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EXHIBITING A VIEW OF THE

PROGRESSIVE DISCOVERIES AND IMPROVEMENTS

IN THE

SCIENCES AND THE ARTS.

CONDUCTED BY

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Berzelius criticised this argument with justice. He declared that it seemed to him the same as if a man who is stumbling in the dark, should hesitate to make use of a light, because he would then see more than he required, and because he hoped to find his way without it.

In order to appreciate fully the great merit of Berzelius, in putting forward his mineral system, it is only necessary to call to mind how great was the chaos in mineralogy before his time, and especially with regard to the classification of the numerous compounds of silica. Although both Döbereiner and Smithson commenced to regard silica as an acid, at about the same time as Berzelius, still it was he who first made an extended application of this view, in the new mineral system which he proposed, by means of which siliceous minerals were included under the head of saline compounds, and the correct conception of their composition first rendered possible.

The greater number of natural compounds of silica are double salts; and observing the great diversity among them, Berzelius raised the question, as to whether it was probable that the individual members of such double salts were different stages of saturation. As he had previously assumed only the most simple relations in chemical compounds, he was at first led to infer upon theoretical grounds, that the existence of dissimilar stages of saturation in the double salts of silica, was less probable, especially as he had never met with any similar phenomena in his investigations of the double salts of other acids. Nevertheless, he subsequently altered this view, after he had himself first prepared the remarkable double salt of neutral carbonate of magnesia and bicarbonate of potash.

The salts of silicic acid, and indeed all true compounds occurring in natural as well as artificially prepared salts, received formulæ which expressed their composition. But as Berzelius was long doubtful how many atoms of oxygen he should assume in silica, and even when he afterwards decided for three atoms, did not regard this assumption as perfectly certain, he introduced more simple formulæ for siliceous compounds, which he termed mineralogical, and distinguished from the chemical formulæ by the printers' type employed.

The establishment of correct formulæ, especially for siliceous compounds, involved great difficulties since the composition of very few minerals was known with any degree of certainty. The first quantitative analyses of minerals were made by Torbern Bergman, but according to such imperfect methods that they scarcely indicated anything more than the qualitative composition. After these came the analyses of Klaproth, which compared with those of Bergman were a considerable and encouraging advance, for he had not only employed better methods of investigation, but also worked with much greater accuracy. But even the analyses of Klaproth as well as those of Vauquelin and others, who worked simultaneously with him, when put to the test of definite chemical proportions were not found to be unquestionable. It is true that at first Berzelius could very often only propose a conjectural formula for the composition of many minerals, and generally only when he made some slight alterations in the results of the then known analyses, in doing which, however, he always proceeded with great caution. Afterwards these incorrect analyses were replaced by correct ones, and indeed especially by Berzelius himself and his pupils, who employed in their analyses the most accurate methods proposed by him.

Berzelius first arranged minerals according to their electro-positive constituents. But after Mitscherlich's discovery of isomorphism, which has exerted so important an influence upon the arrangement of the system, he considered it more advantageous to classify minerals according to their electro-negative constituents, because the substitution of isomorphous substances is far more frequent among the bases than among the acids; and therefore the classification according to the electro-negative constituents corresponded more with the requirements of mineralogists. Both methods have their advantages; they are equally philosophical, and may be employed with equal justice; it is therefore a great injustice that Berzelius should have been charged with inconsistency in making this alteration.

The mineral system of Berzelius is not even yet completed. He was far from wishing to affirm that it was incapable of improvement, on the other hand, during his whole after-life he continually improved it, and from time to time published it in a more perfect form. The last edition was superintended by Rammelsberg in 1847 at the request of Berzelius.

The most important modifications still to be made on this system, are perhaps those which would result from a more simple application of the doctrine of isomorphism. It is certainly difficult to harmonize the opinions as to how this ought to be done.

Berzelius was not quite right in affirming that it is the constituents of a substance alone which must determine its place in a system. Even in the last "*Jahresberichte*" published by him, he declares that, in a mineral system, the sole question for consideration is the elements and their inorganic combinations, and that it is these which must be systematically arranged. But he himself directs attention to the difficulties which this view necessarily involves. Is it, he asks, admissible to make one species of diamond and graphite, or of rutile, Brookite, and anatase, or of calcareous spar and arragonite? It is scarcely to be expected that mineralogists will give their consent to such a course.

However, Berzelius decides in the affirmative. Still I am of opinion that there are even many chemists who will not unconditionally agree with him in this. For it is not alone from the constituents that all the characteristic properties of the compound result, but also from the mode and action of their combination, which is frequently indicated by the form. Taking all this into consideration, it appears probable that dolomite is more closely related to calcareous spar than arragonite, and even that tinstone is nearer to rutile than anatase and Brookite.

Since the external characters of minerals are determined, as well by their constituents as by the mode in which these are combined with each other, it follows that that chemical system of mineralogy which approaches most closely to the natural systems, or which even corresponds with them, must be the most perfect.

Some time after the appearance of the mineral system, Berzelius published his work "*Ueber die Auwendung des Löthrohrs in der Chemie und Mineralogie.*" He had, in Fahlun, under the guidance of his older friend Gahn, a pupil of Torbern Bergman, acquired an uncommon dexterity in the use of the blow-pipe, enriched this special part of chemistry with a number of original investigations, and brought it to a high degree of perfection. In the above-mentioned work he makes known everything connected with the subject, as well what he learned from Gahn as what he had himself discovered.

It is rarely that a work has been welcomed by chemists as this was; but it is also seldom possible at once to recognise the practical value of a work, as in the case of this. It was immediately translated into most European languages; and in some, especially the German, passed through several editions. Everywhere it met with merited appreciation; and Mr Children alone, the editor of the English edition, allowed himself to add remarks as superfluous as ill-natured.

Besides the behaviour of the most important chemical compounds, all metallic oxides, acids, and their salts, sulphurets, &c., before the blow-pipe, Berzelius described the behaviour of all minerals which he could obtain, and which were so much the more readily placed at his disposal, as he required only very small quantities for these experiments. He entered upon this investigation with untiring industry, and was thus able to furnish even those mineralogists who but unwillingly admitted the influence of chemistry upon mineralogy, with an extremely welcome gift, since, by simple blow-pipe experiments, it was possible to distinguish minerals with ease and certainty, especially among siliceous compounds, which were with difficulty, or only ambiguously, recognisable by means of their external characters.

This work bore so manifestly the stamp of perfection, even on its first appearance, that, with the exception of Plattner, in Freiberg, no one has contributed any essential additions or improvements to blow-pipe investigations; and it is quite as indispensable to the chemist and mineralogist at the present day as it was thirty years ago.

About this time, Berzelius discovered selenium, and was engaged upon the admirable investigation of this element. Never was there an examination so accurate and thoroughly exhaustive, of an interesting and hitherto unknown element, comprising all its characters and remarkable combinations, so that, if we except the discovery of selenic acid by Mitscherlich, which escaped Berzelius, nothing essentially new was added to our knowledge of this element during the next thirty years. Our astonishment at this must be raised, when it is recollected that all these investigations were carried on with a very small quantity of material, only about an ounce of selenium, of which quantity a part was lost, owing to the carelessness of a servant.

This paper upon selenium can only be compared with that by Gay-Lussac upon iodine, which appeared several years before, and has yielded, in so many respects, such valuable results. It must, nevertheless, be remarked, that Gay-Lussac was not the discoverer of iodine, and did not undertake the investigation until after the first chemist of that time, Davy, had almost established the true nature of iodine; and that he had large quantities of material at his disposal.

Almost at the same time that Berzelius was engaged in the examination of the compounds of selenium, Arfvedson occupied himself in his laboratory with the analysis of some Swedish minerals; and under the guidance of Berzelius, succeeded in discovering lithium, which, as it came so unexpectedly, justly created great interest.

The following larger papers of Berzelius form, as it were, a series of monographs upon separate and important branches of chemistry, which were at that time still obscure. It was natural, that when he commenced the demonstration of the law of definite proportions by means of a succession of laborious investigations, that he must throw aside much, in order to sketch the groundwork of his system. The investigations which he now undertook, were all instituted in accordance with a matured plan, and he had long meditated upon them before actually entering upon them.

The first of these investigations was upon the ferruginous cyanogen compounds. Gay-Lussac had, in his very important paper upon cyanogen, neglected to study these compounds. After him several chemists had occupied themselves with their examination, but all obtained very different results, the greater number, however, assuming that the iron in the so-called ferro-prussic acid salts was an essential constituent of the acid which was combined in the salts with an oxidized body.

Berzelius, however, shewed that these salts contained neither prussic acid nor oxidized bases, but that they consist of cyanide of iron combined with the cyanide of an alkaline metal, and consequently were double cyanides. He also extended his investigations to the so-called sulpho-cyanic acid salts, and shewed that they consist of metal, sulphur, and cyanogen, the latter two united to form a radical (which he subsequently called Rhodan); and that in them likewise there was neither prussic acid nor oxidized bases.

These investigations, which fully confirmed the views of Gay-Lussac regarding cyanogen, were, however, of still greater importance to Berzelius in another respect. After Davy had been induced, by his researches in 1810, to consider that it was simpler and more correct to look upon chlorine as elementary, and not, as he had formerly done, as a compound of oxygen with a radical that had not been isolated; most chemists concurred with him in this view. Gay-Lussac and Thénard, who, even before Davy, considered a similar view possibly correct, although not exactly more probable than the old one, after the discovery of iodine, openly declared themselves, with Vauquelin and all the other French chemists, in favour of the new doctrine; and the famous paper of Gay-Lussac upon iodine, which appeared in 1813, is written in this spirit.

Berzelius alone, who from the first had disputed the hypothesis of Davy, continued to defend the old doctrine, even after the discovery of iodine. He did this especially in a paper which first appeared in Gilbert's Annalen for 1815. He there endeavoured, with a profound sagacity which cannot but be highly admired by every one, even on reading the paper after the lapse of so long a time, to prove the truth of the doctrine of the compound nature of chlorine. He directed attention to the remarkable phenomenon that the constituents of chloride of nitrogen, which are united only by a very feeble affinity, separate with such an energetic evolution of heat as is never observed except in chemical combinations. But above all, he pointed out the analogy which existed between muriates, which, according to the new theory, in the anhydrous state contain no oxygen, and the sulphates, phosphates, and other salts, which are indisputably compounds of oxygen acids with oxygen bases, and in which the presence of oxygen may be readily detected.

The great authority of Berzelius, and the soundness with which he carried out his refutation of all the evidence brought forward in favour of the new theory, were the reasons why many chemists, especially in Germany, did not adopt Davy's view of the nature of chlorine.

The immediate cause of Berzelius undertaking the investigation of the cyanides of iron was evident, viz., he expected to find in them a more compound radical (united with oxygen forming an acid) associated with an oxygen base, and similar to that which he assumed to exist in muriates. It cannot be disputed that to some extent he doubted the accuracy of Gay-Lussac's experiments on cyanogen. Then, as the salts of the ferrocyanic radicals resemble so closely in their characters the ordinary oxygenous salts, and especially as several metallic cyanides, such as cyanide of mercury or silver, correspond so completely with the analogous chlorine compounds, he was of opinion that if he could by this investigation detect oxygen in the ferrocyanic compounds, it would be a strong proof of its presence in muriates likewise, and, consequently, evidence in favour of the old theory of the nature of chlorine.

However, the result of these investigations was the opposite of that which he expected, and thus the main argument against the new doctrine of the nature of chlorine fell to the ground. When gradually other reasons for the greater probability of the new theory were discovered, Berzelius adopted it with the most amiable candour, and relinquished the old theory which he had so long and so ably defended.

One, among other, of these reasons was, as I know, the following :—Immediately after Berzelius' investigations on the cyanides of iron, Leopold Gmelin obtained the interesting red double salt of cyanide of potassium and cyanide of iron, which is anhydrous and contains no oxygen. The red colour of the peroxide of iron, which is more or less communicated to all its salts except the neutral ones, was to Berzelius an additional reason for regarding the red perchloride of iron as an actual salt with an oxygenous base ; and, as in the salt obtained by Gmelin, notwithstanding its red colour, the iron was not in the state of oxide, but directly combined with cyanogen, one double atom of iron with three double atoms of cyanogen, Berzelius saw that it was probable that the red colour of iron compounds was not owing alone to the presence in them of peroxide, but was also common to those in which one double atom of iron is combined with three double atoms of chlorine or cyanogen.

Another main inducement to adopt the new theory of the nature of chlorine, consisted in the results which he derived in favour of it from his subsequent comprehensive researches upon alkaline sulphurets. According to Berthollet's investigations, these bodies were regarded as combinations of sulphur with alkalies until Vauquelin put forward the opinion, that when a fixed alkali was melted with sulphur, a part of the alkali was reduced to the metallic state, sulphuric acid was formed, and a mixture of alkaline sulphate and sulphuretted metal was obtained. This which Vauquelin was only able to put forward conjecturally, and could not demonstrate by convincing proofs, was immediately proved most satisfactorily by Berzelius through his successful reduction of sulphate of potash by means of hydrogen or the vapour of the sulphuret of carbon. He thus obtained sulphuret of potassium in which there could not be any oxygen. By treating anhydrous lime with sulphuretted hydrogen at a high temperature, Berzelius likewise obtained water and sulphuret of calcium. This experiment rendered it obvious that when liver of sulphur is obtained by melting together sulphur and carbonate of potash, the solution in water contains sulphuric acid, which is not, as Berthollet conjectured, first formed by the decomposition of water, but is a joint product with the liver of sulphur of the reduction of the alkali. Berzelius found, moreover, that the alkaline metals combine in several definite proportions with sulphur forming substances which are all soluble in water. Thus arose the question : What is contained in such a solution ?—a question, the answer to which is especially important when regarded in connection with the solutions of metallic chlorides. Is this liquid a solution of the unaltered sulphuret in water, or is the alkaline metal oxidized, and, consequently, a compound of sulphuretted hydrogen with alkali formed, or a compound of sulphuretted hydrogen, sulphur, and alkali ? Since, in the last case, it would be necessary to assume as many compounds of sulphur with hydrogen as there are compounds of sulphur with the alkaline metals, Berzelius decided in favour of the second view. Subsequent investigations of the solution of sulphur compounds of the metals of alkaline earths in water, have, in fact, shewn that a decomposition of water really does take place in this case, and that a compound of metallic sulphuret with sulphuretted hydrogen and alkaline oxide is formed.

Berzelius regarded these investigations as proving that sulphur compounds exist which are very analogous to the muriates, and that there might likewise be bodies which, without containing an acid and an oxygenous base, possess, like the chlorides, all the peculiar characters of salts ; and, consequently, if this were so, all that evidence against the new theory of chlorine fell to the ground which he had derived from the perfect analogy of muriates with salts, which consist of an oxygen acid and an oxygenous base.

With this investigation of alkaline sulphurets was connected the equally important one upon the sulphur salts, which, however, did not appear until several years afterwards. In the former paper Berzelius had directed attention to the fact, that the sulphur compounds of alkaline metals and of earthy metals combine with other metallic sulphurets in the same way as the oxides of these metals combine with other oxides. Double sulphurets are thus formed which admit of being compared with ordinary salts, inasmuch as one metallic sulphuret constitutes the electro-positive, that is, the basic part of the compound; the other, on the contrary, the electro-negative part, representing the acid. But here only the lowest sulphurets of the alkaline metals, that is, those corresponding as regards their composition with the basic oxides of these radicals, will fill the place of basic sulphurets; the higher sulphurets behave, as it were, like peroxides; they may sulphurise other metals, but do not combine with their sulphur compounds.

The different stages of sulphuration of the electro-negative metals which Berzelius called sulphides, and whose composition is analogous to that of the metallic acids, combine with the electro-positive or basic sulphurets in such proportions, that if the sulphur were replaced by an equal number of atoms of oxygen, some one of the salts would be formed which the same radicals would yield in their oxidized state.

Of the sulphur compounds of the non-metallic elements, those of carbon and hydrogen alone combine with the basic sulphurets of the metals; the latter class of compounds,—those of sulphuretted hydrogen with alkaline sulphurets,—were already known under the name of hydrothio-alkalies, but their true composition was not recognised until now.

Berzelius regarded this extensive series of sulphur compounds quite appropriately as salts, and gave them the suitable name of sulphur salts, in order to distinguish them from the oxygen salts, or those which had been long known, and the so-called haloid salts, under which name Berzelius comprised the compounds of chlorine, bromine, iodine, fluorine, and cyanogen, as well as other compound radicals with metals.

This discovery of sulphur salts is indisputably one of the most important extensions of chemistry. Berzelius entered upon their study with great industry, and the number of sulphur salts examined by him amounted to about 120, to many of which he certainly could only give a passing attention, although he analyzed many quantitatively.

Next to this followed his investigation of hydrofluoric acid, one of the most important which Berzelius executed, since it has thrown such an unexpected light upon several of the most interesting departments of chemistry.

Thénard and Gay-Lussac had indeed already prepared hydrofluoric acid in a pure state, and several of its compounds. But as they were at the same time occupied with a number of other important researches, they did not pursue this subject further, and especially did not study with sufficient accuracy the phenomena which presented themselves when potassium was heated in fluoride of silicium.

Berzelius, in the first instance, prepared the most important metallic fluorides; then he went on to the remarkable compounds which hydrofluoric acid forms with electro-negative fluorides, especially fluoride of silicium, and fluoride of boron, but also with fluoride of titanium and others. It was through him that we first acquired a correct conception of the composition of hydrofluosilicic acid and the fluosilicates, as well as of the action of water upon fluoride of silicium. But the most productive part of this investigation was when Berzelius repeated the experiments of Gay-Lussac and Thénard, for the purpose of decomposing fluoride of silicium by means of potassium. He had just at this time learned from Wöhler how to prepare potassium by means of carbonate of potash and carbon according to Brunner's method, and thus provided himself with large quantities of this metal. On decomposing fluoride of silicium by potassium he obtained the same results as the French chemists, namely, the brown non-metallic substance which they regarded as a complex compound of fluosilicide of potassium and of fluoride of potassium with silica. Berzelius found that it was impure silicium, which, when washed with water, could be obtained free from all fluorine compounds. It then contained only an admixture of silica, which could be extracted by concentrated hydrofluosilicic acid, after having previously been slowly heated to redness. He moreover shewed that the silicium could be obtained in different states of density, and with different characters.

This unexpected result induced him to undertake similar investigations with fluoride of boron. We are indebted to him for a correct knowledge of the decomposition of fluoride of boron by water, and of the composition of the fluoborides, as well as an easy method of preparing boron, by treating fluoboride of potassium with potassium. He likewise discovered at this time the gaseous chloride of boron, and corrected the views of the composition of boracic acid by his own experiments and those of Arfvedson. He moreover prepared the compounds of fluoride of titanium with metallic fluorides, especially fluoride of potassium, from which body he shewed how metallic titanium was to be obtained by means of potassium. This is the only method by which titanium can be obtained in a pure state ; for the experiments of Wöhler have proved that the substance found in the slags of iron furnaces, and formerly called metallic titanium, contains nitrogen and cyanogen. The compounds of fluoride of tantalum with metallic fluorides were also prepared, and he obtained metallic tantalum in the same way as titanium. He then reduced zirconium from the zirco-fluoride of potassium by means of potassium, studied the characters of zirconia, and finally turned his attention to the double compounds of fluoride of molybdenum and fluoride of wolfram with metallic fluorides, of which, however, he only prepared the compounds of fluoride of potassium with molybdate and tungstate of potash.

Berzelius had intended to pursue these very interesting investigations of fluorine compounds further. But when he found that a distinguished French chemist had also commenced the study of fluorine compounds, and had already named some newly discovered ones, he gave up his intention.

It must be remarked, that in these investigations Berzelius assumed that fluoric acid was an oxygen acid, and that it contained a radical, combined with two atoms of oxygen, as he had previously done in the case of hydrochloric acid. But in the same year that he gave up his study of fluorine compounds, viz., in 1825, he observed in the first part of the third German edition of his " Lehrbuch," that it was more probable that fluoric acid, like hydrochloric acid, was a hydrogen acid; and he described all the fluorine compounds according to this view.

Together with these comprehensive researches, Berzelius published a number of less extensive ones. They all originated in his meeting with a number of doubtful statements while editing his " Lehrbuch," in reference to which he immediately instituted experiments in his laboratory, for the purpose of quickly deciding upon them. From among these I will here mention only the research upon chloride of lime, which was formerly regarded, according to Gay-Lussac, as a compound of chlorine with lime, and the chlorides of potash and soda were likewise regarded as similar in composition. Berzelius, on the contrary, directly after adopting the view of the elementary nature of chlorine, declared these bleaching compounds to be mixtures of metallic chlorides with salts, containing an oxide of chlorine as an acid. He was of opinion, as he did not closely examine the subject, that the acid was chlorous acid, until the researches of Balard proved that it was hypochlorous acid.

Berzelius proved, that all the other explanations of the composition of the bleaching compounds were incorrect, by shewing that these contained an oxide of chlorine. He dissolved, in a solution of carbonate of potash, as much chloride of potassium as it would take up, and passed chlorine through the liquid without saturating it. After a few minutes chloride of potassium was precipitated, which contained no chlorate of potash, or scarcely any; the liquid had acquired the power of bleaching. When the liquid was separated from the precipitated chloride of potassium, and perfectly saturated with chlorine, chlorate of potash was precipitated, containing scarcely any chloride of potassium. Consequently, during the first action of the chlorine, chloride of potassium must have been formed from potash, the oxygen of which could only have combined with chlorine, giving rise to the production of the bleaching compound.

It had long been the wish of Berzelius to investigate the rare metals accompanying platinum, the knowledge of which had been left imperfect by the chemists who discovered them. He was enabled to carry this into execution, when, after the discovery of the large quantities of platinum in the Ural, he received, through Herrn von Caucrin, a considerable quantity of native platinum, as well as native Osmium-Iridium. This circumstance led him into a very important investigation of the process for decomposing native platinum ores, by means of which the rare metals accompanying platinum were first properly made known. He studied the characters, determined the atomic weights of Rhodium, Palladium, Iridium, and Osmium, and prepared a number of their compounds. Owing to the great number of the oxides and chlorides of these metals, and their great similarity to each other, this investigation was very difficult; and, as regarded osmium and osmic acid, a very unpleasant one. But although Berzelius himself declared that he had as it were given only the first sketch of the history of these metals, still this research, like all that came from his hands, was an extremely accurate, and to a certain extent, perfect one.

The next investigation of Berzelius was in reference to a new and peculiar earth, Thoria, which he had discovered in a mineral from Brevig, in Norway. He had previously, on examining the mineral near Fahlun, found an earthy substance in very small quantity, which he regarded, although not with certainty, as a new earth, which he called Thoria; subsequently, however, he convinced himself that it was phosphate of Yttria. Since the newly discovered earth resembled, in some of its peculiar characters, alumina, he called it likewise Thoria; the mineral in which he had detected it, Thorite, and the metal which he obtained from its volatile chlorine compound, Thorium. Thoria belongs to a group of earths which are very similar in their characters to zirconia, and of which Svanberg, Bergemann, and Sjögren have recently discovered several. At first Berzelius assumed that thoria contained only one atom of oxygen; the experiments, however, which he made for the purpose of determining the atomic weights of the metal and earth, are probably not quite decisive, and it is perhaps more likely that the earth is composed of two atoms of metal and three atoms of oxygen.

The next subject to which Berzelius turned his attention belongs to organic chemistry. It was a comparative investigation of tartaric and racemic acids. He first corrected his former analysis of tartaric acid, in which he had given an atom more hydrogen than Prout and Hermann, and adopted the results of these chemists. But he then found that the crystallised tartaric acid had precisely the same composition as the effloresced racemic acid, and that both acids had the same capacity of saturation,—facts which, especially at that time, were in the highest degree remarkable. This was one of the first clearly demonstrated examples that bodies of different characters may have the same composition. Berzelius had, sometime before, observed a somewhat similar fact in reference to the oxides of tin, and Faraday, a short time afterwards, in reference to the compounds of carbon and hydrogen. Clarke had also discovered the remarkable modification of phosphoric acid, which he called pyrophosphoric acid. On this occasion Berzelius combined together, in an interesting manner, what was known of these bodies, to which he gave the name Isomeric. This term has been universally adopted, now that the number of such bodies has been so greatly increased.

From this time Berzelius frequently occupied himself with subjects which are certainly of the greatest interest for every thinking chemist, and indeed for every scientific man, since they are calculated to unfold to us somewhat more fully the nature of matter. He made known his views on this subject repeatedly, both in his "Jahresberichte," and in the several editions of his "Lehrbuch." Finally, he assumed two essentially distinct kinds of isomerism, and, in the strictest sense of the word, called those bodies only isomeric in which the elementary atoms may be regarded as grouped in different ways, forming compound bodies. These isomeric bodies may again be of two different kinds. They consist either of compounds which, with equal atomic weights, present different characters, or of compounds in which, though they possess different characters, the relative proportion of the constituents is the same, but in which the atomic weights are not equal, but twice, thrice, etc., times as great as that of each other. Such bodies Berzelius termed, for the sake of antithesis, Polymeric compounds.

The other kind of isomerism Berzelius called Allotropism. It refers solely to elementary bodies, which, owing to causes not yet sufficiently understood, assume a different character from that which is usual to them, and, as it appears, retain this difference in many combinations, when it may be the cause of differences in the character of these compounds. When isomeric conditions are observed in compound bodies, which consist of only two elements, combined in very simple proportions, this isomerism is, according to Berzelius, to be regarded less as owing to the different arrangement of the elementary atoms than to the allotropic condition of one or both of these elements; nevertheless, instances may occur in which both causes are simultaneously at work.

It is possible that Berzelius may sometimes have gone too far in his assumption of allotropic conditions, for there are some grounds for believing that an apparent allotropism may result merely from a different state of division. Thus, a few years before the discovery of the first example of isomerism, Magnus observed the interesting fact, that when the oxides of iron, nickel, and cobalt, are reduced by means of hydrogen to the lowest possible temperature, the metals obtained ignite spontaneously, and oxidize when exposed to the atmosphere. This pyrophoric character evidently results from the finer subdivision of these metals, and it is destroyed when a higher temperature is employed in their reduction, which causes the particles to cohere together. The differences in platinum, according as it is reduced from its salts by the humid process, or obtained by igniting the ammonio-chloride: likewise the unequal combustibility of silicium, and its variable solubility in hydrofluoric acid, may probably be explained in the same way. Nevertheless, Berzelius was inclined to ascribe all these differences to allotropic conditions.

Shortly after the appearance of the paper in which Berzelius treated of bodies which, with the same composition, have dissimilar characters, Dumas went so far as to put forward the bold question, Whether many elementary bodies were not allotropic conditions of one substance, especially such as have the same, or very nearly the same, atomic weight, as nickel and cobalt, platinum and iridium, &c.? Berzelius favoured this hypothesis, and regarded it as befitting, that new ideas should be followed up in all directions, even when it is not possible at the same time to adhere strictly to that which is, for the moment, to be regarded as probable; for truth sometimes appears inconsistent at the first glance, and in any case this was a way to arrive more rapidly at the results which might follow from a new idea. Certainly, upon the other hand, it cannot be denied that the question respecting a relation similar to isomerism between elements which have analogous but still distinctly different chemical characters, belongs to a domain, where perhaps our conjectures will never admit of being put to the proof.

The next paper by Berzelius was upon Vanadium. Sefström had found a new metal in the bar-iron of Taberg, which he called by this name. He had, however, restricted his investigation to the preparation of the oxide, or rather the acid of this metal, from the finer slags of the Taberg iron, and the determination of its distinguishing characters. He then transferred his stock of Vanadic acid to Berzelius, in order that he might investigate the characters and history of the new metal. This investigation is a very extended one, and through it we have become acquainted with the new body in all its relations; whilst, as these are manifold and interesting, and as the acid has but little resemblance to other acids, it was difficult to assign to it its true position among them. In this respect the paper of Berzelius on vanadium may almost be compared with that upon selenium; for both have this peculiarity in common, that by them we have become so thoroughly acquainted with new and hitherto entirely unknown bodies, although in both instances but very minute quantities of rare material could be employed, that subsequent investigations have added but little more at all, and nothing essential. Vanadium was afterwards found at several places, although always in very small quantities. Wöhler directed especial attention to the fact, that the acid of the new metal was contained in the lead ores of Zimapan, in Mexico, in which, as early as 1801, Del Rio discovered a new metal, and called it Erythronium; but, misled by the authority of Collet-Descotils, who declared it to be chromium (with which Vanadium has certainly some similarity), he afterwards admitted that his discovery was an error.

His next researches, which were upon Tellurium, were of a similar nature. Berzelius had already instituted experiments with very minute quantities of this metal, in so many respects interesting, but he was compelled to discontinue them for want of material. When Wöhler sent him a considerable quantity of this rare metal, which he had prepared from the telluric bismuth of Schemnitz, he again commenced the investigation. He first shewed how this metal can be prepared in its purest state. He then prepared all the compounds of tellurous acid (peroxide), as well of telluric acid, discovered by him, with bases, and indeed the different isomeric modifications which these acids form. These researches are likewise so complete, that they have fully developed the history of this remarkable metal in all its relations.

The last great investigation by Berzelius, is that upon meteoric stones. He undertook this with the intention of studying these bodies, as my brother and Nordenskjöld had already done, as species of rocks, and, by this means, to determine what individual minerals they contained. The immediate inducement was a meteoric stone sent to him by Reichenbach, which had fallen a year previously in Moravia. But besides this, he examined three other earthy meteoric stones, and two masses of metallic iron. Berzelius inferred from his analyses that meteoric stones consist entirely of such minerals as are found upon the earth, and that they certainly do not contain any elementary constituent which is not met with in terrestrial bodies. It was only in the meteoric stone of Alais that he found carbon in an unknown state of combination: this stone, when placed in water, disintegrated and fell to powder, which had a mixed smell of clay and hay. This shewed that if, as Berzelius considered, meteoric stones originated from other cosmical bodies, in their native state they could be converted into clayey mixtures, like the rocks on our own globe. He then raised the question as to whether this carbonaceous earth from the surface of another cosmical body contained organic remains, and consequently, whether there were upon its surface organised bodies, more or less resembling those on our earth? It is easy to conceive the interest with which he attempted to solve this question. This solution was not affirmative, but the results of his experiments did not justify a negative inference. Water and alkalies did not extract anything organic from the meteoric mass; on dry distillation, however, carbonic acid, water, and a blackish-grey sublimate were obtained, but no empyreumatic oil and no hydrocarbon; the carbonaceous matter was, therefore, not of the same nature as the humus upon the earth's surface. The sublimate heated in oxygen, gave no carbonic acid or water, and changed into a white insoluble substance, whose nature could not be determined on account of the minute quantity. But to have pronounced it to be an elementary body, not originally belonging to our earth, would have been an exaggeration.

This was the last extensive research made by Berzelius. His health, which, never strong, had already often necessitated the interruption of his labours, became, with increasing age, more delicate, and no longer admitted of his remaining continuously in the laboratory. He suffered, as is not unfrequent with intellectual men, especially from nervous headaches, which could not be mitigated by the most moderate living. He now began to complain of a failing of the senses, especially his sight, and also of the weakness of his memory.

But his scientific activity did not on this account cease. He interested himself to the last for every branch of chemistry, and took the most active share in all the achievements of this science. Indeed, now that he was no longer occupied by important practical labours, he concentrated his activity more especially upon undertakings of a literary character, and with a zeal and industry which deserve the greater acknowledgment, since his bodily sufferings increased every year.

Among the products of the literary activity of Berzelius, I will here only make especial mention of the different editions of his "Lehrbuch der Chemie," and his "Jahresberichte ueber die Fortschritte der Physikalischen Wissenschaften." His other works, the lectures upon Animal Chemistry, and his work on the Blowpipe have already been spoken of.

The "Lehrbuch der Chemie" first appeared in Swedish. It was translated into German first by Blumhof, then by Blöde and Palmstedt, and the later editions were translated by Wöhler and Wiggers. It was also translated into other languages, but did not pass through so many editions in any, as in the German, for besides the translations of Blumhof and Blöde, five editions have appeared. The last but one, the fourth, consisted, on completion, of ten parts. The fifth and last was commenced by Berzelius in 1842, but was not completed, only five volumes having appeared, certainly very large, each one containing nearly sixty sheets. The inorganic chemistry alone is completed. Of the organic part contained in the last two volumes, the most important—the animal chemistry—is wanting.

In this work Berzelius has treated very fully of all the facts appertaining to the science, with a remarkable clearness, perspicuity, and apt illustration. At the same time, every subject is criticised in such an impartial and just manner as can be displayed only by one who stands as high in science as he did. The arrangement which he selected is indeed not a strictly systematic one, which, in a science so imperfect as chemistry, can certainly only be called convenient. But especially in the inorganic part, there is still a certain well-founded succession, such that it is very easy to become familiar with the work. In the organic part the facts are not arranged according to a strict scientific principle, and a classification adapted for inorganic compounds could not possibly be carried out with organic bodies. For although Berzelius had always declared himself strongly in favour of the application to organic chemistry of what we know of the mode of combination of the elements in inorganic nature, as the clue by which alone we could arrive at a knowledge of organic bodies, still he was compelled to admit, that we were far from having advanced so far as to be able to treat of all organic bodies as radicals, oxides, chlorides, &c., as in inorganic chemistry. Most of the assumed organic radicals, often of a complicated nature, are of a hypothetical nature; they gain a somewhat certain character only when some compounds of the radical with other simple radicals can be produced, and the oxygen in them replaced by chlorine, sulphur, &c. In addition to this, chemists are of very different opinions as to how the composition of organic bodies is to be represented, even when they agree in a fundamental principle. Moreover, as is natural, the different arrangements vary, according as more new facts are discovered. For the present, therefore, it is at least more advantageous to treat of organic bodies in an elementary work in such a way as Berzelius has done, namely, in groups containing those bodies which have the greatest general similarity in chemical characters. It has frequently been seen, that works in which a theoretical principle has been strictly followed throughout, do not so well fulfil their principal object.

In the organic part of his work, Berzelius has declared himself against the so-called substitution theory, and the law of types. He assumes, on the contrary, that conjugate compounds exist in organic bodies, in which, for instance, acids are united with compound radicals, or with their oxides, chlorides, &c., in such a way that the acid is not saturated, but is still capable of combining with bases without separation of the associated substance,—the conjunct,—which enters with the acid as a constituent of the salt. When an acid has entered into such a conjugate combination, it has generally acquired such altered characters, that neither the acid nor its salts are similar to the free acid and its salts. When hydrogen is replaced in an organic substance by chlorine, or another halogen, this generally takes place in the conjunct and not in the acid, and the former does not on this account cease to play its former part, of modifying the character of the salts into which it enters, with its acids, more or less, and accordingly as its composition is altered by substitution.

It has been asserted that the replacement of hydrogen by chlorine, in organic compounds, was not to be explained at all in accordance with the electro-chemical views of Berzelius, and that consequently these views were incorrect. But when such a substitution takes place, it is, as already mentioned, generally only in the compound radical,—that is, the conjunct, and a new radical is thus formed, in which chlorine may perhaps occupy the place of hydrogen, but cannot play the same part as it did. Substitution of elements may therefore be very satisfactorily explained, according to the principles of Berzelius ; and if his theory be impartially compared with the others which have been put forward in such number in organic chemistry, the inference will be, that in the present state of the science it is in a position to explain the facts more satisfactorily than any other.

On looking carefully through the various editions of this work, it is impossible not to regard it with admiration. It is not only the clear and comprehensive description which attracts,—the sound, impartial criticism, which compels men of opposite opinions to appreciate justly,—or the great minuteness which has not left unnoticed a single fact, however trifling, if it was of any influence—but it is also the enormous industry which must create astonishment. A scientific man who had done nothing more than publish this excellent work, in so many editions, each of which was so completely revised that but little of the previous edition was retained, could not be refused by us our grateful acknowledgments of his great industry: and yet this constitutes but a fraction of the achievements of Berzelius.

It is touching to call to mind the words with which he concluded the preface to the last German edition, which he could not quite complete; it is dated November 1842. He says, " I cannot overlook that, even if the Almighty should grant me life and power to complete the edition of which the first part is now published, this will be the last. For this reason, I considered it necessary to revise it so thoroughly, that I could express the final views which have appeared to me as the most probable during the long space of time in which I was so fortunate as to be able to follow with uninterrupted attention the development of the science, from the first growth of the antiphlogistic chemistry up to the present time—fortunate if, among the many views which a future extended experience will alter or correct, at least some few may prove to have been rightly conceived. With the profoundest conviction of the uncertainty of our theoretical views as well as of their indispensability, I have endeavoured, in presenting them to the reader, not to inspire him with any more firm conviction of their accuracy than they appear to me to merit, and I have therefore always directed his attention to the uncertainty in the selection of modes of explanation. It is a great obstacle to the progress of science to attempt to cause conviction of the truth of that which is uncertain. What is believed is not submitted to any further examination; and the history of science shews that a deeply-rooted belief in theoretical conceptions has often withstood the most palpable proofs of their inaccuracy. Many of the defenders of Phlogiston required a regular development of the doctrine of oxidation in order to be convinced of its truth, and many distinguished men died believing in Phlogiston."

An undertaking by no means less gigantic than his "Lehrbuch" was the publication of the "Jahresberichte," which appeared regularly from the year 1820 until the death of Berzelius. The last completed volume comprises the discoveries of the year 1846. Berzelius therefore published twenty-seven volumes.

After Berzelius had been elected, as successor of the botanist Olaf Swartz, to the office of perpetual secretary of the Academy of Sciences, he succeeded, among other important changes which he considered necessary in the statutes of the Academy, in carrying into effect the arrangement that annual reports on the progress made in the various physical sciences should be written by members of the Academy, especially the different curators of the Natural History collections of the Academy, and that these reports should be presented at the annual public meeting held upon the 31st of March, the anniversary, and extracts read from them, after which they should appear in print. Members of the Academy undertook to write such annual reports in the departments of Botany, Zoology, Astronomy, Mathematics, and Technology. Berzelius himself undertook the reports on Physics, Inorganic

Chemistry, Mineralogy, Vegetable and Animal Chemistry, and Geology.

It was only a man like him, who as it were surveyed at one glance the whole range of chemistry, and himself worked so much in all its branches, that could have adequately executed such an undertaking. These reports will long remain an example of the way in which such productions ought to be carried out. They were very comprehensive in those departments with which Berzelius was most intimately acquainted, —inorganic chemistry, chemical mineralogy, and vegetable and animal chemistry; less so in the other parts, which contained only the most important discoveries in those sciences with which Berzelius had not especially occupied himself, or which he had not pursued during the latter half of his scientific career, such as physics and geology. The reports were generally objectively written. If the views of the author of the original paper corresponded more or less with those of Berzelius, he gave an abstract, proportionate in extent to the importance of the subject, but always most admirable. If, on the contrary, their views differed from his, he allowed himself to express his opinion upon them, and observed a noble and impartial criticism, which rarely became at all violent. In this respect, it is certainly to be regretted that precisely his last "Jahrbericht" closes with an energetic attack upon another celebrated chemist. But Berzelius never mixed up personalities with his judgments; and if sometimes one could not agree with them, still they were always of such a nature, that although they occasionally gave pain to those upon whom they were passed, they could never excite any bitterness.

For the science itself these reports were of the greatest value. Berzelius, on several occasions, drew from the investigations of others important conclusions, which had entirely escaped the notice of their authors; and as frequently did he direct attention to new experiments which should be made in order to strengthen the results already obtained, or upon which to found new arguments. In this manner he exercised a very beneficial influence. He was also led to make experiments himself by these reports; and he then gave their results, when they contradicted, improved, or extended those of others, in the reports.

These reports were especially long when it was necessary to refute opinions and views which Berzelius considered as detrimental to the progress of science. Thus, the reports of the discoveries of the years 1838 and 1839 contain very detailed arguments against the hypothesis that all organic acids are hydrogen acids, and against the substitution theory. These arguments have always a rare clearness and simplicity.

The objection has often been made to this report, that it was sometimes very complete, and in some instances too extended; sometimes, on the contrary, especially in the physical part, scanty and imperfect. This is certainly true; but it was very natural that Berzelius should have a partiality for the treatment of those subjects in which he especially interested himself and of which he was most master; but as he was almost equally at home in all parts of chemistry, this objection cannot be made to the strictly chemical parts of the reports. With regard to the physical part of the reports, Berzelius had only undertaken it because no other member of the Academy would or could do so. It was only in the years 1838 and 1839 that the report was written by Von Wrede. As Berzelius had only occupied himself with those parts of physics which were intimately connected with chemistry, it is almost only these parts which are touched upon in his reports.

In the same way, there was no other reporter to be found for the geological part; but as Berzelius had never occupied himself specially with geology, and only in so far as it was connected with chemistry, he treated only of the chemical part of that science in his reports, and otherwise noticed only the geological researches referring to Sweden. In the latter volumes reports upon geology are altogether omitted.

I have thus attempted to furnish a sketch of the comprehensive scientific activity of Berzelius. It is probably seldom that science is so greatly advanced through the labours of one man, and there is scarcely any chemist who has furnished such admirable and sound contributions as he.

This representation of his scientific merits would, however, give only a feeble idea of the whole greatness of the man, were we to judge from it alone. It is rare that so perfect a correspondence of mind and character is found in a man as in him. That which so irresistibly attached those who had the happiness to have any long intercourse with Berzelius, was not merely the lofty genius visible in all his researches; it was not merely the clearness, the astonishing copiousness of ideas, the untiring care, and the great industry—the general impression which he made was that of the highest perfection. It was—and every one who knew him intimately will agree with me—it was at the same time those characters which placed him so high as a man; it was the consideration for others, the noble friendship which he evinced towards all whom he considered worthy of it, the lofty disinterestedness, the extreme conscientiousness, the perfect and just recognition of the merits of others; in short, it was all those traits together which spring from a worthy and honourable character. These were the sentiments which inspired all those who for a longer or shorter time came into contact with him, especially his pupils—of whom our Academy contains more than all the rest of Germany—with the most pious respect for his memory.

Berzelius travelled the path of Science together with other distinguished men, who likewise advanced chemistry with giant steps. This was a time such as no other science has yet known, for no other has grown up from its childhood to a certain maturity in so incredibly short a space of time.

Berzelius was born almost in the same year as H. Davy and Gay-Lussac. However similar were the labours of these three men in science, they were in other respects very different.

Davy's brilliant discoveries, especially that of the metallic nature of the alkalies, gave chemistry an extraordinary impulse, and caused great enthusiasm in its pursuit. He achieved great things by his discoveries, the further following out of which, however, he left to others. He died in the prime of life, but in a certain degree his intellectual blossom was already past. Born poor, he had attained to great honours and great riches, which were perhaps obstacles to his being subsequently as active for science as formerly. It is, moreover, in the highest degree to be regretted that, in the latter years of his life, his very extraordinary talents were entirely estranged from that science for which he might have achieved so much.

Gay-Lussac commenced his scientific career with the discovery of an important law in physics, but he afterwards applied himself wholly to chemistry, and advanced it as much by accurate investigations as brilliant discoveries. To him is owing, among other important facts, the law, so important for the doctrine of definite proportions, that gases unite in simple relations of volume,—a discovery of which, however, he did not at first make many applications of which it was capable. But the most brilliant researches of Gay-Lussac are indisputably,—besides those published in common with Thénard on physico-chemical subjects,—the two sets of researches upon cyanogen and iodine. Even independently of the extremely important influence which these researches exercised upon the whole range of chemistry, they may be regarded as models of investigation, both as regards the total results, the strict consistency of the reasoning, and the admirable description. As often as they are read, even at the present day, they will be regarded with astonishment.

But when, soon after the appearance of his paper upon cyanogen, Gay-Lussac undertook, in conjunction with Arago, the editorship of the "Annales de Chim. et de Physique," his scientific activity became gradually less. The first volumes of this Journal certainly contain several small papers and remarks which call to mind the author of those on Iodine and Cyanogen; but after a few years he ceased to write almost altogether; and it is almost more to be sincerely regretted than in the case of Davy, that Gay-Lussac, who died but a short time since, and after Berzelius, should already in the vigour of life have renounced his active scientific career, which seemed to promise so much.

It was not so with Berzelius. He also, after years of poverty, gradually attained, if not to great wealth at least to external honours, without having sought them in the least. But these could not estrange him from science; on the contrary, he took advantage of every higher position for its benefit. Science was always solely the object of his endeavours, and he never employed them for a purpose foreign to it. So completely was his whole life dedicated to science, that, even under the sufferings resulting from a painful disease during his latter years, his whole thoughts remained bent upon it alone.

Such men present in their inspired labours, as it were, the type of the true man of science; and who does not feel himself happy to meet them in life?

Notes on the Geology of Ceylon.—Laterite Formation.—Fluviatile Deposit of Nuera Ellia. By E. F. KELAART, M.D., F.L.S., F.G.S., Assistant Surgeon to the Forces. Communicated by the Author.

Though the geological formations of Ceylon are of a simple nature, and described as such by writers, that attention has not been paid to the laterite formation of the island which it deserves; some have called it decayed clay ironstone, others have described it to be granitic rocks weathered *in situ*. It has not, however, been so slightly regarded by Indian geologists; their more recent researches have discovered new features in this peculiar formation, which have thrown great doubts as to its being the mere result of disintegrated or decomposed trappean rocks *in situ*. Captain Newbold of the Madras Engineers has even gone so far as to suspect it to be of tertiary origin. It is with a view of drawing the attention of observers in this island, for a more complete elucidation of this subject, that this communication is submitted to the Ceylon Asiatic Society.

The term laterite (derived from *later*, a brick) is applied to those masses of reddish clay, more or less indurated, and containing pebbles or crystals of quartz. It is called by the Singalese *cabook*, and it is used extensively for building purposes. There are several varieties of laterite, and which admit of classification. 1. Laterite, properly so called, of a hard, compact, almost jaspedeous rock, formed of indurated clay, tubular or sinuous, in which are impacted quartz crystals of various sizes and colours; generally of a reddish or brick colour. To this kind, the term Quartzose may be applied, as it contains a larger proportion of undecomposed quartz. The cavities and sinuosities are lined or sometimes filled with a whitish, yellowish or reddish clay. 2. A second variety of laterite, and that most frequently met with in Ceylon, is of a softer consistence, and can be cut easily with a knife, but hardens on exposure to the atmosphere. The term Lithomargic laterite has been applied to this kind. 3. There is another form, which my friend Staff-Surgeon Dr Clark calls Detrital. This is found in nullahs or ravines. It is evidently formed of pebbles of quartz, loosely imbedded in clay, both being washed down to these nullahs by the heavy rains. The detritus of laterite is seen about Colombo forming a bræccia with marine shells. A laterite gravel is also seen in various parts of the island, covering the laterite hills, and it is also found at their base. This gravel is nothing more than the quartz crystals of the lateritic rocks, separated by the rains from their clayey matrix. Some of the pebbles are denuded entirely of the clayey covering; others retain still a thin coating of it. Lithomarge is a sectile clayey substance of variegated colours. It is chiefly formed of a decomposed felspar and hornblende; whitish when the former prevails, and yellow or reddish when hornblende predominates in the rock from which it is derived, owing to the larger proportion of oxide of iron which the latter mineral contains. There are extensive hills of lithomarge in Ceylon, and frequently it lies under the hard laterite, and is often interposed between its layers.

With the exception of Voysey, and his few supporters (who regard the laterite to be of igneous or volcanic origin), geologists consider laterite to be the product of the disintegration and decomposition of granitic rocks. The difference of opinion rests upon the question, whether the disintegration or decomposition took place *in situ*, or whether the disintegrated masses were deposited, or brought from a distance, and laid over the rocks on which laterite now lies; or, in other words, is it a formation in itself derived from rocks which formerly existed?

To the former view (weathering *in situ*) there are many more supporters than to the latter, and among them our late much lamented Dr Gardner, who, from observations both in this island and on the continent of India, attributed the formation of laterite to the simple decay of gneiss or granitic rocks. I cannot but agree with him that in many cuts or sections of the rock, nature is detected in the act of disintegration, some of the original stratification (often seen running almost vertically) of the gneiss being preserved. In other places it is difficult to trace where the gneiss terminates, and the laterite commences, one as it were running into the other. But I must observe that I could never trace this continuity in the hills of the harder variety of laterite. Here, certainly, the appearances are favourable to the opinion that laterite is a distinct formation of itself. And yet this hard laterite rests on gneissic rocks, as is seen at the bottom of wells sunk in the lateritic hills at Mutwall, and in the Fort of Colombo. Laterite may also be seen, says Captain Newbold, capping hypogene or trap-rocks of great elevations, while the adjacent hills, composed of an exactly similar rock, and forming a continuation of the same bed, equally exposed to the action of the weather, are quite bare of the laterite. He also observed laterite resting on limestone, without a trace of lime in the laterite. If my information be correct, laterite is also seen over some of the limestones of Jaffna, in the north of the island. General Cullen found on the western coast of India, fifteen miles south of Quilon, a layer of lignite in the laterite, imbedded in a stratum of dark shale and clays. Lignite has also been seen in the laterite of Travancore; and graphite has also been observed there. These are the observations which have made Newbold and others view the laterite of Southern India as a distinct formation, more recent than any of the rocks. Till similar features are observed in some of the laterites of Ceylon, we are obliged to regard them to be the weathering of rocks *in situ*.

To comprehend, how a hard compact rock like granite or gneiss, could moulder away into laterite and lithomarge, it is necessary to know the composition of the minerals which enter into the formation of these rocks.

The following are the mineral constituents of the most common forms of

	Felspar.	Mica.	Hornblende.
Silica, ...	66·75	48·00	42·00
Alumina, ...	17·50	34·25	12·00
Lime, ...	1·05	...	11·00
Potash, ...	12·00	8·75	a trace.
Magnesia, ...	...	...	2·25
Oxide of Iron, ...	0·75	0·50	0·25
Oxide of Manganese,	...	0·50	0·25
Water, ...	...	—	0·75
	98·25	96·00	98·25

Quartz consists of nearly pure silica, with a trace however of alumina, and sometimes of iron.*

It is easily seen, that the chief source of the alumina necessary for the formation of clay, is derived from the felspar and mica which enter into the composition of granitic rocks, and that hornblende supplies the largest quantity of iron, the hyperoxidation of which, assisted probably by electric influences, precedes the disintegration of these rocks. In rocks in which felspar and hornblende predominate, the clay formed is much variegated, pure felspar forms the porcelain clay or kaolin so abundant on the plains of Nuwera Ellia. Quartz, if deeply impregnated with oxide of iron, will also moulder away, but not quite so soon as the other mineral constituents of hypogene rocks.

Before I had observed the immense lithomargic hills of Ouvah and Nuwera Ellia, it was difficult for me to believe that large mountain masses of hard rock could disintegrate so completely into lithomarge. When there are, however, such unequivocal proofs of rocks, several hundred feet high, mouldering away into kaolin or white porcelain clay in some parts, and in others into lithomargic earths and clays of various colours and consistence, it is not difficult to account even for the formation of the harder forms of laterite. In sections made in Nuwera Ellia for the construction of roads,

* From Jameson's Journal.

successive layers of sienitic gneiss are seen in various stages of decomposition, and these layers retain in some parts, where the decay is not far advanced, the original lines of stratification. Some of these layers are of pure kaolin, others of a reddish or yellowish clay, some mixed of all three, giving a beautiful variegated surface to these exposed parts of the hills. In half-decomposed portions of some of the hills on the plains of Nuwera Ellia may be seen dark reddish spots, which are formed of decomposed garnets, and in other hills are seen scaly graphite. Adularia and Ceylonite are sometimes found in the beds of clay. If such, then, be the striking illustration of the decomposition of one form of gneiss in which hornblende and felspar prevail, it is easy to conceive other forms of granitic or gneissic rocks weathering into laterite in other circumstances and other situations. Laterite in any shape is not found in Nuwera Ellia. The stones used here for building are half-decomposed gneiss obtained from lithomargic hills, and it is yet to be ascertained how long these will last. I fear that the decomposed stone is too felspathic to last many years.

The presence of lignite in some of the laterites of Southern India, and sometimes laterite being found over limestone, would lead us to suppose that laterites are of two periods. The one, and only one perhaps existing in Ceylon, being of the weathering of rocks *in situ*, and therefore still being formed, and the other a deposit of disintegrated lateritic matter (over more recent formations) derived from previously existing lateritic rocks. The subject, however, requires further investigation: it is involved in greater mystery than many other geological phenomena. Ceylon affords many opportunities for carrying on observations necessary for its complete solution. The features of the laterite of Southern India which induced Newbold to suppose laterite to be a distinct formation, may also exist in Ceylon, therefore members of the Asiatic Society will do well to note the nature of the rocks on which the Ceylon laterite lies, and to examine whether any of it contains lignite, or is in the slightest degree fossilliferous. The discovery of fóssils alone will not prove that laterite is not decomposed gneiss *in situ*, for Sir

Charles Lyell and others have suggested the possibility of finding fossils even in gneiss of later origin. Granting that this is the case, nothing could then be easier than to account for the presence of fossils in decomposed masses of the same kind of rocks. This subject is now engaging the attention of the Geological Society of London, their notice being attracted to it by the so-called "*foot prints*" on the gneissic rock at Kornegalle, which I have not yet had an opportunity of examining.*

Though the geological features of Ceylon resemble those of Southern India, yet from the paucity of observations perhaps there appears to be considerable difference in many respects, especially in the nature of more recent deposits. Kunker, a limestone gravel, has not been noticed in Ceylon, nor has clay-slate been seen in this island, though its associate rocks are found in great abundance. Both are found in extensive beds in Southern India. Regur, the black cotton soil which covers nearly two-thirds of Southern India, has not been noticed in Ceylon, and yet it is most probable that all these three formations exist in some parts of the island: most likely in the northern districts.

