sufficiently apparent:—

After the rising ground, and with it the hard wood trees, were reached at the point where it branches, there was no very urgent necessity for the branches. But their construction along the base of the high ground gave them a frontage upon the canal of 215 feet of hard-wood lands, thus affording to them, along this extended line, the great advantages of water transportation for their cuttings.

One more proof of engineering purpose in the construction of canals will be sufficient to place beyond all

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ose in the conplace beyond all question the fact that beavers form these canals, as they form their dams, with a far-seeing perception of the suitability of highly artificial means to the attainment of particular ends, under a variety of special circumstances. Mr. Morgan observed one or two instances where the land included in a wind or loop of a river was cut through by a beaver canal across the narrowest part, 'apparently to shorten the distance in going up and down by water.' Judging from the figures which he gives, drawn to measurement, there can be no question that such was the object; and as these structures may be one or two hundred feet in length, and represent the laborious excavation of some 1,500 cubic feet of soil, the animals must be actuated by the most vivid conception of the subsequent saving in labour that is to be effected by making an artificial communication across the chord of an arc, instead of always going round the natural curve of a stream.

Regarding now together all these facts relating to the psychology of the beaver, it must be confessed, as I said at the outset, that we have presented to us a problem perhaps the most difficult of any that we have to encounter in the whole range of animal intelligence. On the one hand, it seems incredible that the beaver should attain to such a level of abstract thought as would be implied by his forming his various structures with the calculated purpose of achieving the ends which they undoubtedly subserve. On the other hand, as we have seen, it seems little less than impossible that the formation of these structures can be due to instinct. Yet one or other hypothesis, either singly or in combination, must be resorted to. The case, it will be observed, thus differs from that of the more wonderful performances of instinct elsewhere, such as that of ants and bees, inasmuch as the performances here are so complex and varied, as well as having reference to physical principles of a much more recondite or less observable nature. The case from its theoretical side being thus one of much difficulty, I think it will be better to postpone its discussion till in 'Mental Evolution' I come to treat of the whole subject of instinct in relation to intelligence

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I must not, however, conclude this epitome of the facts without alluding to the only other publication on the habits of the beaver which is of distinctly scientific value. This is a short but interesting paper by Prof. Alexander Agassiz. He says that the largest dam he has himself seen measured 650 feet in length, and 31 feet in height, with a small number of lodges in the vicinity of the pond. The number of lodges is always thus very small in proportion to the size of the dam, the greatest number of lodges that he has observed upon one pond being five. It is evident from this that beavers are not really gregarious in their habits, and that their dams and canals 'are the work of a comparatively small number of animals; but to make up for the numbers the work of succeeding inhabitants of any one pond must have been carried on for centuries to accomplish the gigantic results we find in some localities.'

In once case Prof. Agassiz obtained what may be termed geological evidence of the truth of an opinion advanced by Mr. Morgan, that beaver-works may be hundreds if not thousands of years in course of continuous formation. For the purpose of obtaining a secure foundation for a mill dam erected above a beaver dam, it was necessary to clear away the soil from the bottom of the beaver pond. This soil was found to be a peat bog. A trench was dug into the peat 12 feet wide by 1,200 feet long. and 9 feet deep; all the way along this trench old stumps of trees were found at various depths, some still bearing marks of having been gnawed by beavers' teeth. calculated the growth of the bog as about a foot per century, so that here we have tolerably accurate evidence of an existing beaver dam being somewhere about a thousand years old.

The gradual growth of these enormous dams has the effect of greatly altering the configuration of the country where they occur. By taking levels from dams towards the sources of streams on which they occur, Agassiz was able ideally to reconstruct the original landscape before the growth of the dams, and he found that, 'from the

¹ Note on Beaver Dams (*Proc. Boston Soc. Nat. Hist.*, 1869, p. 101, et seq.).

itome of the ication on the cientific value. rof. Alexander s himself seen n height, with the pond. The l in proportion nber of lodges ng five. It is y gregarious in s are the work s; but to make g inhabitants of for centuries to some localities.' t may be termed oinion advanced be hundreds if ntinuous formacure foundation m, it was necesm of the beaver bog. A trench 1,200 feet long, rench old stumps me still bearing teeth. Agassiz t a foot per cenrate evidence of about a thousand

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nature of the surrounding country, the open spaces now joining the beaver ponds—the beaver meadows where the trees are scanty or small—must at one time have been all covered with forests.' At first the beavers 'began to clear the forest just in the immediate vicinity of the dams, extending in every direction, first up the stream as far as the nature of the creek would allow, and then laterally by means of their canals, as far as the level of the ground would allow, thus little by little clearing a larger area according to the time they have occupied any particular place.' In this way beavers may change the whole aspect of large tracts of country, covering with water a great extent of ground which was once thickly wooded.

CHAPTER XIII.

ELEPHANT.

THE intelligence of the elephant is no doubt considerable. although there is equally little doubt that it is generally exaggerated. Some of the most notorious instances of the display of remarkable sagacity by this animal are probably fabulous, or at least are not sufficiently corroborated to justify belief. Such, for instance, is the celebrated story told by Pliny with all the assurance of a 'certum est,' and repeated by Plutarch, of the elephant, who having been beaten for not dancing properly, was afterwards found practising his steps alone in the light of the moon. Although this story cannot, in the absence of corroboration, be accepted as fact, we ought to remember, in connection with it, that many talking and piping birds unquestionably practise in solitude the accomplishments which they desire to learn.

Quitting, however, the enormous multitude of anecdotes, more or less doubtful, and which may or may not be true, I shall select a few well-authenticated instance of the display of elephant intelligence.

Memory.

As regards memory, several cases are on record of tamed elephants having become wild, and, on again being captured after many years, returning to all their of matter b habits under domestication. Mr. Corse publishes i the 'Philosophical Transactions' an instance which cam He saw an elephant, which under his own notice.

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¹ Plin., *Hist. Nat.*, viii. 1-13. ² De Solert. Anim., c. 12. ³ Philosophical Transactions, 1799, p. 40.

¹ See Bi

² Hist. ' For th

d i., pp. 1 Memoi

was carrying baggage, take fright at the smell of a tiger and run off. Eighteen months afterwards this elephant

was recognised by its keepers among a herd of wild companions, which had been captured and were confined in an enclosure. But when anyone approached the animal he struck out with his trunk, and seemed as fierce as any of the wild herd. An old hunter then mounted a tame elephant, went up to the feral one, seized his ear and ordered him to lie down. Immediately the force of old associations broke through all opposition, the word of ibt considerable. command was obeyed, and the elephant while lying down at it is generally gave a certain peculiar squeak which he had been known ous instances of to utter in former days. The same author gives another this animal are and more interesting account of an elephant which, after ficiently corrobohaving been for only two years tamed, ran wild for fifteen nce, is the celeyears, and on being then recaptured, remembered in all assurance of a details the words of command. This, with several other ² of the elephant, well-authenticated facts of the same kind, shows that the ng properly, was elephant certainly has an exceedingly tenacious memory, ne in the light of rendering credible the statement of Pliny, that in their in the absence of more advanced age these animals recognise men who were ght to remember, their drivers when young.2 and piping birds

Emotions.

Concerning emotions, the elephant seems to be usually actuated by the most magnanimous of feelings. Even his moverbial vindictiveness appears only to be excited under sense of remembered injustice. The universally known story of the tailor and the elephant doubtless had a bundation in fact, for there are several authentic cases on are on record of elephants resenting injuries in precisely the nd, on again being sme way; 3 and Captain Shipp 4 personally tested the g to all their old matter by giving to an elephant a sandwich of bread, orse publishes in atter, and cayenne pepper. He then waited for six

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plert. Anim., c. 12. 9, p. 40.

¹ See Bingley, loc. cit., vol. i., pp. 148-51.

² Hist. Nat., viii., 5.

¹ For these and other cases of vindictiveness, see Bingley, loc. cit., vl. i., pp. 156–8.

^{&#}x27; Memoirs, vol. i., p. 448.

weeks before again visiting the animal, when he went into the stable and began to fondle the elephant as he had previously been accustomed to do. For a time no resentment was shown, so that the Captain began to think that the experiment had failed; but at last, watching for an opportunity, the elephant filled his trunk with dirty water, and drenched the Captain from head to foot.

Griffiths says that at the siege of Bhurtpore, in 1805, the British army had been a long time before the city, and, owing to the hot dry winds, the ponds and tanks had dried up. There used therefore to be no little struggle for priority in procuring water at one of the large well.

which still contained water:—

On one occasion two elephant-drivers, each with his elephant the one remarkably large and strong, and the other comparatively small and weak, were at the well together; the small elephan had been provided by his master with a bucket for the occasion which he carried on the end of his proboscis, but the large animal, being destitute of this necessary vessel, either spon taneously, or by the desire of his keeper, seized the bucket, and easily wrested it from his less powerful fellow-servant; the latter was too sensible of his inferiority openly to resent the insul though it is obvious that he felt it; but great squabbling an abuse ensued between the keepers. At length the weak animal, watching the opportunity when the other was standing with his side to the well, retired backwards a few paces in very quiet and unsuspicious manner, and then, rushing forwar with all his might, drove his head against the side of the other and fairly pushed him into the well.

Great trouble was experienced in extricating the elephant from the well—a task which would, indeed, have been impossible but for the intelligence of the animitself. For when a number of fascines, which had been employed by the army in conducting the siege, we thrown down the well, the elephant showed sagacite enough to arrange them with his trunk so as to construe a continuously rising platform, by which he gradual raised himself to a level with the ground.

Allied to vindictiveness for small injuries is revenged large ones, and this is often shown in a terrible mann

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by wounded elephants. For instance, Sir E. Tennent writes:-

Some years ago an elephant which had been wounded by a native, near Hambangtotte, pursued the man into the town, followed him along the street, trampled him to death in the bazaar before a crowd of terrified spectators, and succeeded in making good its retreat to the jungle.

Many other cases of vindictiveness, more or less well authenticated, may be found mentioned by Broderip,1 Bingley,² Mrs. Lee,³ Swainson,⁴ and Watson.⁵ This trait of emotional character seems to be more generally present in the elephant than in any other animal, except perhaps the monkey.

Another emotion strongly developed in the elephant is sympathy. Numberless examples on this head might be adduced, but one or two may suffice. Bishop Huber saw an old elephant fall down from weakness, and another elephant was brought to assist the fallen one to rise. Huber says he was much struck with the almost human expression of surprise, alarm, and sympathy manifested by the second elephant on witnessing the condition of the first. A chain was fastened round the neck and body of the sick animal, which the other was directed to pull. For a minute or two the healthy elephant pulled strongly; but on the first groan given by its distressed companion it stopped abruptly, 'turned fiercely round with a loud mar, and with trunk and fore-feet began to loosen the chain from the neck.

Again, Sir E. Tennent says:—

The devotion and loyalty which the herd evince to their ence of the animal lader are very remarkable. This is more readily seen in the es, which had bee ase of a tusker than any other, because in a herd he is geneng the siege, we ally the object of the keenest pursuit by the hunters. On such t showed sagaci wasions the others do their utmost to protect him from danger: k so as to construction to extremity they place their leader in the centre

¹ Zoological Recreations, p. 315.

² Animal Biography, i., pp. 156-8. ³ Anecdotes of Animals, p. 276.

⁴ Habits and Instincts of Animals, p. 37. 5 Reasoning Power of Animals, chap. iv.

and crowd so eagerly in front of him that the sportsmen have to shoot a number which they might otherwise have spared. In one instance a tusker, which was badly wounded by Major Rogers, was promptly surrounded by his companions, who supported him between their shoulders, and actually succeeded in covering his retreat to the forest.

Lastly, allusion may be made to the celebrated observation of M. le Baron de Lauriston, who was at Laknaor during an epidemic which stretched a number of natives sick and dying upon the road. The Nabob riding his elephant over the road was careless whether or not the animal crushed the men and women to death, but not so the elephant, which took great pains to pick his steps among the people so as not to injure them.

The following account of emotion and sagacity is quoted from the Rev. Julius Young's Memoirs of his father, Mr. Charles Young, the actor. The animal mentioned is the one that subsequently attained such widespread notoriety at Exeter Change, not only on account of his immense size, but still more because of his cruel death:—

In July 1810, the largest elephant ever seen in England was advertised as 'just arrived.' As soon as Henry Harris, the manager of Covent Garden Theatre, heard of it, he determined if possible, to obtain it; for it struck him that if it were to be introduced into the new pantomime of 'Harlequin Padmenaba,' which he was about to produce at great cost, it would add greatly to its attraction. Under this impression, and before the proprietor of Exeter Change had seen it, he purchased it for the sum of 900 guineas. Mrs. Henry Johnston was to ride it, and Miss Parker, the columbine, was to play up to it. Young happened to be one morning at the box-office adjoining Covent Garden Theatre, when his ears were assailed by a strange and unusual uproar within the walls. On asking one of the carpenters the cause of it, he was told 'it was something going wrong with the elephant; he could not exactly tell what.' I am not aware what the usage may be nowadays, but then, whenever a new piece had been announced for presentation on a given night, and there was but scant time for its preparation, a rehearsal would take place after the night's regular performance was over, and the audience had been dismissed. One such there had been the night before my father's curiosity had been roused As it had been arranged that Mrs. Henry Johnston, seated in

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a stall, and offered them to him. Chuny eyed him askance, took them, threw them beneath his feet, and when he had crushed them to pulp, spurned them from him. Young, who had gone into Covent Garden on the same errand as the gentleman who had preceded him, shortly after re-entered, and also held out to him some fruit, when, to the astonishment of the bystanders, the elephant ate every morsel, and after he had done so, twined his trunk with studied gentleness around Young's waist, marking by his action that, though he had resented a wrong, he did

not forget a kindness.

It was in the year 1814 that Harris parted with Chuny to Cross, the proprietor of the menagerie at Exeter Change. One of the purchaser's first acts was to send Charles Young a life ticket of admission to his exhibition; and it was one of his little innocent vanities, when passing through the Strand with any friend, to drop in on Chuny, pay him a visit in his den, and show the intimate relations which existed between them. Some years after, when the elephant's theatrical career was run, and he was reduced to play the part of captive in one of the cages of Exeter Change, a thoughtless dandy one day amused himself by teasing him with the repeated offer of lettuces—a vegetable for which he was known to have an antipathy. At last he presented him with an apple, but, at the moment of his taking it, drove a large pin into his trunk, and then sprang out of his reach. The keeper seeing that the poor creature was getting angry, warned the silly fellow off, lest he should become dangerous. With a contemptuous shrug of the shoulder, he trudged off to the other end of the gallery, and there displayed his cruel ingenuity on other humbler beasts, till, after the absence of half-an-hour, he once more approached one of the cages opposite the elephant's. By this time he had forgotten his pranks with Chuny, but Chuny had not forgotten him; and as he was standing with his back towards him, he thrust his proboscis through the bars of his prison, twitched off the offender's hat, dragged it in to him, tore it to shreds, then threw it into the face of the offending gaby, consummating his revenge with a loud guffaw of exultation. All present proclaimed their approbation of this act of retributive justice, and the discomfited coxcomb had to retreat from the scene in confusion, jump into a hackney coach, and betake himself to the hatter's in quest of a new tile for his unroofed skull. The tragic end of poor Chuny must be within the recollection of many of my readers. From some cause unknown he went mad, and after poison had been tried in vain it took 152 shots, discharged by a detachment of the Guards, to despatch him.

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¹ Quoted in Animal World, March 1882.

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The elephant in many respects displays strange peculiarities of emotional temperament. Thus Mr. Corse says:—'If a wild elephant happens to be separated from its young for only two or three days, though giving suck, she never after recognises or acknowledges it;' yet the young one knows its dam, and cries plaintively for her assistance.

Again, in the wild state, the spirit of exclusiveness shown by members of a herd (i.e. family) towards elephants of other herds is remarkable. Sir E. Tennent writes:—

If by any accident an elephant becomes hopelessly separated from his own herd, he is not permitted to attach himself to any other. He may browse in the vicinity, or frequent the same place to drink and to bathe; but the intercourse is only on a distant and conventional footing, and no familiarity or intimate association is under any circumstances permitted. To such a height is this exclusiveness carried, that even amidst the terror of an elephant corral, when an individual, detached from his own party in the mêlée and confusion, has been driven into the enclosure with an unbroken herd, I have seen him repulsed in every attempt to take refuge among them, and driven off by heavy blows with their trunks as often as he attempted to insinuate himself within the circle which they had formed for common security. There can be no reasonable doubt that this ealous and exclusive policy not only contributes to produce, but mainly serves to perpetuate, the class of solitary elephants which are known by the term goondahs in India, and which from their vicious propensities and predatory habits are called *Hora*, or Rogues, in Ceylon.²

The emotional temper, or rather transformation of emotional psychology, which is exhibited by the Rogues here mentioned, is as extraordinary as it is notorious. From being a peaceable, sympathetic, and magnanimous animal, the elephant, when excluded from the society of its kind, becomes savage, cruel, and morose to a degree unequalled in any other animal. The repulsive accounts of the bloodthirsty rage and wanton destructiveness of Rogues show that their actions are not due to sudden bursts of fury at the sight of man or his works, but rather to a

¹ Philosophical Transactions, 1873.

² Natural History of Ccylon, p. 114.

deliberate and brooding resolve to wage war on everything, so that the animal patiently lies in wait for travellers, rushing from his ambush only when he finds that the latter are within his power. As showing the cold-blooded determination of this murderous desire, I may quote the following case, as it was communicated to Sir E. Tennent:—

We had, says the writer, calculated to come up with the brute where it had been seen half an hour before; but no sooner had one of our men, who was walking foremost, seen the animal at the distance of some fifteen or twenty fathoms, than he ex. claimed, 'There! there!' and immediately took to his heels. and we all followed his example. The elephant did not see us until we had run some fifteen or twenty paces from the spot where we turned, when he gave us chase, screaming frightfully as he came on. The Englishman managed to climb a tree, and the rest of my companions did the same; as for myself, I could not, although I made one or two superhuman efforts. But there was no time to be lost. The elephant was running at me with his trunk bent down in a curve towards the ground. At this critical moment Mr. Lindsay held out his foot to me, with the help of which and then of the branches of the tree, which were three or four feet above my head, I managed to scramble up to a branch. The elephant came directly to the tree and attempted to force it down, which he could not. He first coiled his trunk round the stem, and pulled it with all his might, but with no He then applied his head to the tree, and pushed for several minutes, but with no better success. He then trampled with his feet all the projecting roots, moving, as he did so, several times round and round the tree. Lastly, failing in all this, and seeing a pile of timber, which I had lately cut, at a short distance from us, he removed it all (thirty-six pieces) one at a time to the root of the tree, and piled them up in a regular businesslike manner; then placing his hind feet on this pile, he raised the fore part of his body, and reached out his trunk, but still he could not touch us, as we were too far above him. The Englishman then fired, and the ball took effect somewhere on the elephant's head, but did not kill him. It made him only the more furious. The next shot, however, levelled him to the ground. I afterwards brought the skull of the animal to Colombo, and it is still to be seen at the house of Mr. Armitage.¹

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¹ Natural History of Ceylon, p. 140.

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Another highly curious trait in the emotional psychology of the elephant is the readiness with which the huge animal expires under the mere influence of what the natives call a 'broken heart.' The facts on this head are without a parallel in any other animal, and are the more remarkable from the fact that, so far as natural length of life is any token, the elephant may be said to have more vitality, or innate power of living, than any other terrestrial mammal. Again, to quote from Sir E. Tennent:—

Amongst the last of the elephants noosed was the rogue. Though far more savage than the others, he joined in none of their charges and assaults on the fences, as they uniformly drove him off, and would not permit him to enter their circle. When dragged past another of his companions in misfortune, who was lying exhausted on the ground, he flew upon him and attempted to fasten his teeth in his head; this was the only instance of viciousness which occurred during the progress of the corral. When tied up and overpowered, he was at first noisy and violent, but soon lay down peacefully, a sign, according to the hunters, that his death was at hand. Their prognostication was correct; he continued for about twelve hours to cover himself with dust like the others, and to moisten it with water from his trunk; but at length he lay exhausted, and died so calmly, that having been moving but a few moments before, his death was only perceived by the myriads of black flies by which his body was almost instantly covered, although not one was visible a moment before.1

But this peculiarity is not confined to rogue elephants. Thus Captain Yule, in his 'Narrative of an Embassy to Ava in 1855,' records an illustration of this tendency of the elephant to sudden death. One newly captured, the process of taming which was exhibited to the British Envoy, 'made vigorous resistance to the placing of a collar on its neck, and the people were proceeding to tighten it, when the elephant, which had lain down as if quite exhausted, reared suddenly on the hind quarters, and fell on its side—dead!'

Mr. Strachan noticed the same liability of the elephants to sudden death from very slight causes. 'Of the

¹ Natural History of Ceylon, p. 196.

fall,' he says, 'at any time, though on plain ground, they either die immediately, or languish till they die; their great weight occasioning them so much hurt by the fall.' 1

And Sir E. Tennent observes that,-

In the process of taming, the presence of the tame ones can generally be dispensed with after two months, and the captive may then be ridden by the driver alone; and after three or four monthshe may be entrusted with labour, so far as regards docility; but it is undesirable, and even involves the risk of life, to work an elephant too soon; it has frequently happened that a valuable animal has lain down and died the first time it was tried in harness, from what the natives believed to be 'broken heart,' certainly without any cause inferable from injury or previous disease.²

Nor is this tendency to die under the influence of mere emotion restricted to the effect of a 'broken heart;' it seems also to occur under the power of strong emotional disturbances of other kinds. For instance, an elephant caught and trained by Mr. Cripps is thus alluded to by Sir E. Tennent:—

This was the largest elephant that had been tamed in Ceylon; he measured upwards of nine feet at the shoulders, and belonged to the caste so highly prized for the temples. He was gentle after his first capture, but his removal from the corral to the stables, though only a distance or six miles, was a matter of the extremest difficulty; his extraordinary strength rendering him more than a match for the attendant decoys. He on one occasion escaped, but was recaptured in the forest; and he afterwards became so docile as to perform a variety of tricks. He was at length ordered to be removed to Colombo; but such was his terror on approaching the fort, that on coaxing him to enter the gate he became paralysed in the extraordinary way elsewhere alluded to, and died on the spot.

General Intelligence.

The higher mental faculties of the elephant are more advanced in their development than in any other animal, except the dog and monkey. I shall, therefore, devote

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¹ Phil. Trans., A.D. 1701, vol. xxiii., p. 1052.

² Loc. cit., p. 216.

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some considerable space to the narration of instances of its display. The general fact that elephants are habitually employed in certain parts of India for the purposes of building, storing timber, &c., in itself shows a level of docile intelligence which only that of the dog can rival; but I shall here confine myself to stating special instances of the display of sagacity unusually high, even for the elephant.

Capt. Shipp, in his 'Memoirs,' gives the following incident, of which he was an eye-witness. During a march with guns in the mountainous districts of India, the force of which he was a member came to a steep ascent. A staircase of logs was prepared to enable the elephants to ascend the slope. When all was ready the first elephant

was led to the bottom of the staircase:-

He looked up, shook his head, and when forced by his driver, roared piteously. There can be no question, in my opinion, but that this sagacious animal was competent instinctively to judge of the practicability of the artificial flight of steps thus constructed; for the moment some little alteration had been made, he seemed willing to approach. He then commenced his examination and scrutiny by pressing with his trunk the trees that had been thrown across; and after this he put his fore-leg on with great caution. . . . The next step for him to ascend by was a projecting rock, which he could not remove. Here the same sagacious examination took place, the elephant keeping his flat side close to the side of the trunk, and leaning against it. The next step was against a tree, but this, on the first pressure of his trunk, he did not like. driver made use of the most endearing epithets, such as 'Wonderful,' 'My life,' 'Well done, my dear,' 'My dove,' 'My son,' 'My wife;' but all these endearing appellations, of which elephants are so fond, would not induce him to try again. Force was at length resorted to, and the elephant roared terrifically, but would not move.

Something was then altered, the elephant was satisfied, and at last succeeded in mounting to the top of the staircase:—

On reaching the top his delight was visible in a most eminent degree; he caressed his keepers, and threw dirt about in a most playful manner. Another elephant, a much younger animal, had now to follow. He had watched the ascent of the other with the utmost interest, making motions all the while as though he was assisting him by shouldering him up the acclivity, in such gestures as I have seen some men make when spectators of gymnastic exercises. When he saw his comrade up, he evinced his pleasure by giving a salute something like the sound of a trumpet. When called upon to take his turn, however, he seemed much alarmed, and would not act at all without force.

After a performance similar to that of the previous elephant, however, he too neared the top, when 'the other, who had already performed his task, extended his trunk to the assistance of his brother in distress, round which the younger animal entwined his, and thus reached the summit.' There was then a cordial greeting between the two animals, 'as if they had been long separated from each other, and had just escaped from some perilous achievement. They mutually embraced each other, and stood face to face for a considerable time, as if whispering congratulations.'

Mr. Jesse says: 'I was one day feeding the poor elephant (who was so barbarously put to death at Exeter Change) with potatoes, which he took out of my hand. One of them, a round one, fell on the floor, just out of reach of his proboscis.' After several ineffectual attempts to reach it, 'he at length blew the potato against the opposite wall with sufficient force to make it rebound, and he then without difficulty secured it.'2

This remarkable observation has fortunately been corroborated by Mr. Darwin. He writes:—

I have seen, as I dare say have others, that when a small object is thrown on the ground beyond the reach of one of the elephants at the Zoological Gardens, he blows through his trunk on the ground beyond the object, so that the current reflected on all sides may drive the object within his reach.³

The observation has also been corroborated by other observers.4

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¹ Memoirs, vol. ii., p. 64 et seq.

² Jesse, Gleanings in Natural History, vol. i., p. 19.

³ Descent of Man, p. 96.

See Animal Kingdom, vol. iii., p. 374.

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l. i., p. 19.

