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The twenty-ninth meeting of this Association met at Boston, Mass., on the 25th of August, under the Presidency of Professor Lewis H. Morgan, of Rochester N. Y. It was probably the largest and in many respects the most successful ever held, the membership reaching nearly to a thousand, and the city of Boston, with the educational and other institutions within and near it, having made most liberal promises for the comfort and entertainment of the members.

The Association is divided into two sections, namely:

A.—Mathematics, Astronomy, Chemistry and Mineralogy.

B.—Geology, Zoology, Botany and Anthropology.

These, again, are subdivided, and the late meetings have embraced subsections of Chemistry, Microscopy, Biology and Anthropology. The last though a new department was one of the most popular and energetic, if it may be judged by the crowded audiences and earnest discussions. The other sections were characterised rather by solid papers than by lively discussions. A detailed account of all that was done and said would far exceed the limits of this journal, but we propose to give a few extracts from or abstracts of some of the more important addresses and papers presented during the meeting.

Address of Professor George F. Barker, the retiring President of the Association.

Professor Barker's able address was upon the all absorbing topic of "Life," and was entitled "Some Modern Aspects of the Life Question." After a few preliminary remarks he continued:

"What now are we to understand by the word 'Life' in this discussion? A noteworthy parallel is disclosed in the progress of human knowledge between the ideas of life and of force. Both conceptions have advanced, though not with equal rapidity, from a stage of complete separability from matter to one of complete inseparability. Life is now universally regarded as a phenomenon of matter, and hence of course, as having no separate existence. But there still exists a certain vagueness in the meaning of the term 'Life.' Two distinct senses of this word are in use; the one metaphysical, the other physiological. The former, synonymous with mind and soul, at least in the higher animals, has been evolved from human consciousness; the latter has arisen from a more or less careful investigation of the phenomena of living beings. It need scarcely be said that it is in the sense last mentioned that the word "Life" is used in science. The conception represents simply the sum of the phenomena exhibited by a living being.

"Moreover, the progress which has been made in the solution of the life-question has been gained chiefly by investigation of special functions. But the functions of a vital organism are themselves vital. What then is the meaning of 'vital' as applied to a function? Fortunately the answer is not difficult. 'Life,' says Küss, the distinguished Strasburg physiologist, 'is all that cannot be explained by chemistry or physics.' Guided by such a definition the work of the physiological investigator is simple. He has only to test each separate oparation which he finds going on in the organism and to declare whether it be chemical or physical. If it be either, then since each function is non-vital, the entire organism must be non-vital also. Hundreds of able investigators, provided with the most effective appliances of research, are now in full cry after the life principle. Naturally, a vast amount of collateral knowledge is accumulated in the process. The quantitative as well as the qualitative relations of things are fixed, and many important facts are collected.

"As a first result of recent work, the living organism has been brought absolutely within the action of the law of the Conservation of Energy. Whether it be plant or animal, the whole of its energy must come from without itself, being either absorbed directly or stored up in the food. An animal, like a machine, only transforms its energy. Lavoisier's guinea-pig, placed on the calorimeter, gave as accurate a heat-return for the energy it had absorbed in its food, as any thermic engine would have done. But the parallel goes further. The mechanical work of an engine is measured by the loss of its heat and not of its substance. So the mechanical or intellectual work of living beings is measured by the amount of food rather than the amount of tissue which is burned. The energy evolved daily by the human body would raise it to a height of about six miles."

The subject of muscular contraction is then discussed and regarded as due to electric discharges generated within the muscle itself and not carried to the muscle by the nerves. The electrical charge which appears in the muscular fibre, may, it is supposed, have its origin in so purely a physical cause as the contact of the heterogeneous substances of which the tissue is built up; the maintenance of this charge being effected by chemical changes going on constantly in the substance of the muscle, by which the carbon dioxide is produced, which is shown to be a measure of the work done.

" Conceding now, that muscular contraction is of the nature of an electric discharge, by what mechanism is the contraction effected? A string of electrical masses, like a muscular fibril, would seem at first to oppose the view now advanced. Such a row of particles would indeed attract each other when electrified, and shorten the length of the whole. But the force of contraction would increase as the length diminished; whereas the fact in the case of the muscle is precisely the reverse. Two theories have been advanceed to account for the result. The first, proposed by Marey, likens the muscular fibre to a string of india-rubber which, when stretched, contracts upon the application of heat, thus transforming heat directly into work. The other, brought forward and strongly supported by Radcliffe, explains contradiction by direct electric charge. Each fibre of the muscle, together with its sheath, constitutes a veritable condenser, the charge upon the exterior being positive, and upon the interior negative. When a charge is communicated to the fibre, literal compression results from the attraction of the electricities of opposite name, and since the volume remains constant, elongation is the consequence—precisely as a band of caoutchouc, having strips of tin-foil upon its sides, may be shown to elongate when charged like a condenser. In this view of the matter the normal condition of the muscle is one of charge, of elongation. Contraction results from the simple elasticity of the muscle itself, the function of the nerve being only that of a discharger. Whether this theory represents the actual fact or not, in all its details, it is supported by the existence of *rigor mortis*, by the continued relaxation of muscle during the flow of the current, by the cessation of contraction on the free access of blood, and by many other phenomena otherwise difficult to explain.

"From this brief review, does it not seem probable that the phenomenon of muscular contraction may be satisfactorily accounted for without the assumption of 'vital irritability,' so long invoked? May it not be conceded that the theory that muscular force has a purely physical origin is at least as probable as the vital theory?

"Time would fail me to discuss the many other phenomena of the living body which have been found, on investigation, to be non-vital. Digestion, which Prout said it was impossible to believe was chemical, is now known to take place as well without the body as within it, and to result from non-vital ferments. Absorption is osmotic, and its selective power resides in the structure of the membrane and the diffusibility of the solution. Respiration is a purely chemical function. Oxyhæmoglobin is formed wherever hæmoglobin and oxygen come in contact, and the carbon dioxide of the serum exchanges with the oxygen of the air according to the law of gaseous diffusion. Circulation is the result of muscular effort both in the heart and capillaries, and the flow which takes place is a simple hydraulic operation. Even coagulation, so tenaciously regarded as a vital process, has been shown to be purely chemical, whether we adopt the hypothesis of Shmidt that it results from the union of two proteids, fibrinogen and fibrinoplastic substance, or the latter theory of Hammarsten that fibrin is produced from fibrinogen by the action of a special ferment."

Professor Barker then considers the function of the nervous system and states that "the nerve-cell and the nerve-fibre are occupied solely in the transmission of energy which is in all probability electrical." The only objection to the electrical character of nerve energy is based upon its slow propagation; but considering that it has been shown by Weber that animal tissues in general have a conductivity only one fifty-millionth of that of copper, the fact that the energy of nerve moves at the rate of only twenty-eight metres per second is really no proof that it is not electricity.

Of the "physical aspects of the mind-question," Professor Barker says:

"The problem of the quantitative changes which take place in the organism is a very curious and interesting one. That the energy of the brain comes from the food will be disputed by no one in these days. Hence, the brain must act like a machine and transform energy. There is then a purely physiological representation of mental action, concerned with forces which are known and measurable. The researches of Lombard long ago showed the concomitant heat of mental action. Recent researches are equally interesting, which show that mental operations are not instantaneous but require a distinct time for their performance. By accurate chronographic measurement, Hirsch has shown that an irritation on the head is answered by a signal with the hand only after one-seventh of a second; that a sound on the ear is indicated by the hand in one-sixth of a second; and that when light irritates the eye, one-fifth of a second elapses before the hand moves."

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"Another important fact concerning nervous action is that its amount may be measured by the quantity of blood consumed in its performance. Dr. Mosso of Turin has devised an apparatus called the Plethysmograph—drawings of which were exhibited at the London Apparatus Exhibition of 1876—designed for measuring the volume of an organ. The fore-arm, for example, being the organ to be experimented on, is placed in a cylinder of water and tightly enclosed. A rubber tube connects the interior of the cylinder with the recording apparatus. With the electric circuit by which the stimulus was applied to produce contraction, were two keys, one of which was a dummy. It was noticed that, after using the active key several times, producing varying current strengths, the curve sank as before on pressing down the inactive key. Since no real effect was produced, the result was caused solely by the imagination, blood passed from the body to the brain in the act. To test further the effect of mental action, Dr. Pagliani, whose arm was in the apparatus, was requested to multiply 267 by 8, mentally, and to make a sign when he had finished. The recorded curve showed very distinctly how much more blood the brain took to perform the operation. Hence the plethysmograph is capable of measuring the relative amount of mental power required by different persons to work out the same mental problem. Indeed Mr. Gaskell suggests the use of this instrument in the examination room, to find out, in addition to the amount of knowledge a man possesses, how much effort it causes him to produce any particular result of brain-work. Dr. Mosso relates that while the apparatus was set up in his room in Turin, a classical man came in to see him. He looked very contemptuously upon it and asked of what use it could be, saying that it could'nt do anybody any good. Dr. Mosso replied, "Well now, I can tell you by that whether you can read Greek as easily as you can Latin." As the classicist would not believe it, his own arm was put into the apparatus and he was given a Latin book to read. A very slight sinking of the curve was the result. The Latin book was then taken away and a Greek book was given him. This produced immediately, a much deeper curve. He had asserted before that it was quite as easy for him to read Greek as Latin and that there was no difficulty in doing either. Dr. Mosso, however, was able to show him that he was labouring under a delusion. Again, this apparatus is so sensitive as to be useful for ascertaining how much a person is dreaming. When Dr. Pagliani went to sleep in the apparatus, the effect upon the resulting curve was very marked indeed. He said afterward that he had been in a sound sleep and remembered nothing of what passed in the room —that he had been absolutely unconscious; and yet, every little movement in the room, such as the slamming of a door, the barking of a dog, and even the knocking down of a bit of glass, were all marked on the curves. Sometimes he moved his lips and gave other evidences that he was dreaming; they were all recorded on the curve, the amount of blood required for dreaming diminishing that in the extremities. The emotions too left a record. When only a student came into the room, little or no effect appeared in the curve. But when Professor Ludwig himself came in, the arteries in the arm of the person in the apparatus contracted quite as strongly as upon a very decided electrical stimulation."

Professor Barker is a strong believer in the capacities of the chemist and the great things yet to be accomplished by him With reference to protoplasm he says:

"Because life is unlike other properties of matter, it by no means follows that it is not a property of matter. No dictum is more absolute in science then the one which predicates properties upon constitution. To say that this property exhibited by protoplasm, marvellous and even unique though it be, is not a natural result of the constitution of the matter itself, but is due to an unknown entity, a *tertium quid*, which inhabits and controls it, is opposed to all scientific analogy and experience. To the statement of the vitalist that there is no evidence that life is a property of matter, we may reply with emphasis that there is not the slightest proof that it is not.

"Chemistry tells us that complexity of composition involves complexity of properties. The grand progress which Organic Chemistry has made in recent times has been owing to the distinct recognition of the influence of structure upon properties. Isomerism is one of its most significant developments. The number of possible isomers increases enormously with the complexity of the molecule. Granted that we now know several of the proteid group of substances: how many thousand may there be yet to know? Bodies of such extreme complexity of constitution may well have an indefinite number of isomers. Not only does chemistry not say that there cannot be such a thing but she encourages the expectation that there will be yet found the precise proteid of which the changes of protoplasm are properties. The rapid march of recent organic synthesis makes it quite certain that every distinct chemical substance of the living body will ultimately be produced in the laboratory; and this from inorganic material. Given only the exact constitution of a compound, and its synthesis follows. When, therefore, the chemist shall succeed in producing a mass constitutionally identical with protoplasmic albumin, there is every reason to expect that it will exhibit all the phenomena which characterize its life; and this equally whether protoplasm be a single substance or a mixture of several closely allied substances."

Address of Professor Alexander Agassiz on Paleontological and Embryological Developmont.

Prof. Agassiz read a paper on Paleontological and Embryological Development. He said: "Since the publication of the 'Poissons Fossiles' by Agassiz and of the 'Embryologie des Salmonidées' by Vogt, the similarity, traced by the former between certain stages in the growth of young fishes and the fossil representatives of extinct members of the group, has also been observed in nearly every class of the animal kingdom, and the fact has become a most convenient axiom in the study of paleontological and embryological development. This parallelism, which has been on the one side a strong argument in favor of design in the plan of creation, is now, with slight emendations, doing duty on the other as a newly discovered article of faith in the new biology.

"But while in a general way we accept the truth of the proposition that there is a remarkable parallelism between the embryonic development of a group and its paleontological history, yet no one has attempted to demonstrate this or rather to show how far the parallelism extends. We have up to the present time been satisfied with tracing the general coincidence, or with striking individual cases.

"The resemblances between the pupa stage of some Insects and of adult Crustacea, the earlier existence of the latter, and the subsequent appearance of the former in paleontological history, furnished one of the first and most natural illustrations of this parallelism; while theoretically the necessary development of the higher tracheate insects from their early branchiate aquatic ancestors seemed to form an additional link in the chain, and point to the Worms, the representatives of the larval condition of Insects, as a still earlier embryonic stage of the Articulates."

Whilst stating there was hardly a class of the animal kingdom which would not admit of some most interesting parallelism being drawn, he remarked he had chosen for the illustration and critical examination of this parallelism the limited group of Sea-urchins, on account of his own familiarity with their development, and with the living and extinct species. Noticing the paleontological history of several families of the Echinodermata he speaks of the Clypeastridæ as follows:

"We find there as among the Desmosticha that the earliest type, Pygaster, has existed from the Trias to the present time; and that, while we can readily reconstruct, on embryological grounds, the modifications the earliest Desmosticha-like Echini should undergo in order to assume the structural features of Pygaster, yet the early periods in which the precursors of the Echinoconidæ and Clypeastridæ are found have thus far not produced the genera in which these modifications actually take place. But, starting from Pygaster, we naturally pass to Holectypus, to Discoidea, to Conoclypus, on the one side, while on the other, from Holectypus to Echinocyamus, Sismondia, Fibularia, and Mortonia, we have the natural sequence of the characters of the existing Echinanthidæ, Laganidæ, and Scutellidæ, the greater number of which are characteristic of the present epoch. If we were to take in turn the changes undergone in the arrangement of the plates of the test, as we pass from Pygaster to Holectypus, to Echinocyamus, and the Echinanthidæ, we should have in the genera which follow each other in the paleontological record an unbroken series showing exactly what these modifications have been. In the same way, the modifications of the abactinal and anal systems, and those of the poriferous zone, can equally well be followed to Echinocyamus, and thence to the Clypeastridæ; while a similar sequence in the modifications of these structural features can be followed from Mortonia to the Scutellidæ of the present period."