The only alluvial, or rather fluviatile deposit in Ceylon, resembling in external characters the *Regur* of India, is the black soil of Nuwera Ellia and its neighbourhood. With this difference, however, *regur* lies over a limestone gravel, and the blackish loam of Nuwera Ellia over a quartz gravel, with a substratum of clayey earths formed of the lithomargic hills and valleys over which the loam and gravel were deposited. A deposit of gravel and loam has also been observed on the Nielgherries 6000 feet above the sea level. These deposits of loam and gravel on the patnas and plains of Nuwera Ellia, are considered by casual observers to be the decayed particles of the rocks in the immediate vicinity brought down by the rains. If this is their real nature, the decomposed particles of the gneiss and quartzite which chiefly compose these existing rocks above the plains, could not by any means have taken their present position of the loam and

* Since this paper was written, I have examined the rock, and found it to be alminated granite, and the marks merely the effects of weathering.

gravel. The colour, too, of the decomposed particles would not be dark brown or black, but whitish or yellowish. The loam and gravel lie so conformably on the lithomargic surface of the hills and valleys, that it is unreasonable to suppose that they were deposited from any other source than from a large sheet of water.* The heavier particles in the form of gravel sinking first, and then the lighter particles held in suspension in the water were deposited over the bed of gravel, or, as in some places seen, on layers of various sized pieces of quartzite and gneiss. The loam is not mixed with gravel, it is composed of fine sand, just such as mud of rivers or lakes is composed of. In the lower layers this loam is of a brown colour, but becoming darker as it approaches the surface, and after being mixed with the decomposed matter of the grasses which grow on it, the loam becomes nearly of a peaty nature and of a blackish colour.

In sections along the different roads which traverse the plains, a continuous layer of gravel, from one inch to two or three feet in thickness, is seen lying over the lithomargic hills, and on this gravelly surface the brown or blackish loam is seen of various thickness, generally from one to three feet; in some places even five or six feet of loam is found. In a section near the Governor's cottage an interruption appears to have taken place after about a foot of mud was deposited, and then came over the pure mud masses of gneiss and pebbles now lying several feet thick mixed with loam of a brownish colour. Over this mixed deposit is again seen a thin layer of loam such as is found in other parts of the plain—the whole forming a curious variegated structure.

The above observations lead me to conclude that the plains of Nuwera Ellia, and perhaps those of higher parts, have once been the channel of a slow winding river or bed of an extensive lake. And it is probable that the lower hills, which look like inverted tea cups, were elevated by subse-

* May not this account for the want of luxuriant vegetation on these patnas, the water having washed and carried away to the lower parts of the island the alkalies and phosphates, so necessary to plants? The black soil of Nuwera Ellia, however rich in appearance, requires much manuring; the best potatoes are the products of well-manured grounds. Guano is as much required here as anywhere else.

quent upheavals after the waters had deposited the gravel and loam. It is, perhaps, in this manner only that the almost uniform thickness of the gravel and loam in the valleys and on the tops of the hills can be accounted for. Had the present elevated surface existed while the waters were depositing the heavier particles held in suspension, we should expect to find thicker layers of gravel on the valleys than on the sides of hills; such is not, however, the case: thick beds of gravel are even found on the tops of the hills several hundred feet above the present drainage of the plains. Geologists have decided that the mountains of Southern India were elevated to their present heights by successive upheavals, and therefore it is not objectionable to consider the higher lands of Ceylon to have also been elevated by more than one upheaval. There is abundant evidence, too, besides the one just alluded to, to conclude that Ceylon has been subjected to successive internal forces, which will explain also the present configuration of the mountain masses of Nuwera Ellia and the characters of Nuwera Ellia and Horton Plains.

Hitherto no evidence of deluvial or glacial currents have been found in Ceylon. The rounded rocks of granite and gneiss, seen on various parts of the island, are the effects of a spontaneous concentric exfoliation, which small and large masses of these rocks are susceptible of. Major Lushington has instanced this peculiar exfoliation in a gigantic scale on the rock of Dambool. Alluvial and fluviatile deposits are seen in various parts of the island; but none, perhaps, so extensive as the fluviatile deposits of Nuwera Ellia, which appear to extend from Horton Plains passing over Nuwera Ellia, and progressing towards the valleys of Maturatte on one side, and to Dimboola on the other. Although these deposits are not of a diluvial nature, still there is an importance attached to them, as they shew that at a former epoch the interior of Ceylon was traversed by broader and more expansive sheets of water than any of the rivers of the present day. It is doubtful, however, whether this large lake or river, which has deposited its mud on the plains of Nuwera Ellia, is dwindled down into the narrow streams which now exist on these plains as tributaries to the great Mahavilla ganga.

On the Condition and Prospects of the Aborigines of Australia. By W. Westgarth, Esq.

(Continued from vol. liii. p. 241.)

9. *Past and Present Methods, and Proposed Plans for the Welfare of the Aborigines.*

All plans that have been hitherto adopted for the civilisation of the Australian Aborigines appear to have proved almost uniformly unavailing for the accomplishment of any permanent good. Amidst the difficulties which beset the subject, and the discordant opinions as to the methods that are best adapted to their condition and circumstances, it is not to be supposed that the eye of the Government possessed the faculty of discerning the proper path more clearly than others. Various apparently feasible plans have been tried, and are still being followed out by the authorities; and expense has not been spared, where there appeared any prospect of benefit.

Missions.—The following table, taken from the appendix to the Committee's Report, contains an abstract of Mr Auditor-General Lithgow's Return for the Colony of New South Wales, of the expenses of Missions to the Aborigines, from the 1st January 1821 to 30th June 1845. The period of duration of each Mission is taken from Mr Dredge's pamphlet:

Aboriginal Native Institution, 1821 to 1833,	£3,364	9	$10\frac{1}{4}$
Inquiry under Lt. R. Sadlier, 1826 and 1827,	388	4	4
Mission at Lake Macquarie, 1827 to 1841,	2,145	5	10
Mission at Wellington Valley, 1832 to 1843,	5,964	10	2
German Mission at Moreton Bay, 1838 to 1842, ...	1,516	14	2
Wesleyan Mission at Port Philip, 1836 to 1848, ...	4,538	8	9
Total expense of Missions, .	£17,917	13	$1\frac{3}{4}$
Protectorate at Port Philip, established 1838,	32,756	15	$6\frac{3}{4}$
Cost of Blankets, &c., not included elsewhere,	9,746	14	$7\frac{1}{2}$
Total Expense of the Aborigines,	£60,421	3	4*
* 30th June to 30th December, . .	£1,170	1	9
Making a total (exclusive of Police) of .	£61,591	5	1
One-half of the expense of Border Police, (usually considered to be on account of the Aborigines) 1839 to 30th June 1845,	44,954	5	6
Total,	£105,375	8	10

There is a Roman Catholic Mission at Stadbroke Island in Moreton Bay, where there are four Missionaries employed. This island is a band of sand about 20 miles long, and was selected as the site of a Mission in the hope that the barrenness of the spot might prevent its being settled on by the colonists. Parties have since settled there, however; and the Pilot Station is on the island. The Wesleyan Mission at Buntingdale, will be noticed hereafter.

The Protectorate.—Missions to the Aborigines having proved unsuccessful, a generous effort was made by the British Government in the establishment, about eight years since, of the Port Philip Protectorate, by which it was intended to protect and provide for the considerable number of Aborigines scattered throughout the then newly colonized territory of Australia Felix. The Protectorate was established in conformity with instructions issued in 1838, under the Colonial Secretaryship of Lord Glenelg; and owes its existence to the results of the inquiries of a Committee of the House of Commons, which sat in 1833–4, to ascertain what measures should be adopted for the general benefit of Aboriginal races in British Colonies. The district was accordingly sub-divided, and four sub-protectorate stations were occupied.

According to general opinion in the colony, the Protectorate has entirely failed in the accomplishment of the objects for which it was benevolently intended. But some consideration is due to the opposite testimony of the Protectors themselves. They have been able in some degree to restrain the Aborigines from robberies and mutual warfare. Mr Robinson claims that they have demonstrated that large bodies of Aborigines may be associated together without injury to themselves or to Europeans. Mr Thomas attributes much of the harmony of his district to his continually moving about with the Aborigines, and settling their mutual disputes and the aggressions. They have doubtless been instrumental, within the sphere of their influence, in checking the practice on the part of the colonists of shooting or otherwise destroying the blacks, whom hunger or revenge had impelled to rob them, and whose lives were frequently sacrificed on very slight pretexts. The inconvenient scrutiny which the Protectors have exercised with reference to the commission of any violence upon the population placed under their care, is not to be ranked in the list of their non-efficiency. "Indeed, the virulent opposition evinced against the department, I am sure," says Mr Robinson, "must be considered rather as a proof of its efficiency than otherwise."

In most other respects, however, the Port Philip Protectorate appears to have been equally unsuccessful with other experiments on the Aborigines; one of the assistant Protectors himself honestly acknowledging, that though he cannot charge himself with dereliction of duty towards the Aborigines, to whom he has endeavoured to communicate religious truth, yet as far as regards his own exertions, no visible benefit has resulted.

Mission at Buntingdale.—This Wesleyan Mission, which had in vain laboured to effect some change in the habits and religious sentiments of the Aborigines, was within the last three years about to be abandoned as an unsuccessful attempt, when it occurred to the Rev. Mr Tuckfield, one of the missionaries, to try a new principle of management with these untractable tribes. This was simply to separate the different tribes, and maintain them distinct and isolated, alike from the white population, and from one another. Buntingdale is a retired spot about thirty-five miles to the south west of Geelong, and remote from any principal thoroughfare. Mr Tuckfield appears to have selected one of the tribes of that locality. There are at present (1845) about fifty Aborigines attached to that mission.

Its Success.—The results of this experiment appear to have exceeded expectation. The natives have remained on the place. Some of them have built slab huts for themselves; others have made their own shirts and trousers. Some of the young men have become expert at fencing, ploughing, reaping, &c.; others have shepherded, washed, and shorn small flocks of sheep—contributions from neighbouring settlers. From these successful beginnings, Mr Dredge is so sanguine as to anticipate that the mission will ere long even more than defray its own expenses, and assist in the formation of other missions.

Plans and Alterations proposed.—Experience of plans, and more accurate knowledge of the habits and character of the Aborigines, have combined to give a somewhat definite and mutually accordant aspect to the methods that have latterly been suggested. The plan of the Protectorate appears to have been in error chiefly in the attempt to amalgamate different tribes, without respect to their long-standing mutual antipathies and prejudices. * It appears, indeed to be quite as necessary to separate and remove the respective tribes from one another, as to isolate the whole body from the whites. Mr Robinson admits, with reference to the Protectorate operations, that it is questionable how far it may be advisable thus to congregate large numbers of Aborigines, unless teachers, as originally intended by Government, were appointed to promote among them the knowledge and practice of Christianity.

Mr Dredge recommends that Missions be established in each of the most numerous and powerful of the tribes; and that the location of the respective Missions be as remote as possible from purchased lands and squatting stations, and also from one another, so as to

* Mr Parker, Assistant Protector of Aborigines, denies that the principle of the Protectorate differs so essentially from that pursued at Buntingdale, as Mr Dredge makes it appear. All the difference Mr Parker can find is, that whereas as Mr Tuckfield's exertions are limited to fifty individuals; there are from 250 to 300 immediately connected with his own station, all of whom have been held together without any sacrifice of life, or even the occurrence of bloodshed.—*Parker*, quoted by *Robinson*, 18.

prevent the members of one tribe from mixing with those of another. Their mutual animosities are deep rooted and incurable. They should, therefore, be taken in hand tribe by tribe; and not a tribe here and there, but at one and the same time, as those who are not in charge will decoy the others.

Missions in the vicinity of squatting stations will not answer, on account of the many inducements presented to the natives to ramble from the establishment; those planted far in the interior would, however, require the assistance of a police force.

There is undoubtedly more hope of success with the children than the grown-up blacks; but it appears to be absolutely necessary to withdraw the former from association with their parents and the tribe. Little can be otherwise accomplished towards the improvement of their condition. "The boys are invariably practising to throw the spear and bomerang, and look forward with evident pleasure to the time when they may be permitted to join in a hunt or a fight; the charms of both seem to be equal." Mr Robinson remarks, that, when out of their own districts, the Aborigines have been found exceedingly tractable; and he thinks that interchange of locality with those of Port Philip and the middle district would prove beneficial.

Distributing of Clothing and Provisions.—It had been the practice of Government to distribute considerable numbers of blankets among the Aborigines; but within the last two or three years this liberality had been much restricted, under an impression that the privilege was generally abused or disregarded by the blacks. One of the queries of the Committee's circular relates to this subject, and the evidence afforded by the answers is almost unanimously to the contrary effect. The Aborigines have a strong partiality for blankets. They will patch and mend them to the last. Other descriptions of dress are passed about from one to another, and soon disappear; and they have been known to make fires and burn very good clothes on leaving town. An oppossum rug has frequently been given in exchange for a blanket.

In the Broulee district, blankets had been issued regularly since 1837 up to last year (1844); and in expectation of the usual supply, the Aborigines of that district had made no suitable provision for winter, so that many old people perished in consequence. Mr Dunlop describes the plaintive but indignant remonstrance of the native chief at the discontinuance of the miserable dole on the part of the Government "to his very few old women and six young ones, all so cold—no hut, no blanket, no light fire on white fellow's ground." Women and children and old men are particularly objects for the distribution of blankets. In some instances the men are apt to barter them away for spirits or tobacco. Some of the witnesses considered that none who were able to work should get a blanket, without giving an equivalent in labour.

Captain Fyans, on the other hand, thinks they are sometimes the occasion of riot and assassination, and had better not be distributed, or at least not without an equivalent in labour. Mr Wickham says, that blankets seldom remain long in their possession, and considers that a long robe or shirt of blue cotton cloth would be more suitable. This garment would be more decent, and cost but a trifle. Count Strzelecki suggests the justice and humanity of supplying the wants of the Aborigines by a weekly simultaneous issue of rations of bread and meat.

Legislation.—The present state of the criminal law with regard to the Aborigines is somewhat anomalous and oppressive. In the first place they are declared subjects of the British Crown,—an honour conferred without either their knowledge or concurrence, and which " it is verily believed they have never yet been able to comprehend." Again, they are accountable to British laws for offences not only against the colonists, but also for those committed among themselves. They are at the same time legally disqualified from giving evidence in a court of justice; a circumstance which, in Mr Robinson's opinion, has tended to accelerate the destruction of the Aborigines among the whites. Mr Thomas urges the necessity for some special law adapted to their case. Mr Powlett considers that native evidence, when strongly corroborated, might be permitted to go to a jury, to be received for what it might be thought worth.

Count Strzelecki reflects upon the anomalous nature of the whole policy pursued by the government towards the Aborigines. He considers they should have been placed more directly under the public authorities, have been supplied with food, and have been declared a conquered race, to render their actual position intelligible to themselves.

Mr Parker recommends some stringent enactments to prevent the prostitution of the native women by the labouring population. He is convinced, from minute inquiry on the subject, that this is the most frequent cause of Aboriginal outrages.

At Swan River, an island is appointed exclusively for Aboriginal criminals; and according to the reports of the Rotnest establishment, the best results have been realised.*

Suitable Agents.—Mr Dredge strongly contends that the Christian missionary is the only qualified party to civilise the Aborigines. Suitable agents should be supplied by the church, a term he would by no means use in a sectarian or exclusive sense.

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* In consequence of incessant mutual hostility between the Aborigines and the colonists of Van Diemen's Land, the entire body of the former were hunted out and removed, in the year 1835, to Flinder's Island, in Bass's Straits, where the miserable remnant still resides. They numbered 210 on their first arrival, but in 1842, when Count Strzelecki visited the island, they were reduced to 54. There had been only 14 children born during eight years.—(*Strzelecki*, pp. 352-5.)

10. *Prospects for Aboriginal Civilisation.*

If the prospects of the Aborigines with reference to civilisation are to be estimated by what has hitherto been accomplished, they are miserable indeed. The difference of opinion that prevails on this subject can scarcely relate to the actual results of the past, which have been so uniformly unfortunate; it is due rather to theoretical deductions connected with views and principles of religion.

Mr Dredge contends that Christianisation must be the pioneer and parent of civilisation, and that all attempts to reverse this process must fail, and always have failed. "The degradation and moral wretchedness of the heathen are the sad and direful results of moral and spiritual causes; and for their removal the only adequate and appointed instrument is the Gospel, the spirit of Christianity." He then exhibits the various steps that will be successively taken by these heathens, after the Gospel has begun to operate on their minds, concluding that "it can thus be clearly demonstrated that vital heart-felt Christianity, truly embraced and spiritually enjoyed, develops the only plan for emancipating the heathen from their moral thraldom."*

But judging from past and present experience, these applications of the abstract truths of religion are probably little adapted to forward practically the cause of Aboriginal civilisation. In opposition, also, to the usual views that, the teaching of religion should precede all other modes of civilisation, Count Strzelecki remarks that the Aborigines' institutions being as it were sapped by the preaching of Christianity among them, some civil organisation should have preceded the new faith. But he conceives very slender hopes as to any ultimate good that may result to the Aborigines, from these attempts to initiate them into feelings and habits so widely different from their own. "From what has been observed of the two races, one may affirm, without fear of contradiction, that *it will be easier to bring the whites down to the level of the blacks, than to raise the latter to the ideas and habits of our race.*"

The Australian savage has been suited to the circumstances which surround him. In these he is seen healthful and contented, "securing all the worldly happiness and enjoyment of which his condition is capable." But this economy has been disturbed by the arrival of Europeans. He can neither stem the inpouring torrent, nor imbibe the civilisation that is offered him; he retreats, and finally disappears. Amidst the wrecks of schemes, says the traveller with pathetic eloquence, there remains yet one to be adopted for the benefit of the Aborigines—to listen and attend to the last wishes of the departed,

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* Mr Parker speaks to the same effect, adding, that he is well assured there is nothing either in the nature of true religion, or the capacity of the Aboriginal intellect to exclude this race from a full participation of its benefits.—(*Extracts in Robinson's Replies*, 18.)

and to the voice of the remaining few :—" Leave us to our habits and customs ; do not embitter the days which are in store for us, by constraining us to obey yours ; nor reproach us with apathy to that civilisation which is not destined for us."

11. *General Review.*

Regard the Aboriginal Australian, as he now appears, surrounded by civilised man. Behold him a wandering outcast ; existing, apparently, without motives and without objects ; a burden to himself, a useless cumberer of the ground ! Does he not seem pre-eminently a special mystery in the designs of Providence, an excrescence, as it were, upon the smooth face of nature, which is excused and abated only by the resistless haste with which he disappears from the land of his forefathers ? Barbarous, unreflecting, and superstitious, how strangely contrasted is an object so obnoxious and so useless, with the brightness of a southern sky, and the pastoral beauty of an Australian landscape.

Such are the reflections that will naturally occupy the mind of the passing observer, after a cursory glance at the wandering tribes of Australia. But the arrangements of Providence for the benefit of the great and varied family of mankind, should not be studied in accordance with one uniform standard of customs and institutions. The instinctive and mental faculties peculiar to each race, though widely different one from another, may yet exist in perfect accordance with the circumstances by which each is surrounded. To the philosophic traveller who beholds the Aboriginal native in his yet uninvaded haunts, and remarks his health, his cheerfulness, his content, his freedom from anxieties and cares, few spectacles can be more gratifying ;* and he readily admits that the broad and beaten tract of civilisation is by no means the only road which the Creator has left open to man for the attainment of happiness.

These mutual relations have been destroyed by the approach of civilised man. In his irresistible progress he has either driven off the Aboriginal tribes, or subdued their native spirit, and subverted their social polity. Their peculiar habits and ideas, the result of physical and psycological laws operating throughout many successive generations, are permanently engrafted in their constitution, and are not to be eradicated without the long continued use of counteracting moral and physical appliances, involving a far greater lapse of time than is usually considered necessary in the estimate of the philanthropist or the missionary.

Deeply feeling the alien occupation of their country, yet their savage arts are utterly powerless against the arms and authority of

* Strzelecki, pp. 338, 342, 343, where he describes the real enjoyment of existence among the Aborigines after their own fashon—now moving about, hunting, fishing, with occasional war, alternated by feasting, and lounging on the spots best adapted to repose.

their opponents. The prostration of spirit, the listless indifference of the Aboriginal mind, are the natural result of this relative position to the whites. The Aboriginal native, widely different in his habits and pursuits, is unable to rise to a comprehension of the actions, motives, and principles that compose the structure of civilisation. Simple in his ideas, his griefs are evanescent, and he is in general cheerful, and even docile and gentle. The vicinity of civilised man acts, after a time, like a powerful spell upon his conduct; but the mind remains radically unchanged; and when he again returns to the security and undisturbed solitude of his native wilds, this influence is quickly counteracted and thrown off.

All efforts to civilise and Christianise the Aborigines have hitherto proved singularly abortive. True, indeed, as might be anticipated, the management of the young children presents fewer difficulties than that of the adult natives. There is also with Aboriginal tribes, as with civilised nations, a conspicuous diversity of individual character. They are not all equally fierce or barbarous, or untractable; and the dark phalanx is occasionally relieved by the advance of some solitary member, whose comparative aptitude and docility have too readily stimulated the anticipations of sanguine and zealous minds.

But the care and diligence of the missionary, though they cannot convert the mind of the Australian savage, may yet tame and subdue his spirit; and by removing, as far as practicable, every known inducement to his barbarous customs and wandering habits, maintain him at least in quietness, without injury to himself or the colonists. Isolation and solitude, the total absence of hostile tribes, the periodical and regular supply of food at the missions or stations; all these circumstances, so different from those in which his habits have been moulded, must gradually weaken that stimulus which gives a zest and pleasure to his erratic and turbulent existence. The savage is deprived of much of the enjoyment congenial to his disposition. But his primitive manner of life is no longer attainable in the present circumstances of the colony. His country has been occupied by a race, whose habits and customs, and daily avocations of life, are to him alike unenticing, irksome, and monotonous, destitute of visible motive or of adequate results. He has neither the desire nor the capacity to associate with the whites; and when he would retreat from their blighting presence, into territories still uninvaded in the progress of colonisation, he is repulsed by other tribes of his own race, who already occupy the locality to which he might retire. His lot is truly hard and unfortunate. The tranquillity of an Australian savage is not that of enjoyment, but rather of quiescence and torpor. The restraints and deprivations to which, in the attempt to reclaim his mind and habits, it is sought to subject him, are to be excused and justified only in the view, that they are the means of avoiding still greater impending evils.

All projects for the civilisation of the Aborigines should be framed in consonance with the view that in other circumstances than the present, (that is, in the previously undisturbed condition of these tribes,) these appliances for their behoof would be a positive injury and injustice. To remove the Australian savage from all intercourse, whether amicable or otherwise, with other tribes, to anticipate, by a gratuitous supply of food, the necessity for his accustomed corporeal and mental exertion, are simply to undermine the chief sources of the variety, excitement, and happiness of which his existence is susceptible. In the moral and physical condition in which the Aboriginal Australian has been placed, even the mutual wars of the tribes must not be overlooked, as incorporated with those various adaptations by which the energy and activity of the mind and body are duly maintained. It is indeed only considerations of a different and a higher character than the mere miseries, great as these may often be, that immediately result from war, that will eventually banish such scenes from the catalogue of human affairs.

In all localities where the Aborigines are peaceably conducted, and contrive to pick up a subsistence sufficient for their wants, it appears advisable to leave them to themselves. In places where the sources of their support are diminished, the women and old men, or, if necessary, all the individuals of the tribe, should be regularly and simultaneously supplied with weekly rations of bread and meat.*

All the women and old men, otherwise unprovided for, should be supplied at stated intervals with blankets : to the children may be given the long robe or shirt of blue cotton cloth recommended by Mr Wickham. It cannot, indeed, be considered too great a stretch of generosity on the part of the Colonial Government to supply blankets, at stated intervals, to all Aborigines applying for and properly using them, whose territories have been occupied by the Colonists.

Some degree of success may undoubtedly be anticipated in the training of the Aboriginal children, particularly where they can be separated from their parents and tribes. On this principle, the present Aboriginal School is conducted at the Merri Creek, near Melbourne, under charge of Mr Peacock. It now contains 14 boys and 7 girls. As its existence dates only from the end of last year, the result of the experiment cannot as yet be decided on ; but the prospects appear favourable. The children are noways deficient in ability in learning to read.

The experiment of Mr Tuckfield, at Buntingdale, may also be regarded as successful ; namely, that of isolating a single tribe of Aborigines upon a reserve of ground, and separating its members

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* Tribes which are inclined to be turbulent, are probably best kept in check by a force of Aboriginal police. In the *Port Philip Herald*, of the 30th of June 1846, an estimate is made of the expense of the Native Police (Aborigines), as compared with that of the Border Police (Colonists), each of the former costing annually £36, 14s. 4d. ; each of the latter £53, 7s. If the native Police, therefore, continue to give the same satisfaction as heretofore, there is every inducement to employ the Aborigines in this capacity.

alike from those of other tribes, and from the colonists, and engaging the various individuals in useful, active, and self-supporting occupations.

The means of support should be extended by the Government to each of such descriptions of schools or missions, both by conditional grants of land, and by the assistance of money or rations. Where a locality has been thickly settled with squatting stations, it is indeed highly desirable that the scattered remnants of surviving tribes should if possible be transferred to the care of the missionary. In such localities, the Aborigines usually wander about, either begging from or plundering the settlers, and with but little scope or stimulus for the exercise of their primitive manner of life. At the missionary reserve, on the other hand, they would be secured from the disease and dissipation to which their restless habits continually expose them.

The plan of the Protectorate is unsuited to the case of the Aborigines, from the circumstance of the mutual distrust and animosity of the tribes. Another mistake, and of a more evident character, has also been made in committing to the accidents of a civil appointment the responsible and laborious duties attending the work of Christianising and civilising the Aborigines. The exalted motives, strength, and perseverance of religious zeal, form, generally speaking, the only efficient agent in such a work.* It appears desirable, however, except in particular instances, and in the case of the native children, to leave the Aborigines, as far as circumstances will permit, to the free enjoyment of their own mode of life. Interference should be the exception, not the rule, and the apparatus of the Protectorate appears to be no longer necessary. In other respects this establishment might perhaps have been continued with advantage under a modified form. The heavy expenses attending it were unavoidable, under any practical arrangements for the civilisation and maintenance of large bodies of the Aborigines.

Such of the natives as were not under the special care of missionaries, or employed by the colonists, might be nominally under charge of the Crown Land Commissioners, who should furnish periodical reports on the numbers and condition of the Aborigines in their respective districts. The services of a few of the magistrates residing in different parts of the colony might be made available for the occasional distribution of such provisions and clothing as the neighbouring tribes might be considered to require.†—(*Vide Westgarth on the Condition and Prospects of the Aborigines of Australia, in Journal of the Indian Archipelago and Eastern Asia*, vol. v. p. 704.)

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* From the evidence given by the two present assistant Protectors, Messrs Parker and Thomas, it is very apparent that they have been actuated in their labours by a missionary spirit, and stimulated by religious zeal. They have in fact been missionaries, operating on an extensive scale.

† These remarks are intended to apply to the Port Philip District only, which is best known to the writer.

Synopsis of Meteorological Observations made at the Observatory, Whitehaven, Cumberland, in the year 1851. By JOHN FLETCHER MILLER, Esq., F.R.S., F.R.A.S., Assoc. Inst. C.E., &c. Communicated by the Author.

1851.	Standard Barometer. Corrected and Reduced to 32°.								Self-Registering Thermometer.						Pluviometer.				Winds.	
	Max.	Min.	Mean at 3 P.M.	Mean at 10 P.M.	Mean Atmospheric Pressure.	Pressure of Vapour.	Mean Pressure of Dry Air.	Range.	Absolute Max.	Absolute Min.	Mean of Max.	Mean of Min.	Approximate Mean Temperature.	Range.	Rain and Snow.	Snow.	Wet Days.	Evaporation Gauge.	Two Daily Observations.	Force of Wind, 0—6.
	Inches	Inches	Inches	Inches	Inches	Inches	Inches	Inches	°	°	°	°	°	°	Inches	Inches		Inches		
Jan.	30·180	28·820	29·471	29·463	29·467	0·259	29·208	1·360	52·	31·	45·35	39·79	42·57	21·	9·412	0·744	25	0·991	SW.	3·0
Feb.	30·489	29·148	29·854	29·876	29·865	·251	29·654	1·341	50·	32·5	45·43	37·91	41·67	17·5	3·775		15	·929	SW.	2·1
March	30·422	28·923	29·587	29·596	29·591	·262	29·329	1·499	54·	30·5	48·00	38·64	43·32	23·5	3·458		17	1·544	SW.	2·4
April	30·166	29·320	29·747	29·763	29·755	·272	29·483	·846	60·	31·	51·85	39·20	45·52	29·	2·301		16	2·481	NE.	2·5
May	30·480	29·496	29·940	29·949	29·944	·309	29·635	·984	66·3	33·	56·46	45·34	50·90	33·3	1·065		15	3·308	NW.	2·3
June	30·380	29·408	29·854	29·838	29·846	·388	29·458	·972	83·5	41·	62·38	51·13	56·75	42·5	3·883		16	3·658	SW.	2·7
July	30·201	29·156	29·723	29·717	29·720	·404	29·316	1·045	74·	44·	64·33	53·98	59·16	30·	3·470		13	3·415	Wy.	2·3
Aug.	30·326	29·218	29·872	29·892	29·882	·449	29·433	1·108	74·	47·5	65·76	54·77	60·26	26·5	4·068		18	3·063	SW.	2·0
Sept.	30·610	29·132	30·076	30·070	30·073	·394	29·679	1·478	69·5	41·	61·45	48·43	54·94	28·5	2·737		8	2·631	SW.	1·6
Oct.	30·381	28·740	29·663	29·670	29·666	·360	29·306	1·641	63·	33·	56·98	48·24	52·61	33·	4·726		24	1·554	Wy.	2·7
Nov.	30·394	29·234	29·836	29·852	29·844	·230	29·614	1·160	49·	28·5	43·46	35·71	39·59	20·5	2·547		16	1·029	NE.	2·1
Dec.	30·548	29·462	30·093	30·095	30·094	·274	29·820	1·086	52·5	29·	44·88	39·61	42·24	23·5	1·678		12	0·737	SW.	1·3
1851*	30·381	29·171	29·809	29·815	29·812	·321	29·494	1·210	62·3	35·1	53·86	44·39	49·12	55·0	43·120	·744	195	25·340	SW.	2·2
1850†	30·372	29·074	29·788	29·797	29·792	·319	29·473	1·298	63·1	33·5	54·13	44·07	49·40	62·5	40·473	·352	189	27·349	SW.	2·1
1849†	30·346	29·055	29·778	29·788	29·794	·321	29·473	1·291	62·3	33·7	53·24	44·15	48·69	56·8	38·999	·090	190	28·699	SW.	2·1

* Max. and Min. uncorrected. † Max. and Min. corrected.

SOLAR AND TERRESTRIAL RADIATION.

1851.	Absolute Minima.			Mean Nocturnal Temperature.				Terrestrial Radiation.						In Sun's Rays.		
					Naked Thermometers.			Maximum.		Minimum.		Mean.				
	Six's Thermometer, 4 feet above Ground.	On Grass.	On Wool on Grass.	Six's Thermometer, 4 feet above the Ground.	On Grass.	On Wool on Grass.	Difference.	On Grass.	On Wool on Grass.	On Grass.	On Wool on Grass.	On Grass.	On Wool on Grass.	Max.	Mean.	Solar Radiation.
	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°
January, . .	31·	24·5	20·	39·79	34·99	33·66	1·33	8·5	12·	1·5	2·5	4·80	6·13	53·	47·2	1·85
February, .	32·5	24·	20·	37·91	32·74	30·72	2·02	9·3	13·	1·5	1·5	5·17	7·19	69·	54·7	9·27
March, . .	30·5	23·	17·	38·64	34·48	32·12	2·36	7·5	14·5	0·	1·	4·16	6·52	81·5	66·7	18·70
April, . .	31·	23·	18·	39·20	33·79	30·53	3·26	11·	16·	1·	3·5	5·41	8·67	99·	75·3	23·45
May, . . .	33·	26·5	20·5	45·34	39·31	36·31	3·00	15·	19·5	1·	2·5	6·03	9·03	105·	85·5	29·04
June, . . .	41·	35·	31·5	51·13	45·41	43·11	2·30	12·5	16·5	0·5	2·	5·72	8·02	110·	86·5	24·12
July, . . .	44·	37·	32·	53·98	49·25	47·42	1·83	7·5	13·5	1·	1·5	4·73	6·56	104·	86·5	22·17
August, . .	47·5	39·5	34·5	54·77	49·88	47·63	2·25	10·	17·5	0·	1·	4·89	7·14	105·	91·0	25·24
September, .	41·	35·	27·5	48·43	43·62	39·59	4·03	13·5	21·5	0·	0·	4·81	8·84	98·	80·0	18·55
October, . .	33·	29·5	28·	48·24	43·87	41·27	2·60	8·	12·5	0·5	1·5	4·37	6·97	76·	65·5	8·52
November, .	28·5	19·8	16·5	35·71	29·14	27·57	1·57	12·4	12·5	2·5	4·	6·57	8·14	62·	49·8	6·34
December, .	29·	18·3	14·	39·61	34·49	32·47	2·02	12·8	17·	0·	0·5	5·12	7·14	52·	45·3	0·42
1851, . .	35·1	27·9	23·3	44·39	39·24	36·86	2·38	10·6	16·3	0·8	1·8	5·15	7·53	84·5	69·5	15·64
1850, . .	33·5	26·0	20·8	44·07	39·04	36·26	2·78	10·7	15·2	0·3	1·0	5.02	7·80	85·0	69·7	15·60
1849, . .	33·7	23·5	18·8	44·15	38·04	35·05	2·98	14·0	18·4	1·5	2·2	6·11	9·09	87·0	69·2	15·99
1848, . .	32·5		20·2	43·79		35·73			15·9		1·9		8·06			
1847, . .	33·7		20·5	43·50		35·95			15·1		1·1		7·45	90·2	71·0	17·15
1846, . .	36·1		23·1						14·6		1·4		7·45			

Hygrometers.

1851.	Dry Bulb.		Wet Bulb.		Deduced Dew Point.		Weight of Vapour in a Cubic Foot of Air.	Required for saturation of a Cubic Foot of Air.
	9 A.M.	3 P.M.	9 A.M.	3 P.M.	9 A.M.	3 P.M.	Grs.	Grs.
January	42·02	44·28	40·62	42·34	38·92	39·99	2·58	0·98
February	40·78	44·55	39·27	42·10	37·50	39·37	2·45	1·32
March	43·16	46·95	41·09	44·11	38·58	40·91	2·51	1·37
April	45·66	50·26	42·65	46·35	39·29	42·40	2·49	2·45
May	52·24	54·66	47·85	49·65	43·40	45·76	·2·76	2·46
June	58·10	61·04	53·78	55·54	50·79	51·70	3·54	2·52
July	59·89	62·08	55·45	56·48	52·35	52·58	3·64	2·63
August	60·34	64·51	57·19	59·41	55·00	56·13	4·25	2·51
September	56·55	59·63	53·48	55·12	51·37	51·93	3·74	2·03
October	51·94	54·53	50·37	51·43	48·80	49·02	3·50	1·44
November	38·94	42·13	37·40	39·87	35·00	37·26	2·30	1·03
December	41·71	43·75	40·94	42·88	40·05	41·88	3·05	0·44
1851,	49·27	52·36	46·67	48·77	44·25	45·74	3·07	1·76
1850,	49·27	52·35	46·62	48·46	44·19	45·17		
1849,		52·00		48·21		44·91	3·61	1·10
1848,		51·93		48·23		44·98		
1847,		51·94				44·12		

Remarks.

January.—The wettest on record at this place. Those months which approach the nearest to January 1851 in point of wetness during the last nineteen years, are December 1833, January 1834, and July 1846, in each of which the fall of rain slightly exceeded 9 inches. At Scathwaite in Borrowdale, the fall was 28·63 inches, and on the "Stye" it amounted to no less than 38·86 inches, by far the greatest quantity ever measured in the same period in Great Britain.

The mean temperature is 4°·66 *above* the average of the preceding eighteen years.

February.—Wet till the 19th; fine and clear during the remainder of the month. Mean temperature, 2°·09 *above* the average. During January and February, the thermometer reached the freezing point on two nights only.

March.—Mild, with an unusual absence of easterly winds. Temperature 1°·87 *above* the average.

The temperature of the quarter ending March 31, is 2°·87 *above* the average.

The deaths in the town and suburb of Preston Quarter, are 155, being three *above* the calculated average of the preceding twelve years, allowing for increase in population.

April.—A very fine, but somewhat cold month. Sun shone out more or less on 29 days. Mean temperature, 0°·57 below the average.

Swallows were seen at St Bees on the 9th, and in the immediate neighbourhood of this town on the 20th. On the 23d, the Cuckoo was heard in various parts of the Lake District.

On the 18th, at 6.30 P.M., a magnificent *triple* rainbow with gorgeous colours. On the 27th, about 10.5 P.M., being in the Observatory, my attention was attracted by a sudden blaze of light illuminating the sky, and on reaching the open air, I perceived a very large comet-shaped meteor proceeding from the head of Draco through Cassiopeia, but I did not see it more than a couple of seconds. The meteor greatly resembled a rocket; its body might be 1½ degrees in length, and it was followed by a long and brilliant train of bluish coloured sparks. I am told that when first seen, it resembled an ordinary shooting-star. The light of the meteor exceeded that of the full moon, and I feel assured, moderate sized print might have been read by it. It was seen at 10 P.M. in the neighbourhood of Manchester, Rochdale, and other places. "It proceeded in (query? from) a south-easterly direction, and, to the eye, the luminous appendage appeared to be twenty yards in length; it was followed by repeated flashes of lightning."

Frequent showers of hail and snow during the latter part of the month; and on the 28th, the Ennerdale mountains were as thickly covered with snow as at any time during the winter.

May.—A fine and dry, but ungenial month. Temperature, 2°·13 below the average of the previous eighteen years. On the 3d and 4th, the ground was covered with hail.

June.—Cold and wet till the 26th, which, with one exception, was the first really warm and summer like day in 1851. On the 27th, the maximum of the thermometer rose from 65° to 77°; and on the 28th, 29th, and 30th, it reached 82°, 83°·5, and 79°, respectively; and these were the three hottest days during the season. Temperature, 1°·52 *under* the average. On the morning of the 5th, there was frost in Gosforth, and snow on the Ennerdale mountains. All the mountains visible from Keswick were likewise covered with snow. On the 5th, at 4 P.M., there was a smart hail-shower at Whitehaven, which measured ·04 in the Pluviometer.

During the month, five parhelia and four solar halos were seen. On the 11th, between 7 and 7.30 P.M., a solar halo and two parhelia were seen at Whitehaven. The sun was surrounded by a ring or halo of a reddish tinge, which intersected two bright spots or discs, one to the right, the other to the left. The parhelion to the left or west side of the sun was somewhat fainter than its companion, the cloud being more dense in that direction. Altogether, the phenomenon was visible twenty minutes or upwards.

On the evening of the 13th, about half-past 6 o'clock, two very beautiful parhelia were seen by Isaac Fletcher, Esq., from the village of Eaglesfield. The parhelia appeared on each side of the true sun at a distance of about 23°, and the diffused light in their vicinity was slightly prismatic. A line drawn through the three luminous discs was not parallel to the horizon, but slightly inclined upwards towards the north. The northern parhelion had attached to it a bush of light, 3° or 4° in length, which tended upwards, and evidently formed a segment of a circle, which, if complete, would have had the sun for its centre, whilst the southern parhelion had a similar luminous appendage of about the same size, stretching downwards, and which, doubtless, was another segment of the same circle. Nearly a quarter of an hour elapsed before the phenomenon entirely disappeared. On the evening of the 26th, between 6 and 6.30 P.M., a similar, but much less perfect exhibition of parhelia was noticed by the writer at Whitehaven.

On the night of the 22d, about 10 P.M., when in the Observatory, my attention was directed to a singular white serpentine cloud in the NNW., at an altitude of about 15°. The cloud was luminous, and white as frosted silver. Between it and the horizon, separated by blue sky, were two inky black cirrostrati in strong contrast. The luminous cloud was visible about fifteen minutes. The sky was generally clear, and, at midnight, it was perfectly cloudless, but there was no trace of aurora or other visible cause for the appearance, though it was probably of electric origin.

June 16. A field of hay in cock near Workington; 28th, first cast of bees; 30th, met with glow-worms in Borrowdale.

The temperature of the quarter ending June 30th, is 1°·40 *below* the average. The deaths are 39 below the corrected average number, which is 124.

July.—Temperature 1°·06 *under* the average.

On the morning of the 4th, ice of the thickness of half-a-crown was found on the glass of the hotbeds in Holm Rook gardens. The potatoes in the neighbourhood were completely blackened by the severity of the frost. Similar accounts have reached us from Ulverstone, and various places in this vicinity.

Three solar halos were seen during the month.

August.—Temperature 0°·72 *above* the average of 18 years.

Several bright meteors or falling stars were noticed; one on the evening of the 8th conveyed the impression of such extreme proximity as to resemble a spark from a distant chimney. The grain harvest commenced in this neighbourhood on the 26th. Several fields near Egremont, and one at Distington, are already cut.

September.—A beautifully fine month; very heavy dews at night. Temperature 0°·63 *under* the average. On the 5th, the temperature fell 20°·5 in 10 hours, and between the 24th and 25th at 3 P.M., 18° in 24 hours. During the nights of the 28th and 29th, a naked thermometer on wool, exposed on a grass-plot, fell 21°·5 below the temperature of the air at 4 feet above the ground. The terrestrial radiation is now at a maximum.

On the 25th, the Borrowdale mountains were capped with snow.

The temperature of the quarter ending September 30, is 0°·32 *below* the average. The deaths in the town and suburb are 92, being 30 *below* the average number.

October.—Mild and wet. Temperature 2°·77 above the average. Auroræ on the nights of the 1st and 2d; the latter covered three-fourths of the sky, and it was particularly noticed that the streamers did not generally emanate from the horizon, but at various altitudes above it. One very bright streamer appeared to proceed from Arided, and shot beyond the zenith. A still more splendid aurora occurred on the night of the 1st October 1850, which is described in my report for that year, published in this Journal.

On the 24th, a very singular irridescent phenomenon was witnessed on Windermere Lake, but as the description of it would occupy too much space in this report, it will probably form the subject of a separate paper.

November.—The coldest November on record at this place. The temperature is 4°·32 *below* the average, and a naked thermometer exposed on a grass-plot, fell below the freezing point on 21 nights.

December.—A mild but exceedingly dull and damp month. The air was nearly saturated with moisture, yet the rain-fall did not exceed 1·67 inches. The solar rays pierced through the thick stratum of cloud on 11 days only.

The mean temperature of the last quarter of 1851 is nearly coincident with the average of the preceding 18 years. The deaths are 120, or 15 under the average number.

Winds.—In 1851 the winds have been distributed as under:—

N., 25 days: NE., 52 days; E., 19½ days; SE., 23½ days; S., 69 days; SW., 89 days; W., 27 days, and NW., 60 days.

Weather.—In the past year, there have been 19 perfectly clear days; 195 wet days; 151 cloudy without rain; 276 days on which the sun shone out more or less; 22 days of frost; 5 snow showers, and 13 days on which hail fell. There have also been 9 solar and 4 lunar halos; 5 parhelia; 1 day of thunder and lightning; 5 days of thunder without lightning; 1 day of lightning without thunder; and 13 exhibitions of the aurora borealis.

The mean temperature of the year 1851 is about a quarter of a degree above the average of 18 years, and the fall of rain is 3·83 inches under the mean annual quantity.

The deaths in 1851 are 452, being 82, or 18 per cent. under the average number; the births exceed the deaths by 285, and are 72 above the average of the preceding 12 years, from 1839 to 1850 inclusive.

The mortality in the town and suburb in 1851, with a population of 19,281, is equivalent to 23·4 deaths per thousand, or 1 death in every 42·6 inhabitants.

The average number of deaths in the 12 years ending with 1850, is 503, which, with an assumed population of 18,143, gives 27·7 deaths per thousand, or 1 death in every 36 persons.

In 1846, 1847, and 1848 (assumed average population, 18,329), the mean annual number is 694, being 37·8 deaths per thousand, or one in every 26·4 inhabitants, in those exceedingly fatal years.

In 1849, the mortality is equivalent to 32·2 deaths per thousand, or 1 in every 31 persons; and in 1850, to 24·9 deaths per thousand, or 1 in every 40 inhabitants. The improvement in the sanitary condition of Whitehaven during the last two years is very striking, and is probably to be attributed, in a great measure, to the abundance and cheapness of food, and to the copious supply of pure water conveyed to the town from Ennerdale Lake.

Observatory, Whitehaven,
November 6, 1852.

On the Basin-like Form of Africa. By Sir R. I. Murchison, late President of the Geographical Society.

Geographers will be gratified to learn that a map of South Africa, compiled by our learned associate Mr Cooley, and extending from the equator to 19° S. latitude, is about to appear under the execution of Mr Arrowsmith. With such a valuable document, and with the map of the whole of the Cape Colony, we shall soon have before us a general sketch of the physical features of a large portion of this quarter of the globe. So much, however, has our knowledge increased by the valuable original map of the Cape Colony made upon the spot by Mr Hall (of which Mr Arrowsmith is preparing a reduction), that we are, as I will now endeavour to shew, almost entitled to speculate on the prevailing structure of Africa being similar to that of its southernmost extremity.

In support of the general view to which I now call your attention, I must state that it has been suggested to my mind by the explanation of the geological phenomena of the Cape Colony by Mr A. Bain. This modest but resolute man, having been for many years a road-surveyor in the colony, had, in all his excursions, collected specimens of the rocks and their organic remains; and, gradually making himself acquainted with the true principles of geology, he has at length traced the different formations, and delineated them on the above-mentioned map. In this way he has shewn us that the oldest rocks (whether crystalline gneiss or clay-slate, here and there penetrated by granite) form a broken coast fringe around the colony, from the southern to its western and eastern shores, and are surmounted by sandstones which, from the fossils they contain, are the equivalents of the Silurian or oldest fossil-bearing rocks.* These primeval strata, occupying the higher grounds, of which the Table Mountain is an example, and dipping inland from all sides, are overlaid by carboniferous strata, in which, if no good coal has yet been found, it is clear that its true place is ascertained; and as Mr Bain has detected many species of fossil plants of that age, we may still find the mineral pabulum for the steamers which frequent these coasts.

Above all these ancient strata, and occupying, therefore, a great central trough or basin, strata occur which are remarkable from being charged with terrestrial and fresh-water remains only; and it is in a portion of this great accumulation that Mr Bain disinterred fossil bones of most peculiar quadrupeds. One of the types of these, which Professor Owen named *Dicynodon* from its bidental upper jaw, is a representative, during a remote secondary period, of the lacertine associates of the hippopotami of the present lakes and waters. The contemplation of this map has, therefore, led me to point out to you how wide is the field of thought which the labours of one hard-working geologist have given rise to, and to express, on my part, how truly we ought to recognise the merits of the pioneer among the rocks, who enables us, however inadequately, to speculate upon the entirely new and grand geographical phenomenon, that such as South Africa is now, such have been her main features during countless past ages, anterior to the creation of the human race. For the old rocks which form her outer fringe, unquestionably circled round an interior marshy or lacustrine country, in which the Dicynodon flourished at a time, when

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Mr Bain himself so styles these rocks in the Map deposited in the Library of the Geological Society.

not a single animal was similar to any living thing which now inhabits the surface of our globe. The present central and meridian zone of waters, whether lakes, rivers, or marshes, extending from Lake Tchad to Lake Ngami, with hippopotami on their banks, are, therefore, but the great modern, residual, geographical phenomena of those of a mesozoic age. The differences, however, between the geological past of Africa and her present state are enormous. Since that primeval time the lands have been much elevated above the sea-level—eruptive rocks piercing in parts through them; deep rents and defiles have been suddenly formed in the subtending ridges, through which some rivers escape outwards, whilst others flowing inwards are lost in the interior sands and lakes; and with those great ancient changes entirely new races have been created.

Travellers will eventually ascertain whether the basin-shaped structure, which is here announced as having been the great feature of the most ancient, as it is of the actual geography of *Southern Africa* (*i. e.* from primeval times to the present day), does or does not extend into *Northern Africa*. Looking at that much broader portion of the continent, we have some reason to surmise, that the higher mountains also form, in a general sense, its flanks only. Thus, wherever the sources of the Nile may ultimately be fixed and defined, we are now pretty well assured that they lie in lofty mountains at no great distance from the east coast. In the absence of adequate data, we are not yet entitled to speculate too confidently on the true sources of the White Nile; but, judging from the observations of the missionaries Krapf and Rebmann, and the position of the snow-capped mountains called Kilmanjaro and Kenin (only distant from the eastern sea about 300 miles), it may be said that there is no exploration in Africa, to which greater value would be attached than an ascent of them from the east coast, possibly from near Mombas. The adventurous travellers who shall first lay down the true position of these equatorial snowy mountains, to which Dr Beke has often directed public attention, and who shall satisfy us that they not only throw off the waters of the White Nile to the north, but some to the east, and will further answer the query, whether they may not also shed off other streams to a great lacustrine and sandy interior of this continent, will be justly considered among the greatest benefactors of this age to geographical science!

The great east and west range of the Atlas, which in a similar general sense forms the northern frontier of Africa, is, indeed, already known to be composed of primeval strata and eruptive rocks, like those which encircle the Cape Colony on the south, and is equally fissured by transverse rents. As to the hills which fringe the west coast, and through apertures of which the Niger and the Gambia escape, we have yet to learn if they are representatives of similar ancient rocks, and thus complete the analogy of Northern with Southern Africa. *But I venture to throw out the general suggestion of an original basin-like arrangement of all Africa, through the existence of a grand encircling girdle of the older rocks, which, though exhibited at certain distances from her present shores, is still external, as regards her vast interior.*

Let me, therefore, impress on all travellers who may visit any part of Africa, that their researches will always be much increased in value, if they bring away with them (as I have just learned that Mr Oswell has done) the smallest specimens of rocks containing fossil organic remains, and will note the general direction and inclination of the strata.

With no region of the old world have we been till very lately so ill acquainted as Africa. But now the light is dawning quickly upon us from all sides; and in the generation which follows, I have no doubt that many of the links in the chain of inductive reasoning, as to the history of the successively lost races of that part of the globe, will be made known, from the earliest recognisable zones of animal life, through the secondary and tertiary periods of geologists. Passing thence to the creation of mankind and to the subsequent accumulations of the great delta of the Nile, we have recently been put in the way of learning what has been the amount of wear and tear of the upland or granitic rocks, and what the additions to the great alluvial plain of Lower

Egypt, since man inhabited that almost holy region, and erected in it some of his earliest monuments.* But how long will it be before we shall be able to calculate backwards by our finite measure of time, to those remote periods, in which some of the greatest physical features of this continent were impressed upon it, when the lofty mountains from which the Nile flows were elevated, and when the centre of Africa (certainly all its southern portion) was a great lacustrine jungle, inhabited by the Dicynodon and other lost races of animals ?—(*Vide Address at the Anniversary Meeting of the Royal Geographical Society*, 1852.)

Solidification of the Rocks of the Florida Reefs, and the Sources of Lime in the Growth of Corals. By Professor Horsford, of Harvard.

I. It is required to ascertain by what processes, chemical or mechanical, or both chemical and mechanical, the surface and the submerged coral rocks have become hardened.

By the surface rock is intended that thin brown crust, composed of numerous layers, which is distinguished by great compactness, and a peculiar ring, when, in detached condition, it is struck by a hammer, and which occurs on the abrupt ocean side, and more abundantly on the long slopes on the land side of the Keys.

By the submerged rock, is intended the rock of oolitic appearance which has solidified under water, and which is of inferior hardness to the surface rock.

The surface rock, so called, has, in many places, no longer the outermost position, though it had at the time of its formation. It is, indeed, interstratified with friable light coloured limestone. The epithet indicates the circumstances of its formation, not its present position.

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* See the account of the instructive suggestions of my friend Mr Leonard Horner, to ascertain the amount of the successive deposits in the Lower Valley of the Nile, as given in Jameson's Edinburgh Philosophical Journal of July 1850. Mr Horner informs me that the researches are now going on vigorously on the site of Memphis, having been already applied to the site of Heliopolis, our Consul-General in Egypt, the Hon. C. Murray, taking a lively interest in their progress.

1. We are familiar with the fact that a mixture of quicklime, water and sand, spread out upon walls and ceilings exposed to an atmosphere containing more or less of carbonic acid, in a few days becomes hard. Analyses have shewn that two chemical phenomena are concerned in the solidification, to wit—the absorption of carbonic acid from the air, forming carbonate of lime (which salt, uniting in equivalent proportions with the hydrate, forms, according to Fuchs, a compound of great stability); and the union of the outer portions of the sand-grains with the lime, forming a silicate. Investigation has shewn that sand fulfils mechanically a more important office, by increasing the extent of surface to which the compound of the hydrate and carbonate may attach itself. The latter office may also be performed, and equally well, by pulverized limestone.

2. It is well known that calcareous springs deposit carbonate of lime in crystalline forms. The salt had been held in solution by carbonic acid contained in the water. Upon reaching the surface, under less pressure and the influence of a high temperature, its carbonic acid is given up, and with it a precipitate of carbonate of lime takes place. The process is exclusively chemical.

3. The value of hydraulic cements is now conceived to depend chiefly upon the presence of silica and lime, the oxide of iron having little or nothing to do with the process of solidification. The alumina, in the form of a silicate, yields its silica to the lime, which, for its transportation, requires water. This explains the necessity of its being retained under water periods of variable length, according to the proportions of the ingredients. The processes are both chemical and mechanical.

4. Gypsum, from which the two atoms of water of crystallisation have been expelled by heat, rapidly hardens upon being mixed with water. This is ascribed to the reunion of the sulphate of lime with the water.

Do either of the above processes suggest the method by which the rocks of the Florida reefs have been hardened?

The facts presented in the furnished specimens are as follow:—

The rock formed under water exclusively is composed of grains of size less than that of a mustard seed, which to the naked eye appear quite globular, and of uniform diameter. More carefully examined with a microscope, they are found to be far from regular in form or uniform in size, but present numerous depressions and prominences. Distributed throughout the intervening spaces is a fine deposit of carbonate of lime, which adheres with considerable tenacity to the surface upon which it rests.