The following is quoted from Mr. Watson's book: 1-

Of the elephant's sense and judgment the following instance is given as a well-known fact in a letter of Dr. Daniel Wilson, Bishop of Calcutta, to his son in England, printed in a Life of the bishop, published a few years ago. An elephant belonging to an Engineer officer in his diocese had a disease in his eyes, and had for three days been completely blind. His owner asked Dr. Webb, a physician intimate with the bishop, if he could do anything for the relief of the animal. Dr. Webb replied that he was willing to try, on one of the eyes, the effect of nitrate of silver, which was a remedy commonly used for similar diseases in the human eye. The animal was accordingly made to lie down, and when the nitrate of silver was applied, uttered a terrific roar at the acute pain which it occasioned. But the effect of the application was wonderful, for the eye was in a great degree restored, and the elephant could partially see. The doctor was in consequence ready to operate similarly on the other eye on the following day; and the animal, when he was brought out and heard the doctor's voice, lay down of himself, placed his head quietly on one side, curled up his trunk, drew in his breath like a human being about to endure a painful operation, gave a sigh of relief when it was over, and then, by motions of his trunk and other gestures, gave evident signs of wishing to express his gratitude. Here we plainly see in the elephant memory, understanding, and reasoning from one thing to another. The animal remembered the benefit that he had felt from the application to one eye, and when he was brought to the same place on the following day and heard the operator's voice, he concluded that a like service was to be done to his other eye.

The fact that elephants exhibit this sagacious fortitude under surgical operations—thus resembling, as we shall afterwards observe, both dogs and monkeys—is corroborated by another instance given in Bingley's 'Animal Biography,' and serves to render credible the following story given in the same work:—

In the last war in India a young elephant received a violent wound in its head, the pain of which rendered it so frantic and ungovernable that it was found impossible to persuade the mimal to have the part dressed. Whenever any one approached

¹ Reasoning Power of Animals, pp. 54-5.

² Bingley, Animal Biography, vol. i., p. 155.

it ran off with fury, and would suffer no person to come within several yards of it. The man who had care of it at length hit upon a contrivance for securing it. By a few words and signs he gave the mother of the animal sufficient intelligence of what was wanted; the sensible creature immediately seized her young one with her trunk, and held it firmly down, though groaning with agony, while the surgeon completely dressed the wound; and she continued to perform this service every day till the animal was perfectly recovered.

Again, as still further corroboration of this point, I may quote the following from Sir E. Tennent's 'Natural History of Ceylon:'—

Nothing can more strongly exhibit the impulse to obedience in the elephant than the patience with which, at the order of his keeper, he swallows the nauseous medicines of the native elephant-doctors; and it is impossible to witness the fortitude with which (without shrinking) he submits to excruciating surgical operations for the removal of tumours and ulcers to which he is subject, without conceiving a vivid impression of his gentleness and intelligence. Dr. Davy when in Ceylon was consulted about an elephant in the Government stud, which was suffering from a deep, burrowing sore in the back, just over the back-bone, which had long resisted the treatment ordinarily employed. He recommended the use of the knife, that issue might be given to the accumulated matter, but no one of the attendants was competent to undertake the operation. 'Being assured,' he continues, 'that the creature would behave well, I undertook it myself. The elephant was not bound, but was made to kneel down at his keeper's command; and with an amputating knife, using all my force, I made the incision required through the tough integuments. The elephant did not flinch, but rather inclined towards me when using the knife; and merely uttered a low, and as it were suppressed groan. In short, he behaved as like a human being as possible, as if conscious (as I believe he was) that the operation was for his good, and the pain unavoidable.

Major Skinner witnessed the following display of intelligent action by a large herd of wild elephants. During the hot season at Nenera Kalama the elephants have a difficulty in finding water, and are therefore

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¹ Bingley, Animal Biography, vol. i., p. 155.

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obliged to congregate in large numbers where water is to be obtained. Being stationed near a water supply, and knowing that a large herd of elephants were in the neighbourhood, Major Skinner resolved to watch their proceedings. On a moonlight night, therefore, he

climbed a tree about four hundred yards from the water, and waited patiently for two hours before he heard or saw anything of the elephants. At length he saw a huge beast issue from the wood, and advance cautiously across the open ground to within a hundred yards of the tank, where he stood perfectly motionless; and the rest of the herd, meanwhile, were so quiet that not the least sound was to be heard from them. Gradually, at three successive advances, halting some minutes after each, he moved up to the water's edge, in which, however, he did not think proper to quench his thirst, but remained for several minutes listening in perfect stillness. He then returned cautiously and slowly to the point at which he had issued from the wood, from whence he came back with five other elephants, with which he proceeded, somewhat less slowly than before, to within a few yards of the tank, where he posted them as patrols. He then re-entered the wood and collected the whole herd, which must have amounted to between eighty and a hundred, and led them across the open ground with the most extraordinary composure and quiet till they came up to the five sentinels, when he left them for a moment, and again made a reconnaissance at the edge of the tank. At last, being apparently satisfied that all was safe, he turned back, and obviously gave the order to advance; 'for in a moment,' says Major Skinner, 'the whole herd rushed to the water with a degree of unreserved confidence so opposite to the caution and timidity which had marked their previous movements, that nothing will ever persuade me that there was not rational and preconcerted 60-operation throughout the whole party, and a degree of responsible authority exercised by the patriarch-leader.' I

Mr. H. L. Jenkins writes to me:-

What I particularly wish to observe is that there are good reasons for supposing that elephants possess abstract ideas; for instance, I think it is impossible to doubt that they acquire through their own experience notions of hardness and weight, and the grounds on which I am led to think this are as follows.

¹ See his letter to Sir E. Tennent in Nat. Hist. of Ceylon, pp. 118-20.

A captured elephant after he has been taught his ordinary duty. say about three months after he is taken, is taught to pick up things from the ground and give them to his mahout sitting on his shoulders. Now for the first few months it is dangerous to require him to pick up anything but soft articles, such as clothes, because the things are often handed up with consider. After a time, longer with some elephants than others, they appear to take in a knowledge of the nature of the things they are required to lift, and the bundle of clothes will be thrown up sharply as before, but heavy things, such as a crowbar or piece of iron chain, will be handed up in a gentle manner; a sharp knife will be picked up by its handle and placed on the elephant's head, so that the mahout can also take it by the handle. I have purposely given elephants things to lift which they could never have seen before, and they were all handled in such a manner as to convince me that they recog. nised such qualities as hardness, sharpness, and weight. You are quite at liberty to make any use of these remarks you please if they are of service.

Again, as Dr. Lindley Kemp observes, 'the manner in which tame elephants assist in capturing wild ones affords us an instance of reasoning in an animal,'&c.; and similarly, Mr. Darwin observes: 'It is, I think, impossible to read the account given by Sir E. Tennent of the behaviour of the female elephants used as decoys, without admitting that they intentionally practise deceit.'2

The following is an extract from the more interesting of the observations to which Mr. Darwin here alludes, and I think it is impossible to read them without assenting to his judgment. Several herds of wild elephants having been driven into a corral, two tame decoys were ridden into it:—

One was of prodigious age, having been in the service of the Dutch and English Governments in succession for upwards of a century. The other, called by her keeper 'Siribeddi,' was about fifty years old, and distinguished for gentleness and docility. She was a most accomplished decoy, and evinced the utmost relish for the sport. Having entered the corral noise lessly, carrying a mahout on her shoulders with the headman of

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¹ Indications of Instinct, p. 129.

² Descent of Man, p. 69.

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the noosers seated behind him, she moved slowly along with a gy composure and an assumed air of easy indifference; sauntering leisurely in the direction of the captives, and halting now and then to pluck a bunch of grass or a few leaves as she passed. As the approached the herd they put themselves in motion to meet her, and the leader, having advanced in front and passed his munk gently over her head, turned and paced slowly back to is dejected companions. Siribeddi followed with the same istless step, and drew herself up close behind him, thus affordthe nooser an opportunity to stoop under her and slip the mose over the hind foot of the wild one. The latter instantly erceived his danger, shook off the rope, and turned to attack he man. He would have suffered for his temerity had not wibeddi protected him by raising her trunk and driving the sailant into the midst of the herd, when the old man, being whily wounded, was helped out of the corral, and his son, langhanie, took his place.

The herd again collected in a circle, with their heads wards the centre. The largest male was singled out, and no tame ones pushed boldly in, one on either side of him, till three stood nearly abreast. He made no resistance, but strayed his uneasiness by shifting restlessly from foot to foot. anghanie now crept up, and holding the rope open with both ands (its other extremity being made fast to Siribeddi's collar), d watching the instant when the wild elephant lifted its id foot, succeeded in passing the noose over its leg, drew it me, and fled to the rear. The two tame elephants instantly back, Siribeddi stretched the rope to its full length, and more interesting hist she dragged out the captive, her companion placed here alludes, and inself between her and the herd to prevent any inter-

elephants having In order to tie him to a tree he had to be drawn back-ecoys were ridden was some twenty or thirty yards, making furious resistance, lowing in terror, plunging on all sides, and crushing the aller timber, which bent like reeds beneath his clumsy in the service of the nggles. Siribeddi drew him steadily after her, and wound ssion for upwards of rope round the proper tree, holding it all the time at its er 'Siribeddi,' was Itension, and stepping cautiously across it when, in order to gentleness and docine it a second turn, it was necessary to pass between the tree y, and evinced the other tree of the elephant. With a coil round the stem, however, it is beyond her strength to haul the prisoner close up, which with the headman of the property of the difficulty results that the second town one processing the difficulty results that the second town one processing the difficulty results that the second town one processing the difficulty results. but the second tame one, perceiving the difficulty, remed from the herd, confronted the struggling prisoner,

pushed him shoulder to shoulder, and head to head, forcing him backwards, whilst at every step Siribeddi hauled in the slackened rope till she brought him fairly up to the foot of the tree, where he was made fast by the cooroowe people. second noose was then passed over the other hind-leg, and secured like the first, both legs being afterwards hobbled to gether by ropes made from the fibre of the kitool or jagger palm, which, being more flexible than that of the cocoa-nut occasions less formidable ulcerations. The two decoys the ranged themselves, as before, abreast of the prisoner on eithe side, thus enabling Ranghanie to stoop under them and noon the two fore-feet as he had already done the hind; and the ropes being made fast to the tree in front, the capture wa complete, and the tame elephants and keepers withdrew

repeat the operation on another of the herd.

The second victim singled out from the herd was secured the same manner as the first. It was a female. The tan ones forced themselves in on either side as before, cutting h off from her companions, whilst Ranghanie stooped under the and attached the fatal noose, and Siribeddi dragged her of amidst unavailing struggles, when she was made fast by ea leg to the nearest group of strong trees. When the noose w placed upon her fore-foot, she seized it with her trunk, and su ceeded in carrying it to her mouth, where she would speedily ha severed it had not a tame elephant interfered, and placing his fi on the rope pressed it downwards out of her jaws. . . . T conduct of the tame ones during all these proceedings was true wing to wonderful. They displayed the most perfect conception every movement, both of the object to be attained and of dephant means to accomplish it. They manifested the utmost enjequence ment in what was going on. There was no ill-humour, lalged in malignity in the spirit displayed, in what was otherwise inging it heartless proceeding, but they set about it in a way that showed their d thorough relish for it, as an agreeable pastime. Their caut beir necl was as remarkable as their sagacity; there was no hurrying heir side confusion, they never ran foul of the ropes, were never in leads and way of the animals already noosed; and amidst the violent struggles, when the tame ones had frequently to across the captives, they in no instance trampled on them are to occasioned the slightest accident or annoyance. So far forth qu this, they saw intuitively a difficulty or a danger, and addresimber, h themselves unbidden to remove it. In tying up one of larger elephants, he contrived, before he could be hauled up to the tree, to walk once or twice round it, carrying

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rope with him; the decoy, perceiving the advantage he had thus gained over the nooser, walked up of her own accord, and pushed him backwards with her head, till she made him unwind himself again; upon which the rope was hauled tight and made fast. More than once, when a wild one was extending his trunk, and would have intercepted the rope about to be placed over his leg, Siribeddi, by a sudden motion of her own tunk, pushed his aside, and prevented him; and on one occasion, when successive efforts had failed to put the noose over the fore-leg of an elephant which was already secured by one foot, but which wisely put the other to the ground as often as it was attempted to pass the noose under it, I saw the decoy watch her opportunity, and when his foot was again raised, suddenly push in her own leg beneath it, and hold it up till the noose was attached and drawn tight.

One could almost fancy there was a display of dry humour in the manner in which the decoys thus played with the fears of the wild herd, and made light of their efforts at resistance. When reluctant they shoved them forward, when violent they move them back; when the wild ones threw themselves down, the tame ones butted them with head and shoulders, and forced them up again. And when it was necessary to keep them down, they knelt upon them, and prevented them from rising,

ill the ropes were secured.

At every moment of leisure they fanned themselves with a ed, and placing his for bunch of leaves, and the graceful ease with which an elephant f her jaws. . . . T sees his trunk on such occasions is very striking. It is doubtless proceedings was true owing to the combination of a circular with a horizontal moveperfect conception ment in that flexible limb; but it is impossible to see an oe attained and of dephant fanning himself without being struck by the singular ted the utmost enjoyee are degance of motion which he displays. The tame ones, too, inthed the utmost engagement of motion which he displays. The tame ones, too, invas no ill-humour, sugged in the luxury of dusting themselves with sand, by what was otherwise finging it from their trunks; but it was a curious illustration; in a way that shows of their delicate sagacity, that so long as the mahout was on astime. Their caut their necks, they confined themselves to flinging the dust along their sides and stomach, as if aware that to throw it over their opes, were never in the sand and back would cause annoyance to their riders. I have a midst the next the sand stomach as if a ware that the sand and back would cause annoyance to their riders.

had frequently to se Sir E. Tennent has also some observations on other trampled on them sees to which tame elephants are put, which are well anoyance. So far forth quoting. Thus, speaking of the labour of piling a danger, and address inber, he says that the elephant

Natural History of Ceylon, pp. 181-94.

manifests an intelligence and dexterity which are surprising to a stranger, because the sameness of the operation enables the animal to go on for hours disposing of log after log, almost without a hint or direction from his attendant. For examp' two elephants employed in piling ebony and satinwood in the yards attached to the commissariat stores at Colombo, were so accustomed to their work, that they were able to accomplish it with equal precision and with greater rapidity than if i had been done by dock-labourers. When the pile attained a certain height, and they were no longer able by their conjoint efforts to raise one of the heavy logs of ebony to the summit, they had been taught to lean two pieces against the heap, up the inclined plane of which they gently rolled the remaining logs, and placed them trimly on the top.

It has been asserted that in their occupations 'elephants are to a surprising extent the creatures of habit,' that their move. ments are altogether mechanical, and that 'they are annoyed by any deviation from their accustomed practice, and resent any constrained departure from the regularity of their course. So far as my own observation goes, this is incorrect; and I am assured by officers of experience, that in regard to changing his treatment, his hours or his occupation, an elephant evinces no more consideration than a horse, but exhibits the same pliance

and facility. At one point, however, the utility of the elephant stops Such is the intelligence and earnestness he displays in work, which he seems to conduct almost without supervision that it has been assumed that he would continue his labour and accomplish his given task, as well in the absence of his keeper as during his presence. But here his innate love of ease displays itself, and if the eye of his attendant be withdrawn the moment he has finished the thing immediately in hand, he will stroll away lazily, to browse or enjoy the luxury of fanning himself and blowing dust over his back.

The means of punishing so powerful an animal is a question of difficulty to his attendants. Force being almost inapplicable they try to work on his passions and feelings, by such ex pedients as altering the nature of his food or withholding i altogether for a time. On such occasions the demeanour of the creature will sometimes evince a sense of humiliation as well as of discontent. In some parts of India it is customary, it dealing with offenders, to stop their allowance of sugar cane or of jaggery; or to restrain them from eating their own share of fodder and leaves till their companions shall have finished

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and in such cases the consciousness of degradation betrayed by the looks and attitudes of the culprit is quite sufficient to identify him, and to excite a feeling of sympathy and pity.

The elephant's obedience to his keeper is the result of affection, as well as of fear; and although his attachment becomes so strong that an elephant in Ceylon has been known to remain out all night, without food, rather than abandon his mahout, lying intoxicated in the jungle, yet he manifests little difficulty in yielding the same submission to a new driver in the event of a change of attendants.

Lastly, Sir E. Tennent writes:-

One evening, whilst riding in the vicinity of Candy, towards the scene of the massacre of Major Dabies' party in 1803, my horse evinced some excitement at a noise which approached us in the thick jungle, and which consisted of a repetition of the ejaculation urmph / urmph / in a hoarse and dissatisfied tone. A turn in the forest explained the mystery, by bringing us face to face with a tame elephant, unaccompanied by any attendant. He was labouring painfully to carry a heavy beam of timber, which he balanced across his tusks, but, the pathway being parrow, he was forced to bend his head to one side to permit it to pass endways; and the exertion and this inconvenience combined led him to utter the dissatisfied sounds which disturbed the composure of my horse. On seeing us halt, the elephant raised his head, reconnoitred us for a moment, then fung down the timber, and voluntarily forced himself backwards among the brushwood so as to leave a passage, of which he expected us to avail ourselves. My horse hesitated: the dephant observed it, and impatiently thrust himself deeper into the jungle, repeating his cry of urmph / but in a voice evidently meant to encourage us to advance. Still the horse trembled; and, anxious to observe the instinct of the two agacious animals, I forebore any interference: again the dephant of his own accord wedged himself further in amongst the trees, and manifested some impatience that we did not pass lim. At length the horse moved forward; and when we were airly past, I saw the wise creature stoop and take up its heavy burden, trim and balance it on its tusks, and resume its route s before, hoarsely snorting its discontented remonstrance.

ance of sugar canes Dr. Erasmus Darwin records an observation which ting their own share was communicated to him by a 'gentleman of undoubted

¹ Natural History of Ceylon, pp. 181-94.

veracity,' of an elephant in India which the keeper was in the habit of leaving to play the part of nurse to his child when he and his wife had occasion to go away from home. The elephant was chained up, and whenever the child in its creeping about came to the end of the elephant's tether, he used gently to draw it back again with his trunk.

In 'Nature,' vol. xix., p. 385, Mr. J. J. Furniss writes:—

In Central Park one very hot day my attention was drawn to the conduct of an elephant which had been placed in an enclosure in the open air. On the ground was a large heap of newly-mown grass, which the sagacious animal was taking up by the trunkful, and laying carefully upon his sun-heated back. He continued the operation until his back was completely thatched, when he remained quiet, apparently enjoying the result of his ingenuity.

Mr. Furniss in a later communication (vol. xx., p. 21) continues:—

Since the publication of my former letter (as above), I have received additional data bearing on the subject from Mr. W. A. Conklin, the superintendent of the Central Park I am informed by him that he has frequently observed elephants, when out of doors in the hot sunshine, thatch their backs with hay or grass; that they do so to a certain extent when under cover in the summer time, and when the flies which then attack the animals, often so fiercely as to draw blood, are particularly numerous; but that they never attempt to thatch their backs in winter. This seems to prove that they act intelligently for the attainment of a definite end. It would be interesting to learn whether elephants in their wild state are in the habit of so thatching their backs. It seems more probable to suppose that in their native wilds they would avail themselves of the natural shade afforded by the jungle, and that the habit is one which has been developed in consequence of their changed surroundings in captivity.

Mr. G. E. Peal writes to 'Nature' (vol. xxi., p. 34):-

One evening, soon after my arrival in Eastern Assam, and while the five elephants were as usual being fed opposite the bungalow, I observed a young and lately caught one step up to a bamboo-stake fence, and quietly pull one of the stakes up.

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Placing it under foot, it broke a piece off with the trunk, and after lifting it to its mouth threw it away. It repeated this twice or thrice, and then drew another stake and began again. Seeing that the bamboo was old and dry I asked the reason of this, and was told to wait and see what it would do. At last it seemed to get a piece that suited, and holding it in the trunk firmly, and stepping the left fore-leg well forward, passed the piece of bamboo under the armpit, so to speak, and began to scratch with some force. My surprise reached its climax when I saw a large elephant leech fall on the ground, quite six inches long and thick as one's finger, and which, from its position, could not easily be detached without this scraper or scratcher which was deliberately made by the elephant. I subsequently found that it was a common occurrence. Such scrapers are used by every elephant daily.

On another occasion, when travelling at a time of the year when the large flies are so tormenting to an elephant, I noticed that the one I rode had no fan or wisp to beat them off with. The mahout, at my order, slackened pace and allowed her to go to the side of the road, when for some moments she moved along rummaging the smaller jungle on the bank; at last she came to a cluster of young shoots well branched, and after feeling among them and selecting one, raised her trunk and neatly stripped down the stem, taking off all the lower branches and leaving a fine bunch on top. She deliberately cleaned it down several times, and then laying hold at the lower end broke off a beautiful fan or switch about five feet long, handle included. With this she kept the flies at bay as we went along, flapping them off on each side.

Say what we may, these are both really bond fide implements, each intelligently made for a definite purpose.

My friend Mrs. A. S. H. Richardson sends me the following. The Rev. Mr. Townsend, who narrated the episode, is personally known to her:—

An elephant was chained to a tree in the compound opposite Mr. Townsend's house. Its driver made an oven at a short distance, in which he put his rice-cakes to bake, and then overed them with stones and grass and went away. When he was gone, the elephant with his trunk unfastened the chain round his foot, went to the oven and uncovered it, took out and ate the cakes, re-covered the oven with the stones and grass as before, and went back to his place. He could not

fasten the chain again round his own foot, so he twisted it round and round it, in order to look the same, and when the driver returned the elephant was standing with his back to the oven. The driver went to his cakes, discovered the theft, and, looking round, caught the elephant's eye as he looked back over his shoulder out of the corner of it. Instantly he detected the culprit, and condign punishment followed. The whole occurrence was witnessed from the windows by the family

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CHAPTER XIV.

THE CAT.

THE cat is unquestionably a highly intelligent animal, though when contrasted with its great domestic rival, the dog, its intelligence, from being cast in quite a different mould, is very frequently underrated. Comparatively unsocial in temperament, wanderingly predaceous in habits. and lacking in the affectionate docility of the canine nature, this animal has never in any considerable degree been subject to those psychologically transforming influences whereby a prolonged and intimate association with man has, as we shall subsequently see, so profoundly modified the psychology of the dog. Nevertheless, as we shall immediately find, the cat is not only by nature an animal remarkable for intelligence, but in spite of its naturally imposed disadvantages of temperament, has not altogether escaped those privileges of nurture which unnumbered centuries of domestication could scarcely fail Thus, as contrasted with most of the wild to supply. species of the genus when tamed from their youngest days, the domestic cat is conspicuously of less uncertain temper towards its masters—the uncertainty of temper displayed by nearly all the wild members of the feline tribe when tamed being, of course, an expression of the interference of individual with hereditary experience. contrasted with all the wild species of the genus when tamed, the domestic cat is conspicuous in alone manifesting any exalted development of affection towards the human kind; for in many individual cases such affection, under favouring circumstances, reaches a level fully comparable to that which it attains in the dog. We do not know the wild stock from which the domestic cat originally sprang, and therefore cannot estimate the extent of the psychological results which human agency has here produced; but it is worth while in this connection to remember that the nearest ally of the domestic cat is the wild cat, and that this animal, while so closely resembling its congener in size and anatomical structure, differs so enormously from it in the branch of psychological structure which we are considering, that there is no animal on the

face of the earth so obstinately untamable.

As regards the wild species of the tribe in general, it may be said that they all exhibit the same unsocial, fierce, and rapacious character. Bold when brought to bay, they do not court battle with dangerous antagonists, but prefer to seek safety in flight. Even the proverbial courage of the lion is now known, as a rule, to consist in 'the better part of valour; and those exceptional individuals among tigers which adopt a 'man-eating' propensity, snatch their human victims by stealth. That the larger feline animals possess high intelligence would be shown, even in the absence of information concerning their ordinary habits, by the numerous tricks which they prove themselves capable of learning at the hands of menageriekeepers; though in such cases the conflict of nature with nurture renders even the best-trained specimens highly uncertain in their behaviour, and therefore always more or less dangerous to the 'lion-kings.' The only wild species that is employed for any practical purpose—the cheetah —is so employed by utilising directly its natural instincts; it is shown the antelope, and runs it down after the manner of all its ancestors.

Returning now to the domestic cat, it is commonly remarked as a peculiar and distinctive trait in its emotional character that it shows a strongly rooted attachment to places as distinguished from persons. There can be no question that this peculiarity is a marked feature in the psychology of domestic cats considered as a class, although of course individual exceptions occur in abundance. Probably this feature is a survival of an instinctive attachment to dens or lairs bequeathed to our cats by their wild progenitors.

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The only other feature in the emotional life of cats which calls for special notice is that which leads to their universal and proverbial treatment of helpless prey. The feelings that prompt a cat to torture a captured mouse can only, I think, be assigned to the category to which by common consent they are ascribed-delight in torturing for torture's sake. Speaking of man, John S. Mill somewhere observes that there is in some human beings a special faculty or instinct of cruelty, which is not merely a passive indifference to the sight of physical sufferings, but an active pleasure in witnessing or causing it. Now, so far as I have been able to discover, the only animals in which there is any evidence of a class of feelings in any way similar to these-if, indeed, in the case even of such animals the feelings which prompt actions of gratuitous cruelty really are similar to those which prompt it in manare cats and monkeys. With regard to monkeys I shall adduce evidence on this point in the chapter which treats of these animals. With regard to cats it is needless to dwell further upon facts so universally known.

General Intelligence.