Passing next to the embryological development of the several families, he remarked: "Among the Clypeastroids the changes of form they undergo during growth are most instructive. We have in the young Fibularinæ an ovoid test, a small number of coronal plates surmounted by few and large primary tubercles, supporting proportionally equally large primary radioles, simple rectilinear poriferous zones, no petaloid ambulacra,—in fact, scarcely one of the features we are accustomed to associate with the Clypeastroids is as yet prominently developed. But rapidly with increasing size, the number of primary tubercles increases, the spines lose their disproportionate size, the pores of the abactinal region become crowded elongate, and a rudimentary petal is formed. The test becomes more flattened, the coronal plates increase in number, and it would be impossible to recognize in the young Echinocyamus, for instance, the adult of the Cidaris-like or Echinometra-like stages of the Sea-urchin, had we not traced them step by step. Most interesting, also, is it to follow the migrations of the anal system which, to a certain extent, may be said to retain the embryonic features of the early stages of all Echinoderm embryos, in being placed in more or less close proximity to the actinostome. What has taken place in the growth of the young Echinocyamus is practically repeated for all famillies of Clypeastroids; a young Echinarachnius, or Melita, or Encope, or a

Clypeaster proper, resembles at first more an Echinometra than a Clypeastroid; they all have simple poriferous zones and spines and tubercles out of all porportion to the size of the test."

Comparing in the same way the paleontological development of the several families, he said: "We find that the Echinidæ proper, on the whole, agree well with the changes of growth we can still follow to-day in their representatives, and that, as we approach nearer the present epoch, the fossil genera more and more assume the structural features which we find developed last among the Echinidæ of the present day. Very much in the same manner as a young Echinus develops, they lose, little by little, first their Cidaridian affinities, which become more and more indefinite, next their Didematidian affinities, if I may so call the young stages to which they are most closely allied, and, finally, with the increase in number of the coronal plates, the great numerical development of the primary tubercles and spines, and that of the secondaries and miliaries which we can trace in the fossil Echini of the Tertiaries, we pass insensibly into the generic types characteristic of the present day."

He then adds: "The comparison of the genera of Echini which have appeared since the Lias with the young stages of growth of the principal families of Echini, shows a most striking coincidence amounting almost to identity between the successive fossil genera and the various stages of growth. This indentity can, however, not be traced exactly in the way in which it has usually been understood, while there undoubtedly exists in the genera which have appeared one after the other a gradual increase in certain families in the number of forms, and a constant approach in each succeeding formation, in the structure of the genera, to those of the present day. It is only in the accordance between some special points of structure of these genera and the young stages of the Echini of the present day that we can trace an agreement which, as we go further back in time, becomes more and more limited. We are either compelled to seek for the origin of many structural features in types of which we have no record, or else we must attempt to find them existing potentially in groups where we had as yet not succeeded in tracing them. The parallelism we have traced does not extend to the structure as a whole. What we find is the appearance among the fossil genera of certain structural features giving to the particular stages we are comparing their characteristic aspect. Thus, in the succession of the fossil genera, when a structural feature has once made its appearance, it may either remain as a persistent structure, or it may become gradually modified in the succeeding genera of the same family, or it may appear in another family, associated with other more marked structural features which completely overshadow it."

Summing up, he says: "We may, however, in a very general way, state that we know the earliest embroyonic stages of the order of Echinoderms of to-day, which, with the exception of the Blastoidea and Cystideans, are identical with the fossil orders, and that as far as we know they all begin at a stage where it would be impossible to distinguish a Sea-urchin from a Star-fish, or an Ophiuran, or a Crinoid, or an Holothurian,—a stage in which the test, calyx, abactinal and ambulacral systems are reduced to a minimum. From this identical origin there is developed at the present day, in a comparatively short period of time, either a Starfish, a Sea-urchin, or a Crinoid; and if we have been able successfully to compare, in the development of typical structures, the embryonic stages of the young Echini with their development in the fossil genera, we may fairly assume that the same process is applicable when instituting the comparison within the different limits of the orders, but with the same restrictions. That is, if we wish to form some idea of the probable course of transformations which the earliest Echinoderms have undergone to lead us to those of the present day, we are justified in seeking for our earliest representatives of the orders such Echinoderms as resemble the early stages of our embryos, and in following, for them as for the Echini, the modifications of typical structures. These we shall have every reason to expect to find repeated in the fossils of later periods, and, going back a step further, we may perhaps get an indefinite glimpse of that first Echinodermal stage which should combine the structural features common to all the earliest stages of our Echinoderm embryos. And yet, among the fossil Echinoderms of the oldest periods, we have not as yet discovered this earliest type from which we could derive the Star-fishes, Ophiurans, Sea-urchins, or Holothurians."

"This may not seem a very satisfactory result to have attained. It certainly has been shown to be an impossibility to trace in the paleontological succession of the Echini anything like a sequence of genera. No direct filiation can be shown to exist, and yet the very existence of persistent types, not only among Echinoderms, but in every group of marine animals, genera which have continued to exist without interruption from the earliest epochs at which they occur to the present day, would prove conclusively that at any rate some groups among the marine animals of the present day are the direct descendants of those of the earliest geological periods. When we come to types which have not continued as long, but yet which have extended through two or three great periods, we must likewise accord to their latest representatives a direct descent from the older."

"But in spite of the limits which have been assigned to this general parallelism, it still remains an all-essential factor in elucidating the history of paleontological development, and its importance has but recently been fully appreciated. For, while the fossil remains may give us a strong presumptive evidence of the gradual passage of one type to another, we can only imagine this modification to take place by a process similar to that which brings about the modifications due to different stages of growth,—the former taking place in what may practically be considered as infinite time when compared to the short life history which has given us as it were a *résumé* of the paleontological development. We may well pause to reflect that in the two modes of development we find the same periods of rapid modifications occurring at certain stages of growth or of historic development, repeating in a different direction the same phases. Does it then pass the limits of analogy to assume that the changes we see taking place under our own eyes in a comparatively short space of time,—changes which extend from stages representing perhaps the original type of the group to their most complicated structures,—may, perhaps, in the larger field of paleontological development, not have required the infinite time we are in the habit of asking for them?"

THE PHOTOPHONE.

By Alexander Graham Bell.

In bringing before you some discoveries made by Mr. Sumner Tainter and myself, which have resulted in the construction of apparatus for the production and reproduction of sound by means of light, it is necessary to explain the state of knowledge which formed the starting point of our experiments. I shall first describe the remarkable substance selenium, and the manipulations devised by various experiments; but the final result of our researches has evidenced the class of substances sensitive to light-vibrations, until we can propound the fact of such sensitiveness being a general property of all matter. We have found this property in gold, silver, platinum, iron, steel, brass, copper, zinc, lead, antimony, German silver, Jenkin's metal, Babbitt's metal, ivory, celluloid, gutta percha, hard rubber, soft vulcanized rubber paper, parchment, wood, mica and silvered glass; and the only substances from which we have not obtained results are carbon and thin microscopic glass. We find that when a vibratory beam of light falls upon these substances they emit sounds,—the pitch of which depends upon the frequency of the vibratory change in the light. We find farther that, when we control the form or character of the light-vibration on selenium, and probably on the other substances, we control the quality of the sound and obtain all varieties of articulate speech. We can thus, without a conducting wire as in electric telephony, speak from station to station, wherever we can project a beam of light We have not had opportunity of testing the limit to which this photophonic influence can be extended, but we have spoken to and from points 213 meters apart; and there seems no reason to doubt that the results will be obtained at whatever distance a beam of light can be flashed from one observatory to another. The necessary privacy of our experiments hitherto has alone prevented any attempt at determining the extreme distance at which this new method of vocal communication will be available. I shall now speak of selenium.

In the year 1817 Berzelius and Gottlieb Gahn made an examination of the method of preparing sulphuric acid in use at Gripsholm. During the course of this examination they observed in the acid a sediment of a partly reddish, partly clear brown color, which, under the action of the blow-pipe gave out a peculiar odor, like that attributed by Klaproth to tellurium. As tellurium was a substance of extreme rarity, Berzelius attempted its production from this deposit; but he was unable, after many experiments, to obtain further indications of its presence. He found plentiful signs of sulphur mixed with mercury, copper, zinc, iron, arsenic and lead, but no trace of tellurium. It was not in the nature of Berzelius to be disheartened by the result. In science every failure advances the boundary of knowledge as well as every success, and Berzelius felt that, if the characteristic odor that had been observed did not proceed from tellurium, it might possibly indicate the presence of some substance then unknown to the chemist. Urged on by his hope he returned with renewed ardor to his work. He collected a great quantity of the material, and submitted the whole mass to various chemical processes. He succeeded in separating successively the sulphur, the mercury, the copper, the tin, and the other known substances whose presence had been indicated by his tests:—and after all these had been eliminated, there still remained a residue which proved upon examination to be what he had been in search of—a new elementary substance. The chemical properties of this new element were found to resemble those of tellurium in so remarkable a degree that Berzelius gave to the substance the name of "Selenium," from the Greek word *selene*, the moon—("tellurium," as is well known being derived from *tellus*, the earth.) Although tellurium and selenium are alike in many respects, they differ in their electrical properties; tellurium being a good conductor of electricity, and selenium, as Berzelius showed, a non-conductor. Knox discovered in 1837, that selenium became a conductor when fused; and Hittorff, in 1852, showed that it conducted, at ordinary temperatures, when in one of its allotropic forms. When selenium is rapidly cooled from a fused condition, it is a non-conductor. In this, its vitreous form, it is of a dark brown color, almost black by reflected light, having an exceedingly brilliant surface. In thin films it is transparent, and appears of a beautiful ruby red by transmitted light. When selenium is cooled from a fused condition with extreme slowness, it presents an entirely different appearance, being a dull lead color, and having throughout a granulated or crystalline structure, and looking like a metal. In this form it is perfectly opaque to light, even in very thin films. This variety of selenium has long been known as "granular" or "crystalline" selenium, or, as Regnault called it, "metallic" selenium. It was selenium of this kind that Hittorff found to be a conductor of electricity at ordinary temperatures. He also found that its resistance to the passage of an electrical current diminished continuously by heating up to the point of fusion, and that the resistance suddenly increased in passing from the solid to the liquid condition. It was early discovered that exposure to sunlight hastens the change of selenium from one allotropic form to another; and this observation is significant in the light of recent discoveries.

Although selenium has been known for the last sixty years it has not yet been utilized to any extent in the arts, and it is still considered simply as a chemical curiosity. It is usually supplied in the form of cylindrical bars. These bars are sometimes found to be in the metallic condition; but more usually they are in the vitreous or non-conducting form. It occurred to Willoughby Smith that, on account of high resistance of crystalline selenium, it might be usefully employed at the shore-end of a submarine cable, in his system of testing and signalling during the process of submersion. Upon experiment, the selenium was found to have all the resistance required—some of the bars employed measuring as much as 1400 megohms—a resistence equivalent to that which would be offered by a telegraph wire long enough to reach from the earth to the sun! But the resistance was found to be extremely variable. Experiments were made to ascertain the cause of this variability. Mr. May, Mr. Willoughby Smith's assistant, discovered that the resistance was less when the selenium was exposed to light than when it was in the dark.

In order to be certain that temperature had nothing to do with the effect, selenium was placed in a vessel of water so that the light had to pass through from one to two inches of water in order to reach the selenium. The approach of a lighted candle was found to be sufficient to cause a marked deflection of the needle of the galvanometer connected with the selenium, and the lighting of a piece of magnesium wire caused the selenium to measure less than half the resistance it did the moment before.

These results were naturally at first received by scientific men with some incredulity, but they were verified by Sale, Draper, Moss and others. When selenium is exposed to the action of the solar spectrum, the maximum effect is produced, according to Sale, just outside the red end of the spectrum, in a point nearly coincident with the maximum of the heat rays; but, according to Adams, the maximum effect is produced in the greenish-yellow or most luminous part of the spectrum. Lord Rosse exposed selenium to the action of non-luminous radiations from hot bodies, but could produce no effect :. whereas a thermopile under similar circumstances gave abundant indications of current. He also cut off the heat rays from luminous bodies by the interposition of liquid solutions, such as alum, between the selenium and the source of light, without affecting the power of the light to reduce the resistance of the selenium; whereas the interposition of these same substances almost completely neutralize the effect upon the thermopile. Adams found that selenium was sensitive to the cold light of the moon, and Werner Siemens discovered that in certain extremely sensitive varieties of selenium, heat and light produced opposite effects. In Siemens's experiments, special arrangements were made for the purpose of reducing the resistance of the selenium employed. Two fine platinum wires were coiled together in the shape of a double flat spiral in the zig-zag shape, and were laid upon a plate of mica so that the discs did not touch one another. A drop of melted selenium was then placed upon the platinum-wire arrangement, and a second sheet of mica was pressed upon the selenium, so as to cause it to spread out and fill the spaces between the wires. Each cell was about the size of a silver dime. The selenium cells were then placed in a paraffine bath, and exposed for some hours to a temperature of 210° C., after which they were allowed to cool with extreme slowness. The results obtained with the cells were very extraordinary; in some cases the resistance of the cells, when exposed to light, was only one-fifteenth of their resistance in the dark.

Without dwelling farther upon the researches of others, I may say that the chief information concerning the effects of light upon the conductivity of selenium will be found under the names of Willoughby Smith, Lieutenant Sale, Draper and Moss, Professor W. G Adams, Lord Rosse, Day, Sabini, Dr. Werner Siemens and Dr. C. W. Siemens. All observations by these various authors had been made by means of galvanometers; but it occurred to me that the telephone, from the extreme sensitiveness to electrical influences, might be substituted with advantage. Upon consideration of the subject, however, I saw that the experiments could not be conducted in the ordinary way for the following eason :. The law of audibility of the telephone is precisely analogous to the law of electric induction. No effect is produced during the passage of a continuous steady current. It is only at the moment of change from a stronger to a weaker state, or *vice versa*, that any audible effect is produced, and the amount of effect is exactly proportional to the amount of variation in the current. It was, therefore, evident that the telephone could only respond to the effect produced in selenium at the moment of change from light to darkness, or *vice versa*; and that it would be advisable to intermit the light with great rapidity, so as to produce a succession of changes in the conductivity of the seleninm corresponding in frequency to musical vibrations within the limits of the sense of hearing. For I had often noticed that currents of electricity, so feeble as to produce scarcely any audible effects from a telephone when the circuit was simply opened or closed, caused very perceptible musical sounds when the circuit was rapidly interrupted, and that the higher the pitch of sound the more audible was the effect. I was much struck by the idea of producing sound by the action of light in this way. Upon farther consideration it appeared to me that all the audible effects obtained from varieties of electricity could also be produced by variations of light acting upon selenium. I saw that the effect could be produced at the extreme distance at which selenium would respond to the action of a luminous body, but that this distance could be indefinitely increased by the use of a parallel beam of light, so that we could telephone from one place to another without the necessity of a conducting wire between the transmitter and receiver. It was evidently necessary, in order to reduce the idea to practice, to devise an apparatus to be operated by the voice of a speaker, by which variations could be produced in a parallel beam of light, corresponding to the variations in the air produced by the voice.

