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THE

CANADIAN NATURALIST

AND

Quarterly Journal of Science.

THE THEORY OF ATOMS IN THE GENERAL CONCEPTION OF THE UNIVERSE.

Opening Address by the President, M. Wurtz, at the Meeting of the French Association.

Francis Bacon conceived the idea of a society of men devoted to the culture of science. In his "New Atlantis," in which he describes the organisation of this society and its influence upon the destinies of a wisely governed people, he shows it rising to the dignity of a State institution. The progress of civilisation by the search for truth, and truth discovered in the order of nature by experiment and observation—such are the ends proposed and the means made use of. Thus, in an age when the syllogism was still supreme, and which was firmly held beneath the scholastic yoke, the English Chancellor assigned to science at once its true method and its mission in the world.

The plan of Bacon embraced all branches of human knowledge. The land was overrun by a multitude of observers, engaged, some in studying the monuments of the past, the language, the manners, the history of the nations; others in observing the configuration and the productions of the soil, noting the superficial structure of the globe and the traces of its revolutions, collecting all the data concerning nature, the organisation and distribution of plants and animals. Other men, located in various regions, cultivated the exact sciences. Towers were constructed for the observation of stars and meteors; vast edifices, arranged for the study of physical and mechanical laws, contained machines which supplied the deficiency of our forces, and instruments which added to the precision of the senses and rendered abstract demonstrations sensible. This immense labour was uninterrupted, co-ordinated, controlled; it had its origin in self-abnegation, it was regulated by precision, and had time for its sanction. Thus was it fruitful.

Such was the idea of Francis Bacon. To observe all things; by the rational comparison of these observations to disclose the hidden connections of phenomena, and to rise by induction to the discovery of their real nature and their causes, all with the view "of extending the empire of man over entire nature, and of executing everything possible for him to do;" such is the object which he has pointed out to us; such is the function of science.

This great exploration of the earth which he desired to institute, this patient and exact research of the laws of the universe, this deliberate intervention of science in the affairs of life and of the universe,—could all this be the work of his own time? He knew it too well to venture to hope it himself, and it is on this account, doubtless, that he placed the fortunate country which enjoyed so noble an institution in the solitude of the great ocean.

Two centuries and a half ago the conception of Bacon was regarded as a noble utopia; to day it is a reality. That magnificent programme which he then drew out, is ours, gentlemen; ours, not in the narrow sense of the word, for I extend this programme to all who, in modern times and in all countries, give themselves to the search for truth, to all workers in science, humble or great, obscure or famous, who form in reality, in all parts of the globe and without distinction of nationality, that vast association which was the dream of Francis Bacon. Yes, science is now a neutral field, a commonwealth, placed in a serene region, far above the political arena, inaccessible, I wish I could say, to the strifes of parties and of peoples; in a word, this property is the patrimony of humanity. It is, too, the principal conquest of this century, which my illustrious predecessor characterised, with so much justice, as the century of science.

Modern generations are spectators, indeed, of a magnificent spectacle. For a century past the human mind has directed an immense effort to the study of the phenomena and the laws of the physical universe. Hence an astonishing development of all the sciences founded on observation and experiment. New ideas which have arisen in our days in the correlation and conservation of forces have been like a revelation to some of these sciences.

Mechanics, physics, chemistry, physiology itself, have found at once a *point d'appui* and a bond of connection. And this powerful flight of ideas has been sustained by the progress of the methods, I should say by the more careful exactness of observations, the perfect delicacy of experiments, the more rigorous severity of deductions. These are the springs of this movement which hurry along the sciences, and of which we are the astonished and moved witnesses. It is to propagate it broadcast over our country that we hold, each year, this parliament, to which are invited all who take part or are interested in the war against the unknown. Science is indeed a war against the unknown; for, if in literature it is enough to give expression, and in art a body, to conceptions or beauties deposited either in the human mind or in nature, it is not so in science, where truth is deeply hidden. She must be conquered, she must be stolen, like the Promethean fire.

It is of some of these conquests that I wish to speak to-day, full of doubt and apprehension in presence of so great a task. To respond to the demands of his position and to follow noble examples, your president ought, at the beginning of this session and of the ceremonies which inaugurate our young association, to trace the progress accomplished in the sciences, mark by a few bold lines the various routes over which it has recently run, and the culminating points which it has attained. I shrink from such a programme: if it does not exceed the powers of some of my colleagues, and doubtless of some among you, it greatly surpasses mine. Less justified and less daring than was Condorcet at the end of last century, I only perceive the outlines and some bright patches of the sketch which he attempted to draw; and to see it accomplished, I shall call to my assistance those who will follow me in the honourable and perilous post I now occupy.

I shall confine myself, then, gentlemen, to speaking to you of what I know, or of what I think I know, by directing your attention to the science to which I have devoted my life.

Chemistry has not merely grown, it has been regenerated since Lavoisier. You know the work of that immortal master. His labours in connection with combustion gave to our science an immovable basis by fixing at once the notion of simple bodies and the essential character of chemical combinations. In these latter we find in weight all that is ponderable in their elements. These, in uniting to form compound bodies, do not lose any of their proper substance; they lose only an imponderable thing, the heat disengaged at the moment of combination. Hence that conception of Lavoisier that a simple body such as oxygen is constituted, properly speaking, by the intimate union of the ponderable matter oxygen with the imponderable fluid which constitutes the principle of heat, and which he named caloric—a profound conception, which modern science has adopted, giving it a different form. It is, then, unjust that, in recent times, Lavoisier should be accused of having misconceived what is physical in the phenomenon of combustion, and that an attempt should be made to rehabilitate the doctrine of Phlogiston which he had the honour of overturning. It is true that in burning bodies lose something: "It is the combustible principle," said the partisans of Phlogiston; "It is caloric," said Lavoisier; and he adds, an *essential thing, that they gain in oxygen.*

Thus Lavoisier perceived completely the phenomenon, of which the great author of the phlogiston theory, G. E. Stahl, had only a glimpse of the external appearances, and of which he misconceived the characteristic feature. Such is, gentlemen, I maintain, the foundation and the origin of modern chemistry. Is that to say that the monument raised upon these bases by Lavoisier and his contemporaries subsists in all its parts, and that it was accomplished at the end of last century? It would not be from want of materials, and even in its outlines we may notice lines which have in time disappeared. It has then been added to and in part transformed; but it still rests upon the same foundations. Such has been in all sciences and in all times the lot of theoretical conceptions; the best of them contain obscurities and gaps which, on disappearing, become the occasion of important developments or of a new generalisation.

That of Lavoisier embraced especially the bodies best known in his time, *i. e.*, the compounds of oxygen, the true nature of which was discovered by him in his researches on combustion. All these bodies are formed of two elements; their constitution is binary, but it is more or less complicated. Some, oxides or acids, contain a simple body united to oxygen; others, more complex, are formed by the combination of acids and oxides among themselves, a combination which gives rise to salts. These last then are formed of two constituent parts, each of which contains oxygen united to a simple body. Such is the formula of Lavoisier on the constitution of salts; it is in harmony with the fundamental idea which he enounced on chemical combination, an idea according to which all compound bodies are formed of two immediate elements, which are either simple bodies or themselves compound bodies.

This dualistic hypothesis was embodied, in his time and with his consent, in French nomenclature, the work of Guyton de Morveau, the principle of which may be thus summarised: two words to designate each compound, one to mark the genus, the other the species. Thus, one of the fundamental conceptions of the system of Lavoisier—dualism in combinations—found a striking expression in the binary structure of the names, and is, as it were, insinuated into the mind by the very terms of chemical language; and we know what is, in such a case, the power of words.

The great successor of Lavoisier, Berzelius, extended to the whole of chemistry the dualistic hypothesis of Lavoisier on the constitution of salts. Wishing to give it a solid support, he added to it the electro-chemical hypothesis. All bodies are formed of two constituent parts, each of which possesses, and is, as it were, animated by, two electric fluids. And as the electro-positive fluid attracts the electro-negative, it is natural, it is necessary that in every chemical compound the two elements should reciprocally attract each other. Is not the one carried towards the other by electric fluids of opposite kinds? We see that the hypothesis of Berzelius gives at once a striking interpretation of the dualism in combinations and a simple and profound theory of chemical affinity. This elective attraction which the final particles of matter exercise upon each other was referred to electric attraction.

Another theoretic conception gave a body to the electro-chemical hypothesis, and has given since a solid basis to chemistry as a whole. We speak of the atomic theory, revived from the Greeks, but which took, at the commencement of this century, a new form and a precise expression. It is due to the penetration of an English thinker, a teacher of chemistry in Manchester in the beginning of the century. It was less a pure speculation of the mind, as were the ideas of the ancient atomists and of the philosophers of the Castesian school, than a theoretical representation of well-established facts, viz., the parity of the proportions according to which bodies combine, and the simplicity of the relations which express the multiple combinations between two bodies.

Dalton found, in fact, that, in cases where two substances combine in several proportions, if the quantity of one of them remains constant, the quantities of the other vary according to very simple relations. The discovery of this fact was the starting-point of the atomic theory. Here is the substance of this theory:—That which fills space, viz. matter, is not infinitely divisible, but is composed of a universe of invisible, imperceptible particles, which, nevertheless, possess a real extension and a definite weight. These are atoms. In their infinitely attenuated dimensions, they offer points of application to the physical and chemical forces. They are not all like each other, and the diversity of matter is owing to inherent differences in their nature. Perfectly identical for the same simple body, they differ from one element to another in their relative weights, and perhaps by their form. Affinity sets them in motion, and when two bodies combine with each other, the atoms of the one are drawn towards the atoms of the other. As this approach always takes place in the same manner between a determinate number of atoms, which are in juxtaposition one to one, or one to two, or one to three, or two to three—in other words, according to very simple proportions, but invariable for a given combination—it results therefrom that the smallest particles of this combination present a fixed composition rigorously similar to that of the entire mass.

Thus the most important fact of chemistry, the immutability of the proportions according to which bodies combine, appears as a consequence of the fundamental hypothesis that chemical combinations result from the coming together of atoms possessing invariable weights. Berzelius compared these atoms to minute magnets. He imagined them to have two poles where the two electric fluids are separated but unequally distributed, so that one of them is in excess at one of the poles. "There exist," he said "atoms with excess of positive fluid and others with excess of negative fluid"; the first attract the second, and this attraction, the source of chemical affinity, preserves the atoms under all combinations. At the moment that these last are formed they are set in motion; in the completely formed compound they are at rest, and are divided as if into two camps, at once kept together and maintained in opposition by the two electric fluids of opposite kinds.

Thus the electro-chemical theory, ingeniously adapted to the hypothesis of atoms, raised the dualism of Lavoisier to the dignity of a system, which appeared solidly established during the first half of this century. The facts then known were included in it without difficulty, and the rich materials which the patience or the genius of experimenters amassed without ceasing were very soon co-ordinated.

Without attempting to enumerate the older works relating to the decomposition of alkalis, to the nature of chlorine recognised as a simple body, to various newly-discovered elements, such as selenium, tellurium, iodine, we shall mention in a special manner among so many discoveries, that of cyanogen, which we owe to our own Gay-Lussac. The demonstration of the chemical functions of this compound gas, which behaves like a simple body, which is capable of forming the most varied combinations with true elements, which finally, when it is engaged in such combinations lends itself to double decompositions, as does chlorine in the chlorides, was a great step in the progressive march of science. Hence the definition: cyanogen is a compound radical, and the triumphant appearance of the doctrine of radicals. It had been vaguely intimated by Lavoisier; it really dates from the discovery of cyanogen, and will make a rapid advance. Up to that time great efforts had been directed to the side of inorganic chemistry, and great ideas had arisen in this domain. The application of these ideas to organic chemistry, upon which attention then began to be directed, presented some difficulties.

We know that the innumerable bodies which nature has distributed in the organs of plants and animals contain a small number of elements—carbon, hydrogen, oxygen, and often nitrogen. It is then not in their general composition that they differ, but by the number and arrangement of the atoms which enter into their composition. By increasing more or less and grouping themselves in various manners, these atoms give rise to an immense multitude of distinct compounds which are true chemical species. But what is the arrangement of these atoms? What is the structure of these organic molecules, so much alike in the nature of their elements, so wonderful in the infinite diversity of their properties? Berzelius solved this question without hesitation. Comparing organic compounds to the bodies of inorganic chemistry, he divided both classes of atoms into two lots, grouping on one side carbon and hydrogen, electropositives, and on the other, oxygen, electro-negative. And when, at a later time, chlorine was artificially introduced into organic compounds, the atoms of this powerful element were ranged on the side of oxygen, both being invariably found in binary combinations of which they formed the electro-negative element, the atoms of carbon and hydrogen constituting the electro-positive radical.

Thus the great promoter of inorganic chemistry attempted to fashion organic molecules according to the image of those molecules of dead matter which he had studied so thoroughly. The paths which Lavoisier traced in this domain he wished to extend to the world of products formed under the influence of life; they resulted in a dead-lock. In proportion as the riches of science increased it was necessary, in order to uphold the system, to accumulate hypotheses, to invent radicals, to construct, with insufficient or imaginary data, formulæ more and more complicated —a thankless task, in which the feeling of experimental realities and sober appreciation of facts often gave place to outrageous reasonings and vague subtleties. These barren efforts of a great mind inaugurated the decline or marked the termination of the dualistic ideas which were at the foundation of what has been called, improperly perhaps, the old chemistry. The new began at that point. Great discoveries, cleverly and boldly interpreted, gave it an impulse which still endures.

There were then—I speak of forty years ago—a number of young men, with Dumas and Liebig at their head, in the opposite camp, who cultivated with ardour the investigation of organic compounds. Convinced that the constitution of these compounds could only be deduced from the attentive investigation of their properties and metamorphoses, they undertook to investigate these bodies themselves, to transform them, to torment them in some sort by the action of the most diverse reagents, in the hope of discovering their intimate structure. And this is, gentlemen, the true method in chemistry; to determine the composition of bodies, and by careful analysis of their properties to fix, as far as possible, the grouping of their ultimate particles. This, then, is the glory of our science, and the single but precious contribution which it is able to furnish for the solution of that eternal problem, the constitution of matter.