Coming now to the higher faculties, it is to be noted as a general feature of interest that all cats, however domesticated they may be, when circumstances require it, and often even quite spontaneously, throw off with the utmost ease the whole mental clothing of their artificial experience, and return in naked simplicity to the natural habits of their ancestors. readiness of cats to become feral is a strong expression of the shallow psychological influence which prolonged domestication has here exerted, in comparison with that which it has produced in the case of the dog. A pet terrier lost in the haunts of his ancestors is almost as pitiable an object as a babe in the wood; a pet cat under similar circumstances soon finds itself quite at home. The reason of this difference is, of course, that the psychology of the cat, never having lent itself to the practical uses of, and intelligent dependency on, man, has never, as in the case of the dog, been under the cumulative influence of human agency in becoming further and further bent away from its original and naturally imposed position of selfreliance; so that when now a severance takes place between a cat and its human protectors, the animal, inheriting unimpaired the transmitted experience of wild progenitors, knows very well how to take care of itself.

Having made these general remarks, I shall now pass on to quote a few instances showing the highest level of

intelligence to which cats attain.

As to observation, Mrs. Hubbard tells me of a cat which she possessed, and which was in the habit of poaching young rabbits to 'eat privately in the seclusion of a disused pigsty.' One day this cat caught a small black rabbit, and instead of eating it, as she always did the brown ones, brought it into the house unhurt, and laid it at the feet of her mistress. 'She clearly recognised the black rabbit as an unusual specimen, and apparently thought it right to show it to her mistress.' Such was 'not the only instance this cat showed of zoological discrimination,' for on another occasion, 'having caught another unusual animal—viz., a stoat—she also brought this alive into the house for the purpose of exhibiting it.'

Mr. A. Percy Smith informs me of a cat which he possesses, and which, to test her intelligence, he used to punish whenever her kittens misbehaved. Very soon this had the effect of causing the cat herself to train the kittens, for whenever they misbehaved 'she swore at them and boxed their ears, until she taught the kittens to be

clean.

Mr. Blackman, writing from the London Institution, tells me of a cat which he has, and which without tuition began to 'beg' for food, in imitation of a terrier in the same house whose begging gesture it must have observed to be successful in the obtaining of tit-bits. The cat, however, would never beg unless it was hungry;—

And no coaxing could persuade it to do so unless it felt so inclined. The same cat also, whenever it wanted to go out, would come into the sitting-room, and make a peculiar noise to attract

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unless it felt so to go out, would noise to attract attention. failing that mode being successful, it would pull one's dress with its claw; and then having succeeded in attracting the desired attention, it would walk to the street door and stop there, making the same cry until let out.

Coming now to cases indicative of reason in cats, Mr. John Martin, writing from St. Clement's, Oxford, informs me: 'I have a cat which a short time ago had kittens, and from some cause or other her milk failed. My house-keeper saw her carrying a piece of bread to them.' The process of reasoning here is obvious.

Mr. Bidie, writing from the Government Museum of Madras to 'Nature' (vol. xx., p. 96), relates this instance

of reasoning in a cat:

In 1877 I was absent from Madras for two months, and left in my quarters three cats, one of which, an English tabby, was a very gentle and affectionate creature. During my absence the quarters were occupied by two young gentlemen, who delighted in teasing and frightening the cats. About a week before my return the English cat had kittens, which she carefully concealed behind bookshelves in the library. On the morning of my return I saw the cat, and patted her as usual, and then left the house for about an hour. On returning to dress I found that the kittens were located in a corner of my dressing-room, where previous broods had been deposited and nursed. On questioning the servant as to how they came there, he at once replied, 'Sir, the old cat taking one by one in her mouth, brought them here.' In other words, the mother had carried them one by one in her mouth from the library to the dressing-room, where they lay quite exposed. I do not think I have heard of a more remarkable instance of reasoning and affectionate confidence in an animal, and I need hardly say that the latter manifestation give me great pleasure. The train of reasoning seems to have been as follows: 'Now that my master has returned there is no risk of the kittens being injured by the two young savages in the house, so I will take them out for my protector to see and admire, and keep them in the corner in which all my former pets have been nursed in safety.'

Dr. Bannister writes me from Chicago, of a cat belonging to his friend the late Mr. Meek, the palæontologist, who drew my correspondent's attention to the fact:—

He had fixed upright on his table a small looking-glass, from

which he used to draw objects from nature, reversed on wood. The cat seeing her image in this glass made several attempts to investigate it, striking at it, &c. Then coming apparently to the conclusion that there was something between her and the other animal, she very slily and cautiously approached it, keeping her eye on it all the while, and struck her paw around behind the mirror, becoming seemingly much surprised at finding nothing there. This was done repeatedly, until she was at last convinced that it was beyond her comprehension, or she lost interest in the matter.

Mr. T. B. Groves communicates an almost precisely similar observation to 'Nature' (vol. xx., p. 291), of a cat which, on first seeing his own reflection in a mirror, tried to fight it. Meeting with resistance from the glass, the cat next ran behind the mirror. Not finding the object of his search, he again came to the front, and while keeping his eyes deliberately fixed on the image, felt round the edge of the glass with one paw, whilst with his head twisted round to the front he assured himself of the persistence of the reflection. He never afterwards condescended to notice a mirror.

The following is communicated to me by a correspondent whose name I cannot obtain permission to publish. I am sure, however, that it is communicated in good faith, and the incident can scarcely be supposed to have been due to accident. After describing the cat and the parrot in their amiable relationship, my correspondent proceeds:—

One evening there was no one in the kitchen. Cook had gone upstairs, and left a bowl full of dough to rise by the fire. Shortly after, the cat rushed up after her, mewing, and making what signs she could for her to go down; then she jumped up and seized her apron, and tried to drag her down. As she was in such a state of excitement cook went, and found 'Polly' shricking, calling out, flapping her wings and struggling violently, 'up to her knees' in dough, and stuck quite fast.

No doubt if she had not been rescued she would have sunk in the morass and been smothered.

I shall here introduce two or three cases to show the ingenious devices to which clever cats will resort for the purpose of capturing prey.

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Mr. James Hutchings writes in 'Nature' (vol. xii., p. 330) an account of an old tom cat using a young bird, which had fallen out of its nest, as a decoy for the old birds. The cat touched the young bird with his paw when it ceased to flutter and cry, in order that, by thus making it display its terror, the old cock bird, which was all the while flying about in great consternation, might be induced to approach near enough to be caught. Many times the cock bird did so, and the cat made numerous attempts to catch it, but without success. All the while a kitten had to be kept from killing the young bird. As this scene continued for a long time—in fact, till terminated by Mr. Hutchings—and as there does not appear to have been any opportunity for errors of observation, I think the case worth recording.

The following case is communicated to me by Mr. James G. Stevens, of St. Stephen, New Brunswick:—

Looking out on the garden in front of my residence, I observed a robin alight on a small tree: it was midwinter, the ground covered with about a foot of light snow. A cat came stealthily along, with difficulty making her way through the snow until within about three feet of the tree where the bird was; the robin was sluggishly resting on a twig distant three feet from the ground or surface of snow; the cat could not well, owing to the softness of the snow, venture to make a spring. crouched down and at first gently stirred herself, evidently with the purpose of causing the bird to move. The first attempt failed. She again more actively stirred herself by a shaking motion. She again failed, when she stirred herself vigorously again and started the bird, which flew about fifty feet away, and alighted on a small low bush on the northern side of a closeboarded fence. The cat keenly watched the flight and the alighting of the bird; as quickly as she could cross through the snow, she then took a circuit of about one hundred feet, watching the place where the bird was all the while, and covering her march by making available every bush to hide her. When out of range of vision of the bird she more actively made for the fence, leaped over it, came up on the southern side of it, and jumped on it, calculating her distance so accurately that she came within a foot of the bush where the bird was, and at once sprung. She missed her prey, but I thought she proved herself a cunning hunter. If this case is worth relating you may use the name of Judge Stevens, of St. Stephen, New Brunswick, as a witness to the same.

Again, I quote the following case communicated to 'Nature' by Dr. Frost, because, although it shows an almost incredible amount of far-sighted stratagem, I cannot on the one hand see much room for mal-observation, and on the other hand it is, as I shall show, to some extent corroborated by an independent observation of my friend Dr. Klein, and another correspondent:—

Our servants have been accustomed during the late frost to throw the crumbs remaining from the breakfast-table to the birds, and I have several times noticed that our cat used to wait there in ambush in the expectation of obtaining a hearty meal from one or two of the assembled birds. Now, so far, this circumstance in itself is not an 'example of abstract reasoning.' But to continue. For the last few days this practice of feeding the birds has been left off. The cat, however, with an almost incredible amount of forethought, was observed by myself, together with two other members of the household, to scatter crumbs on the grass with the obvious intention of enticing the birds.¹

Although this account, as I have said, borders on the incredible, I have allowed it to pass, because up to a certain point it is, as I have also said, corroborated by an observation communicated to me by my friend Dr. Klein, F.R.S.

Dr. Klein satisfied himself that the cat he observed had established a definite association between crumbs already sprinkled on the garden walk, and sparrows coming to cat them; for as soon as the crumbs were sprinkled on the walk, the cat used to conceal himself from the walk in a neighbouring shrubbery, there to await in ambush the coming of the birds. The latter, however, showed themselves more wide awake than the cat, for there was a wal running behind the shrubbery, from the top of which the birds could see the cat in his supposed concealment, and then a long line of sparrows used to wait watching the cal and the crumbs at the same time, but never venturing to fly down to the latter until the former, wearied with waiting, went away. In this case the reasoning observation

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¹ Nature, vol. xix., p. 519.

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of the cat-crumbs attract birds, therefore I will wait for birds when crumbs are scattered '-was as complete as in the case of Dr. Frost's cat, but the reasoning in the latter case seems to have proceeded a stage furthertherefore I will scatter crumbs to attract birds.'

Now, in the face of the definite statement made by Dr. Frost, that his cat did advance to this further stage of reasoning, I have not felt justified in suppressing his remarkable observation. And, as lending still further credence to the account, I may quote the corroborative observation of another correspondent in 'Nature,' which is of value because forming an intermediate step between the intelligence displayed by Dr. Klein's cat and that displayed by Dr. Frost's. This correspondent says:—

A. case somewhat similar to that mentioned by Dr. Frost, of a cat scattering crumbs, occurred here within my own knowledge. During the recent severe winter a friend was in the habit of throwing crumbs outside his bedroom window. The family have a fine black cat, which, seeing that the crumbs brought birds, would occasionally hide herself behind some shrubs, and when the birds came for their breakfast, would pounce out upon them with varying success. The crumbs had been laid out as usual one afternoon, but left untouched, and during the night a slight fall of snow occurred. On looking out next morning my friend observed puss busily engaged scratching away the snow. Curious to learn what she sought, he waited, and saw her take the crumbs up from the cleared space and lay them one by one after another on the snow. After doing this she retired behind the shrubs to wait further developments. This was repeated on two other occasions.

Taking, then, these three cases together, we have an ascending series in the grades of intelligence from that displayed by Dr. Klein's cat, which merely observed that crumbs attracted birds, through that of the cat which exposed the concealed crumbs for the purpose of attracting birds, to that of Dr. Frost's cat, which actually sprinkled the crumbs. Therefore, although, if the last-mentioned or most remarkable case had stood alone, I should not have wearied with wait let justified in quoting it, as we find it thus led up to by soning observation ther and independent observations, I do not feel that I

¹ Nature, vol. xx., p. 197.

should be justified in suppressing it. And, after all, regarded as an act of reason, the sprinkling of crumbs to attract birds does not involve ideas or inferences very much more abstruse or remote than those which are concerned in some of the other and better corroborated instances of the display of feline intelligence, which I shall

now proceed to state.

In the understanding of mechanical appliances, cats attain to a higher level of intelligence than any other animals, except monkeys, and perhaps elephants. Doubtless it is not accidental that these three kinds of animals fall to be associated in this particular. The monkey in its hands, the elephant in its trunk, and the cat in its agile limbs provided with mobile claws, all possess instruments adapted to manipulation, with which no other organs in the brute creation can properly be compared, except the beak and toes of the parrot, where, as we have already seen, a similar correlation with intelligence may be traced. Probably, therefore, the higher aptitude which these animals display in their understanding of mechanical appliances is due to the reaction exerted upon their intelgence by these organs of manipulation. But, be this as it may, I am quite sure that, excepting only the monkey and elephant, the cat shows a higher intelligence of the special kind in question than any other animal, not forgetting even the dog. Thus, for instance, while I have only heard of one solitary case (communicated to me by a correspondent) of a dog which, without tuition, divined the use of a thumb-latch, so as to open a closed door by jumping upon the handle and depressing the thumb-piece, I have received some half-dozen instances of this display of intelligence on the part of cats. These instances are all such precise repetitions of one another, that I conclude the fact to be one of tolerably ordinary occurrence among cats, while it is certainly very rare among dogs. add that my own coachman once had a cat which, certainly without tuition, learnt thus to open a door that led into the stables from a yard into which looked some of the windows of the house. Standing at these windows when the cat did not see me, I have many times witnessed he

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modus operandi. Walking up to the door with a most matter-of-course kind of air, she used to spring at the half-hoop handle just below the thumb-latch. Holding on to the bottom of this half-hoop with one fore-paw, she then raised the other to the thumb-piece, and while depressing the latter, finally with her hind legs scratched and pushed the doorposts so as to open the door. cisely similar movements are described by my correspon-

dents as having been witnessed by them.

Of course in all such cases the cats must have previously observed that the doors are opened by persons placing their hands upon the handles, and, having observed this, the animals forthwith act by what may be strictly termed rational imitation. But it should be observed that the process as a whole is something more than imitative. For not only would observation alone be scarcely enough (within any limits of thoughtful reflection that it would be reasonable to ascribe to an animal) to enable a cat upon the ground to distinguish that the essential part of the process as performed by the human hand consists, not in grasping the handle, but in depressing the latch; but the cat certainly never saw any one, after having depressed the latch, pushing the doorposts with his legs; and that this pushing action is due to an originally deliberate intention of opening the door, and not to having accidentally found this action to assist the process, is shown by one of the cases communicated to me (by Mr. Henry A. Gaphaus); for in this case, my correspondent says, 'the door was not a loose-fitting one by any means, and I was surprised that by the force of one hind leg she should have been able to push it open after unlatching it.' Hence we can only conclude that the cats in such cases have a very definite idea as to the mechanical properties of a door; they know that to make it open, even when unlatched, it requires to be pushed—a very different thing from trying to imitate any particular action which they may see to be performed for the same purpose The whole psychological process, therefore, by man. implied by the fact of a cat opening a door in this way is really most complex. First the animal must have observed that the door is opened by the hand grasping the handle and moving the latch. Next she must reason, by 'the logic of feelings'-If a hand can do it, why not a paw? Then, strongly moved by this idea, she makes the The steps which follow have not been observed, so we cannot certainly say whether she learns by a succession of trials that depression of the thumb-piece constitutes the essential part of the process, or, perhaps more probably, that her initial observations supplied her with the idea of clicking the thumb-piece. But, however this may be, it is certain that the pushing with the hind feet after depressing the latch must be due to adaptive reasoning unassisted by observation; and only by the concerted action of all her limbs in the performance of a highly complex and most unnatural movement is her final purpose attained.

Again, several very similar cases are communicated to me of cats spontaneously, or without tuition, learning to knock knockers and ring bells. Of course in both cases the animals must have observed the use to which knockers and bells are put, and when desiring a door to be opened, employ these signals for the purpose. It betokens no small amount of observation and reasoning in a cat to jump at a knocker with the expectation of thereby summoning a servant to open the door—especially as in some of the cases the jump is not a random jump at the knocker, but a deliberate and complex action, having for its purposes the raising and letting fall of the knocker. For instance, Mr. Belshaw, writing to 'Nature' (vol. xix., p. 659), says:—

I was sitting in one of the rooms, the first evening there, and hearing a loud knock at the front door was told not to heed it, as it was only this kitten asking admittance. Not believing it, I watched for myself, and very soon saw the kitten jump on to the door, hang on by one leg, and put the other fore-paw right through the knocker and rap twice.

In such cases the action closely resembles that of opening thumb-latches, but clearly is performed with the purpose of summoning some one else to open the door. Wonderful, however, as these cases of summoning

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sembles that of performed with lse to open the es of summoning by knockers undoubtedly are, I think they are surpassed by other cases in which the instrument used is the bell. For here it is not merely that cats perfectly well understand the use of bells as calls, but I have one or two cases of cats jumping at bell-wires passing from outside into

1 Some of my correspondents tell me of pet or drawing-room cats jumping on chairs and looking at bells when they want milk—this being their sign that they want the bell pulled to call the servant who brings the milk; and Mr. Lawson Tait tells me that one of his cats—of course without tuition—has gone a step further, in that she places her paws upon the bell as a still more emphatic sign that she desires it pulled. But Dr. Creighton Browne tells me of a cat which he has that goes a step further than this, and herself rings the bell. This is corroborative of Archbishop Whately's anecdote. 'This cat lived many years in my mother's family, and its feats of sagacity were witnessed by her, my sisters, and myself. It was known, not merely once or twice, but habitually, to ring the parlour bell whenever it wished the door to be opened. Some alarm was excited on the first occasion that it turned bell-ringer. The family had retired to rest, and in the middle of the night the parlour bell was rung violently; the sleepers were startled from their repose, and proceeded downstairs with poker and tongs, to intercept, as they thought, the predatory movements of some burglar; but they were equally surprised to find that the bell had been rung by pussy, who frequently repeated the act whenever she wished to get out of the parlour.' The cases, however, mentioned in the text are more remarkable than any of these, which, nevertheless, all tend to lead up to them as by a series of steps. Dogs attain to the level of asking by gesture their masters to ring bells. One instance will be sufficient to quote. Mr. Rae says in 'Nature' (vol. xix., p. 459): 'A small English terrier belonging to a friend has been taught to ring for the servant. To test if the dog knew why it rang the bell he was told to do so while the girl was in the room. The little fellow looked up in the most intelligent manner at the person giving the order (his master or mistress, Iforget which), then at the servant, and refused to obey, although the order was repeated more than once. The servant left the room, and a few minutes afterwards the dog rang the bell immediately on being

It must also be added that dogs sometimes attain to the level of knocking knockers—though I should think this must be very rare with these animals, as I have only met with one case of it. This, however, is a remarkably good case, not only because it rests upon the authority of a famous observer, but also because it is so very definite as proving an act of reason. Dureau de la Malle had a terrier born in his house. It had never seen a knocker in its native home, and when grown up it was taken by its master to Paris. Getting fatigued by a walk in the streets, the animal returned to the house, but found the door shut, and it endeavoured vainly to attract the attention of those within by barking. At length a visitor called, knocked at the knocker, and gained admittance. The dog observed what had been done, and went in together with the visitor. The same afternoon he went in and out

houses the doors of which the cats desired to be opened. My informants tell me that they do not know how these cats, from any process of observation, can have surmised that pulling the wire in an exposed part of its length would have the effect of ringing the bell; for they can never have observed any one pulling the wires. I can only suggest that in these cases the animals must have observed that when the bells were rung the wires moved, and that the doors were afterwards opened; then a process of inference must have led them to try whether jumping at the wires would produce the same effects. But even this, which is the simplest explanation possible, implies powers of observation scarcely less remarkable than the process of reasoning to which they gave rise.

As further instances corroborating the fact that both these faculties are developed in cats to a wonderful degree, I may add the following. Couch ('Illustrations of Instinct,' p. 196) gives a case within his own knowledge of a cat which, in order to get at milk kept in a locked cupboard, used to unlock the door by seating herself on an adjoining table, and 'repeatedly patting on the bow of the key with her paw, when with a slight pull on the door' she was able to open it; the lock was old, and the

key turned in it 'on a very slight impulse.'

As a still further instance of the high appreciation of mechanical appliances to which cats attain, I shall quote an extract from a paper by Mr. Otto, which will have been read at the Linnean Society before this work is pub-

half a dozen times, gaining admittance on each occasion by springing at the knocker.

Lastly, Dr. W. H. Kesteven writes to 'Nature' (xx., p. 428) of a cat which used to knock at a knocker to gain admittance, in the way already described of so many other cats; but as showing how much more readily cats acquire this practice than dogs, it is interesting to note that Dr. Kesteven adds that a dog which lived in the same house ascertained that the cat was able to gain admittance by knocking, and yet did not imitate the action, but 'was in the habit of searching for her when he wanted to come in, and either waiting till she was ready to knock at the door, or inducing her to do it to please him.'

Consul E. L. Layard gives in *Nature* (xx., p. 339) a precisely similar case of a cat habitually and without tuition ringing a bell by pulling

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lished. After describing the case of a cat opening a thumb-latch in the same way as those already mentioned, this writer proceeds:—

At Parara, the residence of Parker Bowman, Esq., a full-grown cat was one day accidentally locked up in a room without any other outlet than a small window, moving on hinges, and kept shut by means of a swivel. Not long afterwards the window was found open and the cat gone. This having happened several times, it was at last found that the cat jumped upon the window-sill, placed her fore-paws as high as she could reach against the side, deliberately reached with one over to the swivel, moved it from its horizontal to a perpendicular position, and then, leaning with her whole weight against the window, swung it open and escaped.

To give only one other instance of high reasoning power in this animal, Mr. W. Brown, writing from Greenock to 'Nature' (vol. xxi., p. 397), gives a remarkable story of a cat, the facts in which do not seem to have admitted of mal-observation. While a paraffine lamp was being trimmed, some of the oil fell upon the back of the cat, and was afterwards ignited by a cinder falling upon it from the fire. The cat with her back in a blaze, in an instant made for the door (which happened to be open). and sped up the street about 100 yards,' where she plunged into the village watering-trough, and extinguished the 'The trough had eight or nine inches of water, flame. and puss was in the habit of seeing the fire put out with water every night.' The latter point is important, as it shows the data of observation on which the animal reasoned.

CHAPTER XV.

FOXES, WOLVES, JACKALS, ETC.

THE general psychology of these animals is, of course, very much the same as that of the dog; but, from never having been submitted to the influences of domestication, their mental qualities present a sufficient number of differences from those of the dog to require another

chapter for their consideration.

If we could subtract from the domestic dog all the emotions arising from his prolonged companionship with man, and at the same time intensify the emotions of self-reliance, rapacity, &c., we should get the emotional character now presented by the wolves and jackals. It is interesting to note that this genetic similarity of emotional character extends to what may be termed idiosyncratic details in cases where it has not been interfered with by human agency. Thus the peculiar, weird, and unaccountable class of emotions which cause wolves to bay at the moon has been propagated unchanged to our domestic dogs.

The intelligence of the fox is proverbial; but as I have not received many original observations on this head, I shall merely refer to some of the best authenticated observations already published, and shall begin with the instance narrated by Mr. St. John in his 'Wild

Sports of the Highlands':-

When living in Ross-shire I went out one morning in July, before daybreak, to endeavour to shoot a stag, which had been complained of very much by an adjoining farmer, as having done great damage to his crops. Just after it was daylight I saw a large fox coming quietly along the edge of the plantation

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in which I was concealed; he looked with great care over the turf wall into the field, and seemed to long to get hold of some hares that were feeding in it, but apparently knew that he had no chance of catching one by dint of running; after considering a short time he seemed to have formed his plans, and having examined the different gaps in the wall by which the hares might be supposed to go in and out, he fixed upon the one that seemed the most frequented, and laid himself down close to it in an attitude like a cat watching a mouse. Cunning as he was, he was too intent on his own hunting to be aware that I was within twenty yards of him with a loaded rifle, and able to watch every movement that he made. I was much amazed to see the fellow so completely outwitted, and kept my rifle ready to shoot him if he found me out and attempted to escape. In the meantime I watched all his plans. He first with great silence and care scraped a small hollow in the ground, throwing up the sand as a kind of screen between his hiding-place and the hares' mews; every now and then, however, he stopped to listen, and sometimes to take a most cautious look into the field; when he had done this he laid himself down in a convenient position for springing upon his prey, and remained perfectly motionless with the exception of an occasional reconnoitre of the feeding hares. When the sun began to rise, they came one by one from the field to the cover of the plantation; three had already come in without passing by his ambush; one of them came within twenty yards of him, but he made no movement beyond crouching still more closely to the ground. Presently two came directly towards him; though he did not venture to look up, I saw by an involuntary motion of his ears that those quick organs had already warned him of their approach: the two bares came through the gap together, and the fox, springing with the quickness of lightning, caught one and killed her immediately; he then lifted up his booty and was carrying it off like a retriever, when my rifle-ball stopped his course by passing through his back-bone, and I went up and despatched

Numberless instances are on record showing the remarkable cunning of foxes in procuring bait from traps without allowing themselves to be caught. These cases are so numerous, and all display so much the same quality of intelligence, that it is impossible to doubt so great a concurrence of testimony. I shall only give two or three specific cases, to show the kind of intelligence that is in

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morning in July, , which had been farmer, as having it was daylight I of the plantation question. It will be observed that it is much the same as that which is displayed under similar circumstances by rats and wolverines, in which animals we have already considered it. In all these cases the intelligence displayed must justly be deemed to be of a very remarkable order. For, inasmuch as traps are not things to be met with in nature, hereditary experience cannot be supposed to have played any part in the formation of special instincts to avoid the dangers arising from traps, and therefore the astonishing devices by which these dangers are avoided can only be attributed to observation, coupled with intelligent investigation of a remarkably high character.

I extract the following from Couch's 'Illustrations of Instinct' (p. 175):—

Whenever a cat is tempted by the bait, and caught in a foxtrap, Reynard is at hand to devour the bait and the cat too, and fearlessly approaches an instrument which the fox must know cannot then do it any harm. Let us compare with this boldness the incredible caution with which the animal proceeds when tempted by the bait in a set trap. Dietrich aus dem Winkell had once the good fortune of observing, on a winter evening, a fox which for many preceding days had been allured with loop baits, and as often as it ate one it sat comfortably down, wagging its brush. The nearer it approached the trap, the longer did it hesitate to take the baits, and the oftener did it make the tour round the catching-place. When arrived near the trap it squatted down, and eyed the bait for ten minutes at least; whereupon it ran three or four times round the trap, then it stretched out one of its fore-paws after the bait, but did not touch it; again a pause, during which the fox stared immovably at the bait. At last, as if in despair, the animal made a rush and was caught by the neck. (Mag. Nat. Hist., N. S., vol. i., p. 512.)