I proposed to pass light through a large number of small orifices, which might be of any convenient shape, but were preferably in the form of slits. Two similarly perforated plates were to be employed. One was to be fixed and the other attached to the centre of a diaphragm actuated by the voice, so that the vibration of the diaphragm would cause the moveable plate to slide to and fro over the surface of the fixed plate, thus alternately enlarging and contracting the free orifices for the passage of light. In this way the voice of a speaker could control the amount of light passed through the perforated plates without completely obstructing its passage. This apparatus was to be placed in the path of a parallel beam of light, and the undulatory beam emerging from the apparatus could be received at some distant place upon a lens, or other apparatus, by means of which it could be condensed upon a sensitive piece of selenium placed in a local circuit with a telephone and galvanic battery. The variations in the light produced by the voice of the speaker should cause corresponding variations in the electrical resistance of the selenium employed: and the telephone in circuit with it should reproduce audibly the tones and articulations of the speaker's voice. I obtained some selenium for the purpose of producing the apparatus shown; but found that its resistance was almost infinitely greater than that of any telephone that had been constructed, and I was unable to obtain any audible effects by the action of light. I believed, however, that the obstacle could be overcome by devising mechanical arrangements for reducing the resistance of the selenium, and by constructing special telephones for the purpose. I felt so much confidence in this that, in a lecture delivered before the Royal Institute of Great Britain, upon the 17th of May, 1878, I announced the possibility of hearing a shadow by interrupting the action of light upon selenium. A few days afterwards my ideas upon this subject received a fresh impetus by the announcement made by Mr. Willoughby Smith before the Society of Telegraph Engineers that he had heard the action of a ray of light falling upon a bar of crystalline selenium, by listening to a telephone in circuit with it.

It is not unlikely that the publicity given to the speaking telephone during the last few years may have suggested to many minds in different parts of the world somewhat similiar ideas to my own.

Although the idea of producing and reproducing sound by the action of light, as described above, was an entirely original and independent conception of my own, I recognize the fact that the knowledge necessary for its conception has been disseminated throughout the civilized world, and that the idea may therefore have occurred to many other minds. *The fundamental idea, on which rests the possibility of producing speech by the action of light, is the conception of what may be termed an undulatory beam of light in contradistinction to a merely intermittent one.* By an undulatory beam of light, I mean a beam that shines continuously upon the selenium receiver, but the intensity of which upon that receiver is subject to rapid changes, corresponding to the changes in the vibratory movement of a particle of air during the transmission of a sound of definite quality through the atmosphere. The curve that would graphically represent the changes of light would be similar in shape to that representing the movement of the air. I do not know whether this conception had been clearly realized by "J. F. W.," of Kew, or by Mr. Sargent, of Philadelphia; but to Mr. David Brown of London, is undoubtedly due the honor of having distinctly and independently formulated the conception, and of having devised apparatus—though of a crude nature—for carrying it into execution. It is greatly due to the genius and perseverance of my friend, Mr. Sumner Tainter, of Watertown, Mass., that the problem of producing and reproducing sound by the agency of light has at last been successfully solved.

The first point to which we devoted our attention was the reduction of the resistance of crystalline selenium within manageable limits. The resistance of selenium cells employed by former experimenters was measured in millions of ohms, and we do not know of any record of a selenium cell measuring less than 250,000 ohms in the dark. *We have succeeded in producing sensitive selenium cells measuring only* 300 *ohms in the dark, and* 155 *ohms in the light.* All former experimenters seemed to have used platinum for the conducting part of their selenium cells, excepting Werner Siemens, who found that iron and copper might be employed. We have also discovered that brass, although chemically acted upon by selenium, forms an excellent and convenient material; indeed, we are inclined to believe that the chemical action between the brass and selenium has contributed to the low resistance of our cells by forming an intimate bond of union between the selenium and brass. We have observed that melted selenium behaves to the other substances as water to a greasy surface, and we are inclined to think that when selenium is used in connection with metals not chemically acted upon by it, the points of contact between selenium and the metal offer a considerable amount of resistance to the passage of a galvanic current. By using brass we have been enabled to construct a large number of selenium cells of different forms. The mode of applying the selenium is as follows: The cell is heated, and, when hot enough, a stick of selenium is rubbed over the surface. In order to acquire conductivity and sensitiveness, the selenium must next undergo a process of annealing.

We simply heat the selenium over a gas stove and observe its appearance. When the selenium attains a certain temperature, the beautiful reflecting surface becomes dimmed. A cloudiness gradually extends over it, somewhat like the film of moisture produced by breathing upon a mirror. This appearance gradually increases, and the whole surface is soon seen to be in the metallic, granular or crystalline condition. The cell may then be taken off the stove and cooled in any suitable way. When the heating process is carried too far, the crystalline selenium is seen to melt. Our best results have been obtained by heating the selenium until it crystallizes, and continuing the heating until signs of melting appear, when the gas is immediately put out. The portions that had melted instantly re-crystallize, and the selenium is found upon cooling to be a conductor, and to be sensitive to light. The whole operation occupies only a few minutes. This method has not only the advantage of being expeditious, but it proves that many of the accepted theories on this subject are fallacious. Our new method shows that fusion is unnecessary, that conductivity and sensitiveness can be produced without long heating and slow cooling; and that crystallization takes place during the heating process. We have found that on removing the source of heat immediately on the appearance of the cloudiness, distinct and separate crystals can be observed under the microscope, which appear like leaden snow-flakes on a ground of ruby red. Upon removing the heat when crystallization is further advanced, we perceive under the microscope masses of these crystals arranged like basaltic columns standing detached from one another, and at a still higher point of heating the distinct columns are no longer traceable, but the whole mass resembles metallic pudding-stone, with here and there a separate snow-flake, like a fossil, on the surface. Selenium crystals formed during slow cooling after fusion present an entirely different appearance, showing distinct facets.

We have devised about fifty forms of apparatus for varying a be. m of light in the manner required, but only a few typical varieties need be shown. The source of light may be controlled or a steady beam may be modified at any point in its path. The beam may be controlled in many ways. For instance, it may be polarized, and then affected by electrical or magnetic influences in the manner discovered by Faraday and Dr. Ker. The beam of polarized light, instead of being passed through a liquid may be reflected from the pollished pole of an electro-magnet. Another method of affecting a beam of light is to pass it through a lens of variable focus. I observe that a lens of this kind has been invented in France by Dr. Cusco, and is fully described in a recent paper in "La Nature;" but Mr. Tainter and I have used such a lens in our experiments for months past. The best and simplest form of apparatus for producing the effect remains to be described. This consists of a plain mirror of flexible material—such as silvered mica or microscopic glass. Against the back of this mirror the speaker's voice is directed. The light reflected from this mirror is thus thrown into vibration corresponding to those of the diaphragm itself.

In arranging the apparatus for the purpose of reproducing sound at a distance, any powerful source of light may be used, but we have experimented chiefly with sunlight. For this purpose a large beam is concentrated by means of a lens upon the diaphragm mirror, and, after reflection, is again rendered parallel by means of another lens. The beam is received at a distant station upon a parabolic reflector, in the focus of which is placed a sensitive selenium cell, connected in a local circuit with a battery and telephone. A large number of trials of this apparatus have been made with the transmitting and receiving instruments so far apart that sounds could not be heard directly through the air. In illustration, I shall describe one of the most recent of these experiments. Mr. Tainter operated the transmitting instrument, which was placed on the top of the Franklin schoolhouse in Washington, and the sensitive receiver was arranged in one of the windows of my laboratory, 1325 L street at a distance of 213 metres. Upon placing the telephone to my ear I heard distinctly from the illuminated receiver the words: "Mr Bell, if you hear what I say, come to the window and wave your hat." In laboratory experiments the transmitting and receiving instruments are necessarily within earshot of one another, and we have therefore been accustomed to pooling the electric circuit connected with the selenium receiver, so as to place the telephones in another room. By such experiments we have found that articulate speech can be reproduced by the oxy-hydrogen light, and even by the light of a kerosene lamp. The loudest effects obtained from light are produced by rapidly interrupting the beam by the perforated disk. The great advantage of this form of apparatus for experimental work is the noiselessness of its rotation, admitting the close approach of the receiver without interfering with the audibility of the effect heard from the latter; for it will be understood that musical tones are emitted from the receiver when no sound is made at the transmitter. A silent motion thus produces a sound. In this way musical tones have been heard even from the light of a candle. When distant effects are sought another apparatus is used. By placing an opaque screen near the rotating disk the beam can be entirely cut off by a slight motion of the hand, and musical signals, like the dots and dashes of the Morse telegraph code, can thus be produced at the distant receiving station.

We have made experiments, with the object of ascertaining the nature of the rays that affect selenium. For this purpose we have placed in the path of an intermittent beam various absorbing substances. Prof. Cross has been kind enough to give me his assistance in conducting these experiments. When the solution of alum, or bisulphide of carbon, is employed the loudness of the sound produced by the intermittent beam is very slightly diminished; but a solution of iodine in bisulphide of carbon cuts off most but not all, of the audible effect. Even an apparently opaque sheet of hard rubber does not entirely do this. When the sheet of hard rubber was held near the disk interrupter the rotation of the disk interrupted what was then an invisible beam which passed over a space of about twelve feet before it reached the lens which finally concentrated it upon the selenium cell. A faint but perfectly perceptible musical tone was heard from the telephone connected with the selenium. This could be interrupted at will by placing the hand in the path of the invisible beam. It would be premature, without further experiments, to speculate too much concerning the nature of these invisible rays; but it is difficult to believe that they can be bent rays, as the effect is produced through two sheets of hard rubber containing between them a saturated solution of alum. Although effects are produced as above shown by forms of radiant energy which are invisible, we have named the apparatus for the production and reproduction of sound in this way "*The Photophone*," because an ordinary beam of light contains the rays which are operative.

It is a well-known fact that the molecular disturbance produced in a mass of iron by the magnetizing influence of an intermittent electrical current can be observed as sound by placing the ear in close contact with the iron. It occurred to us that the molecular disturbance produced in crystalline selenium by the action of an intermittent beam of light should be audible in a similar manner without the aid of a telephone or battery. Many experiments were made to verify this theory without definite results. The anomalous behaviour of the hard rubber screen suggested the thought of listening to it also. The experiment was tried with extraordinary success. I held the sheet in close contact with my ear, while a beam of intermittent light was focussed upon it by a lens. A distinct musical note was immediately heard. We found the effect intensified by arranging the sheet of hard rubber as a diaphragm, and listening through a hearing-tube. We then tried crystalline selenium in the form of a thin disk, and obtained a similar but less intense effect. The other substances which I enumerated at the beginning of my address were now successively tried in the form of thin disks, and sounds were obtained from all but carbon and thin glass. We found hard rubber to produce a louder sound than any other substance we tried, excepting antimony, and paper and mica to produce the weakest sound. *On the whole, we feel warranted in announcing as our conclusion that sounds can be produced by the action of a variable light from substances of all kinds, when in the form of thin diaphragms.* We have heard from interrupted sunlight very perceptible musical tunes through tubes of ordinary vulcanized rubber, of brass and of wood. These were all the materials at hand in tubular form, and we have had no opportunity since of extending the observations to other substances.—(*Address before the American Association at Boston, August*, 1880.)

THE CHEMICAL COMPOSITION AND NUTRITIVE VALUES OF FISH.

A paper with this title was read before the chemical sub-section at the recent meeting of the American Association by Professor W. O. Atwater, of Middleton, Ct., and gave the results of an investigation made under the auspices of the Smithsonian Institution and the United States fish commission. They included analyses of a large number of specimens of more common food fishes, whose details, though quite extended, were mainly of theoretical value. Some of the applications, however, were of much practical interest. In 100 pounds of the flesh of fresh cod we have 83 pounds of water and only 17 pounds of solids, while the flesh of the salmon contains only 66½ per cent. of water and 33½ per cent. of solids: that is to say, about one-sixth of the flesh of cod and one-third of that of salmon consists of solids, that is, of nutritive substances, the rest being water. Lean beef, free from bone, contains about seventy-five per cent. water and twenty five per cent. solids. The figures for some of the more common sorts of fish were:—

In flesh of	Solids. per cent.	In flesh of	Solids. per cent.
Flounder	17.2	Halibut, fat	30.7
Cod	16.9	Mackerel	:2.2
Striped bass	20.4	Shad	30.7
Bluefish	21.8	Whitefish	30.4
Halibut, lean	20.6	Salmon	33.6

If we take into account not the flesh only, but the whole fish as sold in the market, including bones, skin and other waste, the actual percentage of nutritive material is, of course, smaller. Thus the following percentages of edible solids were found in samples analysed :—

Flounder	7.1	Shad	14.8
Cod	10.5	Shad	18.7
Mackerel	11.4	Lake trout	13.6
Halibut, lean	15.6	Salmon	25.6
Halibut, fatter	27.2		

This subject has of late attracted unusual attention. The chemico-physiological investigation of the past two decades has brought us where we can judge with a considerable degree of accuracy, from the chemical composition of a food-material, what is its value for nourishment as compared with other foods. The bulk of the best late investigation of this subject has been in Germany, where a large number of chemists and physiologists are busying themselves in the experimental study of the laws of animal nutrition. They have already got so far as to feel themselves warranted in computing the relative values of our common foods, and arrange them in tables, which are coming into popular use. The valuations are based upon the amounts of albuminoids, carbohydrates and fats, each being rated at a standard, just as a grocer makes out his bill for a lot of sugar, tea and coffee, by rating each at a certain price per pound, and adding the sums thus computed to make the whole bill. A table was given showing the composition of a list of animal foods. Thus it appeared that, while medium beef has about three-fourths water and one-fourth solid, milk is seven-eighths water and one-eighth solids. Assuming a pint of milk to weigh a pound, and speaking roughly, a quart of milk and a pound of beefsteak would both contain the same amount—about four ounces—of solids. But the quart of milk would not be worth as much for food as the pound of steak. The reason is that the nutrients of the steak are almost entirely albuminoid, while the milk contains a good deal of carbohydrates and fats, which have a lower nutritive value. According to the valuations given, taking medium beef at 100, we should have for like weights of flesh free from bone:—

Medium beef	100.0	Bluefish	85.0
Fresh Milk	23.8	Mackerel	86.0
Skimmed milk	18.5	Halibut	88.0
Butter	124.0	Lake trout	94.0
Cheese	155.0	Eels	95.0
Hens' eggs	72.0	Shad	99.0
Cod (fresh fish)	68.0	Whitefish	103.0
Flounders	65.0	Salmon	104.0
Halibut	88.0	Salt Mackerel	111.0
Striped bass	79.0	Dried codfish	346.0

These figures differ widely from the market values. But we pay for our foods according, not to their value for nourishing our bodies, but to their agreeableness. Taking the samples of fish at their retail prices in the Middletown, Conn., markets, the total edible solids in striped bass came to about $2.30 a pound, while the Connecticut shad's nutritive material was bought at 44 cents per pound. The cost of the nutritive material in one sample of halibut was 57 cents, and in the other $1.45 per pound, though both were purchased in the same place at the same price,—15 cents per pound, gross weight. In closing, Professor Atwater referred to the widespread but unfounded notion that fish is particularly valuable for brain food on account of its large content of phosphorus. Suffice it to say that there is no evidence as yet to prove that the flesh of fish is specially richer in phosphorus than other meats are, and that, even if it were so, there is no proof that it would be on that account more valuable for brain food. The question of the nourishment of the brain and the sources of intellectual energy are too abstruse for speedy solution in the present condition of our knowledge.