From the researches which were made at this epoch and in this spirit, an all-important fact issued; it relates to the action of chlorine on organic compounds. This simple body deprives them of hydrogen and may be substituted for that element, atom for atom, without affecting the molecular equilibrium and without, adds Dumas, modifying the fundamental properties. This proposition encountered at first the most violent contradiction. How could chlorine take the place of hydrogen and play its part in combinations? These two elements, said Berzelius, are endowed with opposite properties, and if the one is lacking the other cannot supply its place; for, in short, they are two inimical brothers, little disposed and by no means fit to be kept in the same house. These critics and many others have not prevailed against facts. The theory of substitutions has come triumphantly out of this great discussion, which marks a date in the history of our science. Its natural development has gradually introduced into it new ideas on the constitution of chemical compounds, on the mode of combination of the elements which they contain.

These ideas have come to light by various ingenious comparisons. Laurent considered organic compounds as formed of nuclei with appendages, both the one and the other admitting into their structures atoms grouped with a certain symmetry. Dumas compared them to edifices of which the atoms constitute, in a manner, the materials. Hence the graphic but frequently correct expression, of molecular edifices capable of being modified, in certain cases, by the substitution of one part for another, and which, in other cases, the shock of powerful reagents may shatter to pieces. In both conceptions the chemical molecules were regarded as forming a whole. A little later Dumas compared them to planetary systems; and here he veritably shot ahead of his time in giving us a glimpse of groups of atoms maintained in equilibrium by affinity, but carried along by movements, as the planets of a solar system are acted upon by gravitation and carried into space. It is in these movements of atoms and molecules that at a later period the source of the physical and chemical forces must be sought for; but I must not anticipate. I have attempted to show how the ideas on chemical combinations have been gradually modified under the double influence of the atomic hypotheses and of facts brought to light by the French school concerning their reciprocal replacement in combinations. Forming a whole, more or less complex, the molecules of organic substances may be modified by substitution and give rise to a multitude of derivatives which naturally attach themselves to the mother substance. The latter serves them as a model or type. The typical idea thus introduced into science very soon occupied a large place. It first brought to it important elements of classification. All the compounds derived by substitution from the same body were ranged in the same family, of which the latter was, so to speak, the chief. Hence arose groups of bodies perfectly distinct from each other, and the number of which were being constantly increased by daily discoveries. It was necessary not only to introduce order into all these tribes, but to connect them with each other by a common bond. The honour of having discovered the superior principle of classification belongs to Laurent and Gerhardt, valiant champions of French science, from whom premature death has snatched, if not victory, at least the gratification of victory. Laurent was the first to say that a certain number of mineral and organic compounds possessed the constitution of water, and this idea, brilliantly developed by Williamson, was generalised by Gerhardt. According to the last named, all inorganic and organic compounds may be connected with a small number of types, of which hydrochloric acid, water, and ammonia, are the chief. In these compounds, relatively simple, one element may be replaced by another element, or by a group of atoms performing the function of a radical, so that this substitution gives rise to a multitude of various compounds bound together by the analogy of their structure, if not by the harmony of their properties.

This last point was novel and important. Bodies belonging to one type and similar in their molecular structure may differ much in their properties: these depend not only on the arrangement of the atoms, but also on their nature. Thus the inorganic and organic bodies ranged under the type water, are, according to the nature of their elements or their radicals, powerful bases, energetic acids, or indifferent substances—a great and bold idea, which has established a connection between the most diverse bodies, and which has definitely overturned the barriers which use had raised, and which the weakness of theory had maintained, between inorganic and organic chemistry. And yet this was only a stage in the march of ideas. By what right and by what privilege, it was said, may the relatively simple compounds we have named serve as types for all others, and why should nature be restricted to make all bodies on the model of hydrochloric acid, water, and ammonia? This was a serious difficulty, but it has been removed, it became the occasion of a profound discussion and the germ of a real progress.

These typical compounds represent at bottom various forms of combination, the diversity of which it is necessary to refer to the nature of the elements themselves. The latter impress on each of these compound types a particular character and a special form. The atoms of chlorine are so formed that to one of them only a single atom of hydrogen needs to be added to form hydrochloric acid; then that an atom of oxygen takes two atoms of hydrogen to form water; that an atom of nitrogen requires three to constitute ammonium, and that an atom of carbon demands four to become marsh-gas. What a difference in the power of combination of these elements, and, so to speak, in their appetites for hydrogen! And will this difference not be connected with some peculiarities in their mode of existence, to some property inherent in matter itself, and which will impress on each of these hydrogenic compounds a special form? Such is the case.

It is now admitted that atoms are not motionless, even in bodies apparently the most fixed and in completely formed combinations. At the moment when these are being formed the atoms come into violent collision with each other. In this conflict a disengagement of heat is ordinarily observed, resulting from the expenditure of active energy which the atoms have lost in the *mêlée*, and the intensity of this heat-phenomenon gives the measure of the energy of the affinities which have presided at the combination. But there is another thing in chemical phenomena besides the intensity of the forces at work, and which are more or less exhausted by a disengagement of heat; I refer to their *mode;* it was of this elective attraction that Bergman spoke a century ago, and which governs the form of the combinations. The atoms of the various simple bodies are not endowed with the same aptitude for combination with each other; they are not equivalent to each other. This is what is called atomicity, and the fundamental property of atoms is without doubt connected with the various modes of motion by which they are animated. When these atoms combine with each other, their movements require to be reciprocally co-ordinated, and this co-ordination determines the form of the new systems of equilibrium which will be formed; that is, the new combinations.

It is with atoms thus endowed that chemists now construct molecular edifices. Resting at once upon the data of analysis and on the investigation of reactions, they express the composition of bodies by formulæ which mark the nature, the number, and the arrangement of the atoms which each molecule of these bodies contains. But what! is this merely an ingenious exercise of the mind? and the construction of formulæ by means of these symbolic materials which are selected, which are arranged so as to give to the molecular edifice a determined form,—is this a mere matter of curiosity? By no means. These formulæ, by whose aid are expressed the composition of bodies and the constitution of their molecules, offer also a valuable aid for the interpretation of their properties, for the study of their metamorphoses, for the discovery of their reciprocal relations,—all things which are intimately connected in each body with the nature and arrangement of the atoms. Now, the investigation and comparison of these formulæ furnish to the inquiring spirit the elements of a powerful synthesis. What treasures have been acquired by science by this process, which consists in deducing the transformations of bodies from their molecular structure, and in creating, by a sort of intuition, new molecules by means of those already known! The artificial formation of a number of combinations, the syntheses of as many organic compounds as nature alone seemed to have the privilege of forming—in a word, the greater part of chemical discoveries which have enriched science and the world for twenty years—are founded on this inductive method, the only efficacious and the only rational one in the sciences. I shall cite only one example among many others.

A happy chance led to the discovery of that brilliant substance, of a bright purple, which is known under the name of fuchsine or rosaniline. Analysis determines its composition, skilled investigations find its molecular structure. Soon it is known how to modify it, to multiply the number of its derivatives, to vary the sources of their production, and from attentive study of all these reactions, issue a pleiad of analogous substances whose diverse colours rival in brilliancy the richest tints of the rainbow. A new and powerful industry has already resulted from all these investigations, which theory has followed step by step and guided the fertile evolution. In this order of investigation, science has recently gained one of her most striking triumphs. She has succeeded in forming at once the colouring matter of madder (alizarin). By an ingenious combination of reactions, and by theoretic reasonings still more ingenious, MM. Graebe and Liebermann have succeeded in obtaining this body synthetically, by means of anthracene, one of the numerous bodies which is now obtained from coal-tar, the impure source of so many wonders. Such is a discovery which has issued from the womb of science, and of science the most abstract; confirming preconceived ideas on the relations of composition and of atomic structure between anthracene, alizarin, and the intermediate terms. And this will not be the last product of this beautiful development of chemistry. Future conceptions on the intimate structure of complex organic compounds will be so many landmarks for new syntheses, and hypotheses rigorously deduced from acquired principles will be fruitful in the happiest applications.

Saccharine matters, alkaloids, other complex bodies whose properties and diverse transformations are actively investigated with a view of deducing their molecular constitution—all these substances may be artificially reproduced, as soon as this preparatory work, so difficult and often seemingly so useless, will have sufficiently advanced. So fine a programme justifies the great efforts which have been made, in our days, in this direction. To discover, to analyse, to study, to classify, reproduce artificially so many diverse substances, to study their internal structure, to indicate their useful applications; to surprise, in a word, the secrets of Nature and to imitate her, if not in her processes, at least in some of her productions—such is the noble aim of contemporary science. She can only reach it by the sure but slow paths we have indicated; experiment guided by theory. In chemistry, at least, empiricism has had its day; problems, clearly stated, must be boldly faced, and henceforth the rational conquests of experiment will only leave a place more and more circumscribed for fortunate finds and the surprises of the crucible. Away, then, with the detractors of theory, who go in quest of discoveries which they can neither foresee nor prepare; they reap where they have not sown. But you, courageous workers, who trace methodically your furrows, I congratulate you. You may be sometimes deceived, but your work will be fruitful, and the goods which you amass will be the true treasure of science.

Will not this science be one day embarrassed and as if encumbered with so much riches, and will the strongest memory be able to support all the weight? If the danger exists, there is no need to fear it. The classification of all these materials will free us from embarrassment. In a well-arranged edifice, each stone requires to be prepared before taking its place; but the construction accomplished, all do not strike the eye equally, though each has its use; only the strong courses, the corner-stones and the salient parts, are noticed. It will be thus with the monument of science. The details which have for their end to fill up gaps will disappear in the great whole, of which we only need consider the foundation, the principal lines, and the crowning of the edifice.

Gentlemen, chemistry thus constituted, and physics, have between them necessary connections. Both the one and the other investigate the properties of bodies, and it is evident that, so far as the ponderable bodies are concerned, these properties must be intimately connected with the constitution of matter. Hence the atomic hypothesis which suffices for the interpretation of chemical phenomena ought also to be adapted to physical theories. This is the case. It is in the movements of atoms and of molecules that we now seek, not only the source of the chemical forces, but the cause of the physical modifications of matter, changes of condition which it can undergo, phenomena of light, of heat, of electricity, of which it is the support.

Two French *savans*, Dulong and Petit, discovered some time ago a very simple law which connects the weights of atoms with their specific heats. It is known that the quantities of heat necessary to change by one degree the temperature of the unit, of weight of bodies are very unequal. This is what we call specific heat; but the quantities of heat which bring about in simple bodies, taken under conditions in which they are rigorously comparable, the same variations of temperatures, are equal, if we apply these quantities of heat not to the unit of weight but to the atomic weight; in other words, the atoms of these elementary bodies possess the same specific heats, though their relative weights are very unequal.

But as to this heat which is thus communicated to them, and which raises their temperature equally, what is in reality its mode of action? It augments the intensity of their vibratory movements. Physicists recognise heat as a mode of motion, and that it comes under the cognisance of our perceptions by the vibrations of atomic matter or ether; of ether, that fluid material perfectly elastic, incoercible, imponderable, which fills all the immensity of space and the depth of all bodies. It is in this fluid that the stars describe their orbits; in this fluid atoms perform their movements and describe their trajectories. Thus the ether, the radiant messenger of heat and light, conveys and distributes their radiations through all the universe; and that which it loses in vibratory energy when it penetrates a cold body. which it warms, it communicates to the atoms of this body and augments the intensity of their movements; and that which it gains in energy by contact with a warm body, which it cools, it withdraws from this body and diminishes the intensity of their vibratory movements. And this kind of light and heat which comes from material bodies is transmitted across space to other material bodies. You will remember in reference to this the words which Goethe put into the mouth of the Prince of Darkness in cursing the light—"It is born of bodies, it is brought forth and maintained by bodies, and it will perish with them."

But this exchange of forces which circulate from ether to atoms and from atoms to ether, must it manifest itself always in the phenomena of light or heat? This vibratory force which is transmitted by ether, can it not be preserved and stored up by matter, or appear under other forms?

It can be preserved as affinity, liberated as electricity, transformed into dynamic movements. It is this which is stored up in the innumerable compounds elaborated by the vegetable kingdom; it is this which provokes the decomposition of carbonic acid and of the vapour of water by the most delicate organs of plants which blossom in the sunlight. Originating with the sun, luminous radiation becomes affinity in the immediate organic principles which are formed and accumulated in vegetable cellules. That mode of motion of ether which was "light" is become another mode of motion which is "affinity," and sways the atoms of an organic compound. In its turn this force thus stored up is expended again when the organic compounds are destroyed in the phenomena of combustion. Affinity, satisfied and as it were lost by the combination of combustible elements with oxygen, again becomes heat or electricity. Wood in burning, and carbon in becoming oxidised, produce sparks or flames: a metal which exhausts its affinities in decomposing an acid warms the liquid or, under other conditions, produces an electric current, warming it less when the current is exterior. And in another order of phenomena, heat which distributes or propagates itself unequally between two surfaces, rubbing one against the other, or in a crystal that is warmed, or in two metals united by solder, disappears partially as such and manifests itself as static electricity or as an electric current. Thus all these forces are equivalent to one another and appear under diverse forms, whether they are passing from atoms to ether or from ether to atoms; but we never see them disappear or lose their force—only transform themselves and perpetually renew their youth.

And this is not all. These vibratory movements which sway atoms and which whirl about in ether can cause movements of the mass, displacement either of the bodies or of the molecules. Warm a bar of iron, it will dilate with a force almost irresistible; a part of the heat will be employed in producing a certain pull-asunder of the molecules. Warm a gas, it will in like way dilate, and a part of the heat disappearing as such, will produce a separation very considerable in this case between the gaseous molecules; and the proof of the consumption of heat in work of dilation is not difficult to give, for if you warm the same gas to the same degree, but prevent it from dilating, less heat need be given to it than in the former case. The differance between the two quantities of heat corresponds exactly to the mechanical work performed by the molecules in dilatation. That is one of the most simple considerations, on which is founded the principle of the mechanical equivalent of heat so often now referred to in mechanics, in physics, and in physiology.