In 'Nature,' vol. xxi., p. 132, Mr. Crehore, writing from Boston, says:—

Some years since, while hunting in Northern Michigan, I tried with the aid of a professional trapper to entrap a fox who made nightly visits to a spot where the entrails of a deer had been thrown. Although we tried every expedient that suggested itself to us we were unsuccessful, and, what seemed very

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thern Michigan, I o entrap a fox who trails of a deer had pedient that sugwhat seemed very singular, we always found the trap sprung. My companion insisted that the animal dug beneath it, and putting his paw beneath the jaw, pushed down the pan with safety to himself; but though the appearance seemed to confirm it, I could hardly credit his explanation. This year, in another locality of the same region, an old and experienced trapper assured me of its correctness, and said in confirmation that he had several times caught them, after they had made two or three successful attempts to spring the trap, by the simple expedient of setting it upside down, when of course the act of undermining and touching the pan would bring the paw within the grasp of the jaws.

In connection with traps, my friend Dr. Rae has communicated to me a highly remarkable instance of the display of reason on the part of the Arctic foxes. I have previously published the facts in my lecture before the British Association in 1879, and therefore shall here quote them from it:—

Desiring to obtain some Arctic foxes, Dr. Rae set various kinds of traps; but as the foxes knew these traps from previous experience, he was unsuccessful. Accordingly he set a kind of trap with which the foxes in that part of the country were not acquainted. This consisted of a loaded gun set upon a stand pointing at the bait. A string connected the trigger of the gun with the bait, so that when the fox seized the bait he discharged the gun, and thus committed suicide. In this arrangement the gun was separated from the bait by a distance of about 30 yards, and the string which connected the trigger with the bait was concealed throughout nearly its whole distance in the snow. The gun-trap thus set was successful in killing one fox, but never in killing a second; for the foxes afterwards adopted either of two devices whereby to secure the bait without injuring themselves. One of these devices was to bite through the string at its exposed part near the trigger, and the other device was to burrow up to the bait through the snow at right angles to the line of fire, so that, although in this way they discharged the gun, they escaped with perhaps only a pellet or two in the nose. Now both of these devices exhibited a wonderful degree of what I think must fairly be called power of reasoning. I have carefully interrogated Dr. Rae on all the circumstances of the case, and he tells me that in that part of the world traps are never set with strings; so that there can have been no special association in the foxes' minds between strings and traps. Moreover, after the death of fox No. 1, the track on

the snow showed that fox No. 2, notwithstanding the temptation offered by the bait, had expended a great deal of scientific observation on the gun before he undertook to sever the cord. Lastly, with regard to burrowing at right angles to the line of fire, Dr. Rae justly deemed this so extraordinary a circumstance, that he repeated the experiment a number of times, in order to satisfy himself that the direction of the burrowing was really to be attributed to thought, and not to chance.

¹ I have requested Dr. Rae to write out all the particulars of these remarkable observations, and the following is the response which he has kindly made: - 'When trapping foxes in Hudson's Bay it sometimes happens that certain of these acute animals, probably from having seen their companions caught, studiously avoid the ordinary steel and wooden traps, however carefully set. The trapper then sets one or more guns in a peculiar manner, having a line 15 or 20 yards long uniting the trigger with a bait, on taking hold of which the fox sets the gun off. and commits suicide. The double object of the bait being placed so near the gun is that the fox may be certainly killed-not wounded only—and that the head alone should be hit, and the body not riddled all over with shot, which would spoil the skin. It is also necessary to mention that four or five inches of slack line must be allowed for contraction of the line by change from a dry to a moist atmosphere. which otherwise would cause so great a strain on the trigger that the gun would be discharged without the bait being touched. So as to conceal as far as possible all connection between bait and gun, that part of the line next the bait is carefully hid under the snow.

'When the fox takes the bait, he will have lifted it five inches (the length of the slack line) from its normal position before the gun goes off; consequently, instead of pointing the gun at the bait, it is aimed fully eight or nine inches higher, at the probable position of the brain

of the animal when the gun is discharged.

'For reasons which scarcely require explanation, foxes very generally go about in pairs (long before the snow disappears), not necessarily always close together, because they have a better chance of finding

food if separated some distance from each other.

'After one or more foxes have been shot, the trapper on visiting his guns perhaps finds that a fox has first cut the line connecting the bait with the gun, and then gone up and eaten the bait; or, if the gun has been set on a drift bank of snow, he or she has scraped a trench ten or twelve inches deep up to the bait, taken hold of it whilst lying in the trench, set the gun off, and then trotted coolly away with the food (taken, one may say, from the gun's mouth) safe and uninjured, as is clearly evinced by there being no mark of blood on the tracks.

'In pulling the bait whilst in the trench, the fox would drag it five inches, or the length of the slack line, downwards, and therefore his head and nose would be completely out of harm's way, both because of the snow protection, and also these parts of his body being twelve or

thirteen inches below the line of aim.

'In the cases seen by myself, and by a friend of greater experience, the trench was always scraped at right angles, or nearly so, to the line of fire of the gun. This at first sight may appear erroneous, but on Dr.
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greater experience, nearly so, to the line or erroneous, but on Dr. Rae also informs me with regard to wolves, that 'they have been frequently known to take the bait from a gun without injury to themselves, by first cutting the line of communication between the two.' 1 He adds:—

I may also mention what I have been told, although I have never had an opportunity of seeing it, that wolves watch the fishermen who set lines in deep water for trout, through holes in the ice on Lake Superior, and very soon after the man has left, the wolf goes up to the place, takes hold of the stick which is placed across the hole and attached to the line, trots off with it along the ice until the bait is brought to the surface, then returns and eats the bait and the fish, if any happens to be on the hook. The trout of Lake Superior are very large, and the baits are of a size in proportion.

Mr. Murray Browne, Inspector of the Local Government Board, writes to me from Whitehall as follows:—

I once, at the Devil's Glen, Wicklow, found a fox fast in a trap by the foot. We did not like to touch him, but got sticks and poked at the trap till we got it open. The process took ten minutes or a quarter-hour. When first we came up the fox strained to get free, and looked frightfully savage; but we had not poked at the trap more than a very short time before the whole expression of his face changed, he lay perfectly quiet (though we must at times have hurt him); and when at last we had got the trap completely off his foot, he still lay quiet,

reflection it really is not so, for if the truch is to be a shelter one—thinking, as the fox must have done, that the gun or something coming from it was the danger to be protected from or guarded against—it must be made across the line of fire, for if scratched in the direction of fire it would afford little or no protection or concealment, and the reasoning power or intelligence of the fox would be at fault.

'My belief is that one of these knowing foxes had seen his or her companion shot, or found it dead shortly after it had been killed, and not unnaturally attributed the cause of the mishap to the only strange

thing it saw near, namely, the gun.

'It was evident that in all cases they had studied the situation carefully, as was sufficiently shown by their tracks in the snow, which indicated their extremely cautious approach when either the stringcutting or trench-making dodge was resorted to, in attempting to obtain the coveted bait without injury to themselves.'

It will be remembered that, from evidence previously detailed, both the wolverine or glutton and certain deer have been shown capable

of similarly obviating the danger of gun-traps.

and looked calmly at us, as if he knew we were friends. In fact, we had some little difficulty in getting him to move away, which he did readily enough when he chose. Was not this a case of reason and good sense overpowering natural instinct?

Couch says ('Illustrations of Instinct,' p. 178): 'Derham quotes Olaus in his account of Norway as having himself witnessed the fact of a fox dropping his tail among the rocks on the sea-shore to catch the crabs below, and hauling up and devouring such as laid hold of it.'

Under the present heading I must not omit to refer to an interesting class of instincts which are manifested by those species of the genus *Canis*, whose custom it is to hunt in packs. The instincts to which I refer are those which lead to a combination among different members of the same pack for the capture of prey by stratagem. These instincts, which no doubt arose and are now maintained by intelligent adaptation to the requirements of the chase, I shall call 'collective instincts.' Thus Sir E. Tennent writes:—

At dusk, and after nightfall, a pack of jackals, having watched a hare or a small deer take refuge in one of these retreats, immediately surrounded it on all sides; and having stationed a few to watch the path by which the game entered, the leader commences the attack by raising the cry peculiar to their race, and which resembles the sound 'okkay' loudly and rapidly repeated. The whole party then rush into the jungle and drive out the victim, which generally falls into the amount previously laid to entrap it.

A native gentleman, who had favourable opportunities of observing the movements of these animals, informed me that when a jackal has brought down his game and killed it, his first impulse is to hide it in the nearest jungle, whence he issues with an air of easy indifference to observe whether anything more powerful than himself may be at hand, from which he might encounter the risk of being despoiled of his capture. If the coast be clear he returns to the concealed carcass and carries it away, followed by his companions. But if a man be in sight, or any other animal to be avoided, my informant has seen the jackal seize a cocoa-nut husk in his mouth, or any similar substance, and fly at full speed, as if eager to carry off his pretended

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prize, returning for the real booty at some more convenient season.1

Again, Jesse records the following display of the same instinct by the fox, as having been communicated to him by a friend on whose veracity he could rely:—

Part of this rocky ground was on the side of a very high hill, which was not accessible for a sportsman, and from which both hares and foxes took their way in the evening to the plain below. There were two channels or gullies made by the rains, leading from these rocks to the lower ground. Near one of these channels, the sportsman in question, and his attendant, stationed themselves one evening in hopes of being able to shoot some hares. They had not been there long, when they observed a fox coming down the gully, and followed by another. After playing together for a little time, one of the foxes concealed himself under a large stone or rock, which was at the bottom of the channel, and the other returned to the rocks. He soon, however, came back, chasing a hare before him. the hare was passing the stone where the first fox had concealed himself, he tried to seize her by a sudden spring, but missed his The chasing fox then came up, and finding that his expected prey had escaped, through the want of skill in his associate, he fell upon him, and they both fought with so much animosity, that the parties who had been watching their proceedings came up and destroyed them both.

Similarly, Mr. E. C. Buck records ('Nature,' viii., 303) the following interesting observation made by his friend Mr. Elliot, B.C.S., Secretary to Government, N.W.P.:—

He saw two wolves standing together, and shortly after noticing them was surprised to see one of them lie down in a ditch, and the other walk away over the open plain. He watched the latter, which deliberately went to the far side of a herd of antelopes standing in the plain, and drove them, as a sheep-dog would a flock of sheep, to the very spot where his companion lay in ambush. As the antelopes crossed the ditch, the concealed wolf jumped up as in the former case, seized a doe, and was joined by his colleague.

Mr. Buck draws attention to another closely similar display of collective instinct of wolves in the same district observed by a 'writer of one of the books on Indian sport.'

With reference to this case I wrote to 'Nature' as The friend to whom I allude was the late Dr. Brydon, C.B. (the 'last man' of the Afghan expedition of 1841), whom I knew intimately for several years, and always found his observations on animals to be trustworthy:—

In response to the appeal which closes Mr. Buck's interest ing letter ('Nature,' vol. viii., p. 302), the following instance of 'collective instinct' exhibited by an animal closely allied to the wolf, viz., the Indian jackal, deserves to be recorded. It was communicated to me by a gentleman (since deceased) on whose veracity I can depend. This gentleman was waiting in a tree to shoot tigers as they came to drink at a large lake (I forge the district), skirted by a dense jungle, when about midnight a large axis deer emerged from the latter and went to the Then it stopped and sniffed the air in the direct tion of the jungle, as if suspecting the presence of an enemy apparently satisfied, however, it began to drink, and continued to do so for a most inordinate length of time. When literally swollen with water it turned to go into the jungle, but wa met on its extreme margin by a jackal, which, with a shar yelp, turned it again into the open. The deer seemed much startled, and ran along the shore for some distance, when i again attempted to enter the jungle, but was again met and latter imp driven back in the same manner. The night being calm, my straight friend could hear this process being repeated time after time— Newfoun the yelps becoming successively fainter and fainter in the distance dr tance, until they became wholly inaudible. The stratagem thusef them v employed was sufficiently evident. The lake having a long the dogs narrow shore intervening between it and the jungle, the jackal into his of formed themselves in line along it while concealed within the Why thi extreme edge of the cover, and waited until the deer was water arey whi Their prey, being thus rendered heavy and short there can winded, would fall an easy victim if induced to run sufficiently ome goo far, i.e., if prevented from entering the jungle. It was, of course, impossible to estimate the number of jackals engaged in this hunt, for it is not impossible that as soon as one had don duty at one place, it outran the deer to await it in another.

A native servant who accompanied my friend told him that this was a stratagem habitually employed by the jackals in the place, and that they hunted in sufficient numbers 'to leav nothing but the bones.' As it is a stratagem which could only be effectual under the peculiar local conditions described,

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must appear that this example of collective instinct is due to separate expression, and not to 'inherited habit.'

Cases of collective instinct are not of unfrequent occurrence among dogs. For the accuracy of the two following I can rouch. A small Skye and a large mongrel were in the habit of hunting hares and rabbits upon their own account, the small log having a good nose, and the larger one great fleetness. These qualities they combined in the most advantageous manner, the terrier driving the cover towards his fleet-footed

companion which was waiting for it outside.

The second case is remarkable for a display of sly sagacity. eceased) on whose A friend of mine in Ross-shire had a small terrier and a large Newfoundland. One day a shepherd called upon him to say rge lake (I forget that his dogs had been worrying sheep the night before. gentleman said there must be some mistake, as the Newfoundand went to the and had not been unchained. A few days afterwards the he air in the direct hepherd again called with the same complaint, vehemently asserting that he was positive as to the identity of the dogs. ink, and continued Consequently the owner set one watch upon the kennel and When literally mother outside the sheep enclosure, directing them (in conne jungle, but was squence of what the shepherd had told him) not to interfere hich, with a sharp with the action of the dogs. After this had been done several deer seemed much nights in succession, the small dog was observed to come at e distance, when it havdawn to the place where the large one was chained; the vas again met and latter immediately slipped his collar, and the two animals made the being calm, my straight for the sheep. Upon arriving at the enclosure the I time after time— Newfoundland concealed himself behind a hedge, while the fainter in the disterrier drove the sheep towards his ambush, and the fate of one The stratagem thus of them was quickly sealed. When their breakfast was finished ake having a long the dogs returned home, and the larger one, thrusting his head a jungle, the jackal into his collar, lay down again as though nothing had happened. ncealed within the Why this animal should have chosen to hunt by stratagem the deer was water rey which it could easily run down, I cannot suggest; but heavy and short there can be little doubt that so wise a dog must have had

A similar instance of the display of collective instinct on as one had don thus narrated by M. Dureau de la Malle:—

> I had at one time two sporting dogs, the one an excellent winter with a very smooth skin, and of remarkable beauty and intelligence; the other was a spaniel with long and thick hair, but which had not been taught to point, but only coursed in the woods like a harrier. My château is situated on a level pot of ground, opposite to copse wood filled with hares and

When sitting at my window, I have observed these two dogs, which were at large in the yard, approach and make signs to each other, and first glancing at me, as if to see if I offered any obstacle to their wishes, step away very gently, then quicken their pace when they were at a little distance from my sight, and finally dart off at full speed when they thought I could neither see them nor order them back. Surprised at this mysterious manœuvre, I followed them, and witnessed a singular sight. The pointer, who seemed to be the leader of the enterprise, had sent the spaniel out to beat the bushes, and give tongue at the opposite extremity of the bushwood. himself, he made with slow steps the circuit of the wood by following it along the border, and I observed him stop before passage much frequented by rabbits, and there point. I continued at a distance to observe how the intrigue was going to end. At length I heard the spaniel, which had started a hare drive it with much tongue towards the place where its companion was lying in ambush, and the moment that the har came out of the passage to gain the fields, the latter darted upon it and brought it to me with an air of triumph. I have seen these two dogs repeat this same manœuvre more than hundred times; and this conformity has convinced me that i was not accidental, but the result of a concerted agreement and combined plan of operations understood beforehand.

Again, among Mr. Darwin's MSS., I find a letter from Mr. H. Reeks (1871), which says that the wolves of New foundland adopt exactly the same stratagem for the cap ture of deer in winter as that which is adopted by the hunters. That is to say, some of the pack secrete them selves in one or more of the leeward deer-paths in the forest or 'belting,' while one or two wolves make a circuit round the herd of deer to windward. The her invariably retreats by one of its accustomed runs, and 'i rarely happens that the wolves do not manage by this stratagem to secure a doe or young stag.' And Leroy, in his book on Animal Intelligence, narrates closely similar facts of the wolves of Europe as having faller within his own observation.

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CHAPTER XVI.

THE DOG.

THE intelligence of the dog is of special, and indeed of unique interest from an evolutionary point of view, in that from time out of record this animal has been domesticated on account of the high level of its natural intelligence; and by persistent contact with man, coupled with training and breeding, its natural intelligence has been greatly changed. In the result we see, not only a general modification in the way of dependent companionship and docility, so unlike the fierce and self-reliant disposition of all wild species of the genus; but also a number of special modifications, peculiar to certain breeds, which all have obvious reference to the requirements of man. The whole psychological character of the dog may therefore be said to have been moulded by human agency with reference to human requirements, so that now it is not more true that man has in a sense created the structure of the bull-dog and greyhound, than that he has implanted the instincts of the watch-dog and pointer. proof which we thus have afforded of the transforming and creating influence exerted upon the mental character and instincts of species by long and persistent training, coupled with artificial selection, furnishes the strongest possible corroboration of the theory which assigns psychological development in general to the joint operation of individual experience coupled with natural selection. For thousands of years man has here been virtually, though unconsciously, performing what evolutionists may regard as a gigantic experiment upon the potency of individual experience accumulated by heredity; and now there stands before us this most wonderful monument of his labours—the culmination of his experiment in the

transformed psychology of the dog.

In my next work I shall treat of this subject with the fulness that it deserves—especially in its relation to the origin of instincts and the development of the moral sense; but to enter upon this topic at present would demand more space than can be allowed.

To do full justice to the psychology of the dog a separate treatise would be required. Here I can only

trace a sketch.

Memory.

As regards memory, one or two instances will suffice. Mr. Darwin writes: 'I had a dog who was savage and averse to all strangers, and I purposely tried his memory after an absence of five years and two days. I went near the stable where he lived, and shouted to him in my old manner; he showed no joy, but instantly followed me out walking, and obeyed me, as if I had parted with him only an hour before.' 1

It is not only persons or places that dogs remember for long periods. I had a setter in the country, which one year I took up with me to town for a few months. While in town he was never allowed to go out without a collar on which was engraved my address. A ring upon this collar made a clinking sound, and the setter soon learnt to associate the approach of this sound with the prospect of a walk. Three years afterwards I again took this setter up to town. He remembered every nook and corner of my house in town, and also his way about the streets, and the first time that I brought his collar, slightly clinking as before, he showed by his demonstrations of joy that he well remembered the sound with all its old associations, although he had not heard this sound for three years.

Emotions.

The emotional life of the dog is highly developed—more highly, indeed, than that of any other animal. His

1 Descent of Man, p. 74.

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gregarious instincts, united with his high intelligence and constant companionship with man, give to this animal a osychological basis for the construction of emotional character, having a more massive as well as more complex consistency than that which is presented even in the case of the monkey, which, as we shall afterwards see, attains

to a remarkably high level in this respect.

Pride, sense of dignity, and self-respect are very conspicuously exhibited by well-treated dogs. As with man, so with the friend of man, it is only those whose lines of fortune have fallen in pleasant places, and whose feelings may therefore be said to have profited by the refining influences of culture, that display in any conspicuous measure the emotions in question. 'Curs of I'w degree,' and even many dogs of better social position, have never enjoyed those conditions essential to moral refinement, which alone can engender a true sense of self-respect and dignity. 'low-life' dog may not like to have his tail pulled, any more than a gutter child may like to have his ears boxed; but here it is physical pain rather than wounded pride that causes the smart. Among 'high-life' dogs, however, the case is different. Here wounded sensibilities and loss of esteem are capable of producing much keener suffering than is mere physical pain; so that among such dogs a whipping produces quite a different and a much more lasting effect than in the case of their rougher brethren, who, as soon as it is over, give themselves a shake and think no more about it. As evidence of the delicacy of feeling to which dogs of aristocratic estate may attain, I shall give one or two among many instances that I could render.

A reproachful word or look from any of his friends would make a Skye terrier that I owned miserable for a whole day. If we had ever ventured to strike him I do not know what would have happened, for his sentiments were quite abreast of the age with respect to moral repugnance to the use of the lash. Thus, for instance, at one time when all his own friends were out of town, he was taken for a walk every day in the park by my brother, to whose care he had been entrusted. He enjoyed his walks very much, and was wholly dependent upon my brother for obtaining them. Nevertheless, one day while he was amusing himself with another dog in the park, my brother, in order to persuade him to follow, struck him with a glove. The terrier looked up at his face with an astonished and indignant gaze, deliberately turned round, and trotted home. Next day he went out with my brother as before, but after he had gone a short distance he looked up at his face significantly, and again trotted home with a dignified air. After thus making his protest in the strongest way he could, the dog ever afterwards refused to accompany him.

This terrier habitually exhibited a strong repugnance to corporal punishment, even when inflicted upon others. Thus, whenever or wherever he saw a man striking a dog, whether in the house or outside, near at hand or at a distance, he used to rush in to interfere, snarling and snapping in a most threatening way. Again, when driving with me in a dog-cart, he always used to hold the sleeve of my coat every time I touched the horse with the whip. As bearing upon this sensitiveness of feeling produced in dogs by habitually kind treatment, I shall here give an extract from the letter of one of my correspondents (Mrs. E. Picton). It relates to a Skye terrier which had a strong aversion to being washed:—

In process of time this aversion increased so much that all the servants I had refused to perform the ablutions, being in terror of doing so from the ferocity the animal evinced on such occasions. I myself did not choose to undertake the office, for though the animal was passionately attached to me, such was his horror of the operation, that even I was not safe. Threats, beating, and starving were all of no avail; he still persisted in his obstinacy. At length I hit upon a new device. Leaving him perfectly free, and not curtailing his liberty in any way, I let him know, by taking no notice of him, that he had offended me. He was usually the companion of my walks, but now I refused to let him accompany me. When I returned home I took no notice of his demonstrative welcome, and when he came looking up at me for caresses when I was engaged either in reading or needlework, I deliberately turned my head aside. This state of things continued for about a week or ten days, and the poor animal looked wretched and forlorn. There was

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evidently a conflict going on within him, which told visibly on his outward appearance. At length one morning he crept quietly up to me, and gave me a look which said as plainly as any spoken words could have done, 'I can stand it no longer; I submit.' And submit he did quite quietly and patiently to one of the roughest ablutions it had ever been his lot to experience; for by this time he sorely needed it. After it was over he bounded to me with a joyous bark and wag of his tail, saying unmistakably, 'I know all is right now.' He took his place by my side as his right when I went for my walk, and retained from that time his usually glad and joyous expression of coun-When the period for the next ablution came round the old spirit of obstinacy resumed its sway for a while, but a single look at my averted countenance was sufficient for him, and he again submitted without a murmur. Must there not have been something akin to the reasoning faculty in the breast of an animal who could thus for ten days carry on such a struggle?

This strong effect of silent coldness shows that the loss of affectionate regard caused the terrier more suffering than beating, starving, or even the hated bath; and as many analogous cases might be quoted, I have no hesitation in adducing this one as typical of the craving for affectionate regard which is manifested by sensitive dogs.

In this connection I may point out the remarkable change which has been produced in the domestic dog as compared with wild dogs, with reference to the enduring of pain. A wolf or a fox will sustain the severest kinds of physical suffering without giving utterance to a sound, while a dog will scream when any one accidentally treads upon its toes. This contrast is strikingly analogous to that which obtains between savage and civilised man: the North American Indian, and even the Hindoo, will endure without a moan an amount of physical pain—or at least bodily injury—which would produce vehement expressions of suffering from a European. And doubtless the explanation is in both cases the same—namely, that refinement of life engenders refinement of nervous organisation, which renders nervous lesions more intolerable.

As evidence of the idea of caste in a dog, I shall quote only one instance, although many others might be

given: this also may be taken as typical. I extract it from St. John's 'Wild Sports of the Highlands,' where, speaking of his retriever, this very good observer states: 'He struck up an acquaintance with a ratcatcher and his cur, thoroughly entering into their way of business; but the moment he saw me he instantly cut his humble friends, and denied all acquaintance with them in the most comical manner.'

Dogs likewise display in a high degree the feelings of emulation and jealousy. I once had a terrier which took great pains, and manifested paternal delight, in teaching his puppy to hunt rabbits. But in time the puppy outgrew his father in strength and fleetness, so that in the chase, in spite of straining every nerve, the father used to be gradually distanced. His whole demeanour then changed, and every time that he found his son drawing away from him he used in desperation to seize the receding tail of the youngster. Although the son was now much stronger than the father, he never used to resent this exercise of paternal authority, even though the rabbit were close under his nose.

Of jealousy in dogs innumerable instances might be given, but I shall merely quote one from my bulky correspondence on this head. It is sent me by Mr. A. Oldham:—

He had grown old, and having some affection in his legs which made walking difficult to him, he had sunk into a very stagnant sort of life, when a Scotch terrier was brought to live with us, and treated with much favour. All Charlie's old vigour revived upon the advent of this rival. He exhibited agonies of jealousy, and has since spent his life in following, watching, and imitating him. He insists on doing everything that Jack does. Although he had previously given up walking, he now makes a point of going out whenever Jack does so. Several times he has started with us, but finding that Jack was not of the party, has turned back and quietly gone home. In the same way,

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¹ So many cases are on record of large dogs (especially of the Newfoundland breed) throwing troublesome curs into the water, and again rescuing them if they show danger of drowning, that we can scarcely fail to accept them as true. Such cases exhibit a wonderful play of human-like emotions.