The surface or crust-rock, though not strictly homogeneous, is composed of particles so minute as not to be distinguished from each other. It dissolves in hydrochloric acid, leaving a flocculent residue. The solution, when evaporated to dryness, and ignited, readily redissolves in hydrochloric acid, with only an occasional residue. The solution gives no precipitate with chloride of barium. Nitrate of silver gives, in a nitric acid solution, a white precipitate, soluble in ammonia. The aqueous extract gives to alcohol flame the characteristic soda tint. The powdered rock, dried at 100° C., when heated in a dry tube, gives off water.

Thus the qualitative analysis of the incrusting rock shewed it to consist of lime, soda, carbonic acid, hydrochloric acid, water, and organic matter. There were also variable traces of peroxide of iron, magnesia, and silica. The former two were wanting in most of the specimens examined, and the silica in some. Numerous specimens were examined for alumina, without in any instance finding a trace of this substance.*

* I examined, also, all the species of coral at my command, without finding a trace of alumina in any of them. The hydrochloric acid solution of the coral was precipitated with ammonia. The washed precipitate was digested for several hours with potassa (previously tested for, and found to be free from, alumina), and filtered. The filtrate was then neutralised with hydrochloric acid, and ammonia added. After standing for several hours, there appeared filaments which were soluble neither in potassa nor nitric acid, and which, examined with the microscope, proved to be paper; they had been derived from the filter. Beside these, there was no precipitate. The quantities employed were, in several instances, from a quarter to half a pound of material. There were examined, Millepora alcicornis; Meandrina labyrinthica, two specimens; Manicina palmata; Mycedia areolata; Astræa microcosmos, two specimens; rock subaerial and rock submarine, numerous specimens.

In a quantitative analysis by Homer, and another by Mariner, the following results were obtained :—

The total loss by prolonged ignition, included organic matter, water as hydrate of lime, and carbonic acid, was as follows :—

I. 2·7875 gr. lost 1·2687 gr. II. 0·5910 gr. lost 0·2600 gr.

The water was determined in a chloride of calcium tube, with the aid of a low red-heat and an aspirator. (A heat of 175° C. in an oil-bath, expelled but a very small proportion of the water.)

I. 0·7519 gr. lost 0·0259 gr. II. 1·2890 gr. lost 0·0280 gr.

The organic matter was determined by washing on a dried filter the hydrochloric acid residue.

I. 1·7181 gr. gave 0·0028 gr. II. 0·4461 gr. gave 0·0021 gr.

The carbonic acid was determined in an evolution flask glass. The results with different specimens varied greatly, and are far from being satisfactory.

I. 0·8605 gr. lost 0·3347 gr. III. 0·1720 gr. lost 0·0585 gr.
II. 0·1745 gr. lost 0·0600 gr. IV. 1·6116 gr. lost 0·6277 gr.

The lime was precipitated as oxalate and weighed as carbonate.

I. 1·3248 gr. gave 1·2581 gr. II. 0·2550 gr. gave 0·2330 gr.

The silica was determined in the usual way.

I. 1·3245 gr. gave 0·0002 gr. II. 0·3760 gr. gave 0·0005 gr.

The chlorine of the chloride of sodium was determined as chloride of silver.

I. 0·8933 gr. gave 0·0303 gr. II. 0·6850 gr. gave 0·0101 gr.

Expressed in per-cents. we have :—

Volatile Matter from	43·99 ℔ cent. to		45·51 ℔ cent.
Water ...	2·17	...	3·44
Organic Matter ...	0·16	...	0·47
Carbonic Acid ...	{ 34·01 34·38	...	{ 38·89 38·94
Lime ...	51·17	...	53·12
Chloride of Sodium	0·04	...	0·04
Silica ...	0·01	...	0·01

It is conceivable that the variability in the carbonic acid and water is due to the more or less advanced stages of change which the rock has undergone. In the ultimate form of limestone all the water existing as hydrate in the earlier stages will have become carbonate.

These ingredients permit no action like that occurring in hydraulic cements, in which silica plays an important part; or like that presented in the hardening of gypsum, in which sulphuric acid is necessary. To one of the two remaining processes, if to either, must it be ascribed; and as hydrate of lime is present, it cannot be exclusively assigned to a place with calcareous spring deposits. Now, how could hydrate of lime be provided from carbonate of lime?

The completeness of the suite of collections provided for me by Prof. Agassiz, has enabled me to answer this question in such a manner as leaves, I think, little room for doubt. On the main land against the Keys, there are depressions which are filled with water only at long and irregular intervals. This water, like that within and about the Keys, abounds with animal life. As the water evaporates, these animals die, and fall upon and mingle with the coral mud at the bottom. As the beds become more and more completely dry, the layer of mud and animal matter hardens till it forms a mass resembling the surface or crust rock.

Of this soft, growing rock, specimens were collected. Agitated with water, it yielded a turbid, fœtid solution. Tested with acetate of lead, it betrayed the presence of hydrosulphuric acid. After standing some hours, a delicate white film was deposited upon the containing vessel, at the surface of the water, which proved to be carbonate of lime. Test-paper shewed the liquid to be alkaline. The addition of soda solution set ammonia free, and the addition of chloride of barium and hydrochloric acid shewed the presence of sulphuric acid.

Conceiving this soft rock to be in the condition in which the solidified crust was at first, the process of hardening seemed of easy explanation.

The animal matter mixed with the carbonate of lime, containing sulphur and nitrogen, besides carbon, hydrogen, and oxygen, in the progress of decay, which warmth and a small quantity of water facilitated, gave, as an early product of decomposition, hydrosulphuric acid; this, by oxidation at the expense of the oxygen of the atmosphere, became water and sulphuric acid. The sulphuric acid coming in contact with carbonate of lime, a salt soluble in 10,600 parts of water, resolved it into sulphate of lime, a salt soluble in 388 parts of water. The carbonic acid set free, uniting with an undecomposed atom of carbonate of lime, rendered it soluble. The nitrogen going over into the form of ammonia, at a later period, decomposed the sulphate of lime, forming sulphate of ammonia and soluble hydrate of lime. This hydrate of lime, with an atom of carbonate of lime, united to form the compound in ordinary mortar investigated by Fuchs. The carbonate of lime in solution from the added carbonic acid, as the water is withdrawn by evaporation, takes on the crystalline form, giving increased strength and solidity to the rock.

That this explanation may serve, in however small measure, for the crust rock on the land slopes of Key West and all localities of a similar character, it is necessary that there be animal exuviæ in coral mud, or finely divided carbonate of lime. Both these occur. The water about the Keys abounds in animal life.

With the influx of the tide, the slopes became overspread with the water and what it contains in suspension. The retreating water, at ebb tide, leaves a thin layer of the animal matter, mixed always when the water is agitated with the fine calcareous powder. Before the return of flood tide, exposure to the atmosphere and warmth have secured the succession of chemical changes enumerated above, and a thin layer of rock is formed. A repetition of this process makes up the numerous excessively thin layers of which this rock is composed.

On the ocean side the deposit is formed from spray, during winds which drive the froth of the sea, containing, with coral mud, the exuviæ from the barrier of living corals upon the low bluffs of the Keys.*

* Professor Dana in a note to his last paper on Coral Reefs and Islands in the July number of this Journal, p. 83, after enumerating briefly the details of the above process of consolidation, remarks:—

To these chemical changes must be added the simple admixture of the animal and vegetable matter, which, like

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" In the first place, his (Prof. H.'s) paper only alludes to the rock formed above low-tide level, which I have called the coral sand-rock. Again, the amount of organic matter in corals, as found by analysis, does not exceed five per cent.; and the sulphur present in this organic matter, is not over *one-tenth of one* per cent. It hence appears that the amount of sulphur is altogether inadequate for such changes.

" But as the sands of the beach (which have a peculiarly white and clear appearance) are washed by the breakers, and the animal matter they contain is either undecomposed within the several grains, or is borne off by the waters, even the animal matter present cannot contribute to the consolidation. The waters of the tides along a sand beach on the open ocean have certainly not been proved to carry in dissolved animal matter for dissemination among the sands."

Two or three points in this note demand attention from me.

The first sentence of the first paragraph should be read in connection with the conclusions I. and II., expressed at the end of my paper.

In reply to the remainder of the paragraph, the criticism would be just, if I had any where ascribed the solidification, or any part of it, to any action of the organic matter in corals.

Since the publication of my article in the Proceedings of the Association, there have been made quantitative analyses of the more important ingredients of the soft rock, corresponding, as I conceive, with the rock of sub-aerial solidification in the first stages of its formation. When first supplied to me, it was of the consistency of well-tempered pottery clay. It is now so hard as to yield only to a severe blow with a hammer, and is, beside, brittle and coated with fibrous crystals of common salt.

The following analyses made by Everett and Warren, upon samples differing but little from each other in appearance, have been conducted with great care. They vary, it will be seen, considerably from each other :—

	Dried at a temperature of 100° C.	By prolonged ignition.
I.	1·1450 gr. lost 0·0890 gr.	0·8270 gr. lost 0·4870 gr.
II.	1·5325 gr. lost 0·1175 gr.	1·9020 gr. lost 0·8000 gr.

The hydrochloric acid solution left a residue of organic matter.

I. 1·1450 gr. gave 0·2930 gr. II. 1·6424 gr. gave 0·2805 gr.

The mass, digested in diluted hydrochloric acid, yielded from existing sulphate upon the addition of chloride of barium to the filtrate, sulphate of baryta.

I. 2·3380 gr. gave 0·1040 gr. II. 1·5325 gr. gave 0·1304 gr.

The organic matter by itself, oxydated in nitro-hydrochloric acid, with addition of pulverized chlorate of potassa, yielded to chloride of barium a precipitate of sulphate of baryta.

I. 1·5325 gr. gave 0·1505 gr.

The whole mass oxidated in a mixture of fused nitrate of potassa and carbonate of soda, yielded to chloride of barium and hydrochloric acid, a precipitate of sulphate of baryta.

mucilage or glue, fills up the interstices, increases the extent of surface, and with it the cohesive attraction; and still

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I. 2·3090 gr. gave 0·2850 gr. II. 1·4322 gr. gave 0·1550 gr.

The hydrochloric acid solution filtered from the organic matter gave a precipitate of oxalate of lime, which was determined as carbonate.

I. 0·8770 gr. gave 0·4100 gr.

Expressed in per cents. the above determinations give of

Water, expelled at 100° C.

I. 7·77 per cent. II. 7·66 per cent. Average, 7·72 per cent.

Total volatile matter,

I. 41·17 per cent. II. 42·06 per cent. Average, 41·58 per cent.

The following per cents. are estimated upon the substance as dried at 100° C.

Sulphur existing as sulphate and soluble in diluted hydrochloric acid.

I. 0·65 per cent. II. 0·90 per cent. 1·26 per cent. Average, 0·94 per cent.

Sulphur in organic matter.

I. . . . . 1·45 per cent.

Total sulphur of the above determinations, 2·39 per cent.

Total sulphur by oxidation of the mass, including the organic and inorganic parts.

I. 1·61 per cent. II. 1·84 per cent. Average, 1·72 per cent.

Average by the two methods, ... 2·05 per cent.

Lime, I. . . . . . 30·09 per cent.

Placing side by side the results of the above determinations with the quantities which Prof. Dana justly conceives to be inadequate to the changes ascribed, we have,

	Per cent.	Per cent.
Organic matter, ...	5·	20·16
Sulphur, ...	0·1	2·05

The conditions of this soft rock, and of the surface or crust rock at the time of its formation, I conceive to have been quite identical. The soft rock is the residue left by spontaneous evaporation of a considerable body of sea-water thrown, with its mingled coral mud and animal matter, into an inland basin, at the rare juncture of favourable high wind and tide. A single layer of the surface rock is the residue left by evaporation of the water mingled with coral mud and animal matter, thrown up in spray from the dashing of the waves, or carried up by flood-tide, and left by evaporation in the interval between the two tides. This will account for its stratification, for its occurrence on eminences as well as in depressions and along abrupt slopes, for its interstratified arrangement with the coarse coral sand; indeed, for all the phases and peculiarities of it which are presented in the extensive suite of collections submitted to me.

In addition to the changes enumerated in the above paper as resulting from the decay of the animal matter, another may be mentioned. The ammonia evolved in the process of decomposition, would provide hydrate of lime from the sulphate present in the sea-water. This ingredient, taking the average of Bibra's analysis, is to the chloride of sodium as 1 to 16, and may be conceived further to the decomposition of the organic matter furnishing carbonic acid, which gives solubility to the pulverulent carbonate of lime.

The exceeding fineness of the coral mud is due in part to the stone plants which flourish in the waters within the reef, and which admit of ready reduction to a powder of extreme fineness. Of these, two species of Millepora, I., II., and one of Opuntia, III., were analysed by Mr Scoville in my laboratory.

	I.		II.		III.	
Organic matter,	4·45	4·45	1·26	2·58	4·18	5·72
Carbonic acid,	40·09	39·64	41·08	2·70	37·68	35·81
Sulphuric acid,	0·0056	0·0056	...	...	...	...
Lime,	47·71	47·98	46·35	46·80	51·81	51·36
Magnesia,	...	...	6·23	5·90	...	...
Water,	3·67	3·30	4·52	...	5·59	5·92
	95·92	95·37	99·44	8	99·26	98·81

The discrepancies in the analyses of the different specimens of the same species are due to the circumstance that different parts of the stone plant contain organic matter in unlike proportions; and it is very difficult to procure two

to have furnished no inconsiderable amount of hydrate of lime for the process of consolidation.

Prof. Dana attributes the formation of this crust-rock which has been the more prominent object of my investigation, to the action of simple rain-water, dissolving the carbonate of lime and again depositing it upon evaporation.* This would account for its occurrence in depressions of the rock, but would not account for its occurrence on eminences or on abrupt slopes; nor would it account for the presence of water as hydrate of lime.

The first sentence of the second paragraph of the above criticism has been replied to. I have ascribed no solidifying action to the animal matter in corals.

In regard to the second:—It will not be questioned that there is a great amount of organic matter in various stages of decomposition about coral reefs. Bibra found organic matter in all the ten specimens of sea-water analysed by him. I have, in the paper above, repeated the statement made to me by the parties who collected the specimens, that the waters within the Keys abound in animal life. That procured for analysis from within the Keys was found exceedingly offensive from the decomposition of animal matter. It yielded the odour and reactions of hydrosulphuric acid, and gave a total amount of organic matter of 2·98 per cent.

Now, it is difficult to see how sea-water should fail to carry the animal matter it holds in solution, and more or less of that it holds in suspension into the coral sands, which are saturated at every high water and again drained at low tide.

* Am. Jour. Sci. [2], xiv. 67 and 81.

specimens which, when pulverized, will present homogeneous powders of the same constitution.

II. *Source of Lime in the Growth of Corals.*

Marcet,* as early as 1823, observed carbonate of lime in the sea-water near Portsmouth. Jackson† found it in two specimens of sea-water furnished by the United States Exploring Expedition; one from 600 feet, and the other from 2700 feet below the surface. J. Davy‡ found the sea-water of Carlisle Bay, Barbadoes, to contain about $\frac{1}{10000}$th part of carbonate of lime. There was found scarcely a trace near the volcanic island of Fayal. White‖ is of the opinion that it fails only near the surface; but the elaborate analysis by Bibra,§ of no less than ten specimens taken generally from a depth of twelve feet, but in one instance from a depth of four hundred and twenty feet, in various latitudes on both sides of the equator, shews quite conclusively that it is not a constant ingredient of sea-water. His analyses do not mention a trace of carbonate of lime. The quantity found by Davy is very nearly that which is soluble in water and is obviously due to the calcareous marl which abounds near the Barbadoes.

The water from within the Keys was carefully analysed in my laboratory; it contained lime and sulphuric acid among its ingredients, but not a trace of carbonic acid.

The total want of carbonic acid in a water in which coral life is so luxuriant, suggests naturally that the stone plant, as well as the coral animal, possesses the power of abstracting lime from the sulphate; the change being due to double decomposition with carbonate of ammonia excreted from the plant and animal, yielding carbonate of lime, quite insoluble, and sulphate of ammonia of the highest solubility. The building up of the calcareous skeleton becomes, upon this hypothesis, of exceeding simplicity. The surrounding ele-

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* Annals of Philosophy, April 1823, p. 261.

† Am. Jour. Science, [2] vol. v., p. 47.

‡ Phil. Magazine, [3] xxxv., p. 232. ‖ Ib., p. 308.

§ Ann. de Chemie et de Pharmacie, lxxvii., 90.

ment yields at once to the exhaling carbonate of ammonia the framework of stone.

With this view, there is no difficulty in finding a supply of carbonate of lime for the vast masses of coral. The sulphate of lime, decomposed to furnish the carbonate, is perpetually renewed through rivers from the continents and islands.

The following inferences are legitimately deducible from this view :—

1*st,* Corals would soon die in bodies of salt water wholly cut off from the ocean.

2*d,* They might flourish to some extent in waters accessible to the sea only at high tide.

In Dana's Report on Coral Reefs and Islands,* he states that "where there is an open channel, or the tides gain access over a barrier reef, corals continue to grow, &c. At Henuake the sea is shut out except at high water, and there were consequently but few species of corals, &c. At Ahii there was a small entrance to the lagoon ; and though comparatively shallow, corals were growing over a large portion."†

These facts seem to me to give some support to the view expressed above.

It was of interest to ascertain, in the case of corals, whether the formation of new coral without was attended with absorption or partial solution in the interior, and a corresponding reduction of its specific gravity. Specimens of coral, from the centre, periphery, and midway between, of a

* Am. Jour. Science, [2] xii., 34 to 41, and Geol. Report Expl. Exp., p. 63.

† In my article, as published in the Proceedings of the Association, I have further quoted from Professor Dana's papers in support of other inferences deduced from the foregoing view. I have since learned from the author that I had misconceived the sense in which the quotations were to be understood, and have become satisfied, especially after examination of the map of the Feejee Islands accompanying Professor Dana's last article, that the inference, that fresh-water streams, by their supply of sulphate of lime, exerted any considerable influence upon coral formations, is not sustained. The sulphate of lime of sea-water, however, being one-sixteenth of the chloride of sodium, is abundant for the supply of the carbonate of lime, without the aid to be derived from such a source.

mass of Meandrina, a foot in diameter, were reduced to powder, washed with hot water until the chloride of sodium was all removed, and their specific gravity ascertained by Storer. The average of three specimens from the centre, three from the middle, and two from the periphery, gave the following specific gravities :—

Centre.	Middle.	Periphery.
2,695	2,749	2,785

These results so far support the affirmative of the suggestion above, as to make a repetition of the determinations desirable.

The chief conclusions to which the above research has conducted are :—

I. That the submerged or oolitic rock has been solidified by the infiltration of finely powdered (not dissolved) carbonate of lime, increasing the points of contact; and the introduction of a small quantity of animal mucilaginous matter, serving the same purpose as the carbonate of lime, that of increasing the cohesive attraction.

II. That the surface rock has been solidified by having, in addition to the above agencies, the aid of a series of chemical decompositions and recompositions resulting in the formation of a cement.

And I may add that it lends support to the suggestion,

III. That the carbonate of lime of corals is derived from the sulphate in sea-water, by double decomposition with the carbonate of ammonia exhaled from the living animal.—(*Silliman's American Journal,* vol. xiv. 2d Series, No. 41, p. 224.)

Observations on a remarkable Deposit of Tin-Ore at the Providence Mines, near St Ives, Cornwall. By WILLIAM JORY HENWOOD, Esq., F.R.S., F.G.S., Member of the Geological Society of France, &c. Communicated by the Author.*

The Providence Mines, in the parish of Lelant, comprise the mines formerly known as *Wheal Speed*, *Wheal Laity*, *Wheal Comfort*, and *Wheal Providence*, long worked on the eastern side of the hill which slopes from Knill's monument to the sea.

(*a*) Observations on the eastern workings in the slate, and on the western within the granite formation, have already appeared in the Royal Cornwall Geological Society's Transactions.† The intermediate tract, now to be described, is wholly in granite, of which the upper beds are composed of a basis of greyish felspar and quartz, imbedding medium-sized crystals of white felspar, as well as numerous small groups of schorl in radiating crystals: but near the productive parts of the *lodes* the rock is mostly rather coarse-grained, its basis is greenish-grey felspar, black mica, and quartz; and the included porphyritic crystals of felspar are either of a pale buff, a pink, or a reddish-brown hue.

(*b*) These veins are—

The *Cross-course* or *Trawn*,	which bears about	22° W. of N.,	and dips	E.‡
Wheal Comfort lode	,,	15° W. of N.,	,,	W.
and *Wheal Laity lode* or *lodes*	,,	17° S. of W.,	,,	S.

Connected with the *Wheal Comfort lode* there is a "*Carbona*,"§ to which further reference will be made presently.

It may be here stated generally, that the *Cross-course* is from one foot and a half to two feet in breadth, and is composed of disintegrated fine-grained granite, divided by numerous joints parallel to the "*walls*;" as well as by many other curved and irregular ones which intersect each other in every imaginable manner, and are filled with oxide of iron, and closely but unconformably striated.

The *Wheal Comfort lode* varies in width, from a few inches to more than six feet. At a distance from the *Wheal Laity lodes* it is of granite, very thinly impregnated with tin-ore;—the remainder consists of quartz, schorl-rock (*capel*), brown iron-ore, and greenish and brownish felspar, in some places,—near the *Wheal Laity lodes*,—abounding in tin-ore.

* For the Paper in full *vide* vol. vii. of Transactions of the Royal Geological Society of Cornwall.

† Vol. v., pp. 16–20; Plate ii., fig. 7; Tables 21 and 22.

‡ The "directions" have reference to true north, the "dips" are from the horizon.

§ I have already described a similar though a much smaller formation in one of these mines. Corn. Geol. Trans., v., Table 22.

At about 105 fathoms deep this *lode* is connected with one of those curious deposits of tin-ore locally called "*Carbonas*,"* as yet unknown in any other part of Cornwall. The union takes place about 14 fathoms south of the contact between the *Wheal Comfort* and the *Wheal Laity lodes;* and for 10 fathoms above and 20 fathoms below, as well as for the whole distance between the *Wheal Laity lodes* and the *Carbona*, the *Wheal Comfort lode*, when alone, is very productive: but immediately as the *Wheal Comfort lode* and the "*Carbona*" separate in descending,—each taking its own downward course,—the *lode* becomes unproductive, and so also remains as far southward as it has yet been traced.

At the northern contact of the *Wheal Comfort lode* and the *Carbona*" there is a rich mass of quartz, felspar, schorl, and tin-ore, at least 15 feet in width for about 5 fathoms in length: both southward of and below this spot the *lode* preserves its usual direction and dip; but the "*Carbona*" southward bears about 5° east of the course of the *lode*, and holds nearly perpendicularly downward. Descending about 5 fathoms, it abuts on the granite rock, and is seen no deeper; except that as it is pursued southward the irregular granitic bed on which it rests declines at an angle of about 8°. With the exception of a single short string or pipe no trace whatever of the "*Carbona*" has rewarded the numerous researches which have been made at greater depths. Nothing can, however, be more irregular than its size and various ramifications. Though the upper edge of the "*Carbona*" generally continues to touch the lower side (*foot-wall*) of the *lode*, in some places the contact is only a few inches, but in others as much as two fathoms and a half wide. Again, in some cases the continuity of the "*Carbona*," where it joins the *lode*, is almost entirely cut off by intervening masses of granite; the union with the main body being still preserved, though merely by "pipes" or "pillars" of *lode-like* matter. Many portions of the "*Carbona*" are as much as five or six fathoms high; others not more than four or five feet; some parts are two fathoms and a half wide; whilst others do not exceed six inches. The largest portions are, however, seldom or never entirely separated from each other by the containing rock; for there is always a sufficient connection to conduct the miner from one large and rich mass to another.

The composition of the *Wheal Comfort lode* has been already noticed: but, notwithstanding their intimate connection, that of the "*Carbona*" is widely different, as its tin-ore occurs chiefly in quartz and schorl, which minerals, either separate or mixed, constitute the far greater portion of this remarkable deposit.

* Some persons pretend to derive this term from the ancient Cornish language, whilst others suppose it to have been recently *coined* by the miners. Both the word itself and the metalliferous deposit it is meant to designate are, I believe, confined to the St Ives mining district. Corn. Geo. Trans., v., p. 21, note.

Everywhere eastward the *Wheal Laity lode* is but a single vein of about a foot and a half wide, and composed of quartz, earthy brown iron-ore, greenish, and in some places brick-red, felspar, a little tin-ore, together with some vitreous copper-ore, and iron pyrites. Westward, however, it consists of at least two separate veins, called, for distinction sake, the *Wheal Laity north and south lodes;* and sometimes there is also a third vein. At one spot the third vein is simply crystallized felspar, and the axes of the crystals are parallel to each other, but lie across the vein; in other parts it is slightly productive of tin-ore. The *Wheal Laity north*, and *Wheal Laity south, lodes*, in general from a foot to a foot and a half in width, are occasionally much wider. Greenish felspar, quartz, schorl, and occasionally brown iron-ore, are their chief ingredients: in some parts both veins are rich in tin-ore; vitreous copper-ore, copper and iron pyrites also occur, but are not common constituents. In the deepest part of the mine (*i. e.*, at 150 fathoms deep), the *Wheal Laity north lode* is for some fathoms in length about two feet in width, and is then composed of chlorite, vitreous copper-ore, and iron pyrites, and has a vein of rather fine-grained granite on one side. At a depth of 120 fathoms, and about 60 fathoms west of the portions already described, where the same *lode* consists of granite, quartz, red iron-ore, and a little tin-ore, there is connected with its northern side (*foot-wall*) an off-shoot or excrescence, about four fathoms in all directions, but most irregular in figure, and having many small vein-like branches. This mass, consisting chiefly of chlorite, quartz, and iron pyrites, is not only far richer in tin ore than the adjoining portion of the *lode*, but is remarkably different in mineral composition. We have thus the same ore richly impregnating, not only the *Wheal Comfort lode* and the "*Carbona*," two parallel but entirely dissimilar deposits, but also the *Wheal Laity lode*, which has a direction nearly at right angles to them.

(*c*) The intersections of the lodes just mentioned exhibit almost an epitome of that class of phenomena.

(1) The *Wheal Laity* and the *Wheal Comfort lodes* cross each other: still at some levels there is no evidence to show that either is cut through; whilst at others the *Wheal Comfort lode* not only intersects, but also *heaves* the *Wheal Laity lode*. It is not the least remarkable circumstance attending this intersection, that the *Wheal Laity lode* is a single vein everywhere eastward of the *Wheal Comfort lode*, whereas westward of their contact it is divided into two, and in some places even into three distinct and separate veins.

(2) All these veins are intersected by the *Cross-course*, and all are *heaved* by it: the two larger (the *Wheal Laity north* and the *Wheal Laity south lodes*) in general from 10 to 15 fathoms: the displacement of the smaller vein is, however, much less considerable, and does not exceed six fathoms and a half.

Again, notwithstanding the *Wheal Comfort lode* and the *Cross-*

course have opposite inclinations, they respectively *heave* the *Wheal Laity lodes* in the same direction.

At a depth of 110 fathoms, where the *Wheal Laity north lode* is for some distance unproductive, whilst the *Wheal Laity south lode* is rich in tin ore on both sides of the *Cross-course*, and for some fathoms both above and below the gallery (*level*), the *Cross-course* consists of a rich vein of tin-ore for the whole interval (five fathoms) between the eastern portions of the two *lodes*, as well as of a fine mass of the same ore at its contact with the western part of the *Wheal Laity south lode.*

(3) At 130 fathoms deep the *Wheal Laity south lode* is also *heaved*, but in an opposite direction, by a vein of granitic clay (the *Flucan*). This *flucan* is not prolonged to either of the other *Wheal Laity* veins; nor, indeed, does it reach any other gallery (*level*) even on the same *lode.*

(4) The *Wheal Comfort lode* and the *Cross-course* have the same direction, but, as already observed, opposite inclinations; and are so situated that they come into contact on the line of their dips at about 130 fathoms deep. From the point where they first touch each other they descend perpendicularly side by side for about three fathoms, each keeping the same relative position it had previously when separate (viz., the *Cross-course* on the west, and the *Wheal Comfort lode* on the east). At length, however, the *lode* cuts through the *Cross-course.* After this intersection, though they have changed sides, and their relative position is reversed, they still proceed together, but now take the line of the *lode's* previous underlie for several fathoms. When they separate the *lode* preserves its dip; but the *Cross-course*, though it resumes the previous direction of its inclination, dips eastward far more rapidly than before. It may, indeed, be generally observed, that a vein which has been displaced by another, whether the intersection be horizontal or vertical, makes (if I may be permitted the expression) an effort to resume its original course.

(5) The *Wheal Laity lodes* are intersected as well by the *Wheal Comfort lode* and the *Cross-course*, during their union, as by each of them when separate; the union, however, has little or no influence on the extent of the *heave.*

Many details of local, and some, indeed, of general interest, scarcely need be mentioned here, as this paper may be deemed supplementary to my remarks on the Saint Ives District;* and especially to a description of a similar interesting formation at the *St Ives Consolidated Mines*, which has already appeared in the Transactions of the Royal Geological Society of Cornwall.†

A small stream issues from the *Wheal Laity north lode* at 150 fathoms deep, having a temperature of 71°; whilst that of the water

* Vol. v., p. 16. † Idem, p. 21.

discharged by the pump at the adit (45 fathoms from the surface) is only 63° 6′.*

The Orchard, Penzance, Oct. 15, 1851.

Arctic Natural History.

The following interesting statements illustrative of Arctic Natural History we select for the information of our readers.

1. *Cause of Intense Thirst in Arctic Regions.* 2. *Thickness of the Arctic Ice.* 3. *Warmth of Snow Burrows.* 4. *Snow a bad Conductor of Sound.* 5. *The breaking up of an Arctic Iceberg.* 6. *Refrigerating Power of Icebergs.* 7. *The droppings of Eider Ducks.* 8. *Arctic Minute Animal and Vegetable Forms, and Colour of the Sea.* 9. *On the Flesh of Little Auks and Rotges, and Sea-Fowl generally.* 10. *Red Snow.* 11. *On the Colouring Matter of Marine Algæ, by Dr Dickie.* 12. *Nostoc Arcticum, by Dr Dickie.* 13. *On the Magnitude of Arctic Glaciers and their advance towards and their termination in the Sea.* 14. *Ice and Sea-Water Coloured by the Diatomaceæ.*

1. *Cause of Intense Thirst in Arctic Regions.*

After saying farewell to Mr Mecham and his party Mr Stewart returned to the ships in Assistance Bay, where he arrived in the evening a little fatigued, having suffered as usual from excruciating thirst. I believe the true cause of such intense thirst is the extreme dryness of the air when the temperature is low. In this state it abstracts a large amount of moisture from the human body. The soft and extensive surface which the lungs expose, twenty-five times or oftener every minute, to nearly two hundred cubic inches of dry air, must yield a quantity of vapour which one can hardly spare with impunity. The human skin, throughout its whole extent, even where it is brought to the hardness of horn, as well as the softest and most delicate parts, is continually exhaling vapour, and this exhalation creates in due proportion a demand for water. Let a person but examine

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* Observations on the temperature of other parts of the *Providence Mines* are recorded in the Society's Transactions, vol. v., p. 390.

the inside of his boots after a walk in the open air at a low temperature, and the accumulation of condensed vapour which he finds there will convince him of the active state of the skin. I often found my stockings adhering to the soles of my Kilby's boots after a walk of a few hours. The hoar frost and snow which they contained could not have been there by any other means except exhalation from the skin.—(*Sutherland's Journal of Captain Penny's Voyage to Wellington Channel, in* 1850–51, vol. i., p. 404.)

2. *Thickness of the Ice.*

The ships were by this time almost completely banked up with snow, and a gangway of the same material with two parapet walls sloped gradually from the door in the awning to the surface of the ice. The dogs were now located on the ice in a little snow house at the ship's bow, with a quantity of straw between them and the cold and soft ice beneath. The ice in the harbour was upwards of 2 feet thick. Since the 26th of September, when it was 10 or 11 inches, it increased at the rate of half-an-inch per day. The ice on Kate Austin Lake presented the same thickness with that in the harbour, although it was 7 or 8 inches thick when the harbour was one continuous sheet of water. This may appear rather strange, seeing that fresh water freezes at a higher temperature than sea water; but it may be proper to observe that sea water ice, from the saline matter which it contains, will probably conduct the heat faster from the water underneath than fresh water ice, and also, that the saline matter, reduced to a low temperature at the surface, sinks while the water is congealing, and cools the stratum into which it descends. The lakes a little beyond the beach, to which allusion has been made already, were frozen to the bottom, although the depth of some of them was more than 2 feet. This is probably owing to the proximity of the ice on the surface with the bottom, which must conduct the heat away from the water laterally, in addition to the action of the air at the surface. It is not improbable that in the centre of Kate Austin Lake the bottom does not present ice even after the winter has devoted itself to the extension of the ice from the sides towards the centre. Here, then, we would find a perforation in the frozen crust which envelops the earth's surface in this high latitude. Were it not so, it is highly improbable that the salmon could exist between two ices.—(*Sutherland's Journal.*)

3. *Warmth of Snow-Burrows.*

Captain Penny suggested the idea of ascertaining what amount of warmth and comfort could be attained in a close burrow in the snow. In November, a single individual raised the temperature of one from 4°, that of the air at the time, to + 20° in about twenty minutes; but the heat of the snow and the ice must have been much greater than it was at this time. Two burrows, each six and a-half feet long, and two and a-half feet wide, were excavated about six inches above the level of the blue ice, in a wreath which had accumulated during an easterly gale. There was a thickness of at least four feet above each from the surface of the snow downwards; and the entrances into both were made so as to shut very closely. A thermometer inclosed in one of them for four hours rose to − 2°, the temperature of the external air at the time being − 29°. Two persons, the capacities of whose lungs were represented by 240 and 210, were inclosed in them for an hour and a quarter, at the end of which time the temperature had risen from − 28°, that of the air, to + 3° and − 3° respectively; the person with the most capacious lungs raising it seven degrees higher than the other. To say the most of the burrows, they were not warm; and closed up in them, as the two persons were, an idea of being buried alive was continually uppermost in their minds. However, there is no doubt, had our circumstances demanded it, we should have overcome this idea, and have appreciated the comforts of burrowing in preference to sleeping in the open air.

4. *Snow a bad conductor of Sound.*

While inclosed in the burrows, the two persons kept up a conversation through the partition of dense snow that intervened between them. They had to bawl loudly to one another, although the thickness of the partition did not exceed a foot; and when they were spoken to through the doorway, which was securely closed also with firm snow, one had to call out in quite a stentorian voice before a reply could be obtained. The thickness of the slab of snow which closed the doorway was not above nine inches. This is at once a proof of the bad conductor of sound we have in snow. It is very probable that the property of conducting sound diminishes with the density from ice down to the softest snow.—(*Sutherland's Journal.*)

5. *The Breaking up of an Iceberg.*

When an immense iceberg begins to tumble to pieces and change its position in the water, the sight is really grand,—perhaps one that can vie with an earthquake. Masses inconceivably great, four times the size of St Paul's Cathedral, or Westminster Abbey, are submerged in the still blue water to appear again at the surface, rolling and heaving gigantically in the swelling waves. Volumes of spray rise like clouds of white vapour into the air all round, and shut out the beholder from a scene too sacred for eyes not immortal. The sound that is emitted is not second to terrific peals of thunder, or the discharge of whole parks of artillery. The sea, smooth and tranquil, is aroused, and oscillations travel ten or twelve miles in every direction ; and if ice should cover its surface in one entire sheet, it becomes broken up into detached pieces, in the same manner as if the swell of an extensive sea or ocean had reached it ; and before a quiescent state is assumed, probably two or three large icebergs occupy its place, the tops of some of which may be at an elevation of upwards of two hundred feet, having, in the course of the revolution, turned up the blue mud from the bottom at a depth of two to three hundred fathoms.

6. *Refrigerating power of Icebergs.*

When we lost sight of this iceberg, or, I should rather say, of its ruins, a state of perfect rest had not been acquired. One half of it had but turned over upon its side, so that the pinnacled top had become the one side, while the bottom had become the other ; and the other half appeared to have been reduced to three or four smaller masses, on the smooth parts of which muddy spots were distinctly visible.

When such immense quantities of ice are floating about in and on the sea in Baffin's Bay, one need not wonder at the low temperature of the water. We very rarely had it above 32°, and at that degree it would hardly effect a perceptible change upon the icebergs, although certainly it might dissolve the floating ice of the sea water. The towering ice-bergs, over which the water exercises so little control in this latitude, are the store-houses of cold, carrying it into the depths of the ocean, and there concealing it from the searching rays of the sun.—(*Sutherland's Journal.*)

7. *The Droppings of Eider Ducks.*

The droppings of so many large birds accumulating for thousands of years would soon raise an island to a considerable height above its original level. This happened on several islands on the coasts of Africa and South America; but I do not believe it has ever been found extending to any great distance into the temperate zones, especially the zones of constant precipitation of rain, although sea-fowl are sufficiently abundant in those parts to produce it in very large quantities. There is little doubt this is owing to its being washed away by rains or melting snow, or it may be owing to vegetation, by which it becomes dissipated into the atmosphere, or converted into a thin coating of brown mould on the rock, in which grasses and other plants take root and flourish luxuriantly, affording shelter to myriads of flies and their enemies, the spiders, even on and beyond the 74° of north latitude. At the distance we were from the island with the ships the luxuriant vegetation could be clearly discerned, and in that respect it was in the most striking contrast with the rugged and bleak-looking land on both sides of the bay.—(*Sutherland's Journal.*)

8. *Arctic Minute Animal and Vegetable Forms and Colour of the Sea.*

Wherever the ice had been very much decayed a dirty brownish slimy substance was observed floating in loose *flocculi* amongst it, in the surface of the water. The naked eye could detect in it no structure whatever; but on viewing a drop of it through a microscope which magnified about two hundred and fifty diameters, it was found teeming with animal life, and minute vegetable forms of very great beauty. Now would have been the time to perpetuate them with the pencil and chalk, but unfortunately I could only consign them to the bottle, with the expectation that their delicate silicious shells would retain their forms until our arrival in England. No one can conceive the vast numbers of these infusorial animalcules in the polar seas. Varying in size from $\frac{1}{500}$ to $\frac{1}{1000}$ of an inch, a single cubic inch will contain perhaps four or five hundred millions of individuals, each furnished with perfect instruments of progression. In some of them I could see the cilia in rapid motion, while, to use the words of Professor Jones, "they were swimming about with great activity, avoiding each other as they passed in their rapid dance, and evidently directing their motions with wonderful precision and accuracy."* In others no cilia could be detected; but as they too were seen in motion, although not so often as the others, there is no doubt that they also possess similar delicately constituted organs. A beautiful sieve-like diatoma was very abundant; but the shells which are silicious were broken very readily. They resemble the *Coscinodiscus minor* of Kutzing.

Colour of the Sea.—I do not think that these infusoria can be included in the forms of animal life, described by Captain Scoresby, under the comprehensive genus *Medusa*, which is very abundant in the Greenland seas visited by that most distinguished arctic voyager; nor does there appear to be the slightest resemblance between them, except that both are of very minute size. He says that the sea is sometimes of an olive-green or grass-green colour. This is not at all peculiar to the still bays in Davis Strait, where the infusoria are so abundant. This phenomenon applies to the sea generally for many leagues or even degrees, and is not confined to the surface only; neither is it essential to that condition that there be

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* A General Outline of the Animal Kingdom, by T. R. Jones, F.Z.S., 1841.

ice. In Davis Strait the infusoria are generally found most abundant where there is ice never extending above a few inches, at most a foot, beneath the water; and when the ice disappears for the season, the brown slimy substance is rolled into rounded pellicles by the rippling of the water, retires from the surface, and ultimately sinks completely out of view, having never tinged the water in the slightest degree, except when it gave the decaying ice a dirty appearance. It is a well known fact, however, that *Entomostraca*, *Acalephæ*, and *Pteropodous mollusca*, in great abundance and of various sizes, from $\frac{1}{30}$ to $\frac{1}{40}$ of an inch in diameter up to half a foot or more, cannot fail to change the colour of the sea in a remarkable manner. —(*Sutherland's Journal.*)

9. *On the Flesh of little Auks or Rotges and Sea-Fowl generally.*

Immense flocks of rotges were continually seen flying north or south according to the direction of the wind. They generally fly against the wind where they are sure to find open water. Their flight is invariably high over a tract of ice presenting no lanes or pools of water to receive them. In consequence of the closeness of the ice around the ships our sport among them was not very extensive. Captain Stewart, on one occasion, travelled a few miles to a large angular opening where they were very abundant, and succeeded in shooting a great number. He brought down twenty to thirty at every shot. The rotge is excellent eating and is highly prized by every taste. I have heard the eider duck and the long-tailed duck, and even the loon, denounced by persons whose tastes were really fastidious, but I never heard a word against the little auk. Its flesh, and that of sea-fowl generally in the Arctic Regions, improves very much by keeping for a few weeks after being shot; indeed it is not uncommon to use them after they have been three months hanging to the booms around the ship's quarter.—(*Sutherland's Journal.*)

10. *Red Snow.*

The surface of the glaciers was of a dirty colour, but there were no moraines. It appeared to be owing to fine dust and sand blown from the adjacent land, or carried by small rills of water from the sides of the valley. Where there were patches of snow on the land a close examination would discover more than the dirty colour, which was also present, a tinge of dirty red, which, in suitable localities, applied also to the glaciers. This is owing to a minute plant which has excited great interest, and has been most carefully described by many distinguished botanists, under the popular name of the red snow (*Protococcus nivalis*). From what Mr Petersen told me, after he had visited the famous localities where it is said to extend to depth of 12 feet, and also from the replies of the natives to questions upon the same subject, there appears to be no reason for any other opinion than this, that it is a foreign body among snow or ice, which it can only find access to by being carried, either by the water of the pools in which it grows after they begin to overflow by influx of water from snow melting at higher elevations, or by the wind after the water has left it dry upon the rock. There does not appear to be any objection to the idea that this plant may grow upon stones and sand on the surface of a glacier, provided that there be water covering them; nor to the supposition that a part of an increasing glacier may become impregnated with it by being carried from some neighbouring locality by the wind. Although the red snow appears as red as blood when viewed with a high magnifying power, among the snow, along with probably abundance of other adventitious substances, it fails to exhibit its real colour, and rarely does more than impart a dirty appearance. It would prove highly interesting to examine whether the circumstances under which it is developed in the Alps and in the Arctic Regions are the same.*—(*Sutherland's Journal.*)

11. *On the Colouring Matter of Marine Algæ.* By Dr Dickie.

It may be worthy of remark here that the colouring matter

* Agassiz Etudes, chap. v.; Travels in the Alps, by Prof. Forbes. chap. ii.

of ice in the Arctic Regions sometimes consists of the remains of algæ, either in a state of decomposition or reduced to a pulp by the abrading action of drifting bergs, &c.; such at least was the nature of specimens examined by me several years ago.

In conclusion, it may be observed how few species there are of the olive-coloured and red algæ ; such as are recorded may be considered as fairly representing these plants in the parts visited by the Expedition. The number of littoral species in such regions must be few, or in many places altogether absent ; the continual abrading influence of bergs and pack ice would effectually prevent their growth.

In the thinning out of algæ in such latitudes, it is a point of interest to ascertain what genera and species resist longest the influence of conditions inimical to the development of vegetable organisms. Only five of the olive-coloured series are recorded here, four of which are British ; the fifth, viz., the Agarum, being exclusively an American form. Of the red series there are only three ; one of them, the Polysiphonia, being a common species in Britain, the Dumontia is an American form, the third, new.

The green Algæ are better represented, six being marine, and fourteen from fresh water or moist places on land, confirming the opinions entertained respecting the more general diffusion of the green than of the olive and red. Of the twenty enumerated, about a third are British.

Of Desmidieæ, only three were detected in Dr Sutherland's collection, two of which are British, and the Arthrodesmus has been found in France and Germany.

The Diatomaceæ, as might have been expected, are numerous. Their importance in reference to the existence of animal life in high latitudes has been already alluded to ; an importance out of proportion to their size, the generality of them being so minute that their presence can only be detected by the microscope ; or rather, it may be remarked, that their minuteness renders them important, since they are readily conveyed to the digestive organs of mollusca by currents produced by the numerous cilia on the mantle and gills of these animals. By a wise arrangement their numbers compensate for their small size. The climate is so unfavourable that gigantic algæ, such as occur in more favoured regions, cannot exist; the organisms in question, the representatives of the individual cells of which the larger species are composed, supply their place, and the siliceous matter which they have the power of separating from the medium in which they live, renders them better fitted to resist the injuries to which they are exposed.—(*Sutherland's Journal.*)

12. *Nostoc Arcticum*, Berk. By Dr Dickie.

This species has been recently described by the Rev. M. J. Berkeley, in a paper read before the Linnean Society. He refers it to Hormosiphon, expressing a doubt whether the latter genus is anything but a young or abnormal state of Nostoc. It appears to grow in great profusion in the localities where it occurs, and Dr Sutherland communicates the following notes respecting it:—

" It grows upon the soft and almost boggy slopes around Assistance Bay; and when these slopes become frozen, at the close of the season, the plant lying upon the surface in irregularly plicated masses becomes loosened, and if it is not at once covered with snow, which is not always the case, the wind carries it about in all directions. Sometimes it is blown out to the sea, where one can pick it up on the surface of the ice, over a depth of probably one hundred fathoms. It has been found at a distance of two miles from the land, where the wind had carried it. Each little particle lay in a small depression in the snow, upon the ice: this tendency to sink commenced early in June, owing to the action of the sun. At this distance from the land it was infested with Poduræ; and I accounted for this fact by presuming that the insects of the previous year had deposited their ova in the plant upon the land, where, also, the same species could be seen in myriads upon the little purling rivulets, at the sides of which the Nostoc was very abundant."

Dr Sutherland found this plant to be edible, and superior to the Tripe de Roche, in connection with which it may be worthy of remark here, that *Nostoc edule* (Berk. & Mont.) is used as food in China.—(*Sutherland's Journal of Captain Penny's Voyage to Wellington Channel.*)

13. *On the Magnitude of Arctic Glaciers—and their advance towards and termination in the Sea.*

To the eastward of Cape Hay, we observed a glacier, of not very large size, entering the sea from a valley, through which it could be traced until it was lost among the rugged, sharp-pointed, and bleak-looking, almost inaccessible heights, on both sides. The main valley appeared to be entered by smaller ones, which also contained ice; some of them entered at right angles, while others seemed to be a sort of division of the main one into smaller branches. The edge of the glacier protruded into the sea considerably beyond the coast line, and it looked as if an iceberg was to be detached very soon,—the water marked its sides with lines corresponding with the high and low water marks; and in this respect there was a striking resemblance with what we had often observed, on the sides of icebergs, on the eastern shore of Davis Straits, which had taken a firm lodgment on the bottom during very high tides. The protruding edge was quite perpendicular, just as it had been left by the last iceberg that had floated away from it, and it rose to a height of forty to fifty feet above the water; this would give the part under water about three hundred and fifty or four hundred feet. In many parts of its surface the glacier was very dirty, and masses of rock could be seen resting upon it, but there appeared to be very little order in their arrangement, except that, about the middle, the larger fragments followed the direction of the valley; and at the west side, there seemed to be a collection of a dark colour and muddy consistence, which also followed the direction of the valley, but gradually thinned away as it ascended; while the east side was perfectly white from the very edge, until it was lost sight of in the distance. From the appearance of the mud, I had no other idea than that it had been brought down by water in a running stream, which must have made its escape into the sea over the edge of the glacier. To the eastward of this glacier there is a second, which appeared to be a little higher, where it entered the water, than the former, and it was also of greater breadth. The surface was quite white, and did not appear to have a single fragment of rock upon it; the night, however, was coming on, and this precluded a sufficiently correct view to enable one to make out the presence or entire absence of foreign bodies. These two glaciers, although extending to the bottom at a depth of sixty to seventy fathoms, appear in very humble contrast beside the towering cubes which escape annually, through the deep valleys, from the immense glacier range of the Greenland continent into Davis Straits, and which in some cases (Claushaven, lat. 69°) rise to a height of nearly three hundred feet, and raise moraines at the bottom, at the depth of the same number of fathoms.—(*Sutherland's Journal of Captain Penny's Voyage to Wellington Channel.*)

14. *Ice and Sea-Water Coloured by the Diatomaceæ.*

At my request, made previous to the departure of the expedition, Dr Sutherland paid special attention to the colouring matters of ice and sea-water; samples of such from different localities were carefully collected and forwarded for my inspection. They were found to consist almost solely of Diatomaceæ; and in some instances fresh water forms were detected, though rather sparingly, intermixed with others exclusively marine. This is not surprising when we consider the copious discharges of fresh water from the land, occasioned by the melting of snow and ice during the brief summer.

The contents of the alimentary canal of examples of Leda, Nucula, and Crenella, dredged in Assistance Bay, consisted of mud in a fine state of division, including also numerous Diatomaceæ identical with those colouring the ice and the water.

Though not a new fact, it is one of some interest in relation to the existence of animal life in those high latitudes. Where Diatomaceæ abound, certain Mollusca obtain sure supplies of food ; these in turn are the prey of fishes ; these last contribute to the support of sea mammalia and birds.

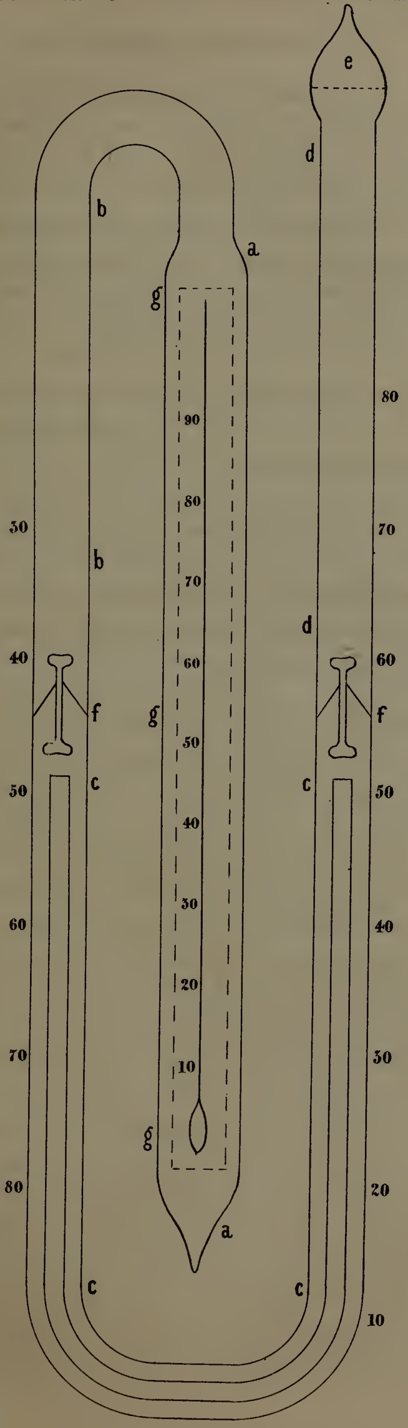
After bestowing considerable pains on this family, still I cannot write with full confidence regarding some of the species. Improvements in high powers of the microscope reveal the necessity of paying greater attention to the minute markings of the surface in addition to mere external form. The recent investigations of the Rev. W. Smith, in reference to such characters of British species, shew the importance of this, and in some measure detract from the general value of Professor Kutzing's useful work, the only one on the subject to which I have access here.—(*Sutherland's Journal.*)

On an Improvement in Sikes' Self-Registering Thermometer. By Richard Adie, Esq., Liverpool. Communicated by the Author. (With a Plate.)

The want of a self-registering thermometer, easily kept in working order, is still felt among a portion of the public. The instrument invented by Dr Rutherford is excellent so long as it remains in the hands of parties connected with observatories, who from their daily practice become skilful in the use of delicate instruments. A proof of this is, that Rutherford's thermometers may be often seen at observatories in good order after many years' constant use ; but when transferred from thence to the hall, the parsonage, or the farm offices, several sources of derangement soon become manifest, which those usually in charge of registers in these places cannot control ; hence a very general feeling of disfavour has of late years been shewn towards this form of registering thermometers.

The self-registering thermometer invented by Sikes has been long before the public, enjoying a variable degree of favour. In works on meteorology it is described without a notice, however, of a source of error in its readings, to which it is my wish in the present communication to call attention, and to suggest a remedy. The instrument, as at

SIKES' IMPROVED SELF REGISTERING THERMOMETER



Schenck & McFarlane, Lith.rs Edinburgh

present made by the London glass-blowers, works without much liability to derangement, after it has been safely suspended in the place intended for its reception. The annexed diagram is given in order to explain the principle on which Sikes' self-registering thermometer is constructed: Briefly it may be styled a spirit-thermometer, with a prolonged stem ending in an inverted mercurial syphon, the two surfaces of the mercury syphon working small indexes which register the temperature.

a a, is the thermometer bulb filled with alcohol.

b b, the thermometer stem.

c c d d e, a prolongation of the thermometer stem.

c c c c, the portion of the prolonged stem filled with mercury.

d d, further prolongation of the stem filled with alcohol.

e, a small bulb at the top filled with air or vapour of alcohol.

f f, two small indexes worked by the mercurial surfaces.