In physics it explains the mystery of latent heat, of fusion, and of volatilisation. But how is it that heat supplied continuously to a boiling liquid to maintain ebullition does not ever raise the temperature of the liquid above a point which under similar pressure remains fixed? The reason is that this heat is continually absorbed, and diappears as such to produce the mechanical work of driving apart the molecules. And so in the phenomena of fusion, the constancy of the temperature indicates the absorption of the heat consumed in molecular work. These conceptions have modified and thrown much light on the definitions which physicists have applied to different states of matter, and it is seen that they are in harmony with chemical theories of the constitution of bodies. These are formed of molecules which represent systems of atoms animated by harmonic movements, and whose equilibrium is exactly maintained and strengthened by these movements.

Applied to molecules thus constituted, heat can produce three different effects. In the first place, an elevation of temperature by the increase of vibratory energy; in the second place, an increase of volume by the driving apart of atoms and molecules, and this augmentation becoming very considerable, a change of condition, solid becoming liquid, and liquid becoming gas; in the last, the driving apart of the molecules is become immense in relation to their dimensions. Thus acting on the atoms which compose the molecule and amplifying their trajectories, heat can disturb the equilibrium which exists in the system, causing a conflict of these atoms with those of another molecule in such a way that this disturbance or this conflict leads to fresh systems of equilibrium, that is to new molecules. There commence the phenomena of decomposition and dissociation, or, inversely, of combination, which is the main spring of chemistry, and it is seen they are but the continuation or consequence of the physical phenomena we have just analysed, the same hypothesis, that of atoms, applied to one and the other with an equal simplicity.

I ask, will it not be easy to conceive that the physical and chemical forces which act on ponderable bodies are applied also to diffuse continuous matter in some way, and is it not natural to suppose that there are limited and definite particles which represent the points of application of all these forces? And this view ought to apply to the two sorts of matter which form the universe, ether and atomic matter, the one infinitely rarefied but homogeneous, filling all space, and in consequence enormous in its mass, both unseizable and imponderable; the other non-continuous, heterogeneous, and only occupying a very limited portion of space, although it forms all worlds.

Yes, it forms all worlds, and the elements of ours have been discovered in the sun and in the stars. Yes, the radiations given off by incandescent atomic matter which forms these stars are also, for the most part, those which are produced by the simple bodies of our planet. Marvellous conquest of physics which reveals at once to us the abundance of forces which environ the sun and the simplicity of the constitution of the universe!

A solar ray falls upon a prism and is turned aside in its path and decomposed into an infinity of different radiations. These take each a particular direction, and all range themselves in bands in juxtaposition, and spread themselves out in the spectrum if the light thus received and decomposed is thrown on to a screen. The visible part of this spectrum shines with all the colours of the rainbow; but besides this, beyond both ends of the coloured bands the radiations are not absent. The heat-rays can be made to reveal themselves beyond the red; the chemical rays, more powerful than the others to make and destroy the chemical combinations, are known beyond the violet. All the forces which manifest themselves on the surface of our globe, as heat, light, and chemical energy, are sent to us in a ray of white light.

But this brilliant spectrum is not continuous. Fraunhofer has discovered in it an infinity of black lines cutting the shining band; these are the "dark lines" of the spectrum, and Kirchhoff has found that a certain number of them occupy the same position as the "bright lines" which occur in the spectra of metallic substances when in a state of incandescence. This last physicist, generalising an observation of Foucault, has seen further that under given circumstances these bright lines can be obscured and "reversed," coinciding then with the dark lines of the solar spectrum.

We have been able to conclude that these have an identical origin and are due to radiations given off by metallic substances spread in vapour over the solar globe, radiations which are obscured by these same vapours in the atmosphere of the sun. Thus the star which gives us heat, light, and life, is formed of elements like those which form our globe. These elements are hydrogen and metals in a state of vapour. They are not distributed equally in the mass of the sun and in his rarefied envelopes; the hydrogen and most volatile metals are raised to a greater height on the surface of the sun than are the other metals. They are never in repose; this ocean of incandescent gas is continually agitated by tremendous tempests. The *trombes* throw themselves out in immense columns to the height of 50,000 leagues above the gaseous sphere; these are the "protuberances," and they shine with a rose light peculiar to themselves; and they are formed, according to Jansen and Lockyer, by hydrogen, very rarefied, and also by an unknown substance—"helium." The luminous globe itself, the photosphere, gives the spectra of our ordinary metals, except gold, silver, platinum, and mercury; the precious metals, those which have little affinity for oxygen, being wanting. But, on the contrary, in the solar spectrum there are "lines" different from those which the metals of our earth give, but which are like them. The lines of the metalloids are wanting, as are the lines which are characteristic of compound bodies. The gaseous mass has such an incandescence that no chemical combination could withstand it.

The lines of Fraunhofer are dark, only the lines of the protuberances and those seen a moment after the disappearance of the sun in an eclispe, and a moment before its reappearance, are bright, like those which characterise the spectra of incandescent metallic vapours. Here we have a curious relationship which has furnished most important and precise indications on the physical constitution of the sun.

I have spoken of the chemistry of the sun, but the spectroscope has explored all the far-off space of heaven. The light of hundreds of stars has been analysed, and nebulæ, scarcely visible, have had the quality of their radiations revealed by its aid. The light, in some cases very feeble, with which a number of stars shine, gives a spectrum with dark lines like the solar spectrum, and this fact proves to us that the constitution of these stars is like that of our sun. Aldebaran sends us records of hydrogen, magnesium, and calcium, which abound in solar light, but also those of metals which are rare or absent, as tellurium, antimony, and mercury.

Nebulæ, twenty thousand times less brilliant than a candle at a distance of 400 metres, have still given a spectrum, for their light, although feeble, is very simple in its constitution, and the spectrum which it gives consists only of two or three bright bands, one of hydrogen, the other of nitrogen. These nebulæ which give a spectrum of bright lines, are those which the most powerful telescopes cannot resolve: there is an "abyss" between them and resolveable nebulæ, which, like ordinary stars, give a spectrum with dark lines.

What an effort of the human mind! To discover the constitution of stars of which the distances even are unknown; of nebulæ which are not yet worlds; to establish a classification of all the stars, and still more to guess their ages—ah, tell me, is not this a triumph for science? Yes, we have classed them according to their ages. Stars coloured, stars yellow, stars white; the white are the hottest and the youngest; their spectrum is composed of a few lines only, and these lines are dark. Hydrogen predominates. Traces of magnesium are also met with, of iron, and perhaps of sodium, and if it is true that Sirius was a red star in the time of the ancients, it owed perhaps its tint to the greater abundance of hydrogen at that epoch. Our sun, Aldebaran, Arcturus, are among the yellow stars. In their spectra the hydrogen lines are less developed, but the metallic lines are fine and numerous. The coloured stars are not so hot, and are older. In consequence of their age they emit less vivid light. In them there is little or no hydrogen. Metallic lines abound, but one also finds channelled spaces like the lines of compounds, The temperature being lower, these latter can exist whether they consist of atoms joined to others of the same kind, or whether they contain groups of heterogeneous atoms. In referring recently to this classification of Father Secchi and the distribution of simple bodies in distant stars, Lockyer has observed that the elements the atoms of which are lightest, are to be found in the hottest stars, and that the metals with high atomic weights are, on the contrary, met with in the colder stars; and he adds this—Are not the first elements the result of a decomposition brought about by the extreme temperatures to which the latter are exposed, and taking them altogether, are they not the product of a condensation of very light atoms of an unknown primordial matter, which is perhaps ether?

Thus is brought forward afresh, from considerations taken from the constitution of the universe, this question of the unity of matter which chemistry has before raised from a consideration of the relative weight of atoms. It is not solved, and it is probable that it never will be in the sense here indicated. Everything leads to the belief in the diversity of matter, and the *indestructible, irreducible nature of atoms. Does it not require* as M. Berthelot has pointed out, the same quantity of heat to put them in motion, whether they are heavy or light, and ought not the law of Petit and Dulong to prevail in its simplicity against the opposite hypothesis, however ingenious it may be?

I have endeavoured, gentlemen, to trace out for you the most recent progress accomplished in chemistry, in physics, and in physical astronomy, sciences so diverse in their object, but which have a basis in common—matter—and one supreme object—a knowledge *of its constitution* and *of its* properties and *of its* distribution in the universe. They teach us that the worlds which people infinite space are made like our own system, and that this great universe is all movement, co-ordinated movement. But new and marvellous fact, this harmony of the celestial spheres of which Pythagoras spoke, and which a modern poet has celebrated in immortal verse, is met with in the world of the infinitely little. There also all is co-ordinated movement, and these atoms, whose accumulation forms matter, have never any repose; a grain of dust is full of innumerable multitudes of material unities each of which is agitated by movements. All vibrates in the little world, and this universal restlessness of matter, this "atomic music" to continue the metaphor of the ancient philosopher, is like the harmony of worlds; and is it not true that the imagination is equally bewildered and the spirit equally troubled by the spectacle of the illimitable immensity of the universe and by the consideration of the millions of atoms which people a drop of water. Hear the words of Pascal: "I wish to picture not only the visible universe, but the immensity of nature that one can conceive within the limits of an atom; one may picture there an infinity of worlds, where each has its firmament, as in the visible universe."

As to matter, it is everywhere the same, and the hydrogen of water we meet with in our sun, in Sirius, and in the nebulæ, everywhere it moves, everywhere it vibrates, and these movements which appear to us inseparable from atoms, are also the origin of all physical and chemical force.

Such is the order of nature, and as science penetrates it further, she brings to light both the simplicity of the means set at work and the infinite variety of the results. Thus, through the corner of the veil we have been permitted to raise, she enables us to see both the harmony and the profundity of the plan of the universe. Then we enter on another domain which the human spirit will be always impelled to enter and explore. It is thus, and you cannot change it. It is in vain that science has revealed to it the structure of the world and the order of all the phenomena; it wishes to mount higher, and in the conviction that things have not in themselves their own *raison d'être*, their support and their origin, it is led to subject them to a first cause—unique, universal God.—*Nature.*

ON A COLLECTION OF HIMALAYAN BIRDS

Recently presented to the Natural History Society by Major G. E. Bulger.

By J. F. Whiteaves.

The collection to which these notes refer, is only a small portion of one of the largest donations the Society has ever received. As an act of simple justice to the donor it is thought desirable to give a short account of previous contributions from the same liberal hand before considering that most recently received. In 1867 Major Bulger presented to the Society no less than 200 skins of Himalayan birds. This collection must have taken no little time, trouble and pecuniary expenditure, to get together. All the specimens were correctly and carefully labelled, not only with the scientific and English name of each species, but also with the local Indian appellations, with exact localities, and often with the name of the collector. The packing was very carefully attended to: the specimens were first put in a strong tin case, which was soldered up so as to be perfectly air tight. A stout wooden box was then made, into which the tin case was fitted, and after the lid had been nailed down, a covering of stout canvass was glued round the package, and over the canvass a thick coat of some waterproof composition was painted. Unfortunately the very care with which the box was packed proved almost fatal to the specimens. The journey was a long and circuitous one, from India round the Cape to England and then to Canada via New York. The package was received in Montreal early in 1868, and it was found that at least two-thirds of the specimens were hopelessly rotten, and that all were badly injured. Perhaps some of the skins were not perfectly dry when they were put in, and it seems probable that if the box had not been air tight, but had allowed tolerable free ventilation to the specimens, they would have arrived in better condition. Be this as it may, the late Mr. Hunter, who was then the Society's taxidermist, and whose abilities in that capacity will be remembered by many of its members, exerted himself to the utmost to save as many as possible. The result was that about 60 specimens were mounted in more or less good order.

Not discouraged by the mishaps which had befallen his first consignment, in 1869 Major Bulger gave the Society a large and interesting series of woods and various other specimens collected in British India, and in the following year a still larger collection of miscellaneous objects, botanical specimens, and seven species of birds from India and Africa. A paper descriptive of a portion of this latter collection will be found on pages 66-75 of Vol. 5 (New Series) of this Journal. The Society is also indebted to this gentleman for the donation of several scientific works, among which are copies of Hooker's Himalayan Journals, and Gould's elaborately illustrated Monograph on the Odontophorinæ or Partridges of America.

The beautiful collection of the birds of the Neilgherries and Deccan of which these notes are illustrative, was received early in 1873. The specimens, 60 in number, were received in a good state of preservation, and have been mounted by Mr. S. W. Passmore.

The remarks which follow have no claims to originality, their object being simply to call attention to the salient points of interest in the various species in the collection. The general structural peculiarities of the well-known order Raptores or Birds of Prey are too well known even to the general reader to call for any special comment here. To this group belong the Vultures, Buzzards, Eagles, Falcons, Hawks, and Owls, besides other smaller and more critical groups.

In the Buzzards, the beak is straight from the apex to the cere and the mandibles are untoothed. The birds of this section may be recognized also by their usually heavy build, and by their broad, thick, and flat heads.

The Eagles are characterized not only by their large size and powerful frame, but also by the characters of their beaks. In these birds, as in the Buzzards, the beak is straight for a considerable distance from the base, and terminates in a curve or hook. The upper mandible is without teeth but is slightly waved at the side.

In the true Falcons the head is of medium size, the neck is short, as is the bill, which is curved immediately from the base and has its upper mandible conspicuously toothed. The tarsi are short and there is a naked ring round the eye. The wings are very long and pointed.

The Hawks proper have a small head and a long neck, their wings are short and rounded, the tail is long, the tarsi high, and the bare circle round the eye is wanting. The beak is curved directly from the base, but the mandibles are rarely toothed.