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although before he ate nothing but meat, he now eats any food that is also given to Jack; and if Jack is caressed he watches for some time, and then bursts out whining and barking. I have seen the same rage manifested by a fine cockatoo at the sight of his mistress carrying on her wrist and stroking affectionately a little green parrot. Such jealousy seems to me a very advanced emotion, as it has passed beyond the stage when it may be supposed to be caused by a fear of other animals monopolising material benefits which they desire for themselves; it is excited solely by seeing affection or attention bestowed by those they love upon other animals. The actions in which Charlie tries to participate—such as walking far, plunging into cold water after sticks, &c.—are in themselves extremely disagreeable to him, and he performs them only that he may obtain a share in the companionship and notice bestowed upon Jack.

Akin to jealousy is the sense of justice. If a master is not equal in his ways towards his dogs, the dogs are very apt to discover the injustice and to resent it accordingly. The well-known observation of the great Arago may be taken as a typical one in this connection. Having been detained by a storm at a country inn, and having ordered a chicken for his dinner, Arago was warming himself by the kitchen fire, when he saw the innkeeper put the fowl on the spit and attempt to seize a turnspit dog lying in the kitchen. The brute, however, refused to enter the wheel, got under a table, and showed fight. On Arago asking what could be the meaning of such conduct, the host replied that the dog had some excuse, that it was not his turn but his comrade's, who did not happen to be in the kitchen. Accordingly, the other turnspit was sent for, and he entered the spit very willingly, and turned away. When the fowl was half roasted Arago took him out, and the other dog, no longer smarting under the sense of injustice, now took his turn without any opposition, and completed the roasting of the fowl.

Deceitfulness is another trait in canine character of which numberless instances might be given; but here, again, it seems unnecessary to quote more than one or two cases as illustrative of the general fact. Another of my correspondents, after giving several examples of the display of hypocrisy of a King Charles spaniel, proceeds:—

He showed the same deliberate design of deceiving on other occasions. Having hurt his foot he became lame for a time, during which he received more pity and attention than usual. For months after he had recovered, whenever he was harshly spoken to, he commenced hobbling about the room as if lame and suffering pain from his foot. He only gave up the practice when he gradually perceived that it was unsuccessful.

The following instance, which I observed myself, I regard as more remarkable. It has already been published in 'Nature' (vol. xii., p. 66), from which I quote it:

The terrier used to be very fond of catching flies upon the window-panes, and if ridiculed when unsuccessful was evidently much annoyed. On one occasion, in order to see what he would do, I purposely laughed immoderately every time he failed. It so happened that he did so several times in succession—partly, I believe, in consequence of my laughing—and eventually he became so distressed that he positively pretended to catch the fly, going through all the appropriate actions with his lips and tongue, and afterwards rubbing the ground with his neck as if to kill the victim: he then looked up at me with a triumphant air of success. So well was the whole process simulated that I should have been quite deceived, had I not seen that the fly was still upon the window. Accordingly I drew his attention to this fact, as well as to the absence of anything upon the floor; and when he saw that his hypocrisy had been detected he slunk away under some furniture, evidently very much ashamed of himself.

This allusion to the marked effects of ridicule upon a dog leads to a consideration of the next emotion with which I feel certain that some dogs are to be accredited. I mean the emotion of the ludicrous. This same terrier used, when in good humour, to perform several tricks, which I know to have been self-taught, and which clearly had the object of exciting laughter. For instance, while lying on his side and violently grinning, he would hold one leg in his mouth. Under such circumstances, nothing pleased him so much as having his joke duly appreciated, while if no notice was taken of him he would become sulky. On the other hand, nothing displeased him so much as being laughed at when he did not intend to be ridiculous, as could not be more con-

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emotion with be accredited. is same terrier several tricks, d which clearly For instance, ning, he would circumstances, his joke duly ten of him he d, nothing dist when he did be more conclusively proved than by the fact of his behaviour in pretending to catch the fly. Mr. Darwin observes: 'Dogs show what may be fairly called a sense of humour, as distinct from mere play; if a bit of stick or other such object be thrown to one, he will often carry it away for a short distance; and then squatting down with it on the ground close before him, will wait until his master comes close to take it away. The dog will seize it and rush away in triumph, repeating the same manœuvre, and evidently enjoying the practical joke.'

General Intelligence.

I have very definite evidence of the fact that dogs are able to communicate to one another simple ideas. communication is always effected by gesture or tones of barking, and the ideas are always of such a simple nature as that of a mere 'follow me.' According to my own observations, the dogs must be above the average of canine intelligence, and the gesture they invariably employ is a contact of heads, with a motion between a rub and a butt. It is quite different from anything that occurs in play, and is always followed by a definite course of action. I must add, however, that although the information thus conveyed is always definite, I have never known a case in which it was complex—anything like asking or telling the way, which several writers have said that dogs can do, being, I believe, quite out of the question. One example will suffice. A Skye terrier (not quite pure) was asleep in the room where I was, while his son lay upon a wall which separates the lawn from the high road. The young dog, when alone, would never attack a strange one, but was a keen fighter when in company with his father. Upon the present occasion a large mongrel passed along the road, and shortly afterwards the old dog awoke and went sleepily downstairs. When he arrived upon the door-step his son ran up to him and

Descent of Man, p. 71.

made the sign just described. His whole manner immediately altered to that of high animation. Clearing the wall together, the two animals ran down the road as terriers only can when pursuing an enemy. I watched them for a mile and a half, within which distance their speed never abated, although the object of their pursuit

had not from the first been in sight.

It is almost superfluous to give cases illustrating the well-known fact that dogs communicate their desires and ideas to man; but as the subject of the communication by signs will afterwards be found of importance in connection with the philosophy of communication by words, I shall here give a few examples of dogs communicating by signs with man, which for my purpose will be the more valuable the less they are recognised as unusual.

Lieutenant-Gen. Sir John H. Lefroy, C.B., K.C.M.G., F.R.S., writes me that he has a terrier which it is the duty of his wife's maid to wash and feed. 'It was her habit after calling her mistress in the morning to go out and milk a goat which was tethered near the house, and give "Button" the milk. One morning, being rather earlier than usual, instead of going out at once she took up some needlework and began to occupy herself. The dog endeavoured in every possible way to attract her attention and draw her forth, and at last pushed aside the curtain of a closet, and never having been taught to fetch or carry, took between his teeth the cup she habitually used, and brought it to her feet. I inquired into every circumstance strictly on the spot, and was shown where he found the cup.'

Similarly I select the following case from a great number of others that I might quote, because it is so closely analogous to the above. It is communicated to

me by Mr. A. H. Baines:—

There is a drinking-trough for him in my sitting-room: if at any time it happens to be without water when he goes to drink, he scratches the dish with his fore-paws in order to call attention to his wants, and this is done in an authoritative way, which generally has the desired effect. Another Pomeranian a member of the same family—when quite young used to soak hard bi the bis leave it paw.

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sitting-room: if when he goes to in order to call uthoritative way, er Pomeranian ing used to soak hard biscuits in water till soft enough to eat. She would carry the biscuit in her mouth to the drinking-trough, drop it in and leave it there for a few minutes, and then fish it out with her paw.

One more instance of the communication of ideas by gestures will no doubt be deemed sufficient. It is one of a kind which has many analogies in the literature of

canine intelligence.

Dr. Beattie relates this case of canine sagacity, of which the scene was a place near Aberdeen. The Dee being frozen, a gentleman named Irvine was crossing the ice, which gave way with him about the middle of the river. Having a gun, he was able to keep himself from sinking by placing it across the opening. 'The dog made many fruitless efforts to save his master, and then ran to a neighbouring village, where he saw a man, and with the most significant gestures pulled him by the coat, and prevailed on him to follow. The man arrived on the spot in time to save the gentleman's life.'

Numberless other instances of the same kind might be given, and they display a high degree of intelligence. Even the idea of saving life implies in itself no small amount of intelligence; but in such cases as these we have added the idea of going for help, communicating news of a disaster, and leading the way to its occurrence.

Having thus as briefly as possible considered the emotional and the more ordinary intellectual faculties of the dog, I shall pass on to the statement of cases showing the higher and more exceptional developments of canine

sagacity.

Were the purpose of this work that of accumulating anecdotes of animal intelligence, this would be the place to let loose a flood of facts, which might all be well attested, relating to the high intelligence of dogs. But as my aim is rather that of suppressing anecdotes, except in so far as facts are required to prove the presence in animals of the sundry psychological faculties which I believe the different classes to present, I shall here, as elsewhere, follow the method of not multiplying anecdotes further than seems necessary fully to demonstrate the

highest level of intelligence to which the animal under consideration can certainly be said to attain. But in order that any who read these pages for the sake of the anecdotes which they necessarily present may not be disappointed by meeting with cases already known to them, I shall draw my material mainly from the facts communicated to me by private correspondents, alluding to previously published facts only as supplementary to those now published for the first time. It may be well to explain to my numerous correspondents that I select the following cases for quoting, not because they are the most sensational that I have received, but rather because they either contain nothing sufficiently exceptional to excite the criticism of incredulity, or because they happen to have been corroborated by the more or less similar cases which I quote from other correspondents.

As showing the high general intelligence of the dog, I shall first begin with the collie. It is certain that many of these dogs can be trusted to gather and drive sheep without supervision. It is enough on this head to refer to the well-known anecdotes of the poet Hogg in his 'Shepherd's Calendar,' concerning his dog 'Sirrah.'

Williams, in his book on 'Dogs and their Ways,' says (p. 124) that a friend of his had a collie which, whenever his master said the words 'Cast, cast,' would run off to seek any sneep that might be cast, and on finding it would at once assist it to rise. He also knew of another dog (p. 102), which would perform the same office even in the absence of his master, going the round of the fields and pastures by himself to right all the sheep that he found to be cast.¹

One of my correspondents (Mr. Laurie Gentles) sends me an account of a sheep-dog belonging to a friend of his (Mr. Mitchell, of Inverness-shire) which strayed to a neighbouring farm, and took up his residence with the farmer. On the second night after the dog arrived at the farm the farmer 'took the dog down to the meadow to see if the cattle were all right. To his dismay he found that

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¹ For many other instances of sheep-dog sagacity, see Watson, Reasoning Power of Animals, under 'Sheplerd's Dog.'

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e Gentles) sends of a friend of his ayed to a neigh-with the farmer. The at the farm neadow to see if y he found that

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the fence between his meadow and his neighbour's had got broken down, and that the whole of his neighbour's cattle had got mixed up with his. By the help of the dog the strange cattle were driven back into their proper meadow, and the fence put into temporary repair. The next night, at the same hour, the gentleman started off to look after the cattle. The dog, however, was not to be seen. On arriving at the meadow, what was the gentleman's astonishment to find that the dog had preceded him! astonishment soon changed into delighted approbation when he found the dog sitting on the broken fence between the two meadows, and daring the cattle from either side to cross. The cattle had during the interval between the first and second visits broken down the fence, and had got mixed up with each other. The dog had quietly gone off on his own account to see if all was right, and finding a similar accident to the one the previous evening, had alone and unaided driven back the strange attle to their proper meadow, and had mounted guard over the broken fence as I have already indicated.'

Colonel Hamilton Smith says that the cattle-dogs of Cuba and Terra Firma are very wise in managing cattle, but require to display different tactics from the cattle-dogs

of Europe :—

When vessels with live stock arrive at any of the West India harbours, these animals, some of which are nearly as large as mastiffs, are wonderfully efficient in assisting to land the cargo. The oxen are hoisted out with a sling passing bound the base of their horns; and when an ox, thus suspended by the head, is lowered, and allowed to fall into the water, so that it may swim to land, men sometimes swim by the side of it and guide it, but they have often dogs of this breed which will perform the service equally well; for, catching the perplexed animal by the ears, one on each side, they will force it to swim in the direction of the landing-place, and instantly let to their hold when they feel it touch the ground, as the ox will then naturally walk out of the water by itself.

That this sagacity need not be due to special tuition, may be inferred from a closely similar display sponta-

¹ Naturalist's Library, vol. x., p. 154 (quoted by Watson).

neously shown in the following case. It is communicated light, and to me by a correspondent, Mr. A. H. Browning. This rid of the gentleman was looking at a litter of young pigs in their sty, and when he went away the door of the sty was inadvertently left unfastened. The pigs all escaped into his garden. My correspondent then proceeds:—

My attention was called to my dog appearing in a great state of excitement, not barking (he seldom barks), but whining and performing all sorts of antics (in a human subject I should have said 'gesticulating'). The herdmen and myself returned to the sty; we caught but one pig, and put him back; no sooner had we done so than the dog ran after each pig in succession, brought him back to the sty by the ear, and then went after quent de another, until the whole number were again housed.

In Lord Brougham's 'Dialogues on Instinct' (iii.) there is narrated the story told to the author by Lord Truro of a dog that used to worry sheep at night. animal quietly submitted to be tied up in the evening. but when everybody was asleep he used to slip his collar, he occup worry the sheep, and, returning before dawn, again get log (a re into his collar to avoid suspicion. I allude to this remarkable display of sagacity because I am myself able the cook fully to corroborate it by precisely similar cases. A friend litchen for of mine (the late Mr. Sutherland Murray) had a dog way the which was always kept tied up at night, but nevertheless the neighbouring farmers complained of having detected lefter the him as the culprit when watching to find what dog it was the fire, lot that committed nightly slaughter among their sheep. My bir him, he friend therefore set a watch upon his dog, and found to be at a set of the sheet. friend, therefore, set a watch upon his dog, and found shoot, s that when all was still he slipped his collar, and after ress. Or being absent for some hours, returned and slipped his is old pla head in again.

A precisely similar case is given further back, and man I s others are communicated to me by two correspondents oprove a (Mr. Goodbehere, of Birmingham, and Mr. Richard Williams, of Buffalo). The latter says:—

And here let me ask if you are aware of the cunning and sagacity of these sheep-killing dogs, that they never kill sheet was k on the farm to which they belong, or in the immediate vicinity hastised but often go miles away; that they always return before day key used

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Instinct' (iii.) to slip his collar. lude to this re-

o correspondents prove an alibi. Mr. Richard Wil-

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is communicated ight, and before doing so wash themselves in some stream to get Browning. This rid of the blood.

In Germany I knew a large dog that was very fond of all escaped into gapes, and at night used to slip his collar in order to satisfy his propensity; and it was not for some time that the thief was suspected, owing to his returning before aylight and appearing innocently chained up in his kennel.

A closely similar case is recorded in Mr. Duncan's book on 'Instinct' of a dog belonging to the Rev. Mr. pig in succession, Taylor, of Colton. The only difference is that the delinid then went after quent dog slipped and afterwards readjusted a muzzle instead of a collar.

In connection with sly sagacity I may also give anauthor by Lord ther story contained in my correspondence, although in at night. The his case I am specially requested by my correspondent in the evening, let to publish his name. I can, therefore, only say that he occupies a high position in the Church, and that the dawn, again get log (a retriever) was his own property:

The dog was lying one evening before the kitchen fire where am myself able the cook had prepared a turkey for roasting. She left the r cases. A friend sitchen for a few moments, when the dog immediately carried rray) had a dog away the turkey and placed it in the cleft of a tree close to the but nevertheless to rapid were his movements that he returned to his post having detected before the cook had come back, and stretching himself before their sheep. My for him, however, a man who was in the habit of taking him dog, and found shoot, saw him carrying away his prize and watched his procollar, and after ress. On coming into the kitchen the man found the dog in and slipped his is old place pretending to be asleep. Diver's conduct was all long dictated by a desire to conceal his theft, and if he were further back, and man I should have said that he intended, in case of inquiry,

> Mr. W. H. Bodley writes me of a retriever dog that elonged to him:

Before he came to me he lived where another dog of similar ey never kill sheel ize was kept, and on one occasion they fought. Having been immediate vicinity hastised for this, on future occasions when they quarrelled return before day key used to swim over a river of some breadth, where they could not be interfered with, and fight out their quarrel on the What seems to me noteworthy in this conduct is the self-restraint manifested under the influence of passion, and the mutual understanding to defer the fight till they could prosecute it unmolested; like two duellists crossing the Channel fight in France.

It is, of course, a well-known thing that dogs may easily be taught the use of coin for buying buns, & bjects of In the 'Scottish Naturalist' for April, 1881, Mr. Japl Walter Struckes for the fact that a collie which he knew was in columteer the habit of purchasing calcas with compare without our purchasing calcas with compare without or the habit of purchasing cakes with coppers without ever and of having been taught the use of coin for such purposes if he This fact, however, of a dog spontaneously divining bund that the use of money requires corroboration, although in the flower is certain that many dogs have an instinctive idea of less to a giving peace-offerings, and the step from this to the usiness t idea of barter may not be large. Thus, to give only two illustrations, Mr. Badcock writes to me that a friend of his reductio had a dog which one day had a quarrel with a companion ave the dog, so that they parted at variance. 'On the next day healty, the friend appeared with a biscuit, which he presented a persons, a peace-offering.' Again, Mr. Thomas D. Smeaton write Mr. to me of his dog that he 'has an amusing practice whereavs: he is restored to favour after some slight offence, of im mediately picking up and carrying anything that it as playi handiest, stone, stick, paper: it is a deliberate effort to rought a please, a sort of good-will offering, a shaking hands over een. the past.'

I am indebted for the following to Mr. Goodbehere, and sudden Birmingham; it may be taken as typical of many similal over, h cases:-

My friend (Mr. James Canning, of Birmingham) was at the picture quainted with a small mongrel dog who on being presente wed, sea with a penny or a halfpenny would run with it in his mouth t a baker's, jump on to the top of the half-door leading into the shop, and ring the bell behind the door until the baker came for vol. xx., ward and gave him a bun or a biscuit in exchange for the coil The dog would accept any small biscuit for a halfpenny, but no as present thing less than a bun would satisfy him for a penny. On on the baker (being annoyed at the dog's too frequent is gaze well as the dog and visits), after receiving the coin, refused to give the dog any

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ging in exchange, and on every future occasion the latter (who heir quarrel on the kelined being taken in a second time) would put the coin on in this conduct is he floor, and not permit the baker to pick it up until he had re-

Mr. R. O. Backhouse writes to me:—

My dog is a broken-haired rabbit-coursing dog, and is very that dogs may intelligent. I took him one day to an exhibition of pictures and buying buns, &c bjects of interest, among which were statues and a bust of Sir Walter Scott. It was a local exhibition, and as there was wellery, some one had to sit up all night with it as guard. I be without every the flowers, my dog suddenly began to bark, and made or such purposes if he had found some one hiding. On looking round I meously divining fund that it was the bust of Sir Walter Scott standing among ion, although is the flowers, and in which he evidently recognised sufficient likes. ion, although it he flowers, and in which he evidently recognised sufficient likeistinctive idea of less to a human being to think the supposed man had no from this to the usiness there at so late an hour.

to give only two I adduce this instance because it serves as a sort of inhat a friend of his roduction to the more remarkable faculty which I cannot with a companion lave the least doubt is manifested by some dogs—the On the next day healty, namely, of recognising portraits as representing he presented a tersons, or possibly of mistaking portraits for persons.

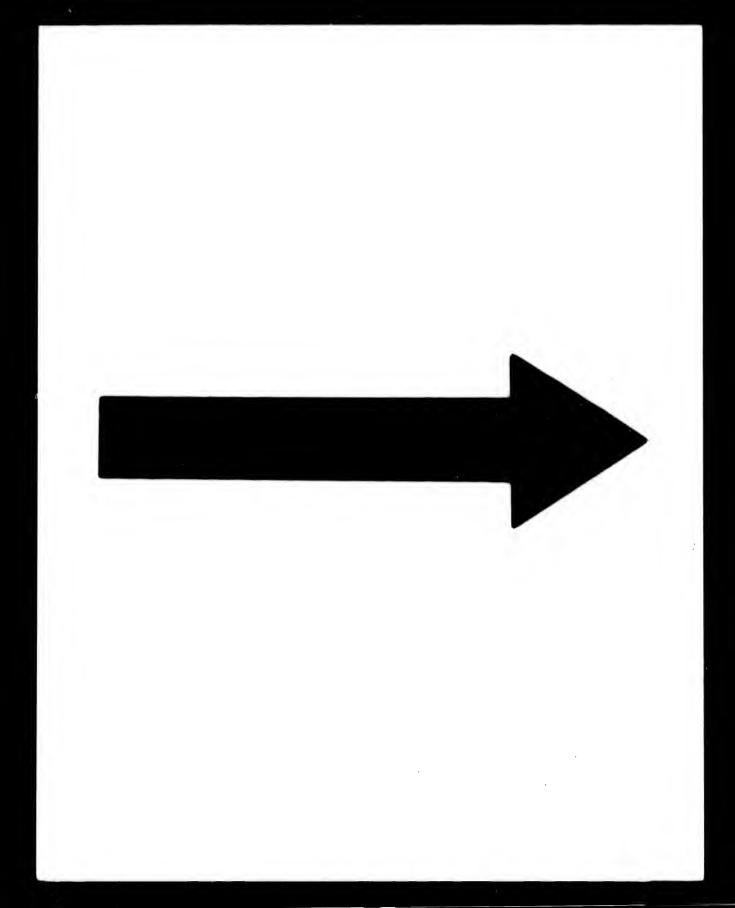
On the next day healty, namely, of recognising portraits as representing he presented a tersons, or possibly of mistaking portraits for persons.

On the next day healty, namely, of recognising portraits as representing he had been presented as the present of the pr

A Dandie-Dinmont terrier, after the death of his mistress, anything that it as playing with some children in a room into which was eliberate effort to rought a photograph (large) of her that he had never previously aking hands overen. It was placed upon the floor leaning against the wall. In the words of my informant, who witnessed it, the dog, when r. Goodbehere, one suddenly caught sight of the picture, crouched and trembled l of many similal over, his whole body quivering. Then he crept along the for till he reached it, and, seating himself before it, began to ark loudly, as if he would say, 'Why don't you speak to me?' rmingham) was at the picture was moved to other parts of the room, and he folon being presente wed, seating himself before it and repeating his barking.

Mr. Charles W. Peach also gives an account in 'Nature' the baker came for vol. xx., p. 196) of a large dog recognising his portrait:—

When it (the portrait) was brought to my house, my old dog halfpenny, but no was present with the family at the unveiling; nothing was said a penny. On on him, nor invitation given to him to notice it. We saw that dog's too frequencies gaze was steadily fixed on it, and he soon became excited and



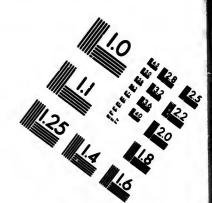
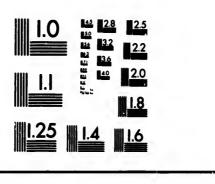


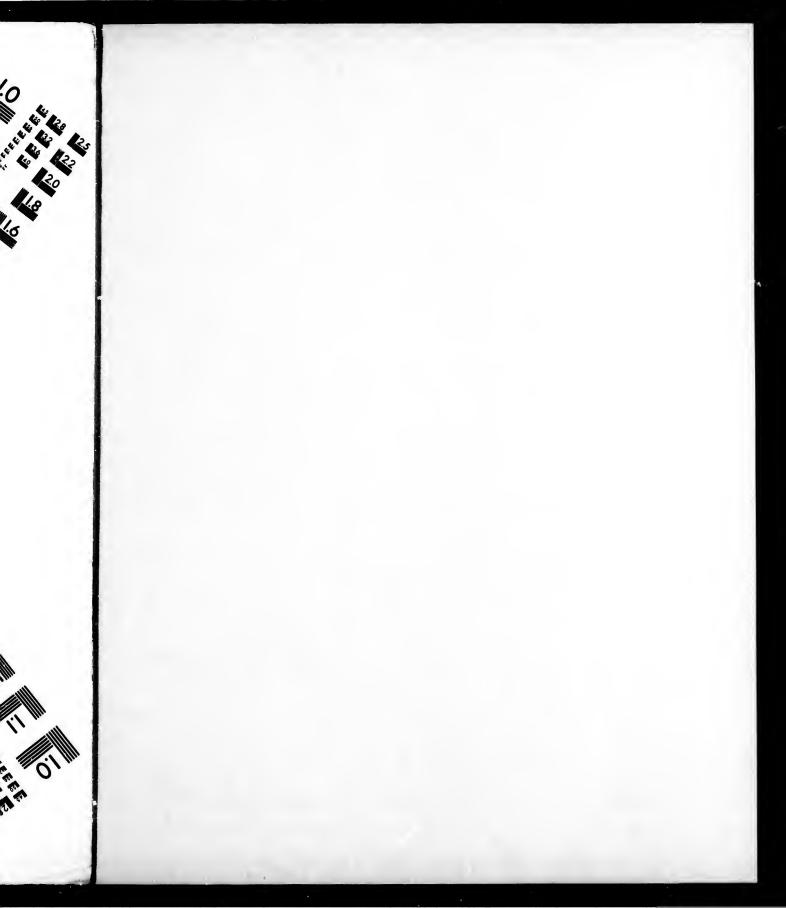
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whined, and tried to lick and scratch it, and was so much taken up with it that we—although so well knowing his intelligence were all quite surprised—in fact, could scarcely believe that he should know it was my likeness. We, however, had sufficient proof after it was hung up in our parlour. The room was rather low, and under the picture stood a chair: the door was left open. without any thought about the dog; he, however, soon found it out, when a low whining and scratching was heard by the family, and on search being made, he was in the chair trying to get at the picture. After this I put it up higher, so as to prevent its being injured by him. This did not prevent him from paying attention to it, for whenever I was away from home whether for a short or a long time—sometimes for several days —he spent most of his time gazing on it, and as it appeared to give him comfort the door was always left open for him. When I was long away he made a low whining, as if to draw attention This lasted for years—in fact, as long as he lived.

From this account it appears that when in the first instance the dog's attention was drawn to the picture if was on the floor in the line of the dog's sight; the behaviou of the animal then and subsequently was too marked and peculiar to admit of mistake.