The error in the indications of the instrument which I have alluded to, arises in periods of extreme variations of temperature. It is occasioned by the great difference in the specific gravities of mercury and of alcohol, and also from the mercury not adhering to the tube as the alcohol does. In frosty weather the mercury on the side *b b* stands highest, but in warm weather the side *d d* is the higher; the difference in level often amounts to a hydrostatic pressure equal to one pound per superficial inch. The part of the syphon occupied by the mercury is coated with a film of alcohol, which connects the alcohol of the thermometer *a a b b*, with the alcohol in the part *d d*. Now when there is a difference of pressure in the arms of the mercurial syphon, alcohol passes slowly by a capillary process from the one side of the syphon to the other, to restore the equilibrium of the mercury, and in doing so destroys the accuracy of the instrument; for it is necessary that the quantity of alcohol in the thermometric part *a a b b*, should be constant. This is the fault of Sikes' registering thermometer; in practise, both sides of the mercury exhibit the same reading, yet when a mercurial thermometer is suspended beside it, the indication is found 7 to 10 degrees wrong. For this great error, there is no direct remedy, but the following addition is a ready mode of making the instrument efficient by shewing at all times what the derangement amounts to. Before sealing the end of the bulb *a a*, I propose to insert a delicate mercurial thermometer on an ivory scale *g g g* similar to the one inserted in the bulb and stem of Daniel's hygrometer. The reading of this inside thermometer will be a check on the error arising from the transfer of alcohol from side to side of the syphon, and when the register differs from the inside mercurial thermometer reading the difference must be used to correct the register. With a Sikes' thermometer thus constructed and placed in the open air, it will soon be seen how variable the differences between the register and the enclosed thermometer are, in consequence of the alcohol passing from side to side of the syphon to restore the equilibrium. Indoors, where the range of temperature is small, the differences will be much less.

In concluding, it may be well to mention another source of variation between the readings of a mercurial and of a spirit thermometer, which for registers requires to be guarded against. It is the action of light on the opaque mercury and the transparent alcohol: the light increases the temperature of the opaque body more than that of the transparent one; consequently in a bright day, a mercurial thermometer gives a higher reading than one of alcohol does, and to obtain from them corresponding results the light must be excluded. On the mercury thermometer in the bulb of Sikes' thermometer the effect of the light will be nearly prevented by the alcohol in contact with the mercurial bulb; so that in this proposed construction, in a bright light the mercury and spirit will read closely together, both standing lower than a detached mercurial thermometer.

Memoir of the late Dr Thomas Thomson, F.R.S., M.W.S., &c., Professor of Chemistry in the College of Glasgow. Communicated by his relative, Dr R. DUNDAS THOMSON.

[Having laid before our readers Gustav Rose's complete biography of Professor Berzelius, it is now our duty to communicate, for their information, a Memoir of his celebrated contemporary and rival, the late Dr Thomas Thomson.*]

Thomas Thomson, M.D., F.R.S., Regius Professor of Chemistry in the University of Glasgow, was the seventh child and youngest son of John Thomson and Elizabeth Ewan, and was born at Crieff on the 12th April 1773. He was first educated at the parish school of Crieff, and was sent, in 1786, in his thirteenth year, for two years, by the advice of his brother and of his uncle, the Rev. John Ewan, minister of the parish of Whittingham, in East Lothian, a man of some independent means, to the burgh school of Stirling, at that time presided over by Dr Doig, the distinguished author of the "Letters on the Savage State." Here he acquired a thorough classical education, the benefits of which have been so signally manifested in his numerous improvements of chemical nomenclature now generally adopted in the science. In consequence of having written a Latin Horatian poem of considerable merit, his uncle was recommended by Principal M'Cormack of St Andrews to advise that he should try for a bursary at that University, which was open to public competition. He accordingly went, in 1788, to that school of learning, which has produced among its celebrated scientific students in our own day, a Playfair, an Ivory, and a Leslie, &c., and, having stood an examination, carried the scholarship, which entitled him to board and lodging at the University for three years. In 1790 he came to Edinburgh, and became tutor in the family of Mr Kerr, of Blackshiels, one of his pupils being afterwards well known in connection with the bank of Leith. At the end of 1791, being desirous of studying medicine, he came to Edinburgh, and resided with his elder brother, now the Rev. James Thomson, D.D., minister of the parish of Eccles, one of the fathers of the Church of Scotland, the author of many articles in the "Encyclopædia," and of a recent work on the Gospel by St Luke, who survives, and had succeeded the

* The conflicting statements made by Berzelius and Thomson may give rise to explanations from the friends of the illustrious and distinguished philosophers.—*Ed. of Edin. New Phil. Journal.*

late Bishop Walker as colleague to Dr (afterwards Bishop) Gleig, father of the present eminent Inspector of Army Education, in the editorship of the "Encyclopædia Britannica." It was in the session of 1795–96 that Dr Thomson attended the lectures of the celebrated Dr Black, of whom he always spoke in terms of the utmost veneration and of gratitude for those invaluable instructions which first awoke the latent taste for the science of which he was destined to become so bright an ornament. In this session he wrote the article "Sea" for the "Encyclopædia." In November 1796, he succeeded his brother in the editorship of the Supplement to the third edition of the "Encyclopædia," and remained in this position till 1800. It was during this period that he drew up the first outline of his "System of Chemistry," which appeared in the Supplement to the "Encyclopædia," under the articles Chemistry, Mineralogy, Vegetable Substances, Animal Substances, and Dyeing Substances. These all appeared before the 10th December 1800, when the preface was published, in which it is stated, by Dr Gleig, of the author "of these beautiful articles, a man of like principles with Dr Robison, it is needless to say anything, since the public seems to be fully satisfied that they prove their author eminently qualified to teach the science of chemistry." From this authority we infer that it was during the winter session of 1800-1 he first gave a chemical course. Hence, he appears to have been before the public as a lecturer for the long period of fifty-two years, and, as he used lately to say, he believed he lived to be the oldest teacher in Europe.

1. It was in the article Mineralogy, written about 1798, that he first introduced the use of symbols into chemical science, universally acknowledged to be one of the most valuable improvements in modern times. In this article he arranges minerals into genera, according to their composition. Thus his first genus is A, or alumina, under which are two species, topaz and corundum, in accordance with the analyses of the day. The second genus is A M C, comprising spinell, which, according to Vanquelin, contained alumina, magnesia, and chrome iron. The fourth genus is S, including the varieties of silica or quartz. The eighth genus is S A G, or silica,

alumina, and glucina, including the emerald or beryl; and thus he proceeds throughout. In the editions of his "System," the first of which (a development of the original article in the Encyclopædia) was published in 1802, he continued the same arrangement and symbols, and was thus not only the originator of symbolic nomenclature in modern chemistry, but was the first chemist to bring mineralogy systematically within the domain of that science. In the third edition of his "System," published in 1807, in illustrating the atomic theory of Dalton, and in his article on oxalic acid, in the Philosophical Transactions for 1808, he freely uses symbols. Berzelius, who appeared some years later on the chemical stage, being Dr Thomson's junior by five years, published a work in 1814, in Swedish, in which he adopted the system of symbols used by Dr Thomson, with some modifications, (the introduction of Latin initials in certain cases,) but he strictly "followed the rules for this purpose given by Thomson in his 'System of Chemistry,'" (öch skall dervid följa en enledning som Thomson gifvit i sin kemiska handbok.) The work in which this passage occurs, entitled "Försök att genom användandet af den elecktrokemiska theorien, &c., grundlägga för mineralogier," af J. Jacob Berzelius, Stockholm, 1814, p. 18, was sent by Berzelius to Dr Thomson, in the same year, with a request, in a letter which is still extant, that he would endeavour to procure a translator for it. Dr Thomson applied to Dr Marcet and others without success; but at last prevailed on his learned friend, John Black, Esq., who so ably conducted the "Morning Chronicle" for many years, to undertake the task. Dr Thomson graduated in 1799. 2. He continued to lecture in Edinburgh till about 1811, and during that time opened a laboratory for pupils, the first of the kind it is believed in Great Britain. Among those who worked in his laboratory were Dr Henry of Manchester, a chemist for whom he had always the greatest regard, who had visited Edinburgh for the purpose of graduation, and who there made many of his experiments on the analysis of the constituents of coal gas. 3. During this period, likewise, Dr Thomson made his important investigations for Government on the malt and distillation questions, which laid the basis of the Scottish legislation on excise, and rendered him in after-life the arbitrator in many important revenue cases. 4. He likewise invented his saccharometer, which is still used by the Scottish excise under the title of Allan's saccharometer. 5. In 1807, he first introduced to the notice of the world, in the third edition of his " System," Dalton's views of the atomic theory, which had been privately communicated to him in 1804. He did not confine his remarks to mere details, but made many important new deductions, and by his clear, perspicuous, and transparent style, rendered the new theory soon universally known and appreciated. Had Richter possessed such a friend as Thomson, the atomic theory of Dalton would have long been previously fully discovered, and attributed to Richter. In his papers on this theory, which occupied much of his thoughts, from the mathematical precision which it promised to impart to the science, we find numerous suggestions cautiously offered, which have often been subsequently examined and confirmed, or developed in another direction. Thus, in August 1813, he states, that, according to the atomic numbers then determined, " an atom of phosphorus is ten times as heavy as an atom of hydrogen. None of the other atoms appear to be multiples of ·132 (the atom of hydrogen at that time adopted by chemists), so that if we pitch upon hydrogen for our unit, the weight of all the atoms will be fractional quantities, except that of phosphorus alone." It was undoubtedly this observation which caused Dr Prout to make new inquiries, and to announce, in November 1815, the view that the relation of phosphorus as a multiple of hydrogen, as detected by Thomson, may be general, connecting all other atomic weights with that unit, a view now generally adopted, and considered as a nearly demonstrated law.

The existence of such mathematical relations Dr Thomson was continually in the habit of testing at the conclusion of his own researches, or in examining the experiments of others. Any peculiarity of character in a substance hitherto known, or in a newly-discovered body, he never failed to point out in his " System ;" and innumerable instances have occurred, and might be mentioned if our space admitted, where lucrative patents have resulted from a simple statement or foot-note, often original, on the part of the author. A fact of this kind in the "Animal Chemistry" led Mr Robert Pattison to his ingenious patent invention of lactarin, a preparation of casein from milk, for fixing ultramarine on cotton cloth; and Dr Thomson's systematic plan of describing all the characters of bodies in detail led Henry Rose, of Berlin, to the discovery of niobium and pelopium, two new metals. From the fragments of four imperfect crystals of certain tantalites, as the mineral dealers who sold them to him termed them, he was enabled to make some analyses, and to take a series of specific gravities, which he published in a paper "On the Minerals containing Columbium," in his nephew Dr R. D. Thomson's "Records of General Science," vol. iv., p. 407, in 1836. He found that these minerals possessed an analogous constitution, but their specific gravity differs. He termed them, toreylite, columbite, tantalite, and ferrotantalite. In making his experiments, he expended all the material he possessed, and he had passed the great climacteric. Professor Rose, struck with the facts, examined the minerals upon a greater scale, and, after immense labour, shewed that not only columbic or tantalic acid was present in these minerals, but likewise two new acids, niobic and pelopic acids. Instances of this kind of contribution made by Dr Thomson to chemistry might be indefinitely particularised. About 1802 he invented the oxy-hydrogen blowpipe, in which he introduced the oxygen and hydrogen into one vessel, but the whole apparatus having blown up and nearly proved fatal to him, he placed the gases in separate gas-holders. His apparatus of this description has been annually exhibited in the Chemistry class of the College of Glasgow, and has been figured in Dr R. D. Thomson's "School Chemistry." At that time he made many experiments on its powers of fusion, but as Dr Hare had invented an apparatus at the same time, and published his experiments, Dr Thomson did no more than exhibit the apparatus in his lectures. 7. In August 1804, in a paper on lead, he first published his new nomenclature of the oxides and acids, in which Latin and Greek numerals were made to denote the number of atoms of oxygen in an oxide. He thus introduces this important invention, which has been almost universally adopted in the science:—"As colour is a very ambiguous criterion for distinguishing metallic oxides, I have been accustomed for some time to denote the oxide with a minimum of oxygen, by prefixing the Greek ordinal number to the term oxide. Thus, protoxide of lead is lead united to a minimum of oxygen; the oxide, with a maximum of oxygen, I call peroxide. Thus, brown oxide of lead is the peroxide of lead. I denominate the intermediate degrees of oxidizement by prefixing the Greek ordinals, 2d, 3d, 4th, &c. Thus, deutoxide is the second oxide of lead, tritoxide of cobalt the third oxide of cobalt, and so on." This paper was translated and published in France; the nomenclature was speedily introduced into that country. But the improvements which he afterwards adopted, by denoting the exact number of atoms of oxygen present by the Latin, and those of the base by the Greek numerals, and used in Great Britain, never superseded, in that country, the original suggestion in the above note. 8. All these inventions were merely particular parts of a systematic arrangement adopted in his "System of Chemistry," a work which, if carefully examined with a philosophic eye, will be found to have produced beneficial results to chemical science similar to those which the systems of Ray, Linnæus, and Jussieu effected for botany. In his second edition, published in 1804, (the first large edition having been sold in less than ten months,) he divided the consideration of chemical bodies into—Book I. *Simple substances:* 1. Confinable bodies, including oxygen, simple combustibles, simple incombustibles, metals; 2. Unconfinable bodies, comprising heat and light. Book II. *Compound bodies:* 1. Primary compounds; 2. Secondary compounds, &c. It is most interesting to observe how his plan was developed with the progress of the science in the different editions. It is sufficient to say that it was generally considered as a masterly arrangement, and used to be quoted by the Professor of Logic in Edinburgh, as an admirable example of his analytic and synthetic methods. Previous to the publication of his "System" British chemists were contented with translations from the French, and hence it was believed on the Continent that " Britain possessed scarcely a scientific chemist." That all his contemporaries viewed his plans as highly philosophic cannot be affirmed. There are some men who, having no mental powers of arrangement in themselves, discover in a systematic treatise only a compilation possessing the generic characters of matter; while those who can pry below the surface, on the other hand, know that the art of arranging is one of the most difficult tasks of the philosopher; that it requires a comprehensiveness of mind, a clearness of judgment, and a patience of labour, which fall to the lot of a small number of the human race. When we recollect that many of these remarkable views began to be devised by the self-taught chemist, in a narrow close in the High Street of Edinburgh, the author being in the receipt of a salary of £50 a year, from which he sent £15 to his aged parents; when we contrast such a picture with the costly education and refined apparatus of the modern laboratory, it is impossible to avoid the inference that Britain has just lost a genius of no common order.

One immediate result of the publication of his " System," was the appropriation of their due merit to respective discoverers, and especially to British chemists, who had been overlooked in the Continental treatises. It was the subject of our memoir who thus first imparted to us the true history of chemistry, and in doing so often gave offence to disappointed individuals; but the honesty of his nature and his unswerving love of truth never allowed him for a moment to sacrifice, even in his own case, the fact to the fallacy.

During the first years of this century, he discovered many new compounds and minerals, as chloride of sulphur, allanite, sodalite, &c.; but to give a list of the numerous salts which he first formed and described during his onward career, would be difficult, as he scarcely ever treated of them in separate papers, but introduced them into the body of his " System" without any claim to their discovery. His exact mind was more directed towards accurate knowledge and principles than to novelties, merely for their own sake, although there is probably no chemist who has added so many new bodies to the science. Hence many of his discoveries have been attributed to others, or rediscovered over and over again; as was the case with many of his chromium compounds—viz., chlorochromic acid, the two potash oxalates of chromium, bichromate of silver, potash chromate of magnesia, chromate of chromium, hyposulphurous acid (1817), and hydrosulphurous acid (1818), S_5O_5, &c., &c., all of which were examined by him nearly a quarter of a century ago. The enumeration of these and numerous other discoveries must be left to a more extended memoir, for which we understand there is a mass of matter having an important bearing on the science and literature of the country in the early part of the century.

In 1810, Dr Thomson published his "Elements of Chemistry," in a single volume, his object being to furnish an accurate outline of the actual state of the science. In 1812, he produced his "History of the Royal Society," a most important work, as shewing the influence which that society produced on the progress of science. In August 1812, he made a tour in Sweden, and published his observations in that country in the following year. It is still a valuable work, and contains a very complete view of the state of science and society in that country. In 1813, he went to London, and started the "Annals of Philosophy," a periodical which he continued to conduct till 1822, when the numerous calls upon his time in the discharge of the duties of his chair at Glasgow compelled him to resign the editorship in favour of Mr Richard Phillips, one of his oldest friends, who predeceased him by one year. The journal was, in 1827, purchased by Mr Richard Taylor, and was merged in the "Philosophical Magazine." In 1817, he was appointed Lecturer on Chemistry in the University of Glasgow; and, in 1818, at the instance of the late Duke of Montrose, Chancellor of that institution, the appointment was made a professorship, with a small salary, under the patronage of the Crown. As soon after his appointment as he was enabled to obtain a laboratory, he commenced his researches into the atomic constitution of chemical bodies, and produced an amount of unparalleled work in the whole range of the science, in 1825, by the publication of his "Attempt to Establish the First

Principles of Chemistry by Experiment," in two volumes. It contained "the result of many thousand experiments, conducted with as much care and precision as it was in his power to employ." In this work he gives the specific gravities of all the important gases, ascertained by careful experiment. In these researches he had associated with him Mr Alexander Harvey as his assistant, a gentleman possessed of high mechanical and intellectual talents, who has since risen to eminence as a valuable citizen and magistrate of his adopted city. The data thus ascertained were often disputed and attacked in strong but unphilosophical terms, as they tended to supersede previous experimental deductions; but the excellent subsequent determinations of specific gravities by Dumas, which were made at the request of Dr Thomson, after that distinguished chemist had visited him at Glasgow in 1840, fully substantiated the greater accuracy of Dr Thomson's numbers over those which preceded him, and in most cases furnished an identity of result. The atomic numbers given in his "First Principles" as the result of his labours, were the means of a vast number of experiments made by himself and pupils, the data of which still exist in his series of note-books. They all tended to the result that the atomic weights of bodies are multiples by a whole number of the atomic weight of hydrogen, a canon confirmed to a great extent by the recent experiments of French and German chemists, and which he himself was the first to point out in the case of phosphorus. That the author of our memoir was frequently in error in his experiments is not attempted to be denied; for, as the great Liebig has said, it is only the sluggard in chemistry who commits no faults; but all his atomic weights of important bodies have been confirmed. After the publication of this work, he devoted himself to the examination of the inorganic kingdom of nature, purchasing and collecting every species of mineral obtainable, until his museum, which he has left behind him, became not only one of the noblest mineral collections in the kingdom, but a substantial monument of his taste and of his devotion to science. The results of his investigation of minerals were published in 1836, in his "Outlines of Mineralogy and Geology," in two vols., and contained an account of about fifty new minerals which he had discovered in a period of little more than ten years. In 1830–31, Dr Thomson published his "History of Chemistry," a masterpiece of learning and research. During these feats of philosophic labour, the eyes of the community were attracted to Glasgow as the source from which the streams of chemistry flowed, the class of chemistry and the laboratory being flocked to as to fountains of inspiration. Could the splendid results of his teaching be more powerfully demonstrated than in the enumeration of the faithful students of truth who have emanated from his school? Among his older pupils, John Tennant of St Rollox, Walter Crum, Alexander Harvey, Thomas Graham, Thomas Clark, Andrew Steel, James F. W. Johnston; and, of a junior class, Thomas Andrews, R. D. Thomson, William Blythe of Church, Andrew P. Halliday of Manchester, Thomas Richardson, John Stenhouse, John Tennent of Bonnington, &c., have all occupied positions as chemical teachers or manufacturers of the highest character in the kingdom.

It would be a great omission not to mention that it was Dr Thomson who introduced a system of giving annual reports on the progress of science in his "Annals of Philosophy;" the first of these was published in 1813, and the last in 1819. These reports were characterised by his usual perspicuity and love of *suum cuique* which distinguished his conduct through life, and were composed with a mildness of criticism far more conducive to the dignity of the science than those which, three years after his reports had ceased, were begun by the distinguished Swedish chemist, Berzelius. In 1835, when Dr R. D. Thomson started his journal, "The Records of General Science," his uncle contributed to almost every number, and encouraged him by his sympathy in his attempts to advance science.

Dr Thomson continued to lecture till the year 1841, discharging all the duties of his chair without assistance; but being then in his 69th year, and feeling his bodily powers becoming more faint, he associated with him at that period his nephew and son-in-law, Dr R. D. Thomson, who was then resident in London. He continued, however, to deliver the inorganic course only till 1846, when the dangerous illness of his second son, from disease contracted in India, hurried him for the winter to Nice, when his nephew was appointed by the University to discharge the duties of the chair, which he has continued since to perform. Of the hardship of being obliged in his old age thus to toil in harness, and to have no retiring allowance, he never murmured or complained. But there were not wanting suggestions, that one who had raised himself to eminence from comparative obscurity, and who had benefited his country in no common measure, might have been relieved in some degree by the guardians of the state, without popular disaffection, from fatigues which even a green old age cannot long sustain. Dr Thomson continued to attend the examinations for degrees for some years after retiring from the duties of the chair; but in consequence of the increasing defect in his hearing, he ultimately gave up this duty, and confined his public labours to attendance at the fortnightly meetings of the winter session of the Philosophical Society of Glasgow (of which he was president from the year 1834), until the last two sessions—his last appearance there having been on the 6th November, at the first meeting of the session 1850–51, when he read a biographical account of his old and affectionate friend, Dr Wollaston, to whom he was ever most strongly attached. During the early part of the present year, his frame became visibly weaker, and latterly having removed to the country, where it was hoped the freshness of the summer season might brace his languishing powers, his appetite failed; but no pain appeared to mar the tranquil exit of the philosophic spirit. To inquiries after his health,—"I am quite well, but weak," the good old man replied, within a few hours of his last summons. On the morning of the 2d of July, he breathed his last in the bosom of his affectionate family, on the lovely shores of the Holy Loch. Dr Thomson married, in 1816, Miss Agnes Colquhoun, daughter of Mr Colquhoun, distiller, near Stirling, with whom he enjoyed most complete and uninterrupted happiness. He was left a widower in 1834. He has left a son, Dr Thomas Thomson, of the Bengal army, the author of "Travels in Tibet," about to appear,—the result of several years' researches into the botany and physical structure of the Himalaya Mountains; and a daughter, married to her cousin, Dr R. D. Thomson. On strangers, Dr Thomson occasionally made unfavourable impressions; but by all who knew him intimately, he was universally recognised as the most friendly and benevolent of men. He contributed to most of the charitable institutions of the city, and was never once known to refuse assistance to the poor and friendless. Dr Thomson was originally destined for the Church of Scotland, and continued to the last a faithful adherent. He was wont to attribute his sound and intellectual views of the Christian faith to the care of his mother—a woman of great beauty and sense; and it was perhaps from his affection for her that his favourite axiom originated—that the talents are derived from the maternal parent. Who shall prescribe exact limits to the benefits conferred on her country and her race by this humble, but pious Christian woman, who taught in early life religion to her elder son, the author of the article *Scripture*, in the "Encyclopædia Britannica," which, in the third, and many subsequent editions of that work, has been read and distributed over the globe for nearly half a century, to a greater extent than perhaps any other religious treatise, and who gave the earliest impressions of his relations to his Maker to the great chemical philosopher?*

On the Reconcentration of the Mechanical Energy of the Universe. By William John Macquorn Rankine, C.E., F.R.S.E., &c.†

The following remarks have been suggested by a paper by

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* [The very prominent part Dr Thomson took in the important and harmoniously-conducted discussions in the Royal Society of Edinburgh on the Wernerian and Huttonian geologies, and which led to the establishment of the Wernerian Society of Edinburgh, and the Geological Society of London, &c., should have formed an important feature in his Biography.—*Ed. Edin. New Phil. Jour.*]

† Read to the British Association for the Advancement of Science, Section A, at Belfast, on the 2d September 1852.

Professor William Thomson of Glasgow, on the tendency which exists in nature to the dissipation or indefinite diffusion of the mechanical energy originally collected in stores of power.

The experimental evidence is every day accumulating of a law which has long been conjectured to exist,—that all the different kinds of physical energy in the universe are mutually convertible—that the total amount of physical energy, whether in the form of visible motion and mechanical power, or of heat, light, magnetism, electricity, or chemical agency, or in other forms not yet understood, is unchangeably the transformations of its different portions from one of those forms of power into another, and their transference from one portion of matter to another, constituting the phenomena which are the objects of experimental physics.

Professor William Thomson has pointed out the fact, that there exists (at least in the present state of the known world) a predominating tendency to the conversion of all the other forms of physical energy into heat, and to the uniform diffusion of all heat throughout all matter. The form in which we generally find energy originally collected, is that of a store of chemical power, consisting of uncombined elements. The combination of these elements produces energy in the form known by the name of electric currents, part only of which can be employed in analysing compounds, or in reproducing electric currents. If the remainder of the heat be employed in expanding an elastic substance, it may be entirely converted into visible motion, or into a store of visible mechanical power (by raising weights, for example) provided the elastic substance is enabled to expand until its temperature falls to the point which corresponds to absolute privation of heat; but unless this condition be fulfilled, a certain proportion only of the heat, depending upon the range of temperature through which the elastic body works, can be converted, the rest remaining in the state of heat. On the other hand, all visible motion is of necessity ultimately converted entirely into heat by the agency of friction. There is thus, in the present state of the known world, a tendency towards the conversion of all physical energy into the sole form of heat.

Heat, moreover, tends to diffuse itself uniformly by conduction and radiation, until all matter shall have acquired the same temperature.

There is, consequently, Professor Thomson concludes, so far as we understand the present condition of the universe, a tendency towards a state in which all physical energy will be in the state of heat, and that heat so diffused, that all matter will be at the same temperature; so that there will be an end of all physical phenomena. Vast as this speculation may seem, it appears to be soundly based on experimental data, and to represent truly the present condition of the universe, so far as we know it.

My object now is to point out how it is conceivable that, at some indefinitely distant period, an opposite condition of the world may take place, in which the energy which is now being diffused may be concentrated into foci, and stores of chemical power again produced from the inert compounds which are now being continually formed.

There must exist between the atmospheres of the heavenly bodies a material medium capable of transmitting light and heat; and it may be regarded as almost certain, that this interstellar medium is perfectly transparent and diathermanous; that is to say, that it is incapable of converting heat, or light (which is a species of heat), from the radiant into the fixed or conductible form.

If this be the case, the interstellar medium must be incapable of acquiring any temperature whatever; and all heat which arrives in the conductible form at the limits of the atmosphere of a star or planet, will there be totally converted, partly into ordinary motion, by the expansion of the atmosphere, and partly into the radiant form. The ordinary motion will again be converted into heat, so that *radiant heat* is the ultimate form to which all physical energy tends; and in this form it is, in the present condition of the world, diffusing itself from the heavenly bodies through the interstellar medium.

Let it now be supposed, that, in all directions round the visible world, the interstellar medium has bounds, beyond which there is empty space.

If this conjecture be true, then, on reaching these bounds, the radiant heat of the world will be totally reflected, and will ultimately be reconcentrated into foci. At each of these foci, the intensity of heat may be expected to be such, that, should a star (being at that period an extinct mass of inert compounds), in the course of its motions, arrive at that part of space, it will be vaporised and resolved into its elements; a store of chemical power being thus reproduced at the expense of a corresponding amount of radiant heat.

Thus it appears, that, although, from what we can see of the known world, its condition seems to tend continually towards the equable diffusion, in the form of radiant heat, of all physical energy, the extinction of the stars, and the cessation of all phenomena, yet the world, as now created, may possibly be provided within itself with the means of reconcentrating its physical energies, and renewing its activity and life.

For aught we know, these opposite processes may go on together, and some of the luminous objects which we see in distant regions of space may be not stars, but foci in the interstellar æther.

The Classification of Insects from Embryological Data. By Professor Louis Agassiz.

I. *General Considerations.*

The various classifications of insects which have been proposed by zoologists rest either on considerations derived from their external characters and form, and in part from their internal structure, or on the various modes of their development from the egg. The earliest writers on classification availed themselves principally of the number and structure of their wings, to divide the numberless insects into several general divisions, and such an arrangement, as finally adopted by Linnæus, has prevailed to a great extent, sometimes modified by the introduction of some smaller groups, which have been more generally admitted by English writers than by those of the Continent of Europe.

Fabricius introduced an entirely new view of the subject, dividing the insects according to the structure of the organs by which they take their food, and the various structures and degrees of complication of the jaws became the foundation of his system, which he not only applied in a general manner, but worked out in all its details, assigning even to the smaller divisions characters derived chiefly from the peculiar form of those parts.

More recently the metamorphosis of insects has been made the foundation of their classification, and they have been grouped according to the extent of changes they undergo from the egg, and according to the condition in which the young animal remains for a time before it has arrived at its complete perfect growth.

According to these views, those insects that are hatched from the egg with a form very similar to the full-grown perfect animal, and which undergo slight or only partial changes during their growth, such as the additional development of wings, or which remain active throughout their metamorphosis, have generally been considered as belonging to one and the same great division, and have been brought together as insects without metamorphosis, or with imperfect metamorphosis. On the other hand, such insects as are hatched from the egg in the form of a maggot, grub, or caterpillar, resembling worms in their earlier period of life more than they resemble the perfect insects which are to grow out of them, and from that condition passing into the state of immovable mummy-like pupæ, or chrysalids, and during this period taking no food, but afterwards giving rise to a winged, perfect fly, beetle, or butterfly, have been considered as insects with perfect metamorphoses, and on that account have been brought together in one great division.

A glance at the classification resting upon such considerations will shew, that each of these fundamental divisions contains insects, which, in their perfect condition, chew their food with powerful jaws, and others which are provided with suckers to pump the more liquid nourishment upon which they live. It has long been a question with me, whether the nature of the metamorphoses or the structure of the jaws was to be considered as the prominent character on which to found the primary divisions. It struck me as possible, that a classification, in which the chewing insects should be brought together, and all sucking insects combined in another group, and both of them subdivided according to their transformations, might lead to as natural an arrangement as a classification resting in its fundamental divisions upon considerations derived from the metamorphoses alone. In order to satisfy myself upon the importance of these two sets of characters, I have examined the metamorphoses themselves, which various groups of insects undergo, and have been deeply impressed with the fact, that most of those insects which undergo the so-called complete metamorphosis, are provided, in their early stages of growth, with a chewing apparatus, which is gradually transformed into the various kinds of suckers with which the perfect insects are provided.

This led me to the question, whether the structure of this peculiar apparatus for chewing food did not indicate, among insects, a condition of existence lower than that of those insects which assume, during their metamorphosis, another type of jaws in the shape of a sucker. And upon that suggestion I attempted an arrangement of the different orders of insects, which seems to me not only more natural, but to correspond more fully with the lessons of embryology. I propose the following classification :—

I. *Chewing Insects* (Mandibulata).

- Neuroptera,
- Coleoptera,
- Orthoptera,
- Hymenoptera.

II. *Sucking Insects* (Haustellata).

- Hemiptera,
- Diptera,
- Lepidoptera.

The reason why Coleoptera have been so universally considered as the highest among insects, is plainly shewn by the position assigned to Cicindela, which is placed at the head. That group is the most carnivorous of the order. But I do not think it right to assign to the carnivorous insects the highest rank, if there is no other reason to consider them as such than the fact, that among Mammalia the Carnivora rank higher than the herbivorous animals.

Far from inclining to such views, I am prepared to shew that the very fact of the complication of their jaws, and the multiplication of their parts, the greater resemblance which those parts have to common legs, the immobility of the prothorax, the hardness of their anterior wings, the frequent deficiency of the lower wings, the similarity in structure between the jaws of the larva and those of the perfect insect, are so many characters which assign to the Coleoptera a lower rank than that of the Lepidoptera.

Indeed, if we institute a comparison between Coleoptera and Lepidoptera, we are struck with the greater resemblance between the former when perfect, and the caterpillar, than between the beetle and the butterfly. It may be said, that the beetle preserves the characters of the larvæ of other insects, and assumes only wings and more developed legs in addition, without reaching other successive metamorphoses, —those other changes through which the caterpillar passes before it is transformed into the perfect image.

This being once granted, it must be acknowledged in general, that chewing insects should rank lower than sucking insects; and we may perhaps find in the complete matamorphoses of the higher Haustellata sufficient data to carry out this view in determining the relative position to be assigned to all the orders of that class.

Among the mandibulate insects, for instance, we have, besides Coleoptera, the Orthoptera, Neuroptera, and Hymenoptera. Now, the Neuroptera, though undergoing metamorphoses as complete, in many respects, as the Coleoptera, have larvæ whose structure seems decidedly lower than that of the Coleoptera, for they are mostly aquatic worms, provided not only with powerful jaws and all the complicated chewing apparatus of mandibulate insects, but also with aquatic respiratory organs, namely true external gills similar to those of the aquatic worms. And the great and complicated changes which they undergo, both in structure and form, lead to a development which does not rank higher than that observed among Coleoptera. Indeed, the soft wings of Neuroptera indicate, in my opinion, a character of low development; for their peculiar structure resembles more that of the wings of the young butterfly, before passing into the condition of the pupa, than that of the elytra. The wings of Coleoptera, again, resemble more closely the condition of the wings in the pupa of the butterfly, at the period when the outer wing is hardened and soldered to the body, covering the lower wings, which remain soft. I would, therefore, without hesitation, place Neuroptera as the lowest order of Mandibulata.

Next might come the Coleoptera, followed by the Orthoptera; for Hymenoptera, no doubt, rank highest in this division. To satisfy ourselves that this is the case, we need only consider the structure of their jaws, the upper pair of which alone preserve the character of chewing insects, while the lower are transformed into a kind of proboscis very similar to that of Haustellata. Again, their larvæ rank higher than the larvæ of either Neuroptera or Coleoptera. They are for the most part larvæ with aërial respiratory organs, and in that respect, rank decidedly above those of Neuroptera, and might be considered as of equal value with those of Coleoptera.

Though the fact, that many Hymenoptera have caterpillar-like larvæ, will at once place them one stage higher, that is, nearer the Haustellata, some facts presently to be mentioned, respecting the changes which caterpillars undergo before they pass into the state of complete pupæ, will establish more fully the value of this argument.

There is, however, one order of chewing insects, the position of which is somewhat embarrassing; I mean the Orthoptera. If the views expressed above are correct, the very fact of their having chewing jaws will place them among the Mandibulata, below the Haustellata. But what is the proper position to assign to them among Mandibulata? They cannot be placed higher than the Hymenoptera, for their jaws are completely masticatory. But their position in relation to Coleoptera and Neuroptera is difficult to determine. They undergo no change after they have been hatched from the egg, except that of assuming wings. They are born from the egg with an aërial respiratory system ; indeed, in a condition which is already higher than that of the larvæ of Coleoptera, and decidedly higher than that of the Neuroptera. We should, therefore, look to the changes which these animals undergo within the egg, to determine their true position. But upon this point observations are still wanting. At present I am inclined to place them above Coleoptera, as we generally find that the degree of perfection which the young assumes before it is hatched, corresponds, to a remarkable extent, with the perfection of the animal in its general structure. And if it were not for the peculiar structure of the jaws in Hymenoptera, I should not hesitate to place Orthoptera highest among Mandibulata. Again, the perfection of the wings of Hymenoptera leads so decidedly to a parallelism between them and some of the moths, that I cannot help thinking the best arrangement is the one mentioned above; namely, Neuroptera lowest, next Coleoptera, next Orthoptera, and Hymenoptera highest. The peculiar piercers, with which so many Orthoptera are provided to lay their eggs, remind us of similar apparatus in Hymenoptera, which would go to substantiate the position now assigned to these two orders of insects in close juxtaposition.

Let us now consider the different orders belonging to the division of the Haustellata, which contains only three groups, the Hemiptera, Diptera, and Lepidoptera. The order in which I have mentioned them above seems to me to be that in which they should naturally be placed, according to their structure and metamorphoses. If we can be guided by the changes which the highest of the animals undergo, it will be perceived that among Lepidoptera we have the true key for their natural arrangement. The larvæ of this last group are hatched in a condition far superior to that of the larvæ of any other insects. Not only are they all provided with aërial respiratory organs, but the different regions of their body are already more fully marked out than in the larvæ of any other insects, by the different structure of their various legs, and by the decided distinction which is introduced between the head and body. Moreover, their skin is variously coloured, and provided with a most astonishing diversity of external appendages.

At first, these animals are voracious in their habits. Provided with powerful jaws, they chew large quantities of food, mostly derived from the vegetable kingdom. But before they undergo their metamorphosis into pupæ, before casting the last skin of the caterpillar, the young Lepidoptera begin to form their wings, which grow out of the second and third ring of the thorax in the shape of short, folded bags, very similar indeed to the first rudiments of wings in Neuroptera. These appendages rapidly enlarge, and when the caterpillar casts its skin, they have already attained a considerable size. But, instead of remaining free, they are soldered to the body of the pupa, the outer wings become hard, and form what have generally been called the wing-covers, resembling then very much the wings of Coleoptera. But the jaws have undergone greater changes. They are now transformed into long appendages, similar to the articulated threads which constitute the sucking apparatus of Hemiptera and some Diptera. The resemblance of the jaws of Lepidoptera at this period to those of Hemiptera is so great, that we may truly say, that the form of this apparatus in the pupa completely exemplifies the permanent structure of the sucking apparatus in Hemiptera; and the hardness of the wing-covers reminds us at the same time of the hardness of the base of the upper wings in the greater part of Hemiptera; so that Hemiptera, in their perfect condition, would correspond to the earliest condition of the pupæ of Lepidoptera. So the higher degree of locomotive power of these parts in Diptera would remind us of the condition of the jaws in the Lepidoptera, at the moment that the perfect butterfly leaves its pupa, when the pieces of the mouth move independently of each other, as is the case with the piercers of most Diptera, which remain free, while in Lepidoptera they finally form the articulated proboscis. This type of jaws of the Diptera, intermediate between those of Hemiptera and the perfect Lepidoptera, would therefore assign to them also an intermediate position in the system.

Again, the peculiar development of the wings, the anterior of which become perfect and membranous in Diptera, while the posterior ones remain rudimentary, shews plainly that, in the character of their wings, as well as in all other respects, Lepidoptera rank highest among Haustellata, and therefore highest among all insects.

Whatever be now the value of these considerations, it must be obvious to all those familiar with the subject, that such a classification differs radically from the classifications founded upon metamorphosis simply. For here the system is founded, not merely upon the fact of the insects undergoing changes to various extent, but upon the nature of the changes themselves. This is a generic classification, based upon embryological changes, while the classification of the physico-philosophers rests simply upon the circumstance of the insects undergoing metamorphoses or not, without direct reference to the particular character of the successive changes. They bring together Hemiptera and Orthoptera, because both undergo hardly any changes after they have been hatched from the egg. But here it is shewn that the peculiarities which characterise Hemiptera correspond, to a certain degree, to the transformations which Lepidoptera undergo, and that Hemiptera therefore appear, upon embryological data, to belong to the same series, to which we must also refer Diptera and Lepidoptera, but from which Orthoptera are excluded. Again, according to the views of the physico-philosophers, the Coleoptera, Neuroptera, Hymenoptera, Diptera, and Lepidoptera belong together, because they undergo extensive changes in their metamorphoses. But I have already shewn that, however extensive these metamorphoses may be, they do not rise in any of these orders beyond the development which the Lepidoptera attain in their pupa condition; as in the pupa of Lepidoptera the jaws are already transformed into a sucker-like proboscis, when wings and legs are developed; while Coleoptera, Orthoptera, and Hymenoptera have arrived at their mature condition before the jaws have reached a higher development of structure than that which is exemplified in the metamorphoses of Lepidoptera before they fully pass into the condition of their pupa. So that, notwithstanding their extensive metamorphoses, the mandibulate insects must be placed altogether below the haustellate, even below the Hemiptera; and thus the classification proposed at the outset seems fully justified by embryological evidence; and, if I am not mistaken, we shall in future consider Mandibulata as forming one great natural division among insects, to be placed below the Haustellata.

This conclusion furnishes another illustration of the fallacy of our reasoning, when we allow ourselves to be guided simply by analogy derived from other classes. If among the higher animals we had not a natural series passing from man, through monkeys to the carnivorous animals, I doubt very much whether we should ever have been led to consider the muscular power and the strength of the jaws as indicating anywhere a higher degree of organisation. But this impression, which is correct among Mammalia, can no longer obtain in other classes. We should, on the contrary, be better advised, by this evidence, and in future derive our views, as far as possible, solely from the classes to which they are to be applied.

The same evidence which shews Lepidoptera to rank highest among insects, shews also that insects as a class rank higher than Crustacea. And it will not be out of place to remember here the happy suggestion of Oken, who says, that "Lepidoptera are born as Worms, then pass into the condition of Crustacea, and are finally developed into true insects, exemplifying the natural order of gradation of the three classes of Articulata."

The detailed history of the metamorphoses of some Lepidoptera will sustain more fully the views introduced in the preceding observations.

(To be concluded in next Number.)

Humboldt, one of the first Philosophers who delivered Popular Courses of Lectures on Science to the People.

Humboldt commenced his lectures on Physical Cosmography on the 3d November 1827. The announcement sufficed to assemble all the intellect of Berlin and its vicinity to hear the celebrated naturalist.

As he had before done in Paris, in the French language, Humboldt now, in his native tongue, gave the rich fruits of his researches in physical *cosmography* to the public, in a course of lectures delivered before a select but numerous assemblage. He enchanted his hearers by the peculiar force of his intellectual clearness, and by his eloquence, by the genuineness and warmth of his feelings, and by the inexhaustible novelty of his subject: he stood before them as a convincing inspiring teacher, who, like a talented creative artist, brought a series of wonderful natural pictures of a boldly explored world before an attentive public. This course of sixty-one lectures, commenced on the 3d November, and concluded on the 26th April 1828, was, as it were, the first sketch of the "Kosmos," published subsequently as the result of his life and studies, given to the world in one work, whose contents may be compared to a mine rich in precious metals, and which such persons can best appreciate who already have a general knowledge of natural sciences. The first lectures which Alexander von Humboldt gave in the university (Berlin) building, and which no scholar living within a practicable distance missed, caused such a great sensation, not only in the town but in all parts of the country, that scholars and friends of science frequently came from long distances to be present at least at one of these lectures, of which they could read the reports and effects in nearly every newspaper, and to be able to say that they had seen Humboldt. When some of the first lectures had been delivered, the press of people from all ranks was so great that Humboldt was literally forced to give a repetition of the first course, adapted for a more general public, nearly contemporary with the others, in the large hall of the Musical Academy. And these popular lectures were eagerly visited by the highest and the most learned persons in the town. The King, the Royal Family, the Court, the highest Aristocracy, attended regularly and listened with the people, which shewed its pride in the celebrated man, by its enthusiastic admiration. Here Humboldt stood immediately before his fellow countrymen as an intellectual giant and inexhaustible spring of mental riches. Every one, even the lowest and most ignorant, heard his name ; he was something wonderful, mysterious, and remarkable, and they thronged to see the man who had discovered a new world. His brother, William, wrote to a friend in Vienna, who considered every intellectually uncommon development as something demoniacal :—" Alexander is really a 'puissance,' and has gained a new kind of glory by his lectures. They are unsurpassable ; he is always the same ; and it is still one of the principal features of his character to have a peculiar timidity and undeniable anxiety in the mode of his appearance." These lectures of Humboldt were also new and remarkable, in respect of the position he took towards the people. For, while other learned men, whose social position is always higher than that of the people, nearly all, in their scientific and academic pride, did not deem it worth their while to disseminate their knowledge among the people, whom it must ultimately most benefit ;—while they generally keep their learning as the property and mystery of a caste, and interchange it among themselves ;—while they consider it degrading for a man of science to popularise his knowledge ;—Alexander von Humboldt set them the noble example, that a baron, a chamberlain, a privy councillor, and confidential adviser of his king, did not consider it beneath his rank and dignity to appear publicly as the teacher of his favourite science. He shewed that a true man of science does not attach himself to an exclusive caste, and that all considerations of birth, rank, and title, are as nothing in the high service of science. And thus Humboldt, in the impulses of his heart and of his mind, fulfilled the noble duty which the mentally-gifted man owes to his people, of bestowing on them and instructing them with the rich treasury of his knowledge and experience, thereby raising them nearer to himself.—(*Lives of the Humboldts.*)

Professor Oken, the originator of the now Popular Assemblies for the Advancement of Science.

Humboldt's devotion to natural science, made the year 1828 important far more than the preparations for his Asiatic journey. For the purposes of comparative researches, he caused the temperature to be measured in all the Prussian mines, and this led Humboldt's reflective and comparative mind to new results; and besides this, he was occupied in the autumn of this year by the Seventh Annual Meeting of the German Naturalists and Natural Philosophers (an institution originated with the celebrated Naturalist, *Oken*), which held its sittings in Berlin this time, and elected Humboldt and Lichtenstein, as presidents for the year. Here Humboldt's penetrating mind was again revealed, in his just conception and comprehension of science and its duties, which consist, partly in extending and popularising knowledge, partly in exciting to further inquiries, in gaining new disciples, and in making itself of practical utility in life, and of educational service for the people. These annual assemblies failed to fulfil their purpose, partly because the different branches of natural science were not properly separated from each other, and the constantly-increasing material could not be surveyed, and certainly not arranged in the few days that the Assembly lasted. Humboldt soon recognised this imperfect arrangement, and caused the institution of sections for the various special departments, in which every one had the privilege of an interchange of progress, and only the universal matter of general science was debated in the general meetings. Humboldt opened this seventh annual convention with a profound speech on the spirit and utility of such annual meetings, and his words had, as always, such a deep influence over the whole intellectual world, that soon afterwards, annual convocations were instituted on the model of Oken's society of natural historians, in England and Italy.—(*Biography of the Humboldts.*)

The Earl of Rosse's Telescopes, and their Revelations in the Sidereal Heavens. By the Rev. Dr SCORESBY, F.R.S.L. & E., Member of the Wernerian Society, and Corresponding Member of the Institute of France, &c. Communicated by the Author.

In a second lecture on these interesting subjects, recently delivered at Torquay, much and important consideration was given to the inquiry,—What has the gigantic telescope done?

The lecturer having himself had the privilege of observing on different visits, and for considerable periods, with both the instruments, was enabled to speak, he hoped, in a satisfactory manner to this inquiry. His opportunities of observing, he said, notwithstanding interruptions from clouds and disturbed atmosphere, had been somewhat numerous, and, not unfrequently, highly instructive and delightful. Of these observations he had made records of nearly 60, on the moon, planets, double stars, clusters, and nebulæ. He had been permitted also to have free access to, and examination of, all the observatory records and drawings, so that he was enabled on the best grounds, he believed, to say, that there has been no disappointment in the performance of the instruments; and that the great instrument, in its peculiar qualities of superiority, possesses a marvellous power in collecting light and penetrating into regions of previously untouched space. In what may be called the domestic regions of our planet—the objects in the solar system—all that other instruments may reveal is within its grasp or more, though by the prodigious flood of light from the brighter planets, the eye is dazzled unless a large portion is shut out.

But in its application to the distant heavens and exploration of the nebulous systems there, its peculiar powers have, with a steady atmosphere, their highest developments and noblest triumphs. In this department—that to which the instrument has been particularly directed—every known object it touches, when the air is favourable, is, as a general fact, exhibited under some new aspect. It pierces into the indefinite or diffuse nebulous forms shewn by other instruments generally, and either exhibits configurations altogether unimagined, or resolves perhaps the nebulous patches of light into clusters of stars. Guided in the general researches by the works of the talented and laborious Herschels—to whom astronomy and science owe a deep debt of gratitude—time has been economised, and the interest of the results vastly enhanced. So that many objects in which the fine instruments of other observers could discern only some vague indefinite patch of light, have been brought out in striking, definite, and marvellous configurations.

Among these peculiar revelations is that of the *spiral* form—the most striking and appreciable of all—which we may venture to designate "*The Rossean Configuration.*" Its discovery was at once novel and splendid; and in reference to the dynamical principles on which these vast aggregations of remote suns are whirled about within their respective systems and sustained against interferences, promises to be of the greatest importance.

One of the most splendid nebulæ of this class—the *great spiral* or *whirlpool*—has been figured in the Philosophical Transactions for 1850. It may be considered as the grand type and example of a class; for near 40 more, with spiral characteristics, have been observed, and about 20 of them carefully figured. Dr Scoresby had the pleasure of being present at the discovery of this particular form in a nebula of the planetary denomination, in which two portions following spiral forms were detected. Its colour was peculiar,—pale blue. He had the privilege, too, of being present on another interesting occasion, where the examination of the great nebula in Orion was first seen to yield decisive tokens of resolution.

In these departments of research, the examination of the configurations of nebulæ, and the resolution of nebulæ into stars, the six-feet speculum has had its grandest triumphs, and the noble artificer and observer the highest rewards of his talents and enterprise. Altogether, the quantity of work done, during a period of about seven years,—including a winter when a noble philanthropy for a starving population absorbed the keenest interests of science,—has been decidedly great, and the new knowledge acquired, concerning the handiwork of the Great Creator, amply satisfying of even sanguine anticipations.

Transferred to the ledger records from the journals of the Observatory (comprising only a selection from the general observations) about 700 catalogued nebulæ, Dr S. found, September last, had been already examined, and *new nebulæ*, or nebulous knots, discovered merely incidentally, to the amount of 140 or more. The number of observations, involving separate sets of the instrument, recorded in the ledger (exclusive of very many hundreds, possibly thousands, on the moon and planets), amount to near 1700, involving several hundreds of determinations of position and angular measurements with the micrometer on the far distant stars. The carefully drawn configurations, eliciting *new characteristics*, exceed 90, and the rough or less-finished sketches amount to above 200. Of the 700 catalogued nebulæ already examined, it should be observed, that in fully one-half, or more, something new has been elicited.

In speaking of the effects of the flood of light accumulated by the six-feet speculum of the Earl of Rosse, Dr Scoresby remarked, that this peculiarity of the instrument (connected as it is with due length of focus and admirable definition) enabled it to reach distances in space far beyond the powers of any other instrument. This was its peculiar province; and in this, as to existing instruments, there was not, nor, as he hoped to shew, could there be, any competition. For comparing the space-penetrating power of the six-feet speculum with one of two feet (which has rarely been exceeded) we find it three to one in favour of the largest, with an accumution of *light* in the ratio of 6^2 to 2^2, or 9 to 1. On comparing the powers of this magnificent instrument with those of a refractor of two feet aperture, the largest hitherto attempted, we have a *superiority*—making a due allowance for the loss of light by reflection from two mirrors, and assuming an equal degree of perfectness, figure, and other optical requirements in the refractor, and *no* allowance for absorption of light—in the ratio of about 4·5 to 1, as to light, and as 2·12 to 1, as to the capability of penetrating space, or detecting nebulous or sidereal objects at the extreme distance of visibility. Hence, whilst the range of telescopic vision in a refractor of two feet aperture would embrace a *sphere* in space represented by a diameter of 2; the six-feet speculum (assuming both instruments to be of equal optical perfection, magnifying equally, and allowing fifty per cent. for loss of light for two reflections in the one case, and none (?) in the other) would comprehend a sphere of about 4·24 diameter,—the outer shell of which, 1·12 in thickness, being the province of the great instrument alone. But let us reduce these proportions to *sections* of equal spaces, that we may judge more accurately of the relative powers. Now, the solid contents of different spheres, we know, are in the ratio of the cubes of their diameters. Hence the comparative spheres, penetrated by the two instruments referred to, should be as $4{\cdot}24^3$ to 2^3; that is, as 9·5 to 1. Deducting, then, from this vast grasp of space the inner sphere, capable of being explored by other instruments, we find that, out of nearly ten sections of space reached by this telescope, there are nearly nine sections which the six-feet speculum may embrace as peculiarly its own!

What its revelations yet may prove, then, we can have no idea. Several thousands of nebulæ have been catalogued: the great reflector might add to these tens of thousands more. But this, seeing how few nights in a year are favourable for the highest powers, must be the work of years of perseverance. It would be a worthy undertaking for the Government of a great country, to afford the means of multiplying such gigantic instruments. Application is to be made, in this direction, for a six-feet reflector at the Cape of Good Hope, for the examination of the heavens towards the southern pole. Lord Rosse, with his usual nobleness of liberality, will yield up his laboratory, machinery, and men, to the service of Government, and is willing, moreover, to give the direction and guidance of his master-mind. Will the British nation be content with a refusal?

The range opened out to us by the great telescope at Birr Castle, is best, perhaps, apprehended by the now usual measurement—not of distances in miles, or millions of miles, or diameters of the earth's orbit, but—of the progress of light in free space. The determination, within, no doubt, a small proportion of error, of the parallax of a considerable number of the fixed stars, yields, according to M. Peters, a space betwixt us and the fixed stars of the smallest magnitude, the sixth, ordinarily visible to the naked eye, of 130 years in the flight of light. This information enables us, on the principles of *sounding the heavens*, suggested by Sir W. Herschel, with the photometrical researches on the stars of Dr Wollaston and others, to carry the estimation of distances, and that by no means on vague assumption, to the limits of space opened out by the most effective telescopes. And from the guidance thus afforded us, as to the comparative power of the six-feet speculum in the penetration of space, as already elucidated, we might fairly assume the fact, that if any other telescope now in use could follow the sun if removed to the remotest visible position, or till its light would require 10,000 years to reach us, the grand instrument at Parsonstown would follow it so far, that from 20,000 to 25,000 years would be spent in the transmission of its light to the earth. But in the case of clusters of stars, and of nebulæ exhibiting a mere speck of misty luminosity, from the combined light perhaps of hundreds of thousands of suns, the *penetration* into space, compared with the results of ordinary vision, must be enormous; so that it would not be difficult to shew the *probability* that a million of years, in flight of light, would be requisite, in regard to the most distant, to trace the enormous interval.

But after all, what is all this, vast as the attainment may seem, in the exploration of the extent of the works of the Almighty? For in this attempt to look into space, as the great reflector enables us, we see but a *mere speck*—for SPACE IS INFINITE. Could we take, therefore, not the tardy wings of the morning, with the speed of the mere spread of day, nor flee as with the leaden wings of light, which would require years to reach the nearest star, but, like unhampered *thought*, could we speed to the farthest visible nebula at a bound,—there, doubtless, we should have a continuance of revelations; and if bound after bound were taken, and new spheres of space for ten thousand repetitions explored,—should we not probably find each additional sphere of telescopic vision garnished with suns and nebulous configurations rich and marvellous as our own? If these views serve to enlarge our conception of creative wonders, and of the glory and power of the Great Architect of the heavens, should they not deeply impress us in respect to the Divine condescension in regarding so graciously this little, inferior world of ours! Animated with the spirit of the Psalmist, we shall each one, surely, be disposed appropriately to join in his emphatic saying,—"When I *consider* thy heavens, the work of thy fingers, the moon and the stars which thou hast ordained; what is man, that thou art mindful of him? or the son of man, that thou visitest him?"