There are four species of raptorial birds in the collection under consideration. The first of these, though not labelled, is obviously the Pondicherry fish eagle, the Falco Ponteccrianus of Shaw, the Haliastur Indus of recent systematists. As its latest generic name imports, it has affinities with the sea eagles, and, as it seems to the writer, very remote ones indeed with the goshawk. Its systematic place seems to be between the eagles and the buzzards The Pondicherry Eagle, called the Brahminy Kite by European residents in India, feeds to a certain extent on fishes, which it snatches from the surface of the water; but it also preys upon small birds and other animals, including crabs and insects, and will not, so some say, refuse carrion. It is regarded by the Hindoos as sacred to Vishnu. Pearson says among the Mohammedans there is a prevalent notion that when two armies are about to engage the appearance of one of these birds over either party prognosticates victory to that side. Colonel Sykes, who has closely studied the habits of this species, denies that it ever lives on carrion, and says its food is almost always fish, but exceptionally crustacea.

The Kestrel, although in some respects a true falcon, is more slender, fragile, and less powerful than the noble falcons, such as the Gyr and Peregrine. The Kestrels indeed, for there are at least four species, have been separated from the true falcons and have been formed into a separate sub-genus, characterised by a lax and streaming plumage, the comparative weakness of the quills that form the wings, the length of the tail, the strong and short toed feet and lastly by the difference in the colour of the feathers, which varies with the sex. The Common Kestrel is by far the most abundant hawk in Great Britain. It feeds principally upon field mice and shrews, occasionally on small birds, and not unfrequently on earthworms and insects. Selby states that kestrels have been seen, late in the summer evenings, hunting for cockchafers: one was seen to dash among the insects, seize one in each foot and then devour both on the wing. Another writer remarks: "The flight of the kestrel, when searching for its favourite food is very peculiar. It flies gently along at some 30 or 40 feet from the ground, but stops every now and then and remains perfectly stationary, hovering in the air and minutely inspecting the ground beneath it. Should no motion in the grass betray the presence of its prey, it moves on a little farther and again repeats its manœuvres: but as soon as its quarry comes into view, the wings and tail are closed in an instant, and the bird falls like a stone on its victim. Just as it reaches the ground however, the wings and tail are again expanded, the kestrel clutches its prey, and usually goes off with it at once to some place where it can devour it without fear of interruption." This habit of hovering in the air, which, although it is common to many other hawks, is possessed in the greatest perfection by the kestrel, has obtained for it, in some parts of England, the name of the Windhover. The bird is common in almost all parts of the Eastern Hemisphere, but has never been found in America. The so-called Sparrow Hawk of this country, however, belongs to the same subgenus. To show in how little estimation kestrels were held for hawking purposes, a portion of a table enumerating the kinds of hawks proper to be used by persons of various titles, professions, or callings, is taken from an antique volume on falconry quoted in Cassell's Book of Birds:

The Eagle, Merlin, and Vulture, -	for an Emperor.
The Jer Falcon, - - - - -	for a King.
The Rock Falcon, - - -	for a Duke.
The Peregrine, - - - - -	for an Earl.
The Lanner, - - - - -	for an Esquire.
The Goshawk, - - - - -	for a Yeoman.
The Sparrow Hawk, - - -	for a Priest.
The Kestrel, - - - - -	for a Knave, or Servant.

The next raptorial bird in this collection is an example of Swainsons or the Pale Chested Harrier. While the Caracara Eagles of Tropical America are considered to be the connecting link between the Buzzards and the Vultures, of all the Hawk tribe the Harriers approach most closely to the Owls. Not only are the eyes of the Harriers unusually large and the plumage soft and downy, as in the owls, but the face is also partially encircled by a ring or ruff of short projecting feathers. The Harriers, it may be observed, are not nocturnal in their habits. While on the one hand the Harriers undoubtedly present strong resemblances to the Owls they have another striking peculiarity in the unusual length of their tarsi. In this respect they are nearly allied to the singular Secretary bird of the dry plains of South Africa. These Secretary birds are snake-eating falcons, with legs as long as those of a heron or crane. They have curious erectile crests, which hang from the back of the head. 'These, when seen in repose and in profile, resemble a pen stuck behind the ear, hence the name Secretary bird. The Harriers, in general feed upon small quadrupeds such as young hares, rabbits, rats, &c. They also greedily devour birds, sometimes reptiles, but rarely insects and fishes. The specimen exhibited had a lizard in its stomach. When searching for their prey, they fly gently along, at a small elevation, and appear to beat over every part of the ground like a dog hunting for game; to this habit no doubt they are indebted for their name of Harriers. The Marsh Harrier, which from its destructiveness in poultry yards, is called the Hen Hawk in Canada, is common to Europe, Asia and America.

The only Owl in the collection is a small species received without any name, and which has not yet been identified. It seems to belong to that section in which the facial disks are nearly complete, and in which the head is almost destitute of ear tufts.

The birds of prey, the waders, and the swimming birds, have for the most part a very wide geographical range, but the climbing and perching species seem to be confined within comparatively narrow limits. In high northern and in temperate latitudes not a few of the birds of prey are circumpolar in their range but the nearer we get to the equator the less is this the case. Thus, the Peregrine falcon, the Goshawk, Rough-legged Buzzard, Osprey, Golden and White tailed Eagles, and Marsh Harrier, as well as some Owls, are common to the continents of Europe and North America. With the exception of the Marsh Harrier, and perhaps the Goshawk, none of the East Indian birds of prey are to be met with in America, and very few in either Europe or Africa. In warm or semi tropical countries, the birds of prey are restricted to a very small area. Tropical America, Southern Europe and Asia, Africa and Australia have each their own characteristic genera and species. And lastly, as regards these birds of prey, although there seems to be a northern circumpolar fauna, there does not appear to be the slightest approach to any corresponding antarctic one.

The large order of the Perching Birds, which have three toes in front and one behind, has been variously subdivided. Throughout this paper the classification followed is that adopted at the British Museum. The first division of this order is the Fissirostres, or Gapers, a section characterized by the depth to which the beak is cleft. The most typical representatives of this group are the Goatsuckers and the Swallows.

The Burmese Roller belongs to the typical genus Coracias, in which the bill is flattened sideways. The Rollers are confined exclusively to the Eastern Hemisphere. In tropical America they are represented by the Motmots, Red breasted Crows and Trogons. The Rollers are arboreal in their habits and feed on insects and fruits. They breed sometimes in trees and often in holes in the ground. The European species is called the Birch Jay by the Germans, and the Ultramarine Jay by the Italians. The Rollers are essentially tropical birds.

The Bengal Kingfisher of India and the Crested Kingfisher of the Cape of Good Hope, are fluviatile in their habits, and feed on fish. Like the common British species, which they resemble very closely in colour, both breed in holes in river banks. The Ruddy and the White breasted Halcyons are Tree Kingfishers and mostly inhabit woodland districts often far from water. Their beaks are much broader than those of the true kingfishers, and they have more powerful feet. They live upon insects, such as beetles and grasshoppers, and breed in holes in trees generally at some distance from any water.

The Green Bee Eater of India belongs also to an exclusively Old World group, of singularly elegant and swallow-like form. This species often selects a perch in some prominent position from which it dashes off in pursuit of any insect that comes within sight, returning again to its perch in the same manner as the fly-catchers do. On coming back to their station, Mr. Layard has observed them beating their prey against the perch to bruise it before swallowing it. This mode of capturing food is principally resorted to in the middle of the day, for in the mornings and evenings these same species may be seen hawking about in company with swallows. The habits of the European species were known to Aristotle, who describes it as a great enemy to bees, and as building in holes in the ground. Montague says that in the South of Russia, where the Common Bee Eater is very numerous, the clayey banks of the Don and Wolga are excavated by them to such an extent as to have the appearance of honeycomb. In the Island of Crete the Common Bee Eater is often taken by boys in a singular manner. A Cicada is fastened to a bent pin, or fish hook, which is attached to a long slender line. The insect is then allowed to fly, and as soon as a Bee-

Eater catches sight of it he dashes at it, and swallowing the baited hook is readily captured. In South America and the West Indies, the Bee-Eaters are represented by the Jacamars.

In India the Slender Billed Birds are mostly Sunbirds, which there take the place of the Humming birds of Central America, and the Honey-Eaters of the Australian Continent.

In the third section of the Insessores, the Dentirostres have the mandibles more or less toothed. Among the typical warbling birds in the present collection is a specimen of the Magpie Robin, which in structure is allied to the Redbreast of Great Britain, and in colour only to the European Magpie. In India the Magpie Robin is constantly caged, both for the sake of its song and for its pugnacity. According to Mr. Hodgson, fighting the tame birds is a favourite amusement in India, and he adds that no game cocks can contend with more energy and perseverance than these little birds. The same author states that the professional bird keepers take advantage of this pugnacious disposition in their pets to make them instrumental in the capture of their wild brethren. During the spring it appears the male birds are continually challenging each other, and as soon as one has uttered his note of defiance it is answered by another, and these altercations usually end in a battle. The bird keeper accordingly carries a tame male on his hand to the nearest garden or grove, when the bird at his bidding utters its challenge, and if this is answered by a wild bird, the tame one is immediately slipped, and a desperate combat commences, in the course of which the man easily secures the wild bird, the tame one actually assisting in the act, by holding its opponent with its bill and claws.

Another warbler in this collection is the Ceylon or Short-tailed Iora, which is allied to the Hedge Accenter of Europe. From the Warblers proper we pass on to the true Thrushes. The Malabar Whistling Thrush belongs to the Formicarinæ or Ant Thrushes. In this group the wings and tail are much shorter than in the typical Thrushes; they feed upon insects and devour large quantities of ants, hence their popular name. The Blue Rock Thrush is the only typical thrush in the collection; it is also, though rarely, found in southern Europe.

The Old World Orioles are very closely allied to the Thrushes, while the American species belong to the Starling family. The Indian Golden Oriole (Oriolus Kundoo) is often called the Mango bird by British residents. It is said (by Jerdon) to have a loud mellow, plaintive cry, something resembling pee ho. The Ceylon or Southern Black Headed Oriole, which is very common in Bengal, has, according to Pearson, a monotonous low note resembling one lengthened full toned note on the flute, which is so constantly repeated as to become a positive nuisance. One species of Oriole is not uncommon in Southern Europe. In Italy, its appearance is said to indicate the time of the ripening of the figs, and indeed the country people fancy they can recognize the words Contadino e maturo lo fico (the peasant of the fig ripening) in its notes. The Orioles live upon insects and fruit, and build in trees.

The Bulbuls are related to the Thrushes on the one hand and to the Flycatchers on the other. They are very sprightly, fine songsters, easily tamed, and very pugnacious. Hence, like the Magpie Robin, they are kept for fighting purposes, and are often exposed for sale in the bazaars of India. They inhabit woods, jungles and gardens, and feed principally upon fruit and seeds, but occasionally also on insects, which they capture on the ground. Allusions to these birds are frequent in the pages of Lallah Rookh. There are 6 representatives of this family in the specimens exhibited. These are

The Red-whiskered Bulbul	-	*Otocompsa rufiventris.* Typical.
The Malabar Green Bulbul	-	*Phyllornis Malabaricus.*
The Common Green Bulbul	-	*Phyllornis Jerdoni.*
The Small Minnivet	-	*Pericrocotus peregrinus.*
The Short-billed Minnivet	-	" *brevirostris.*
The Orange Minnivet	-	" *flammeus.*

The last sub-family of the Dentirostres is that of the Shrikes. The Ashy Swallow Shrike belongs to a group sometimes called wood swallows, which are peculiar to India and Australia. By several writers these birds are classed with the true swallows, which in some respects they much resemble. By Gray they are placed between the Drongo or Fly-Catching Shrikes (a purely Asiatic group) and the Chatterers. In their powers of flight, the Swallow Shrikes are said to be equal to the swallows and the birds of prey. The fancy of this particular species for certain trees is said to be so strong that where these grow it is often found living at an altitude of 4000 feet above the level of the sea. These birds appear to take their prey, which consists of insects, almost exclusively in the air, and rarely descend to the ground, as their progress on foot is attended with much difficulty. The true Shrikes are the most typical of the Dentirostres, and in them the toothing of the mandibles is best seen. In their strongly hooked bill and curved claws, a close resemblance may be traced to the birds of prey. The Shrikes are eminently carnivorous in their habits, and not only prey upon insects, worms and molluscs, but also on small birds and mammals. From the habit which these birds have of impaling their prey upon sharp thorns before eating it, they are commonly known as butcher birds, and the generic name Lanius applied to them also means a butcher. The Rufous Backed and Hardwicke's Shrike, in the present collection, belong to the type genus Lanius, and are more nearly allied to the Red backed Shrike of England than to the Great Northern or Loggerhead Shrikes of Canada.

The last sub-order of the perching birds is that of the Conirostres, which feed to a large extent on fruit and seeds. The large sub-family of the Starlings is more largely represented in America than in any other part of the world. The Meadow Larks, Grakles, and all the Orioles of tropical America, as well as the Crow Blackbird and Red-Winged Starling, are members of this family. The Mina bird of India is the only specimen of this group in the present collection. A well-known East Indian naturalist thus writes: " The Minas are among the commonest birds in India, Assam and Burmah, where they frequent the neighbourhood of towns and villages in preference to more wooded districts. A tree is usually selected as their sleeping place; and from this point they fly over the country in small parties in search of food, stealing occasionally even into the huts of the natives, in order to obtain cooked rice, of which they are very fond; some follow the flocks and herds, and seize the grasshoppers as they rise from the grass when disturbed by the cattle, others seek subsistence by plundering the gardens and orchards in their vicinity. When upon the ground the Mina walks with ease, constantly bowing its head as it goes, and occasionally springing to a considerable distance; its flight is heavy, direct, and tolerably rapid, and its notes rich and varied. So little fear is exhibited by these birds, that they build almost exclusively in the vicinity of houses, or even in temporary cages that are hung out for their accommodation. In Mosuri, where this species is only a summer visitor, it usually prefers making its nest within a hollow tree. Like the common Starling, it easily acquires the art of speaking, and of imitating a variety of sounds. The Mina has been dedicated by the Indians to their God Ram, and is usually represented as perched upon his hand." Major Norgate says of this species. Regular pitched battles are of constant occurrence amongst these pugnacious little creatures; the two combatants, who usually belong to different flocks, coming to the ground, in order the better to carry on their struggle, which is maintained by clawing, beating with the wings, and rolling round each other, screaming loudly as the combat waxes hot: only for a very brief space, however, is the fight confined to these two champions of the rival parties; one after another the rest come down and mingle in the fray, which often rages so fiercely that broken wings or other injuries at last compel the untiring combatants to cease their strife. The same writer describes the Mina's manner of singing as very amusing: "it inflates its chest as though about to make a most tremendous effort, and then gives voice to such a variety of crowing, grunting and squeaking sounds as cannot fail to astonish its hearer. When in flight the notes of these birds are by no means unpleasing; but if alarmed their cry rises to a loud, hoarse shriek, the rest of the party usually joining chorus, till the uproar becomes general. The nest is constructed with the utmost carelessness, and is, in fact, a mere heap of straw, twigs, rags, or even shreds of paper; but in spite of the discomfort of the home thus provided for the young, the latter are tended by both parents with great affection." This bird is said to be a special enemy to locusts of all kinds, so much so that the species has been exported from the Philippines to the Isle of France, to rid that island of the locusts with which it was overrun. Under the protection of the Mauritius government, the Minas have increased so rapidly that (according to Bory St. Vincent) they have completely ruined the entomology of the Island.