Another correspondent in 'Nature' (vol. xx., p. 220) alluding to the previous letter, writes:-

Having read Mr. Peach's letter on 'Intellect in Brutes as shown by the sagacity he witnessed in his dog, I have been asked to send a similar anecdote, which I have often told to friends. Many years ago my husband had his portrait taken by J. Phillips, R.A., and subsequently went to India, leaving the portrait in London to be finished and framed. When it was sent home, about two years after it was taken, it was placed of the floor against the sofa, preparatory to being hung on the wall. We had then a very handsome black-and-tan setter which was a great pet in the house. As soon as the dog can into the room he recognised his master, though he had not see him for two years, and went up to the picture and licked the When this anecdote was told to Phillips, he said it was the highest compliment that had ever been paid him.

Similarly, in the same periodical (vol. xx., p. 220) Mr. Henry Clark writes:—

Some years ago a fine arts exhibition was held at Derby. portrait of a Derby artist (Wright) was thus signalised:—'The then turn

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was so much taken g his intelligence ely believe that he ever, had sufficient ie room was rather door was left open, ever, soon found it was heard by the the chair trying to p higher, so as to i not prevent him as away from home. es for several days d as it appeared to en for him. When if to draw attention g as he lived.

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(vol. xx., p. 220)

Intellect in Brutes, is dog, I have been have often told to is portrait taken b India, leaving the $\mathbf{med}.$ When it wa en, it was placed of being hung on the lack-and-tan setter on as the dog cam ugh he had not see cture and licked th illips, he said it wa paid him.

(vol. xx., p. 220)

s held at Derby.

artist's pet dog distinguished this from a lot of pictures upon the floor of the studio by licking the face of the portrait."

Again, I learn from Dr. Samuel Wilks, F.R.S., that a friend of his, whom I shall call Mrs. E., has a terrier which recognised her portrait. 'The portrait is now (1881) hanging in the Royal Academy. When it first arrived home the dog barked at it, as it did at strangers; but after a day or two, when Mrs. E. opened the door to show the portrait to some friends, the dog went straight to the picture and licked the hand. The picture is a threequarter length portrait of a lady with the hand at the bottom of the picture.'

Lastly, my sister, who is a very conscientious and accuate observer, witnessed a most unmistakable recognition of portraits as representative of persons on the part of a small but intelligent terrier of her own. At my request she committed the facts to writing shortly after they occurred. The following is her statement of them:—

I have a small terrier who attained the age of eight months without ever having seen a large picture. One day three nearly life-sized portraits were placed in my room during his absence. Iwo were hung up, and one left standing against the wall on the floor awaiting the arrival of a picture-rod. When the dog entered the room he appeared much alarmed by the sight of the pictures, barking in a terrified manner first at one and then at another. That is to say, instead of attacking them in an aggressive way with tail erect, as he would have done on thus encounwring a strange person, he barked violently and incessantly at some distance from the paintings, with tail down and body elongated, metimes bolting under the chairs and sofas in the extremity of his fear, and continuing barking from there. Thinking it might be merely the presence of strange objects in the room which excited him, I covered the faces of the portraits with cloths and turned the face of the one on the floor to the wall. log soon after emerged from his hiding-place, and having looked intently at the covered pictures and examined the back of the frame on the ground, became quite quiet and contented. then uncovered one of the pictures, when he immediately flew at it, barking in the same frightened manner as before. I then re-covered that one and took the cover off another. The dog left the covered one and rushed at the one which was exposed. us signalised:—'The then turned the face of the one on the floor to the room, and he

This I did many times. flew at that with increased fierceness. covering and uncovering each picture alternately, always with the same result. It was only when all three paintings were uncovered at the same time, and he saw one looking at him in whatever direction he turned, that he became utterly terrified. He continued in this state for nearly an hour, at the end of which time, although evidently very nervous and apt to start, he ceased to bark. After that day he never took any more notice of the pictures during the three months he remained in the He was then absent from the house for seven months. On his return he went with me into the room where the portraits were hung, immediately on his arrival. He was evidently again much startled on first seeing them, for he rushed at one. barking as he had done on the first occasion, but he only gave three or four barks when he ran back to me with the same apologetic manner as he has when he has barked at a wellknown friend by mistake.

It will have been observed that in all these cases the portraits, when first recognised as bearing resemblance to human beings, were placed on the floor, or in the ordinary line of the dog's sight. This is probably an important condition to the success of the recognition. That it certainly was so in the case of my sister's terrier was strikingly proved on a subsequent occasion, when she took the animal into a picture-shop where there were a number of portraits hanging round the walls, and also one of Carlyle standing on the floor. The terrier did not heed those upon the walls, but barked excitedly at the one upon the This case was further interesting from the fact that there were a number of purchasers in the shop who were, of course, strangers to the terrier; yet he took no notice of them, although so much excited by the picture. This shows that the pictorial illusion was not so complete as to make the animal suppose the portrait to be a real person; it was only sufficiently so to make it feel a sense of bewildered uncertainty at the kind of life-in-death appearance of the motionless representation.

If, notwithstanding all this body of mutually corroborative cases, it is still thought incredible that dogs should be able to recognise pictorial representations, we should

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do well to remember that this grade of mental evolution is reached very early in the psychical development of the human child. In my next work I shall adduce evidence to show that children of one year, or even less, are able to distinguish pictures as representations of particular objects, and will point at the proper pictures when asked to show these objects.

Coming now to cases more distinctly indicative of reason in the strict sense of the word, numberless ordinary acts performed by dogs indisputably show that they possess this faculty. Thus, for instance, Livingstone gives the following observation. A dog tracking his master along a road came to a place where three roads diverged. Scenting along two of the roads and not finding the trail, he ran off on the third without waiting to smell. Here, therefore, is a true act of inference. If the track is not on A or B, it must be on C, there being no other alternative.

Again, it is not an unusual thing for intelligent dogs, who know that their masters do not wish to take them out, to leave the house and run a long distance in the direction in which they suppose their masters are about to go, in order that when they are there found the distance may be too great for their masters to return home for the purpose of shutting them up. I have myself known several terriers that would do this, and one of the instances I shall give in extenso (quoted from an account which I published at the time in 'Nature'); for I think it displays remarkably complex processes of far-seeing calculation:—

The terrier in question followed a conveyance from the house in which I resided in the country, to a town ten miles distant. He only did this on one occasion, and about five months afterwards was taken by train to the same town as a present to some friends there. Shortly afterwards I called upon these friends in a different conveyance from the one which the dog had previously followed; but the latter may have known that the two conveyances belonged to the same

display of the recognition of a portrait by a dog. The portrait was one of myself, and the dog a half-bred setter and retreiver of my own.

Missionary Travels, chap. i.

Anyhow, after I had put up the horses at an inn, I spent the morning with the terrier and his new masters, and in the afternoon was accompanied by them to the inn. I should have mentioned that the inn was the same as that at which the conveyance had been put up on the previous occasion, five months before. Now, the dog evidently remembered this, and, reasoning from analogy, inferred that I was about to return. This is shown by the fact that he stole away from our party—although at what precise moment he did so I cannot say, but it was certainly after we had arrived at the inn, for subsequently we all remembered his having entered the coffeeroom with us. Now, not only did he infer from a single precedent that I was going home, and make up his mind to go with me, but he also further reasoned thus:—'As my previous master lately sent me to town, it is probable that he does not want me to return to the country; therefore, if I am to seize this opportunity of resuming my poaching life, I must now steal a march upon the conveyance. But not only so, my former master may possibly pick me up and return with me to my proper owners; therefore I must take care only to intercept the conveyance at a point sufficiently far without the town to make sure that he will not think it worth his while to go back with me.'

Complicated as this train of reasoning is, it is the simplest one I can devise to account for the fact that slightly beyond the third milestone the terrier was awaiting me, lying right in the middle of the road with his face towards the town. I should add that the second two miles of the road were quite straight, so that I could easily have seen the dog if he had been merely running a comparatively short distance in front of the horses. this animal should never have returned to his former home on his own account I cannot suggest, but I think it was merely due to an excessive caution which he also manifested in other things. However, be the explanation of this what it may, as a fact he never did venture to come back upon his own account, although there never was a subsequent occasion upon which any of his former friends went to the town but the terrier was seen to return with them, having always found some way of escape from his intended imprisonment.

The Rev. J. C. Atkinson gives an account ('Zoolo-

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account ('Zoolo-

gist,' vol. vii., p. 2338) of his terrier, which, on starting a water-rat out of reeds into the running stream, would not plunge directly after it, knowing that the rat would beat him at swimming. But the moment the rat plunged, the dog ran four or five yards down the bank, and there waited till the water-rat, being carried down stream, appeared upon the surface, when he pounced upon it successfully.

Cases of this kind might be multiplied indefinitely, and they appear to show a true faculty of reason or inferring.

Professor W. W. Bailey, writing from Broun University to 'Nature' (xxii., p. 607), says:—

A friend of mine, a naturalist, and a very conscientious man, whose word can be implicitly trusted, gives the following, to which he was an eye-witness. His grandfather, then a very old but hale and hearty man, had a splendid Newfoundland. There was a narrow and precipitous road leading from the fields to the house. It was regarded as a very dangerous place. One day when the old gentleman was doing some work about the farm his horse became alarmed, and started off with the waggon along this causeway. The chances were that he would dash himself and the empty waggon to pieces. At once the dog seemed to take in the situation, although until that time he had been impassive. He started after the horse at full speed, overtook him, caught the bridle, and by his strength arrested the frightened creature until help could reach him. My friend gives many other stories of this fine dog, and thinks he had a decided sense of humour. I will repeat that both of these tales come to me well authenticated, and I could, by seeking permission, give names and places.

Couch gives the following, which is worth quoting, as showing the intelligence of dogs in attacking unusual prey:—

On the first discovery of the prey (crabs) a terrier runs in to seize it, and is immediately and severely bitten in the nose. But a sedate Newfoundland dog of my acquaintance proceeds more soberly in his work. He lays his paw on it to arrest it in its escape; then tumbling it over he bares his teeth, and, seizing it with the mouth, throws the crab aloft. It falls upon the stones; the shell is cracked beyond redemption, and then the dainty dish is devoured at his leisure.

¹ Illustrations of Instinct, p. 179.

I myself know a large dog in Germany which used to kill snakes by dexterously tossing them in the air a great number of times, too quickly to admit of the snake biting. When the snake was thus quite confused, the dog would tear it in pieces. This dog can never have been poisoned by the bite of a snake; but he seems to have had an instinctive idea that the snake might be more harmful in its bite than other animals; for while he was bold in fighting with dogs, and did not then object to receiving his fair share of laceration, he was extremely careful never to begin to tear a snake till he had thoroughly bewildered it by tossing it as described.

The reasoning displayed by dogs may not always be of a high order, but little incidents, from being of constant occurrence among all dogs, are the more important as showing the reasoning faculty to be general to these animals. I shall therefore give a few cases to show the

kind of reasoning that is of constant occurrence.

Mr. Stone writes to me from Norbury Park concerning two of his dogs, one large and the other small. Both being in a room at the same time,

one of them, the larger, had a bone, and when he had left it the smaller dog went to take it, the larger one growled, and the other retired to a corner. Shortly afterwards the larger dog went out, but the other did not appear to notice this, and at any rate did not move. A few minutes later the large dog was heard to bark out of doors; the little dog then, without a moment's hesitation, went straight to the bone and took it. It thus appears quite evident that she reasoned—'That dog is barking out of doors, therefore he is not in this room, therefore it is safe for me to take the bone.' The action was so rapid as to be clearly a consequence of the other dog's barking.

Again, Mr. John Le Conte, writing from the University of California, tells me of a dog which used to hunt rabbits in an extensive pasture-ground where there was a hollow tree, which frequently served as a place of refuge for the rabbits when they were pressed:—

On one occasion a rabbit was 'started,' and all of the dogs, with the exception of 'Bonus,' dashed off in full pursuit. We were astonished to observe that the sedate 'Bonus,' fore-

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going the intense excitement of the chase, deliberately trotted by a short cut to a hollow oak trunk, and crouching at its base calmly awaited the advent of the fleeing rabbit. And he was not disappointed (they frequently escaped without being reduced to this extremity), for the pursuing dogs pressed the rabbit so hard that, after making a long detour, it made for the place of refuge. As it was about entering the hollow trunk, the crouching 'Bonus' captured the astonished rodent.

Similarly, Dr. Andrew Wilson, F.R.S.E., writes me as follows:—

There is a shrubbery near the house, about 200 or 300 yards long, and running in the shape of a horseshoe. A small terrier used to start a rabbit nearly every morning, at the end of the shrubbery next the house, and hunt him through the whole length of it to the other end, where the rabbit escaped into an old drain. The dog then appears to have come to the conclusion that the chord of a circle is shorter than its arc, for he raised the rabbit again, and instead of following him through the shrubbery as usual, he took the short cut to the drain, and was ready and in waiting on the rabbit when he arrived, and caught him.

A somewhat similar instance is communicated to me by Mr. William Cairns, of Argyll House, N.B.:—

I was watching the operations of a little Skye terrier on a wheatstack which was in the course of being thrashed, when suddenly a very large rat bounced off, just from under Fan's nose. It darted into a pit of water about a dozen yards from the stack, and tried to escape. Fan, however, plunged after, and swam for some distance, but found she was being left behind. So she turned to the shore again and ran round to the other side of the pit, and was ready and caught it just on landing.

I never saw anything more remarkable. If it was not reason, I do not know how it is possible that it could come much more closely to the exercise of that faculty.

Dr. Bannister, editor of the 'Journal of Nervous and Mental Diseases,' writes me from Chicago, that having spent a winter in Alaska, he 'had a good opportunity to study animal intelligence in the Eskimo dogs,' and he reports it as 'a fact of common occurrence,' when the dogs are drawing sledges on the ice near the coast, that

on coming to sinuosities in the coast-line, they spontaneously leave the beaten track and strike out so as to 'cut across the windings by going straight from point to point' of land. This is frequently done even when the leading dog 'could not see the whole winding of the beaten track; he seemed to reason that the route must lead around the headlands, and that he could economise travel by cutting across.'

It will be remembered in connection with these dogs, that Mr. Darwin in the 'Descent of Man' (p. 75) quotes Dr. Hayes, who, in his work on 'The Open Polar Sea,' 'repeatedly remarks that his dogs, instead of continuing to draw the sledges in a compact body, diverged and separated when they came to thin ice, so that their weight might be more evenly and widely distributed. This was often the first warning which the travellers received that the ice was becoming thin and dangerous.' Mr. Darwin remarks, 'This instinct may possibly have arisen since the time, long ago, when dogs were first employed by the natives in drawing their sledges; or the Arctic wolves, the parent stock of the Esquimaux dog, may have acquired an instinct, impelling them not to attack their prey in a close pack when on thin ice.'

Mrs. Horn writes me:—

One morning, soon after his usual time for starting, I saw the dog looking anxiously about, evidently afraid that my brother had gone without him. He looked into the room where we had breakfasted, but my brother was not there. He went up two or three stairs, and listened attentively. to my astonishment, he came down, and going to the hat-stand in the hall, stood on his hind legs and sniffed at the great-coats hanging there, undoubtedly trying to ascertain whether my brother's coat was there or not.

Another correspondent (Mr. Westlecombe) writes:—

My cat had kittens, of which two were preserved, the rest being drowned. The dog tolerated the two kittens, but did not care about them with any friendship. When the kittens were a few weeks old, I—finding that I could get but one of them off my hands—determined to kill the other, and, as the quickest mode of death, to shoot it by a pistol close behind its head. The

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the kittens were but one of them ad, as the quickest and its head. The dog saw me do this in my garden, and in a few minutes afterwards she appeared with the other kitten dead in her mouth; she had killed it. If that was not reasoning I do not know what is.

Mr. W. F. Hooper writes me of a Newfoundland dog that was in the habit of accompanying the nursemaid and baby belonging to its mistress. On one occasion a keen wind began to blow, and the nursemaid drew her shawl over the child:—

The nursemaid had not taken many steps towards home before her progress was barred by the dog, who placed himself in the centre of the path and growled whenever she advanced. She was much alarmed, and tried to coax the dog to move, but Leo would not, and abated nothing of the hostile display. Half an hour passed, and the girl became nearly distracted. What would be the matter with the dog? Was she to be a prisoner all day? Would the animal fly at her throat? Was Leo suffering from hydrophobia? These and similar questions crossed the girl's mind. At length a suggestion of despair—it was nothing more—occurred to her. She thought it might win the dog round to good humour if she showed it the baby; so she removed the folds of her shawl and presented it at arm's length to the The result was magical, and far in excess of all expectation, for not only did the dog cease to growl, but he began to cambol and caress, and removed himself from the path altogether, so that there was now a free course, and home was soon reached. The explanation of the whole affair is, when the nursemaid turned on her path thinking she had gone sufficiently far, the dog missed sight of the baby, and believed it was gone. Under this impression the dog converted himself into a sentinel, with the resolve that not one step should be taken towards home without the baby; and faithfully did the animal keep watch and ward until the demonstration was given that the child had not been left behind, but was still in the nurse's arms alive and well. I think this is an exhibition of intelligence worthy of being known to you.

I extract the following instance from Col. Hutchinson's 'Dog-breaking.' It is briefly alluded to in the 'Descent of Man.' The observer and narrator is Mr. Colquhoun:—

I may mention a proof of his sagacity. Having a couple of long shots across a pretty broad stream, I stopped a mallard with each barrel, but both were only wounded. I sent him

across for the birds. He first attempted to bring them both, but one always struggled out of his mouth: he then laid down one intending to bring the other; but whenever he attempted to cross to me, the bird left fluttered into the water; he immediately returned again, laid down the first on the shore and recovered the other. The first now fluttered away, but he instantly secured it, and, standing over them both, seemed to cogitate for a moment; then, although on any other occasion he never ruffles a feather, deliberately killed one, brought over the other, and then returned for the dead bird.

The following, communicated to me by Mr. Blood, is a closely analogous, and therefore confirmatory case. He was out shooting with a companion, and three wild ducks were simultaneously dropped into a lake—one falling dead and the other two winged. Mr. Blood sent in his spaniel to retrieve,

and of course when the wounded birds saw her coming they swam out, so that she first reached the dead duck. She swam up to it, paused for a moment, and passing it went after the nearest wounded bird. Having caught this, she again hesitated. and apparently after consideration she gave it a chop and let it go, quieted for the present. She then caught and brought to land the other wounded duck, and going back she again reached the dead bird; but looking at the other and seeing that it was again moving, she went out and brought it in, and last of all brought the dead bird. The dog was a first-rate retriever and never injured game, so that it was an entirely new thing for her to kill a bird.

Again, Mr. Arthur Nicols, in 'Nature,' vol. xix., page 496, says:—

Can we conceive any human being reasoning more correctly than a dog did in the following instance? Towards the evening of a long day's snipe-shooting on Dartmoor, the party was walking down the bank of the Dart, when my retriever flushed mlist, kn a widgeon which fell to my gun in the river, and of course master to instantly dived. I said no word to the dog. He did not swim a c plunge into the river then, but galloped down stream some fifty water he or sixty yards, and then entered and dashed from side to side— was flowing it was about twenty or thirty feet wide-working up stream. Tide was and making a great commotion in the water until he came to well that the place where we stood. Then he landed and shook himself, letter to and carefully hunted the near bank a considerable distance calculate

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ning more correctly owards the evening or, the party was ver, and of course from side to side—

to the opposite side, and diligently explored that Two or three minutes elapsed, and the party was for poving on, when I called their attention to a sudden change in he dog's demeanour. His 'flag' was now up and going from ide to side in that energetic manner which, as every sportsman knows, betokens a hot scent. I then knew that the bird was as afe as if it was already in my bag. Away through the heather rent the waving tail, until twenty or thirty yards from the ank opposite to that on which we were standing there was a mementary scuffle; the bird just rose from the ground above he heather, the dog sprang into the air, caught it, came away at full gallop, dashed across the stream, and delivered it into my ands. Need I interpret all this for the experienced sportsman? The dog had learned from long experience in Australia and the marrow canadas in the La Plata that a wounded duck goes down gream; if winged, his maimed wing sticks out and renders it mpossible for him to go up, so he will invariably land and try whide away from the bank. But if the dog enters at the place where the bird fell, the latter will go on with the stream for an adefinite distance, rising now and then for breath, and give infinite trouble. My dog had found out all this long since, and had proved the correctness of his knowledge times out of number, and by his actions had taught me the whole art and mystery of etrieving duck. His object, I say without a doubt, because I had numberless opportunities of observing it, was to fling the bird and force it to land by cutting it off lower down the stream. Then assuming, as his experience justified him, that the bird had landed, he hunted each bank in succession for the trail, which he knew must betray the fugitive.

As showing in a higher, and therefore rarer degree, the ratiocinative faculty in dogs, I may quote a brief exract from my British Association lecture:—

My friend Dr. Rae, the well-known traveller and natuhy retriever flushed mlist, knew a dog in Orkney which used to accompany his master to church on alternate Sundays. To do so he had to dog. He did not swim a channel about a mile wide; and before taking to the stream some fifty water he used to run about a mile to the north when the tide was flowing, and a nearly equal distance to the south when the vorking up stream, tide was ebbing, 'almost invariably calculating his distance so r until he came to well that he landed at the nearest point to the church.' In his and shook himself, letter to me Dr. Rae continues: 'How the dog managed to siderable distance alculate the strength of the spring and neap tides at their various rates of speed, and always to swim at the proper angle is most surprising.

As a confirmatory case, I may also quote an extrac from a letter sent me by Mr. Percival Fothergill. Writing of a retriever which he has, he says:—

I have seen her spring overboard from our gangway 16 fee from the water-line. The tides ran more than 5 knots, and she invariably came down to a little wharf abreast the ship, and gazed intently for small pieces of stick or straw, and having thus ascertained the drift of the tide (did as you mention d another dog), ran up tide and swam off. The sentry on the forecastle always kept a look-out for the dog, and threw ove a line with a bowling knot, and she was hauled on board.

But one day she was observed to wait an unusual time of the wharf; no wood or straw gave her the required information After waiting some time, she lay down on the planks, an dropped one paw into the water, and found by the feel which way the tide ran, got up, and ran up stream as usual.

Mr. George Cook writes me that he recently had pointer, which one morning, when the grass was covere with frost, dragged a mat out of his kennel, from which shelf in he had got loose, to the lawn beneath the house windows where he was found lying upon the mat, which thus serve to protect him from the frost. The distance over which h had dragged the mat for this purpose was about 100 yards Mr. Cook adds: 'I have since frequently seen him bring this which s mat out of his kennel and lay it in the sunshine, shifting I shall it if a shadow came upon the place where he had laid it. sause the

The following is sent me by the Rev. F. J. Penky wise bed He gives me the name of his friend the canon, but doe part of not give me express permission to publish it. In quoting his account, therefore, I leave this name blank. says:-

The following is an instance of sagacity—indeed, amount ing to reason—in a dog, a French poodle that belonged t Colonel Pearson (not the lately beleaguered colonel at Ekow but a Colonel Pearson living some years ago at Lichfield The circumstance happened to a friend of mine, Canon rector of ——. I have the story from his own lips, but I have no permission for his name to be used in any publication, shoul Being mo

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ty—indeed, amoun mine, Canon ---

the story be thought worthy of it. My friend the canon, I may say, has no leanings. Being a guest at luncheon with the log's master, my friend fed the dog with pieces of beef. After luncheon the beef was taken into the larder. The dog did not think he had his fair share. What did he do? Now he had been taught to stand on his hind legs, put his paw on a lady's wrist, and hand her into the dining-room. He adopted the ame tactics with my friend the canon, stood on his hind legs, put his paw on his arm, and made for the door. To see what would follow, Canon —— suffered himself to be led; but the agacious dog, instead of steering for the dining-room, led him in the direction of the larder, along a passage, down steps, &c., and did not halt till he brought him to the larder, and close to the shelf where the beef had been put. The dog had a small hit given him for his sagacity, and Canon —— returned to the drawing-room. But the dog was still not satisfied. He tried the same trick again, but this time fruitlessly. The canon was not going again with him to the larder. What was Mori to do? and here comes the instance of reason in the poodle. Finding he could not prevail on the visitor to make a second excursion the larder, he went out into the hall, took in his teeth Canon —'s hat from off the hall table, and carried it under the kennel, from which shelf in the larder, where the coveted beef lay out of his reach. There he was found with the hat, waiting for the owner of the lat, and expecting another savoury bit when he should come for his hat.

as about 100 yards Many anecdotes might be adduced of the cleverness seen him bring this which some dogs show in finding their way by train; but sunshine, shifting I shall give only three, and I select these, not only beere he had laid it cause they all mutually corroborate one another, but like-Rev. F. J. Penky wise because they all display such high intelligence on the

Mr. Horsfall, in 'Nature,' vol. xx., p. 505, says:—

Last year we spent our holidays at Llan Bedr, Merionethshire. Our host has a house in the above village, and another at Harlech, a town three miles distant. His favourite dog, le that belonged to Mero, is of Norwegian birth, and a highly intelligent animal. It is at liberty to pass his time at either of the houses owned s ago at Lichfield by his master, and he occasionally walks from one to the other.

More frequently, however, he goes to the railway station at own lips, but I have Bedr, gets into the train, and jumps out at Harlech. Being most probably unable to get out of the carriage, he was on one occasion taken to Salsernau, the station beyond Harlech, when he left the carriage and waited on the platform for the return train to Harlech. If Nero did not make use of 'abstract reasoning' we may as well give up the use of the term.

Miss M. C. Young writes to me:—

You may perhaps think the following worthy of notice, as illustrating the comparative failure of instinct in an animal which has begun to reason. A friend of mine has a mongre fox-terrier of remarkable intelligence, though undeveloped by any training. This dog has always shown a great fondness for accompanying any of the family on a railway journey, often having to be taken out of the train by force. One morning in the summer of 1877 the groom came, in great distress, to say that Spot had followed him to the station, and jumped into the train after a visitor's maid who was going to see her friends and he (the groom) felt sure the dog would be stolen. The railway is a short single line, with three trains down and up each day, and my friend is well known to all the officials, so she sent to meet the next train, when the guard said the dog (apparently finding no friend in the train) had jumped out a a little roadside station about five miles distant. Most dog would have found their way home easily, though the place itself was strange, but Spot did not appear till late in the evening, after ten hours' absence, and dead tired. On inquir we found that the guard had seen nothing of her at 9 A.M., a 12 A.M., at 1 P.M., nor at 4 P.M.; but when he reached the little station on his return at 5.30, 'she was walking up and down the platform like a Christian, jumped into his box, and jumped out again of her own accord at the right station for her home She had evidently spent the interval in trying to find her wa home on foot, and not succeeding, had resolved on returning instance the way she came.