Of the Proper Application of Reservoirs to the Improvement of Rivers. By CHARLES ELLET Jun., Civil Engineer, United States of America.

It is not intended to recommend the mode of collecting the superfluous water into reservoirs for their improvement to all streams. It is only those rivers, or parts of rivers, on which the imperfections of the channel are caused essentially by a deficiency of water in seasons of drought, and not by the rapidity of their fall, or obstructions in their beds, that are susceptible of this mode of improvement. Rivers which, like the Ohio, Alleghany, Cumberland, and Tennessee, are always navigable when there is sufficient water in their channels to float the boats freely, but of which the navigation fails because the supply of water fails, and on which lakes may be formed at small expense, without injury to valuable property or to the salubrity of the country,—such rivers as these can be best, most cheaply, permanently, and effectually improved, by collecting a portion of the waters which are wasted in producing floods, and holding them in store for the season when the sources of supply fail to render their customary tribute to the channel.

Such are essentially the characteristics of all the great rivers of the Mississippi valley.

Many of these streams rise in the mountain ridges, and flow great distances through depressions parallel with the range in which they originate. Those which descend from the Alleghany break through the subordinate ranges of Laurel Hill, Greenbriar, Big Sewell, and other parallel and analogous formations, where many gorges are presented, easy to dam up, and where the lakes to be formed will lie inclosed within a rim of rock, which will insure a purity equal to that of the waters of Erie or Ontario. Tens, and perhaps hundreds, of such sites exist in the valleys of the Alleghany, Monongahela, Great Kanawha, and their tributaries; and, indeed, along all the rivers that flow from the mountains on either slope of the great dividing ridge.

It is not to be maintained that the water will become less salubrious because it is confined. The lakes which it is proposed to form are in all respects analogous to the great fresh-water lakes of the globe, which are provided with outlets to the Ocean, through which the water is slowly discharged, but, nevertheless, so adjusted as to retain the same water for a long series of years.

The salubrity of the fluid is not impaired by this exposure. The Falls of Niagara probably do not vent the volume of water which is contained in Lake Erie more than once in six or eight years; and it is certain that the contents of all the upper lakes would not pass over the cataract in half a century.

Nature relies for effecting the change which is for ever taking place in great bodies of fresh water, almost exclusively on the process of evaporation; and has provided that the fluid shall be thoroughly exposed to sun, and light, and air, by the agitation of its surface when in volume, and by its suspension in the clouds after its evaporation.

The healthfulness of the country cannot be impaired by the formation of artificial reservoirs in all respects analogous to those of nature, liable to be drained off, to some extent, more than once in every year. They need not cover vegetable matter in sufficient quantity to cause apprehension from the effect of its decomposition. These reservoirs are not intended to be wholly exhausted; and need only to be reduced at the surface, so as to lay bare a portion of their rocky borders.

But the salubrity of rivers, when no longer subject to become dry, and have their sands and vegetable deposits exposed to the summer's sun, must necessarily be increased; for the same experience which teaches that large masses of fresh water, existing as lakes, are salubrious, also teaches that shallow, stagnant pools, such as are found in the place of an exhausted river, are deleterious to health.

It is difficult to imagine a serious objection to the improvement of this great natural system of inland navigation, by a method which accomplishes so much for an outlay so small—by a plan which places no incidental impediment in the way of trade, and the application of which is limited to no State or section of the Union.

From the base of the Rocky Mountains to the base of the Alleghany, there is not a great river or navigable tributary that may not be benefited by this process; while on the eastern slope of the dividing range there are numerous rivers flowing into the Atlantic, which have been improved by other means, and which must ultimately be subjected to this treatment, and relieved of the dams by which they are now obstructed.

The North Branch of the Susquehanna may be easily made navigable, from its mouth into the State of New York, for a convenient class of steamboats, by this simple expedient; and there are several rivers in Virginia, which, for an insignificant cost, may probably be supplied with abundant water for a permanent navigation.

The personal observation of the writer does not extend to the great rivers of the Southern States. But the elevations of their surfaces above tide, from point to point, seem to indicate that they are even more susceptible of the application of this method of improvement than those farther north; while the Cumberland and Tennessee, and the rivers of Kentucky, possess all the essential characteristics of the Ohio, and will always afford a good navigation for steamboats, whenever they are adequately supplied with water.

Further west, the field of valuable improvement is immense. Probably 2000 miles of precarious navigation on the Missouri alone, may be rendered permanent and safe by a few dams constructed upon the great tributaries above the mouth of the Yellow Stone; and, as civilisation is carried by steam into those distant regions, it is reasonable to suppose that the same incidental advantages to society will be experienced there, which, it can be shewn, are certain to follow the application of this system on the Ohio.

It is not asserting more than the measurements presented in this paper will justify, when it is maintained that it is entirely in the power of man to control all the waters of the Mississippi and the Missouri, and compel every river to flow with an even current from its source in the Alleghany or Rocky Mountains, to its home in the ocean, for ever free from the hurtful effects of floods and droughts.

The writer can scarcely hope immediately to remove the suspicion and distrust with which the first announcement of his plan was met by the public; but yet he believes that the period is past when prejudice or doubt can long resist the force of demonstration. When, in a former age, it was proposed in Spain to unite two rivers by a navigable canal, a commission of the Inquisition decided against the project, on the broad ground that, if it had been the will of God that those rivers should be united, they would have been joined in their creation. The decision was in conformity with the spirit of the age and the people, and was doubtless dictated by honest views of piety and right.

But times have changed, and men are learning to look upon this earth and all it contains as a gift from God to the beings of his creation, to be used, explored, studied, and improved.

The waters are not the least of these bounteous gifts. But it does not follow, because they are supplied in abundance, they were intended for ever to be wasted. It is more in unison with what is known of the original design, to conclude that the apparent excess was intended for many useful purposes; to be collected for the benefit of the parched earth; for the power that it affords; for the transportation of the products which it serves to increase and prepare; and not for ever to burst, periodically, in a wave of destruction upon man and his works.—(*Smithsonian Contributions to Knowledge*, vol. ii.)

Notices of various Animal Remains, as Bos longifrons, &c., *found with Roman Pottery, near Newstead, Roxburghshire:* with Notes in reference to the Origin of our Domestic Cattle, and the Wild White Cattle of this Country. By JOHN ALEXANDER SMITH, M.D. Communicated by the Author.*

In the winter of 1846–7, during the excavation of a cutting on the Hawick branch of the North British Railway, in the neighbourhood of Melrose, and a little to the east of the village of Newstead, a number of shafts or well-like pits were come upon. There were about five or six of these of a large size, two of which were built round the sides with stones, and were about 20 feet deep, and about 2 feet 6 inches in diameter; the others, being simply dug out of the ground, were about 4 feet in diameter, and varying from 15 to 18 feet in depth. These pits were all found in a space of about 30 yards square, and among them were discovered some 15 or 16 small pits, about 3 feet deep and 3 feet in diameter, which were lined throughout with a layer of whitish clay, some 5 or 6 inches thick. All these pits were filled with a black peaty-like stuff, apparently damp ashes and earth, and in them were observed numerous pieces of Roman pottery, consisting principally of the dark-coloured or smother-kiln ware, coarser varieties of the gray, and yellowish, and also some portions of the fine red or Samian ware, both plain and embossed. Many of these, I have been informed, might have been preserved entire, or the broken fragments collected together, which, I regret to say, were carelessly thrown with the earth and rubbish to form the adjoining mound. I have been able to collect a few specimens of the

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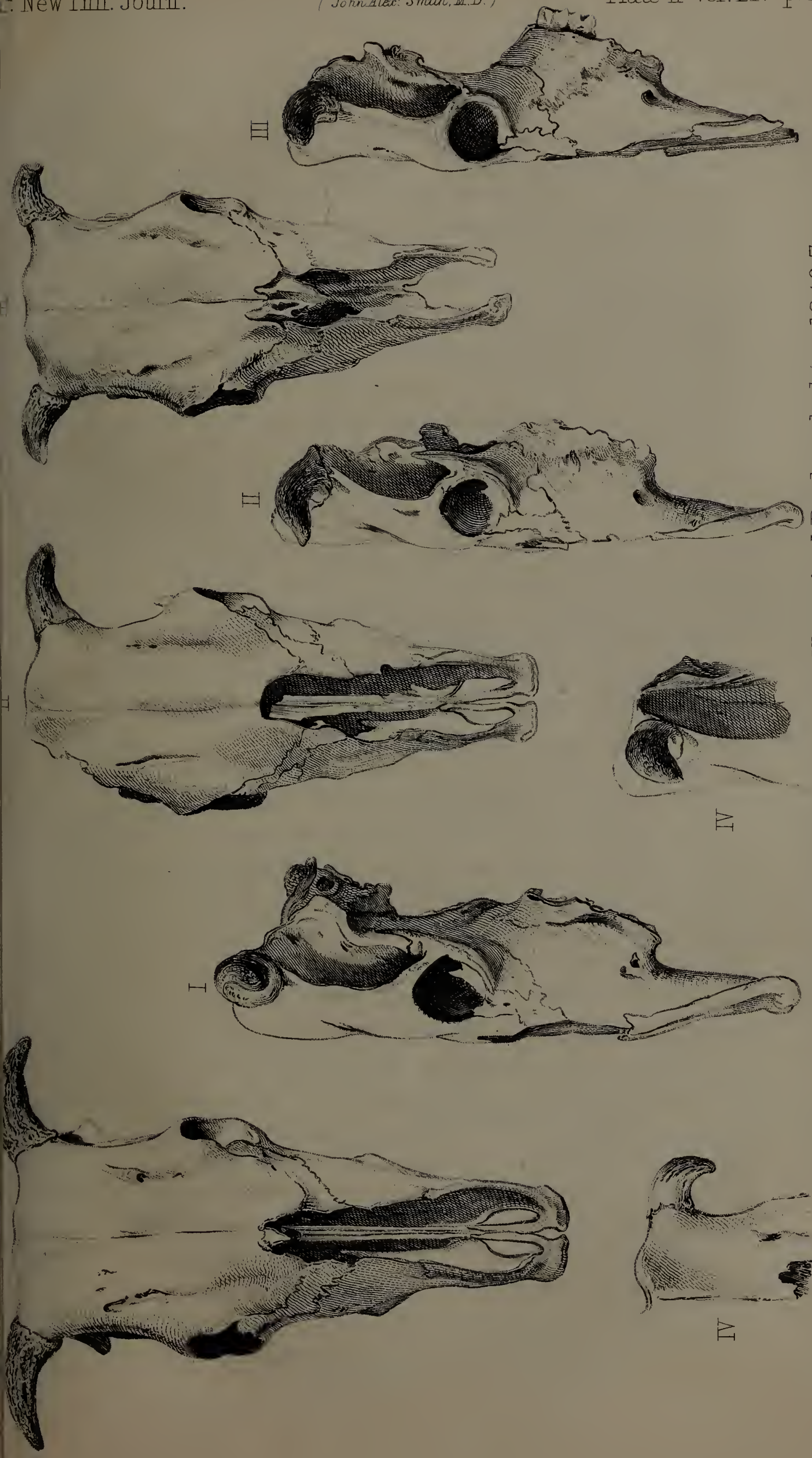
* Read before the Royal Physical Society, Edinburgh, April 2, 1851.



Sculls found with Roman Remains near Newstead, Roxburgh-shire. 1846-7.

Jas Drummond, R.S.A. del. W. & A.K. Johnston. Sc.

BRITISH MUSEUM
NATURAL HISTORY.

different kinds of ware (some of which I exhibit), and have presented them to the museum of the Scottish Antiquaries. Several silver and brass coins, of the Emperors Vespasian, Trajan, and Hadrian, were also found, and the bones of various animals.

I shall not enter here into the more strictly antiquarian details of the subject (which I have already, sometime ago, fully described in another place—Soc. Ant. of Scot., May 1850), farther than to say, that the popular idea of these pits having been wells, seems rather absurd, if we consider the number of them clustered together, as well as their near neighbourhood to the River Tweed. English archæologists call pits of this kind rubbish-holes, or dirt-pits,—the name sufficiently pointing out their supposed use; but it certainly seems to me very strange, that the Romans should have taken so much apparently unnecessary trouble for such a purpose, as the land would surely not be so very valuable in those ancient days, and the River Tweed runs at no great distance from them on the north, which would seem to afford a simple means for carrying off anything of the kind. I am inclined to the opinion, from considering all the circumstances of the case, that these had been the burying-places of the ancient Roman town, which I believe to have existed in the immediate neighbourhood, and that in these pits were deposited the inurned ashes gathered from the extinguished funeral piles of the dead; the remains of sacrificed animals being then apparently laid over them as their most appropriate covering. However this may be, pits of a corresponding kind have been discovered in various places in England; but, as far as I am aware, this is only the second time anything at all resembling them has been noticed, or described, as occurring in Scotland. A little to the east of these pits a bed or stratum, of considerable size, and consisting apparently of burnt earth, mixed with wood charcoal, was observed, and a little farther to the east, another of smaller size was also come upon; and in both of these, various pieces of pottery, and the bones and teeth of animals, were discovered. I regret my not being able to give a full and satisfactory account of the various animal remains which these beds and pits contained, as most of them were carelessly dug out by the rough hands of the "navies," and added with the earth to form an adjoining mound. Those I have been able to collect and examine are the following:—In the first place, however, I must notice the discovery of a *human skeleton* in a pit, about three feet in diameter, and ten feet in depth, a little to the south-west of the large built pits. It was found standing erect, with a spear beside it; the head of the spear was of iron, 14 inches long, and $1\frac{1}{4}$ inch broad at its widest part, and traces of the handle still remained, the rotten wood falling out on the spear being touched. The skull alone was preserved, and through the kindness of my friend Dr Brown, Melrose, is now in my possession (since presented to the Museum of the Scottish Antiquaries). It is well formed, of moderate size, of the Caucasian type, with strongly-marked muscular impressions, and the teeth generally sound, and little worn, being evidently the skull of an adult male in the prime of life. An examination of it was carefully made by Dr D. Wilson and myself, for his interesting paper "On the Crania of the Tumuli," (read to Brit. Assoc. here), and the following are the details of its various dimensions, according to the terms used by Dr Morton in the "*Crania Americana*:"—Longitudinal diameter, 7 in. 3 lin.; parietal diameter, 5 in. 4 lin.; frontal diameter, 4 in. 6 lin.; vertical diameter, 5 in. 4 lin.; intermastoid arch, 14 in. $7\frac{1}{2}$ lin.; intermastoid arch, from upper root of zygomatic process, 12 in.; intermastoid line, 5 in. $3\frac{1}{2}$ lin.; do. from upper root of zygomatic process, 5 in. 6 lin.; occipito-frontal arch, 14 in. 4 lin.; do., from occipital protuberance to root of nasal bones, 12 in. 9 lin.; horizontal periphery, 20 in. 6 lin.; relative capacity (which is here assumed by adding together the longitudinal and vertical diameters, and the horizontal periphery), 33 in. 1 lin.

If this skeleton, from the place where it was found, be considered that of a Roman citizen, it must, in my opinion, have belonged to the later period of their occupation of this district; as it was not until then that the practice of burning the dead began to be given up, and the simpler rite of inhumation reintroduced. Or, it is not improbable it may belong to a much later period; but on this difficult subject it is no easy matter to decide.

Of the various remains of the *lower animals* which were collected, the first I shall notice has been well called "the noble associate of man,"—I refer to the *Horse, Equus Caballus*, Linn., to which I consider this back part of a mutilated skull to have belonged, and which seems to have been an individual of rather a small size. The next is the Common Hog, *Sus scrofa*, Linn., of which a lower jaw was preserved. It is easily distinguished by its peculiar form, the posterior grinders being oblong, with tuberculated crowns, and the incisors sloping forwards. The third animal which I have to notice, is represented merely by a portion of a round antler, apparently of the Common Stag or Red Deer, *Cervus elaphus*, Linn. It seems to be a part of the first or brow antler; and I was informed, that tolerably perfect antlers, said to be those of the red deer, had also been found; but these I was unable to get for examination.

The other remains consisted of skulls, and apparently other bones of *short-horned oxen*, which I shall attempt more particularly to describe. I need hardly allude to the well known fact, of the previous existence in Britain of two species of enormous wild oxen; the one the shaggy Bison, the other the large horned and mighty Urus (*Bos primigenius*, Bojan.); an animal, according to Cæsar, almost equalling the elephant in bulk; but, in addition to these, there were also short-horned cattle of a very inferior size, which have been proved to have existed in Britain from the period of the newer pliocene formation, their remains being found in drifts and fresh-water deposits, along with those of the mammoth and the rhinoceros, and in the caves of the same period, the prey, it may have been, of tigers, bears, and hyænas; as well as through the deposits of the alluvium; down to their existence in the bogs, and among the traces of men in the latest of all the formations; being spared apparently, for man's sake, while their dread contemporaries of earlier times had passed from the face of the earth. After this, however, they also seem to disappear as a distinct species; still existing, it may be, in some of the many varieties of our present domesticated ox. This small short-horned ox, Professor Owen has designated the *Bos longifrons.* "It belongs," the learned Professor says in his excellent work on 'British Fossil Mammals,' "like our present cattle, to the sub-genus *Bos*, as is shewn by the form of the forehead, and by the origin of the horns from the extremities of the occipital ridge; but it differs from the contemporary *Bos primigenius*, not only by its great inferiority of size, being smaller than the ordinary breeds of domestic cattle, but also by the horns being proportionally much smaller and shorter, as well as differently directed, and by the forehead being less concave. The horn cores of the *Bos longifrons* describe a single short curve outwards and forwards in the plane of the forehead, rarely rising above that plane, more rarely sinking below it; the cores have a very rugged exterior, and are usually flat at their upper part." Vide *Owen's Brit. Fos. Mammal.* With regard to the horn cores, Professor Owen seems to allow some little latitude, both as to their size and curvature. In alluding, p. 501, to the Urus being distinguished from the *Bos taurus* by its great size, and the direction of the horns, he quotes from Cuvier the following remark: "The naturalist well knows that such characters are neither constant nor proper for the distinction of species;" and, accordingly, he admits that the Urus was subject to some variety in these respects; and, in the passage just quoted, he also appears to allow a certain amount of range in the curvature of the horn cores of the *Bos longifrons;* for he says, as already mentioned, they "rarely rise above the plane of the forehead, and more rarely fall below it." The four skulls in my possession (which I now exhibit), seem to correspond very considerably with these general characters of the *Bos longifrons*, if we consider an allowance made for the slightly upward bend of the horn cores of one at least of them, while they agree with the forward curvature, and scarcely rise above the plane of the forehead. Indeed, two of them (Nos. III. and IV.), seem very closely to resemble the description given by Professor Owen, and the horns of No. IV. especially correspond; the other two, Nos. I. and II. (*vide* Plate), although perhaps slightly different, and of rather a larger size, still agree considerably in most particulars; the largest of these No. 1, being probably a bull, as well from its larger size, and more strongly-marked horn cores, as from the proportionally broader and squarer forehead, which is believed to be characteristic of the male; and the others being in all probability cows. I would be inclined to account for their slight differences upon the supposition of these skulls being the remains of cattle which had become domesticated at that early period in our country's history, when the Roman soldier was a dweller in the south of Scotland; and should they be considered as not absolutely identical with the *Bos longifrons*, they seem apparently so closely allied, as to afford a strong reason for believing it to be, at all events, the native source from which they had been derived. I have made out a table of their different dimensions, as compared with those given by Professor Owen, and it will be seen how very closely they correspond (*vide* Table). One of the skulls, No. IV., seems to have been sawn through the middle, and, from the appearance of some of the others, you might fancy the animals had been killed by the heavy blow of an axe, or some such instrument, striking them obliquely immediately behind the horns. On examining these skulls, I have been struck by what appears to me to be the *large relative size of their prominent orbits*, as contrasted with those of the *Bos primigenius*, and even of our domestic cattle. In the *B. primigenius*, indeed, the orbit seems to be small in relation to the immense bulk of the skull. And I may also notice the peculiar prominence in the middle of their supra-occipital ridge, especially in the skulls Nos. III. and IV. Since writing these notes, I have read a very interesting paper by Professor Nilsson of Lund, in the Annals and Magazine of Natural History, vol. ii. of Second Series, "On the Extinct and Existing Bovine Animals of Scandinavia," in which he gives a detailed account of the characters of the *Bos longifrons* of Professor Owen, or Dwarf Ox, a few of which I may enumerate here. He says: "As far as we yet know, it is the smallest of the ox tribe that had lived wild in our portion of the globe; the whole length, from the muzzle to the end of the rump bone, he supposes to have been about 6 ft. 8 inches, and, from the slender make of its bones, it had rather resembled a deer than an ox. The forehead upwards over the eyes is flattened, with an edge going along the frontal seam, which is most prominent upwards, and ends with a rounded indenting backwards. Between the eyes, is a more or less considerable depression, above which there is often a rising, and beneath which lies the incision for the nasal bones, which go right up to the line drawn between the lower borders of the orbits. (Thus the frontal bones are not longer in this species than they are in the Urus or Taurus.) The horn cores are small, cylindrical, short, curved only in one direction forwards; sometimes, though seldom, downwards, in the plane of the forehead. The form of the temporal cavity is, behind, transverse-obtuse; before, oblique-pointed; *its hinder part* (to the angle above the joint of the under jaw), *only one-fourth part broader than the forepart.* The anterior palatine apertures lancet-shaped, at the back oblique inward-pointed; the back ones lie between the palate bones; the nape transverse, upwards with a vertical indenting; downwards with a vertical edge over the circular foramen of the nape. *The skull of this species varies considerably in size, and even something in form, according to its age and sex. The species, however, is always known by a protuberance upon the upper part of the forehead in front, and an indenting backwards.*" (The *italics* I may observe, are not in the original.) He gives a table, also, of the usual dimensions of young specimens, which I have added to mine, to shew their general correspondence.

These four skulls then, (before you,) which were found near the village of Newstead, Roxburghshire, seem to me to agree so very closely with all these distinctive characters, as to prove them to have been very nearly allied indeed, if not absolutely identical with, the *B. longifrons;* and should you agree with me in this opinion, then I may say, *I consider these as of course proving their existence in the south of Scotland at the time of the Roman occupation of the country, of which, as far as I am aware, these skulls are the only evidence.*

The examination of the skulls of cattle, which had undoubtedly existed in our country at a very remote period, naturally suggests some queries as to the *Origin of our ordinary Domestic Cattle*, which is a question of considerable interest as well as difficulty, but into which I do not intend to enter farther than to bring forward a few gleanings and remarks bearing upon this interesting subject. Professor Nilsson, in the valuable paper already alluded to, after describing what he considers to have been an additional species of extinct and fossil ox, which, according to him, had existed in this country as well as in Sweden, which he calls the *Bos frontosus*, and to which, in passing, I must allude. It is distinguished, he says, by the ridge of the occiput rising high in the centre, convex; the horns, which rest on longer pedicles than among any known species of ox, are short, and directed outwards and backwards, and then bend forwards. The size of the skulls denote an animal which, although much less than the *B. primigenius*, is yet considerably larger than the *B. longifrons*. It belongs, he says, to the country's oldest post-pliocene period. And with regard to the question of the origin of our present cattle, the Professor *considers that a race of our domestic cattle have probably been derived from each of the three species he describes of the sub-genus Bos with the flat forehead; the B. primigenius, B. frontosus, and B. longifrons;* none of them, according to the general opinion of naturalists, being derived from the Bison or Aurochs, which is quite different in its characters, and never pairs with the domestic cow. Other naturalists, however, consider the *Bos primigenius* as the origin from which our domestic cattle are derived. I entirely concur with the opinion of Professor Owen, in considering it highly improbable, in fact almost impossible, that the enormous and savage Uri, of which Cæsar says, "great is their strength and great their speed, and they spare neither man nor beast which they catch sight of; and that the man who killed the greatest number of them, even by the pitfall, brings the horns as an evidence of his prowess, and is highly applauded by his countrymen; and so savage is their nature, that, *though taken never so young, they cannot be tamed*,"—(lib. vi., 27, 28.) To suppose beasts like these, not only tamed, in opposition to such decided evidence to the contrary, but also so strangely degenerated into the comparatively small-sized and placid ox of the present day, seems to me really past belief.

And with regard to the opinion, that the domesticated British cattle were originally derived from those of the Roman colonists, we must recollect that we have evidence which proves the existence of numerous herds of domesticated cattle in Britain before ever Cæsar's troops set foot in the country. This Professor Owen seems rather to overlook, when he says, (p. 500, *Brit. Fos. Mam.*,) that in all probability the "herds of newly conquered regions would be derived from the already domesticated cattle of the Roman colonist." No doubt to a certain extent this might afterwards be the case; but Cæsar himself tells us, in his Commentaries, at the very commencement of his operations in England, that "the country was well peopled, and that they possessed 'pecoris magnus numerus,'"—(lib. v. 12)—numerous herds of cattle; for "pecus" is frequently used when domesticated cattle are spoken of, although certainly its more correct signification refers to sheep; and that in this instance it refers to cattle, we think is rendered the more likely, by his going on to tell us that the natives of the interior of the country seldom troubled themselves with the tillage of the ground, but lived on *milk* and flesh meat, and clothed themselves with the skins—(lib. v., 12, 14);—all of which facts are proofs of the reference being at least to domesticated herds; and also, as has been well remarked, that the proverbial fondness of the natives of the southern parts of our island, at the present day, for the "roast beef of Old England," is a taste of no recent origin. It should also be remembered, that it must have taken no little time before the country could be filled with "numerous herds of cattle," especially if we consider the difficulty of transit from one country to another, in the still earlier and ruder times; and I may remind you of the fact, of which Cæsar also informs us, that the Germans were, like the British, in possession of numerous herds of cattle before the Romans invaded them; not being tillers of the ground, but resembling the British in their "milk, cheese, and flesh" diet,—derived of course from their domesticated cattle. Considerations such as these would make me rather agree with Professor Owen's other remarks, when, treating of the *Bos longifrons*, he says, "that if it still be contended that the natives of Britain, or any part of them, obtained their cattle by taming a primitive breed, this small-sized, original variety of ox, is most likely to have furnished the source." Now, I am inclined to think that the several instances where bones of this animal have been found along with the ancient works of man, as mentioned by Professor Owen, as well as in the present case, are, in all probability, proofs of the early domesticated state of an ox identical with the *B. longifrons;* which, as already mentioned, had existed in this country from the times of the newer pliocene period.

And in support of the opinion of the *Bos longifrons* being the true origin of our domesticated cattle, or at least as shewing its more general resemblance to them, I may extract one or two statements from the paper of Professor Nilsson already referred to; for example, when describing the *Bos frontosus*, he says, "*It seems to have been about the size of our common cow, from which, however, in form it totally differs.*" And in the *Bos longifrons*, as already noticed, "the form of the temporal cavity is behind transverse-obtuse, before oblique-pointed; *its hinder part (to the angle above the joint of the under jaws) only one-fourth broader than the fore part. Herein it resembles the tame ox, but differs visibly from the B. frontosus, in which the back part is twice as broad as the forepart, and also from the Urus.*" And he also states that in the Urus the nasal bones are five times as long as broad; in the *B. longifrons* they are nearly six; while in the domestic ox they are six-and-a-half times as long as broad.

It is curious to notice the fact, that the wilder districts of Britain, as the extremity of Devon and Cornwall for example, and the mountainous districts of Wales, as well as our own rugged land, seem all, according to Mr Youatt, to have been originally stocked with cattle having even yet as it were a general family likeness, with moderate sized horns, and of no great general bulk; being the very localities, as Professor Owen well remarks, where the natives would drive their domestic cattle before the advance of an invader, and where of course traces of the original breeds are most likely to be found. Full allowance must, however, at the same time, be made for the wonderful changes produced on cattle by variety of situation, and climate, by pastures, and attention on the part of their possessors to their breeding, so as to favour, from what originally might be an accidental peculiarity, the preservation and gradual spreading over the herd of some fancied excellence, or beauty, or fashion of the time. The Galloway cattle may perhaps be cited as an instance of the changes produced in this way; they are now known as a breed of polled or hornless cattle; whereas, it is said, that so late as the middle of the last century, the greater part of them had horns of a rather small or medium size.

The Ancient White Cattle, still existing in some gentlemen's parks, may also, it seems to me, be considered as an instance of a beautiful and much-esteemed variety of our domesticated cattle, being artificially preserved; and, as these are believed by many to be the last remains of our native wild cattle, I may perhaps be excused entering a little into detail on this curious subject. We find, among these various herds of park-kept, so-called Wild White Cattle, at present or lately in existence in the country, a considerable diversity in their general appearance; some with red ears, others with black, and this latter peculiarity occurring occasionally even among those of the red-eared variety, as mentioned by Bewick of the Chillingham cattle; and some having horns, while others have none, as the breed of wild white cattle at Gisburne, in Craven, Yorkshire (*Vide* Bewick's Quadrupeds); and, besides other little peculiarities, we have also the occurrence from time to time among these breeds, of cattle more or less marked with brown or black spots, but these individuals are always killed, to prevent this variety spreading among the herd:—"And when the calves have been taken young, they have been completely tamed, and become like the common domestic ox, feeding as rapidly in confinement as a short-horned steer."—(*Vide* Paper "On the Wild White Cattle of Chillingham," by William Hindmarsh, Esq., in the *Annals of Nat. Hist.* for 1839, vol. ii.) All these peculiarities seem to me to favour the idea of these cattle being merely a fancy breed of ancient domesticated cattle, preserved for their beauty in the parks of the nobility.

It is well known that the colour of many animals is changed by domestication, and that they frequently become more or less entirely white; and it is interesting, as shewing apparently where some of the last traces of the original colour of an animal, which has been changed in this way, may be expected still to remain; to notice the remark of Professor Bell of London, in his valuable work on "British Quadrupeds," that "It appears the ears are more liable to retain colour in animals which become white by domestication than any other parts. This is the case, as we have seen, with the guinea pig, and it is no less true of the ox, and some others."—(P. 355.) I have heard a similar remark made by Professor Fleming, that he had never seen an entirely white ox, but that the ears always remained of a different colour. Now in these park-kept white cattle, we have this same peculiarity also existing. And Professor Nilsson alludes in his paper, to the well-known fact, that no race of *wild oxen* of this *white colour* is known to naturalists. In Mr Hindmarsh's paper, already referred to, he quotes passages from several ancient authors, to justify the hypothesis of their being the remains of the ancient wild cattle of the country: these authors are, Hector Boece or Boethius, "Scotorum Historiæ a Prima Gentis Origine," published at Paris in 1526; and Bishop John Leslie's work "De Origine, Moribus, et Rebus Gestis Scotorum," published at Rome in 1578. Now these, I suspect, must be considered, not as two independent authorities, but merely as one; for the Bishop, in his book, published some fifty-two years after the other, gives manifestly, in this instance, almost a *verbatim* copy of the statements of Boethius. To shew this, I may compare the original passages, which refer to the existence of these white cattle in the Great Caledonian Forest, which formerly covered the country from Stirling to Athol. 1, BOETHIUS, "*Scotorum Historiæ a Prima Gentis Origine*," fol. 6, l. 63; *Scotorum Regni Descriptio*, &c., of edit. Paris 1574:—"Hic initia olim fuere Caledoniæ sylvæ, manentibus videlicet veteribus adhuc nominibus Callendar et Caldar, excurrens per Monteh et Erne-vallem longo tractu ad Atholiam et Loquhabriam usque. Gignere solet ea sylva boves candissimos in formam leonis jubam ferentes, cætera mansuetis simillimos, verum adeo feros indomitósque atque humanum refugientes consortium, ut quas herbas, arborésque aut frutices humana contrectatas manu senserint plurimos deinceps dies fugiant: capti autem arte quapiam (quod difficilimum est) mox paulo præ mæstitia moriantur."—"Hujus autem animalis carnes esui jucundissimæ sunt, atque in primis nobilitati gratæ, verum cartilaginosæ. Cæterum quum tota olim silva nasci ea solerent: in una tantum nunc ejus parte reperiuntur, quæ Cummirnald appellatur, aliis gula humana ad, internecionem redactis."

2. Bishop Leslie, *De Origine, Moribus et Rebus Gestis Scotorum*, Rome, 1578, p. 19, (*Scotia Descriptio*):—"Ab his regionibus vastissima illa olim Caledonia sylva initium sumpsit, ut quædam locorum nomina hodie indicant."—"In Caledonia olim frequens erat sylvestris quidem bos, nunc vero rarior, qui colore candissimo, jubam densam, ac demissam instar leonis gestat, truculentus, ac ferus ab humano genere abhorrens, ut quæcunque homines vel manibus contrectarint, vel halitu perflaverint, ab iis multos post dies omnino abstinuerint."—"Ejus carnes cartilaginosæ sed saporis suavissimi. Erat is olim per illam vastissimam Caledoniæ sylvam frequens, sed humana ingluvie jam assumptus, tribus tantum locis est reliquus, Stirivilingi, Cumernaldiæ, et Kincarniæ." And as for Boethius himself, we must remember, that though perhaps a good enough authority as to anything that happened under his own observation, he is so credulous as to believe apparently all that was told him, however extraordinary; so that his description of these cattle, of the purest white, maned like lions, untameably wild, and fleeing the very neighbourhood, or even the scent of men, and which apparently he had never seen, must all be taken with a considerable allowance, and in all probability were nothing more than *strayed domestic cattle*, which, in the course of years, had lapsed into a semiwild state. As an instance of his credulity, I may refer, in the words of Bellenden's Translation of 1553, to his account of the extraordinary animal described

by Sir Duncan Campbell,—"That out of Garloll, ane loch of Argyle, the yeir of God M.DX yeiris, came ane terrible beast, als meikil as ane grew hound, futit like ane ganar, and straik down greit trees with the dint of her tail, and slew thre men quhilks wer at their hountis with thre straikis of her tail; and wer not the remanent hunteris clam up in strang aikis, they had been all slane in the samin maner."—(Chap. vii., *Bellenden's Trans. of Boethius' History.*)

It is curious, however, to trace the description of these white cattle, maned like lions, &c., published by Boece in 1526; as it seems to have been adopted by naturalists on his authority, and to have apparently been the only source from which they derived their descriptions. Aldrovandus, in his work, "Quadrupedum Omnium Bisulcorum," Bonon, 1632, referring to the older work of Gesner, "Historia Animalium," 1551; notices these white cattle, in all probability from their being described as having manes like lions, &c., under the name of *Bison album Scoticum, sive Calydonicum*, using the very words of Boece already quoted. Then, in the "Historia Naturalis de Quadrupedibus" of John Jonston, M.D., published at Amsterdam, 1657, we have this same description of Boece, again in part repeated; in two different places, however; first, in the Chap. "De Bove Domestico;" and again, "De Bobus Feris," with a marginal reference to Aldrovand. Histor. Bisul. To shew this more fully I may quote the passages, Art. 1, De Bove Domestico. *Differentiæ*. p. 34. "In Scotia boves sunt sylvestres colore candidissimo, juba densa ac demissa, truculenti et feri, adeoque ab humano genere abhorrentes, ut ab iis quæ homines vel manibus contrectarint, vel halitu perflaverint, per multos dies abstineant, dolo capti, moriantur. Carnes cartilaginosæ habent." And again, Art. 2. De Bobus Feris, p. 1. *De Bisonte*. "Huc pertinet et *Bison Scoticus*. Candidissimum esse aiunt, in formam leonis jubam ferre, cætera mansuetis simillimum, verum adeo ferum et indomitum, humanique consortii hostem, ut quas herbas aut frutices humana contrectatas manu senserit, plurimos deinceps fugiat: captum autem arte quadam, mox præ mæstitia mori." So that we have now *two species*, apparently made out of Boece's description; and accordingly, in the Scotia

ILLUSTRATA, *sive Prodromus Historiæ Naturalis* of Robert Sibbald, M.D., published at Edinburgh in 1684, we find this Scottish naturalist quoting from Jonston's work, referred to above, adding, however, the following remarks :—" Quæquidem ab Historicis nostris petita sunt, *sed confirmatione egent.* In pluribus locis montanæ partis Scotiæ reperiuntur quidem Boves feri, albi quoque : *sed non ita truculenti, neque forma a domesticis differunt.* An jubati Bisontes nunc extent, nescio." *De Bisulcis Ruminantibus Cornigeris*, p. 7. So that Sibbald seems to doubt the existence of the so-called *Bison Scoticus*, though he admits that white cattle, exactly however resembling the domesticated breeds, and by no means so fierce and savage as they are described, still run wild in some of the mountainous districts of the country. The original source of the whole statement being apparently the description given by Boece, and repeated by Bishop Leslie, which I have already taken the liberty of criticising, as being, in all probability, a very exaggerated account. And moreover, if we search still further back in the records of a much greater antiquity, we find evidently the same kind of white cattle described in such a way as seems to me to imply, without a doubt, their thorough domestication. As in the " Leges Wallicæ," of " Howell Dda," the Welsh laws of King Howell the Good, which date from about A.D. 942–3, or before the middle of the tenth century,—*vide* Translation by Gul^s. Wottonus, London, 1730. We there find white cattle with red ears, in all probability the same breed of cattle as those I have been referring to, ordered to be paid as a compensation for offences committed against the Princes of Wales—(*vide* Lib. 1, chap. vi., p. 10–11): "*De solvenda Multa Regis.*—Multa pro injuria Regi Aberfraviæ illata hoc modo solvenda. Centum vaccas pro qualibet centuria subditione ejus *Reus solvet*, et cum singulis centenis vaccis unum *Taurum auribus rufis* præditum cum Virga aurea ejusdem cum Rege longitudinis, magnitudine digiti ejus minimi, et crassitudine unguis aratoris qui per novem annos araverit. Aurum nemini debitur nisi Regi Aberfraviæ."—" 3. Domini Dinevoræ privilegium est accipere pro compensatione injuriæ sibi illatæ *vaccas albas aures rufas habentes*, totidem quot ordine sibi succedentes pertingent ab Argoëlia (*e*) ad Dinevoram, et *cum singulis vicenis vaccis taurum ejusdem coloris.* Aurum nemini penditur nisi Regi Dinevoræ vel Regi Aberfraviæ."—" (*e*) Loci nomen prope Dinevoram, sibi ubi præcise situs sit ignoratur." —It seems very evident that such numbers of *living wild cattle* could never be exacted as payment of a fine, but that beyond all doubt *domesticated cattle* are here referred to, and apparently, from the special character of the notice, a favourite variety, highly prized for their beauty and peculiar colour. And to shew how highly this breed of cattle had been valued at a very early period, I may quote several passages from Mr Youatt's well-known work " On Cattle." He says, (p. 478,) " Howel dha, or Howell the Good, describes some of the Welsh cattle, in the tenth century, as being ' white, with red ears,' resembling the wild cattle of Chillingham Castle. An early record speaks of *a hundred white cows with red ears* being demanded as a compensation for certain offences against the Princes both of North and South Wales. *If the cattle were of a dark or black colour, one hundred and fifty were to be presented.* When the Cambrian Princes did homage to the King of England, *the same number of cattle, and of the same description,* were rendered in acknowledgment of sovereignty. Speed tells us that Maud de Breos, in order to appease King John, whom her husband had offended, sent to his Queen a present from Brecknockshire of *four hundred cows and a bull, all white, and with red ears.* Whether this was the usual colour of the ancient breed of Welsh and British cattle, or a rare variety, esteemed on account of its beauty, and chiefly preserved in the parks of the nobles, we are unable to determine. The latter is the more probable supposition ; and the same records that describe the ' white cattle with red ears,' speak also of the ' dark or black-coloured breed, ' which now exists, and which is general throughout the principality." It appears to me but natural to suppose that these were all *domesticated*, and surely *not wild cattle*, to which reference has been made in these various passages ; and that they were a highly-prized variety, is shewn by their colour being specially mentioned, as well as their being valued at a half more than the dark-coloured, which were most probably the more common breed of the district. And let me call to your recollection a remark of Hector Boece himself, in the passage already quoted: that, with the exception of their colour and manes, the wild white cattle are exceedingly like the ordinary tame or domesticated breed; and that their flesh is very pleasant food, and much approved of by the nobility;—both of which observations, in my opinion, tend to shew the truth of the views now stated.

Youatt says, the old legends of Wales speak of the ancient domesticated cattle, being of a dark or reddish colour, resembling considerably the Devon cattle; and according to the same authority, "the slightest observation will convince us that the cattle in Devonshire, Sussex, Wales, and Scotland, are all essentially the same." He considers that *red* had been their primitive colour, as he traces it through all these varieties, and declares that even where another colour, as black, now prevails, the memory of the red still remains, and has a superstitious reverence paid to it in the legends of the people. In Scotland also there has always existed a popular feeling of preference for the red cow, it being declared to be "luckier," and to give more milk. It is, perhaps, worthy of notice, in relation to the question of colour, that the *Urus*, or *B. primigenius*, is believed to have been of a dark or black colour; and in what I consider to be a very rare specimen of a portion of the skull of the *Bos longifrons*, with the horn and part of the skin and hair still attached, which was kindly shewn me by Professor Fleming, the colour of the hair, as far as you can judge from a specimen found in an Irish bog, is also of a black or dark reddish or brownish tint; it may be, bearing a relation to the very colour to which I have been alluding.

And, in conclusion, I may remark, that the *small size of the domesticated cattle* in this country, from the very earliest times, seems to me an additional and unanswerable objection to their having descended from the gigantic *Urus*. Professor Nilsson, however, in his paper already referred to, considers "that we may take it as a given and general rule, that the tame race is always less than the wild species from which it springs." Now this is a proposition which I am very much inclined to doubt, believing, as I do, that animals are by no means necessarily degenerated and dwarfed in their dimensions, as the Professor supposes, when taken under the care and protection of man, but, on the contrary, are rather increased in size, by careful tending and feeding, as well as by attention to their breeding; and examples in proof of this view, I am inclined to think, may be found in our domesticated dogs, horses, &c. We know, from such specimens as these skulls I have described, the small size of at least some species of cattle in the *Roman* period; and others, of an exactly corresponding kind and size, have been found, as already mentioned, belonging to an immensely older *geologic period*, carrying us back in this way to times altogether prior to the existence of man. Then, in much later times, as shewn in the Welsh Laws of Howell the Good, in the tenth century, (*vide* Wotton's Trans. *Leges Wallicæ,*) we have apparently given to us the different sizes of the yokes used for ploughing; and if so, from these we find that the cattle of that date must have been much smaller than those of the present day. Thus we find it stated in Lib. III., chap. ix., p. 279, *De Societate Arationis.*—"Jugum breve quattuor pedibus (longum); Jugum maiale octonis pedibus; Jugum axillare duodenis pedibus; Jugum longum senis denis pedibus." In other passages of these laws, we have these various yokes referred to as measures of the land; being apparently taken from the well-known sizes of the different yokes themselves. The cattle, Mr Youatt says, were always yoked abreast, and the short yoke for two oxen was only four Welsh feet of nine inches each, or three feet English in length, increasing in the same proportion for four oxen; and for eight, which was 16 Welsh feet, or 12 feet English long. Chap. ix., 2 of Lib. III. of *Leges Wallicæ.*—"Uncia longitudine trium granorum hordeacorum constat—Palma tribus unciis—Pes tribus palmis;" shewing in this way of what these measures consist. Mr Youatt declares that an ox of the present day would require a somewhat larger space than 18 inches, in order to work or even to stand. (*Vide* Youatt "On Cattle.") And when we remember the small size of our domesticated cattle in ancient times, it is interesting to notice another remark in page 3 of his valuable work, in regard to the comparative size of the well-tended *cattle of the present day*: "There is no doubt that within the last century, their size has progressively increased in England, and kept pace with the improvement of agriculture." How far this may go on, seems rather a difficult matter to determine, as well as to what extent a species of animal like the ox, may be changed from its original type, degenerating, it may be, in some places, and improving in others, by being long under the dominion and management of experimenting and calculating man.

These rough notes I consider as tending to shew the extreme improbability of our domestic cattle being the descendants of the large-sized *Bos primigenius*; and shall I say, the probability of their true progenitor being this small and equally-ancient *Bos longifrons*, or short-horned ox, which has been proved to have existed in this country from the later geologic periods down at least to the bustling times of busy man.

And in conclusion I have to return to my catalogue of animal remains, and making a rapid descent in the scale of animal life, allude to an ancient mollusc, which had been prized then as now, as a delicacy for the table, and is the last of these relics I have to notice, which were found with the traces of the Roman occupation of this district; I refer to the Common Oyster, *Ostrea edulis*,* of which this shell (which I exhibit) and several others were found; affording a proof of the large size of this ancient shell-fish, as well as of the fondness of the Roman epicure, even at this inland station, for the celebrated oysters of our British seas.

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* My best thanks are due to my friend Mr Adam Smith, Darnick; and to Mr Francis Burnet, Newstead, for their zeal in procuring for me these various specimens.

Table of Admeasurements of various Specimens of Skulls of the Bos Longifrons. (Owen.)

	Skulls found near Newstead.				From Prof. Owen's Brit. Fos. Mam.					Prof. Nilsson, of Lund, Young Specimens.‡		
	In. lin.	In. lin.	In. lin.	In. lin.	In. lin.	In. lin.	In. lin.	In. lin.	In. lin.	In. lin.	In. lin.	In. lin.
	No. I.	No. II.	No. III.	No. IV.	†(1.)	(2.)	(3.)	(4.)	(5.)	(1.)	(2.)	(3.)
Length of the skull from the supra-occipital ridge, to front edge of intermaxillary bone,	18·6	17	16	...	...	...	...	...	...	16	...	...
Length from supra-occipital ridge to nasal bones,	8·6	8	8	...	8	8	...	...	...	7·2	...	8·4
„ from roots of horn cores to upper edge of orbits	4·2	3·6	3·6	...	...	...	...	...	...	3·4	...	...
„ of orbits,	2·9	2·6	2·6	...	...	...	...	...	...	2·4	...	...
Breadth of orbits,	2·8	2·5	2·5	...	...	...	...	...	...	...	...	...
Length from orbit to end of maxillary bone,	8·3	7·9	7·6	...	...	...	...	...	...	8·4	...	...
„ from orbit to front edge of intermaxillary bone,	10	9·3	9	...	...	...	...	...	...	10	...	...
Breadth of forehead, between roots of horn cores,	6·3	5·6	5·8	5·6	5	5	5	5	...	5	5·3	5·2
„ across narrowest part about midway between roots of horn cores and orbits,	6·9	6	5·9	5·6	...	...	...	...	...	5·4	...	...
Breadth of skull across middle of orbits,	6·9	6·6	6·3	...	6·9	6·6	...	...	...	nearly 7	7·5	...
„ across front of intermaxillary bones,	3·3	3	3	...	..	...	...	...	...	...	...	...
Horn-cores, circumference of base,	6·9	5	4·3	4	4	3·6	4·6	...	7	4·3	7·1	4·2
„ length following outer curvature,	6	4·6	3·6	3	4	3·6	4	4	7	4	...	3
„ span across, from tip to tip,	16·6	11*	10·6*	9*	12	11	12	11·3	...	...	...	...
Length of alveolar sockets and molar teeth of upper jaw,	5	4·9	4·9	...	...	...	...	...	...	5·2	...	...
Height of skull, from supra-occipital ridge to upper edge of foramen magnum,	4·5	...	...	4·3	...	...	...	...	...	4	...	...
Height of skull from supra-occipital ridge to the base of the skull,	5·11	...	...	5·9	...	...	...	...	...	5·5	...	...
Breadth of occipital condyles posteriorly,	4·3	...	...	...	...	...	...	...	...	...	...	...

* These measurements are obtained by doubling the length from the tip of one horn core to central suture of forehead.

† (1.) Hunterian, Irish bog. (2.) Mr Ball, bog, Westmeath. (3.) Mr Brown, Clacton beds (freshwater). (4.) Mr Woods, bog, Bridgewater. (5.) Larger size, supposed to be bull, and others cows.—*Prof. Owen.*

‡ Professor Nilsson says this species seems to vary considerably in size, according to age and sex.

General Results of the Microscopical Examination of Soundings, made by the U. S. Coast Survey off the Atlantic Coast of the United States. By Professor J. W. Bailey, of the Military Academy, West Point.

1*st*, The most remarkable fact determined by the examination of the above-mentioned soundings is, that in all the deep soundings, from that of 51 fathoms south-east of Montauk Point, to that of 90 fathoms south-east of Cape Henlopen, there is a truly wonderful development of minute organic forms, consisting chiefly of Polythalamia, which occur in an abundance rivalling those vast accumulations of analogous forms constituting the marls under the city of Charleston, S. C.

2*d*, While there is a general resemblance between the species found in all the *deep* soundings above mentioned, the same species of Polythalamia occurring with few exceptions at each locality, yet each place has its predominant species; thus in the most southerly sounding (H. No. 1, 90 fathoms), there occurs a much greater number of *Globigerina* than in any of the others; while *Textilaria atlantica*, although present, is by no means so abundant as in G. No. 8, 89 fathoms.

3*d*, Infusoria, as well as Polythalamia, occur in the deep soundings; but the Infusoria are few in number, and consist of *Coscinodisci*, *Galionella sulcata*, and other species, which probably swim freely in the ocean; while none of the littoral parasitic species, such as *Achnanthes*, *Isthmia*, *Biddulphia*, *Striatella*, and *Synedra* are found.

4*th*, It is worthy of notice, that in the deep soundings not a single specimen was found of Polythalamia belonging to the *Plicatilia* of Ehrenberg (*Agathistiques* of D'Orbigny), while a number of these forms were found in the shallow soundings, and they are well known to occur in vast quantities around the shores of Florida and the West India Islands. This group of Polythalamia appears to have been created after the deposition of the chalk formation, in which no trace of such forms occur, while they are very abundant in the tertiary deposits. Their entire absence in the deep soundings, where vast numbers of other Polythalamia occur, and their presence in littoral deposits, would seem to indicate that for their abundant development comparatively shallow seas are necessary; thus affording additional evidence of difference in the depths of the seas from which the cretaceous and tertiary bed were deposited.

5*th*, The deep soundings were all from localities which are more or less under the influence of the Gulf Stream, and it is not improbable that the high temperature of the waters along the oceanic current may be the cause of immense development of organic life, making its path, as is shewn by the soundings, a perfect milky way of Polythalamia forms. The deposits under Charleston may have been produced under the similar influence of an ancient Gulf Stream.

6*th*, From the presence of such great numbers of Polythalamia in the deep soundings, there results a very large proportion of calcareous matter, thus presenting a striking difference between them and the quartzose and felspathic sands nearer shore.

7*th*, The littoral sands obtained in shallow soundings at first view appear to give little promise of affording any Infusoria. But notwithstanding their coarse, and, in some cases, even gravelly nature, they all yield by levigation a considerable number of siliceous Infusoria, which, in variety and abundance, exceed those found in the deep soundings.

8*th*, None of the soundings present anything resembling the vast accumulations of Infusoria which occur in the Miocene infusorial marls of Virginia and Maryland; and indeed, I have never found, even in estuaries, any recent deposit at all resembling the fossil ones, in abundance and variety of species, with the exception of the mud of a small creek opening into the Atlantic near Rockaway, Long Island.

9*th*, The occurrence of the pebble of limestone with encrinal plates in the gravel of F. No. 10, south-east of Little Egg Harbour, is of some interest, as the nearest beds from which it could have come are the Silurian formations of Pennsylvania or northern New Jersey. It indicates a transportation of drift to a considerable distance seaward.

10*th*, In addition to the quartzose grains in the soundings, fragments of felspar and hornblende (recognisable under the microscope by their cleavage planes and colour) are found. The quartz, however, predominates, its grains being sharp and angular in the deep soundings, and often rounded or even polished in the shallower ones.

The Reply of the President and Council of the Royal Society, to a Letter addressed to them by the Secretary of State for Foreign Affairs, on the subject of the co-operation of different Nations in Meteorological Observations.

Somerset House, 10*th May* 1852.

Sir,—I have the honour to acknowledge the receipt of your letter of March the 4th, transmitting, by direction of the Earl of Malmesbury, several documents received from foreign Governments in reply to a proposal made to them by Her Majesty's Government, for their co-operation in establishing a uniform system of recording meteorological observations, and requesting the opinion of the President and Council of the Royal Society in reference to a proposition which has been made by the Government of the United States, respecting the manner in which the proposed co-operation should be carried out.

Having submitted your letter, with its enclosures, to the President and Council of the Royal Society, I am directed to convey to you the following reply.

With reference to the subject of well-directed and systematically conducted meteorological observations generally, and to the encouragement and support to be given to them by the Governments of different countries, the President and Council are of opinion that they are highly deserving of much consideration, not only for their scientific value, but also on account of the important bearing which correct climatological knowledge has on the welfare and material interests of the people of every country.

With reference to the proposal for the establishment of a uniform plan in respect to instruments and modes of observation, the President and Council are not of opinion that any practical advantage is likely to be obtained by pressing such a proposition in the present state of meteorological science. Most of the principal Governments of the European Continent, as Russia, Prussia, Austria, Bavaria, and Belgium, have already organised establishments for climatological researches in their respective states, and have placed them under the superintendence of men eminently qualified by theoretical and practical knowledge, and whose previous publications had obtained for them a general European reputation. Such men are Kupffer, Dove, Kreil, Lamont and Quételet; under whose direction the meteorological observations in the above-named countries are proceeding; the instruments have been constructed under their care, and the instructions drawn up and published by them under the sanction of their respective governments. The observations as they are made are sent to them, are reduced and co-ordinated under their superintendence, and are published at the expense of the governments. Every year is now producing publications of this nature in the countries referred to, and by the rapid intercommunication of these, the results of the experience of one country, and the modifications and improvements which experience may suggest, become quickly known to all. To call on countries already so advanced in systematically-conducted meteorological observations, to remodel their instructions and instruments, with a view of establishing uniformity in these respects, would probably, if pressed, elicit from other governments also the reply which Her Majesty's Government have received from Prince Schwarzenberg, conveyed in the Earl of Westmoreland's letter to Viscount Palmerston, viz., the transmission of a copy of the instructions which have been given to the Meteorological Observatories, forty-five in number, in the Austrian dominions, and a reference to the results obtained at those observatories, which are stated to be in regular course of publication.