The Scansores, or climbing birds, which have two toes directed forward and two backwards, are fairly represented in this part of Mr. Bulger's collection. The Rose-ringed and Blossom-headed Parrakeets belong to a long-tailed group of parrots, for the most part characteristic of the East Indies and Australia. The Alex andrine Parrakeet, of the same country, is by many looked upon as identical with the first of these. This is generally believed to be the first parrot known to the ancients, a species having been brought to Europe after the Indian expeditions of Alexander the

Great. In the Reign of Nero, the Romans became acquainted with other kind from Africa. Pliny describes the present birds with sufficient accuracy to identify it. It is, he says, entirely green, with a red collar on the neck. The Romans kept parrots in cages of silver, tortoise shell and ivory, and had tutors who particularly taught them to utter the name of Cæsar; in those days the price of a parrot that could speak exceeded that of a slave. Ovid is well known to have sung their praises, and Heliogabalus thought he could not set anything more delicate than parrots heads before his guests. "Oh unhappy Rome," wrote Cato the censor, "have we lived to see the day when our women nurse dogs upon their laps, and our men go about with parrots on their hands?" The Indian Lorikeet, of which the specimen exhibited was shot at an elevation of more than 2000 feet above the sea level in the Neilgherries, has been classed by some writers among the true Parrots. The Parrots proper have short square tails, and their heads are without crests. The Lories and Lorikeets, which inhabit India and the Eastern Archipelago, are by some naturalists, however, regarded as a peculiar group, distinct from any other, and characterized by having the tongue terminated with a tuft of glutinous filaments or threads. The Barbets are a small group of climbing birds, so called from the base of the beak being surrounded with stiff hairs or bristles instead of feathers. There are three specimens of the Crimson Breasted or Golden Barbet in the present collection. Respecting this bird Jerdon writes as follows: "This species of barbet is found throughout all India, extending into the Burmese countries, Malayana, Ceylon and the Isles; according to Adams, it is not met with on the Himalayas or in the Punjaub. This bird is very common where there is a sufficiency of trees, inhabiting open spaces in the jungles, groves of trees, avenues and gardens, being very familiar, and approaching close to houses, and not unfrequently perching on the housetop. As far as I have observed, it does not climb like the woodpecker, but hops about the branches like other perching birds. The Rev. Mr. Phillips, however, states that it runs up and down the trees like a woodpecker, and other observers have asserted that it climbs to its hole; but I confess I have never seen this, and Mr. Blyth is most decidedly of opinion that barbets never climb. The latter naturalist found that one of these birds which he kept alive would take insects into its mouth and munch them, but swallowed none, and forsook them immediately when fruit was offered. It has a remarkably loud note which sounds like 'took-took-took,' and this it generally utters when rested at the top of some tree, putting its head at each call first on one side and then on the other. Sundevall states that the call is like a low note on the flute, from the lower G to the second E. This sound, and the motion of the head accompanying it, have given origin to the name "coppersmith," by which this species is known by both natives and Europeans. The sound often appears to come from a different direction to that from which it does really proceed; this appears to me to depend on the direction of the bird's head. Mr. Phillips accounts for it by saying that it alters the intensity of its call. Sundevall remarks that the same individual always utters the same note, but that two of these birds are seldom heard to make it alike. When, therefore, two or more individuals are sitting near each other, a not unpleasing music arises from the alternation of the note, each sounding like the tone of a series of bells. The Crimson-Breasted Barbet breeds in holes of trees, laying two or more white eggs. A pair bred in my garden at Saugor on the cross beam of a vinery. The perfectly circular entrance was on the underside of the beam. This nest appeared to me to have been used for several years, and the bird had gone on lengthening the cavity year by year, till the distance from the original entrance was four or five feet; another entrance had then been made also from below about two feet and a half from the nest. Quite recently I discovered a nest built by this bird in a hole of a decayed tree branch, close to a house in a large thoroughfare in Calcutta."

The typical genus Capito, which embraces the Puff birds, is confined to South America, all the other genera are to be met with only in the eastern hemisphere. The two beautiful species of Woodpecker belong to a group usually known as the Ground or Cuckoo Woodpeckers. These are usually less arboreal in their habits than the ordinary kinds, and are somewhat closely allied to the Golden-winged Woodpecker of Canada. They often feed on the ground, in ants' nests and amongst the dung of animals. They are said to be fond of green corn and of fruits, but like the rest of the group sometimes feed on trees and always nidificate in them. Generally speaking, the beaks of the ground Woodpeckers are less robust and strong than are those of the exclusively tree hunting species.

The Cuckoos are the most aberrant members of this family, and indeed they have less the habit of climbing than of perching birds. The Golden Cuckoos are ground Cuckoos, confined to the Eastern Hemisphere, and easily recognized by their tints of golden green and lemon yellow.

By some writers the Pigeons are classed as perching birds, by others among the game birds (Rasores); but Mr. Gray and other writers make a separate order of them. While the beautiful Indian Bronze-Winged Dove is a good example of the ground-loving species, the no less elegant Pin-Tailed Green Pigeon is typical of the Treronidæ or Tree Turtles. Lastly, the gallinaceous birds in this collection are represented by the Common African Quail from the Cape of Good Hope, a species presenting few salient peculiarities or habits calling for special comment.

ON FLUCTUATIONS OF LEVEL IN LAKE ERIE.

BY COL. CHARLES WHITTLESEY, CLEVELAND, OHIO

In this paper I present very little in reference to fluctuations of the surface of Lake Erie, which I have not published heretofore. My principal object is to place on record a résumé of those publications, for future reference. The subject was taken up simultaneously in 1838, by the Geological Survey, Ohio, in charge of Professor W. W. Mather, and of Michigan under Dr. Douglass Houghton. When the Survey of Ohio was disbanded in 1839, I continued to make occasional observations, and to collect those made by others, until 1859; when the Lake Surveys of the Government, being then in charge of the late General Meade, adopted a general system of water registers. There have been on each Lake since that time two Meteorological Stations, where readings are taken each day of the height of the water, and all phenomena connected with its fluctuations. These readings will in due time enable the officers of the Survey to discuss the subject, on the basis of reliable facts; from which alone philosophical conclusions can be reached.

But prior to 1859 enough had been determined to show, that there is an *annual* rise and fall of the waters of the Lakes, analogous to the high and low water of large rivers, and due to precisely the same cause.

From the head of Lake Superior to the mouth of the St. Lawrence, the channel must be regarded as one great river with expansions, which is raised by the surplus water of the rainy season, and depressed by the dry season. It is simply the *balance between rain-fall and evaporation* over the entire valley of the Lakes; embracing 300,000 square miles. When these two opposite factors shall be obtained by observation, the stage of water can be predicted with as much certainty as the probabilities of the seasons, can be deduced from observations on general meteorology. Both follow a law and are nearly parallel to each other. Both run through cycles of change, returning in periods that are closely similar but which are not regular.

In regard to what I have designated as the general or *secular* changes of level, as distinguished from the *annual*, the former results form the yearly balances. If the annual fall of water equalised for the entire Lake Country is above the average, there must be an accumulation. If it is less, there will be a depression. When several years are on the side of wet, the rise continues each year showing an increase of height, as it was from 1819 to 1838; amounting to a little more than *five feet*. Then a rapid change of the seasons occurred, on the side of drier and more evaporative weather. From 1838 to 1841 inclusive, taking the mean water of each year as a plane of comparison, the water fell 4.15 feet.

Since 1819 the water has not been permanently as low; but in 1846 it reached a point 4.77 below 1838, or within five inches of extreme low water; as at present known. There are, however, causes in operation that increase the suddenness of the discharge of water from the Lake tributaries into the Lakes and thus tend to increase the height of water. If these excessive discharges should occur when other circumstances are in favor of high water, the lakes will reach a higher stage than has been yet known. Thus it it may occur, that the range between high and low water may be greater than *five feet*, and the mean level be somewhat different from what we now put it. For the present it is fixed at two and a-half feet below the flood of 1838; which is five hundred and sixty-four feet above mean tide water at Albany, New York. The city directrix or zero of city surveys, was fixed by an ordinance in 1854 at high water mark of June, 1838, which is also made the zero of most of the railway surveys in Ohio. In a note there will be found some of the bench marks established by the City Engineers.

These two classes of fluctuations, the *annual* and the *general* or *secular*, must not be confounded with those which are temporally due to storms, variation of atmospheric pressure, and *aerial movements or undulations; not yet fully understood*, and which I have called "*transient oscillations*."

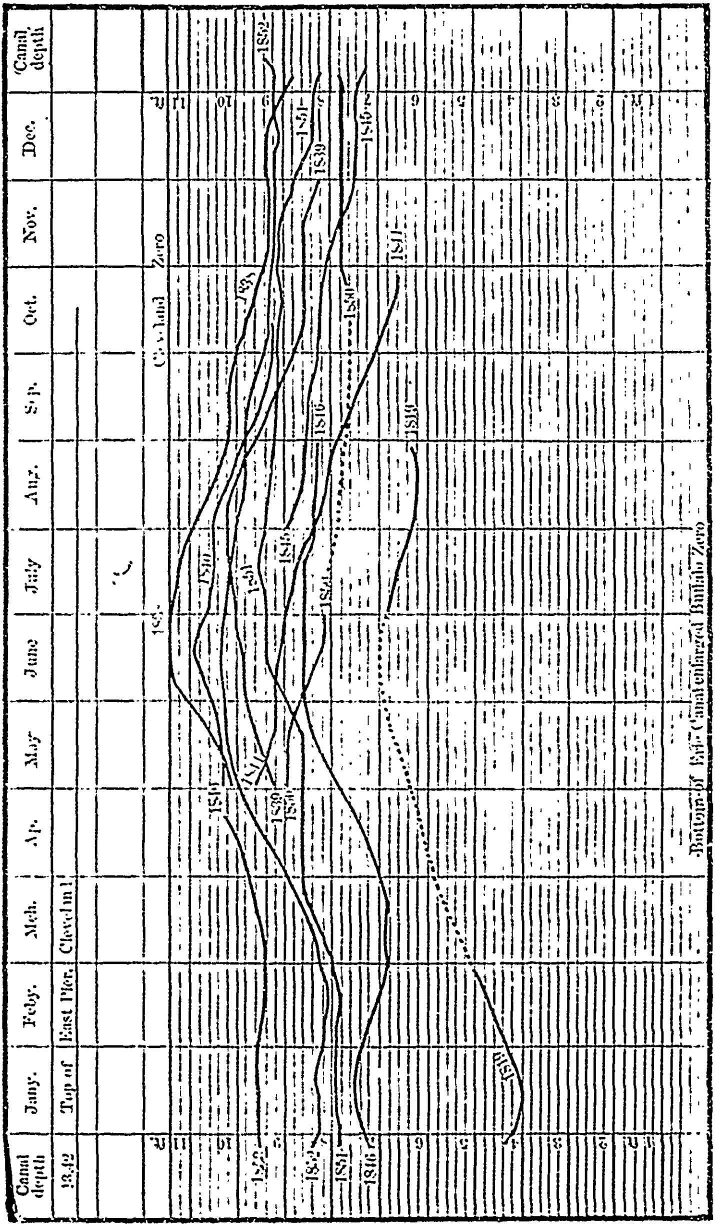
Prior to 1859, there were daily registers kept at Cleveland for only two short periods. The first was by George C. Davies, under the direction of the Government Harbor Agent, Ashbel W. Walworth, Esq., from August to December 1838. Colonel T. B. W. Stockton, who was in charge of the Harbor improvements in 1845-6, caused a full meteorological and water register, to be kept from August 15th, 1845, to September, 1846. A large number of irregular readings were made by the late General

Ahaz Merchant, I. N. Pillsbury, late City Engineer, Captain B. Stanard and myself, extending from 1834 to 1859, but not at regular hours, nor on consecutive days. The labor is too great for any person to undertake who is not employed for that purpose. In addition to the observations made at Detroit, by the first Geological Survey and by A. E. Hathan, City Engineer, and Jacob Houghton as Engineer of the Water Works, there have been a large number of readings at Black Rock, and at Buffalo, New York, by the Engineers of the Erie Canal. All these can be brought together and thus made to supplement each other. On the supposition that the Lake in calm weather is *approximately level*, readings made here and at either of the other places at the *same time*, may be regarded as representing one plane surface. The Detroit gauge is higher than the others by the descent of the river from there to Lake Erie; but the fluctuations are in consonance with those in the Lake, and therefore may be used. After the water tables at Detroit, Cleveland and Buffalo were made out, it appeared that they had some periods of time in common, and thus they could be brought together as one series of observations, good for the entire Lake.

For instance, Mr. John Lothrop, an intelligent engineer in the employ of the State of New York, and myself, made observations for the month of July 1851. The average for that month at Cleveland was 1.96 feet, and at Buffalo 9.46 feet above the metre sill of the guard lock.