Lastly, for the following very remarkable case I an indebted to my friend Mrs. A. S. H. Richardson:

The Rev. Mr. Townsend, incumbent of Lucan, was former ble; or an engineer on the Dundalk line of railway. He had a ver intelligent Scotch retriever dog, which used to have a habit jumping into any carriage in which Mr. Townsend travelled but this had been discontinued for a year when the following incident happened. Mr. Townsend and the dog were on the platform at Dundalk station; Mr. Townsend went to get psychologically for the station of the sta ticket for a lady, and during his absence the dog jumped internaterial a carriage, and when the train started, was carried down theriticism

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There he found himself alone when he jumped out; Clones. he went into the station-master's office and looked about, then into the ticket-collector's and searched there, and then ran off to the town of Clones, a mile distant. There he searched the resident engineer's office, and not finding his master, returned the station and went to the up platform. When the up rain arrived, he jumped in, but was driven out by the guard. A ballast train then drew up, going on to a branch line which was being constructed to Caran, but which was not finished yet. The dog travelled on the engine as far as the line went, and then ran the remaining five miles to Caran, where Mr. Townend's sister lived. He visited her house, and not finding his master, ran back to the station, and took a return train to Clones, where he slept, and was fed by the station-master. At our in the morning he took a goods train down to Dundalk, where he found Mr. Townsend.



It would be easy to continue multiplying anecdotes of anine intelligence; but I think a sufficient number of intances have now been given for the only purpose that I have n view—namely, that of exhibiting in a connected manner the various psychological faculties which are presented by tation for her home logs, and the level of development to which they severally ring to find her was attain. I may again remark that I have selected these olved on returning instances for publication from among many others that I bould have given, only because they conform to one or other of the general principles to which I everywhere adhere in the quoting of facts. That is to say, these facts are either matters of ordinary observation, and so intrinsically credi-Lucan, was formerly ble; or they stand upon the authority of observers well ly. He had a very known to me as competent; or they are of a kind which I to have a habit of not admit of mal-observation; or, lastly, they are well lownsend travelled corroborated by similar accounts received from indepense dog were on the end went to get be sychology of the dog is as accurate as the nature of the materials admits of my drawing it. If it is fairly open to as carried down t criticism on any one side, I believe it is from the side of

the dog-lovers, who may perhaps with justice complain that I have ignored a number of published facts, standing on more or less good authority, and appearing more wonderful than any of the facts that I have rendered. To this criticism I have only to answer that it is better to erron the safe side, and that if the facts which I have rendered are sufficient to prove the existence of all the psychological faculties which the dog can fairly be said to possess, it is of less moment that partly doubtful cases should be suppressed, where the only object of introducing them would be to show that some particular faculties were in some particular instances more highly developed than was the case in the instances here recorded.

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CHAPTER XVII.

MONKEYS, APES, AND BABOONS.

WE now come to the last group of animals which we shall have occasion to consider, and these, from an evolutionary point of view, are the most interesting. Unfortunately, however, the intelligence of apes, monkeys, and baboons has not presented material for nearly so many observations is that of other intelligent mammals. Useless for all purposes of labour or art, mischievous as domestic pets, and in all cases troublesome to keep, these animals have never enjoyed the improving influences of hereditary domestication, while for the same reasons observation of the intelligence of captured individuals has been comparatively scant. Still more unfortunately, these remarks apply most of all to the most man-like of the group, and the nearest existing prototypes of the human ace: our knowledge of the psychology of the anthropoid apes is less than our knowledge of the psychology of any other animal. But notwithstanding the scarcity of the material which I have to present, I think there is enough to show that the mental life of the Simiada is of a distinctly different type from any that we have hitherto considered, and that in their psychology, as in their anatomy, these animals approach most nearly to Homo sapiens.

Emotions.

Affection and sympathy are strongly marked—the latter indeed more so than in any other animal, not even excepting the dog. A few instances from many that might be quoted will be sufficient to show this.

Mr. Darwin writes:--

Rengger observed an American monkey (a Cebus) carefully driving away the flies which plagued her infant; and Duvancel saw a Hylobates washing the faces of her young ones in a stream. So intense is the grief of female monkeys for the loss of their young, that it invariably caused the death of certain kinds kept under confinement by Brehm in North Africa. Orphan monkeys were always adopted and carefully guarded by the other monkeys, both male and female.

Again, Jobson says that whenever his party shot an orang-outang from their boat, the body was carried off by others before the men could reach the shore.

So, again, James Forbes, F.R.S., in his 'Oriental Memoirs,' narrates the following remarkable instance of the display of solicitude and care for a dead companion exhibited by a monkey:—

One of a shooting-party under a banian tree killed a female monkey, and carried it to his tent, which was soon surrounded by forty or fifty of the tribe, who made a great noise and seemed disposed to attack their aggressor. They retreated when he presented his fowling-piece, the dreadful effect of which they had witnessed and appeared perfectly to understand. The head of the troop, however, stood his ground, chattering furiously; the sportsman, who perhaps felt some little degree of compunction for having killed one of the family, did not like to fire at the creature, and nothing short of firing would suffice to drive At length he came to the door of the tent, and, finding threats of no avail, began a lamentable moaning, and by the most expressive gesture seemed to beg for the dead body. was given him; he took it sorrowfully in his arms and bore it away to his expecting companions. They who were witnesses of this extraordinary scene resolved never again to fire at one of the monkey race.

Of course it is not to be supposed from this instance that all, or even most monkeys display any care for their dead. A writer in 'Nature' (vol. ix. p. 243), for instance, says expressly that such is not the case with Gibbons (Hylobates agilis), which he has observed to be highly sympathetic to injured companions, but 'take no notice whatever' of dead ones.

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¹ Descent of Man, p. 70.

Regarding their sympathy for injured companions this writer says:—

I keep in my garden a number of Gibbon apes (Hylobates agilis); they live quite free from all restraint in the trees, merely coming when called to be fed. One of them, a young male, on one occasion fell from a tree and dislocated his wrist; it received the greatest attention from the others, especially from an old female, who, however, was no relation; she used before eating her own plantains to take up the first that were offered to her every day, and give them to the cripple, who was living in the eaves of a wooden house; and I have frequently noticed that a cry of fright, pain, or distress from one would bring all the others at once to the complainer, and they would then condole with him and fold him in their arms.

Captain Hugh Crow, in his 'Narrative of my Life,' relates an interesting tale of the conduct of some monkeys on board his ship. He says:—

We had several monkeys on board; they were of different species and sizes, and amongst them was a beautiful little creature, the body of which was about ten inches or a foot in length, and about the circumference of a common drinking glass. This interesting little animal, which, when I received it from the Governor of the Island of St. Thomas, diverted me by its innocent gambols, became afflicted by the malady which unfortunately prevailed in the ship. It had always been a favourite with the other monkeys, who seemed to regard it as the last born and the pet of the family; and they granted it many indulgences which they seldom conceded to one another. It was very tractable and gentle in its temper, and never took advantage of the partiality shown to it. From the moment it was taken ill their attention and care of it redoubled; and it was truly affecting and interesting to see with what anxiety and tenderness they tended and nursed the little creature. struggle often ensued among them for priority in those offices of affection; and some would steal one thing and some another, which they would carry to it untasted, however tempting it might be to their own palates. Then they would take it up gently in their fore-paws, hug it to their breasts, and cry over it as a fond mother would over her suffering child. The little creature seemed sensible of their assiduities, but it was wofully overpowered by sickness. It would sometimes come to me and look me pitifully in the face, and moan and cry like an

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om this instance iny care for their 43), for instance, se with Gibbons ed to be highly 'take no notice infant, as if it besought me to give it relief; and we did everything we could think of to restore it to health: but, in spite of the united attention of its kindred tribes and ourselves, the interesting little creature did not survive long.

Here is a case which I myself witnessed at the Zoological Gardens, and published in the 'Quarterly Journal of Science,' from which I now quote:—

A year or two ago there was an Arabian baboon and an Anubis baboon confined in one cage, adjoining that which contained a dog-headed baboon. The Anubis baboon passed its hand through the wires of the partition, in order to purloin a nut which the large dog-headed baboon had left within reach expressly, I believe, that it might act as a bait. The Anubis baboon very well knew the danger he ran, for he waited until his bulky neighbour had turned his back upon the nut with the appearance of having forgotten all about it. The dog-headed baboon, however, was all the time slyly looking round with the corner of his eye, and no sooner was the arm of his victim well within his cage than he sprang with astonishing rapidity and caught the retreating hand in his mouth. The cries of the Anubis baboon quickly brought the keeper to the rescue, when, by dint of a good deal of physical persuasion, the dog-headed baboon was induced to leave go his hold. The Anubis baboon then retired to the middle of his cage, moaning piteously, and holding the injured hand against his chest while he rubbed it with the other one. The Arabian baboon now approached him from the top part of the cage, and, while making a soothing sound very expressive of sympathy, folded the sufferer in its arms—exactly as a mother would her child under similar circumstances. It must be stated, also, that this expression of sympathy had a decidedly quieting effect upon the sufferer, his moans becoming less piteous so soon as he was enfolded in the arms of his comforter; and the manner in which he laid his cheek upon the bosom of his friend was as expressive as anything could be of sympathy appreciated. This really affecting spectacle lasted a considerable time, and while watching it I felt that, even had it stood alone, it would in itself have been sufficient to prove the essential identity of some of the noblest among human emotions with those of the lower animals.

As a beautiful instance of the display of sympathy, I may narrate an occurrence which was witnessed by my friend Sir James Malcolm—a gentleman on the accuracy

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of whose observation I can rely. He was on board a steamer where there were two common East India monkeys, one of which was older and larger than the other, though they were not mother and child. smaller monkey one day fell overboard amidships. larger one became frantically excited, and running over the bulwarks down to a part of the ship which is called 'the bend,' it held on to the side of the vessel with one hand, while with the other it extended to her drowning companion a cord with which she had been tied up, and one end of which was fastened round her waist. incident astonished everyone on board, but unfortunately for the romance of the story the little monkey was not near enough to grasp the floating end of the cord. The animal, however, was eventually saved by a sailor throwing out a longer rope to the little swimmer, who had sense enough to grasp it, and so to be hauled on board.

The following account of the behaviour of a wounded monkey seems to suggest the presence of a class of emotions similar to those which we know as feelings of

reproach. The observer was Capt. Johnson:

I was one of a party of Jeekary in the Bahar district; our tents were pitched in a large mango garden, and our horses were picquetted in the same garden a little distance off. When we were at dinner a Syer came to us, complaining that some of the horses had broken loose in consequence of being frightened by monkeys (i.e. Macacus Orhesus) on the trees. As soon as dinner was over I went out with my gun to drive them off, and I fired with small shot at one of them, which instantly ran down to the lowest branch of the tree, as if he were going to fly at me, stopped suddenly, and coolly put his paw to the part wounded, covered with blood, and held it out for me to see. I was so much hurt at the time that it has left an impression never to be effaced, and I have never since fired a gun at any of the tribe. Almost immediately on my return to the party, before I had fully described what had passed, a Syer came to inform us that the monkey was dead. We ordered the Syer to bring it to us, but by the time he returned the other monkeys had carried the dead one off, and none of them could anywhere be seen.

This case is strikingly corroborated by the following

allusion to Sir W. Hoste's Memoirs, given by Jesse as follows:—

One of his officers, coming home after a long day's shooting, saw a female monkey running along the rocks, with her young one in her arms. He immediately fired, and the animal fell. On his coming up, she grasped her little one close to her breast, and with her other hand pointed to the wound which the ball had made, and which had entered above her breast. Dipping her finger in the blood, and then holding it up, she seemed to reproach him with being the cause of her death, and consequently that of the young one, to which she frequently pointed. 'I never,' says Sir William, 'felt so much as when I heard the story, and I determined never to shoot one of these animals as long as I lived.'

Mr. Darwin says that most persons who have observed monkeys have seen them show a sense of the ludicrous. Here is an instance which I have myself observed, and now quote from my article in the 'Quarterly Journal of Science:'—

Several years ago I used to watch carefully the young orangoutang in the Zoological Gardens, and I am quite sure that she manifested a sense of the ludicrous. One example will suffice. Her feeding tin was of a somewhat peculiar shape, and when it was empty she used sometimes to invert it upon her head. The tin then presented a comical resemblance to a bonnet, and as its wearer would generally favour the spectators with a broad grin at the time of putting it on, she never failed to raise a laugh from them. Her success in this respect was evidently attended with no small gratification on her part.

But perhaps the strongest evidence of monkeys having an appreciation of the ludicrous is the same as that which we have seen to be presented in the case of certain dogs—namely, in the animals disliking ridicule. Abundant evidence on this head in the case of monkeys will be given further on.

That monkeys enjoy play no one can question who spends on hour or two in the monkey-house at the Zoological Gardens. According to Savage, chimpanzees congregate together for the sole purpose of play, when

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¹ Gleanings, vol. iii. pp. 86-7.

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Curiosity is more strongly pronounced in monkeys than in any other animals. We all know the interesting illustration on this head furnished by the experiment of Mr. Darwin, who, in order to test the statement of Brehm that monkeys have an instinctive dread of snakes, and yet cannot 'desist from occasionally satiating their curiosity in a most human fashion, by lifting up the lid of the box in which the snakes were kept,' took a stuffed snake to the monkey-house at the Zoological Gardens. Mr. Darwin says:—

The excitement thus caused was one of the most curious spectacles I ever beheld. . . . I then placed a live snake in a paper bag, with the mouth loosely closed, in one of the larger compartments. One of the monkeys immediately approached, cautiously opened the bag, peeped in, and instantly dashed away. Then I witnessed what Brehm has described, for monkey after monkey, with head raised high and turned on one side, could not resist taking a momentary peep into the upright bag, at the dreadful object lying quietly at the bottom.²

Allied, perhaps, to curiosity, and so connected with the emotions, is what Mr. Darwin calls 'the principle of imitation.' It is proverbial that monkeys carry this principle to ludicrous lengths, and they are the only animals which imitate for the mere sake of imitating, as has been observed by Desor, though an exception ought to be made in favour of talking birds. The psychology of imitation is difficult of analysis, but it is remarkable as well as suggestive that it should be confined in its manifestations to monkeys and certain birds among animals, and to the lower mental levels among men. As Mr. Darwin says:—

The principle of imitation is strong in man, and especially, as I have myself observed, with savages. In certain morbid states of the brain, this tendency is exaggerated to an extraordinary degree; some hemiplegic patients and others, at the

2 Descent of Man p. 72.

Boston Journal of Nat. Hist., iv. p. 324.

commencement of inflammatory softening of the brain, unconsciously imitate every word that is uttered, whether in their own or in a foreign language, and every gesture or action which is performed near them.

The same sort of tendency is often observable in young children, so that it seems to be frequently distinctive of a certain stage or grade of mental evolution, and particularly in the branch *Primates*. Other animals, however, certainly imitate each other's actions to a certain extent, as I shall have occasion fully to notice in my next work.

As for the sterner emotions, rage may be so pronounced as to make a monkey exhaust itself with beating about its cage, or a baboon bite its own limbs till the blood flows. Jealousy occurs in a correspondingly high degree, while retaliation and revenge are shown by all the higher monkeys when injury has been done to them, as any one may find by offering an insult to a baboon. The following is a good case of this, as it shows what may be called brooding resentment deliberately preparing a satisfactory revenge. Mr. Darwin writes:—

Sir Andrew Smith, a zoologist whose scrupulous accuracy was known to many persons, told me the following story of which he was himself an eye-witness. At the Cape of Good Hope, an officer had often plagued a certain baboon, and the animal, seeing him approaching one Sunday for parade, poured water into a hole and hastily made some thick mud, which he skilfully dashed over the officer as he passed by, to the amusement of many bystanders. For long afterwards the baboon rejoiced and triumphed whenever he saw his victim.²

General Intelligence.

Coming now to the higher powers, I shall give a few cases to show that monkeys certainly surpass all other animals in the scope of their rational faculty. Professor Croora Robertson writes me:—

I witnessed the following incident in the Jardin des Plantes, now many years ago; but it struck me greatly at the time, and I have narrated it repeatedly in the interval. A large ape—I

1 Descent of Man, 71.

² Ibid., p. 69.

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ardin des Plantes, ly at the time, and . A large ape—I , p. 69.

believe anthropoid, but cannot tell the species—was in the great iron cage with a number of smaller monkeys, and was lording it over them with many wild gambols, to the amusement of a crowd of spectators. Many things—fruits and the like—had been thrown between the bars into the cage, which the ape was always forward to seize. At last some one threw in a small hand looking-glass, with a strongly made frame of wood. the ape at once laid hold of, and began to brandish like a ham-Suddenly he was arrested by the reflection of himself in the glass, and looked puzzled for a moment; then he darted his head behind the glass to find the other of his kind that he evidently supposed to be there. Astonished to find nothing, he apparently bethought himself that he had not been quick enough with his movement. He now proceeded to raise and draw the glass nearer to him with great caution, and then with a swifter dart looked behind. Again finding nothing, he repeated the attempt once more. He now passed from astonishment to anger, and began to beat with the frame violently on the floor of the cage. Soon the glass was shattered, and pieces fell out. Continuing to beat, he was in the course of one blow again arrested by his image in the piece of glass still remaining Then, as it seemed, he determined to make one in the frame. trial more. More circumspectly than ever the whole first part of the process was gone through with; more violently than ever the final dart made. His fury over this last failure knew no bounds. He crunched the frame and glass together with his teeth, he beat on the floor, he crunched again, till nothing but splinters was left.

Mr. Darwin writes: 'Rengger, a most careful observer, states that when first he gave eggs to his monkeys in Paraguay, they smashed them, and thus lost much of their contents; afterwards they generally hit one end against some hard body, and picked off the bits with their fingers. After cutting themselves only once with any sharp tool, they would not touch it again, or would handle it with the greatest caution. Lumps of sugar were often given them wrapped up in paper; and Rengger sometimes put a live wasp in the paper, so that in hastily unfolding it they got stung; after this had once happened, they always first held the packet to their ears to detect any movement within.'

¹ Descent of Man, pp. 77-8.

The powers of observation and readiness to establish new associations thus rendered apparent, display a high level of general intelligence. Mr. Darwin further observes that Mr. Belt 'likewise describes various actions of a tamed cebus, which, I think, clearly show that this animal possessed some reasoning power.' The following is the account to which Mr. Darwin here refers, and I quote it in extenso, because, as I shall presently show, I have myself been able to confirm most of the observations on another monkey of the same genus:—

It would sometimes entangle itself round a pole to which it was fastened, and then unwind the coils again with the greatest discernment. Its chain allowed it to swing down below the verandah, but it could not reach to the ground. Sometimes, when there were broods of young ducks about, it would hold out a piece of bread in one hand, and when it had tempted a duckling within reach, seize it by the other, and kill it with a bite in the breast. There was such an uproar amongst the fowls on these occasions, that we soon knew what was the matter, and would rush out and punish Mickey (as we called him) with a switch; so that he was ultimately cured of his poultry-killing propensities. One day, when whipping him, I held up the dead duckling in front of him, and at each blow of the light switch told him to take hold of it, and at last, much to my surprise, he did so, taking it and holding it tremblingly in one hand. He would draw things towards him with a stick, and even used a swing for the same purpose. It had been put up for the children, and could be reached by Mickey, who now and then indulged himself in a swing on it. One day I had put down some bird-skins on a chair to dry, far beyond, as I thought, Mickey's reach; but, fertile in expedients, he took the swing and launched it towards the chair, and actually managed to knock the skins off in the return of the swing, so as to bring them within his reach. He also procured some jelly that was set out to cool in the same way. Mickey's actions were very human-like. When any one came near to fondle him, he never neglected the opportunity of pocket-picking. He would pull out letters, and quickly take them from their envelopes.1

I shall now proceed to state some further facts, showing the high level of intelligence to which monkeys of various kinds attain.

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¹ Naturalist in Nicaragua, p. 119.

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The orang which Cuvier had used to draw a chair from one end to the other of a room, in order to stand upon it so as to reach a latch which it desired to open; and in this we have a display of rationally adaptive action which no dog has equalled, although, as in the case before given of the dog dragging the mat, it has been closely approached. Again, Rengger describes a monkey employing a stick wherewith to prise up the lid of a chest, which was too heavy for the animal to raise otherwise. This use of a lever as a mechanical instrument is an action to which no animal other than a monkey has ever been known to attain; and, as we shall subsequently see, my own observation has fully corroborated that of Rengger in this respect. More remarkable still, as we shall also subsequently see, the monkey to which I allude as having myself observed, succeeded also by methodical investigation, and without any assistance, in discovering for himself the mechanical principle of the screw; and that monkeys well understand how to use stones as hammers is a matter of common observation since Dampier and Wafer first described this action as practised by these animals in the breaking open of oyster-shells. The additional observation of Gernelli Carreri of monkeys thrusting stones into the open valves of oysters so as to save themselves the trouble of smashing the shells, though not incredible, requires confirmation. But Mr. Haden, of Dundee, has communicated to me the following very remarkable appreciation of mechanical principles which he himself observed in a monkey (species not noted), and which would certainly be beyond the mental powers of any other animal:—

'A large monkey, confined alone in a large cage, had its sleeping-place in the form of a kind of hut in the centre of the cage. Springing near the hut was a tree, or imitation tree, the main branch of which ascended over the top of the hut, and then came forwards away from it. Whether the roof of the hut enabled this animal to gain any part of this branch, I did not observe, but only remarked its method at the time of gaining the part of the branch which led frontwards, and

away from the hut. This could be done by means of the hut door, which, when opened, swung beneath this part The door, either by accident or by the of the branch. design of its construction, swung to each time the animal opened it to mount upon its top edge. After one or two efforts to mount by it in spite of its immediate swinging to, the creature procured a thick blanket which lay in the cage, and threw it over the door, having opened the same, so that its complete swinging to was prevented sufficiently for the creature to mount upon its free edge, and so gain that part of the branch which ran above it.

The following, which I quote from 'Nature' (vol. xxiii., p. 533), also displays high intelligence:—

One of the large monkeys at the Alexandra Palace had been for some time suffering from the decay of the right lower canine, and an abscess, forming a large protuberance on the jaw, had resulted. The pain seemed so great, it was decided to other m consult a dentist as to what should be done; and, as the poor creature was at times very savage, it was thought that if the sif a gen tooth had to be extracted, gas should be used for the safety from his Preparations were made accordingly, but were for of the operation. the behaviour of the monkey was quite a surprise to all who were concerned. He showed great fight on being taken out of the cage, and not only struggled against being put into a sack literatu prepared with a hole cut for his head, but forced one of his a good hands out, and snapped and screamed, and gave promise of being which] very troublesome. Directly, however, Mr. Lewin Moseley, who had undertaken the operation, managed to get his hand on the abscess and gave relief, the monkey's demeanour changed entirely. He laid his head down quietly for examination, and, without the use of the gas, submitted to the removal of a stump of a tooth as quietly as possible.

According to D'Osbonville, certain monkeys that he observed in the wild state were in the habit of administering corporal chastisement to their young. After suckling and cleansing them, the mothers used to sit down and watch the youngsters play. These would wrestle, of his a throw and chase each other, &c.; but if any of them grew malicious, the dams would spring up, and, seizing

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candra Palace had of the right lower surprise to all who being taken out of

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their offspring by the tail with one hand, correct them severely with the other.

We have already seen that dogs and cats display the

idea of maintaining discipline among their progeny.

According to Houzeau the sacred monkey of India (Semnopithecus entellus) is very clever in catching snakes, and in the case of poisonous species destroy the fangs by breaking them against stones.

Of the fact that monkeys act in co-operation, many

proofs might be given, but one will suffice.

Lieutenant Schipp, in his Memoirs, says:—

A Cape baboon having taken off some clothes from the harracks, I formed a party to recover them. With twenty men I made a circuit to cut them off from the caverns, to which they always fled for shelter. They observed my movements, and detaching about fifty to guard the entrance, the others kept otuberance on the their post. We could see them collecting large stones and t, it was decided to other missiles. One old grey-headed one, who had often paid e; and, as the poor us a visit at the barracks, was seen distributing his orders, as thought that if the f a general. We rushed on to the attack, when, at a scream used for the safety from him, they rolled down enormous stones on us, so that we e accordingly, but were forced to give up the contest.

I shall here bring to a close my selections from the ng put into a sack literature of monkey psychology, because I wish to devote forced one of his good deal of space to detailing a number of observations we promise of being which have not yet been published. Thinking it desirable lewin Moseley, who for the purposes of this work that an intelligent monkey et his hand on the should be subjected to close observation for some length anour changed enter of time, I applied to Mr. Sclater for the loan of one from examination, and, the collection of the Zoological Society. He kindly conthe removal of a served to make a least of the collection of the Zoological Society. sented to my proposal, and I selected a specimen of Cebus fatuellus, which appeared to me to be the most intelligent monkey in the collection. Not having facilities for keeping the animal in my own house, I consigned him to the habit of adminis-ing. After suck-used to sit down we would wrestle, of his arrival till that of his departure she kept a diary,

¹ Loc. cit., vol. i., p. 305.

or note-book, in which all the observations that she made when I was absent were entered. It was originally my intention to make an abstract of this note-book; but on afterwards reading it through for this purpose, it seemed to me that I should rather spoil matters by attempting a condensation. There is a certain graphic effect incidental to the diary form and spontaneous style of diction—the notes, of course, not having been written with a view to verbatim publication; and besides, as the psychology of monkeys has been so little studied, I think it is well to give all the details of a continuous series of observations. It is desirable to add that on occasions subsequent to the taking of this or that particular note, I generally had the opportunity of verifying the observation myself; but I may state that I attach no more importance to this circumstance than I should to verifying an observation of my own; for as a careful observer of animals have quite as much confidence in my sister as in myself It only remains to explain that my mother, being an invalid, is confined most of the time to her bedroom and that the monkey was kept there for the first six week of his stay at her house, partly in order that he might be under constant observation, and partly also to furnish he with an entertaining pet. The following are my sister's notes in extenso and without alteration:—

Brown Capuchin (Cebus fatuellus—Linn.), Brazil DIARY, 1880.