In an earlier stage, when these establishments were either forming or were only in contemplation, it was considered that advantage might arise from a discussion of the objects to be principally kept in view, and of the instruments and methods by which these might be most successfully prosecuted. For this purpose, a conference was held at Cambridge, in England, in 1845, which was attended by many of the most distinguished meteorologists in Europe, and amongst them by all the gentlemen whose names are above stated, and who were expressly sent by their respective governments. The impulse communicated by this assemblage was without doubt highly beneficial, and the influence of the discussions which took place may perhaps be traced in some of the arrangements under which the researches in different countries are now proceeding; but in the stage to which they have advanced, it may be doubted whether any measures are likely to be more beneficial than those which would increase the facilities of a cheap and rapid intercommunication of the results of the researches which are in progress.

With reference "to the suggestions made by the scientific men of the United States," the proposition of Lieutenant Maury, to give a greater extension and a more systematic direction to the meteorological observations to be made at sea, appears to be deserving of the most serious attention of the Board of Admiralty. In order to understand the importance of this proposition, it will be proper to refer to the system of observations which has been adopted of late years in the navy and merchant service of the United States, and to some few of the results to which it has already led. Instructions are given to naval captains and masters of ships, to note in their logs the points of the compass from which the wind blows, at least once in every eight hours; to record the temperature of the air, and of the water at the surface, and when practicable, at considerable depths of the sea; to notice all remarkable phenomena which may serve to characterise particular regions of the ocean, more especially the direction, the velocity, the depths, and limits of the currents: special instructions also are given to whalers, to note down the regions where whales are found, and the limits of the range of their different species. A scheme for taking these observations regularly and systematically, was submitted by Lieutenant Maury to the Chief of the Bureau of Ordnance and Hydrography, in 1842, and instantly adopted: detailed instructions were given to every American shipmaster, upon his clearing from the Custom-House, accompanied by a request that he would transmit to the proper office, after his return from his voyage, copies of his logs, as far at least as they related to these observations, with a view to their being examined, discussed, and embodied in charts of the winds and currents, and in the compilation of sailing directions to every part of the globe. For some years the instructions thus furnished received very little attention, and very few observations were made or communicated; the publication, however, in 1848, of some charts, founded upon the discussion of the scanty materials which had come to hand, or which could be collected from other sources, and which indicated much shorter routes than had hitherto been followed to Rio and other ports of South America, was sufficient to satisfy some of the more intelligent shipmasters of the object and real importance of the scheme, and in less than two years from that time it had received the cordial co-operation of the masters of nearly every ship that sailed. At the present time, there are nearly 1000 masters of ships who are engaged in making these observations; they receive freely in return the charts of the winds and currents, and the sailing directions which are formed upon them, corrected up to the latest period.

Short as is the time that this system has been in operation, the results to which it has led have proved of very great importance to the interests of navigation and commerce. The routes to many of the most frequented ports in different parts of the globe have been materially shortened, that to San Francisco in California by nearly one third: a system of southwardly monsoons in the equatorial regions of the Atlantic and on the west coast of America has been discovered; a vibratory motion of the trade-wind zones, and with their belts of calms and their limits for every month of the year, has been determined; the course, bifurcations, limits and other phenomena of the Great Gulf-stream have been more accurately defined, and the existence of almost equally remarkable systems of currents in the Indian Ocean, on the coast of China, and on the North-western coast of America and elsewhere has been ascertained: there are, in fact, very few departments of the science of meteorology and hydrography which have not received very valuable additions; whilst the more accurate determination of the parts of the Pacific Ocean, where the sperm-whale is found (which are very limited in extent), as well as the limits of the range of those of other species, has contributed very materially to the success of the American whale fishery, one of the most extensive and productive of all their fields of enterprise and industry.

The success of this system of co-operative observations has already led to the establishment of societies at Bombay and Calcutta, for obtaining, by similar means, a better knowledge of the winds, currents, and the course of the streams of the Indian seas.

But it is to the government of this country that the demand for co-operation, and for the interchange of observations, is most earnestly addressed by the government of the United States; and the President and Council of the Royal Society express their hope that it will not be addressed in vain. We possess in our ships of war, in our packet service, and in our vast commercial navy, better means of making such observations, and a greater interest in the results to which they lead, than any other nation. For this purpose, every ship which is under the control of the Admiralty should be furnished with instruments properly constructed and compared, and with proper instructions for using them: similar instructions for making and recording observations, as far as their means will allow, should be sent to every ship that sails, with a request that the results of them be transmitted to the Hydrographer's Office of the Admiralty, where an adequate staff of officers or others should be provided for their prompt examination, and the publication of the improved charts and sailing directions to which they would lead; above all, it seems desirable to establish a prompt communication with the Hydrographer's Office of the United States, so that the united labours of the two greatest naval and commercial nations of the world may be combined, with the least practicable delay, in promoting the interests of navigation.

The President and Council refer to the documents which have been submitted to them, and more especially to the "Explanations and Sailing Directions to accompany wind and current charts" prepared by Lieutenant Maury, for a more detailed account of this system of co-operative observations, and of the grounds upon which they have ventured to make the preceding recommendations.

S. Hunter Christie, *Sec. R.S.*

H. U. Addington, Esq.

On the Diurnal Variations of the Magnetic Needle, and on Auroræ Boreales. By AUGUSTE DE LA RIVE; being an extract from a Letter to M. ARAGO.*

Allow me to communicate to you, with the request that you will make it known to the Académie des Sciences, an extract of a memoir recently read before our Société de Physique et d'Histoire Naturelle, on the cause of the diurnal variations of the magnet needle, and of Auroræ Boreales. In assigning successfully these two classes of phenomena to the same origin, I have but followed the path you have pointed out; for more than thirty years ago you established, with indefatigable perseverance, by your numerous observations, the remarkable agreement which prevails between the appearances of the aurora borealis and the disturbance of the magnet needle.

The following is my theory,—you will observe that it rests solely upon well ascertained facts, and on principles of physics positively established.

I had already, in 1836, in a notice upon hail,† attempted to shew that the atmospheric electricity owes its origin to the unequal distribution of temperature in the strata of the atmosphere. It is well known that, in a body of any nature whatsoever, heated at one of its extremities and cooled at the other, the positive electricity proceeds from the hot part to the cold, and the negative electricity in the contrary direction; it thence results that the lower extremity of an atmospheric column is constantly negative, and the upper one constantly positive. This difference of opposite electric conditions must be so much the greater, the more considerable is the difference of temperature; consequently more marked in our latitudes in summer than in winter, more striking in general in the equatorial than in the polar regions. It must be observed that the negative state of the lower portions of the atmospheric columns must be communicated to the surface of the earth on which they repose, whilst the positive state of the upper portions is diffused, more or less, from above downwards, through nearly the whole of each of the columns, according to the facilities offered by the greater or less degree of humidity of the air to the propagation of the electricity. An atmospheric column, therefore, resembles a high-pressure battery, on account of the imperfect conductibility of the elements of which it is composed. A battery, the negative pole of which is in constant and direct communication with the terrestrial globe, discharges itself upon the globe, whilst it becomes itself charged with the electricity of its positive pole, which is distributed over it with an intensity de-

* From the Annales de Chimie et de Physique, for March 1849.

† *Bibliothèque Universelle*, vol. iii. p. 217. Nouvelle serie.

creasing with the distance from this pole; this explains why the positive electricity increases with the height of the atmosphere.

The causes which determine the accumulation of negative electricity at the surface of the earth, and of positive electricity in the upper regions of the atmosphere, act in a continuous manner: there should thence result an unlimited tension of the two opposite electric states, if, having attained a certain degree of energy, they did not neutralize each other by the aid of different circumstances. In other words, having reached a certain limit of tension which varies with the state of the atmosphere and the surface of the earth, the two electricities cannot go beyond it, and unite or neutralize each other as regards the excess over that limit. This neutralization is effected in two ways, in a normal or constant manner, and in an irregular and accidental manner.

This second mode is exhibited under a variety of forms; sometimes it is simply the humidity of the air, and better still, the rain or snow, which re-establish the electrical equilibrium between the earth and the atmosphere; in some cases waterspouts manifest in an energetic form the mutual action of the two electricities, which tend to unite. Sometimes the winds, by mixing the air in contact with the surface of the earth, and like it negative, with the positive air of the more elevated regions, give rise to sheet-lightning, or to storms, when there is at the same time a formation of clouds and condensation of aqueous vapours, owing to the humidity and different temperature of the strata of air which become mixed. The attraction of clouds by mountains, the luminous phenomena exhibited at the extremity of elevated points, are likewise due to the same cause. But I will not stop to discuss further all these natural and intelligible consequences of the theory which I expound. I shall confine myself to one single remark, which is, that we must bear in mind, that in observations of atmospheric electricity, the intensity of the electric signs perceived is not always a proof of the intensity of the electricity itself; for the humidity of the atmosphere, by favouring the propagation of the electricity of the upper strata, may give rise, as is frequently seen in winter, to very powerful electrical manifestations even when the cause producing them is not very powerful. The contrary is frequently seen in summer.

I now pass to the regular and normal mode of neutralization of the two electricities. I had already suspected the existence of this mode in my notice of 1836; but I did not announce it positively, because there was then wanting a fact, which science now possesses, viz., the perfect conductibility of the terrestrial globe, with which the employment of the electric telegraph has made us acquainted.

To make it understood how I conceive this mode of neutralization, I divide the atmosphere into annular strata parallel with the equator; the positive electricity accumulated at the external portion of this layer cannot exceed a certain degree of tension without traversing rarefied and more or less humid air until it reaches the polar regions, where finding an atmosphere saturated with humidity, it will combine readily with the negative electricity accumulated on the earth. We have thus the circuit formed; each annular stratum of the atmosphere gives rise to a current, which proceeds, in the elevated regions, from the upper portion of the stratum towards the pole, redescends to the earth through the atmosphere surrounding the poles, and returns by the surface of the globe from the pole to the lower part of the stratum from which it started. These currents will constantly be the more numerous, and the more concentrated, the nearer we approach the pole; and as they all proceed in the same direction, that is to say, from south to north, in the upper portion of the atmosphere, and from north to south on the surface of the earth, their effect will become the more perceptible in proportion as we leave the equator and approach the pole. But as the currents produced by the equatorial strata are individually stronger than those proceeding from more northerly strata, the difference, although real, will notwithstanding be less than would be believed. What passes in our northern hemisphere must occur in exactly the same manner in the southern hemisphere; the currents proceed equally from the equator to the pole in the upper regions of the air, and from the pole to the equator on the surface of the earth; consequently, for an observer travelling from the north pole to the south, the current would proceed in the same direction from the northern pole to the equator and in a contrary direction from the equator to the southern pole: I speak here of the current circulating on the surface of the earth. I ought, moreover, to observe that the limit which separates the regions occupied by each of these two great currents, is not the equator properly so-called, for it must be variable; it is, according to my theory, the parallel between the tropics which has the sun at its zenith; it changes consequently each day.

Now, it is easy to conceive the cause of the diurnal variations of the magnetic needle. In conformity with the laws established by Limpère, the current which proceeds from the northern pole to the equator ought to cause the north pole of the needle to deviate to the west, which is what takes place in our hemisphere; and the current which proceeds from the southern pole to the equator should cause the north pole of the needle to deviate to the east, which is precisely what occurs in the southern hemisphere. The deviation should be in one and the same place; the more considerable the greater the difference of temperature, and consequently of the electric conditions between the lower and the upper stratum of the atmosphere; thus the deviation increases from the morning to $1^h\ 30^m$ P.M. It is more considerable in those months during which the sun is longer above the horizon; it is at its minimum in the winter months. Lastly, these diurnal variations increase in magnitude in proportion as we recede from the equator and approach the pole;

a result which again perfectly agrees with what I have stated respecting the increase in number of the currents towards the polar regions. In these regions themselves, the variations may be very irregular, and may be entirely absent if the magnetic needle happens to be placed in those very localities where the electric currents traverse the atmosphere to reach the earth ; in fact, a needle surrounded thus on all sides by currents, is no longer affected by them, or at least is no longer affected in a regular manner. This remark may explain certain observations, especially those made at Port Bowen, which appeared rather exceptional.

On examining carefully all the magnetic observations I was able to consult, and in particular those of Colonel Sabine, I was especially struck by the remarkable manner in which they agreed with my theory. I will cite but one example—the observations recently made at St Helena, and just published by Colonel Sabine. At St Helena, the diurnal variation occurs to the west, as long as the sun is to the south of the island, and to the east, as soon as the sun is to the north. In fact, in the first case, as I have previously observed, St Helena must form part of the region in which the electric currents proceed on the surface of the earth from the north pole to the equatorial regions; and, in the second case, it forms part of the region in which these currents pass from the south pole to the equator. The hour of the maximum of the diurnal variation is not the same at the island of St Helena as in the continental countries, which is owing to the temperature of the surface of the ocean not following the same laws in its diurnal variations as the temperature of the surface of the earth. Now, the temperature of the lower stratum of the atmospheric column is always that of the surface of the ocean, or of the soil on which it rests. This circumstance explains certain apparent anomalies exhibited by the diurnal variations in some parts of the globe ; as for instance, at the Cape of Good Hope, which is surrounded almost on every side by a vast extent of ocean.

I wish it to be understood that in the preceding I have only taken notice of the causes disturbing the direction of the magnetic needle, and not of the cause of this direction itself; that is to say, of terrestrial magnetism—a cause which I do not at all believe to be of the same nature, but upon which I at present express no opinion. I am content to consider the terrestrial globe as a large spherical magnet, and to study the external causes capable of modifying the direction which it tends to impart, in its quality of magnet, to magnetic needles.

Now, what is the aurora borealis, according to the theory which I have just expounded ? It is the luminous effect of electric currents travelling in the high regions of the atmosphere towards the north pole, an effect due to the combination of certain conditions which are not always exhibited in the same manner, nor at all seasons of the year.

It is now well proved that the aurora borealis is an atmospheric phenomenon, as we long ago suspected. The name of *magnetic storm*, by which Von Humboldt designates it in his *Cosmos*, implies the same idea, which is moreover confirmed by the interesting details which he gives of this meteor. The observations of Parry, Franklin, and especially those of MM. Bravais and Lottin, so numerous and carefully made, are likewise quite favourable to this opinion, which followed equally from the observations of M. Biot at the Shetland Isles.

Admitting this point, I explain the production of the aurora borealis in the following manner:—When the sun having passed into the northern hemisphere, no longer heats so much our hemisphere, the aqueous vapours which have accumulated during the summer in this part of the atmosphere begin to condense; the kind of humid cap enveloping the polar regions extends more and more, and facilitates the passage of the electricity accumulated in the upper portions of the air. But in these elevated regions and especially at this period of the year, the aqueous vapours must most frequently pass into the state of minute particles of ice or snow floating in the air, similar to those which give rise to the halos; they form, as it were, a kind of semi-transparent mist. Now these half-frozen fogs conduct the electricity to the surface of the earth near the pole, and are at the same time illumined by these currents or electric discharges. In fact, all observers agree in asserting that the aurora borealis is constantly preceded by a mist which rises from the pole, and the margins of which, less dense than the remainder, are coloured the first; and indeed it is very frequent near the pole in the winter months, and especially in those where there is abundance of vapour in the air. For it to be visible at great distances from the pole, it is necessary that these clouds, composed of frozen particles, extend in an almost uninterrupted manner from the polar regions to somewhat southern latitudes, which must be of rare occurrence. These same clouds, when they are partial, which is frequently the case, produce the halos.

Now the analogy pointed out by nearly all observers between the mists which accompany the aurora borealis and those which produce the halos, is a somewhat remarkable circumstance. It is easy to verify by direct experiment the identity which exists between the light of the aurora borealis, and that obtained by passing a series of electric discharges into rarified air containing a large quantity of aqueous vapour, and especially through a very thin layer of snow, or a slight layer of hoar-frost deposited on the glass. I have ascertained that highly rarefied, but perfectly dry air, gives but a very faint light, and that in the experiment of the vacuum tube it is essentially the moisture adhering to the inner sides of the tube, which, by conducting the electric discharges, gives rise to the luminous effects. It will be conceived that the electric discharges transmitted by this kind of network of ice must, on becoming concentrated near the pole, produce there a far more brilliant light than they develop when they are distributed over a much greater extent.

But why does the magnetic pole, and not the terrestrial pole, appear to be the cause of the phenomenon? Here is my answer. Place the pole of a powerful electro-magnet beneath a large surface of mercury; let this surface communicate with the negative pole of a powerful battery; bring near to it the point of a piece of charcoal communicating with the positive pole of the battery; immediately the voltaic arc is formed, and the mercury is seen to become agitated above the electro-magnet; and wherever this is placed, luminous currents are observed to rotate around this pole, and throw out from time to time some very brilliant rays. There is always, as in the case of the aurora borealis, a dark portion in the form of a circular point over the pole of the magnet: this peculiar effect disappears without the voltaic light being interrupted when the electro-magnet ceases to be magnetised. With a continuous current of ordinary electricity arriving at the pole of a powerful electro-magnet in rarefied and moist air, luminous effects, still more similar in appearance to those of the aurora borealis, are obtained.

These phenomena result from the action of magnets on currents: now the same should apply to the action of the magnetic pole of the earth; the neutralisation of the two electricities probably takes place over a somewhat large extent of the polar regions; but the action of the magnetic pole causes the conducting mists to rotate around it, sending forth those brilliant rays which, by an effect of perspective, appear to us to form the corona of the aurora. The sulphureous odour, and the noise which is said sometimes to accompany the appearance of the aurora, would not be inexplicable; for the odour would be due, like that which accompanies lightning, to that modification which the passage of electric discharges produces upon the oxygen of the air, which M. Schonbein has called ozone; while, as regards the noise, it would be analogous to that which, as I have shewn, the voltaic arc produces when it is under the influence of a very near magnet. If it seldom occurs in the case of the aurora, it is owing to its being very rare that the luminous arch is sufficiently near the earth, and consequently to the pole. However, the description which has been given of this noise by those who have heard it, is perfectly identical with that which I have given, without suspecting the analogy, of the noise which the voltaic arc produces in the action of the magnetism.

The magnetic disturbances which always accompany the appearance of an aurora borealis are now easily explained. This accidental union of a greater proportion of the accumulated electricities must derange the normal action of the regular current; with respect to the directions of the disturbance, it will depend on the portion of the current acting upon the needle, and consequently upon circumstances impossible to foresee, since they depend on the extent of the phenomenon, and the position of the needle in relation to it. In fact, according as the horizontal plane in which the declination needle moves, comprises above or below some of the region in which the greatest activity of the phenomenon takes place, it will be either the current circulating on the earth, or that travelling in the air (currents which proceed in a contrary direction), which will act upon the needle: even during the same aurora, it may be sometimes one, sometimes the other of these two currents which will act. The variable directions in which the needle is deflected during an aurora borealis agree very well with this explanation, at least as far as I have been able to judge from the different observations published in the *Annales de Chimie et de Physique*, and in several scientific voyages. The remarkable effect observed by M. Matteucci in the apparatus of the electric telegraph between Ravenna and Pisa during the magnificent aurora of the 17th of last November, fully proves the existence of a current circulating on the surface of the earth, and which, ascending the wire of the telegraph, passed in part through this better conductor. The sounds which long iron wires, strung in the direction of north to south, give out under certain meteorological circumstances, are undoubtedly a proof that they are traversed by a current which is probably derived from the currents circulating on the surface of the earth from north to south in our hemisphere.

It would be highly interesting and important to profit by those telegraphic wires, which are found to have a direction more or less approaching to that of the declination needle, in order to make with them, when they are not in use for ordinary purposes, some observations which would enable us to demonstrate and to measure the electric currents which probably traverse them; it would be easily accomplished by means of a multiplying galvanometer, by completing the communication of these wires with the earth at one of their extremities. The comparison of the results obtained in this manner with these furnished by the simultaneous observation of the diurnal variations of the needle, would certainly present considerable interest, and might lead to meteorological results of a remarkable nature.

I cannot conclude this abstract without drawing attention to the circumstance, that M. Arago had already pointed out in 1820, shortly after Œrsted's discovery, the possibility of acting upon the voltaic arc by this magnet, and the analogy which might result between this phenomenon and that of the aurora borealis.

Meteorological Phenomena in connection with the Climate of Berlin. Translated by Mrs Anne Ramsden Bennett from the German of Professor Dove.

Attention has generally been awakened to atmospherical appearances, where the usual course of nature has been intercepted by striking meteorological phenomena. The cloudless serenity of a tropical sky, and the regular recurrence of periodical changes, attract little observation. The interest which meteorology excites is much more directly associated with uncertainty of weather. It would scarcely occur to any one here to begin a conversation with the remark, that the sun had really set at its appointed time; and as little would it occur to any one in tropical climates to make the weather a subject of conversation. It is for this reason we possess so few meteorological observations on more favoured climates. How, indeed, could it be expected any one should note down changes which regularly take place at certain periodical times. He alone feels prompted to such a course who finds himself transported out of the variable conditions of one atmospherical life into the untroubled regularity which distinguishes tropical regions; and which appears to him in such striking contrast with the weather to which he has been accustomed, that he requires the confirmation afforded by meteorological instruments before he can trust the immediate evidence of his senses. For this reason we so often acquire a more accurate knowledge of the peculiarities of a climate from travellers resident in it for only a short time, than we do from the partial accounts given us by its inhabitants. The only disadvantage which results from this is, that the lively imagination of strangers makes the contrasts appear too striking; thus dwellers in the north see everything in the south through a rose-coloured medium; and in like manner, we rarely forget, when reading Tacitus's description of Germany, that it is an Italian who is speaking of our native land.

The uniformity which distinguishes tropical climates is denied to our latitudes. Europe has been called the April climate of the world; but this description applies in general only to those parts of it which, without being washed by the sea, are still not sufficiently distant from it to be entirely free from its influence. Where this is not the case, the temperature degenerates into sharp contrasts, and a glowing summer succeeds to an icy winter; but when the influence of the sea preponderates, both seasons of the year lose their more marked characteristics. In Italy and the Canary Islands finer grapes are not to be found than grow in Astrachan, and yet in order to protect these vines from the frosts during winter, they are sunk deep into the earth; for even south of Astrachan, at Kitzlar, near the mouth of the Terek, the temperature in winter sinks as low as 36° Fahr. The difference between both extremes is so great, that on the steppes of Orenburg, the camel, the ship of the desert, and the reindeer, the agile inhabitant of the mossy plains of Siberia, meet together. It is quite otherwise in England. In Ireland, which is situated in the same latitude as Koningsberg, the myrtle flourishes equally well as in Portugal; it scarcely freezes in winter, and yet its climate will not ripen grapes. On the coast of the Lake of Killarney the arbutus grows wild; in the island of Guernsey hortensias bloom in the open air; and laurels grow in Cornwall, in the same latitude as Prague and Dresden. England is indebted to this equal distribution of a warm, moist temperature, for the soft verdure of her meadows, and the clear complexions of her population. "Oh ye blooming youthful cheeks," exclaims Moritz; "ye green meadows and ye clear streams of this happy land, how have ye enchanted my heart! Oh Richmond! Richmond! never shall I forget the evening, when, full of ecstasy, I rambled up and down on the flowery banks of the Thames. But all these delights shall not hinder me from returning again to those barren, sand-bestrewed fields, where my destiny has decreed that the little sphere of my active life should be situated." My readers will readily perceive, by the patriotic feeling which will have found its way into their breasts whilst listening to the closing words of Moritz, that he spoke of Berlin. If, however, I confess that the study of meteorology offers peculiar difficulties here, because, in addition to the constituent parts of the atmosphere, sand enters so largely as to form an essential ingredient, and to stand a chance of becoming a meteor, I still assert, that it does not appear to me difficult to take delight in the ever-varying aspect of our skies, when we recal to mind the rigid countenance of their eastern, and the melancholy severity of their western neighbours. Our atmosphere is certainly often obscured, but never to such a degree as in the dense fogs of London, in whose streets boys went about with flaming torches on the 24th May 1838, in order, as they said, to honour the Queen's birth-day with a brilliant illumination. Certainly it often rains with us, but never in such a way as is described in the burden of the song in "*What you will.*"

> "With heigh ho! for the wind and the rain,
> For the rain it raineth every day."

Although Shakespere lays the scene of his play in Illyria, we see at once by these words, that the fool who sings them is a true English fool, who had received his youthful impressions in a country where, in reply to the impatient inquiry of the traveller, "Does it always rain in Bristol?" the satisfactory answer was given. "No! it snows between-whiles." What a continual succession of sunshine and rain, on the contrary, with us! What frequent returns of cold after the warmth seems to have set in! As our poet says:—

> "The sunshine beguiles
> With its mild, false smiles,
> And even the swallow lies,
> For alone he hither flies."

But with this circumstance there is a question connected, which affects us closely. It is this, Can we hope to discover a stationary point amidst this eternal change? Is there, in the closely-associated chain of causes and effects, any prospect of our being able to distinguish between the settled and the variable? Our older meteorologists thought so; for they described the temperature of a place by giving the highest degree of its observed warmth and cold. They were of the opinion that nature does not lawlessly deviate from certain rules, and that she remains conscientiously between the two extremes which limit her regularity. And they were right; for at a moderate depth below the surface of the earth we find that invariable degree of warmth which we fix upon as the mean temperature of the place of observation. Thus, at the depth of 30 inches, there is no difference between day and night; at 30 to 35 feet the difference between summer and winter disappears. So slowly, indeed, does the warmth of the atmosphere penetrate into the soil, that at the depth of 3 feet the warmest day is the 22d of August; at 6 feet, the 30th of August; at 12 feet, the 9th of October; and at 24 feet, the 15th of December, whilst at that depth the greatest cold falls here on the 13th of June. Springs which rise from this depth preserve the same temperature all the year through; thus the one on the road from Potsdam to Templin stands at 50° F. the same as that of the Lomsenbrunnen at Berlin. How surprised the skater must be, when he finds the places where the springs rise in the ponds are not frozen over in winter, though they are the very spots which he had avoided in summer, whilst bathing, on account of their cold. So little power has the stratum in which the life of the earth pulsates in higher latitudes, that the ground which still bears on its surface woods of pine and fir trees, is, even during the summer, frozen so hard at a very moderate depth, that in the year 1821 on Menzikoff's grave being opened at Beresoff, the lines of sorrow might still be traced on the features of the banished exile, whose heart had ceased to beat for more than a century.

If we can imagine this variable stratum removed from the earth, we should obtain on the new surface the simple representation of a climate of mean temperature; of that temperature which every place would shew if its thermometer stood always at the same height. In this way we should find that in Berlin it would stand every day at 48°·875 Fahr. that in Hindostan there are places where the mean temperature would be 81°·5 Fahr.; that Parry, on the contrary, would fix his winter quarters in a place where the mean temperature would sink to — 2° Fahr., or 34° below the freezing point. This variation, however, does not entirely depend on distances from the pole, for places situated in the same degree of latitude are much warmer on the western than on eastern coasts. Scotland, Denmark, and Poland, have climates of equal warmth. Ireland, England, Belgium, and Hungary, enjoy the mean temperature which would characterise a Naples lying on the east coast of Asia. In America we find the climate of Naples in the latitude of Morocco. Canada, which lies south of Paris, has the temperature of Drontheim in Norway. Height above the level of the sea occasions a diminution in the temperature, and therefore Germany has in general a very equal temperature; the greater height of the land in southern Germany compensating for the difference of latitude. Munich and Berlin shew a remarkable harmony in the barren uniformity of the country which surrounds them, as well as in the mean temperature which, without any detriment to either, might be somewhat higher.

But results such as these are not the final ones which we have to seek. They may indeed suffice for Troglodytes who live in cellars and caves, but not for us who breathe the pure fresh air. We must find some means of getting back from this abstract uniformity to the animated reality of atmospherical phenomena. We only arrive at it, however, when we have attained to the consciousness, that in what is apparently arbitrary, a law is concealed; that the language in which nature herself speaks to us though the thunder and the lightning is a reasonable one; and that even the flaming flash of the lightning with which she writes in the night-season is capable of interpretation.

We live on the bed of a sea whose waves roll over our heads without our being able to rise above their surface. This aërial ocean was named by the Greeks the atmosphere; that is to say, a globe of moisture. Whilst our perceptions take in all its constitutent elements, the Greeks thought of that one alone, the deficency of which destroys all animal and vegetable life, and whose enlivening influence the Bedouin Arab recognises when he reaches the edge of the desert, and though still far from the stream, perceives the air becoming moist, and stretching out his hands towards it exclaims with joy, "I taste the Nile."

Steam has become of such essential importance to our life, that I ought to presuppose every one to be acquainted with this miraculous child of dissimilar parents,—this son of water and of fire. But of those who so often use the word steam-engine how few there are who really think of the oldest of them all, the atmosphere. All the water which either falls in soft spring showers, or rushes down in storms, has been raised by the atmosphere in the form of steam generated by heat. The mill which is driven by the mountain stream is also a steam-mill, only that the sun kindly undertakes to produce the heat which continually guides anew the circulation of the water. The steam of water is a perfectly transparent elastic fluid; clouds, mists, and vapours, are not steam, but condensed moisture, which has returned from the aërial into the liquid form. If we observe a locomotive, when conscious of its power it raises the valve, and contemptuously casts off the superfluity, with which electro-magnetism might win its promised prize; at the place where the steam issues forth it is perfectly transparent, the white cloud only appears when it has risen to some little height. Air mixed with this transparent steam is called a moist air, air mixed with condensed steam is termed a cloudy atmosphere. Both may be distinguished from each other, just as our breath in a warm room is distinguished from the clouds which form *before* our mouths in winter, but which we do not exhale *as* clouds. Water mixed with spirits of wine produces a transparent mixture, because both are fluids. Air, however, mixed with opaque solid or fluid bodies, produces an opaque mixture which becomes more opaque in proportion as the mixture is more entire. Thus snow may be formed out of comminuted ice; white sand out of pounded rock-crystal; foam, mist, vapour, or whatever we like to call it, out of water. We look upon clouds habitually as on something really existing, as a kind of magazine in which rain, snow, and hail, are stored up ; bodies which, when they come into contact with one another, produce thunder; which are attracted by mountains and torn asunder by their rocky teeth, when out of the breach thus formed water streams forth ; and what is most remarkable of all, we think of these clouds as floating with all their heavy contents in the air. If, however, we only get amongst the clouds on the top of a mountain we find that they consist of nothing but common mist, and that of all the magnificence we had attributed to them not a trace remains. We might have spared ourselves the trouble of ascending so high to discover this, for a cloud is nothing more than a mist above, and a mist is nothing more than a cloud below. Any one that has been accustomed to think of a cloud as of something tangible and lasting, of which he can take a photography ; or, if he has the talent for it, make out in it resemblances to the forms of men and animals, must be aware how often he is obliged to change his comparison. It may be said, however, that we often see a cloud lying all day long on the top of a mountain. Does not Mount Pilate take his name from the very circumstance that he alway wears a cap ? Is not the Table Mountain at the Cape celebrated for it ? Who, however, that sees the white foam lying on a clear mountain stream, looked down upon from a hill, believes it to be anything lying on the ground ? And is the cloud lying on the top of a mountain, anything more than this? The stream is the air, the stone on which the foam rests is the mountain, the foam is the cloud. Does it not move continually if we ascend the mountain in order to see if it really lies quietly upon it, as it seems to do when we look up at it from below? The appearance of stability is therefore nothing but a delusion, the cloud endures only whilst arising, and in the act of vanishing. Do we find the plains of Lombardy covered with the clouds which are attracted down from the St Gothard in quick succession into the valley of Trevola ? No ! they have entirely disappeared from the hot plains, and the cloudless heaven above them forms a strange contrast to the thick covering which, whenever we look back, conceals the Alps from our view. Do we not often see a storm, which, with the intention of raining in good earnest, comes down from the Charlotten Berg, entirely dissipated when it arrives over the glowing city. If, on the contrary, the atmosphere is very moist, already the absorption does not take place —a long strip of cloud leans down from the top of the mountain, where its first germ had formed itself, and the rain pours down. If the air has lost its absorbing power, it will soon become saturated with water. This is what takes place before a shower, and it is for this reason they say in the Bernese Oberland,

> "Does the Riesen his rapier wear?
> Then it shews that rain is near;
> Is his cap upon his head?
> Then that shews the rain has fled."

But these rules are only applicable to mountains whose points rise boldly into the higher regions of the air, not to lesser heights on our own German plains. If the moisture be already great enough for it to take the form of clouds, then it will soon shew itself in the shape of rain, and therefore they say in Thuringia of the Kyffhauser,

> "Has Frederick cast his crown away,
> The weather will be fine to-day;
> If on his head his crown is set,
> The weather soon will change to wet."

"The mountains are heaving, the Bohemian mists are coming; it will rain," they say in the Hazy Mountains. "The Zoblen is clear; it will continue fine weather," they say in Silesia: and in England the proverb is,

> "When the clouds are on the hills,
> They will come down by the rills."

In winter, clouds often conceal the dome of the Gensd'armes Tower; in summer storms pass over the dark Aachorn, the Jungfrau, and Mont Blanc. But what a difference there is between the fine drops of winter rain, and the large splashes of a summer shower. If, however, we ascend a mountain during this splashing rain, we shall find that the higher we ascend the smaller the drops become; higher still we shall find only a mist; at that height it is no more the cloud which rains, but the whole stratum of air between the cloud and the ground. This is so true, that upon the roof of the King's castle in this place, only 18 inches of rain fall annually, whilst 20 inches fall on the pavement of the castle-yard; for a continually renewed condensation of the mist of water takes place, and meeting with the rain drops in their descent, makes them continually increase in size. This applies equally to snow and hail, which do not therefore produce the destruction which we should expect from the size of the grains if they fell down from a considerable height. If a crow, for example, were to slip down the steep roof of a church at the beginning of a thaw, the descending snowball would become at last a little avalanche. But did the crow cast it down; those must believe so who ascribe the rain to clouds alone.

But how do clouds of snow and rain originate over our plains, which are situated far from the cooling summits of the mountains?

A celebrated amateur gathered together a large assembly in the council-hall of a northern residence. It was one of those icy star-bright nights which are so aptly called iron nights in Sweden. In the saloon, however, there was a fearful crowd, and the heat was so great that several ladies fainted in consequence. An officer tried to end this distressing state of things by attempting to open a window. But it was impossible, so fast it was frozen to the window cill. Like a second Alexander he cut the Gordian knot by breaking a pane of glass, and now, what happened? It snowed in the room. Circumstances so favourable as these seldom present themselves for observation here. But I have, even in Berlin, seen a thick mist, form itself at a private ball, when, on one occasion, the doors opening upon the balcony were thrown open for a moment. Thus, wherever warm air becomes mixed with cold and moist air, a precipitation takes place. This is the reason why an eternal mist overclouds the sea of Okotsk, where the warmth so sensibly declines towards the north, that, on the same neck of land, shapeless sea-horses, the inhabitants of the polar seas, and elegant certhiadæ, the feathered messengers of the south, meet together. It is the same phenomena on a smaller scale which one sees at St Petersburg, at the magnificent festivals given in the winter palace, when a continual condensation is always taking place in the outer apartments. In order, therefore, to understand our weather, we must seek out the principles on which such mixture of unequally warmed air takes place; but to do this I must somewhat enlarge, whilst choosing for my guides two of the learned men of the present day, about whom geology, geography, and meteorology dispute as their heroes, each of the three sciences wishing to claim the two philosophers for itself.

If we open a door leading from an outer passage into a warm room, a double draught of air takes place, the cold air streaming in below, and the warm air flowing out above. This may easily be proved by the flame of a candle. Placed on the ground it is wafted towards the room, held half-way up it stands upright, above it is wafted towards the outer air. On the earth the polar regions represent the outer passage, and the torrid zone represents the warm chamber. There are two cold zones and one torrid, that is to say, a warm room between two cold passages, the doors between the two are always open, the room is always heated to a very high temperature, and there is a constant draught of air, which is called the "trade-winds." Where both currents of air meet, is a region of calms, and it is so named. As, however, the apparent course of the sun varies between the tropics, the region of calms does not always remain in the same place, but follows the sun, and the whole phenomena of trade-winds follow in its train. Where the trade-winds prevail, the sky is perfectly cloudless, because flowing towards warmer regions, the air naturally becomes drier; in the region of calms, on the contrary, it rains constantly, because the lower warm currents in the act of rising lose some of their heats and therefore allow the moisture they contain to be precipitated. Every place between the tropics has therefore a dry season whilst under the influence of the trade-winds, and a rainy season while the calms prevail,—" a time of sun and a time of cloud," as the Indians near the Orinoco say. In the higher regions of the atmosphere, the ascending air flows back towards the poles. We see it often in the light clouds which are attracted towards the lower trade-winds; yes, we even reach this upper opposing current when we ascend high mountains, such as the Peak of Teneriffe, on Mawnaroa, on the island of Hawaia. More strongly still is the influence of this returning upper current seen in volcanic eruptions.

(*To be continued in our next Number.*)

Gieseckite and Bergmannite (Spreustein), two Pseudomorphoses of Transformation from Nepheline. By Professor J. R. Blum, of Heidelberg. Communicated by the Author, from Poggendorff.

At Jyalikko-Fiord, not far from Julianenhaab in Greenland, there occurs, implanted in drift porphyry, a mineral in the form of hexagonal prisms, generally known by the name of Gieseckite. From the similarity of its form, and for the most part amorphous condition of its mass, it was formerly regarded as a variety of Pinite, with which its chemical composition to a considerable extent coincides. It was afterwards grouped by Tamnau with Elæolite (Nepheline), with which it has the same crystalline form, and is said to be, in its fresh condition, as regards hardness, specific gravity, and lustre, identical. But most of the crystals are found in an altered condition, and coincide neither with the qualities just mentioned, nor with the chemical composition of the Elæolite. The cause of this is to be sought in the alteration which the Elæolite has undergone. A short time since there came into my possession a crystal of this sort, which, upon my breaking off a small portion at one end, in order to observe the nature of its interior, was seen to consist entirely of a fine scaly aggregate of very minute micaceous lamellæ. Thus Giesecke is neither more nor less than Elæolite in process of transformation into mica, at one stage of which a condition resembling Pinite, I believe, occurs very frequently. The final result of the transformation is here likewise mica; and with this view both the chemical composition of the mineral, and the mode in which it is affected by the blowpipe and by acids, closely coincide. Whilst the Elæolite fuses before the blowpipe, and under the action of acids dissolves and forms gelatine, Gieseckite is but slightly affected by the latter, and is likewise more difficult of fusion. If we compare the results of analysis,—that of the green Elæolite of Fredericksvärn by Scheerer (*a*), with that of Gieseckite by Stromeyer (*b*),—the process of alteration becomes very apparent. Their constituents are:—

(*a*)			(*b*)
Silicic acid,	45·31		46·0798
Alumine,	32·63		33·8280
Natron,	15·95		0·0000
Potash,	5·45		6·2007
Oxide of iron,	0·45	Protoxide of iron,	3·3587
Chalk,	0·33	Magnesia,	1·2031
Water,	0·60		4·8860
	100·76	Oxide of manganese,	1·1556
			96·7119

According to these analyses, there must have been a loss of natron and an absorption of protoxide of iron and water, together with a small quantity of magnesia and oxide of manganese.

Under the name of Bergmannite or Spreustein, there has long been known a mineral which has been regarded by some mineralogists as a distinct species, and by others as a variety of Wernerite. It is not unfrequently found as a secondary constituent of zircon syenite in Norway, especially in the environs of Brevig, Laurvig, and Fredericksvärn. Scheerer, to whom the external appearance of the Spreustein seemed to indicate that it was *not* a variety of Wernerite, subjected it to an analysis of which the results are given (*Annalen,* vol. lxv., p. 277–8,) and according to which it is a normal natronite (natron-mesotyp.)

I lately received several pseudomorphoses from Dr Krantz of Bonn, amongst which was a specimen labelled "Spreustein nach Beryll und Scapolith von Breveg." I could recognise no scapolitic form in the prismatic crystals of the spreustein, whilst, as hexagonal prisms, they appeared identical with the forms of beryl. But as the occurrence of beryl in the zircon syenites of Norway is very far from ascertained; and as Scheerer (*op. cit.* p. 280) expressly observes that all which he had met with belonged to the apatite; and as, moreover, the origination of spreustein from this mineral appeared to me exceedingly doubtful, I carefully examined the specimens of this substance in my own collection, in hopes that I might perhaps obtain some solution of my doubts. It was not long before I observed in a piece of ore a small hexagonal prism, which superficially had the appearance of spreustein; but at the end, where a portion was broken off, was perceived to be Elæolite; and eleolite accordingly it was, from which the other mineral had borrowed its form. But in order to attain greater certainty upon this point, I imparted my views to Dr Krantz, with a request that he would be good enough again to look through his own specimens, and acquaint me with the result of his observations. The following is an extract from Dr Krantz's answer:—"I have again examined my small collection of pseudomorphous Spreusteins, and have come to the precise conclusion you anticipated, namely, that the hexagonal prisms were formerly not beryl but nepheline (Elæolite). The small prism which you will herewith receive, and which is adherent to unaltered felspar (Orthoklas), with which it has nothing in common, consists, at the unaltered-looking greenish end, upon trial with the blowpipe, entirely of mesotype; there is, therefore, nothing more of the original mineral remaining. The other and larger prism still contains at one end pure white nepheline, but farther in the interior Elæolite. It is remarkable that the nepheline appears here of such a pure white colour as it has never been found with anywhere in Norway. The specimen establishes, I think, in a very satisfactory manner, that the pseudomorphoses were formerly Nepheline. Spreustein from Wernerite I have never met with."

The alteration in these two cases commenced at the surface of the crystals, spreading from thence to the interior; and this process may be observed in various individuals, which are found in its most various stages. Whilst the above-mentioned small crystal is changed into spreustein merely at its surface, the large one mentioned by Dr Krantz (which is about 1½ in. long by 1 in. in thickness, and is broken off at both ends) consists at one end entirely of an aggregate of red and white spreustein, but at the other still contains a nucleus of nepheline, surrounded by a crust of whitish-red spreustein of from one to two lines in thickness; and other crystals, again, are entirely changed into the latter substance. Even crystalline particles of Elæolite have undergone this change. The surrounding felspar (orthoklas) is for most part perfectly fresh, merely exhibiting here and there, at its points of contact with the Spreustein, a slight red colour, arising from oxide of iron, which has interpenetrated its cleavage surfaces. The process of transmutation itself consists in a loss of potash, in the emission of a small quantity of natron and alumine, and the absorption of water, whereby $(\dot{N}a, \dot{K}a)^2\ \dddot{Si} + 2\dddot{Al}\ \dddot{Si}$ becomes $\dot{N}a\ \dddot{Si} + \dddot{Al}\ \dddot{Si} + 2\dot{H}$. And this process occurred in a rock, which—although water was the agent—presents a perfectly fresh character. Nor will it ever occur to any one that the natrolite was here an original formation, or that the water was originally present; for the pseudomorphous nature of the spreustein crystals is too plain to be called in question. They are not genuine crystals; for they consist of a mass of which the composition is confusedly radiated, (whence the name *Spreustein* given them by Werner)—of an aggregate, which sometimes even includes a nucleus of the original mineral. But if it must be admitted to be a transformation, then it is a transformation that can have been effected only by means of water which has penetrated into the mineral, extracted and removed constituents of the Nepheline, partly deposited itself in their room, and formed mesotype; for the phenomenon cannot be explained by assuming either intense pressure or the original presence of water in the mineral. We have here also a beautiful example of the manner in which water, operating upon inorganic bodies, calls into existence new crystalline forms; and we may perceive what a misapprehension it would be of this process, which plays such an important part in the formation of pseudomorphoses, were we to limit it to the originating of kaolins, clays, and other "mineral mires." Moreover, it would seem as if the Elæolite itself were nepheline in process of transformation; at least this would appear to be indicated by the fluctuating amount of water which the mineral contains. Scheerer has observed of the green and brown Elæolites of Fredericksvärn, that when these are finely pulverised and decomposed with concentrated muriatic acid, the resulting siliceous earth possesses the same colour, though in a fainter degree, which the mineral possessed before, and that it disappears only on its being dissolved in nitric acid, or by being brought to a glow; whereupon he remarks: "This is quite sufficient to prove that the colour is of organic origin."—(*Pogg. Ann.*, v. 49, p. 380.) But how can this organic colouring matter have found its way into the mineral unless by means of water? Sure enough it was not there originally.—(*Poggendorff's Annalen.*, bd. 87, st. 2, 1852, No. 10.)

On the Colours of a Jet of Steam and of the Atmosphere. By R. Clausius.

To the Editors of the Philosophical Magazine and Journal.

Gentlemen,—In the August Number of the Philosophical Magazine (p. 128) Mr Reuben Phillips describes a series of interesting experiments on the colours of a jet of steam, which connect themselves with the known experiments of Professor Forbes upon the same subject. At the end of his paper Mr Phillips writes—

"Professor Forbes, after discovering the red colour of a jet of steam, by transmitted light, connected the red colour of the clouds with this fact; and the truth of this connection is beyond dispute. So far, however, as I have been able to go, the colours of the steam-jet are manifestly only influences of ordinary interference, greatly resembling that produced by thin transparent plates. Thus in (192) the transmitted light is red, as in Professor Forbes's experiments, but the reflected light is blue. It is therefore to be inferred, that all the colours of the clouds originate in interference, caused by minute drops of water, the size of which determines their colour; while the blue jet (192) is, I think, strictly analogous to the blue sky."

With reference to this passage I permit myself to make the following remarks:—The blue colour of the firmament and the morning and evening red were explained by me in 1849* upon the principles of "ordinary interference;" and some time afterwards† I applied the same explanation to the colours of a jet of steam observed by Professor Forbes.

In one point, however, my view diverges from that of Mr Reuben Phillips. He names the water-particles which cause the interference "*drops* of water," while I believe that they are water-*bladders*, for which view I have adduced my reasons in a separate paper.‡

Besides this, I should like to mention two points, with regard to which I have been unable to obtain from the paper of Mr Phillips a clear notion of the author's opinion.

(1.) Among the various colours of the atmosphere there appears to me to exist only two simple originating ones; namely, the *blue* colour in all its shades, from dark blue to white, due to interference by *reflection;* and *orange-red* colour in the corresponding shades, due to interference by *transmission.* The other colours exhibited at times in various portions of the heavens, as, for example, purple or green, I hold to be due to the mixing of the above two colours in their different shades.

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* Poggendorff's *Annalen*, vol. lxxvi., p. 188.

† *Die Licht Erscheinungen der Atmosphäre,* described and explained by R. Clausius. Leipzig, E. B. Schwickert, 1850. Also under the title *Beiträge zur Meteorologische Optik,* published by John Aug. Grunert. Part 1, No. 4, p. 395, and in Pogg. *Ann.*, vol. lxxxiv., p. 449.

‡ Pogg. *Ann.*, vol. lxxvi., p. 161.

(2.) When clouds appear coloured, I believe that the colour exhibited is for the most part not formed in the cloud itself, inasmuch as the little bladders generally differ too much in thickness to cause the production of a single determinate colour; but that the light, partly on its way to the cloud, and partly between the cloud and our eye, assumes its colour; even in the apparently clear air there always exist bladders, which, however, are for the most part so attenuated, that they favour in a particular manner the formation of the *first* colours of interference, namely blue and orange-red.—I remain, Gentlemen, very respectfully yours,

R. CLAUSIUS.

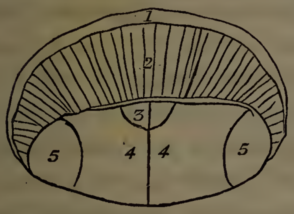
BERLIN, *Oct.* 13, 1852.

Description of the Tongue and Habits of the Aardvark or Ant-eater of the Cape (Orycteropus Capensis). By WILLIAM T. BLACK, Assistant-Surgeon to the Forces, South Africa. Communicated by the Author.

In Professor Jones' General Outline of the Animal Kingdom, is to be found a description of the elongated tongue of the Ant-eaters of South America, and the Echidna of New Holland. The Aardvark (the Earth-hog, Dutch) and these two animals, belong to the order of Edentata, but the last is further distinguished by being monotrematous. Whether Professor Jones' description is intended to refer to the tongues of all the animals in that order that possess them as instruments of prehension does not appear, and it may be correct; but from two or three specimens of the organ dissected by me in the Aardvark, I am led to doubt its applicability to this animal. Professor Jones speaks of two proper muscles not found in the tongues of other mammalia, an external annular one, and an internal elongated spiral one, invested by the former. These I have been unable to detect in the tongue of the Cape Ant-eater, and I subjoin the following description of my acquaintance with its lingual anatomy:—

The tongue is from 10 to 12 inches long, when stretched out. The mucous membrane of its upper surface is rough and of a file-like feeling, when the finger is passed backwards along it. There are three papillæ near the base, situated in the form of a triangle. On the outside, at about the posterior half, are the conjoined *palato* and *stylo-glossus* muscles, and internally to them, the *lingualis*, running from the base to the tip of the tongue; and at the posterior fourth in the mesial line is the lingual attachment of the *mylo-hyoglossus muscle.* The lingual *sensory nerve* is very large, and lies in a groove between the mylo-hyoglossus and the lingualis, and after passing the former, the two nerves lie side by side in the mesial line between the two linguals. The muscular nerves branch off; the fifth enters the mylo-hyoglossus, gives branches to it, and then passes forwards alongside the lingual nerve.

The muscle to which I would attribute the protruding action of the tongue, or the *Extensor lingua*, consists of perpendicular fibres passing from the thick mucous membrane of the upper surface and sides, to the cellular tissue investing the linguales muscles; this occurs throughout the whole length of the tongue, and engrosses more and more of the comparative thickness of the tongue towards the point from the base. The best way of demonstrating the course of its fibres, which are otherwise visible enough, is to incise the tongue either transversely or longitudinally, just through the thickness of the mucous membrane, and then tear open the incision. The laceration is easy, and goes in the direction of the fibres to their attachment at the upper surface of the lingualis. The contraction of this muscle, in all its body, will produce a contraction of the diameter or thickness of the tongue, and at the same time, from the consequent increase of the diameters of the separate muscular fasciculi, must the tongue elongate. It may be otherwise stated, if the mass of the tongue is decreased in



1. The mucous coat.
2. The perpendicular fibres.
3. Nerves and vessels.
4. Linguales and genio-hyoid.
5. The palato-glossus.

one direction, it must correspondingly increase in another—like a bladder nearly full of water, which elongates in the direction lateral to the points of pressure.

Should the mesial fibres of this perpendicular or transverse muscle be thrown into action, then the upper surface of the tongue would become flattened or hollowed out. The retraction of the tongue is of course accomplished by the lingualis, and the other motions of the organ by the other muscles as ordinarily shewn. This action of the perpendicular fibres also renders the tongue, when projected at the same time, somewhat elastic and firmer, so as to allow of the stronger action of the others in bending it in different directions; one or the other lingualis laterally, or both downwards, when the lower fibres of this muscle are thrown into action; and when the upper fibres are in a similar state, the point of the tongue would be directed upwards. What share the muscles of the base of the organ particularly have in its motions, I do not enter upon, merely having considered the actions of the free part of the tongue.

On section of the upper surface of the mucous membrane between the muscular fasciculi, appear yellow oblong ovoid bodies, about a line in length each, probably mucous glands, or, as I had not means of deciding this point, may be particles of fat, though not likely, as they only occur among the muscular fasciculi at the upper surface, and not at the lower extremities of the fasciculi. When the perpendicular or radiating fibres are in action, the secretions from these glands would evidently be expressed out upon the surface of the tongue, thereby supplying the adhesive fluid which is the means employed by the ant-eater for the capture and retention of its insect food. The specimen of the animal which I procured for the above dissection, was a female, had four teats, and was 6 feet 2 inches in length from the nose to the end of the tail.

The next one which I dissected afforded the following description:—The *mylo-hyoid* muscle, or flat muscle next the skin;—*Genio-hyoid* of two bands, on each side of the mesial line between the chin and hyoid-bone;—*Genio-hyoglossus* between the chin hyoid-bone and tongue, the lingual fibres radiating upwards to the tongue; the latter part is broader behind where it is attached to the root of the tongue, and terminates, conically forwards, to about the middle of its length;—*Palato-glossus*, a large flat band on each side of the former, and, together with the lingualis, forms the lateral and inferior muscular of the tongue, from the root to the tip;—*Stylo-glossus*, a small band of fibres, descending from the styloid process, perpendicularly to the root of the tongue, where it comes again forward on the outside, and parallel to the former muscle, and is finally lost at about one-third from the root, in the fibres of the palato-glossus and lingualis. Lying above this mass of muscle, composed of the palato, and stylo-glossus, and lingualis, which—after passing the anterior edge of the genio-hyoglossus, lie side by side, and form also the inferior half of the muscular mass of the tongue where it is free—is the *perpendicular* muscle already described, part of which, at the base of the tongue, is attached below to the lingual termination of the genio-hyoglossus. In the mesial line between the perpendicular fibres and the longitudinal ones, lie the *nerves* and *vessels* of the tongue. There is also a vein, running in the mesial line on the upper surface of the tongue, just underneath the mucous membrane, having transverse branches falling into it from the muscular substance and mucous coat. This specimen was also a female, had four teats, and was 5 feet 4 inches in length from the nose to the tail.