BAKING POWDERS AND THEIR ADULTERANTS.

By J. T. Donald, B.A.,

of Hubbard & Donald, Analytical Chemists, Montreal.

At first sight my subject may seem scarcely a fitting one to bring before such a Society as this, yet when we remember that there is an enormous amount of this substance used, with good or evil results to the consumers; when we recall to mind the fact that there is no Sanitary Association before which such subjects may be ventilated; and especially when we consider that one of the highest duties of science is to contribute to the welfare of mankind, it will be admitted, I hope, that the discussion of this subject is not beyond the scope of a Natural History Society. Glancing first at the history of baking powders, we find that until within a comparatively recent date, in Canada at least, every cook or housewife made her own baking powder as required, by adding to her dough or paste a certain number of spoonfulls of baking soda and twice as many of bitartrate of potash or cream of tartar. The frequent presence of particles of undissolved soda in pastry and the varying degree of lightness of the pastry made under the old system, suggested to some ingenious individual the idea of making a mixture which should supersede—because of its uniformity of action and thorough mixture of ingredients—the time-honored soda and cream of tartar.

About thirty years ago, so far as I can learn, a mixture composed chiefly of these ingredients, and manufactured abroad, was introduced into this country under the name of "German Baking Powder." Shortly afterwards a similar article was manufactured in this city, as well as in the Dominion, for the first time. Since then the manufacture and use of this substance have increased wonderfully; to such an extent, indeed, that large establishments both in our own country and the United States are exclusively engaged in the production of this article. In Britain, strange to say, but little of this substance is used.

A baking powder in so far as the manufacture of this substance is concerned, is essentially a mixture of soda bicarb. and some dry acid substance, which latter acting upon the soda drives off its carbonic acid, and this rising through the mass renders it light and porous. Before proceeding further it will be necessary to define an ideal baking powder wherewith we may compare powders that are offered for sale throughout the land. Our ideal powder then is a mixture of one part soda bicarb. with as nearly as may be, two parts cream of tartar. When moistened these substances acting upon each other give off about 16·5 per cent. of carbonic dioxide, tartrates of potassium and sodium being formed, none of which are injurious to the human system.

And just here I may be permitted to add that if our Government intend the law concerning adulteration of food to be any more than a dead letter, in so far as this substance is concerned it will be necessary for it to define a pure article, which should be done by stating the minimum amount of carbonic acid that the powders shall produce and the acid substances which may or may not be used, for as matters stand at present any one may call his powder pure, for so it may be according to his formula and his idea of pure and impure baking powders.

It has fallen to my lot to examine a large number of baking powders, nearly every powder manufactured to any extent in Canada, and also many from the United States. Nearly all that I have examined may be included in three classes:

The first class contained those powders which come sufficiently near to our theoretical one to be called commercially pure.

One of these contained besides soda and cream of tartar 10·61 per cent. of flour, and produced 15·4 per cent. of carbonic dioxide.

A second contained, in addition to the essential ingredients, flour 9·8 per cent. and lime nearly 2 per cent., and gave off 15·5 per cent. of carbonic dioxide.

Another contained, in addition to soda and cream of tartar, flour 3·2 per cent. and lime 2·78 per cent.

The only points wherein the members of this group depart from our type is that they all contain flour, from 3 to 10 per cent., and that two of them have a small quantity of lime.

Now, whilst flour is certainly not essential to a baking powder as such, it is a necessary ingredient of a powder which is to fully retain its properties for any length of time. When mixed with the soda bicarb. and cream of tartar it to a certain extent keeps the particles of the two substances apart; did they lie in immediate contact a certain amount of the carbonic acid would be dissipated and the powder lose strength. I cannot say with certainty what proportion of flour is necessary for this purpose, I should think, however, that 10 per cent. would amply suffice, although a leading manufacturer tells me that 25 or 30 per cent. is necessary. I should certainly consider this quantity much greater than is absolutely necessary, for baking powders are not generally kept for any great length of time, and further I have found upon careful examination that those powders containing 10 per cent. or less of flour had not lost any of the carbonic acid they originally obtained; of course I cannot say how long they had been made before examined.

The presence of a small quantity of lime, say 2 or 3 per cent., cannot be regarded as injuring the powder. It is a well-known fact that bakers frequently use lime-water to produce in their bread "whiteness, softness, and capacity of retaining moisture." The lime removes all acidity from the dough, and supplies an ingredient needed in the structure of the bones but which is deficient in the flour. It is therefore advantageous rather than otherwise that a baking powder should contain a small percentage of pure lime.

The second class contain those powders which depart from our type in having alum substituted in part or entirely for cream of tartar. One of this class contained alum 4·7, flour 47·59, and yielded carbonic dioxide only 8·42. Another had alum 1·89, flour 34·00, and yielded carbonic dioxide 10·4. In these two, alum only partially replaced the cream of tartar, but in many powders it is the sole acid substance. One of this group contained alum 17·032, flour 67·25, and yielded 11 per cent. of carbonic dioxide.

The second class of powders is remarkable for several reasons. First, the small percentage of gas produced; secondly, from the fact that alum in part or entirely replaces cream of tartar; and lastly, because of the large quantity of flour they contain.

Cream of tartar costs about 28 or 30 cents per lb., whilst alum can be purchased for less than 2 cents per lb. The former must be used in much larger quantity than alum to act upon the same quantity of soda in order to deprive it of all its carbonic dioxide. There is therefore an inducement, so strong that many cannot withstand it, to use alum as a substitute for cream of tartar in the manufacture of baking powder.

Now, is this alum to be regarded as an adulterant? Is it injurious to those who use it in these powders? To both of these questions we answer in the affirmative. The very composition of these alum baking powders shows that those who manufacture them are desirous of concealing the fact. With alum as the acid substance, a baking powder can be produced that will yield a much larger percentage of gas than can possibly be obtained from a powder made solely with cream of tartar. And since the value of these powders, other things being equal, depends upon their available amount of carbonic acid, one would imagine that a manufacturer believing that alum was a wholesome ingredient, and desiring to build up a business, would place upon the market a powder giving off a much greater quantity of gas than could possibly be obtained from a powder whose acid substance is cream of tartar. This, however. is never done; every alum powder that I have examined producing *less* carbonic acid than could be obtained with cream of tartar. Flour is added to make up the difference from 34 to 67·25 per cent., according to amount of alum used.

The great majority of scientific authority condemns alum as an article of food; the law of Britain strictly forbids its use. If alum be present in a baking powder in excess, a certain amount will enter the body unaltered, and tends to "produce dyspepsia, constipation, vomiting, griping, and even inflammation of the gastro-enteric mucous membrane, as it is a powerful astringent, acting chemically on the tissues." Although these effects will not be produced by the quantity in bread or pastry used at any one time, yet it is certain that persons continuing to eat bread containing alum will in time suffer from its evil effects, and the weaker the constitution the sooner will the effects be noticed. If however the alum in the powder be just sufficient to act upon the soda so as to drive off all its gas, when the gas is driven off sulphate of soda will be formed, and the alumina which is set free will form with the phosphates of the flour an insoluble phosphate of alumina, so that the action of phosphates will be lost to the system and the nutritive value of the bread lessened to that extent. In any case, therefore, the use of alum as an article of food is attended with greater or less evil results.

Two samples represent as well as constitute the third group. One of them produced—

Carbonic acid -	9·101	and contained besides soda and cream of tartar,
Flour - - -	40·0	
Sulphate of lime -	6·269	

The other yielded—

Carbonic acid -	9·35	and contained in addition to soda and tartar,
Flour - - -	24·70	
Sulphate of lime -	20·78	

These two powders depart from our type in containing much flour, and also in having a large quantity of sulphate of lime. I do not think it possible that any one would use the latter substance imagining it would act as lime, and therefore the only inference possible is that sulphate of lime is used to increase the weight of the powder and thereby fraudulently augment the producer's gain, a procedure which cannot be too loudly condemned,

From the facts I have submitted we learn that whilst there are before the public, baking powders which contain neither injurious nor unnecessary ingredients, and which therefore may be used safely and advantageously, there are in the market many which besides producing only a very small quantity of carbonic acid gas, contain unnecessary substances, as well as substances acting injuriously upon the human system, and which should therefore be left severely alone.

NATURAL SELECTION AND THE INK-GLAND OF DIBRANCHIATE CEPHALOPODS.

By S. P. Robins, LL.D.

"Nothing at first can appear more difficult to believe than that the "most complex organs and instincts have been perfected, not by "means superior to, though analogous with, human reason, but by "the accumulation of innumerable slight variations each good for the "individual possessor. Nevertheless, this difficulty, though appear-"ing to our imagination insuperably great, cannot be considered real "if we admit the following propositions, namely, that all parts of the "organization and instincts offer, at least individual differences—that "there is a struggle for existence leading to the preservation of profit-"able deviations of structure or instinct—and, lastly, that gradations "in the state of perfection of each organ may have existed, each good "of its kind. The truth of these propositions cannot I think be dis-"puted."—*Darwin, Origin of Species, chapter* 14.

Extensive as is the literature that has gathered around the celebrated "Origin of Species" of Mr. Darwin, the subject is by no means exhausted. The doctrine of the evolution of species by descent, with modifications under natural selection, must still be considered as *sub judice*. Many related topics of the greatest significance have met but partial, incidental, and quite unsatisfactory treatment. Among these neglected topics is the question of the genesis of individual organs by gradual modification under natural selection. For example, how has the eye of the vertebrates reached its highest development? What successive stages of increasing efficiency connect that vague sensibility to sonorous vibrations which may be conceived as inhering to the whole sarcodous mass of a rhizopod, with the highly complex and efficient auditory apparatus of a man? From what common structures and along what lines of development have homologous organs, which subserve different functions, descended? If we trace back the genealogy of the van of a bat and of the paddle of a porpoise, in what sort of structure will they meet? And what, from that structure, have been the causes and the courses of a divarication so wide? Full discussion of a hundred such questions is the necessary but as yet unattempted preliminary to any conclusive deliverance respecting the origin of specific forms through heredity and adaptation. For every specific form results from the integration of a multitude of organs, each of which is of great complexity. The whole, therefore, comprises parts so numerous, and involves correlations so intricate, that no understanding, however comprehensive, can grasp it, before the parts have been separately submitted to exhaustive study.

When the formal attempt shall be made to account for the formation of complex organs "by the accumulation of innumerable slight variations, each good for the individual possessor," the following principles will emerge as the necessary conditions to the solution of the problems presented.

1st. The function which each organ subserves must exist in a rudimentary condition in the ancestral germ, or both the function and the organ will be absent from every individual descendant. No slight variation can account for the first appearance of a new function. The interval between the absence of a function and its presence, in however small amount, is infinitely greater than between its most rudimentary and its most complete manifestation. "Numerous, slight, successive modifications" may account for the development of that which is insignificant until it shall attain commanding proportions and interest, but they can never cause that which is non-existent to arise into being.

2nd. The function in its most rudimentary condition must have been serviceable to its possessor, and with each successive upward modification must have been increasingly serviceable in the struggle for existence, or the organ that subserves it could not have been improved by natural selection.

3rd. A series of profitable modifications, if not known at least conceivable, must connect the diffused and imperfect manifestation of the function in the low ancestral germ with the highly specialized and complex organ that fulfils the function in its most developed form.

It is not necessary to the present purpose to point out that, even if in *the case of any organ or totality of organs in individuals* these three criteria be met, it by no means follows that we must admit genetic connection between the several forms, lowest, higher and highest; but, undoubtedly, if any one of them fail to be met, the possibility of such connection must be emphatically denied. Mr. Darwin says, in the second paragraph of chap. 14 of the "Origin of Species": "If it could be demonstrated that any complex organ existed that could not possibly have been formed by numerous, successive, slight modifications, my theory would absolutely break down." This is true; and it is no less true that we *shall have demonstrated an organ that could not* possibly have been so formed, if we show one that performs a function wholly unrepresented in its supposed ancestral germ, or a function that until highly developed is quite useless to its possessor, or a function that admits of no complete gradation from lowest to highest.

He who attempts to account for the origin of functions by heredity, variability, and the survival of the fittest, will not meet his chief difficulties when he considers the great common functions of animal life and the organs by which they are accomplished. The functions of prehension, ingestion, digestion and assimilation of food; of secretion, of excretion, of sensation, of voluntary motion, of the correlation of sensation to motion; all these without specialization by separate organs are diffusely and vaguely manifested in the lowest amoeboid form. Further, all these functions are not merely advantageous but they are essential to every thing that has animal life, and with each more distinct differentiation of function and specialization of organ they give to the possessor an increased advantage in the struggle for existence. And, again, so numerous are the forms of nature, ranging through so vast a scale of being, that it is possible to connect by gradations almost imperceptibly progressive the lowest with the highest form of each function and organ.

For example, the eye is a most complex, delicate and efficient organ, replete with admirable adjustments and adaptations, yet of its genesis by evolution a plausible account may be given. We can trace the beginning of the function in that sensibility to the presence or absence of light which is exhibited in the whole mass of the humblest protozoan forms. To them their rudimentary and vague appreciation of alternate sunshine and shadow, scarcely to be called vision, is doubtless useful for the avoidance of danger, and every stage of advance in quickness and precision must give increased advantage in escaping from peril and in the procurement of food. And, finally, the comparative anatomist may trace for us the several gradations, insensibly blended, by which we pass from a few pigment cells on the swimming disk of a medusa up to the most fully developed organ of sight in the vertebrate sub-kingdom. Wide as is the interval between tho eye-speck of a radiate and the human eye, that interval may be filled by the selection of a continuous, advancing series of slowly differing forms, such a series as must have united the extremes, if all the structures had originated by descent with accumulated minute modifications from a protozoan ancestry.

Not more difficult will be the task of accounting for the progressive development of any of the remaining common functions of life whether animal or vegetable. They are all represented in a rudimentary manner in the lowest forms of life. They all are profitable to the possessor, and increasingly profitable with increased specialization of the function and development of its organs. And, finally, from the boundless diversity of nature it is possible to choose forms which may be arranged in lineal series, exhibiting the links which may be supposed to connect the simplest with the most highly organized manifestation of the function.

But if there be in nature any organ which does not now exist in a rudimentary form anywhere, and of which nature furnishes no evidence that it ever did exist in a rudimentary form, then it is obvious that evidence of its development through evolution is wanting. And if, further, it is impossible to conceive that the function could ever usefully exist in the rudimentary condition, we are compelled to say that we cannot conceive how such organs as subserve the function could be produced by any process of evolution.