December 18th. Arrived in box with keeper. Seemed rathe frightened and screamed a good deal on being transferred from small box to a larger one.

19th. Took him out of the box he had been in all night an fastened chain on to collar. Was meek and subdued, hiding hi face in my lap.

20th. Has become much more lively and somewhat aggresive, especially towards the servants. He has taken a fancy my mother, and (she holding his chain) he plays with her in gentle and affectionate manner in her bed, but flies angrily a any of the servants who come near the bed. I observed to-dathat he breaks walnuts (which are too hard for him to crac with his teeth) by striking them with the flat bottom of a dis

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he has for drinking out of. He is ceaselessly active all day, and at night covers himself very neatly with warm shawls, and

sleeps soundly till about eight o'clock.

21st. I notice that the love of mischief is very strong in To-day he got hold of a wine-glass and an egg-cup. glass he dashed on the floor with all his might, and of course broke it. Finding, however, that the egg-cup would not break for being thrown down, he looked round for some hard substance against which to dash it. The post of the brass bedstead appearing to be suitable for the purpose, he raised the egg-cup high over his head and gave it several hard blows. When it was completely smashed he was quite satisfied. He breaks a stick by passing it down between a heavy object and the wall, and then hanging on to the end, thus breaking it across the heavy object. He frequently destroys an article of dress by carefully pulling out the threads (thus unripping it) before he begins to tear it with his teeth in a more violent manner. he gets hold of anything that he sees we do not care about, he soon leaves it again; but if it is an article of value (even if it be only a scrap of paper) which he sees we are anxious about, nothing will induce him to give it up. No food, however inviting, will distract his attention: scolding only makes him more angry, and he keeps the article until it is quite destroyed. To-day I gave him a hammer to break his walnuts with, and he uses it in a proper manner for that purpose.

22nd. To-day a strange person (a dressmaker) came into the room where he is tied up, and I gave him a walnut that she might see him break it with his hammer. The nut was a bad one, and the woman laughed at his disappointed face. He then became very angry, and threw at her everything he could lay hands on; first the nut, then the hammer, then a coffee-pot which he seized out of the grate, and, lastly, all his own shawls. He throws things with great force and precision by holding them in both hands, and extending his long arms well back over his head before projecting the missile, standing erect the while.

23rd. There is continual war between him and Sharp [a small terrier], but they both seem to have a certain mutual respect for each other. The dog makes snatches at nuts, &c., and runs away with them beyond the reach of his chain, and the monkey catches at the dog, but seems afraid to hold him or hurt him. He however pelts him with nuts or bits of carrot, and chatters at him. At other times he holds out his hand as if to make friends, but the dog is too suspicious to go near him. His hostility towards the servants (one especially) increases, so that he

will not even take a nut from her without catching fiercely at her hand; he also frequently throws things at her. On the other

hand, he allows my mother to do anything with him.

24th. He bit me in several places to-day when I was taking him away from my mother's bed after his morning's game there. I took no notice, but he seemed ashamed of himself afterwards. hiding his face in his arms and sitting quiet for a time. In ac. cordance with his desire for mischief, he is of course very fond of upsetting things, but he always takes great care they do not fall on himself. Thus he will pull a chair towards him till it is almost over-balanced, then he intently fixes his eyes on the top bar of the back, and when he sees it coming over his way. darts from underneath and watches the fall with great delight: and similarly with heavier things. There is a washband-stand, for example, with a heavy marble top, which he has with great labour upset several times, and always without hurting himself.2

25th. I observed to-day that if a nut or any object he wishes to get hold of is beyond the reach of his chain, he puts out a stick to draw it towards him, or, if that does not succeed, he stands upright and throws a shawl back over his head, holding it by the two corners so that it falls down his back; he then however throws it forward with all his strength, still holding on by the showed corners; thus it goes out far in front of him and covers the nut, and lau, which he then draws towards him by pulling in the shawl. with my When his chain becomes twisted round the bars of a 'clothes- it quiet horse' (which is given him to run about upon), and thus too may of h short for his comfort, he looks at it intently and pulls it with his fingers this way and that, and when he sees how the turns are taken, he deliberately goes round and round the bars, first this way, then that, until the chain is quite disentangled. He often carries his chain grasped in his tail and held high over his back to keep it from getting into the way of his feet. He is always rather excited in the morning when I loosen his chain preparatory to taking him to my mother's bed; jumps about and tugs at the chain. Sometimes, however, if the chain is entangled, and I am rather long in getting it unfastened, he sits quietly down beside me, and begins picking at the chain with

² These heavy objects he overturns with exceeding caution. balancing them several times carefully, and studying them before finally

throwing or pulling them over.

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On subsequent observation (January 14, 1881), I and this quietness was not due to shame at having bitten me, for whether he succeeds in biting any person or not he always sits quiet and dull-looking after a fit of passion, being, I think, fatigued. He has bitten me often since December 24, and seems to enjoy the fun on the whole.

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vhen I was taking ning's game there. imself afterwards, or a time. In acf course very fond care they do not wards him till it is is eyes on the top ing over his way, vith great delight; ashhand-stand, for ne has with great t hurting himself.2 ny object he wishes ain, he puts out a es not succeed, he his head, holding bars of a 'clotheson), and thus too and pulls it with ees how the turns und the bars, first lisentangled. He held high over his f his feet. He is l loosen his chain ed; jumps about if the chain is enunfastened, he sits at the chain with

), I find this quiet-hether he succeeds dull-looking after a en me often since

xceeding caution. them before finally his fingers as if to help me to untie it. I cannot say, however, that he succeeds in helping me at all.

26th. He seems very fond of spinning things round. If he gets a whole apple or orange he generally sits spinning it on one end, before beginning to eat it. He eats an orange by biting off a tiny piece of the peel, and putting his long, thin finger deep into the fruit; he then lays the whole orange under a piece of wire netting he has near him, and, putting his mouth to the hole he has made, presses the wire netting down upon the fruit, thus squeezing the juice up into his mouth. When a good deal of juice begins to run out, he holds the orange up over his head and

lets the juice run into his mouth.

27th. To-day he obtained possession of a rather valuable bcument, and, as usual, nothing I could do would persuade him to give it up. He neglected any kind of food I offered him, and only chattered when I coaxed him. When at last I tried threatening him with a cane, he only became savage and flew at me, chattering. My mother now came and sat down in a chair eside him. He immediately jumped into her lap, and remained quite still while she took the paper out of his hands. When, his back; he then however, she handed it to me and I laughed at her success, he holding on by the showed his teeth and screamed and chattered at me angrily. and covers the nut, and laughing generally irritates him. Thus, when he is playing ing in the shawl. with my mother in the bed in the best of humour, as long as I at quietly on the bed all is well, but if I laugh, for example at my of his affectionate glances, he makes a dart at me to send me off, and then returns with renewed demonstrations of affection my mother, tumbling head over heels and lying on his back, ginning in a most comical manner, and making a sound very ike slight laughter.

> 28th. His chain is fastened to the marble slab of a washhandstand, placed on the floor against the wall. It is too heavy for im to pull along by his chain without hurting himself, so when be desires to do any mischief which is beyond the reach of his thain, he deliberately goes to the marble and pushes an arm hown between an upright part of it and the wall, until he has moved the whole slab sufficiently far from the wall to admit of is slipping down behind the upright part himself. He then laces his back against the wall and his four hands against the pright part of the marble, and pushes the slab as far as he can tretch his long legs. He only does this, however, when he is Lent on mischief, as the fact of food being beyond the reach of is chain does not furnish a strong enough inducement to ead him to take so much exertion. Thus to-day he began to

pull the glazed leather cover off a trunk which was near him. I pulled the trunk away, and when he found it was out of his reach he ran and pushed the marble towards the trunk in the manner I have described, and when he knew his chain was then sufficiently long to reach the trunk, he ran to the latter

and hastily resumed his destructive process.

29th. I notice that nothing the person does who has hold of his chain offends him. I mean, although he is furiously angry at having anything taken away from him, he is not at all angry if he is pulled away by his chain. trying to bite a person, and another person takes hold of his chain behind him and so prevents his spring forward, he does not turn to bite the person who has taken hold of his chain, as a dog would do under similar circumstances, but quietly submits to be thus held. He seems to look upon his confinement and management by a chain as a natural law against which it is useless to struggle. On the other hand, he seems to be quite aware of the place where his chain is fastened, and to know that if he were clever enough to undo it he would be free. After we found he could move about the marble slab of the washhand-stand in the way described, we had a ring sunk in The moment the chain was fastened to the floor to tie him to. that 1 he began to investigate its new connection, and continued to do so for hours, passing the chain rapidly backward and forwards through the ring. When he found this did not loosen it, he began to hammer it and the ring also with all his strength, and this he continued to do for the rest of the day.

30th. He still continues to work at the chain where it is fastened to the ring. He passed the whole of the chain through the ring so many times with his fingers that it became quite blocked up in the ring, which made it very short, and it took me a quarter of an hour to disentangle it. He was very much interested in this process, sitting quietly beside me and watching my fingers intently, sometimes gently pulling my fingers on one side in order to see better, and sometimes casting a quick intelligent glance into my face as if asking how I did it. After I had disentangled and lengthened the chain he worked at it again for hours, but took care not to twist it into the ring a

second time.

31st. To-day he hurt himself by getting one of his toes caught in a hinge of the clothes-horse. He did not make any

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¹ January 14, 1881. The marble slab was left with him after the chain had been fastened to the ring; but since that time he has never attempted to move the marble.

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fuss, although the accident must have been somewhat a painful one, nor did he try to pull the toe out, which would have been useless and only hurt him more; but he sat almost motionless, making slight complaining noises until I discovered that there was something wrong with him. When I began to extricate his foot, he remained perfectly passive—although I dare say I hurt him a good deal—and only looked at me gratefully.

January 1, 1881. He has now quite given up trying to loosen his chain himself; having tried every way and failed, he has evidently become hopeless about it. He now resents being tied up. When I loosen him he is quite pleased, and when I tie him he waits until he is quite sure he is being tied, and not

loosened, and then he flies at me and bites me.

10th. As he is always tied up in the same place he has no new opportunities given him of showing his intelligence. His attachment to my mother has increased. When she goes out he immediately gives up all play and mischief, and does nothing but run round and round in a restless manner, making a peculiar sweet calling noise, such as he never makes when she is in the room, listening intently between times. As long as she remains away he takes no rest or amusement, nor does he ever, or hardly ever, become angry; but the moment she returns he begins all his old ways again, usually becoming more savage at other people than before.

My mother frequently takes things away from him, and he never resents it to her as he would do to any other person. He generally, however, chatters angrily at some one else when my mother removes anything he wishes to keep. At first I thought he was deceived in the matter—that he could not believe it possible that his best friend could deprive him of what he valued, and so thought someone else must have But the same thing has now happened so fredone it. quently that I can hardly think he is not really aware of who takes the things away. He seems rather to think it politic to keep on good terms with one person, and that although he does see her remove the things, and feels angry in consequence, he thinks it more prudent to vent his anger upon someone with whom he has already quarrelled. He always shows more irritation when my mother gives anything to me after having taken it away from him, than when she keeps it herself (as mentioned on December 26), and this may be the reason partly why he resents these matters to me; he thinks when I obtain possession of anything he wants that it is a sort of triumph to me. In the same way my mother may laugh as

much as she likes whether he is with her or not, but if I laugh at all at anything it generally results in something being thrown at me. If my mother calls out to the servants—if, for instance, a servant has left the room and my mother calls her back—he becomes very angry at the servant, and salutes her on her return with a shower of missiles. Sometimes my mother pretends to scold or beat the servants, and then he joins with great energy, by way of supporting his friend. If I scold or beat the servants he does not mind so much. When my mother comes back after being out he does not show any great demonstrations of joy. He screams out with pleasure when he hears her voice approaching on the stairs, but does not make much ado when she enters the room. While my mother is out I can do anything I like with him, just as she can when she is at home. Perhaps being in low spirits he does not feel angry, or perhaps he thinks it prudent to be amiable when his best friend is away. When my mother comes back, a! his ill-temper returns at once and even in an increased degree towards other people, and he immediately resumes playing with all his toys.

11th. When he throws things at people now he first runs up the bars of the clothes-horse; he seems to have found out that people do not much care for having things thrown at their feet, and he is not strong enough to throw such heavy objects as a poker or a hammer at people's heads: he therefore mounts to a level with his enemy's head, and thus succeeds in sending his missile to a greater height and also to a greater distance.

14th. To-day he obtained possession of a hearth-brush, one of the kind which has the handle screwed into the brush. He soon found the way to unscrew the handle, and having done that he immediately began to try to find out the way to screw it in again. This he in time accomplished. At first he put the wrong end of the handle into the hole, but turned it round and round the right way for screwing. Finding it did not hold, he turned the other end of the handle and carefully stuck it into the hole, and began again to turn it the right way. It was of course a very difficult feat for him to perform, for he required both his hands to hold the handle in the proper position and to turn it between his hands in order to screw it in, and the long bristles of the brush prevented it from remaining steady or with the right side up. He held the brush with his hind hand, but even so it was very difficult for him to get the first turn of the screw to fit into the thread; he worked at it, however, with the most unwearying perseverance until he got the first turn of the screw to catch, and he then quickly turned it round and round until it was screwed up to the end. The most remark-

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16th. When he is angry, and has at hand only those things which he wishes to keep, he makes a great show of throwing them at people, but always retains a hold. Thus if he has had a plaything a long time and is tired of it, he throws it right at a person without the least hesitation; but if he has a new thing which he values, he goes through all the appropriate motions for throwing, but only brings the object down with a noise upon the ground, taking care not to let go his hold. He beats people with a long cane he has, and when he cannot reach people he strikes it with all his strength upon the ground to show what he would do if he had the chance. There is no more comical sight than to see him hurriedly climbing his screen in fierce anger, taking (not without great difficulty) his long and awkward stick up with him in order to be high enough to give a good The dog is quite afraid of the stick in the blow to a person. monkey's hands, although he is too petted to be afraid of it in a person's. The monkey is jealous of the dog lying in the armchair in which he sometimes seats himself with my mother, so he pokes the stick at the dog (as the chair is beyond the reach of his chain) and makes him get off.

18th. He was very angry to-day at a servant girl sweeping out his place with a long brush, and he seized the brush every time the servant attempted to sweep. My mother then took it, and he at once became not only quite good-tempered, but assisted her in sweeping, by gathering the rubbish in the corners of his place into little heaps with his hands, and putting

the heaps into the way of the brush.

20th. To-day he broke his chain, and flew at a servant

savagely, but seeing my mother he immediately jumped into While another chain was being prepared he got to the trunk where his nuts are kept. I have long noticed that he looks upon that trunk as in some special sense his own pro-There are other things kept in the trunk as well as the nuts, and if any person goes to the trunk for anything he becomes furiously angry. Indeed nothing makes him so angry as people opening the trunk, and this is not because he wants nuts out of it, for he always has more than he can eat beside him, and generally refuses to take any that are offered to him. Well, to-day, as soon as the breaking of his chain enabled him to get to the trunk, he began picking at the lock with his fingers. I then gave him the key, and he tried for two full hours without ceasing to unlock the trunk with this key. It was a very difficult lock to open, being slightly out of order, and requires the lid of the trunk to be pressed down before it would work, so I believe it was absolutely impossible for him to open it, but he found in time the right way to put the key in, and to turn it backwards and forwards, and after every attempt he pulled the lid upwards to see if it were unlocked. That this was the result of observing people is obvious, from the fact that after every time he put the key into the lock and failed to open the trunk, he passed the key round and round the outside of the lock several times. The explanation of this is that, my mother's sight being bad, she often misses the lock when putting in the key, and then feels round and round the lock with the key; the monkey therefore evidently seems to think that this feeling round and round the lock with the key is in some way necessary to the success of unlocking the lock, so that, although he could see perfectly well how to put the key in straight himself, he went through this useless operation first.

21st. To-day I gave him a wooden box with the lid nailed on, and an iron spoon, to see if he would use the latter as a lever wherewith to raise the lid. The experiment was somewhat spoiled by my mother putting the handle of the spoon into the crack between the lid and the box to show him how to do it. Therefore I cannot tell whether or not he would have taken this first step himself, if he had had time to do so. However, when the handle of the spoon was in he certainly used it in the proper manner, pulling it down with all his strength at the extreme end, thus drawing the nails out of the box and raising the lid.

22nd. He was sitting on my mother's knee, and she washing his hands with a little sponge, a process of which he is

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very fond; she tried to wash his face, and that he disliked very much. Every time she began, the expression of his face became more angry; at last he suddenly jumped off her knee, and made a violent attack on one of the servants who is usually his favourite, although she was doing nothing at all to anger him. This is a good instance of his habit of venting his anger at my mother on other people. He always eats vigorously when he is angry, or after a fit of passion. After a prolonged fit of passion he always lies down on his side as if dead, probably from exhaustion.

30th. He quite understands the meaning of shaking hands. He always holds out his own hand when he wishes to be friendly, especially when a friend is entering or leaving the room. To-day he had been a long time playing with his toys, taking no notice of any one. Suddenly my mother remembered that to-day was my birthday, and (for the first time since he came to the house) shook hands with me in congratulation. He immediately became very angry with me, screamed and chattered and threw things at me, being evidently jealous of the attention my mother was paying me.

February 1st. He has now been moved down to the diningroom, where he is chained between the fireplace and the window. He seems quite miserable on account of the change,

as he does not see so much of my mother.

4th. His low spirits continue, and threaten to make him ill. He will not play with anything, but sits moping and shivering in a corner. To-day I found him very cold and unhappy, and warmed his hands for him. He is very meek and gentle, and

seems to be getting fond of me.

8th. He has quite recovered his spirits since he took a fancy to me. He likes me now apparently as well as he used to do my mother; that is to say, he allows me to nurse him, and walk about in his place, and even take things away from him. When, however, my mother comes to see him, he does not care for me, although he shows none of his old hostility. To the servants, however, he antinues to do so when my mother is present.

10th. We gave him a bundle of sticks this morning, and he amused himself all day by poking them into the fire and pulling them out again to smell the smoking end. He likewise pulls out hot cinders from the grate and passes them over his head and chest, evidently enjoying the warmth, but never burning himself. He also puts hot ashes on his head. I gave him some paper, and, as he cannot, from the length of his chain,

quite reach the fire, he rolled the paper up into the form of a stick, and then put it into the fire, pulling it out as soon as it caught light, and watching the blaze in the fender with great satisfaction. I gave him a whole newspaper, and he tore it in pieces, rolled up each piece as I have described, to make it long enough to reach the fire, and so burnt it all piece by piece. He never once burnt his own fingers during the operation.

13th. He can open and shut the folding shutters with ease, and this seems to be an amusement to him. He also unscrewed all the knobs that belong to the fender. The bell-handle beside the mantelpiece he likewise took to bits, which involves the un-

screwing of three screws.

15th. He is so amiable to me now that he constantly gives me bits of things that he himself is eating, evidently expecting me to share his repast with him. Sometimes this attention on his part is not altogether agreeable. For instance, to-day he thrust into my hand, when I was not looking, a quantity of sopped bread and milk out of his pan, no doubt thinking himself very kind-hearted thus to supply me with food.

17th. He offered the dog a bit of toast which he himself was eating, and the dog took a part of it. I think, however, that he had at the same time a sly design of catching the dog with the other hand, but he did not do so—perhaps because I was looking on, and he knows the dog is a friend of mine; but he had a wicked look in his eye while feeding the dog, which he

has not when he extends his bounty to me.

19th. When I was brushing him to-day he took the brush away from me. Playthings are especially valuable to him now, as he is not allowed to have any lest he should break the windows with them. For this reason I was afraid to leave the brush with him, but found he was not at all disposed to give it up. I threw other things within his reach, but he carried the brush in his hind hand while going after the other things. At last I sat down and called him gently, when he mildly came up to my lap and put the brush into my two hands, evidently resolving that he would not now quarrel with his only friend.

22nd. His manner of showing his humours is interesting, as illustrating the principle of antithesis. Thus when he is angry he springs forward on all four hands with tail very erect and hair raised, so making himself look much bigger. When affectionate he advances slowly backwards with his body in the form of a hoop, so that the crown of his head rests on the ground, face inwards. He walks on three hands (hair very smooth), and puts the fourth fore-hand out at his back in advance

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February 28, 1881.

The above account may be taken as fully trustworthy. Most of the observations recorded I have myself subsequently verified numberless times. From the account, however, several observations which I happened to make myself in the first instance are designedly omitted, and these I shall therefore now supply.

I bought at a toy-shop a very good imitation of a monkey, and brought it into the room with the real monkey, stroking and speaking to it as if it were alive. The monkey evidently mistook the figure for a real animal, manifesting intense curiosity, mixed with much alarm if I made the figure approach him. Even when I placed the figure upon a table, and left it standing motionless, the monkey was afraid to approach it. From this it would appear that the animal trusted much more to his sense of sight than to that of smell in recognising one of his own kind.

I placed a mirror upon the floor, and the monkey at once mistook his reflection in it for a real animal. At first he was a little afraid of it; but in a short time he gained courage enough to approach and try to touch it. Finding he could not do so, he went round behind the mirror and then again before it a great number of times; but he did not become angry, as the monkey of which Prof. Brown Robertson wrote me. Strange to say, he appeared to mistake the sex of the image, and began in the most indescribably ludicrous manner to pay to it the addresses of courtship. First placing his lips against the glass he rose to his full height on his hind legs, retired slowly, and while doing so turned his back to the mirror, looking over his shoulder at the image, and, with a preposterous amount of 'pinch' in his back, strutted up and down before the glass with all the appearance of the most laughable foppery. This display was always gone through when at any subsequent time the mirror was placed upon the floor.

From the first time that he saw me, this monkey took as violently passionate an attachment to me as that which he took to my mother. His mode of greeting, however, was different. When she entered the room after an absence, his welcome was of a quiet and contented character; but when I came in, his demonstrations were positively painful to witness. Standing erect on his hind legs at the full length of his tether, and extending both hands as far as he could reach, he screamed with all his strength, in a tone and with an intensity which he never adopted on any other occasion. So loud, indeed, were his rapidly and continuously reiterated screams, that it was impossible for any one to hold even a shouting conversation till I took the animal in my arms, when he became placid, with many signs of intense affection. Even the sound of my voice down two flights of stairs used to set him screaming in this manner, so that whenever I called at my mother's house I had to keep silent while on the staircase, unless I intended first of all to pay a visit to the monkey.

It has frequently been noticed that monkeys are very capricious in forming their attachments and aversions; but I never knew before that this peculiarity could be so strongly marked as it was in this case. His demonstrations of affection to my mother and myself were piteous; while towards every one else, male or female, he was either passively indifferent or actively hostile. Yet no shadow of a reason could be assigned for the difference. My sister, to whom animals are usually much more attached than they are to me, used always to be forbearingly kind to this one—taking all his bites, &c., with the utmost good Moreover, she supplied him with all his food, and most of his playthings, so that she was really in every way his best friend. Yet his antipathy to her was only less remarkable than his passionate fondness of my mother and myself.

Another trait in the psychology of this animal which is worth observing was his quietness of manner towards my mother. With me, and indeed with every one else, his move but appe boist

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movements were unrestrained, and generally monkey-like; but with her he was always as gentle as a kitten: he appeared to know that her age and infirmities rendered boisterousness on his part unacceptable.

I returned the monkey to the Zoological Gardens at the end of February, and up to the time of his death in October 1881, he remembered me as well as the first day that he was sent back. I visited the monkey-house about once a month, and whenever I approached his cage he saw me with astonishing quickness—indeed, generally before I saw him—and ran to the bars, through which he thrust both hands with every expression of joy. He did not, however, scream aloud; his mind seemed too much occupied by the cares of monkey-society to admit of a vacancy large enough for such very intense emotion as he used to experience in the calmer life that he lived before. Being much struck with the extreme rapidity of his discernment whenever I approached the cage, however many other persons might be standing round, I purposely visited the monkey-house on Easter Monday, in order to see whether he would pick me out of the solid mass of people who fill the place on that day. Although I could only obtain a place three or four rows back from the cage, and although I made no sound wherewith to attract his attention, he saw me almost immediately, and with a sudden intelligent look of recognition ran across the cage to greet me. When I went away he followed me, as he always did, to the extreme end of his cage, and stood there watching my departure as long as I remained in sight.

In conclusion, I should say that much the most striking feature in the psychology of this animal, and the one which is least like anything met with in other animals, was the tireless spirit of investigation. The hours and hours of patient industry which this poor monkey has spent in ascertaining all that his monkey-intelligence could of the sundry unfamiliar objects that fell into his hands, might well read a lesson in carefulness to many a hasty observer. And the keen satisfaction which he displayed when he had succeeded in making any little discovery, such as that of the mechanical principle of the

screw, repeating the results of his newly earned knowledge over and over again, till one could not but marvel at the intent abstraction of the 'dumb brute'—this was so different from anything to be met with in any other animal, that I confess I should not have believed what I saw unless I had repeatedly seen it with my own eyes. As my sister once observed, while we were watching him conducting some of his researches, in oblivion to his food and all his other surroundings—'when a monkey behaves like this, it is no wonder that man is a scientific animal!' And it my next work I shall hope to show how, from so high a starting-point, the psychology of the monkey has passed into that of the man.

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