This gives for the Cleveland zero 11.42 feet above the Buffalo zero. At Detroit Mr. Hathan used the base of the tower of Water Works, and measured downwards from that as zero. By comparing his tables with ours and disregarding the descent of the river, I find his zero to be 3.43 feet above ours, or 14.85 above bottom of Canal at Buffalo.

In this manner, I have combined all the reliable monthly averages from 1838 to 1853, at the three ports of Buffalo, Cleveland and Detroit, into one expression in the form of curves, as shown in the engraving on the next page.


Canal depth
Jany.
Feby.
Mch.
Ap.
May
June
July
Aug.
Sep.
Oct.
Nov.
Dec.
Top of East Pier, Cleveland
13.42
Cleveland Zero
Bottom of Erie Canal enlarged Buffalo Zero

These results and those which may follow from the Government observations are of great importance to the commercial interests of this Lake. Harbors, piers and channels to be permanent must be constructed with reference to low water. Prior to 1854 the chief of the Topographical Corps, under whose direction the surveys of the Lakes were conducted, paid no attention to these fluctuations.

One of the consequences of this oversight has been the reconstruction of the Canal at the Sault Ste. Marie. Locks that were built to pass vessels of *twelve feet* draft, would at times allow of only *nine feet*. Soundings were referred to no fixed plane. There may be a difference of *five feet*, between the early soundings on the lakes and the true depth of water. Private docks and warehouses are also affected.

The proper plane of reference is that of *mean water level*. Below this, arrangements should be made for a depression of two feet six inches for extreme low water, which may temporarily reach *three feet*.

There is another cause of depression which is having its effect continually; but is so small as to be imperceptible during the life of a generation. This is the perpetual wearing away of the channel at the outlet. On the Upper Lakes there are evidences of a perceptible lowering of the outlets, since they assumed their present general level; but on Lake Erie it is not yet perceptible. It does not probably exceed an inch in a century.

According to tradition among the French residents of Detroit, which was settled in 1701, there has not been since that time as high water as that of 1838.

A conjunction of circumstances such as to cause a state of extreme depression, or extreme high water, will occur only at long intervals, owing to the extent of country drained by the lakes. The tables show that there is no period of *seven* years, or a multiple of seven. This is a popular belief derived from Indians, by the early settlers, which has not yet entirely died away, but which never had the support of observations.

Mean *annual* fluctuation, result of sixteen years' observations	1 ft.	$1\frac{1}{2}$	in.
Difference of *highest* and *lowest* months within the year. Cleveland, 4 years obs.	2 "	2	"
Greatest *temporary* difference not due to visible storms. Cleveland	3 "	2	"
Greatest *permanent* difference, 1819 to 1838	5 "	3	"
Greatest *temporary* difference between 1819 and 1838	6 "	11	"

Bench marks in the city of *Cleveland*, referring to city zero, which is the line of high water of Lake Erie in June, 1838, 566.50 feet above mean tide water at Albany, N. York:*

1. Surface of stone work, East Pier, 400 ft. from the south end (now lost)	2.00	feet	A.
2. Capt. Meade's U. S. Top. Engineers, 1859, on a pile east of No. 1	2.92	"	"
3. N. E. corner of base water table, Hotel corner of Main and River streets, west side. City Engineer Strong, 1874	3.129	"	"
4. N. E. corner Myers' Stove Works, River street, west side. Asst. Engineer Wheeler, U. S. Survey, 1874	3.127	"	"
5. Door sill, S. west corner of Engine House, C. C. & C. R. Road, Front street. I. N. Pillsbury, City Engineer, 1851	5.829	"	"
6. Coping of west wing wall of canal lock at the Cuyahoga river. R. E. Howe, State Engineer, 1838	6.300	"	"
7. First course of masonry, base of Light House, 3 ft. above ground, Water street: projection of 0.200 ft. over the course below. Asst. Wheeler, Lake Survey, 1874	67.713	"	"
8. N. E. corner of base of Perry Monument. C. G. Force, Asst. City Engineer, 1874	86.533	"	"
9. Mitre sill of guard lock, Erie canal, Buffalo State Engineer, John Lothrop, 1854	11.420	"	B.
10. Base of water works tower, Detroit. A. E. Hathan, City Engineer, 1854	3.439	"	A.

Plane of Soundings at Cleveland:

	Stage of water		
U. States Assistant Engineer, Geo. Fell—fall of 1873	2.500	feet	B.
City Engineer, Chas. Strong, Feb. 1873	2.920	"	"
Col. T. B. W. Stockton, Harbor Agent, April, 1846	4.400	"	"
Lowest water, monthly mean, March, 1846. Stockton's daily register	4.770	"	"
Average low water at Cleveland, Detroit and Buffalo, 1846	4.620	"	"
Extreme low water—by monthly average—1846	5.100	"	"

* Mr. Jos. T. Gardner, Geographer, Washington, D.C., has in connection with the U. S. Coast Survey revised the elevations of the Lake region and the Mississippi valley, by whom mean tide at Albany is 4.84 feet above mean tide at New York.

*Elevation of the Great Lakes above the Ocean.**

It is not practicable to fix the elevation of the surfaces of these lakes, until their mean fluctuation is known. The results I propose to give, are therefore only approximate.

On Lake Superior the greatest known range of level is three feet, with indications of a much greater range. Lake Ontario has a variation of four feet, nine inches, well determined by water registers, since the year 1812.

The surveys of the Upper Lakes, by the United States Government, now in progress, will eventually fix the mean level of all the lakes, by observations which are made twice each day.

For present use, I give the mean results of instrumental surveys between tide water and the lakes, and between the different lakes.

Before doing this I must remark, that in none of them is the stage of water noted, at the date of the Survey, whether above or below the mean. There is therefore room for a plus or minus error of two or three feet, when referred to a plane, which shall be fixed upon, as the mean level of each lake. There is also another ground of error. The lakes are not strictly level but have an inclination or descent towards their outlets; though this may be small, and in part corrected by the action of winds.

To fix the elevation of the lakes, I begin at those nearest the sea, to which instrumental surveys have been made. The Upper Lakes are not thus connected by direct lines, but their height above tide is determined by reference to those below.

There is quite a discrepancy in the results, which can be accounted for as I have above stated.

LAKE ONTARIO.

By lockage in the St. Lawrence canals, above mean tide,	234½	feet.
By canal surveys of New York, above mean tide, ...	232	"
Mean elevation, ...	233¼	feet.

* In a letter to the Editor, Col. Whittlesey states that this portion of his paper was "inserted in 1866 in a Report on a part of Minnesota," and that the estimates differ somewhat from those which have been recently made by the U. S. Coast Survey. The importance of a "revision of the descent from Lake Ontario to Quebec" is also urged. —Ed.

LAKE ERIE.

By canal surveys in New York, 1817,	561.20	feet.
By Capt. Williams report of 1831, Niagara Ship Canal,	563.00	"
By surveys Caatskill & Portland Railway, 1828,	565 33	"
By locks of New York Canal,	567.00	"
Mean,	564.13	feet.

LAKE HURON.

S. W. Higgins, Geological Report of Michigan, 1838,	577	feet.
A. Murray, Geological Report of Canada, 1849,	578	"
Mean,	577½	feet.
Lake St. Clair, Geological Report Michigan,	570	"

LAKE MICHIGAN.

Southern Michigan Railway, J. H. Sargent Engineer, survey of 1856, south end.	583	feet.

LAKE SUPERIOR.

By Capt. Bayfield's barometical measurement in 1824, 627 feet, evidently too great.

A. Murray's determination, Geological Survey of Canada, 1849, 599.41 feet, say	600	feet.
Survey of Bay D'Enoch & Marquette Rail Road, 1859,	610	"
Mean,	605	feet.

GEOLOGICAL SURVEY OF CANADA.

Report of Progress for 1873–4.

The Canadian Geological Survey may in one sense be said to be the most extensive in the world. Its territory ranges from the Pacific to the Atlantic and from about the latitude of 45° to the North pole. In another sense it is extremely small, nay almost microscopic, for it seems to have only seven or eight explorers to cultivate all this vast field; and its annual revenue is very small even for this limited corps, especially when we consider the great expense attending expeditions into the more remote parts of the territories of the Dominion. But Canada is beginning to wake up to the importance of science, and the Survey has probably by no means reached its full development. Its resources are indeed to some extent yet based merely on the calculations required for the limited Canada of bygone years, and our public men are only beginning to realise the demands of their present extended territory.

The present report of 266 closely filled pages, ranges over the whole vast field of the Survey from west to east. Beginning at the Pacific, Mr. Richardson writes of British Columbia. The Director himself and Prof. Bell report the results of explorations pushed across the great plains on the lines of the North and South Saskatchewan. Mr. Vennor explored the apatite and plumbago regions of Ontario and Quebec. Mr. McOuat, Mr. Barlow, and Mr. Robb report on the coal-fields of Nova Scotia and Cape Breton; and Dr. Harrington contributes a report on iron, which is really a detailed and almost exhaustive treatise on our resources in that important metal. Mr. Whiteaves concludes the volume with notes on the Cretaceous fossils of British Columbia. Some other departments of work which do not appear in the detailed report, are thus noticed in the introductory remarks of the Director:

"In the Museum the re-arranging, re-labelling, numbering and cataloguing the collections is making satisfactory progress. When completed it is proposed to issue a descriptive catalogue which it is thought will tend materially to enhance the value of the collections both for educational purposes and for the general information of the public. Considering the size and population of Montreal, the comparatively few persons who visit the Museum, only 1000 during the past twelve months, is certainly somewhat remarkable. I believe this arises, however, in a great measure, from the fact that the character and interest of the collection is not generally known. The doors are now open gratuitously to the public every day in the week, Sundays excepted, from 10 a.m. to 4 p.m.; and there are in the cases upwards of seven thousand named specimens of Canadian fossils, minerals and rocks, illustrative of the economic and scientific geology of the Dominion."

"In the library, which already contains upwards of 2000 volumes, comprising standard works of reference on Geology, Mineralogy, Metallurgy, Chemistry and Natural History, important additions are annually made both by purchase and presentation. The latter comprising valuable reports and maps issued by State Geological Surveys in America, Europe, India and Australia, as well as copies of the transactions of various scientific societies sent in return for the publications of the Canadian Survey. Like the Museum, the library is available to the public for purposes of reference and study. Want of space, however, at present is a serious drawback to the realization of its full value, and also prevents the proper arrangement of the books, the numbering and cataloguing of which is now in progress."

"Mr. E. Billings, who has charge of the Palæontological branch of the Survey and Museum, reports that in addition to his duties as Curator he has been engaged in studying and describing fossils from Gaspé and from various localities in Nova Scotia and in Ontario. Some of the results of these investigations are given in Part I, Vol. II, of the Palæozoic fossils of Canada, which is now in the press and will be issued shortly. It will contain about fifty wood cuts and six lithographed plates of fossils with 125 pages of descriptive text."

"Mr. A. H. Foord, the artist to the Survey, has done a large amount of very excellent work in the preparation of drawings and lithographs of fossils to illustrate the geological reports, and for the second volume of the Palæozoic fossils of Canada."

"During the month of August and a part of September, Mr. Foord was engaged collecting fossils from the Devonian rocks at Percé, Gulf of St. Lawrence, required by Mr. Billings, to enable him to complete his description of the fossils of the formation."

"In the early part of the summer Mr. Weston devoted some time, and with considerable success, to a careful search for fossils in the dark earthy limestones associated with the dolomites and serpentines in the Eastern Townships. He also secured there, and subsequently at Arisaig in Nova Scotia, a number of interesting and instructive photographs illustrating the geological structure of these districts. He has likewise during the year made a very large number of sections, mounted for microscopic examination, of rocks and fossils, as well as of recent and fossil woods from various parts of the Dominion."

"The chemical and mineralogical branches of the Survey, are now under the charge of Dr. B. J. Harrington, ably assisted by Mr. Christian Hoffman. Respecting the investigations during the past year in these departments, Dr. Harrington reports as follows:

"The work in the laboratory, as in the previous year, has consisted largely in the examination of economic minerals; although a few rocks and minerals, more especially of scientific interest, have been analysed."

Details as to these analyses which are both numerous and important are given in this Report.

In a scientific point of view the Report adds considerably to our knowledge of the Pacific coast and of the great plains stretching westward from Manitoba to the Rocky Mountains. In the former the fossils collected by Mr. Richardson confirm fully the Cretaceous age of the remarkable coal-field of Nanaimo in Vancouver's Island, and shew also the existence of rocks probably of Jurassic age, underlying these, and appearing in Queen Charlotte's Islands. Fossils have also been found in a still lower series of altered rocks, which are recognized by Mr. Billings as probably of Carboniferous age. Thus in this strange country, the old metamorphic rocks, in aspect like our oldest formations in Eastern America, prove to be Carboniferous, while the workable coals exist in the Cretaceous rocks. In the country east of the Rocky Mountains, Mr. Selwyn and Prof. Bell have ascertained the limits and general relations of Cretaceous and Tertiary beds holding productive lignites and coals over a large region of the plains. They have not, it is true, cleared up all the problems as to the geological age of these beds, which have perplexed the geologists who have laboured in the continuation of these formations further to the south, but they have settled the Cretaceous age of some beds associated with the coals and lignites or immediately underlying them; and whether the lignite beds themselves are to be placed in the Miocene, as Newberry and Heer decide from their fossil plants, or as others hold from their animal forms in the Lower Eocene, or even Upper Cretaceous, it is clear that no decided break either in life or physical conditions separates them from the upper Mesozoic.