So far as appears there are many aberrant or peculiar organs in the animal economy that cannot be accounted for by evolution, because the terms of any conceivable theory of evolution cannot apply. Let us take but one example—the ink bag of the octopus. It is well known that all the dibranchiate cephalopods, when threatened by danger, eject into the surrounding water a dense, dark liquid that forms an opaque cloud to cover their escape. This dark brown or black liquid is secreted abundantly by a somewhat large sac-like gland—the ink bag. Exteriorly the ink bag is pear-shaped, and has a pearly or silvery lustre. Within, its walls are cavernous, and pour the secretion into a central cavity, from which a tube conveys it to the funnel of the animal. When alarmed the animal forcibly expels water from its funnel. By the reaction of this water it is driven rapidly backward. At the same time the contents of the ink bag are shed into the escaping jet of water, so that the very act by which the animal escapes, aids in the formation of the cloud that covers its escape.

This function of darkening the water by a dense coloured secretion is one which is not found in protozoan life. It exists nowhere in the animal world in a rudimentary condition. The geological record shows that just when, in the jurassic seas, the armored cephalopods had reached their culmination, the belemnites and teuthidæ suddenly appeared in considerable numbers, both of individuals and species, all destitute of the protection of an external shell, but all fully provided with the unique means of defence described above. But geology gives no record of any preceding form of life that had a similar though less perfectly developed defence. Yet, if such form of life had existed, it would surely have left some record of its existence. If in no other way, its indestructible ink would, in some cases at least, have remained to witness for it. There is no evidence then of the evolution of the ink bag of the cuttle fish. It appears at once fully developed. Nor is it possible to conceive its evolution. A cloud of ink insufficient in quantity or pale and translucent in colour, so far from being of utility, would have been a serious disadvantage to the ink spiller. It could not have served for concealment; it would have been a means of betrayal only. The evolution of an ink bag by selection under the struggle for existence, and the survival of the fittest, is not only not known as a matter of history, it is inconceivable as a matter of hypothesis.

There is one way yet remaining in which, consistently with evolution, it is possible to account for an organ that could not have been evolved from a primitive organ of similar function but of less efficiency. It is by that which has been tacitly assumed but not explicitly named in the speculations of evolution —the *transmutation of function*. What in amphipods are locomotive organs become in lobsters the so-called foot jaws. In like manner it has been assumed that fins for swimming have been transmuted gradually into legs for walking, into wings for flying, into hands for grasping.

Not to speak of the fact that all such plausibly asserted transmutations are not from one function to another of different order but from one modification of a function to another modification of the same function, it is sufficient to the present purpose to point out that in all such cases the transmuted organs are homologous, and necessarily homologous; morphologically they are alike, though functionally they differ. Now so long as it was supposed, as by the earlier anatomists, that the ink bag was a peculiar sort of gall-bladder, it was possible to suppose that by transmutation of function what in other molluscs was an organ of digestion in the naked cephalopods had been transmuted into an organ of defence. But it is now well known that the ink bag is a special organ, homologous to none other among molluscs. It cannot then be accounted for by transmutation of function.

It is worthy of remark that this organ is always found in those cephalopods which have no external shell. It is never found in those which have such a covering except in the case of the paper nautilus, whose fragile shell, belonging only to the female, serves not as a defence to the occupant but merely as a place for the deposition and incubation of its eggs.

Many—not all—evolutionists roundly declare that there is no proof of design in the universe. Many theologians, stunned by the constant and noisy iteration, are almost ready to abandon Paley's grand argument, as though somehow it had grown obsolete. Let them take into consideration the ink-bag of the cuttle fish. Here is one organ that cannot have been produced by natural selection, nor can it have resulted from transmutation of function. It appears early in mesozoic time fully developed in the first of the naked cephalopods. Its sole use is the defence of the possessor by blinding the path of its escape. The construction of the organ, the situation of the organ, the position of its emissive duct, all have a nicely calculated relation to the result. Whether other organs of the animal economy have been produced perfect at once or not, this must have been. Whether other organs have had an intelligent creator and a plan in their *construction or not, this particular organ must have been created* with prescience, calculation, design. If we may no longer with fond delusion worship the Great Unknown as the creator of man, let us still *continue to* bow *down* before Him as the creator of the ink-bag of the cuttle fish.

AMERICAN GEOGRAPHY.*

"My recent predecessors in this chair have dealt, with a knowledge and ability with which I cannot vie, not only with great problems in terrestrial physics, such as the genesis of our oceans, continents, and mountain-chains; the circulation of the waters of the ocean, with its consequences on climate; the reciprocal influence of conditions of nature upon man, and of man's ability to modify those conditions; but also on the progress of geographical discovery on the great theatres of political interest or commercial rivalry; and the archæology of our science, as regards Asia, has been touched by a master's hand. Turning, then, from themes on which I could offer nothing worthy of your attention, I find, with a sense of *relief, that there is a region of* the globe, and it is one with which I have the most personal acquaintance, which has received very little attention at their hands. I refer to the great continent of America, and more especially its northern portion; and I hope for your indulgence if I enlarge a little upon that theme.

"How vast have been, in very recent times, the additions to our knowledge in that quarter, how continuous is the progress of discovery, cannot, I think, but worthily occupy your attention for a few minutes. In other regions geography is the pioneer of

* From the Address to the Geographical Section of the British Association, Swansea, 1880, by Lieut.-General Sir J. H. Lefroy, C. B., K. C. M. G., R. A., F. R. S., F. R. G. S. President of the Section.

civilisation and commerce. We look, and often look 'ong, fo their footsteps to follow. Here for the first time she has been outstripped, for the telegraph and the railway have tracked the forest or prairie, and traversed the mountains by paths before unknown to her.

"I remember that patriarch of science, Sir Edward Sabine, once telling me how eagerly he, as a young man, had desired to retread the footsteps of Lewis and Clarke, whose journey from St. Louis to the Pacific in 1805, was at the time, and must long remain, one of the most remarkable achievements on record,

"Let me, then, remind you that within living memory (I grant a long one) no traveller known to fame had crossed the American continent from east to west, except Alexander Mackenzie, in 1793. No traveller had reached the American Polar Sea by land, except the same illustrious explorer and Samuel Hearne. The British Admiralty had not l ng before instructed Captain Vancouver to search on the coast of the Pacific for some near communication with a river flowing into or out of the Lake of the Woods. The fabulous Straits of Anian are to be found on maps of the last century. 'The sacred fires of Montezuma' were still burning in secluded valleys of Upper California when her Majesty ascended the throne.

"It is very interesting to observe that De la Hontan, whose name has been recently given by the American geologists to the great Miocene Sea, now represented by Carson Lake in Nevada, ascended the Mississippi, and even penetrated up the Yellowstone, very nearly to the 'National Park,' at all events, into the present territory of Montana, so early as 1687. He introduces into his rude map a head-water lake, on Indian information, which must, I think, be identical with a lake in that reserve. 'Je sçais,' says his biographer, 'que tous les voyageurs sont sujets à caution, et que s'ils ne sont point parvenus au privilége des poëtes et des peintres, il ne s'en faut guére: mais il faut excepter de la noblesse; est-il croyable qu'un baron voulût en imposer?' But I am not pursuing the attractive theme offered by historical geography, and must not dwell on the memorable expeditions of Franklin and Richardson, of Back and Simpson and Rae, but proceed to point out the many agencies at work of late years to open up the continent: the military operations, for example, of the United States' Government against Mexico; the discovery of the precious metals; the exploration for the Union Pacific and Canada Pacific Railways; International Boundary Surveys; the Geological Surveys of the American and Canadian Governments. These have all resulted in a surprising extension of geographical knowledge, without any of them having it particularly in view. It was a bold figure of speech of Lord Dufferin's which described the Rocky Mountains in 1877 as being nearly 'as full of theodolites as they could hold,' but the Dominion Government has spent about three-quarters of a million sterling on explorations or surveys for their railway, and we have only to glance at a recent map to discover nine sovereign states, and nine territories, west of the Mississippi, bounded by right lines, which neither war nor diplomacy has determined, laid out like garden-plots, to see that neither Asia nor Africa have unfolded more of their secrets in our times, than has the nobler continent where Britain has cast her swarms.

"The thoroughness characteristic of the scientific operations of the American Government has been greatly favoured by the physical features of the region of their trigonometrical survey, in the American Cordilleras. Sharp rocky peaks, bare of vegetation, rise to altitudes of 10,000 to 12,000 feet, at convenient distances of 60 to 80 miles apart, so situated as to form well-conditioned triangles, while the purity of the atmosphere makes observation easy. In this manner has an immense region comprising some 87,000 square miles in Nevada, Utah, and Colorado, been topographically surveyed since 1867: not indeed with the detail of a European national survey, but with all the accuracy required for first settlement. The two pre-historic seas, now designated Lake Bonneville, of which Salt Lake is the remains, and Lake La Hontan, already referred to, have been defined, and facts of remarkable physical interest have been ascertained. The evaporation of Great Salt Lake, for example, is no longer in excess of its annual tribute; it has risen 11 feet since 1866. The natural basis of Pyramid Lake is now full, its level has risen 9 feet, and the overflow is filling up Winnemucca Lake in like manner; the latter lake has risen 22 feet, and its area has doubled within the same short period. We cannot allow the geologists to monopolise the interest of these physical changes, which the magnificent volume of Mr. Clarence King has presented to them.

"Lying a little to the east and south of the region just referred to is another, which includes yet loftier mountains, and has been surveyed by Professor Hayden. Here, on the tributaries of the rivers Colorado and S. Juan, we find those mysterious monuments of ancient civilisation and a dying people, the cliff-houses on the Rio Mancos and Rio de Chelly, the Pueblos of the Chaso Canon; and here the wandering Apachès still practice on their prisoners those revolting and indescribable cruelties which make humanity shudder, and which seal their doom of extermination. No less than eighteen summits in the Sierra Blanca have been found to rise above 14,000 feet. Blanca Peak, in South Colorado, attains 14,464 feet, and is the monarch of mountains, if such there may be, in the great Republic. Lake Tahoe, the largest of western lakes, familiar to readers of the brilliant pages of Miss Bird, was surveyed by Lieutenant Macomb in 1877, and the height of Pyramid Peak ascertained to be 10,003 feet. A town of 20,000 inhabitants (Leadville, Colorado) has sprung into being at an elevation of 11,000 feet, which ranks it among the highest inhabited places on the globe.

"Very different in their character are the survey operations of the Canadian Government in the north-west, where the problem presented is to prepare a vast territory, wholly wanting in conspicuous points, for being laid out in townships of uniform area, and farms of uniform acreage. The law requires that the eastern and western boundaries of every township be true astronomical meridians; and that the sphericity of the earth's figure be duly allowed for, so that the northern boundary must be less in measurement than the southern. All lines are required to be gone over twice, with chains of unequal length, and the land surveyors are checked by astronomical determinations. In carrying out this operation, which will be seen to be of great nicety, five principal meridians have been rigorously determined, and in part traced—the 97th, 102nd, 106th, 110th, and 114th; and fourteen base-lines, connecting them, have been measured and marked. One of these, on the parallel of 52° 10′ is 183 miles long. Eleven astronomical stations have been fixed since 1876, and from these sixty-six determinate points have been fixed in latitude, forty-five in longitude, often under conditions of no little difficulty from the severity of the climate. The claims of Messrs. Alexander and Lindsay Russell, of Mr. Aldous, and Mr. King, the observers, to rank as scientific travellers, will, I am sure, be warmly recognized by this Section.

"The sources of the Frazer river were first reached in February 1875, and found in a semicircular basin, completely closed in by glaciers and high bare peaks, at an elevation of 5,300 feet. The hardy discoverer, Mr. E. W. Jarvis, travelled in the course of that exploration 900 miles on snow shoes, much of it with the thermometer below the temperature of freezing mercury, and lived for the last three days, as he expressed it, 'on the anticipation of a meal at the journey's end.

"We are still imperfectly acquainted with the region north of the parallel of 50° in British Columbia, where the Canadian engineers have long been searching for a practical railway line from one or other of three known passes of the Rocky Mountains proper through the tremendous gorges of the Cascade Mountains, to the Pacific. These passes are, the Yellowhead, at an elevation of 3,645 feet, the Pine river, at 2,800 feet, and the Peace river, said to be only 1,650 feet above the sea, all of them comparing very favorably in respect to height with the other transcontinental railways. The Upion Pacific Railway, for example, runs, as you will remember, for 1,500 miles at elevations of over 4,500 feet, and its summit level is 8,242 feet. The Dominion Government has recently adopted a line from the Yellowhead Pass to Burrard Inlet, which may be made out in any good map by following the course of the Thompson and Frazer rivers. By this line the Pacific coast will be reached in 1,945 miles from Lake Superior, and it is already partly under contract. This is not a place to enter upon engineering details. I will only remark that greater difficulties have seldom been presented to human enterprise than must here be conquered. That peculiar feature in physical geography, the canon or deep gorge, of which the Via Mala is an example familiar to many persons, is presented all over the region upon a scale of grandeur unsurpassed. When not perpendicular cliffs, their sides are in these latitudes seamed by avalanches on the largest scale; while the mountain torrents which rush down them defy navigation. Mr. Jarvis describes how, on one occasion, having walked into a hole concealed by snow, the current caught his snow-shoes, turning them upside down, and held him like a vice, so that it required the united efforts of all his party to extricate him. * * * *

"The final decision of the Canadian Government to adopt Burrard Inlet for the Pacific terminus of their railway, relegates to the domain of pure geography a great deal of knowledge acquired in exploring other lines: explorations in which Messrs

Jarvis, Horetsky, Keefer, and others, have displayed remarkable daring and endurance. They have forced their way from the interior to the sea-coast or from the coast to the Peace River, Pine or Yellowhead Passes, through country previously unknown, to Port Simpson, to Burke Channel, to the mouth of the Skeena, and to Bute Inlet, so that a region but recently almost a blank on our maps, which John Arrowsmith, our last great authority, left very imperfectly sketched, is now known in great detail, and I regret to add, the better known, the less admired. The botany has been reported on by Mr. Macoun, and the geology by Dr. Dawson, *pari passu* with its topography. I have great hope that the Section will receive from the last-named traveller in person some account of his many arduous journeys in the prosecution of geological research. Of these, the latest is the exploration of Queen Charlotte Islands, a part of the British possessions, very little known to most of us, although we had a communication on the subject in 1868. He regards them as a partly submerged mountain chain, a continuation north-westward of that of Vancouver's Island and of the Olympian Mountains in Washington Territory. An island, 156 miles long and 56 wide, enjoying a temperate climate, and covered with forests of timber of some value (chiefly *Abies Menziesii*), is not likely to be left to nature much longer. But the customs of the natives in regard to the inheritance and transfer of land are unfavorable to settlement, and will demand just and wise consideration when the hour comes. It is as much private property as any estate in Wales.

"Mr. Dawson's report cont..ins a vocabulary of the language, which presents this peculiarity, that the words expressing family relationship vary with the speaker. Thus, 'father,' said by a son is *Haung*; said by a daughter, is *Hah-ta*. 'Son,' said by a father, is *keet*; said by a mother, is *kin*. Evidently at some periods the mothers were captives of a different tribe. It would be difficult to produce on the globe a more conspicuous example of the beneficent effect of missionary influence, combining industrial with religious instruction, than has been presented by the Tsimpsheean Indians at Metla Katla, under Mr. Duncan, a layman commissioned by the Church Missionary Society.