In support of the views which I have been led to take of the powers of the perpendicular fibres, I may mention that a similar muscle exists in all mammiferous tongues which I have examined, and I believe is the co-efficient of all those peculiar movements connected with the protrusion of the tongue; and that the other longitudinal muscles are connected with this act chiefly to guide the organ in different directions, as the sole and separate action of these latter muscles would be that of retracting the organ in one or other directions. Protrusion is, then, the province of the perpendicular muscles; retraction that of the longitudinal ones;—different combinations of the two produce the several movements out of the axis of the tongue, whether the organ is in a state of protrusion or retraction. In the *Lumbricus tines*, or round intestinal worm, may be noticed fasciculi passing from the walls of the abdomen to the integument, and apparently firmly connected to each attachment. These transverse fasciculi seem to exist nearly the whole length of the animal, and to encircle the interior digestive tubes: each fibre is of tolerably visible size, and pale in colour. As these fasciculi pass between the peritoneal lining of the abdominal cavity, and not from the walls of the proper intestinal canal, to the integuments, so each attachment is a fixed point, especially the interior one. That they are not glands may be inferred from their disconnection with the intestinal mucous membrane, though this point can only be strictly determined by the microscope. I have, however, by inspection and analogy, been led to hold that these fasciculi are muscular and perpendicular to the axis of the body of the animal, and to have a similar action to the perpendicular fibres in the tongue of the Cape Ant-eater. On the above supposition, that their action would be to elongate the animal, without, at the same time, compressing the contents of the digestive cavity, as the action of circular fibres would do in producing the same elongating effect. The digestive process would thus be interrupted by such a mode of progression, and defecation would otherwise only result, when the alleged circular fibres were thrown into action. If any effect of the cavity of the abdomen were produced by the perpendicular fibres, it would be to cause a tendency to a vacuum, both by the elongation of the animal, and also by the inner peritoneal walls being made the fixed point of action of these alleged muscular fibres. Ingestion of food and fluids would be thus aided most considerably, and independently of any provision for such a purpose at the mouth. It would, however, require further research to see whether analogous muscles, having actions similar to those attributed to the perpendicular fibres in the tongue of the Aardvark, or the body of the round intestinal worm can be found to bear out the above general interpretation of their actions; but I presume that instances might be obtained to shew such a peculiar modification of muscular power, and make it a more general physiological property—as in the arms of some of the Cephalopoda, the tongue of the chameleon, the trunk of the elephant, &c. &c.

Habits of the Aardvark.—This animal, inhabiting the Fish-River country, lives in immense holes, excavated by their powerful, hoof-like claws, in the ground, some six or ten feet below the surface. There are generally a collection of holes like a warren at these places, all intercommunicating, and situated in or about a clump of trees or bushes. The calibre of these passages is so large in some as to allow a man to creep into. The animal mostly comes out at night, but may sometimes be seen during the day. It is plantigrade on the hind feet, but digitigrade on the fore ones. The fore-feet have four toes, and the hind-feet five each, armed with strong hoof-like claws, very similar except in size to the arrangement of those of the mole, so as to enable the animal to dig and scrape away the earth sideways from them, and also crosswise, the inner toes being longer than the outer ones.

The ponderous conical tail, 18 or 20 inches long, composed of bony joints, and a multitude of muscles, covered by an integument as thick as an ox's hide, hangs ordinarily down, like that of the Cape sheep, when the animal is walking. Its structure is similar to the tail of the Cape iguana or large water-lizard and its use may be, in one point of view, similar, viz., as an instrument of defence from attack, as with it they strike dogs very forcibly that attack them. When surprised, they instantly make for their holes; but as they cannot run fast, they are therefore soon caught by dogs, and easily shot or assegaied. When seized by dogs by their very soft ears, or by their velvety nose, they double in their heads between their fore legs, and strike forwards, or kick with their hind-feet, so as to make their assailants loose hold and often repent their proceedings.

They are best caught in moonlight nights, when out feeding, either by dogs, or waiting near a suspected warren till the animal returns before the break of day. They live chiefly on ants, and, as there are numbers of ant-hills all over the country, their food is ever at hand. They first dig away with their fore-feet, partly, as it were, sitting on their hind-legs, supported by the tail, like the Cape Redistes or jerboa, a large hole at the base of the anthill, and, no doubt, when made sufficiently large, they lie down and thrust their nose in, which is protected from stinging by its velvety hair, when they ascertain the neighbourhood of their game. They then protrude their long, tapering tongue, well covered with secretions through their toothless gums, which, when well covered with ants, is retracted, and the burden disposed of in the mouth for mastication. The mouth is abundantly supplied with mucous glands under its covering membrane, and the sublingual glands are large and open, with many secretory ducts, to pour out an abundant lubricating secretion. From the want of both incisor and canine teeth, the bite of the animal is harmless, and besides, the orifice of the mouth is not much larger than suffices for a tongue-load of ants. By means of the flat grinders on each side, this minute kind of scaly food is ground into paste, and made fit for digestion. In excavating its habitation, no doubt, the very great muscular power of its hinder extremities come into action, and shovelling away, like a spade, the earth loosened by the fore-feet, the two extremities act the part of a pick and lever. From its beautiful buck-like ears, one would suppose its sense of hearing was exquisite, and perhaps of much more use to the animal than its small, laterally-directed eyes, especially for its nocturnal and subterranean habits of life. Its hide is as thick as that of an ox, impenetrable, no doubt, to all attacks from insects, and has much the appearance of a pig's skin, but thicker, and has the same intimate connection with the underlying muscular structure as in the latter animal, so that the natives, when they slaughter the Aardvark for food, cut it up into pieces with the skin on, as we do pork.

Dimensions of the Female killed near Fort Brown, whose oval dissection is above given.—Length, 5 feet 4 inches from the nose to the tail end; nose to the root of the ear, 11 in.; ear to the wrist or carpus, 14½ in.; ankle (tarsus) to the protuberance of the hip-joint, 15 in.; length of the tail, 18½ in.; leg, from the ankle to the spine, over the protuberance of the trochanter, 21 in.; arm, from the wrist over the shoulder to the spine, 18 in.; round the belly, just in front of the thigh, 3 feet 3 in.; round the thorax, behind the shoulders, 2 feet 6 in.; round the neck, behind the ears, 15½ in.

P.S.—I have sent two entire skins to the museum at Fort Pitt, which were forwarded, with other specimens, after the breaking out of this war, and which have all since been acknowledged.

W. T. B.

The Negroes of the Indian Archipelago and Pacific Islands.
By W. John Crawfurd, Esq., F.R.S.

Oriental negroes are found thinly but widely scattered, from the Andaman islands, in about 80° of E. longitude, to the New Hebrides in the Pacific, in about 175° E. longitude, and from the Philippine islands, in 18° N. latitude, to New Caledonia, in about 21° S. latitude. These eastern negroes are known to Europeans under various names. The Malays term the inhabitants of New Guinea, Papua, or more correctly Pua-pua. Europeans taking this as an authority, call New Guinea and its inhabitants both Papua.

The word *pua-pua* is an adjective, and signifies *crisp, frizzled, woolly.* To complete the sense for the country or people, it is necessary to state the nouns-substantive, *tanah* = country, and *oran* = people. Thus *oran pua-pua* = a woolly headed man; and *tanah oran pua-pua* = the land of woolly-headed men.

European writers have also sometimes termed them Alfores, which word has been converted by English and French writers into Arafura and Harafura, and referred to a Malay source. It is not, however, Malay, because the letter *f* is not to be found in any written language of the Indian Archipelago, and seldom does the sound occur in any of the unwritten ones. The word is Portuguese, and means freedman, in which sense it is adopted by the natives of the country. It is nearly equivalent to the *Indios bravos* of the Spaniards, as they term the free unsubjugated Indians of Spanish America.

Spanish writers term the negroes of the Philippine islands, from their diminutive size, *Negritos*, or little negroes. Some English writers have lately termed them Austral negroes, which is manifestly improper, since they are found equally in the northern as in the southern hemisphere; and this even in the islands of the Indian Archipelago.

The oriental negro is even found in a state of civilisation below that of the brown-complexioned and lank-haired race in their neighbourhood, whether these be Malayan or Polynesian. There is great diversity in their civilisation; some, with the least possible knowledge of the commonest arts of life, live precariously on the spontaneous produce of their forests and waters, both animal and vegetable; while others practise a rude husbandry, construct boats, and undertake coasting voyages for the fishing of the tortoise and tripang, or holothurian.

The negro of the Andaman islands is below five feet in stature, and is of the lowest civilisation. The negro of the northern portion of the Malay peninsula is also of short stature. A full-grown male of average height was found to measure only four feet nine inches. The negro of the Philippine islands, found chiefly on the large island of Lucon, is also diminutive. They dwell in the mountains, generally maintain their independence, and live in constant warfare with the Malays.

There are no negroes in Sumatra, Java, Borneo, and Celebes, nor is there any record or tradition of any. The great island of New Guinea is almost wholly peopled by negroes, who differ from each other, and more so from those distant tribes described as existing in the Andaman islands, in the northern parts of the Malay peninsula, and in Lucon.

M. Modera, an officer of the Dutch navy, has described two negro tribes which exist on the west coast of New Guinea. After describing one of these tribes, he says,—" In the afternoon of the same day, at the time of high water, three of the naturalists went in a boat well armed to the same spot, where they found the tree full of natives of both sexes, who sprung from branch to branch with their weapons on their backs, like monkeys, making similar gestures, and screaming and laughing as in the morning. And no offers of presents could induce them to descend from the trees to renew the intercourse."*

The most singular physical character of the negro of New Guinea, consists in the texture of the hair of the head. It is neither that of the negro of Africa, nor seemingly that of the oriental negro, north of the equator. Mr Earl, who has seen most of the negro tribes of New Guinea, and who best describes them, gives the following account of it :—" The most striking peculiarity of the oriental negro," says he, " consists in their frizzled or woolly hair. This, however, does not spread over the surface of the head, as is usual with the negroes of western Africa, but grows in small tufts, the hairs which form each tuft keeping separate from the rest, and twisting round each other, until, if allowed to grow, they form a spiral ringlet. Many of the tribes, especially those which occupy the interior parts of the islands, whose coasts are occupied by more civilised races, from whom cutting instruments can be obtained, keep the hair closely cropped. The tufts then assume the form of little knobs, about the size of a large pea, giving the head a very singular appearance, which has not been inaptly compared to the head of an old worn-out shoe-brush. Others, again, more especially the natives of the south coast of New Guinea, and the islands of Torres Straits, troubled with such an obstinate description of hair, yet admiring the ringlets as a head-dress, cut them off, and twist them into matted skull caps, thus forming very compact wigs. But it is among the natives of the north coast of New Guinea, and of some of the adjacent islands of the Pacific, that the hair receives the greatest attention. These open out the ringlets by means of a bamboo comb, shaped like an eel-spear, with numerous prongs spreading out laterally, which operation produces an enormous bushy head of

* Mr Windsor Earl on the Papuan Indians.—(*Journal of the Indian Archipelago*, vol. iv., p. 1.)

hair, which has procured them the name of Mop-headed Indians."

There are fifteen different varieties of oriental negroes, of eleven of which we have good descriptions. Some of them are feeble dwarfs under five feet, and others are powerful men. To include the whole under one category, is surely contrary to truth and nature.

As far as language can be considered a test of race, and as the present state of our knowledge on the subject will enable us to judge, it goes to prove that all the tribes or nations of whose languages we possess examples, are separate and distinct from each other. I have compared the words of nine negro languages. Three of these consist of the few words of Mallicolo, Tanna, and New Caledonia, given by Foster in his Observations on Cook's Second Voyage, and six of fifty-five words of the Sâman of the Malay peninsula, from my own collection, and those of the Gebe, Waigyu, New Guinea, and New Ireland, and Vanikoro, the scene of the wreck of La Perouse, from that of H. Gaimard.

An examination of these comparative vocabularies corrects an error of very general acceptance, that the negro languages contain no Malay words; for each of the nine contains Malay words. The proportion of Malay words is considerable in the languages of those tribes which are nearest to the Malays, and therefore most amenable to Malayan influence, and diminishes in proportion to distance or other difficulty of communication. Excluding the numerals, which in most cases are Malayan, the proportion in a hundred words of the Sâman is twelve; in the Gebe about eight; in the Waigyu above five; in the Doree Harbour of New Guinea, near four; in the Port Carteret of New Ireland six; and in the Vanikoro little more than three. The greater number of Malayan words in all these negro languages consist of nouns or names of physical objects, and none of them can be said to be essential to the grammatical structure. They are, in fact, substantially extrinsic.

A comparison of the native words of the negro languages themselves shews that they agree in a very small number of cases, where the tribes speaking them are in the vicinity of each other; thus several words are substantially the same in the Waigyu and in the New Guinea. This is, however, the exception, and the rule is a total disagreement. Thus, between the language of the negroes of the peninsula of New Guinea and of New Ireland, there is not one word alike. There is no evidence therefore to justify the conclusion that the oriental negro, wherever found, is of one and the same race.

SCIENTIFIC INTELLIGENCE.

METEOROLOGY.

1. *Analyses of Snow and Rain Water, by M. Eugene Marchand.*—The snow and rain fell at Fécamp (France) in the months of March and April 1850. A kilogramme of water contained—

	Snow.	Rain.
Sulphuric acid, free or combined, .	doubtful	sensible proportions.
Chloride of potassium, . . .	doubtful	trace
Chloride of sodium, ...	0·017037 gr.	0·01143 gr.
Chloride of magnesium, . . .	trace	trace
Alkaline iodides and bromides, . .	trace	trace
Bicarbonate of ammonia, . . .	0·001290	0·00174
Nitrate of ammonia, ...	0·001447	0·00189
Anhydrous sulphate of soda, . .	0·015627	0·01007
Sulphate of magnesia, . . .	trace	trace
Sulphate of lime, ...	0·000877	0·00087
Animalised organic matter, containing some iron and calcium, . . .	0·023846	0·02486
Pure water, ...	999·939876	999·94914
	1000·000000	1000·00000

The organic matter of the snow, deprived of fuliginous matters, afforded oxide of calcium, 0·008116 grammes; peroxide of iron, 0·000450; organic matter, 0·015280 = 0·023846.—(*American Journal of Science and Arts*, vol. xiv., No. 41, 2d Series, p. 263.)

2. *Notes on the Climate of Rangoon, by Dr Alexander Christison, H.E.I.C.S.*—During the last war, the troops stationed at Rangoon were attacked with an epidemic of rare occurrence, and were defectively supplied with ill-preserved provisions, which gave rise to scurvy. From these and other circumstances the climate was reported as very unhealthy; but it now appears from recent information to be much more healthy than it has been represented to be.

Fall of Rain.—At Moulmein, the annual average fall of rain reported is 150 inches. But late information from a gentleman who resided there several years, informs us that the annual fall never exceeded 90 inches. Dr Fayrer has ascertained that the total fall for the present year will scarcely exceed 80 inches, an amount which does not exceed the mean fall of rain at Arddarroch in Dumbartonshire. In May, the fall of rain registered at Rangoon, in pluviometer, 11·79 inches; June, 16·43 inches; July, 21·35; August, 17·07 inches.

Temperature.—The minimum temperature observed at sunrise in May, was 73°; June, 74°·5; July, 74°; August, 75°. The maximum at noon in May, was 96°; June, 90; July, 88°; August, 87°; and at three P.M., in May, 95°; June, 90°·5; July, 89°; August 88°·5. At all periods the temperature and sense of heat are mitigated after two o'clock, either by a sea-breeze, which springs up about that time in the dry season, or by thunder and rain, as the evenings succeed a forenoon of unusual heat. The moisture of the atmosphere is of course great during these months; and often the difference of temperature between the dry and wet bulb thermometers is very trifling.—(*Monthly Journal of Medical Science, December* 1852, p. 544.)

3. *On the Recent Earthquake felt at Adderley; in a Letter to Robert Chambers, Esq., by Richard Corbett, Esq.*—At half-past four o'clock this morning, (Nov. 7, 1852) railway time, we were visited by a really smart shock of an earthquake. Our household consists of twenty-two persons, eighteen of whom were fully alive to it, and all more or less alarmed. Having myself felt a shock in this house, July 1832, I was instantly aware of what was taking place. A rumbling, heavy noise, which seems to have awakened many who were asleep, shortly preceded the shock—this was my case; the sensation was that of being rocked in the bed.

From all that I can collect, it is my belief that the shock passed from west to east, and at present we have reason to suppose it was confined to a very narrow line. Several of our villagers were much shaken and alarmed. The noise must have been considerable, as a very deaf person heard it, and resembled that made by a waggon going over pavement.

The atmosphere was perfectly dead as described—not the slightest movement in the air, and very warm. On Friday last, we had a tremendous thunder-storm, and large pieces of ice. I could rather imagine that there is some peculiarity in our substrata here, for since 1775 or 1776 we have had three very complete shocks of earthquake in this locality. We stand upon the edge of the lias, and there has been very near to us a most extensive subsidence, forming a valley of unknown depth between the face of the lias and that of the new red sandstone, which cross out at the distance of a mile and a-half from each other. The intermediate valley is filled with northern drift, in which I have bored ninety feet, still in the drift.

MINERALOGY.

4. *On Pseudomorphous Minerals. By our friend, Professor Sillem.*—(*Brown's Jahrb.*, 1851, 385.) — The pseudomorphous forms described in this paper are—

Pseudomorphs.	Forms imitated.
Native copper,	Red copper ore.
Silver glance, .	Red silver ore.
Malachite, . .	Red copper ore.
Azurite, . . .	„ „ „
Copper pyrites,	Fahlerz.
Copper glance, .	Copper pyrites.
Horn silver, .	Silver.
Brown iron ore,	Red iron ore.
Wad, ...	Pyrolusite.
Gypsum, . . .	Calcspar.
Bitter spar, . .	„ „
Kaolin, . . .	Leucite, Sodalite.
Mica, ...	Wernerite.
Talc, ...	Kyanite.
Soapstone, . .	Tourmaline, Actinolite, Scapolite, Kyanite, Staurotide.
Galena, . . .	Pyromorphite.
White lead ore,	Galena.
Red and brown iron ore, . .	Pyrites, Specular iron, Sphærosiderite.
Brown iron ore,	Marcasite, Calcite, Beryl.
Scheelite, . .	Wolfram.
Malachite, . .	Copper pyrites, Fahlerz, Calcite.
Electric calamine,	Blende, Psilomelane, Fluorspar.
Calamine, . .	„ „
Calcite, . . .	Felspar, Pyrope Garnet.
Quartz, . . .	Fluorspar, Calcite, Wolfram, Augite, Carbonate of lead, Corundum, Stiblite.
Chlorite, . . .	Calcite, Magnetic iron, Brown ore.
Galena, . . .	Calcite.
Specular iron, .	Calcite.
Marcasite, . .	Stephanite.
Sphærosiderite,	Calcite.
Pyrites, . . .	Marcasite.
Pinite, . . .	Hornblende.
Antimony blende,	Antimonite.
Magnetic iron, .	Actinolite.
Green earth, .	Prehnite.
Talc, ...	Actinolite.

—(*American Journal of Science and Arts*, vol. xiv., No. 41, 2d Series, p. 264.)

5. *Large Deposit of Graphite.*—In Glen Strath, Farer, Inverness-shire, there is a great deposit of graphite in gneiss. A similar one occurs at St John's, New Brunswick; near the new suspension bridge over the St John's river, a very extensive deposit of graphite has been opened and explored to a considerable extent. The vein, or bed, as it might more properly be called, is nearly vertical, and inclosed between beds of highly metamorphic schists. It is entered near the water, on the face of a precipitate cliff about 70 feet high, the walls of the lode being in the main parallel to the graphite deposit. This bed has been explored by a gallery or adit level over 100 feet, and by cross cuts, at right angles to this, some 20 or more feet. All these are in the graphite mass, and of course the floor and roof of the levels are of the same mineral. The quartzose walls have occasionally approached, and, in some cases, masses of quartz or schist have been included in the graphite. The course of this deposit is about north-east and south-west, or nearly in the direction of the strike of the strata of the schist. The graphite is not of a very superior quality as a mass, though portions of it are quite pure. As yet no solid and per-

fectly homogeneous masses have been taken out. It has a foliated structure, more or less highly marked. Iron pyrites is too abundantly diffused in it to admit of its use for crucibles. The chief economical use made of it has been in facing the sand moulds for iron castings, for which purpose it is ground to a fine powder. Some of the finer parts are also used to manufacture pencils. Many hundred tons of graphite from this deposit have already been taken out since the mine was opened two years ago, and the supply may be esteemed inexhaustible. The vein or bed reappears on the opposite side of the St John's river, and on the side now opened it has been traced over a mile. The position of the deposit in conformable metamorphic schists, suggests the conjecture that this deposit of graphite may represent a former coal-bed.—(*American Journal of Science and Arts*, vol. xiv., No. 41, 2d Series, p. 280.)

6. *Sulphur Mine in Upper Egypt.*—An extensive bed of sulphur has been opened in Egypt, between the village of Keneh and the Red Sea, at the strait called Bahar el Sefinque. It is soon to be worked.—(*Ann. des Mines* (4), xviii. 541.)

7. *Strontiano-calcite, a New Species.*—(*Proc. Acad. N. Sci. Phil.*, vi. 114, June 1852.)—Crystallisation and cleavages like calcspar: secondary form an acute rhombohedron of 65° 50′. Crystals minute; occurs in globular masses, the globules terminating in this acute rhombohedron, H = 3·5; gr. undetermined. Colourless and transparent, or white and translucent, the former vitreous, the latter pearly in lustre. B.B., yields a brilliant light, a slightly crimson flame, and becomes caustic. The solution in acid gives a white precipitate with sulphate of lime, but not with sulphate of strontia, and it therefore contains strontia. After precipitating the strontia in a portion of the solution, the addition of oxalate of ammonia produced a precipitate of oxalate of lime. The quantity was too small for a quantitative analysis; but Dr Genth infers that the lime and strontia are in about equal proportions.

The specimen was from Girgenti, Sicily, where it is of rare occurrence, associated with celestine and sulphur.—(*American Journal of Science and Arts*, vol. xiv., 2d series, No. 41, p. 280.)

8. *Platinum and Iridosmine in California, by Dr F. A. Genth*, (*Proc. Acad. Nat. Sci. Philad.*, vi., 113).—A few steel-coloured rounded grains of platinum were observed among specimens of gold from the American Fork, California, 30 miles from Sacramento city. *Iridosmine* from the same locality occurs in lead-coloured scales. A collection of white grains from California, afforded, after separating the platinum, six-sided scales of a colour between lead and tin-white, which, on heating on platinum foil, gave a strong odour of osmium, and were probably, therefore, the *Sisserskite* (Ir Os 4); when thus heated, the scales became irridescent and assumed yellow, orange, and blue colours like steel. Dr Genth, on trying the Ural

iridosmine, found that the lead-coloured scales afforded the same colours; and he suggests that this may be a good test for distinguishing the *Sisserskite* from the *Neujanskite*. He adds, that there are probably in nature only two distinct compounds of iridium and osmium, viz., Ir Os 4, and Ir Os; and the compound Ir Os 3, is probably a mixture of the two.—(*American Journal of Science and Arts*, vol. xiv., 2d series, No. 41, p. 277.)

9. *Identity of Donarium with Thorium.*—Professor Damour and Professor Berlin of Lund, in Sweden, infer from their analyses that orangite is identical with thorite, and consequently donarium with thorium. Bergemann has, however, continued his researches, and while expressing himself with due caution, is not prepared to admit the conclusions of the French and Swedish chemists, so that some doubt may still be entertained upon the subject.—(*Pogg. Ann.* lxxxv. 555.)

10. *Native Iron.*—M. Bahr has described specimens of carbonised wood, associated with bog-ore from Smaoland, which afforded grains of malleable iron, having a specific gravity, 6·248, 6·4972, and 6·6255, after hammering; and he considers it as probably a result of deposition through some electric process, and not artificial in origin. He suggests for coal containing iron in this manner, if hereafter found, the name *Sideroferite*.—(*The American Journal of Science and Arts*, vol. xiv., No. 41, 2d Series, p. 275.)

11. *On Crystallisation and Amorphism; by Prof. F. M. L. Frankenheim.*—(*I. f. pr. Chem.*, liv. 430.)—Frankenheim reviews the subject of crystalline structure and amorphism at considerable length, and arrives at the conclusion, that although the structure of the intimate particles of so-called amorphous substances is not actually proved to be *crystalline* by observation, it is still true that all the properties of substances so called are perfectly consistent with such a structure.

GEOLOGY.

12. *Flora of the Tertiary Formation.*—The flora of the tertiary formation has been hitherto, comparatively speaking, far less known than that of the coal formation, which is of a far older date; and even in Silesia, notwithstanding its numerous and important deposits of brown coal, the entire amount of leaves, blossoms, and fruits belonging to this formation, exclusive of stems of trees, did not exceed forty-three species up to the close of last year.

Since then, however, a discovery has been made, which, in a few months, has already brought more treasures to light, than Monte Bolca in Italy, and the celebrated deposit of Oeningen in Germany, have done in a century. This new deposit was discovered by the Superior Councillor of Mines, Von Oeynhausen, near the end of

January of this year, in the immediate neighbourhood of Breslau, at Schossnitz, near Kanth, on the railroad; it is a bed of fossil plants in tertiary clay, and is unique in richness, variety, and admirable preservation. From the end of January up to the beginning of March, there were already discovered no less than 130 species in about six hundredweight of clay; and every fresh quantity examined gives additional results. Dr Göppert has read a very interesting paper upon the results of the examination thus far made, before the Natural History Section of the Breslau Society. The clay is of a whitish colour; the plants seldom preserve their original texture, but usually occur as impressions of a pale brown colour, in which, however, they are displayed with such precision, that even the delicate anthers of the catkins of the willow tribe are readily distinguishable. These anthers, as well as those of the male catkins of the plane tribe, occasionally exhibit the pollen. With respect to the families and genera, it may be said that they agree, speaking in a general way, with those of the other local floras of the brown coal formation. The species are, however, for the most part different; only one species has been hitherto observed, *Libocedrites salicornioides*, that is met with in Silesia, in amber, and in the brown coal formation of other parts of Germany. Of the 130 species that have been found at Schossnitz up to the beginning of March, there are no less than 118 which are new. As a peculiarity in this tertiary flora, may be cited the considerable number of oaks, of which already 25 varieties have been observed, whereas at present only 13 are known to occur in Europe, and for the most part the species discovered belong to those with incised leaves. There are, moreover, no less than 17 varieties of elm, some unquestionable planes, and varieties of maple, perfectly distinct from any hitherto observed. The genera Daphnogene, Ceonanthus, Dombyayopsis, and Taxodium, have been also met with. It need hardly be observed, that our acquaintance with the riches of this recently-discovered deposit is as yet necessarily very imperfect. Palms, which are met with in other tertiary deposits in the immediate neighbourhood, have not thus far been found; indeed, no monocotyledons have been observed, with the exception of a few leaves of grass. The origin of the deposit has been explained on the supposition that there existed here formerly an inland lake, into which the leaves and blossoms of the trees that perished on its banks were carried by the wind, and became subsequently imbedded in the clayey mud. This recently-discovered deposit bears out the idea, that although the majority of the genera of the plants occurring in the tertiary formation are similar to those now met with in Europe, although the species are different, and agree rather with African forms than ours; yet that this formation, speaking generally, contains a flora distinct from that of the actual flora of the districts mentioned, and analogous rather to that of countries situated several degrees more to the south; the flora of the deposit of Schossnitz answering, it will be seen, to that of the vegetation of the southern portion of the United States, or to that of the north of Mexico. Professor Göppert purposes to lay the results of the examination of the Schossnitz deposit before the scientific public, as far as it has at present been made, in a separate work.—(*American Journal of Science and Arts*, vol. xiv., No. 41, 2d Series, p. 281.)

13. *On the Tides, Bed, and Coasts of the North Sea or German Ocean, by John Murray, Esq.* — The author commenced his paper by remarking that great similarity of outline prevades the western shores of Ireland, Scotland, and Norway, and then observed that the great Atlantic flood-tide wave, having traversed the shores of the former countries, strikes with great fury the Norwegian coast between the Lafoden Isles and Stadtland, one portion proceeding to the north, while the other is deflected to the south, which last has scooped out along the coast, as far as the Sleeve, at the mouth of the Baltic, a long channel from 100 to 200 fathoms in depth, almost close in-shore, and varying from 50 to 100 miles in width. After describing his method of contouring and colouring the Admiralty chart of the North Sea, he traces the course of the tide-wave among the Orkney and Shetland Islands along the eastern shores of Scotland and England to the Straits of Dover, and along the western shores of Norway, Denmark, and the Netherlands, to the same point. He then remarks that the detritus arising from the continued wasting away of nearly the whole line of the eastern coasts of Scotland and England, caused by the action of the flood-tide, is carried by it, and at the present day finds a resting-place in the North Sea; and that this filling process is increased by the sand, shingle, and other matter brought through the Straits of Dover by the other branch of the Atlantic flood-tide. Hence, he remarks, the gradual shoaling of this sea, and the formation of its numerous sandbanks; the silting up the mouth of the Rhine, the Meuse, and the Scheldt; the formation of the numerous islands on the coast of Holland, that country itself, and much of Belgium; the deposits at the mouth of the Baltic, the islands in the Cattegat, and indeed the whole country of Sleswig, Denmark, and Jutland.

The author then takes a view of the tides, and their effects upon the Baltic and its shores before the course of the tide-wave was checked by these shoals and low lands. He considers that, previous to these great changes, the flood-tide entering the North Sea between Norway and Scotland, would make directly towards the German coast, and necessarily heap up the waters in the Baltic considerably above their present level, and that a great part of Finland, Russia, and Prussia, bordering upon that sea, would thus every twelve hours be under water, in the same way as the waters now rise in the Bay of Fundy, at Chepstow, and other places, much above their ordinary level in the open sea; that the current outward, on the receding of the tide which these accumulated waters would occasion, combined with the rivers which fall into the Baltic, when checked by the following flood-tide, would cause deposits in the form of a bar tailing towards Sweden; and that an increase to these deposits would form shoals, drifts, and islands, and eventually a long sand-bank in outline, like the country of Denmark. He further considers that the tide being by these means prevented from entering the Baltic, may account for the subsidence of the waters of the Gulf of Bothnia, better than can the upheaval of the northern part of Scandinavia.

The author then remarked that the great shoal of the North Sea is the Dogger Bank, and that its peculiar form is produced by the meeting of the cotidale waves, of which he traces the course. After bearing testimony to the value of the Admiralty chart of the southern portion of the North Sea, made under the direction of the late Captain Hewitt, he reverted to the importance of contouring such maps, in order to obtain something like a correct notion of the bottom of the sea; and in conclusion expressed a hope that the Admiralty will be induced to continue the survey of the North Sea, so well begun by Captain Hewitt.

ZOOLOGY.

14. *On the Bones and Eggs of a Gigantic Bird in Madagascar.*—M. Saint Hilaire has recently communicated a notice to the French Academy, of the existence, at Madagascar, of a gigantic bird, entirely new to the scientific world. The discovery [of the evidence] was made in 1850, by M. Abadie, captain of a merchantman. During a stay at Madagascar, he one day observed, in the hands of a native, a gigantic egg, which had been perforated at one of its extremities, and used for domestic purposes. The account which he received concerning it soon led to the discovery of a second egg, of nearly the same size, which was found perfectly entire, in the bed of a torrent, among the debris of a landslip which had taken place a short time previously. Not long afterwards was discovered in alluvia of recent formation, a third egg, and some bones, no less gigantic, which were rightly considered as fossil, or rather, according to an expression now generally adopted, as sub-fossil. These were all sent to Paris; but one of the eggs was unluckily broken. The others arrived in safety, and M. Saint Hilaire has presented them to the Academy. These eggs differ from each other in form: one has its two ends very unequal; the other approaches nearly to the form of an ellipsoid.

The dimensions of the latter are:—Largest diameter $13\frac{1}{2}$ inches; smallest diameter $8\frac{1}{2}$ in.; largest circumference, $33\frac{1}{2}$ in.; smallest circumference, $28\frac{3}{4}$ in. The thickness of the shell is about the eighth of an inch. This great Madagascar egg would contain about seventeen English pints, and its gross volume is six times that of an ostrich-egg, and equal to 148 ordinary hen-eggs. To carry out the comparison still further, one of the eggs of the Madagascar bird would be equal in bulk to 50,000 eggs of the humming-bird.

The first question to be decided was: Are these the eggs of a bird or of a reptile? The structure of the shell, which is strictly analogous to that of the eggs belonging to large birds with rudimentary wings, would have sufficed to determine the question; but it has been completely set at rest by the nature of the bones which were sent with them. One of them is the inferior extremity of the great metatarsal bone of the left side; the three-jointed apophyses exist, two of them being nearly perfect. Even a person unskilled in comparative anatomy cannot fail to see that these are the remains of a bird.

M. Saint Hilaire assigns to this bird the generic name of *Æpyornis*, and to the species, *Maximus*. It cannot be classed with the *Ornithichnites* on the one hand, or with the Ostrich and allied genera on the other, but it is the type of a new genus in the group of the Rudipens, or Brevipens. Its height, according to the most careful calculations made by comparative anatomists, must have been about twelve English feet, or about two feet higher than the largest of the extinct birds (Dinornis) of New Zealand. According to the natives of the Sakalamas tribe, of Madagascar, this immense creature, although extremely rare, still exists. In other parts of the island, however, no traces of belief in its present being can be found. But there is a very ancient and universally-received tradition amongst the natives, relative to a bird of colossal size, which used to slay a bull, and feed on the flesh. To this bird they assign the gigantic eggs lately found in their island. That this tradition is wholly a fable, is evident from the character of the bones found, which clearly shew that the bird in question had neither talons, nor wings adapted for flying, but must have fed principally on vegetable substances.

M. Saint Hilaire considers it very probable that the *Æpyornis* has had an existence within the historic period, and that it has even been referred to by two French travellers at different times, viz., by M. Flucourt in 1758, and by another at a later period. These accounts have heretofore been regarded as wholly fabulous. It is not, however, improbable that the Eastern story of the Roc, in the tale of Sinbad the Sailor, may have had its origin in a knowledge of the existence of the bird of Madagascar. It could not, as before observed, have possessed any of the ferocious characters ascribed to this fabled bird. A beautiful model of this gigantic egg was presented to the Museum of Natural History in the University of Edinburgh, by the Professors of the Garden of Plants in Paris.

15. *Domestication of Fishes.*—In a memoir recently presented to the French Academy, M. Coste remarks, that having had his at-

tention directed to the domestication of fishes, he selected the eel to experiment upon, both because its manner of generating is almost wholly unknown, and because its flesh is not only agreeable to the taste, but constitutes an article of food very favourable to health. In proof of this latter statement, the author mentions the inhabitants of a section of France, who live almost entirely upon eels, and who are notoriously healthy. In describing the manner of generation of eels, the author says—" Every year, in the month of March or April, there appear at the mouths of the rivers, just at nightfall, myriads of transparent filiform animalcules from six to seven centimetres long, which raise themselves to the surface of the water in compact masses, and ascend the streams. These animalcules are nothing but newly hatched eels, leaving their birthplace to disperse themselves throughout the canals, lakes, and brooks, which communicate with the rivers." The quantity of these animalcules is sufficient to fill all the waters on the globe, and if transported to basins prepared to receive them, they would furnish an inexhaustible supply of food.

" Pre-occupied with this idea, the author caused a quantity of those animalcules to be brought alive to the College of France, and placed in large wooden vats. The young eels were then from six to seven centimetres long, and one centimetre in circumference around the largest part of the body. After remaining seven months in the vat, they were twelve centimetres long, and two centimetres and two millimetres in circumference; at the age of eighteen months, twenty-two centimetres long, four centimetres and eight millimetres in circumference; at the age of twenty-eight, thirty-three centimetres long, and seven in circumference. Thus, though placed in very small basins, the eels grew from eight to ten centimetres in length, and two and a half in circumference, every nine months.

MISCELLANEOUS.

16. *Freedom of the Arabs from Leprosy.*—M. Guyon, in a note to the Academy of Sciences, Paris, attributes the absence of leprosy among the Arabs to their living under the direct action of light and air in tents, while the Kalzles, who often suffer from this disease, live in fixed dwellings, often more or less beneath the level of the earth's surface.—(*L'Institut*, No. 965.)

17. *Obituary.*—The Academy of Sciences in Stockholm has lost the oldest of its members in the person of M. Wilhelm Hisinger, the mineralogist, who has died at the age of eighty-six.

Owing to new arrangements in the Edinburgh Patent Office, we are obliged to delay our List of Patents until our April number of Journal.

THE

EDINBURGH NEW

PHILOSOPHICAL JOURNAL.

Biographical Account of the late William Macgillivray, A.M., LL.D., Regius Professor of Natural History in the Marischal College and University of Aberdeen. Communicated by ALEXANDER THOMSON, Esq. of Banchory, Aberdeen.

THIS distinguished naturalist and most worthy man, died at Aberdeen on 5th September last, at the early age of 56.

He was a native of Old Aberdeen, and studied and took the degree of A.M. in King's College and University.

Like many of his countrymen, he had a hard struggle through life with the *res angusta domi;* and it is to his friends, a striking and a remarkable dispensation of Providence, that he has died just at the time when he had all but overcome the difficulties with which he had so long contended, and when he had the prospect before him of more usefulness and greater comfort than he ever had enjoyed before. He was enabled by his steady perseverance as a youth, to procure for himself a sound education; and the same perseverance enabled him to build his future fame upon the foundation thus acquired.

After passing through the usual undergraduate curriculum, he resolved to study medicine as a profession, and attended, with this view, the usual medical classes in Aberdeen, studying more especially under the late Dr Barclay, with whom he served a regular apprenticeship. He afterwards attended various classes in Edinburgh, but never took his degree of M.D. nor entered on the practice of his profession; the time, however, thus spent was by no means lost, for his anatomical and physiological studies proved of the greatest value to him in after life.

From an early age, he shewed a decided taste for the study of Natural History in almost all its branches, and his love for it proved too enthusiastic to allow him to follow the medical profession as a means of support; he availed himself of the first opportunity which presented itself to obtain a situation where all his time and energy could be honestly given to his favourite pursuits.

About the year 1823, he accordingly accepted the appointment of "Assistant and Secretary to the Regius Professor of Natural History, and Regius Keeper of the Museum of the Edinburgh University," which he held until 1831, when he was named "Conservator of the Museum of the Royal College of Surgeons in Edinburgh," and in this office he remained for about ten years, when he succeeded the late Dr Davidson as Professor of Natural History in the Marischal College and University of Aberdeen.

Neither of the situations in Edinburgh was by any means lucrative, and he was obliged to add to his scanty emoluments by the occasional delivery of lectures, by furnishing papers to scientific journals, and by translating and editing; but though not lucrative, these situations were highly congenial to his tastes; they furnished him with ample materials for study, and brought him into friendly relationship with many of the naturalists, both of Scotland and England, at an early period of his life.

He had singular qualifications as the Keeper of a Museum. Nothing could exceed his care and patience in preparing an object, except perhaps the delight with which he contemplated the result. His taste in displaying, and his neatness in arranging, were alike remarkable; and both the valuable Museums so long under his care were much indebted to his assiduous labours.

In 1841, he was appointed by the Crown to the Professorship of Natural History in Marischal College, solely on account of his acknowledged merit, for he had no interest whatever; and the zeal, ability, and success, with which he discharged his duties, amply justified the nomination.

To do justice to his memory, he must be regarded as an author, an observer, and a teacher.

His printed works are very numerous, embracing many extensive branches of Natural History. It has been remarked that had he devoted himself more exclusively to some one branch, he would have raised himself to a higher position in the scientific world than that which he attained. Probably the remark is true; but had he done so, it is certain he would have been a less useful member of society. His special duty as a Professor was to convey as much solid information to others as he could, and that duty he very amply discharged, for few modern authors have done more by their writings to extend the knowledge of natural science.

The following list is as correct as can now be furnished of his publications; it is impossible to trace and identify all his anonymous contributions to the periodicals of the day:—

I. *Separate Publications.*

1. The Travels and Researches of Alexander Von Humboldt. One vol., 12mo, 1832. Second Edition, revised, 1834. Third Edition, revised, 1836.
2. Lives of Eminent Zoologists, from Aristotle to Linnæus, with Introductory Remarks on the Study of Natural History, and Occasional Observations on the Progress of Zoology. One vol., 12mo. 1834.
3. Description of the Rapacious Birds of Great Britain. One vol., 12mo. 1836.
4. A History of British Birds, Indigenous and Migratory, including their Organisation, Habits, and Relations; Remarks on Classification and Nomenclature; an Account of the Principal Organs of Birds, and Observations relative to Practical Ornithology. Illustrated by Numerous Engravings. Dedicated, by permission, to the Queen. Five vols., 8vo. 1837–1852.
5. A History of British Quadrupeds. Illustrated by 34 Plates. One vol., 12mo. 1838.
6. A Manual of Geology. One vol., 12mo. 1840. Second Edition, 1841.

7. A Manual of Botany, comprising Vegetable Anatomy and Physiology, or the Structure and Functions of Plants. One vol., 12mo. 1841.
8. A Manual of British Ornithology; being a short description of the Birds of Great Britain and Ireland, including the essential characters of the Species, Genera, Families, and Orders. Two vols., 12mo. Part I., 1840. Part II., 1841. Second Edition, with Appendix of recently observed species. 1846.
9. A History of the Molluscous Animals of the Counties of Aberdeen, Kincardine, and Banff, to which is appended an Account of the Cirripedal Animals of the same district. One vol. 1843. Second Edition, 1844.
10. Elements of Botany and Vegetable Physiology, including the Characters of the Natural Families of Plants, with Illustrative Figures. By A. Richard, M.D. Translated from the Fourth Edition, 1831.
11. The Flowering Plants and Ferns of Great Britain and Ireland, arranged according to the Linnæan system. With Instructions to Beginners, Illustrated with Figures, a Glossary, and Outline of a Natural Classification, compiled for Popular Use. One vol., 8vo. Eighth Edition, 1852.
12. An Introduction to Physiology and Systematical Botany. By Sir James Edward Smith, M.D., F.R.S., &c. A New Edition, with Additions. One vol., 12mo, 1836.
13. Catalogue of the Museum of the Royal College of Surgeons of Edinburgh. Part I., comprehending the Preparations illustrative of Pathology, compiled and edited. One vol., post 8vo. 1836.
14. Domestic Cattle. Portraits of the Principal Breeds reared in Great Britain and Ireland, with Characteristic Descriptions of their Peculiarities and Comparative Merits. The Drawings by Mr J. Cassie junior. Eight parts. Published 1845.

II. *Printed in the Transactions of the Wernerian Natural History Society.*

1. Notice relative to Two Varieties of Nuphar lutea, found in a lake in Aberdeenshire.
2. Remarks on the Specific Characters of Birds.
3. Descriptions, Characters, and Synonymes of the different Species of the genus Larus, with Critical and Explanatory Remarks.
4. Description of a supposed New Species of Ornithorhyncus.
5. Description of a Species of Arvicola, common in Aberdeenshire.
6. Remarks on the Phenogamic Vegetation of the River Dee in Aberdeenshire.

III. *Printed in the Edinburgh Philosophical Journal.*

7. List of Birds found in Harris, part of the outer range of the Hebrides.
8. Remarks on the Flora Scotica of Dr Hooker.
9. Notice regarding the Island of Grimsey, off the north coast of Iceland, and the Isles of St Kilda, on the north-west coast of Scotland.
10. Account of Harris, one of the districts of the Outer Hebrides.
11. Description of Pecten Niveus, a New Species of Shell.
12. On the Covering of Birds, considered chiefly with reference to the Description and Distinction of Species, Genera, and Orders.
13. Description of a Species of Salix found in Braemar.
14. Description of a Species of Aira, found on Lochnagar, in Aberdeenshire.
15. Remarks on the Serrature of the Middle Claw, and the Irregular Denticulation of the Beak, in certain Birds.
16. On the Mammalia of the Counties of Aberdeen, Banff, and Kincardine.
17. On a Species of Teredo found in Cork Floats on the Coast of Aberdeenshire.
18. Remarks on the Cirripedia, with Descriptions of several Species found adhering to Vessels from Ichaboe, on the West Coast of Africa.

[Occurrence of the Sea Horse, Walrus or Morse, (*Trichecus rosmarus*, Lin.) in the Hebrides.

[Description of Annatina villosiuscula, a new species, and of Venerupis Nucleus, a species new to the British Fauna.]

IV. *Printed in the Edinburgh Quarterly Journal of Agriculture.*

19. On Natural Pastures.
20. On the Uses to which certain Indigenous Plants have from time immemorial been employed in the Outer Hebrides.
21. On the Indigenous Trees of North Britain.
22. Remarks on the Sands of the Outer Hebrides.
23. On Geology viewed in relation to Agriculture. Sect. I.—Inequalities of the Earth's Surface, and the Causes which are continually effecting Modifications upon it. Sect. II.—On the Nature and Relations of the Materials of which the Exterior of the Globe is composed. Sect. III.—General View of the Vegetation of the Globe, and of the Causes which Influence its Development.
24. Van Diemen's Land.
25. New Holland.

26. The Cape of Good Hope.
27. The Habits of the White-Tailed Sea Eagle.

V. *Printed in the Prize Essays and Transactions of the Highland Society of Scotland.*

28. Notice respecting Arundo arenaria and Drift Sand.
29. Essay on the Nature and Quality of Soils and Subsoils, as indicated by Plants.
30. Report on the Present State of the Outer Hebrides.

VI. *Printed in the Edinburgh Journal of Medical and Natural Science.*

31. Account of the Series of Islands usually denominated The Outer Hebrides. I.—Introductory Sketch. II.—Geological Constitution. III.—Climate. IV.—Soil. V.—Vegetation. VI.—Mammifera. VII.—Birds.
32. On the Granite of the Upper Districts of Aberdeenshire.

VII. *Additions made by Dr Macgillivray to Various Works.*

1. Drawings for Sixteen 4to Plates, Illustrative of "The Internal Structure of Fossil Vegetables found in the Carboniferous and Oolitic Deposits of Great Britain." By Mr Witham of Lartington.
2. Audubon's Ornithological Biography, 5 vols. royal 8vo. For this work, Dr Macgillivray wrote the Descriptions of all the Species, and of the Alimentary and Respiratory Organs of several hundred Specimens, besides Correcting and Improving the parts referring to the Distribution of the Species.
3. A Synopsis of the Birds of North America. By John Y. Audubon, F.R.SS. L. & E., &c. The whole of this volume, excepting the Notices relative to the Distribution of the Species, was written by Dr Macgillivray.
4. Sketch of the Natatorial Order, for Mr Wilson's Treatise on the Natural History of Birds in the Seventh Edition of the Encyclopædia Britannica.

Besides the above, Dr Macgillivray translated three works on Anatomy and Geology, edited a volume of Travels, translated about a thousand pages of Natural History from French and Latin, and wrote many Papers for the Edinburgh Literary Gazette and the Edinburgh Journal of Natural History.

Dr Macgillivray has left ready for Publication two Works.

1. "A History of the Vertebrated Animals inhabiting the Counties of Forfar, Kincardine, Aberdeen, Banff, Elgin, and Nairn, with the adjoining parts of those of Inverness and Perth." This, though complete in itself, was intended to form part of a work in which Dr Macgillivray had made considerable progress, but which would have taken many years to finish. It was to have given the complete Natural History of these six Counties, comprising their Geology, Mineralogy, Botany, and Zoology in all its branches,—a gigantic undertaking,—but one whose completion would have been of great national importance. No such account of any district of Britain has yet appeared as was contemplated in this work.
2. The Natural History of Balmoral, from Notes made during an Excursion to Braemar in the Autumn of 1850.

It is to be hoped that both these works will be given to the public. The former is complete in itself so far as it goes, though only comprising a small portion of the intended publication. The latter was left ready for the press, and the district which it describes is not only interesting from its alpine character, but doubly so from being the chosen summer residence of our Sovereign and her consort.

It is impossible to read over this list without admiration of the diligence of the author. Had he been a mere closet student, an arranger and describer of other men's labours, his work would have been great, and beyond the powers of most to accomplish; but the charm and value of his books consist in their being so largely the results of his own observations.

His style is singularly clear and distinct; conveying his ideas in an unmistakeable form, there can never be any doubt of what he intends to say—a valuable quality in any writer, but of special importance in books of natural history. Occasionally his delight in the subject before him leads him somewhat beyond the strict limits of scientific technicality, but never beyond those of perfect accuracy.

His descriptions may by some have been criticised as too particular, but this is not a fault which careful students of natural history will be much disposed to find; to be truly useful in the identification of species, a description can scarcely be too minute.

His largest and most important work, and that on which his fame must mainly rest, is his History of British Birds, which was in progress during a great part of his life. The first volume issued from the press in 1837; the fifth and last was published the very week of his death.

As a *scientific* ornithologist, he first introduced the method of determining species by anatomical structure, which, although not yet universally adopted, is undeniably the most correct and certain which has been proposed; and the comparative neglect of it is probably to be attributed to the fact that many intelligent observers and describers of birds are not sufficiently expert anatomists to be able to avail themselves of it.

His views will be best given in his own words:—

"After much consideration, however, and after examining the digestive organs in a great number of birds belonging to nearly all the families, I have resolved to adopt the intestinal canal as a central point of reference. Instead, then, of describing merely the bill, I attend to the mandibles, the mouth, the tongue, the throat, the æsophagus, the crop, the proventriculus, the stomach, the intestines, and the coecal appendages; the modifications of which seem to be to throw more light upon the affinities of the larger groups than those of any other organ."—(*Introduction to History of British Birds*, p. 6.)

"Some ingenious writers have attempted to shew that a knowledge of the internal structure of animals is not essential to the zoologist, who, it is said, may get on remarkably well, and form the most natural arrangements, by attending merely to the exterior. The views of such persons are not likely to find much favour in the eyes of those who have studied animals as organised beings, and who do not remain satisfied with inspecting the surface. Zootomy regards the entire structure of animals, which must be examined in all their parts before the zoologist can arrange them according to their affinities. The study of their interior must in fact form the basis of all arrangement; and although many natural groups may be formed by attending exclusively to the exterior of animals, it is only because their internal organisation is presumed to be similar. The external parts afford an index to the internal; and if we find a bird having a short hooked bill and curved claws, we shall not be wrong in inferring that it has a wide œsophagus and a large membranous stomach. The great divisions of zoology can be laid out only by a zootomist; but the details of the system may occasionally, perhaps frequently, but never with absolute certainty, be elaborated by him who regards only the exterior. No rational system of ornithology has ever appeared for these two reasons:—Because no system-maker has been equally acquainted with the internal structure, the external parts, and the habits and actions of birds; and, more especially, because birds have not yet been subjected to a sufficiently minute examination. I have been induced to offer these remarks because I regret that the science has been degraded by having been left entirely in the hands of those who appear to despise, because they have no knowledge of the internal structure of birds; and I have considered it my duty to impress upon the student the necessity of dissecting with all diligence. Were it possible to cast away all the knowledge already acquired, and commence anew upon the plan of considering birds as admirable specimens of divine workmanship, to be examined in all their details, we should, I believe, be great gainers in real knowledge."—(*Introduction*, pp. 85, 86.) And again—

"To acquire a satisfactory knowledge of any bird, one must, in the first place, obtain a general idea of its external appearance, so as not only to be able to distinguish it at sight, but also to know in what respects it resembles others, or differs from them. Then he ought to examine its interior, and more especially its digestive organs, which indicate the nature of its food, the latter necessarily determining its haunts. He now seeks it there, and observes its mode of walking and flying, its favourite places of resort, and its various actions, listens to its notes, follows it to its nest, which he inspects, and takes note of its migrations or local shiftings. The food can be detected with accuracy only by opening the crop and gizzard; and the changes in the colour of the plumage can be ascertained only by procuring individuals at different seasons. In attending to these and other particulars, one necessarily acquires much enthusiasm, and consumes much time."—(*Introduction*, pp. 90, 91.)

Throughout the work he gives excellent figures of the digestive organs of the orders described, as also of their osseous structure, and occasional very accurate and expressive drawings of their heads and wings. It is matter of regret that the expense of engravings prevented the work being more copiously illustrated by these figures, for they are singularly correct.

He delighted not only in examining the structure of Birds both internal and external, but also in watching their habits, as is shewn in many passages in which they are most graphically described.

The habits of Ptarmigan are thus set before his readers:—"Near the summit of a projecting mass of rock, in this region, I sat down among the crumbling blocks of granite to compare *Aira flexuosa*, which grew in tufts, with its characters in Smith's Compendium; and when I rose, a large covey of Ptarmigans sprung from among the stones about a hundred and fifty yards beneath me.

"These beautiful birds while feeding, run and walk among the weather-beaten and lichen-crusted fragments of rock, from which it is very difficult to distinguish them when they remain motionless, as they invariably do should a person be in sight. Indeed, unless you are directed to a particular spot by their strange, low, croaking cry, which has been compared to the harsh scream of the Missel-thrush, but which seems to me much more like the cry of a frog; you may pass through a flock of Ptarmigans without observing a single individual, although some of them may not be ten yards distant. When squatted, however, they utter no sound, their object being to conceal themselves; and if you discover the one from which the cry has proceeded, you generally find him on the top of a stone, ready to spring off the moment you shew an indication of hostility. If you throw a stone at him, he rises, utters his call, and is immediately joined by all the individuals around, which, to your surprise, if it be your first rencontre, you see spring up one by one from the bare ground. They generally fly off in a loose body, with a direct and moderately rapid flight, resembling, but lighter than, that of the brown Ptarmigan, and settle on a distant part of the mountain, or betake themselves to one of the neighbouring summits, perhaps more than a mile distant."—(Vol. i., p. 199.)