In another field, Dr. Harrington's Report, though chiefly practical, is not without features of scientific interest, more especially as to the mode of origin and metamorphism of iron ores. The following extract may serve as an illustration:

"Concerning the origin of our sedimentary magnetites, the question arises as to whether they were originally deposited as such, or in some other form, and afterwards altered to magnetite. It seems possible that, in some cases, beds may have been formed by the accumulation of iron sands, just as they are forming in the Gulf of St. Lawrence to-day, the material being derived from the disintegration of pre-existing crystalline rocks. Such beds we should expect to contain not only magnetite, but ilmenite, and it is well known that in many cases ores on being pulverised may be more or less completely separated into a magnetic portion containing little or no titanic acid, and a non-magnetic portion consisting essentially of ilmenite. It seems, however, probable that in general their origin has been similar to that of the modern bog and lake ores. Deposits of magnetite, as a rule, do not continue of uniform thickness for any great distance like the enclosing rocks, and this is just what might be expected if we suppose them to have originally occurred as bog or lake ores which accumulated in local hollows or depressions. No ore, moreover, would be more readily converted into magnetite than bog ore, on account of the considerable proportion of organic matter which the latter contains."

"In this connection may be described a very simple but interesting experiment tried with a specimen of bog ore from L'Islet, containing about 22 per cent. of water and organic matter. The pulverized ore was placed in a platinum crucible, and heated for an hour at a temperature of 190° F. At the end of that time it had parted with its combined water, or at any rate with sufficient to cause the colour to change from brown to bright red. It still, however, retained organic matter, and on heating for a few minutes in a tightly closed crucible, and at a temperature considerably below redness, a reduction of the peroxide ensued, and a black, strongly magnetic powder was obtained, apparently consisting of magnetic oxide, and not of metallic iron, as it occasioned no precipitation of metallic copper in a solution of the sulphate. The cover was now removed from the crucible and a red heat given, when in a short time the powder again became red, or rather purplish-red, and non-magnetic. Finally, the heat was raised a little higher (to bright redness), and soon the powder became black and strongly magnetic, having apparently parted with a portion of its oxygen. These changes are instructive, for while brought about in the laboratory they might take place in nature. They shew, too, that in some cases magnetites may have been formed from such ores as bog ore at comparatively low temperatures, the reduction being due to the organic matter of the ore."

The Report is rich in information on coal and iron, the two great staples of our mineral wealth. Though the two provinces of old Canada might truly be said to be destitute of coal, this can no longer be affirmed of the Dominion of Canada. In addition to our 18,000 square miles, or thereabout, of coal-formation in the Lower Provinces, we now find at least 100,000 square miles of the western plains underlaid by coal, or lignite which will serve for coal; and beside this there is the valuable, if less extensive Cretaceous coal-area of Vancouver's Island, with others of unknown extent on the mainland of British Columbia. With regard to the district explored by him, Mr. Selwyn writes:

" Dr. Hector has separated the Edmonton coal rocks from those in the vicinity of the Mountain House by an intervening area which he considered to be occupied by a somewhat higher section or division of the Cretaceous series. He did not apparently see the thick seam of coal which I found, as above stated, below the Brazeau River, about eighty-six miles from Rocky Mountain House; and another seam of five feet six inches thick, which I found at a point some fifteen miles higher up the river, as well as the numerous indications of seams which occur between the out-crop of the eighteen feet seam and Edmonton, probably also escaped his notice, as he travelled partly during the night, and in the winter, on the ice, when many of the exposures along the banks must have been concealed by snow. The observations which I was able to make descending the river do not enable me to say whether the seams retain their thicknesses or are connected for long distances, or whether the very numerous exposures and indications seen in the cliff sections represent only more or less lenticular shaped and isolated patches, repeated at different horizons and over large areas. Dr. Hector appears to incline to the latter idea, and, in a note referring to the seams at Rocky Mountain House, he states, 'The coal beds are not continuous for long distances.' Whether this is actually the case or not, there can be no question that in the region west of Edmonton, bounded on the north by the Arthabaska River and on the south by the Red Deer River, there exists a vast coal field covering an area of not less than 25,000 square miles: and beneath a large portion of this area we may expect to find workable seams of coal at depths seldom exceeding 300 feet, and often, as in the case of the thick seams above described, very favourably situated for working by levels from the surface."

Mr. Richardson contributes additional facts tending to prove the value of the coal-fields of British Columbia, in which province there appear also to exist important developments of silver ores. The coal-fields of Nova Scotia and Cape Breton are better known; but important additional facts are stated with respect to them, and the progress which has been made toward the unravelling of the complexities of the disturded coal-strata in the central part of the Cumberland coal-field, is very creditable to the gentlemen engaged in the work.

Iron is next to coal the greatest source of national wealth, and it is only necessary to glance at this part of the Report to see how largely and liberally Canada is endowed with the richest ores of this metal. It is true that in the large Laurentian and Huronian areas, where the most valuable ores of this kind abound, they are remote from mineral fuel, and their value is thereby lessened; but this does not apply to the equally rich and almost equally extensive deposits of Nova Scotia, which are in the immediate vicinity of coal, and which afford the means of making the best iron perhaps more cheaply than any other region in the world. More especially is this true of the deposits in the Cobequid mountains in the vicinity of the coal-field of Cumberland, and of those of Pictou, close to the great collieries of that district. The former have the advantage of having been already partially opened and worked, but the coal-field in their neighbourhood is less developed. The latter are not yet fully opened up in so far as the iron deposits are concerned, but the coal is fully opened, and its adaptation to iron-smelting ascertained. Both have now attracted the attention of capitalists, and unless mismanagement or abnormal political or commercial conditions prevent, will ere long become great and important sources of wealth and centres of manufacturing industry, and will render Canada independent of the rest of the world in so far as its supplies of iron are concerned. It would be impossible to convey any idea of Dr. Harrington's Report by extracts, and to quote references to particular districts might appear invidious. All interested in the development of our mineral resources should study it for themselves. J. W. D.

ON THE CONDITIONS WHICH DETERMINE THE PRESENCE OR ABSENCE OF ANIMAL LIFE ON THE DEEP-SEA BOTTOM.*

By Dr. W. B. Carpenter, F.R.S.

The foundation of Geological Science must be based upon a study of the changes at present going on upon the surface of the earth, including the depths of the sea. This is the distinctive feature of modern Geology. Until recently nothing was really known of the depths of the ocean; but, owing to improved methods of sounding, the bottom of the sea has been reached in so many places, that we may feel tolerably sure that its depth seldom exceeds four miles. Recent statements regarding an extraordinary depth off the coast of Japan, are most probably due to an error similar to that which formerly represented the Straits of Gibraltar as unfathomable—an error caused by the carrying out of the sounding-line in a strong surface-current. The general depth of the Atlantic does not exceed three miles, though, as an exception, the "Challenger" has recently attained 3800 fathoms in a hole 100 miles north of St. Thomas. As an additional proof that this was a true sounding, both the protected thermometers came up crushed.

The temperature of deep water has only lately been ascertained with accuracy, the earlier attempts having been vitiated by the error arising from pressure. Of the older attempts to ascertain the temperature of the deep strata, that devised by Lenz in the

* Geological Magazine.—The substance of a lecture delivered before the Geologists' Association, on December 4th, 1874.

second voyage of Kotzebue, though fearfully laborious, gave results that correspond most closely with the "Challenger's"; a fact in scientific annals which has been lately dug out by Prof. Prestwich, and by him brought to the notice of the lecturer, who found his own conclusions—made in entire ignorance of those of Lenz—thus singularly confirmed. The conclusions to be drawn from a study of these temperatures point towards a deep flow of polar water towards the Equator, unrestricted, as regards the Atlantic, towards the south, but limited in the direction of the North Polar area, where there are two principal channels: the one between Greenland and Iceland, the other between the Faroe Islands and the 100-fathom line of North-west Europe, on which platform the British Islands repose. This latter is the "Lightning" channel, the scene of the lecturer's first explorations, the study of which led to his view of the existence of two opposite flows in the great oceanic area, quite irrespective of any one current. In this channel it was found that there was a superficial warm stream and a deep cold stream; and that within a vertical space of 50 fathoms a most marked difference of temperature is suddenly encountered; whilst, as regards horizontal distance, temperatures of 29½° F. and 43° F. have been obtained at the same depth in places not 20 miles apart. These facts mean that there are two distinct movements of water, just as a striking difference in the temperature of the atmosphere indicates a change of wind. Hence, speaking with reference to the "Lightning" channel, it is clear that water much colder than the mean winter temperature of the latitude must have a northerly, whilst water that is warmer must have a southerly source. In accordance with this we find that most of the animals of the cold area, such as the beautiful *Comatula Eschrichtii,* belong to the boreal fauna; whilst British species, such as the common *Solaster papposa,* which is dwarfed from the size of a plate to that of a crown-piece, are much stunted. Yet the fauna is abundant, as no temperature seems to prevent life, so long as sea-water is liquid. Pressure, though enormous, will not affect vital functions; since an animal, whose cavities contain air in aqueous solution only, can contract and expand just as well with a pressure of three tons to the square inch as it can on the surface. Not but what change of pressure, brought on by sudden removal, might produce some derangement. Neither temperature nor pressure, then, being directly of supreme importance, it is the supply of oxygen which has most influence on Animal Life in the deep seas. This is regulated by the general flow of water near the sea-bottom,—a flow not confined to any particular passage or area, but maintained by difference of specific gravity, produced by difference of temperature. As sea-water, in this respect differing from fresh-water, continues to increase in density down to its freezing-point, which is 27° F. if agitated, and 25° F. if still, the Polar column will outweigh the Equatorial column, and there will be a lateral outflow at the bottom towards the equatorial area. This will cause a lowering of water in the polar area, and produce a surface-flow of water from the Equator towards the Poles. The two bottom-flows from either pole will thus meet near the Equator, and rising, will bring cold water nearer to the surface there than anywhere else, except where the surface itself is subjected to cold. In this way the bottom-temperature of the South Atlantic would be lower than that of the North Atlantic, by reason of the less restricted body of the polar flow in the former. The tables given in the "Challenger's" report confirm the conclusions thus arrived at. From these we find that the general temperature of the North Atlantic bottom is about $35\frac{1}{2}$° or 36° F., decreasing to 34° F. near St. Thomas, and under the Equator itself to 32·4° F., the lowest temperature of all. This section proves that the South Atlantic under-flow extends north of the Equator, as had been previously surmised by the lecturer. Only one section was made in the South Atlantic, and no temperatures lower than $33\frac{1}{2}$° F. were there obtained, the expedition not happening to hit upon the channel which brought in the water at 32·4° F. found under the Equator. Most remarkable of all is the line of 35° F. which can be traced across the South Atlantic and then gradually slopes down in the North Atlantic till it is lost. The temperature of the North Atlantic depths is probably about 3° F. higher than in the South Atlantic. Off the coast of Lisbon, in lat. 38° N., the line of 40° F. is found at 700 to 800 fathoms; in lat. 22° N. at 700 fathoms; and on the Equator at 300 fathoms only, descending from a surface temperature of 75° F. The reason for this has been already shown to be the continual rise of the Polar under-flow towards the surface in the Equatorial belt. A further confirmation of these views is obtained from a comparison of specific gravities. The density (due to salinity) of surface-water increases from the poles to the tropics, while that of bottom-water in the tropics is nearly the same as in the polar area. Why then does the bottom-water of the tropics, being of lower salinity, underlie the more saline strata? Because the density it lacks from its lower salinity is more than compensated by the lowness of its temperature. Passing, however, from either tropic towards the Equator, the salinity of surface-water is found to diminish, until its specific gravity is reduced from 1027·3 to 1026·4 or 1026·3, which is that of the polar under-flow. Lenz adduced the low salinity of the surface-water under the Equator as evidence of the rise of polar water from the bottom, and showed that there is a band of water at the Equator colder than any to the north or south of it.

The Oceanic Circulation thus produced brings every drop of water in turn to the surface, enabling it to part with carbonic acid and to absorb oxygen; this, then, is its importance to Animal Life. From the analysis of gases dissolved in the water of the oceanic area, it was found that, for 45 per cent. of carbonic acid there was usually from 16 to 20 per cent. of oxygen—this being the result of a series of observations taken off Ireland and Scotland at various depths down to 2000 fathoms. This amount of oxygen is sufficient to support a large quantity of Animal Life, in spite of the, to air-breathers, fatal proportion of carbonic acid—if indeed the carbonic acid be not in a liquefied, and thus perhaps more innocuous form.

In the Mediterranean totally different conditions prevail. It was expected that a Tertiary fauna would be found at great depths, analogous to the Cretaceous-like fauna of the ocean outside. Instead of that, only a viscid mud, almost devoid of life, was brought up. The western basin has a depth of 1600 fathoms, the eastern basin one of 2000 fathoms; the bottom temperature is nearly uniform at about 55° F., a great difference in thermal condition from the Atlantic. The reason is that the Mediterranean is cut off entirely from the polar under-flow, which, off Lisbon, produces a temperature of 40° F. at a depth of 700 fathoms, and 36½° at 1500 fathoms. In the Mediterranean, on the other hand, we have a surface temperature from 60° to 70° F., which, in the first 100 fathoms, falls to 54° or 55° F., below which to the bottom, no matter at what depth, there is no change at all, but a slight variation according to latitude, due in part to the mean winter temperature of the locality. The whole of the lower portion, therefore, below the influence of the Gibraltar current, is a mere stagnant pool; and this is the explanation of the absence of Animal Life except in the shallows. The impalpable mud, which is slowly settling to the bottom, may also not be without its effect. This is the result of the attrition of soft Tertiary shores, and of the clay brought down by the Rhone into the western basin, and by the Nile into the eastern, the finer particles pervading the entire sea. Corals and Bivalves suffer from it especially. The per-centage of carbonic acid was found to be as high as 60, whilst that of oxygen was only 5; this is believed to be due to the organic matter, brought down by the rivers, using up the oxygen. These unfavourable conditions are primarily due to deprivation of the general oceanic circulation, which maintains life at such great depths.