"I must now call your attention to the remarkable explorations, little known in this country, of l,Abbé Petitot, also a lay missionary (Frère Oblat) of the Roman Catholic Church, in the

Mackenzie River district, between Great Slave Lake and the Arctic Sea, a region which that Church has almost made its own. Starting sometimes from St. Joseph's mission station, near Fort Resolution, on Great Slave Lake, sometimes from S. Theresa, on Great Bear Lake, sometimes from Notre Dame de Bonne Espérance on the Mackenzie, points many hundreds of miles asunder, he has, on foot or in canoe, often accompanied only by Indians or Esquimaux, again and again traversed that desolate country in every direction. He has passed four winters and a summer on Great Bear Lake, and explored every part of it. He has *navigated the Mackenzie ten times between Great Slave Lake* and Fort Good Hope, and eight times between the latter post and its mouth. We owe to his visits in 1870 the disentanglement of a confusion which existed between the mouth of the Peel River (R. Plumée) and those of the Mackenzie, owing to their uniting in one delta, the explanation of the so-called Esquimaux Lake, which, as Richardson conjectured, has no existence, and the delineation of the course of three large rivers which fall into the Polar Sea in that neighborhood, the 'Anderson,' discovered by Mr. MacFarlane, in 1859, a river named by himself the Macfarlane, and another he has called the Roncière. Sir John Richardson was aware of the existence of the second of these, and erroneously supposed it to be the 'Toothless Fish,' River of the Hare Indians (Beg-hui-la on his map). M. Petitot has also traced and sketched in several lakes and chains of lakes, which *support his opinion that this region is partaking of that* operation of elevation which extends to Hudson's Bay. He found the wild granite basin of one of these dried up, and discovered in it, yawning and terrible, the huge funnel opening by which the waters had been drawn into one of the many subterranean channels which the Indians believe to exist here.

"These geographical discoveries are but a small part of l'Abbé Petitot's services. His intimate knowledge of the languages of the Northern Indians has enabled him to rectify the names given by previous travellers, and to interpret those descriptive appellations of the natives, which are often so full of significance. He has profoundly studied their ethnology and tribal relations, and he has added greatly to our knowledge of the geology of this region.

"It is, however, much to be regretted that this excellent *traveller was provided with no instruments except a pocket watch* and a compass, which latter is a somewhat fallacious guide in a region where the declination varies betwen 35° and 58°. His method has been to work in the details brought within his personal knowledge, or well attested by native information, on the basis of Franklin's charts.

"M. Petitot expresses his persuasion that the district of Mackenzie river can never be colonized—a conclusion no one who has visited it will be disposed to dispute; but he omits to point out that the mouth of that river is about 700 miles nearer the port of Victoria, in British Columbia, than the mouth of the Lena is to Yokohama, and far more accessible. It needs no Nordenskiold to show the way. Its upper waters, the Liard, Peace, Elk, and Athabasca rivers, drain an enormous extent of fertile country, not without coal or lignite, and with petroleum in abundance. As the geological survey has not yet been extended so far, we are not fully acquainted with its mineral resources; but I can add my testimony to that of more recent travellers, as to the remarkable apparent fertility, and the exceptional climate of the Peace River valley. It is no extravagant dream that sees in a distant future the beneficent influence of commerce, reaching by this great natural channel, races of mankind, in a high degree susceptible to them; and alleviating what appears to us to be the misery of their lot.

"There are few subjects of greater physical interest, or which have received less investigation, than the extent to which the soil of our planet is now permanently frozen round the North Pole. Erman, on theoretical grounds, affirms that the ground at Yakutsk is frozen to a depth of 630 feet. At 50 feet below the surface it had a temperature of 28°.5 F. (—6° R.), and was barely up to the freezing point at 382 feet. It is very different on the American continent. The rare opportunity was afforded me, by a landslip on a large scale, in May 1844, of observing its entire thickness, near Fort Norman, on Mackenzie river, about 200 miles further north than Yakutsk, and it was only 45 feet. At York Factory and Hudson's Bay it is said to be about 23 feet. The recent extension of settlement in Manitoba has led to wells being sunk in many directions, establishing the fact that the permanently frozen stratum does not extend so far as that region, notwithstanding an opinion to the contrary of the late Sir George Simpson. Probably it does not cross Churchill river, for I was assured that there is none at Lake à la Crosse. It depends, in some measure, on exposure. In the neighborhood of high river banks, radiating their heat in two directions, and in situations not reached by the sun, the frost runs much deeper than in the open. The question, however, to which Sir John Richardson called attention so long ago as 1839, is well deserving of systematic enquiry, and may even throw some light on the profoundly interesting subject of a geographical change in the position of the earth's axis of rotation. Indeed, Dr. Haughton has actually, on other grounds, assigned a position in the neighbourhood of Yakutsk to the pole of the earth in Miocene times.

"The Saskatchewan was first navigated by steam in 1875, when a vessel of about 200 tons ascended from the Grand Rapid to Edmonton, 700 miles. There is, however, an obstacle at Cole's Falls, below Carlton House, which has led to a break of navigation, and a small steel steamer, originally intended for the Upper Athabasca, has recently been transferred to the Upper Saskatchewan; between the two, it is now navigated from the Grand Rapids, near Lake Winnipeg, to the base of the Rocky Mountains. A steamer also plies regularly on Lake Winnipeg, and has ascertained many interesting particulars, of which we have hitherto been ignorant. Its greatest depth apparently does not exceed 100 feet. Its discharge has at last been followed by Dr. Robert Bell, down the Nelson river, to the sea. That gentleman reports the impediments to navigation to be insuperable, and a company has been very recently formed to make a railway from the lowest navigable point to the mouth of the Churchill river.

"Our hopes of further light upon the history of the ill-fated Franklin expedition, based on information given by a Netchelli Esquimaux, to the American Captain Potter in 1872, have been again disappointed. An American search expedition landed at Depôt Island, (lat. 64°,) in the neighbourhood of which traces were reported, in August 1878, wintered there, and examined the country, as yet with no result, except a correction of the charts.

"Hudson's Bay itself cannot fail at no distant day to challenge more attention. Dr. Bell reports that the land is rising at the rate of 5 to 10 feet in a century, that is, possibly, an inch a year. Not however, on this account will the hydrographer notice it; but because the natural seaports of that vast interior now thrown open to settlement, Keewatin, Manitoba, and other provinces unborn, must be sought there. York Factory, which is nearer Liverpool than New York, has been happily called by Prof. H. Y. Hind, the Archangel of the West. The mouth of the Churchill, however, although somewhat further north, offers far superior natural advantages, and may more fitly challenge the title. It will undoubtedly be the future shipping port for the agricultural products of the vast north-west territory, and the route by which emigrants will enter the country.

"Before leaving this quarter I must allude to the praiseworthy efforts of some of the Western States, especially Nebraska and Minnesota, to encourage the planting on the great plains by premiums, in which they have been followed by our own Province of Manitoba. Many years must elapse before the full climatic effects can be realized, but in time they cannot be doubtful, and with the impending disappearance of the buffalo, will disappear much of that arid treeless region, embracing nearly 600,000 square miles, which he now wanders over, and assists to keep bare by so doing. On the other hand, the short-sighted and destructive habit of burning off the prairie grasses to promote a young growth, increases with settlement, and is chargeable with incredible mischief. These fires have the curious effect, when they extend into wooded regions, of helping to exterminate the more slow-growing and valuable descriptions of timber, and favouring the prevalence of the more worthless quick-growing kinds. But the Indians are even more chargeable with them than the whites, and the traveller encounters few more melancholy sights than a forest of charred and lifeless trunks extending over an area as large as a county, the fruit perhaps of a signal from one band to another."

GEOLOGICAL NOTES OR ABSTRACTS OF RECENT PAPERS

By T. Sterry Hunt, LL.D., F.R.S.

I. THE TACONIC SYSTEM IN GEOLOGY.

(Abstract of a paper read before the National Academy of Sciences at Washington, April 18, 1880.)

The existence of a series of stratified rocks in the Appalachian Valley, intermediate in age between the older crystalline or Primitive schists and the Palæozoic rocks of the New York system, was taught by Eaton and maintained by Emmons, whose

Taconic system, as first proposed, was later declared by him to consist of an upper division, which he referred to the horizon of the Calciferous sandrock of the New York system, and a lower division, the proper Taconic. In this latter were included a great group of quartzites, limestones, and soft crystalline schists, which have since, by different geologists, been assigned to not less than three distinct horizons in the New York system. The grounds of those contradictory opinions have been supposed stratigraphical relations, and also the apparent association with the Taconic limestones of organic remains belonging to these various horizons.

In localities away from the disturbed regions of the Appalachian Valley there exists a series of rocks, occupying the position assigned by Emmons to his Lower Tàconic, and agreeing with this in its essential characters. Such a series is found to the north-west of the Appalachian region, a little to the north of Lake Ontario, where it rests upon schists like those of the Green Mountains, and is unconformably overlaid by the Trenton limestone and totally distinct from the lower members of the New York system in the adjoining region. Another locality is to the south-east of the Atlantic belt, in southern New Brunswick, where a similar series of several thousand feet of limestone, quartzites, and schists occupies a position inferior to the fossiliferous Cambrian (Menevian). In both of these localities the rocks in question correspond closely in volume and in mineralogical characters to the Lower Taconic rocks of the Appalachian Valley, with which the speaker believed them to be identical.

Again Mr. W. O. Crosby has lately described a similar series in the island of Trinidad, resting on the ancient crystalline rocks, and overlaid unconformably by limestones of Trenton age. We have thus abundant evidence of a great and wide-spread series of rocks, pre-Cambrian in age, and occupying the position assigned by Emmons to the Lower Taconic or Taconian system,—which, according to him, extends continuously along the Appalachian valley from Vermont to Alabama, and moreover occupies large areas to the south-east of the Blue Ridge, from Virginia to Georgia, constituting, in South Carolina, the Itacolumite series of Lieber.

Within the vast region occupied by these rocks in the great valley have been found a few small areas of fossiliferous strata, belonging chiefly to the Ordovian (Siluro-Cambrian) or to the

Cambrian series; but the characters of the great mass of these rocks are such as to lead to the conclusion that they constitute, as maintained by Emmons, a more ancient series.

To the Taconian rocks belong the peculiar magnetic iron ores found at Reading, Cornwall, and Dillsburg, Penn., which have been by some geologists regarded as Mesozoic, but were by Rogers assigned to the base of the Palæozoic. To this same series belong the limonites of the great Valley, which occur in clays derived from the sub-aërial decay of the rocks. These, in their unchanged condition, contain beds and masses of siderite and pyrites, and the alteration of these *in situ* has given rise to the limonites. In the formation of this from the siderite, or iron-carbonate, it was pointed out by the speaker that there is a contraction of volume equal to about 20 per cent.; to which is due the cellular character of the limonites and their frequent occurrence in the form of geodes.

These older rocks are not without traces of organic life, having yielded in the Appalachian Valley the original *Scolithus* and related markings, besides obscure *Brachiopods*; and in Ontario, besides similar Scolithus like markings, a form apparently identical with the *Eozoon* of the more ancient gneisses. We may hope to find in the Taconian series a fauna which shall help to fill the wide interval that now divides that of the Eozoic rocks from the Cambrian. We should seek in the study of stratigraphical geology not the breaks dividing groups from each other, so much as the beds of passage which serve to unite all these groups in one great system, remembering that there is no local hiatus which is not somewhere filled up by the continuous process of nature.

II. THE GENESIS OF CERTAIN IRON ORES.

(Abstract of a paper read before the American Association for the Advancement of Science at Boston, August 28, 1880.)

Dr. Hunt began by considering the presence of iron, generally in a ferrous condition, in mineral silicates in the crystalline rocks, and its liberation therefrom by the sub-aërial decay of these, as hydrous ferric oxide. This, as is well known, is, by the agency of organic matter, again reduced to ferrous oxide, which is dissolved in natural waters by carbonic acid, from which solutions it may be deposited either as hydrous peroxide (limonite, etc.,) as carbonate (siderite), as silicate, or as sulphide (pyrite, etc.), in all of which forms iron is found in sedimentary deposits. As regards the formation of siderite, he described experiments which show that solutions holding five grammes of ferrous carbonate dissolved as di-carbonate in a litre of water, are spontaneously decomposed in close vessels at the ordinary temperature, and deposit two-thirds of their iron as a white crystalline (hydrated) mono-carbonate, with liberation of carbonic-dioxide. This serves to render more intelligible the reduction and segregation of iron as siderite in earthy sediments, as long since pointed out by W. B. Rogers, for the ores of the coal-measures.

The intervention of the soluble sulphates, and their reduction through organic agency to sulphides, determines the formation of sulphide of iron in sediments. The generation of a bi-sulphide (pyrite or marcasite) was then discussed, and it was shown that the ferrous mono-sulphide, which naturally is first generated, may fix a further portion of sulphur, and thus form a more stable compound. One example of this is seen when recently precipitated hydrous ferrous sulphide is brought in contact with a solution of a ferric salt, which takes up a portion of the iron, leaving sulphur free to unite with the undecomposed sulphide, and form therewith a very stable higher sulphide of iron. Experiments now in progress lead the writer to believe that sulphur liberated from soluble sulphides may, in a similar manner, unite with ferrous sulphide, and thus help us to explain the generation of pyrites in nature, in the presence of water, at ordinary temperatures.

The changes of siderite and pyrite under atmospheric influences were next considered. The latter by oxidation yields, as is well known, ferrous sulphate. Its frequent conversion by sub-aerial decay into limonite was conceived to be due to the intervention of water holding carbonates, which conjointly with oxygen, changes it into hydrous peroxide (limonite), which latter often retains the form of the pyrites. The transformation of carbonate of iron into hydrous peroxide is a familiar fact.

Limonite ores may thus be produced in three ways. They are sometimes formed by the peroxidation and precipitation of dissolved salts, as in the so-called bog-ores; but more frequently from the alteration *in situ* of deposits of pyrite or siderite. Such as these are the limonites which mark the outcrops of beds or veins of pyrites in the decayed crystalline rocks of the Blue Ridge. The similar ores found in the decayed Taconic schists of the great Appalachian valley can be shown to be due in some cases to the alteration of included masses of pyrites, and in others to the alteration of similar masses of siderite, both of which species are found in the unaltered Taconic rocks, as, indeed, at various other horizons in the geological series.

If we take the specific gravity of pyrites at 5.0, we shall find that its complete conversion into a limonite of sp. gr. 4.0 would be attended with a contraction of only 2.7 hundredths, while if the limonite have a sp. gr. of 3.6, there would be an augmentation of 10.7 p. c. With siderite of sp. gr. 3.6, on the contrary, its conversion into a limonite of the same density would result in a contraction of 19.5 p. c., and into a limonite of sp. gr. 4.0, in a contraction of 27.5 p. c. The evidences of this contraction may be seen in the structure of the limonite derived from siderite, which is often found a porous or spongy mass. In the case, however, of nodules or blocks of very compact ore, the conversion beginning at the outside of the mass, an external layer of compact limonite is formed, and then another within this, and still another, till the change is complete. The void space resulting from contraction is then found between the layers, which are arranged like the coats of an onion, or sometimes wholly at the centre, where a cavity will be formed, holding in many cases, more or less clay or sand, the impurites of carbonate which have been separated in the process of conversion into limonite. In this way are formed the hollow masses sometimes known as bomb-shell ore. Their structure will generally serve to distinguish the sideritic from the pyritic limonites.

These differences were illustrated in the history of various iron-ores in the Applachian valley, and it was further pointed out that the pyritic limonites, other circumstances being equal, should be freer from phosphorus than those derived from siderite, since the native carbonates almost always contain phosphates, from which pyritous deposits are comparatively free. The source of limonites thus becomes a question of importance to the metallurgist. In conclusion, it was pointed out that deposits of manganese-ores are, in some cases at least, generated by the alteration *in situ* of manganous carbonates, by a process analogous to that by which limonite is produced from siderite.

III. ON THE ORIGIN OF ANTHRACITE.

(Read before the National Academy of Sciences, N. Y., 1880.)

From comparative studies of carbonaceous minerals as long ago as 1861, the author reached the conclusion that petroleum and anthracite form the extremes of a series, all of which may have been derived from organic matters by natural processes at ordinary temperatures.*

To this is opposed the ordinary view that anthracite, on the one hand, and petroleum, on the other, result from the action of heat on matters of intermediate composition;—the one being a distillate, and the other a residuum. Late geological studies, however, show that such an hypothesis is untenable for petroleum, and the author, while not denying that a local coking of bituminous coals must naturally result from the proximity of igneous rocks, has long taught that it is equally so for our anthracite fields. The prevalent notion has hitherto been that the differences between these and the bituminous coals farther west are in some way connected with the mechanical disturbance of the strata in the former region; but to this is opposed the fact that, while the undisturbed coals of Arkansas are anthracitic, the highly disturbed coals of north-eastern America, Belgium and other regions are bituminous.

These considerations I have for many years presented to my classes in geology, and have maintained that the change which results in the conversion of organic matters into anthracite was effected before the disturbance of the strata; that the hydrogen was removed, as in ordinary vegetable decay, in the forms of water and marsh-gas; and that differences in aëration, during the processes of change and consolidation of the carboniferous vegetation, are adequate to explain the chemical differences between anthracitic and bituminous coals. Bischof had already enunciated a similar view.

Prof. J. P. Lesley, to whom I have explained my views, has pointed out that there is an apparent connection in the great Appalachian coal-basin, between the more or less arenaceous and permeable nature of the enclosing sediments and the more or less complete anthracitic character of the coal; while Principal Dawson informs me that he has observed similar facts in the coal-measures

* Canadian Naturalist, July, 1861, and Report Smithsonian Institution for 1862; also Chem. and Geol. Essays, p. 177.

of north-eastern America. Inquiries which promise to throw farther light on this question are in progress, and the present note to the Academy is to be considered as only preliminary to a further discussion of the subject.

IV. ON THE RECENT FORMATION OF QUARTZ AND ON SILICIFICATION IN CALIFORNIA.*

(From the American Journal of Science, Vol. xix, May, 1880.)

At the meeting of the American Institute of Mining Engineers in New York, Feb. 19, 1880, Prof. George W. Maynard exhibited a remarkable specimen lately obtained by him from the mines of the Gold Run Hydraulic Co. at Dutch Flat in California. It consisted of a mass of milky vitreous quartz, in which a recent fracture had disclosed an imbedded fragment, about half an inch in diameter, of the characteristic so-called *blue gravel* of the region, holding in its paste a worn and rounded piece of gold of several grains' weight. Portions of a similar blue gravel adhered closely to certain parts of the mass of quartz. Remarks were made on this specimen by Professors Silliman and Egleston, and by Dr. T. Sterry Hunt, all of whom, after examination of it, were satisfied of the correctness of the opinion expressed by Professor Maynard, that the quartz had made part of a vein formed in the auriferous gravel subsequent to the solidification of the latter.

Dr. Hunt, in commenting on this occurrence, remarked that it is in accordance with what we already know of the recency of some of the quartz of this region, and cited the microscopic

* This communication had been printed and revised before the writer had seen Professor Joseph LeConte's paper on the Old River Beds of California, in the March number of the American Journal of Science, where (on pages 179-181) he has so well described the auriferous gravels here referred to, and pointed out the true relations between the blue gravel and the upper and altered portions of the deposit. As regards the process of silicification, it is not, I think, necessary to suppose the infiltration of alkaline waters from the overlying volcanic rock in order to explain the solution of the silica. As elsewhere pointed out by the writer, the removal of the silica in a soluble form from the silicates which make up a large part of the gravel itself, does not require the intervention of alkalies.

I hope soon to continue the discussion of this problem, which is one of the most important in the whole domain of what I venture to call *mineral physiology*.

studies of John Arthur Phillips, who has shown that a great part of the silicious deposit from certain thermal waters of Lake County, California, and from the Steamboat Springs of Washoe County, Nevada, is of the nature of crystalline quartz.

[Mr. Phillips has, since the first printing of this note, informed the writer in a private note, of the existence of beautiful crystals of quartz which had grown in a cavity found at the meeting of small fissures in the auriferous *blue gravel*, near Washington, Nevada County, California.]

Dr. Hunt then gave an account of some observations made by him at the Blue Tent placer mine, in Nevada County, California, in 1877, showing that the process of depositing quartz is there going on in the auriferous gravel of the region, independent of thermal waters, and is connected with the sub-aërial decay of the silicates in the gravel, which is here made up in great part of the *débris* of the crystalline Huronian schists of the region, including much greenstone or diorite-rock. The gravel below the drainage-level is greenish or bluish in color, and contains disseminated pyrites, together with trunks of trees in the condition of lignite, while the feldspar, and hornblende of the greenstone are undecayed.

Above the drainage-level, however, these silicates are more or less decomposed, the greenstone-pebbles becoming earthy in texture, rusty in color, and exfoliating, and the accompanying pyrites oxidized. The lignite is at the same time more or less completely silicified, being sometimes converted into agatized masses, often with drusy cavities lined with quartz-crystals, and at other times only penetrated or injected with silicious matter, which has filled the pores of the exogenous wood, the vegetable tissue of which still remains, often incrusted with crystals of quartz. In still other cases, a slow subsequent decay of the tissue, in coniferous woods, has left these silicious casts in the form of bundles of fibres, which have been mistaken for asbestus. The various specimens from this locality illustrate perfectly the theory of silicification of vegetable structures set forth by the speaker in 1864,* based on his own microscopic studies conjoined with those of Göppert and of Dawson. The silica by which the tissues are thus successively filled and replaced is, according to the speaker, that which is set free in a soluble form by the decay of the sili-

* See Can. Naturalist, New Series, vol. i, p. 56; also Hunt's Chem. and Geol. Essays, p. 286.

cates in the gravel. The lignite, in the undecomposed and unoxidized portions of this which lie below drainage-level is, as yet unsilicified. Dr. Hunt acknowledged his obligations to Mr. D. T. Hughes, a memberof the Institute of Mining Engineers, in charge of the mine in question, and a skilled and careful observer, who had called his attention to the facts just set forth.

Professor W. C. Kerr stated that his recent and as yet unpublished observations on the fossil woods found in ancient gravels in North Carolina were in accordance with those described by Dr. Hunt.

A PECULIAR MINERAL OF THE SCAPOLITE FAMILY.*

By Chas. Upham Shepard.

The substance here described was sent to me by that zealous mineralogist, Mr. John G. Miller, of East Templeton, Ottawa County, Canada. It occurs in the bluish gray saccharine limestone of Galway, Province of Ontario, Canada. It had been referred with a query to chiastolite, which it certainly resembles in several respects. It presents itself in distinct and rather large crystals, thickly disseminated through the gangue, crossing each other in various directions. Their form is that of a right square prism, with truncated lateral edges. Their terminations are imperfect, and when well defined even, are still rough and drusy. They exhibit no combinations with the prismatic planes. The usual habit of the crystals is distinctly quadrangular, though in the larger individuals they are octangular, having their sides about equally produced. Their length is many times their thickness; and they are uniformly straight and sharply defined. The largest have a diameter of an inch, the smallest are rarely below one-eighth of this size. They preserve the same diameter throughout their length, with the exception of a single example, where one of the larger size, shows a tendency to a regular acumination. The length of this crystal is 3½ inches, its diameter at the largest extremity being half an inch, and at the smaller, but one-third. All the crystals have much evenness of surface and considerable smoothness, notwithstanding a slight degree of

* From the *American Journal of Science*, Vol. XX, July, 1880.

pitting or indentation, which almost requires a microscope for observation. They are without striation. The color is black, with a slight intermixture of gray and blue. In a few instances an area of cyanite-blue occupies a face of the larger crystals, but only to a slight depth from the surface. This part of the crystal is semi-transparent; while for the rest, the entire mineral is dark ash gray to bluish black, and only translucent on the edges. The vertical cleavages, parallel with the primary prism, parallel with the narrower planes in the quadrangular prisms. Only traces of a transverse cleavage exist. A marked peculiarity of the larger crystals is the regular interlamination of thin films of white calcite, parallel with the eight sides of the prism. These layers, to the number of two or three, are equi-distant, thus imparting to the fractured ends of the crystals a checkered aspect, strongly suggesting the structure of chiastolite.[*] Luster, resinous to vitreous. Hardness = 7· . . . 7·5. Specific gravity, 2.608.

A very striking peculiarity of the mineral is the extremely fetid odor occasioned by its fracture; nor [illegible] this cease to be emitted until the fragments are reduced [illegible] impalpable powder. The color of the powder is a bluish ash gray. It cannot be regarded as a hydrated mineral, as its content of water does not exceed 1·6 p. c. By exposure, however, to full ignition in a shallow platinum dish for several hours, it loses 4·6 p. c., this loss proceeding from the presence of organic matter, graphite, and carbonic acid from the decomposition of carbonate of lime. The powder still partially retains its grayish tint after long ignition; and it is only before the blowpipe that the portion most strongly heated loses its color. The thinnest part then undergoes fusion, attended by a feeble ebulition, into a colorless transparent glass.

Owing to the variable presence of graphite, calcite and quartz, the chemical examination is attended with uncertainty. The SiO_2 varied from 48·65 to 51·30; the Al_2O_3 from 13·45 to 19·62; the CaO from 17·43 to 21·6, and the TiO_2 from 4·35

* Prof. E. S. Dana has kindly made a section of one of the crystals, and examined it in polarized light. He finds "the black color to be due to foreign matter, present in the form of minute grains that seem to be metallic, making up no small part of the whole," and is of opinion that "its analysis is not a guide to the real composition of the mineral."

to 5·21. In a single trial, NaO 4·35, and KO 1·109, MgO 0·468 were obtained. The powder is very feebly acted upon by the strong acids.

From the foregoing it would appear that the mineral differs chemically from normal scapolite, and especially from the vitreous couseranite of Saleix (Pyrenees) analyzed by Pisani; though it must be kept in mind that the example analyzed by him, had been so much altered as to have its hardness reduced to 3. I am therefore led to regard the Galway crystals as the original, unaltered mineral, from which couseranite and dipyre have originated through hydration,† in the same manner as scapolite has given rise to wilsonite, huntite, algerite and terénite. Should it prove a new species, I propose to call it *Ontariolite*.

PROCEEDINGS NATURAL HISTORY SOCIETY OF MONTREAL.

The first regular meeting for the session 1880-81 was held in the Society's Rooms on the evening of Monday October 25th. Principal Dawson occupied the chair. Thomas Branierd, Esq. of the Hamilton Powder Co. was nominated for election as an ordinary member. Henry Montgomery Esq. Toronto and Rev. Charles Rogers, LL.D., London, Eng., were nominated for corresponding members.

The deputation to the American Association for the Advancement of Science, reported that they had attended the meeting of this body in Boston, in August last, and presented the invitation of this Society together with the resolutions of the Corporation of McGill University, the Council of Arts and Manufactures and the Medico Chirurgical Society; that the invitation was favorably received by the nominating committee and the general meeting, and that the two resolutions were introduced by the committee and unanimously and most cordially passed by the Association—the first resolution expressing thanks for the invitation, and the second recommending it to the favorable consideration of the next meeting's committee. This was as far as the Association could proceed in accordance with its constitution, which does not per-

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† Possibly chiastolite may have been similarly produced, though the origin must have been attended with a more radical metamorphism.

mit the arrangement of meetings more than a year in advance. It was considered, however, as virtually pledging the American Association to accept the invitation, provided it be renewed at the meeting to be held in Cincinnati next year. The Committee ask that it be continued, with power to add to its numbers, and be authorized to correspond with men of science, abroad or otherwise, to prepare for a meeting of the Association in Montreal in 1882. Further, that this report be communicated to the other bodies which joined in the invitation.

The report was unanimously adopted.

Mr. WHITEAVES, then read a paper on "Some new and remarkable fossil fishes from the Devonian rocks of the northern side of the Baie des Chaleurs." He commenced by remarking that until last year a long strip of the northern side of the bay had been mapped as belonging to the conglomerates of the Bonaventure formation, which form the base of the Carboniferous system. *Last year, however, Mr. R. W. Ells, of the Geological* Survey, discovered a fine specimen of a fossil fish belonging to the genus *Pterichthys*, of Agassiz, in Escuminac Bay, a discovery which led to a careful re-examination of the locality by Messrs. R. W. Ells, T. C. Weston and A. H. Foord. From the researches of these gentlemen, we now know that at this point Devonian rocks crop out from under the Bonaventure conglomerates, and further, that these Devonian rocks hold a rich and extremely interesting series of fossil plants and fishes. The vegetable organisms will be described by Principal Dawson at some future time. but the fossil fishes, of which many specimens were exhibited at the meeting, were shown to belong to the following genera and species:—1. *Pterichthys*. A fine species, supposed to be new, which has been described in the August number of the *American Journal of Science* as *Pterichthys Canadensis*. It is very closely allied to a fossil fish found in the Old Red sandstone of Scotland and Russia, and is the first species of this remarkable genus yet found in America. 2. *Diplacanthus*. A cluster of fin rays only, of a small form, possibly referable to this genus. 3. *Cheirolepis*. A beautifully preserved fossil fish, about a foot in length, which cannot at present be distinguished from the *Cheirolepis cumingiæ* of Agassiz, which was so named in honour of Lady Gordon Cuming, of Altyre. 4. *Phaneropleuron*, nov. sp. 5. *Tristichoporus*, nov. sp. 6. Portion of the vertebral column of the above species of *Tristichoporus* shewing the neural and hæmal spines and the processes which support the rays of the tail, also the two ischiatic bones with the metatarsals attached, which must have formed the bases of two enormously developed ventral fins.

The structural characters of the different specimens exhibited were described and explained at some length.

Mr. McFarlane asked whether these fishes were air breathing animals, whether atmospheric oxygen was essential to their existence.

Mr. Whiteaves replied that the inference was they breathed through their gills like ordinary fishes. Of course only the hard parts had been preserved and there was nothing to show they had gills.