There seems, however, to be a limit, in respect of depth, to the preservation of animal remains; due possibly, as conjectured by Prof. Thomson, to the solvent power of sea-water at pressures below 2200 fathoms. This may serve to explain the passage of true *Globigerina* ooze, first into grey ooze, poorer in calcareous matter, and finally at great depths into red ooze devoid of lime. Moreover, this dissolving of calcareous skeletons at great depths may serve to explain the production of Greensands, such as is now going on along the line of the Agulhas current. These consist largely of the internal casts of foraminifera, the sarcode of which has been replaced by glauconite. The importance of such facts to geologists is immense. It was the examination of a series of casts of similar bodies in a green sillicate, that, years ago, formed the foundation for the lecturer's interpretation of the structure of Eozoön, where there is a replacement of its sarcodic body by a green silicate, viz. serpentine. If the seawater, under this tremendous pressure, has dissolved away the shells of Foraminifera, after their sarcode has undergone the substitution alluded to, a beautiful application of this kind of research to geological phenomena has been brought forward.

Referring to Ed. Forbes's limitation of marine life to 300 fathoms, the lecturer observed that the statement was true of the Ægean, as of the whole of the Mediterranean, where there is abundant life in the littoral zone, diminishing rapidly towards 250 fathoms, below which Animal Life is almost at zero. Finally it is not a limit of pressure, of heat, or even of food, but the limit of oxygenation, as determined by the presence or absence of a thermal circulation, which affects the life of animals.

So that deposits forming in inland seas, excepting in the shallower portions, we must expect to be destitute of fossils. This is well illustrated by the Miocene strata of Malta, where certain coarsish beds, representing shallow water conditions, are full of fossils in a fine state of preservation; whilst the very fine building stone, corresponding closely with the finest calcareous deposit of the Mediterranean, contains hardly any remains but such as would fall in from above, *e.g.* the teeth of sharks. This may explain the paucity of fossils in many strata, especially in the Red Sandstones of inland seas. Much depends upon the depth of the communication, supposing there to be one with the oceanic circulation; and the level of this may be often inferred from a knowledge of the line of permanent temperature of such inland sea. To the general paucity of animal life under such conditions the Red Sea appears to be an exception, notwithstanding the shallowness of the Straits of Babelmandel. This is probably due to the absence of the sediment and oxidating matter of large rivers, and to the rocky nature of its shores, conditions which insure a clear water: whilst a certain circulation, producing oxygenation, is kept up to supply the enormous evaporation, which, if the Straits were closed, would desiccate the basin in three or four hundred years.

MISCELLANEOUS.

New Coal Fields in Russia.—The practical advantages of Geology are well shown in the discovery of new coal-fields in Russia, and in the extension of the known coal areas, far beyond the limits previously assigned to them. In the district of Tula, south of Moscow, is a coal field covering 13,000 square miles, with two seams of coal, one of three feet and the other of seven feet in thickness. On the shores of the Sea of Azoff is another field of 11,000 square miles, containing good seams of both anthracite and bituminous coal. It is reported that sixty seams have been discovered, forty-four of which are workable, having a total thickness of 114 feet. Another small coal-field has been discovered at the base of the Ural Mountains, but this is unimportant. It does not appear that any of these deposits belong to the true old coal formation. They are, nevertheless, of considerable value, and will greatly aid in the development of the mineral wealth of the Russian Empire.—*Athenæum.*

NEW VEGETABLE REMAINS IN FRANCE.—A remarkable collection of sillicified vegetable remains has been discovered by M. Grand'Eury in two beds of conglomerate, occurring in the coal-field of St. Etienne, in the south of France. These remains consist of fossil fruit, or rather of naked seeds resembling those of the cycads or conifers. They have recently received careful study by M. A. Brongniart, who has distinguished among them no fewer than seventeen genera, represented by twenty-four species.—*Ibid.*

WARWICKITE.—Professor J. Lawrence Smith has recently published in the American Journal of Science an analysis of this very interesting mineral—the only borotitanate known. His results are as follows:

Boracic acid	27.80
Titanic acid	23.82
Magnesia	36.80
Oxide of iron	7.02
Silica	1.00
Alumina	2.21
	98.65

The formula for the mineral which Prof. Smith is disposed to adopt is $5\ Mg\ O\ 3\ BO_3 + (Mg\ O,\ Fe\ O)\ 2\ Ti\ O_2$.

PERMANENT ICE IN A MINE IN THE ROCKY MOUNTAINS; by R. Weiser of Georgetown, Colorado.—Geologists have been not a little perplexed with the frozen rocks found in some of our silver mines in Clear Creek Co., Colorado. I will first give a statement of the facts in the case, and then a theory for their explanation.

There is a silver mine high up on McClellan Mountain, called the "Stevens Mine." The altitude of this mine is 12,500 feet. At the depth of from 60 to 200 feet the crevice matter, consisting of silica, calcite, and ore, together with the surrounding wall rocks, is found to be in a solid frozen mass. McClellan Mountain is one of the highest extreme spurs of the Snowy Range; it has the form of a horse-shoe, with a bold escarpment of feldspathic rock near 2000 feet high, which in some places is nearly perpendicular. The Stevens Mine is situated in the south-western bed of the great horse-shoe; it opens from the north-western. A tunnel is driven into the mountain on the lode, where the rock is almost perpendicular. Nothing unusual occurred until a distance of some 80 or 90 feet was made, and then the frozen territory was reached, and it has continued for over 200 feet. There are no indications of a thaw, summer or winter; the whole frozen territory is surrounded by hard massive rock; and the lode itself is as hard and solid as the rock. The miners being unable to excavate the frozen material by pick or drill to get out the ore (for it is a rich lode, running argentiferous galena from 5 to 1200 ounces to the ton), found the only way was to kindle a large wood fire at night against the back end of the tunnel, and thus thaw the frozen material, and in the morning take out the disintegrated ore. This has been the mode of mining for more than two years. The tunnel is over 200 feet deep, and there is no diminution of the frost; it seems to be rather increasing. There is, so far as we can see, no opening or channel through which the frost could possibly have reached such a depth from the surface. There are other mines in the vicinity in a like frozen state.

From what we know of the depth to which frost usually penetrates into the earth, it does not appear probable that it could have reached the depth of 200 feet through the solid rock in the Stevens Mine, nor even through the crevice matter of the lode, which, as we have stated, is as hard as the rock itself. The idea, then, of the frost reaching such a depth from the outside being utterly untenable, I can do no other way than fall back upon the glacial era of the Quaternary. Evidences of the glacial period are found all over the Rocky Mountains. Just above the Stevens Mine there are the remains of a moraine nearly a mile long and half a mile wide. The debris of this moraine consists of small square and angular stones, clearly showing that they have not come from any great distance; and just over the range, on the Pacific slope, there are the remains of the largest moraine I have ever seen, consisting of feldspathic boulders of immense size. I conclude, therefore, that it was during that period of intense cold that the frost penetrated so far down into these rocks; and that it has been there ever since, and bids fair to remain for a long time to come.—*Amer. Jour. Science.*

Deep Borings.—The deepest boring on record is that executed by the Prussian Government engineers at Sperenberg, about 25 miles south of Berlin. The following details concerning it are from the Geological Magazine:

"The boring for the first 956 feet (983¾ English feet) was made by manual labour, at a cost of about £1600.

"Several accidents having happened, the borehole was then lined for a depth of 85 feet (87½ English feet) with tubes of 15 inches diameter; beyond that, to the depth of 100 feet (103 English feet), with 14 inch tubes; and then to 363½ feet (374 English feet) with tubes of 12½ inches diameter.

"The length of time occupied in the above-mentioned work was fifteen months. comprised between May, 1867, and July, 1868.

"From the depth of 956 feet (983¾ English feet), for the remaining distance, the boring was carried on by means of a steam engine. The length of time consumed in sinking this additional 3095 feet (3184¾ feet English), comprised between January, 1869, and the 15th September, 1871, was about 31½ months, during which interval several accidents occurred.

"The total expenditure upon the whole boring, 4051 feet (4172½ English feet), both by manual labour and by steam power, was about £8717 14s., making the average cost for every Prussian foot in depth about two guineas, or about £2 1s. 9d. per English foot.

"The whole time spent on the work was 51½ months; but as there was an interval of 5 months, between July, 1868, and January, 1871, during which period the boring operations were suspended, the actual number of working months becomes reduced to 46½.

"The process of boring throughout was by percussion borers worked by rods; and the rocks bored through belonged to the Triassic series.

"The progress of the work would have been much greater but for the accidents which took place, and for the delays which were caused by the observations that were made as to the increase of the temperature of the earth in depth, &c."

The next hole, as regards depth, is that executed under the direction of Mr. Charles H. Atkeson on the grounds of the St. Louis Co. Insane Asylum in Missouri. It was begun in March, 1866, and finished in August, 1869, the depth reached being 3843½ feet. The last 40 feet of the hole was through granite, but the beds above this were of the Lower Silurian and Carboniferous formations.

Fauna of the Mammoth Cave.—Interesting additions to our knowledge of the fauna of the Mammoth Cave have recently been made by Mr. F. W. Putnam, of Salem, U. S., who, as a special assistant on the Kentucky State Geological Survey, of which Prof. N. S. Shaler is the director, had great facilities extended by the proprietors of the cave, and he made a most thorough examination of its fauna, especially in relation to the aquatic animals. Mr. Putnam passed ten days in the cave, and by various contrivances succeeded in obtaining large collections. He was particularly fortunate in catching five specimens of a fish of which only one small individual had heretofore been known, and that was obtained several years ago from a well in Lebanon, Tennessee. This fish, which Mr. Putnam had previously described from the Lebanon specimen under the name of *Chologaster Agassizi*, is very different in its habits from the blind fishes of the cave and other subterranean streams, and is of a dark colour. It lives principally on the bottom, and is exceedingly quick in its motions. It belongs to the same family as the two species of blind fishes found in the cave. He also obtained fine specimens of four species of fishes that were in every respect identical with those of the Green River, showing that the river fish do at times enter the dark waters of the cave, and when once there apparently thrive as well as the regular inhabitants. A large number of the white blind fishes were also procured from the Mammoth Cave, and from other subterranean streams. In one stream the blind fishes were found in such a position as to show that they could go into daylight if they chose, while the fact of finding the *Chologaster* in the waters of the Mammoth Cave, where all is utter darkness, shows that animals with eyes flourish there, and is another proof that colour is not dependent on light. Mr. Putnam found the same array of facts in regard to the crawfish of the Cave, one species being white and blind, while another species had large black eyes, and was of various shades of a brown colour. A number of living specimens of all the above-mentioned inhabitants of the waters of the Cave were successfully brought to Masschusetts after having been kept in daylight for several weeks, proving that all the blind Cave animals *do not* die on being exposed to light as has been stated.—*Nature.*

OYSTERS IN GREAT SALT LAKE.—The cultivation of Oysters has been attempted by the United States Commission of Fisheries in the Great Salt Lake of Utah, where numbers of these bivalves from California have been placed with a view of testing the possibility of their thriving there. Some beds were choked by mud brought down some small mill streams, but in other parts the oysters promise to succeed. Shad have also been placed in the lake and have been seen in good health, and a lot of salmon fry from the Sacramento, artificially hatched out, have been placed in the Jordan and other rivers running into the Great Salt Lake. So far in the fresh waters they have done well, and at ten months old were from four to six inches long. It remains to be seen whether they will thrive as well in the salt waters of the lake as in the sea itself. The experiment is a most interesting one, and opens up some curious questions in the natural history of the salmon and the other fish under experiment.—*Ibid.*

BEAVERS ABROAD.—According to *Nature*, the Marquis of Bute has recently purchased eight Canadian Beavers, seven of which have arrived safely in the Island of Bute, and have been placed in the enclosure constructed for the four which died some time ago on Drumreoch Moor. They are to be supplied with food for some time to come, until they have learned to provide for themselves in their new home.

OBITUARY NOTICE.*

THE LATE MR. BRYCE M. WRIGHT.

"We regret to have to announce the death of this Cumberland gentleman, which took place a short time ago at his private residence in Great Russell St. Bloomsbury, London. Mr. Bryce Wright was well known in the scientific world, having devoted the whole of his life to the studies of Mineralogy and Geology, more particularly as applied to his native home, the Lake district. His first geological discovery was that of a curious bivalve crustacean, which, although very common in the Skiddaw slates, had not been detected by other geologists. It is remarkable for being the lowest form of crustacean known, and was named by Professor Salter in honour of its discoverer, *Caryocaris Wrightii*. Scores of fossils, through the indefatigable perseverance of this gentleman, have been brought to light, his last discovery being that of the dentigerous bird's head *Odontopteryx toliapicus*, Owen, a notice of which at the time of its discovery appeared in our columns. It was not only in palæontology that Mr. Bryce Wright made important discoveries, for in Mineralogy his discoveries were more numerous if not more important. In the Lake district alone he brought to light more than a dozen new minerals, the most important of which were *Brochantite* (a hydrous oxide of copper with sulphuric acid), *Leadhillite* (sulphato-tricarbonate of lead), *Lanarkite*, *Caledonite*, &c. In other localities (particularly Derbyshire) he was equally successful, and was the first discoverer in England of the minerals *Phosgenite* (murio-carbonate of lead), and *Matlockite* (an oxy-chloride of lead), as well as many others too numerous to mention. He seemed to possess a peculiar instinctive capacity for the detection of any new specimens of natural history, for not a single subject did he take in hand but he left the mark of his originality upon it. In the conchological world he was equally successful, and discovered many new specimens, which have been of the greatest importance to malacological science. The *Volute Ruckeri* from Australia, the *Bulimus (pseudachatina) Wrightii* from Old Calabar, *Spondylus Wrightianus* from Nicholl's Bay, as well as many other shells from all parts of the world, owe their discovery to his keen power of detection. He was a native of Hesket-new-Market, *and by his rambles among the Cumberland mountains* gained experience through Nature itself, which assisted him greatly in the discovery of so many specimens of natural history. He was a member of many learned bodies, and was elected a Commissioner for the Exhibition of 1862. His decease, so universally regretted, will be felt in Hasket-new-Market and Caldbeck, having been a supporter of all schools and schemes for the advancement of knowledge in those districts."

Mr. Wright was a corresponding Member of the Natural History Society of Montreal, and presented many fine specimens of minerals, fossils, shells, &c., to its Museum. Of late years he devoted much time to the study of archæology (especially in its connection with geology), and his practical acquaintance with the former science was by no means inconsiderable.

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