The Chairman said whatever opinion might be entertained of the theory, there must no doubt have been sufficient oxygen in the air for animal life, since butterflies were found in periods before the Carboniferous. There was nothing to prove that these fishes had not a rudimentary lung through which they inhaled oxygen like reptiles, as well as through the gills. He expressed the great obligations the Society were under to Mr. Whiteaves for his excellent paper, and stated that the specimens were a feather in the cap of the Geological Survey, being on a par with the fishes discovered in the Old Red sandstone of Scotland.

The Secretary moved a vote of thanks to Mr. Whiteaves, which was unanimously adopted.

Fifteen specimens were exhibited, all of which, with one exception, were discovered by Messrs. Foord and Ells. Several lithographs illustrative of the subject were also shown.

The following donations to the Museum were upon the table:

1. Apatite Crystal from Bob's Lake, Bedford, Ont., presented by W. J. Morris, Esq.
2. Moss coated with mineral matter from Colorado, presented by Dr. Kennedy.
3. Collection of English Plants, by Col. G. E. Bulger, F.L.S., F.Z.S.
4. A fine *Limulus polyphemus*, from Miss E. Mathewson.

The second meeting was held on Monday 29th November. The President in the chair. The Secretary read minutes of last meeting, and announced that arrangements had been made for the Sommerville lectures.

Messrs. Thomas Brainerd, Henry Montgomery, M.A., and Rev. Charles Rogers, LL.D., were elected members of the Society (the last two corresponding members).

Mr. Wm. Muir then read the Cabinet Keeper's report, which will be found under the head of Miscellaneous Articles.

Mr. J. T. Donald next read a paper on "Baking Powders and their Adulterants."

Drs. T. Sterry Hunt and Harrington made some remarks on the subject, the former expressing his great satisfaction with a Baking Powder in which the acid substance was "Biphosphate of Lime."

Mr. A. R. C. Selwyn, F.G.S., exhibited a very fine series of fossil leaves from the Lignite Tertiary of the Souris River, Manitoba.

Principal Dawson presented some "Notes" on this collection, an abstract of which will be found among our Miscellaneous Articles.

REPORT OF CABINET-KEEPER OF THE NATURAL HISTORY SOCIETY OF MONTREAL.

By Wm. Muir, Esq.

The following is the report of work done on the building and in the Museum from May 1st to December 1st 1880:

I. Work on the Building.—On the left hand side of the Entrance Hall, a convenient store-room has been added, the ceiling of which gives a floor suitable for the accommodation of several specimens formerly in the Museum.

The side entrance has been enclosed by a ceiling and partition, forming an inside porch and adding greatly to the comfort of the place in winter; and the head of the rear stairway leading up to the gallery has been floored over, increasing the accommodation afforded by the gallery.

Eleven windows have been put in on three sides of the gallery, increasing its cheerfulness and light; curtains have also been placed on the skylights.

The whole of the large wall cases in the main room, 27 in number, have been cleaned and painted, and the shelves made narrower and better adapted to show the specimens thereon.

The Gallery (north and south side fronts) has been raised, levelled and supported.

II. Work in the Museum.—The whole of the birds (1194 in all), the mammals, reptiles and fishes have been thoroughly dusted and cleaned. The birds have been remounted on handsome black walnut stands and painted blocks, and the old soiled labels replaced by new ones; the fishes have been removed to the aquarium room, and the mammals rearranged and put in the space thus left vacant.

The whale, two of the alligators and the large seal have been removed to the floor covering the store-room to the left of the main entrance hall; and the floor cases, formerly in the aquarium room, have been brought into the main room.

The following is a list of birds which were found to be so much injured that they were destroyed:

Grass Finch, *Pooecetes gramineus.*
Purple Martin, *Progne purpurea.*
Red-shouldered Hawk, *Buteo lineatus.*
Lesser Red Poll, *Ægiothus linaria.*
Common Crow, *Corvus americanus.*
Yellow-throated Fly Catcher, *Vireo flavifrons.*
Cat Bird, *Galeoscoptes carolinensis.*
Brown Thrush, *Harporhynchus rufus.*
Red-eyed Fly Catcher, *Vireo olivaceus.*
Sparrow Hawk, *Tinnunculus sparverius.*
Shore Lark, *Eremophila cornuta.*
Satin Grakle (female)—*Kitta holosericea.*
Great Northern Shrike (old male), *Collyrio borealis.*
" " " (female), " "
Diphyllodes magnifica—New Guinea. J. F. W.

Additions to the Museum since June 1st 1880.

Donations, with names of donors.

Grey Squirrel, *Sciurus carolinensis.* N. P. Leach, Esqr.
Albino Robin, *Turdus migratorius.* "
Barred Owl, *Syrnium nebulosum.* J. A. Ogilvy, Esqr.
Great Blue Heron, *Ardea herodias.* Geo. Edwards, Esqr., of Thurso.
Barred Owl, *Syrnium nebulosum.* Jno. Nichols, Esqr.
Horned Grebe, *Podiceps cornutus.* "
Two Blue Jays, *Cyanura cristata.* G. L. Marler, Esqr.
A Remora or Sucking Fish. Geo. F. Phelps, Esqr.
Head of a Male Salmon. Robt. J. Fowler, Esqr.
A box made out of a plank from the Royal George. Captain Dutton, of SS. Sardinian.
A lock of Grace Darling's Hair. Capt. Dutton.
Moss Coated with mineral matter, from Colorado. Dr. Kennedy.
Apatite Crystal from Bob's Lake, Bedford, Ont. W. J. Morris., Esqr.
Collection of English Plants. Col. Bulger. F.R.Z.S., F.L.S.
Limulus polyphemus. Miss E. Mathewson.

The Remora or sucking fish mentioned above has the top of the head flattened and occupied by a laminated disk. composed of numerous transverse cartilaginous plates, the edges of which are spiny and directed obliquely backwards. By means of this apparatus these fishes are able to attach themselves to ships, larger fishes, etc.

The natives of the Mozambique coast make use of a larger species in catching turtles. By means of a ring a rope is attached to the tail of the Remora, and it is thrown into the sea. In endeavoring to escape, it attaches itself to the nearest turtle, when both are drawn ashore together.

Purchases:

Belted Kingfisher, *Ceryle alcyon.*
Coot, *Fulica americana.*
Baltimore Oriole, *Icterus baltimore.*
Sparrow Hawk, *Tinnunculus sparverius.*
Shore Lark, *Eremophila cornuta.*
Loggerhead Shrike (male and female), *Collyrio ludovicianus.*
Bonaparte Gull (young), *Larus philadelphia.*
Two Black-bellied Plovers, *Squatarola helvetica.*
Racoon (old female), *Procyon lotor.*
" (young) " "
Mink, *Putorius vison.*

Subjoined is a list of skins that have been mounted. The first three lots are from the number presented, on a former occasion, by the Smithsonian Institute; the others, from the Society's ordinary collection:

California Grey Squirrel, *Sciurus fossor.*
Thirteen-striped Squirrel (2 specimens), *Spermophilus tridecem-lineatus.*
Seven Mice.
Black-throated Blue Warbler, *Dendroica canadensis.*
" " Green " *Dendroica virens.*
Yellow Bird (female), *Chrysomitris Tristis.*
Blue Bird (young), *Sialia sialis.*
Wild Pigeon, *Ectopistes migratoria.*

The Taxidermist is at present engaged mounting the following skins:

Loon, *Colymbus torquatus.*
Spruce Partridge, *Tetrao canadensis.*
Goshawk, *Astur atricapillus.*
Black Woodpecker, *Picoides arcticus.*
Hooded Merganser, *Lophodytes cucullatus.*
Wild Geese (2), *Bernicla leucopareia.*

Brant Goose, *Bernicla brenta.*
American White-footed Goose, *Anser albatus.*
Goshawk (old), *Astur atricapillus.*
Horned Grebe, *Podiceps cornutus.*
Weasel, *Putorius vulgaris.*

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MISCELLANEOUS.

SKETCH OF THE GEOLOGY OF BRITISH COLUMBIA.* By GEORGE M. DAWSON, D.S., A.R.S.M., F.G.S.—British Columbia includes a certain portion of the length of the Cordillera region of the west coast of America which may be described as consisting here of four parallel mountain ranges running in a north-west and south-east bearing. Of these the south-western is represented by Vancouver and the Queen Charlotte Islands, and may be referred to as the Vancouver Range; while the next, to the north-east, is the Coast or Cascade Range, a belt of mountainous country about 100 miles in width. This is succeeded by the interior plateau of British Columbia, relatively a depressed area, but with a height of 3000 to 3500 feet. To the north-east of this is the Gold Range, and beyond this the Rocky Mountains proper, forming the western margin of the great plains of the interior of the continent.

Tertiary rocks, which are probably of Miocene age, are found both on the coast and on the interior plateau. They consist on the coast of marine beds, generally littoral in character, which are capped, in the Queen Charlotte Islands, by volcanic rocks. The interior plateau has been a fresh-water lake, in or on the margin of which, clays and sandstones, with occasional lignites, have been laid down. These are covered by very extensive volcanic accumulations, basaltic or tufaceous.

Cretaceous rocks from the age of the Upper and Lower Chalk to the Upper Neocomian, and representing the Chico and Shasta groups of California, occur on Vancouver and the Queen Charlotte Islands. Beds equivalent to the Chico group yield the bituminous coals of Nanaimo, while anthracite occurs in the somewhat

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older beds of the Queen Charlotte Islands. Within the Coast Range the Cretaceous rocks are probably for the most part equivalent in age to the Upper Neocomian. The Cretaceous rocks are of great thickness, both on the coast and inland, and include extensive contemporaneous volcanic beds.

The Pre-Cretaceous beds have been much disturbed and altered before the deposition of the Cretaceous, and their investigation is difficult. On Vancouver Island, beds probably Carboniferous in age include great masses of contemporaneous volcanic material, with limestones, and become altered to highly crystalline rocks resembling those of parts of the Huronian of Eastern Canada. In the Queen Charlotte Islands these beds also probably occur, but an extensive calcareous argillite formation is there found, which is characterised by its fossils as Triassic.

The Coast Range is supposed to be built up chiefly of rocks like those of Vancouver Island, but still more highly altered, and appearing as gneisses, mica-schists, &c., while a persistent argillaceous and slaty zone is supposed to represent the Triassic argillites of the Queen Charlotte Islands.

The older rocks of the interior plateau are largely composed of quartzites and limestones; but still hold much contemporaneous volcanic matter, together with serpentine. Carboniferous fossils have been found in the limestones in a number of places. The Triassic is also represented in some places by great contemporaneous volcanic deposits with limestones.

In the Gold Range, the conditions found in the Coast Range are supposed to be repeated; but it is probable that there are here also extensive areas of Archæan rocks. Some small areas of ancient crystalline rocks supposed to be of this age have already been discovered.

The Rocky Mountain Range consists of limestones with quartzites and shaly beds, dolomites and red sandstones. The latter have been observed near the 49th parallel, and are supposed to be Triassic in age. The limestones are, for the most part, Carboniferous and Devonian, and no fossils have yet been discovered indicating a greater age than the last-named period. On the 49th parallel, however, the series is supposed to extend down to the Cambrian, and compares closely with the sections of the region east of the Wahsatch, on the 40th parallel, given by Clarence King. Volcanic material is still present in the Carboniferous rocks on the 49th parallel.

The oldest land has been that of the Gold Range, and the Carboniferous deposits laid down east and west of this barrier differ widely in character. The Carboniferous closed with a disturbance which shut the sea out from a great area east ofthe Gold Range, in which the red gypsiferousand saline beds of the Juratrias were formed. In the Peace River region, however, marine Triassic beds are found on both sides of the Rocky Mountains.

A great disturbance, producing the Sierra Nevada and Vancouver ranges, closed the Triassic and Jurassic period. The shore line of the Pacific of the Cretaceous in British Columbia lay east of the Coast Range, and the sea communicated by the Peace River region with the Cretaceous Mediterranean of the great plains. The Coast Range and the Rocky Mountains are probably in great part due to a post-Cretaceous disturbance, though the last-named range existed before the Cretaceous period in the Peace River region.

No Eocene deposits have been found in the province. The Miocene of the interior plateau is probably homologous with King's Pah-Ute lake of the 40th parallel Miocene. In the Pliocene the country appears to have stood higher above the sea-level than at present, and during this time the fiords of the coast were probably worn out.

Abstract of Notes by Principal Dawson on Fossil Plants Collected by Mr. Selwyn, F.R.S., in the Lignite Tertiary Formation, at Roches Percées, Souris River, Manitoba.—The Lignite Tertiary Group of Manitoba and elsewhere in the Western Plains, rests immediately on the Upper Cretaceous, and holds extensive deposits of valuable Lignite, associated with shale and sandstone containing numerous remains of plants. This flora resembles very closely in its aspect that of the Miocene Tertiary of Europe, but its stratigraphical position and animal fossils seem to indicate that its actual age is greater than this. Various attempts have been made to subdivide it, and to separate portions of different ages; but, so far, there is reason to suspect that the subdivisions are merely local, and that the whole belongs to a period of transition between the Cretaceous and Tertiary ages.

Mr. Selwyn's specimens are remarkable for their good state of preservation, being enclosed in a hard arenaceous and ferruginous material, much better adapted to their preservation than the soft shales in which *the fossils of this formation usually occur.*

One of the most remarkable leaves in the collection is that of a magnificent *Platanus* or Sycamore, a foot or more in length and of proportionate width. 'It is identical with *P. Nobilis* of Newberry, from the Tertiary beds of Fort Clarke on the upper Missouri. Mr. Selwyn's specimens, which show the venation and margin very perfectly, justify Newberry's reference of the leaf to the genus *Platanus*. They also show, in one specimen, a feature not preserved in those previously found, namely the presence of two short basilar lobes extending backward on the petiole. Each of these is about an inch in length, pointed at the extremity, and with one large lateral tooth, and two nerves, one extending to the point, the other terminating in the tooth.

Another interesting leaf represents a species of *Sassafras*, a genus not hitherto found in our Lignite Tertiary, though represented in the Cretaceous and in modern times. The species has been dedicated to Mr. Selwyn, being apparently new. The collection also includes several Poplars, as *Populus arctica*, Heer, *P. cuneata*, Newberry, and *P. acerifolia*, Newberry, a Hazel and a chestnut-leaved Oak, apparently a new species. There are also some interesting coniferous trees, as *Sequoia Langsdorfii*, an ally of the giant trees of California, *Taxodium Occidentale*, of Newberry, and *Taxites Olriki* of Heer.

The flora indicated is, on the whole, similar to that of the Porcupine Creek group of Dr. G. M. Dawson's Report on the forty-ninth parallel, that of the Lignitic area of the Mackenzie River, described by Heer as Miocene, that of the Fort Union group of Newberry, and of the Carbon group of Lesquereux,—formations variously regarded as Eocene or Lower Miocene, and very widely distributed over the western plains.

These plants will be fully described in a forthcoming report of the Geological Survey, where their affinities and geological relations will be discussed.

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