Again, let us visit a rookery with him at night: "Not having visited a rookery at night, I was desirous of knowing how the birds would conduct themselves when disturbed by an intruder after they had retired to rest, and accordingly went this evening, the 14th April, to that at Prestonfield, in my neighbourhood. When about four hundred yards from it I stopped to listen, and was surprised to hear several rooks uttering a variety of soft, clear, modulated notes, very unlike their usual cry. In the intervals I could distinguish the faint shrill voice of the newly-hatched young, which their mothers, I felt persuaded, were fondling and coaxing in this manner. Indeed the sounds were plainly expressive of affection and a desire to please. Presently all became still, and I advanced until I could perceive the male birds perched on the twigs in great numbers. They had no doubt observed me, and a few seemed ready to fly off, but it was not until a loud croak from a distance, several times repeated, gave warning to the whole community, that they did so. As I proceeded, all the males removed, and ultimately, I believe, the females also; but with much less clamour than they would have used had it been day, most of them remaining mute, several uttering a kind of low grunt, expressive of dissatisfaction, others a sort of panting noise, indicative of fear, and only a few croaking aloud in anger. I believe the whole colony was on wing, and wheeling over the trees, the young remaining perfectly mute. As I moved along, I heard those whose nests were behind settling in succession on the twigs, and before I had retired to the distance of four hundred yards they all seemed to have returned. Their flight on this occasion was singularly wavering, undulatory, and undecided, and the strong flappings of their wings were distinctly heard, it being a calm evening. After they had all regained their tranquillity, a few croaks only being heard now and then, I broke a stick to see what effect the noise might have, when a few that were on some trees nearer than the rookery flew off in silence. A repetition of the noise produced the same effect, but the sound did not disturb the main body. I then clapped my hands, when presently all was mute, and so long as this sound was repeated, no cry was emitted. They seemed to watch in silence my further proceedings; and, on my ceasing, the rookery resumed its natural state: a young bird now and then uttered its faint cry, on which an old one emitted its curious modulated notes, and a gruff old fellow or two croaked aloud at intervals. The great variety of notes emitted by the rooks under these circumstances greatly surprised me; for although I had been aware that their cry is not always merely a *craa*, I did not imagine that their voice was capable of presenting so many modifications.—(Vol. i., p. 548.)

Or let us take one of his latest descriptions, that of the Great Black-backed Gull:—" The Great Black-backed Gull is among the most beautiful of a tribe remarkable for beauty. The contrast between the dark purple tint of his back and wings, and the snowy white of the rest of his plumage, with the bright carmine-patched yellow of his powerful bill, and the delicate pinkish hue of his feet, render him an object at all times agreeable to the sight. No sprinkling of dust, no spot of mud, ever soil his downy clothing; his bill exhibits no tinge derived from the subject of his last meal, bloody or half-putrid though it be; and his feet, laved by the clear brine, are ever beautifully pure. There he stands on the sandy point, the guardian, as it were, of that flock of not less cleanly, and scarcely less lovely, Herring Gulls and Sea Mews. But not giving us more credit for our good intentions than we deserve, he spreads out his large wings, stretches forth his strong neck, runs a few paces, and uttering a loud screaming cry, springs into the air. Some gentle flaps of those vigorous wings carry him to a safe distance, when he alights on the smooth water, and is presently joined by his clamorous companions. Buoyantly they float, each with his head to the wind, like a fleet of merchantmen at anchor, secured from the attacks of pirates by the presence of their gallant convoy. If in mere wantonness you discharge your artillery, sending a bullet skipping among the flock, they hurriedly rise on the wing, fill the air with their cries, and wheel around at a safe distance, while the Black-backed Gull, disdaining to mingle with the clamorous crowd, after a few wide circlings flies off seaward, and is soon out of sight." * * * * "Vigilant and suspicious, it is not easily approached at any season, it being of all our gulls that which forms the most correct estimate of the destructive powers and propensities of man. Chief of its tribe and tyrant of the seas, it evinces a haughty superiority which none of our aquatic species seem inclined to dispute. Little disposed to associate with its inferiors, it passes its leisure hours or periods of repose, on unfrequented parts of the sand, or on shoals or islets, often on the bosom of the sea, just behind the breakers, where it floats lightly on the waves, presenting a beautiful appearance as it rises and falls on the ever-varying surface. In winter it is scarcely gregarious, more than a few individuals being seldom seen together ; but when there are shoals of fish in the bays or creeks, it mingles with the other gulls, from which it is always easily distinguished by its superior size and very loud clear cry, which may be heard in calm weather at the distance of a mile. Frequently, when flying, it emits also a loud rather hoarse cackle, having affinity in sound, although not analogous in nature, to a human laugh. All the larger gulls are in one sense laughter-loving birds; but if we take note of the occasions when their cachinnations are edited, we discover that so far from being the expressions of unusual mirth, they are employed to express anxiety, alarm, anger, and revenge. Its flight is strong, ordinarily sedate, less wavering and buoyant than that of smaller species, but graceful, effective, and even majestic. There, running a few steps, and flapping its long wings, it springs into the air, wheels to either side, ascends, and on outspread and beautifully-curved pinions, hies away to some distant place. In advancing against a strong breeze, it sometimes proceeds straight forward, then shoots away in an oblique direction, now descends in a long curve so as almost to touch the water, then mounts on high. When it wheels about, and sweeps down the wind, its progress is extremely rapid. It walks with ease, using short steps, runs with considerable speed, and, like the other gulls, pats the sand or mud on the edge of the water with its feet. It generally rests standing on one foot, with its head drawn in; but in a dry place it often reposes by laying itself down."—(Vol. v., p. 530.)

These and many other passages bring most vividly before the mind of even the unscientific reader, the habits of the bird described. Many of them are indeed models of correct and tasteful description.

This work contains a full account of every species of bird known at the time to inhabit or visit any part of Great Britain or Ireland. Doubtless the discovery of new species must occasionally reward the researches of future ornithologists, but at this moment the work contains the only full and detailed technical description hitherto given in this country. The habits of the species are treated with equal extension in every case where he had been enabled to study them advantageously; and the internal structure, especially of the alimentary organs, carefully described wherever it seemed expedient to do so. In short, this work must long continue to be the great Ornithological Thesaurus of the British Isles.

His work on the Mollusca of Aberdeenshire gave an impulse to the study of Conchology on the eastern coast of Scotland. It is the first zoological book which has issued from his college, and it has already reached the second edition; but his edition of "Withering's British Plants" proved to be the most popular of his works, having now reached the eighth edition. He bestowed much pains in correcting and improving it; and on receiving a complete copy of the last edition a few weeks before his death, he remarked "This book is now as perfect as I can make it." It is distinguished by the same minute accuracy and distinctness which characterises his other works.

A pleasing characteristic in all his writings, is the care with which he awards to other writers and discoverers, whatever they have discovered or described; he had so little desire to acquire renown which did not belong to him, that he often failed to do justice to himself and his own labours.

As an observer, he was patient and persevering; and no one but an enthusiastic lover of nature could have undergone the pains and privations he endured in following out his favourite researches. Whatever might be his special pursuit at the time, his eye and ear were ever ready to seize whatever natural object presented itself, and hence the great accumulation which he eventually made of observations of his own in Zoology, Botany, and Geology. Whatever he discovered was at once freely communicated to others; he had no idea of hoarding up either facts or specimens for his own peculiar use. His taste was refined, and he had an intense delight in contemplating natural beauty, whether it were a bird, a plant, a shell, an insect, or an extensive landscape, none of its beauties escaped his notice.

As a lecturer, he was distinct and methodical. He laboured to lay securely the first foundations of each study in the minds of his pupils, well knowing that unless this were duly accomplished, their future acquirements would be of little real value.

He was thoroughly impressed with the importance of the branches which he taught, and honestly valued them far above either classical learning or mathematical science, and it was well for his pupils and himself that he did so, for though other parties may justly estimate the comparative value of different branches of human knowledge, and place his studies below the rank which he contended they ought to possess, it is sure, as a general principle, that neither teacher nor professor can ever be of much use who is not thoroughly persuaded of the paramount importance of his own branch of study; unless he be so, he can never stimulate either himself or his students to work as they ought.

As Professor in Marischal College, he suffered under one disadvantage, which he greatly felt, viz., the almost total want of a Museum, to teach even the elements of his subjects. This defect he was obliged himself to supply, and to expend largely from his own resources in the purchase and collection of specimens for the use of his students. It is to be hoped that means may be devised to remedy this evil, and that Marischal College, which has already done so much to raise the standard of education in the north, will make a vigorous exertion to procure a suitable Museum, so that, in future, the Professor of Natural History shall not be obliged to spend most of his income, for the first few years of his holding the office, in procuring the most common and necessary objects. On the present occasion, in particular, it is to be hoped that Dr Macgillivray's collections will not be allowed to be dispersed, but purchased for the use of the class.

He was a careful lecturer, explaining every part of his subject as minutely as his time would permit. To his students he was ever kind and courteous, and he delighted in encouraging all who shewed any taste for their studies,—all his information was ever at their service, as indeed it was to any one who took an interest in Natural History.

He kept good order and discipline among his pupils, with little trouble either to them or himself, for they generally loved him; and if he at times found occasion to reprove sharply, it was done as a painful duty which he owed to those who were deliberately wasting precious time, and neglecting to improve the talents which he saw that they possessed.

He was mild and gentle in his manners, and of a retiring and unobtrusive disposition, never thinking highly of himself or his acquirements, but rather disposed to give place to others. Engrossed by his own pursuits and duties, he took little interest in the public affairs of the world, or in the momentous changes both in state and church which occurred in his day.

By his colleagues in the University he was highly esteemed. In an address of condolence to his family, adopted at the first meeting of the Senatus after his death, they thus express their feelings regarding him:—"The Senatus, taking into consideration the high and acknowledged eminence of their late colleague, Dr Macgillivray, in natural science, his zealous and laborious efforts to promote the interests thereof, both as a teacher and as an author, and his amiable and estimable personal character, unanimously resolve to record the expression of the deep sense of the loss which this University has sustained by his death, and of their sincere sympathy with his bereaved family; and they appoint an extract of this minute to be sent to the family."

He was a sincere and simple-hearted believer in the truths of the Gospel, and they were his comfort and stronghold during the long months of his gradual decay. As death approached, his faith became stronger and firmer; and it was highly characteristic of his conscientious discharge of duty that he continued to work almost to the last day of his life, though perfectly aware that death was surely and rapidly approaching. The last passages of the British Birds were written under this impression, and cannot now be read by his friends without emotion. See preface to vol. v., and conclusion of vol. v.

To all modern infidel or atheistic theories, so abundant in most branches of natural science imported from the Continent, and reproduced under forms somewhat modified in this country, and which in fact strike at the root of all religious belief, whether under the name of Vestiges, or of Palingenesis, or Development, he was entirely opposed. They were alike repugnant to him as a philosopher, and distasteful and offensive to him as a Christian. Nor did he lose any fitting opportunity of exposing their absurdities.

His health began to fail about a year and a half before his death, and he never appeared to recover from the fatigue and exposure of a month spent in 1850, in exploring the central region of the Grampians, the district around Lochnagar. In November 1851, he was obliged to repair to the south of England, in the expectation of benefiting by the milder air of Devonshire, and at first there was some ground to hope, but after his arrival at Torquay, he was suddenly deprived of his wife, to whom he was tenderly attached; and from this blow, though he received it as a man and a Christian, he appears never to have rallied; he gradually became weaker, and though he never ceased to work, it was most distressing to his family to see his exertions, the mind and will resolutely striving against the weakness of the body. He was confined to bed for a few days at last; spoke much and affectionately to his children when pain did not prevent him; looked forward with calmness and hope to his last struggle; expressed in the clearest terms his simple trust in his Saviour alone, and at last gently fell asleep to be for ever with the Lord, whose *works* he had so ardently admired on earth, and in whose *atoning blood* he trusted for acceptance with his God.

He married early in life and has left a numerous family, for whom we regret to learn he has not been able to make any provision. His eldest son has already distinguished himself as a naturalist. He was employed in that capacity by the late Earl Derby, on board the expedition sent by him round the world; and after his return he wrote the account of the voyage of the "Rattlesnake" in a manner which has justly earned him a high reputation, both as an observer and a describer. He is now absent as Government Naturalist on board the "Herald," which lately sailed to carry out and complete the exploration of the Eastern Archipelago and Southern Pacific, and we trust in due time, by means of this expedition, to have a large accession to our knowledge from the pen of Mr John Macgillivray.

Influence of Terrestrial Magnetism on Iron, and the effect that results from it upon the direction of the Compasses in Vessels.

The terrestrial globe may, like a magnet, exercise at a distance its magnetising powers. If we hold vertically, or, which is still better, in the direction of the dipping needle, a bar of soft iron about a yard in length, we find that it acquires two poles, a north pole at its lower, and a south pole at its upper extremity. The existence of these two poles is manifested by the attractive and repulsive action exercised by the two extremities of the bar upon the same pole of a magnetised needle, delicately suspended and brought near to them. The terrestrial globe, therefore, acts as a great magnet would act whose axis, passing through the centre of the earth, should be situated in the magnetic meridian, and which should have, at the north, a pole contrary to the pole of the needle that is directed to the north; and at the south another pole, in like manner contrary to the pole of the needle that is directed to the south. This hypothesis upon the cause of terrestrial magnetism would also explain the direction of the magnetised needle; which would also be the result of the attractions exercised by the magnetic poles of the globe upon the contrary poles of the magnetised needle. It would be sufficient, therefore, in order to know the position of the magnetic pole of the earth, situated at the north, to determine carefully the direction of the dipping needle in several different places; and the intersection of these lines would be the point where the pole in question would be found. It would be necessary to go through the same process on the other side of the magnetic equator, in order to determine the position of the terrestrial magnetic pole situated on the south. But it is found that the directions of the dipping needle, when produced, whether in the boreal or austral hemisphere, do not all intersect exactly in the same point; which would seem to prove that there is not, therefore, in each hemisphere, a single pole or a single centre of magnetic action. We shall return, in detail, to this interesting subject of terrestrial physics, when we shall be treating upon the numerous observations that have been collected upon the different phenomena of terrestrial magnetism, and upon the hypotheses that have been made of its origin and its nature.

It may not be useless to mention here a denomination still employed in French works, and which owes its origin to the terrestrial theory of the magnet. Setting out from the hypothesis that the earth possesses two magnetic poles, and from the principle established by experiment, that poles of the contrary name attract each other, they have called that pole of the magnetised needle that is directed towards the north, the *aus-*

tral pole; because, say they, it is attracted by the magnetic pole of the earth situated at the north, and which is naturally the boreal pole; for the same reason they have given the name of boreal pole to that end of the needle that is directed towards the south; because, say they, it is attracted by the austral pole of the globe. With regard to ourselves, as we prefer a denomination founded upon fact to that which rests upon theory more or less contestable, we shall continue to call the north pole of the needle that which is directed towards the north, and the south pole that which is directed towards the south.

The magnetisation produced by terrestrial magnetism is facilitated by all actions, whether mechanical or physical, which derange the molecules of iron from their natural position of equilibrium. Thus percussion, torsion, every kind of vibration, impressed upon a bar of iron determines in it the presence of the two magnetic poles; simple oxidation in the air produces the same effect. To prove that this magnetisation is entirely due to the influence of terrestrial magnetism, and not to these actions themselves, we have merely to examine the position of the poles in the bars submitted to experiment, and we find that this position is always that which would result from the immediate action of the globe; thus, the north pole is always the one found at the extremity of the bar that is inclined below the horizon, or at that which is turned towards the side of the north, if the bar is horizontal. We may even, if the bar is of very soft iron, immediately change the poles by suddenly turning it so that the extremity which was directed towards the north shall be to the south, and that which was directed towards the south shall be to the north. Furthermore, it is easy to prove that, whatever be the action by which the body is constrained, the magnetism that it acquires is the more intense as its position approaches more the direction of the dipping needle; and that it becomes altogether null if the bar is placed in a position perfectly perpendicular to this direction. We have thus the evident proof that the effect does not arise in an immediate manner from the action to which the bar is subjected, but simply from terrestrial magnetism, the influence of which is favoured by this action.

To the influence of this magnetism must be attributed the magnetisation possessed by all magnetic bodies left for any length of time in the same place; thus, the rods of lightning conductors, the points of steeples,* bars, or other iron objects, placed in buildings, always present traces of magnetism; it is the same with iron or steel tools, such as those of a locksmith; or punches, or cutting instruments that are liable to undergo vibratory movements by the use to which they are applied. We can even obtain powerful magnets, from the magnetism produced by means of the terrestrial globe, by taking a certain number of iron wires, twelve or fifteen inches in length, and twisting them strongly while held in a vertical position, or which is better still, in the direction of the dipping needle. This operation, which renders them stiffer, facilitates, at the same time, the development within them of a very powerful magnetism; and, when once they have been magnetised, they are united to form a bundle, care being taken that their similar poles are all at the same extremity of the bundle.

The magnetising action exercised by terrestrial magnetism upon iron may determine upon the needles of compasses very serious deviations, when they are placed upon vessels in motion. In fact, these structures which always contain in their fabric a very considerable quantity of bars and plates and rods of iron, are found, from this circumstance, to contain magnets; the poles of which must change with the position of the vessel, in respect to the magnetic meridian. There is produced, therefore, upon the magnetic needle, a variable action, the effect of which it is impossible to determine beforehand; whilst, if the vessel always remained at the same place, it would be an easy matter to appreciate the influence of this cause of deviation, and to take account of it.

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* It is probable that, in respect to elevated iron points, such, in particular, as those of lightning conductors, atmospheric electricity, or more especially that from lightning, contributes its part to their magnetisation as much, and more so, than terrestrial magnetism.

Navigators also are exposed to making great errors, which might be attended with serious consequences. Suppose, for example, that the axis of the vessel, that is to say, the line going from stem to stern, was at first perpendicular to the plane of the magnetic meridian, and directed to the west; that, in this position, the deviation of the needle was 20° to the west of the direction that it ought to have ; a change in the course of the vessel causes the axis to turn 180°, namely, from west to east ; by the effect of this change of direction, the deviation has also passed from west to east, and is consequently 20° to the east. It is evident that the observer, who should not be acquainted with the action of the iron contained in the vessel, to which these two deviations of 20°, first to the west and then to the east, are due, would believe that the needle has remained parallel to itself, and would judge that the rotation of the vessel had only been $180° - 20° + 2$, or $180° - 40°$, namely, 140°, whilst it had really been 180°. He would have been deceived, therefore, to the amount of 40° on the second direction of the vessel, supposing that he had carefully determined the first direction by the ordinary processes.

Mr Barlow proposed various means of avoiding the dangerous errors to navigation that we have just pointed out. One of these means consisted in placing in the neighbourhood of the compass a plate of soft iron, which becomes magnetised like the other masses of iron in the vessel, by the influence of the globes. This plate is put into such a position in front of the compass, that its action upon the needle shall be exactly equal to the total action of all the iron distributed throughout the vessel ; so that, by removing the plate, one half of the local deviation is removed, whence the amount of local deviation due to the ship's iron is readily obtained. The position that should be given to this plate has been previously determined by trials.

Another means has also been employed by Mr Barlow, from numerous experiments made by placing the vessel in every azimuthal position, and comparing, by means of two telescopes, the direction of its compass in every position with that of a magnetised needle remaining on the shore. He succeeded in determining empirically the correction that should be made in the observed deviation, in order to obtain the true magnetic declination of the place where the observation was made. But this process, like the former, requires a series of distinct operations for each vessel in particular, those made for one not being able to be used for another. It is, moreover, not without some practical difficulties.

M. Poisson, impressed with the importance to navigation of the question upon which we have just been treating, and convinced that it had been only imperfectly resolved by the empirical means that we have pointed out, endeavoured to submit it to analysis, and so to arrive at a general formula of correction. He proposed to determine directly the true inclination and declination in any given place on the globe, from observations of the compass made on board a vessel, and under the influence of the iron that it contains. The iron being magnetised by the magnetic force of the earth, it is evident that its action upon the needle will be proportional to this force. Further, since the components of this action correspond to three rectangular axes passing constantly through the same points of the ship, they have, for their expressions, linear functions bearing relation to the components of the action of the globe in the direction of these same axes. The magnetic force of the globe, then, is common to all the terms of the equation of the equilibrium of the compass, and consequently disappears from it. The formula contains different terms that must be determined; and, in particular, the quantities dependent upon the total amount and the distribution of the iron contained by the vessel. But for various reasons connected with the distribution of the masses of iron in vessels, which is, in general, symmetric, and with their position, which is in the most part below the horizontal plane drawn through the point of suspension of the compass, M. Poisson succeeded in simplifying the problem. The two unknown terms to be determined, are the true inclination and declination; and, for this determination, two data from observation are sufficient: Those required by M. Poisson's simplified formula are,—the angles of the principal section, or of the axis of the vessel, with the apparent direction of the compass before and after this section or axis has been made to turn to a known angle. Other formulæ enable us even to avoid this operation, and to be content with merely observing the direction of the compass before and after the addition of a mass of iron, always placed in the same manner, and so as easily to be brought near to the compass to change its direction.

Influence of Temperature on Magnetism.

Among the actions that facilitate magnetisation by terrestrial magnetism, one of the most efficacious consists in heating the magnetic body to redness, and allowing it to cool under the influence of this magnetism. The cooling that follows a much lower elevation of temperature is even sufficient. MM. Moser and Riess have proved that, to this kind of effect, we must refer the phenomena of magnetisation that have been supposed to be produced by rays of light, and especially by the violet rays. They have proved that, as these effects only take place when the needles which experience them are in a position perpendicular to the magnetic meridian, they can be attributed to terrestrial magnetism alone, the action of which is facilitated by the elevation of temperature brought about by the solar rays, or rather by the cooling that follows it. Heat, in fact, far from increasing, notably diminishes, on the contrary, the intensity of the magnetic virtue. A magnetised steel bar, when brought to a red-white heat, totally loses its magnetism; should it have become magnetic during cooling, it is due to the action of the earth. A soft iron bar is no longer magnetic, that is to say, is no longer attracted by the magnet, when it is simply brought to a red heat. Nickel ceases to be magnetic at the temperature of boiling oil. With regard to cobalt, its magnetic force does not seem gradually to diminish, as is the case with other substances, in proportion as its temperature increases; but it suddenly ceases at an extremely high temperature, and it then appears again just as rapidly when the metal is made to descend from this high temperature.

The remarkable influence that is exercised upon magnetism by elevation of temperature had led several philosophers to believe that the property possessed by certain bodies of being magnetic, was due to the small distance existing between the atoms of which they are formed.

In fact, iron, cobalt, and nickel, are among those bodies which, under the same volume, contain the greatest number of atoms, and consequently are those whose atoms are the nearest together. To heat these bodies is to remove their particles from each other; now, since this increase of distance makes them lose their magnetic properties when it is carried to a certain point, it follows that the substances among which the atoms are naturally more apart cannot possess these properties. What must be done, then, to make them acquire these properties? We must bring the particles nearer, and, for this purpose, must cool these bodies. Guided by this ingenious idea, Faraday had exposed, to an exceedingly low temperature, the greater part of the metals, and several of their compounds, and also carbon; and, notwithstanding he acted upon them with a very powerful magnet, he was unable to discover any trace of magnetism; he had the precaution to take all these bodies in a state of great purity, and deprived of all traces of iron. By means of a mixture of ether and carbonic acid placed in a vacuum, he succeeded in reducing their temperature to 105° cent. below 0°. Manganese itself presented no trace of magnetism. Mr Faraday has shewn that it is to the presence of a few particles of iron, of which it is a difficult matter to deprive it, that this metal had hitherto been erroneously classed among those which are magnetic. Thus, iron, nickel, cobalt, and steel, would seem to be the only bodies in nature that are magnetic, that is to say, that present magnetic properties, such as we have just studied and defined them. Faraday has arrived, by other means, to discovering equally in all bodies evident magnetic properties, but variable, in the form under which they are manifested, with the nature of the bodies themselves.—(*A Treatise on Electricity, by A. de la Rive*, vol i., p. 174.)

Meteorological Phenomena in connection with the Climate of Berlin. Translated by Mrs ANNE RAMSDEN BENNETT from the German of Professor DOVE.

(Continued from vol. liv. page 162.)

On the nights of the 30th April and 1st May, an explosion was heard at Barbadoes, so like the discharge of artillery, that the soldiers in the garrison of St Anna remained under arms. On the 1st of May, when day dawned, the eastern edge of the horizon was clearly visible, but the whole upper portion of the heavens was overcast by a thick cloud which soon extended itself and concealed the horizon from view. At last it became so dark that it was impossible for the people in the houses to distinguish the situation of the windows in their chambers, whilst the branches of the trees were weighed down and broken under the pressure of a mass of ashes which fell like rain. Whence came these ashes? According to the direction of the prevailing trade-winds during April and May, they would have come from the Peak of the Azores, and yet these ashes came from the volcano of Morne Carou on the Island of St Vincent, which lies twenty miles to the west, and is so completely separated from Barbadoes at this season by the trade-winds, that it is only possible to sail there by making a very wide circuit. The volcano had therefore ejected its ashes through the under into the upper trade-wind. To this hitherto solitary example of the carrying away of volcanic ashes in the direction of the upper instead of the under current, modern times has added a more striking example. On the 20th January 1835, the whole of the Isthmus of Central America was shaken by an earthquake, accompanied by an eruption of Coseguina. On the 24th and 25th, the sun was darkened at Kingston in Jamaica, distant 800 miles, by a shower of fine ashes, and this was the first indication which the inhabitants received that the explosion which had already been heard had not been the report of cannon. These ashes could only have been carried there by the upper trade-wind, for Jamaica lies to the north-east of Nicaragua. Besides this, the exception is a striking illustration of how the ascending air divides in the region of calms and flows towards both poles, since some ashes also fell on board the ship Conway as it was pursuing its course over the Pacific Ocean at a distance of 700 English miles from Coseguina.

Even on the highest point of the Andes, the upper current of air has never been reached by travellers. In that neighbourhood, therefore, the region of calms must be situated at the height of more than 20,000 feet above the level of the sea. Thus, in order that ashes out of lower volcanoes, such as those of Morne Carou and Coseguina, should be ejected to such a height, the explosion must be tremendous; and so it was in both cases. The roaring of the Coseguina was heard at Kingston, San Salvador, Baliza, Santa Martha, and Santa Fé da Bogota, therefore at a distance of 200 German miles. Union, a seaport on the west coast of Conchagua, was in utter darkness during the space of forty-three hours. When lights began to glimmer again, and render objects visible, it was found that the sea-coast had advanced 800 feet, by means of the mass of falling ashes. In like manner, the volcano of Morne Carou belongs to a chain of magnificent volcanic influences, the last link of which it forms. In the midst of earthquakes, and of smoke and flame which lasted from June till July in the year 1811, the Island of Sabrina was upheaved out of the sea in the neighbourhood of St Miguel, one of the Azores, and rose to the height of 300 feet above it, the depth of the sea in that place being 150 feet, and the circumference of the newly-formed island about an English mile. Then the Lesser Antilles were shaken by earthquakes, and rent the valleys of the Mississippi, Arkansas, and Ohio. But the elastic force found no outlet there; it sought it on the north of Columbia. The 26th of March dawned an extraordinarily hot day in Caraccas; the air was serene, and the skies cloudless. It was Palm Sunday. A regiment of troops of the line stood under arms in the Barracks of El Quartel del San Carlos ready to take part in the procession, and the people were streaming towards the churches, when suddenly loud subterranean thunder was heard, followed by an earthquake so violent, that the Church of Alta Gracia, which is above 150 German feet high, and is supported by buttresses fifteen German feet in thickness, became a mass of ruins six German feet in height. In the evening, the moon, which was almost at the full, shone with mild splendour in a cloudless heaven, and cast its rays on the ruins of the principal town under which 10,000 of the inhabitants were buried. But neither here did the volcanic force succeed in obtaining an outlet. At last, on the 27th of April, it gained the mastery, by forcing open the crater of Morne Carou, which had been closed for a whole century, and, as far as Rio Apura, that is to say, at a distance as great as from Vesuvius to Paris, the thundering hymn of jubilee, entoned by the liberated prisoner, was heard to resound.

The space between two meridians is an isosceles triangle, which has its base line resting on the equator and its points on the pole. The mass of air which ascends from the heated base cannot flow as far as the points in the ever narrowing space; it must descend before reaching them. We find the upper current in the tropical regions, even in summer, already sunk down at the Peak of Teneriffe; in the neighbourhood of the Azores, it has already reached the ground. Europe lies in this upper trade wind.

As, however, the region of calms, and the whole phenomena of the trade winds follow the course of the sun, so also do the places vary where the upper current descends. Places in the neighbourhood of the tropics lie, consequently, for a long time under the influence of the trade winds; but, on the other hand, they are for a time entirely free from them. These places have also a dry and a wet season, but, with this essential difference, that the rain falls there when the sun is at its lowest declination. These south-westerly winds bringing the rain in their train, come slowly down the mountains from the higher regions of the atmosphere. We see them clearly in the clouds which begin at the commencement of October to conceal the point and the Peak of Teneriffe; then they descend lower and lower, till at last they lay themselves down on the crest of the mountain, and reveal themselves by fearful storms. Perhaps a week, sometimes more, passes before they reach the sea-coast, where they remain raging for months, during which time the Peak is covered with snow. In Algiers, the commencement of the rainy season is earlier; and, on account of the place being more out of the track of the trade-winds, it lasts longer. In the south of Italy, the rainy season shrinks into the compass of a month; at the Alps, it entirely disappears; nor do we experience it here, where it rains the whole year through, and most of all in summer. But in Italy, also, the commencement of the rainy season, as well as the end of it, is marked by storms, and the quantity of water which falls is greatest in spring and autumn. Here, on the contrary, the extremes of spring and autumn meet in the height of summer. Our rainy season, therefore, takes place, unfortunately just at the time when we wish to visit our watering places. St John's day fixes our fate; according to the old saying,

> "If it rains on the day of St John,
> Hope of fine harvest is over and gone."

And in England,

> "If the first of July be stormy weather
> 'Twill rain more or less four weeks together."

Well! so it is, and we must try and be thankful that in our weather the laws of nature are strictly observed, but still it is hard to bear. Yet, heaven be praised, there is no rule without an exception.

A slight consideration, only, of this matter will shew that the descent of the upper currents cannot take place on the whole of the outer limits of the trade winds at one and the same time, because the trade wind itself must be compensated for by the air of the temperate zones. The air which consequently flows down in *one* place into the temperate zones must be replaced at *another* place by an upward current from thence that the equilibrium may be restored. Thus the currents which flow over each other in the torrid zones flow side by side in the temperate zones, and as they sometimes change their relative position, the characteristic features of our weather depend on this alternate displacement of the polar and equatorial currents. The extremes of our weather are regulated by the unequal prevalence of the one or the other of these currents, which, as long as they preserve a due equilibrium between each other produce the changeable weather which is most characteristic of our climate. The northern current is cold, heavy, and dry; the southern warm, moist, and light; with the former the barometer is high and the thermometer low, with the latter it is the reverse. I must, however, remark that when air flows from north to south or *vice versa*, its direction is affected by the revolution of the earth on its axis. Air which, for example, sets out as due north from Breslau to Vienna arrives there at NNE.; it would be NE. at Vienna if it set out due north from Konigsberg; ENE. if it set out from Riga; and almost east if we consider it as setting out due north from St Petersburg. Therefore, air which has been stationary between Petersburg and Vienna, and is then set in motion towards the south will cause the vanes at Vienna to turn by degrees from north through NE. to east. If, on the contrary, the air has been set in motion towards the north and has set out from Trieste, it will arrive at Vienna as a SSW. wind,—if it had set out from Rome, it would have been a SW.; WSW. if it had set out from Tunis; and lastly, almost W. if its cradle had been situated farther towards Africa. Every current of air, therefore, which flows from the north becomes more easterly the longer it lasts, every south wind more westerly. North-east is, therefore, a north wind which sets out from a greater distance, and south-west is a south wind setting out from a distant place. The coldest, heaviest, driest wind is therefore north-east, not north; the moistest, lightest, warmest wind, not south, but south-west.

The mutual struggle of the two opposing currents necessarily produces a revolution; under these circumstances a south wind would be followed by a west wind, then by a north, then east, and lastly south again.

Thaw and continued rain accompany the southern currents,—the most cloudless weather and severest cold come with the east wind, —pleasant dry weather is the most striking sign of the north current in summer. In September and the beginning of October, when this current predominates, we have, therefore, our most beautiful weather which, when it becomes strikingly warm, we call our back summer (after summer). But it is not so regular in the time of its duration as in America, where it is named the Indian summer, because the Indians then go to their hunting grounds, when, as they say, the Great Spirit sends them their summer. In November, on the contrary, on account of the then prevailing south current, we experience that very interesting form of weather which goes by the name of Pomeranian mists. The north current flows slowly then in its ever-widening bed, and therefore in the Petersburg Gazette the cold is already spoken of as having set in before the NE. wind has brought it to us. The south current, on the other hand, is stormy, and roars as in an empty street. The Berlin newspapers have for that reason no influence on the wagers as to when the Neva will rise, for the thaw-wind outruns the posts. On account of the impetuosity with which the south wind presses forward into higher latitudes, it loses, by constantly-renewed precipitation, some of its moisture, especially on the southern declivities of mountains. Besides this precipitation there is another of an entirely different kind, which takes place when two opposing currents meet. In Italy the rule is,—

> "Non fu pioggia senza vento,
> Non fu vento senz' aqua."

And in the south of France they say,—

> "Quand le soleil est joint au vent
> On voit en l'air pleuvoir souvent."

This precipitation happens in two cases; the one when the warm current has forced itself through the cold one, and *vice versa.* The most frequent storms, drizzling showers, and raging snow-storms, come with a west wind. But this kind of weather lasts, as they say, only a span long. It cools the air, and a cloudless succeeds to an overcast sky; it is the transition from bad weather to good. The transition in this case takes place quickly, because the heavier cold wind forces itself easily into the place occupied by the warm wind. And on account of the cold wind being heavier than the warm wind which preceded it, the barometer rises during this kind of weather, and then we say—the barometer is on the rise,—it will be fine weather. Thus, too, if the cold wind forces itself in below, as it does into a warm room when the doors are open, it blows before it the clouds which it forms in its progress, and which darken the air as it advances through the sky. Now, in proportion as this cold lower current of wind is more or less directly opposed to the warm current, which until then had prevailed, there takes place between them in summer, the peculiar stillness which we term oppressive air. The expression, "the storm comes up against the wind," finds its explanation in the proverb itself. Just in proportion, then, as the wind gains in strength, the storm more quickly forms; thence the sudden obscuration of the sky which takes place without any previous warning. The rain, on the other hand, which the south wind occasions, when it drives away the north wind, draws near with a south-east and south wind. It first falls on the hills, and then descends below, causing the barometer to fall, because the wind which follows it is lighter; it is the transition from fine weather to cloudy. "The barometer is falling, it will be bad weather," we say,—the north-east wind has gone round to south-east; it will soon be south-west. At what point in the scale the barometer stands, signifies little, the principal thing is, if it be on the rise or the fall. Snow after severe cold, passing into thaw, storms which come with the east wind, and which, heavy though they be, do not cool the air, belong to this class. Rain with a west wind consequently becomes snow in winter, snow with an east wind becomes rain, snow with a west wind and a barometer on the rise, shews an increase of cold, snow with an east wind and a falling barometer, shews a diminution of cold. The proverb "fresh snow, more cold," has its origin hence, for it snows more frequently with a west than with an east wind. Besides this, there are falls of snow, at least of thick flakes of snow, when the cold is not very severe; this takes place when the cold northern current, having gained the predominance, drives away the southern current, and then no cause for precipitation any longer exists. The usual course of winter phenomena is as follows:—

The south wind has prevailed for a long time with the barometer low; the sky is overcast; the air warm, with a fine drizzling rain. Then the wind veers round to the west; dark masses of clouds rise on the western horizon, and a cold wind immediately begins to blow from them towards us, accompanied by thick falls of snow. This phenomenon repeats itself generally pretty frequently, during which time thin streaks of cloud may be seen through the thick masses floating much higher in the atmosphere from the south-west to the north-east. With every fresh blast of wind, the barometer rises suddenly, the snow freezes under our feet, the underlying strata of clouds retreat continually, at least they are torn up into strips and then disappear, when the weather vanes point due north. The sky becomes cloudless, the fight is at an end; its results shew themselves in bright slides on the ground; the air is wonderfully transparent, and it is only by the smoke which floats upwards from the chimneys that the sky is momentarily clouded; the cold now becomes intense, every one hastens his steps over the crackling snow; the north wind has conquered, perhaps for weeks together the vanes point unchangingly towards the north-east. But at last comes the south wind on the scene, and, because of its lightness, it flows above the north wind, and appears in the clear blue heavens as fine streaks of cloud, such as we appropriately term Wind baume (wind trees). The barometer remarks the gentle southlander and falls, although the weather vanes have not as yet perceived its presence, and steadily point as before to the north-east. But with still increased perseverance does the south wind press down on the east wind; the strips of cloud become denser, and appear as a milk-white covering, and a great halo round the moon shews itself as a sure sign of bad weather according to the lines:—

> "The hollow winds begin to blow,
> The clouds look black, the glass is low;
> Last night the sun went pale to bed,
> The moon in halos hid her head,
> 'Twill surely rain."

It begins next to snow with a south-east wind, the barometer sinks more and more, the wind becomes south, it rains, it is now south-west, and our short winter has passed by in order to be followed by a like set of phenomena. Farther towards the north, snow does not become rain with a south wind. There the snow of the whole winter does not thaw, but forms large masses; the sledge paths, too, are never broken up by thaw; every vehicle is changed into a sledge, and the frozen river becomes a highway. In these countries, there is a decided jump into winter weather, a jump which distinguishes a Konigsberg from a Berlin winter. If the south wind presses on with stormy quickness, then sleet falls, that is to say, drops of rain which have been frozen in their descent. The summits of the mountains, in such a case, are seen to thaw, whilst it is still bitterly cold in the valleys below. "The Fohn (south wind) drives the cold into the valley," the Tyrolese say. If, on the contrary, the warm and cold currents meet together, then the mixture of warm and cold air only takes place on the limits of contact of both currents. Thick mists in this instance are formed with the barometer high, because the northern current dams itself up as it were against the warm opposing south current. The two winds drive one another backwards and forwards. "They are fighting together," the sailors say, and thus we often pass from the limits of contact back again into the cold current, that is to say, the thick mist often disappears suddenly, and is again as quickly back again.

The most superficial observation shews that the weather is less variable in winter than in summer. In winter lasting cloudiness alternates with lasting brightness; whereas in summer entirely overcast and cloudless days are very rare. The reason of this is a double one. If I travel in winter, from Berlin to Moscow, I find a marked difference in the temperature; in July, on the contrary, it is almost equally warm in both cities. For the winds which do not come from any great distance lose their peculiarities, so that from whatever points of the compass they may blow they bring with them air of equal warmth. It is not till the winds are at rest that the influence of the soil first tells on the atmosphere in all its significance, an influence which, when it was entirely covered by snow, had wholly disappeared. The moisture which, rising from cool woods and meadows, is condensed into a cloud, is entirely dissipated by a warm surface of land. Hence those manifold masses of clouds which, in single separate masses, with a level base and dazzling hemisphere, float over the blue heavens, and impart such ever-varying beauty to a landscape when contemplated from a height. How delighted are we when, after having been long deprived of this beautiful sight, we see once more in spring these glowing cupolas towering up like mountains from the horizon, for they are a sure sign that winter is come at last. In summer, the clouds are in general nothing more than an image of the ground projected on the sky, and in proportion as the landscape is diversified by meadows, rocks, and woods, hills and valleys, so much the more beautiful is the sky. Hence, on the northern declivity of the Russian Riesen Giberge and over the fruitful plains of Silesia, the summer heaven is much more beautiful than over the Markischen Heideland. The practised eye of the Indian traces in the sky the course of a river in countries where from the absence of civilisation no artificial means have been at work to modify the natural diversity of the ground, and it is clear that as a rank vegetation generates rain which again in its turn nourishes the soil, so an injudicious destruction of woods often destroys irrevocably the fertility of the soil. Here the periods of the day have each their significance. As soon as the sun rises, the morning clouds ascend like pillars of smoke out of the valleys, but soon disappear in the increasing temperature. Towards noon, they again appear in the sky like a thin veil, or sometimes they resemble flocks of sheep according to the English saying,

> If woolly fleeces strew the heavenly way,
> Be sure no rain disturbs the summer day.

In the south of Europe, on the contrary, the clouds which bring wind to us take the form of sheep, and it is from this circumstance the following proverb takes its origin,

> Brebis qui paraissent ès-cieux,
> Font temps pluvieux ou venteux.

According to Virgil and Aratus the "vellera lanæ" are a sign of rain.

But to return to our subject. If the ascending current of air is protected against lateral currents by high mountain walls, or rises from a valley in which an alpine lake is situated, then as often as for fourteen days together a storm takes place at noon, as on the Lago Maggiore and the Lake of Como, because the cold current seizes on the warm air at the moment it rises above the mountains. The like phenomena characterise the rainy season in the region of calms. Thus, at a stated period of the day, a storm regularly begins in those climates, so that the Brazilian ladies do not, like those in Berlin, invite their friends to tea and coffee, but request the pleasure of their company "before or after the storm." In the evening, the contrary process takes place, the gradually cooling air loses its expansive power, the clouds sink down on the mountain, and are again dissipated in the warm air. This clearing up is not, however, a sign of lasting fine weather, according to the French proverb,

> "Temps qui fait beau la nuit—
> Dure peu quand le jour luit."

The spectacle of the dissipation of the clouds at the setting of the sun, enlivens a walk amidst even the most solitary scenery. The air becomes transparent—and every form is sharply defined against the clear sky. And if the moon should chance to shine in the cloudless heavens, the scene becomes so beautiful that it drives all thoughts of meteorology out of one's head.

The difference in the configuration of a country has also a modifying effect on all the phenomena connected with this ascending current of air. Under this class of phenomena may be chiefly reckoned the rain precipitation which takes place more regularly at certain times of the day than at others. Thus, for one thunder or hail storm which takes place at four o'clock in the morning, sixty-seven come on at two o'clock in the afternoon. Great and magnificent as these phenomena appear, they are still only local, and, therefore, the per-centage of the Hail Insurance Company varies for different provinces. A hail-storm is seldom more than half a mile in breadth—a small, desolating strip. Snow falls in winter, sleet in spring, hail in summer. The warmth of the atmosphere decreases now, however, from below upwards. This is why snow in the higher regions takes the form of sleet whilst falling, to which, when it has descended into the warmer and lower strata, a transparent crust of ice is added. Whilst pieces of nearly a pound weight are falling, a lateral whirlwind, which apparently comes in an oblique direction and continues warm for some time, mingles the moist lower air and the cold upper air together.

In Berlin, even, we have tolerably severe hail-storms now and then. Our weather is, however, better in this respect than it has the character of being. Why, then, has it gained such an ill name?

A distinguished foreigner visited Berlin in the year 1767, and was invited by Frederick the Great to San Souci. "Of what do they talk in Berlin?" asked the King. "That your Majesty is arming, and that there will be war," was the reply. In order, therefore, to give a different turn to the conversation of the metropolis, the King commanded a report to be drawn up of a severe hail-storm at Potsdam, which was to be copied into the Berlin newspapers, with directions to take no refutation. The reporter laid on his colours pretty thick. Masses of ice of the size of a pumpkin had fallen; all the windows had been shattered; a brewer had had his arm broken; and one of two oxen yoked to a waggon had been killed. On the arrival of the Berlin newspapers at Potsdam—where there had been most beautiful weather during the whole time—astonishment and vexation laid hold of every body's mind; the neighbourhood rose as one man, seized pen in hand, and protested solemnly to the contrary of what had been stated. Never had the posts in Berlin received so many letters; each of them asserting that everything was going on as usual in Potsdam, that nothing extraordinary had taken place, no windows had been shattered, no one's arm broken, no living being killed. But none of these letters were published; the news was copied into all the papers, and the King's design had perfect success. Everywhere the hail-storm, and nothing but the hail-storm, formed the subject of conversation. As the report was never contradicted, it was transcribed into all the scientific compendiums of the day; for at that time people were still possessed by the extraordinary idea that everything contained in a newspaper must be true.

We must not, however, over-estimate the influence of the configuration of the ground and of the soil. They may, indeed, foretell or decide the course of a storm, but they cannot retard continued rain. For even in summer the currents of air are the peculiar precursors, only in very different forms at different seasons of the year; forms however which are all related to each other. If the south wind in winter rushes very suddenly, and with great force, towards the north, it often announces itself by a magnificent storm, as it did in December 1839, when the sky seemed to be rent open by the lightning, and crackling peals of thunder resounded every moment. Unusual warmth is ushered in with storms like these. Later on, the south wind appears in the form of the gentle messenger of spring, beneath whose soft breath nature awakes from her heavy sleep, as out of a long dream, and wakes us with her. The strife between the two currents then becomes animated, for winter disputes every inch of the ground. The cold days "die gestrengen Herren," those hard masters who slew the orangery at St Louis are sent as its last despairing efforts. In summer, the south wind often blows suddenly as out of a fiery oven, and roars furiously around. I remember the passionate raging of this wind during last summer, when it tore off the zinc roof from the Anhalt Tower, and by the manner in which the trees were rooted up in the Thier Garten, it clearly shewed its power—a storm beneath whose raging, Germany's most honoured tree, "The beech of Luther," was torn up and destroyed. I do not know where the cradle of this storm was situated, but the newspapers told us that it came over the Alps, so that, at all events, it was not a German wind which was guilty of such crimes.

We can, however, often trace such storms as these to their origin. They are generally parts of the upper trade winds which, descending too early, come into contact with the lower currents and occasion those fearful whirlwinds of the Tropics, the influence of which is felt even in the temperate zones.

In Emmenthal they have an old legend, that a gigantic serpent lay concealed in the caves of the Hohgant, and that for centuries it had never left its abode, till at last it burst forth suddenly with fearful rage. We easily recognize in this gigantic serpent the mountain torrent, which, suddenly swollen by clouds, rushed down into the windings of the valley. Since then nothing more had been heard of the monster, until in August 1837 it again broke forth with such fearful violence that masses of rock of 60 cwt. were hurled before it. The beautiful tale of the "Wassers noth im Emmenthal," by the author of the "Bauern Spiegels," contains a striking description of this great physical phenomenon. But what was it that had scared away the monster from his cave? A storm of wind from the West India islands. And what a storm! On the 2d of August 1837, the harbour-master at Porto Rico announced to the captains of ships lying at anchor, at about four o'clock P.M., that they must prepare for a storm, as the barometer was falling rapidly. But all precautions were in vain. Of the 33 ships lying at anchor not one could be saved from shipwreck, for so great was the violence of the wind that in St Bartholomew alone 250 buildings were thrown down. The destruction was still more fearful on the Island of St Thomas, where the wrecks of 36 ships strewed the harbour; the fort at the entrance of the port was shattered as if by a battery, 24-pounders were carried away by the wind; a large well-built house was torn up from its foundations, and set down upright in the middle of the street, whilst others were turned right upside-down. That smiling tropical heaven plays also tricks of its own.

In so far as the history of the world mirrors itself in the events of the most insignificant places, so also the history of the weather is contained in the meteorological phenomena of every single station of observation. The reports kept at these places form the chronicles of a general history of the weather; but as we cannot grasp all the threads of the world's history by the consideration of any one isolated event, so we cannot arrive at the understanding of all the manifold and closely connected phenomena of the atmosphere by means of observations made at any one place alone. Only out of the association and comparison of separate reports can be determined what is settled and what is variable, for the errors made by a single observer often make a phenomenon appear enigmatical, which by taking the total of observations respecting it would at once be rendered clear. If from the consideration of the phenomena of our weather we have arrived at the conclusion that they represent the continually renewed strife of two opposing currents, it follows that what is revealed by the regular succession of phenomena in one place must be revealed in a clearer and more direct manner if we bring under our consideration simultaneous and widely diffused observations. The power, the direction, and the strife of the two currents will in such a case be clearly represented. If, for example, we desire to settle the usual characteristics of the weather at any particular time, then by proceeding in the direction of these currents, we shall find either the maximum or the minimum of the normal temperature. If, on the contrary, we proceed in a direction more or less at right angles to the currents, then, somewhere or other where they meet and intersect each other, we shall pass from the warm air of the Equatorial into the icy air of the Polar current. If the currents meet one another, then this opposition in their direction comes into play. Next, we shall perceive that while the opposing currents flow simultaneously beside each other, the same peculiarities of weather are scarcely ever common to the whole hemisphere; that the extremes in near and in distant countries are always compensated for, and the equilibrium maintained; and that a mild European winter is made up for by a cold one in

America or Asia. Thus the same amount of temperature is always preserved, and local luxury is elsewhere atoned for by biting poverty.

In this last particular a very great difference exists between the relative temperature of Europe on the one side and of America and Asia on the other. The temperature of the winter of 1821-22, and the January of 1834, was apparently only so strikingly high on account of America and Asia having then such severe winters. In December 1829, the greatest proportional cold was felt at Berlin. It was also very remarkable at Kasan, but at Irkutsk the weather was mild, and America was favoured with an extraordinary degree of warmth. The celebrated winter of 1794-95, which was famed for the conquest of Holland, was mild in America, as well as that of 1809; whilst in Europe, the strikingly mild winters of 1793-94 and 1795-96 fell much below the mean temperature in America; and the warm European winter of 1790-91 was compensated for by a cold one in America. Egede has remarked the same thing of Greenland; and the Danes have observed that if the winter has been severe in Denmark, the Greenland winter has been mild, and *vice versa*. These remarks apply to Copenhagen also, in connection with Iceland, and to such an extent that the exportation of goods from Denmark to that island is, in some measure, guided by it.

If the limits of the two currents fall towards Europe, then the usual weather shews itself here, whilst the extremes lie on both sides of it. Thus, in February 1828, Europe enjoyed a mean temperature between the extreme cold of Kasan and Irkutsk, and the mild winter of America. On the other hand, when the opposing currents become due east and due west, America, Europe, and Asia belong to the same system of weather, whilst the oppositions take place in the direction of north and south. Thus, in December 1802, the greatest degree of cold was felt in central Europe, but it was also cold in Asia and America, whilst in Scandinavia the temperature had risen. On the contrary, during the mild March of 1822, a decrease of temperature took place in the south, whilst it was raised in the north of Europe. In the cold autumn of 1820, the warm places lay on the north-west of Europe; during the severe winter of 1799, in Greenland; and during the mild winter of 1824-25, first on the north and then on the south of Europe. These oppositions characterizing the north and south are also occasioned by a north and south current meeting each other. In the December of 1808, for example, cold weather prevailed in Europe from Torneo to Palermo, which decreased towards the west, and was not experienced in America. In the January of 1809, a very mild temperature distinguished the south of Europe, whilst the cold, the diffusion of which was apparently obstructed towards the south by south winds, was on that account more strongly concentrated in the north of Europe, and was increasingly felt in the direction of Berlin, Dantzic, Stockholm, and Torneo. The increase of warmth was now felt in a westerly direction, and became remarkable, first in Scotland, and then in America. In February, the warmth advanced from the south up to Berlin, and as far as Dantzic, and the cold was moderate in Sweden. In March it took ground again towards the south, then Dantzic and Berlin were brought once more under its dominion. At last it prevailed again in April over the whole of Southern Europe, but was not proportionably felt in America. If northerly currents are, however, the principal cause of the lowering of the temperature in the winter, still the place where the greatest relative cold prevails, especially in the spring, is not dependent on that cause alone. The pressure of a southerly current through a northern one is, as a rule, associated with a heavy fall of snow, which takes place in the higher mountains also, during the prevalence of the southern current. Then the masses of snow which have been heaped up on the heights during the winter form a centre of refrigeration when the spring has already commenced in the plains below, and occasion frequent returns of cold. The cold air then discharges itself in the form of cataracts and waterfalls, which pour down the sides of the Alps. One may easily trace this cold in Berlin, where it arrives, for example, with a south wind. Those who dwell in the place where this cold reaches its maximum, form an exaggerated idea of the extremes if they do not take into consideration the diffusion of warmth in other places. Thus, in the Berlin papers the winter of 1823-24 was mentioned with great emphasis as a hitherto unheard-of occurrence. It was certainly severe, but it was felt only near Berlin, and the weather was much milder in the south of Germany. The atmosphere took very little note of the ideas entertained by many Berlin writers, that it must have been general. For, when with its proud waves it flowed over the Alps, was it likely, they thought, that its progress should be stopped by the walls of our city? The winter of 1740 was also very severe, as well as that of 1840, in which it solemnised its jubilee. Such isolated extremes as these deceive the judgment for a long time; and it was an instance of the same kind, occurring in the climate of France during the war, which gave our troops, who made acquaintance with the country when it was experiencing an accidental degree of cold, much too unfavourable an idea of its climate. They judged of it by the severe winter of 1813-14. The opposite errors are committed by German travellers, who go into Italy to winter, and needlessly expose themselves to the bitter cold of Lombardy. No one could wish that every traveller should be transformed into a meteorologist, still every one ought to know that January is colder in Milan than on the west coast of Iceland.

If extremes of weather have prevailed for a long time during winter, then as the sun's power increases with the advancing season, the spring has already begun in the countries which had a mild winter; whilst in places where the severest cold had prevailed, the temperature has not risen much above the freezing point, and the increased warmth is spent in melting away the winter's ice and snow. The warm air must, however, before long successfully oppose the pressure of the cold air, the return of which will only be the more sudden, the more suddenly the warmth has increased. In such cases as these the spring is unpleasantly distinguished by frequent transitions from warm to very severe weather. It is on this circumstance the proverb is founded which foretells a white Easter from a green Christmas. Hence, too, the English couplet—

> "If the grass grow in Janevier,
> It grows the worse for all the year."

And the still more decided one—

> "If Janevier calends be summerly gay,
> 'Twill be winterly weather till th' calends of May."

In Italy, too, they say—

> "Quando Gennajo mette erba,
> Si tu hai grano, e tu lo serba."

The warmth in the south of Germany 1839, and afterwards in Northern Germany in December, was so great, that people wrote from Munich that they had never till then expected to see the description of an old chronicle realised, that young maidens had come to Church on Christmas eve with roses in their hair. But how soon was this dream dissipated. The icy wind, beneath whose deadly breath those early flowers bloomed, blew from the Salz-steppes, between the Caspian and Oral Seas, from the country which the Kirgisites call the Valley of Death, and from the coast of Emba, where the Russian expedition to China came to a halt in a cold of 40° F. below zero. The cold then experienced was more severely felt on account of its having been preceded by an unusual degree of warmth. In any other year the result of the expedition might have been very different. It is a remarkable thing, that the same power of nature which had obstructed the designs of Russia stopped Napoleon's proud career. And it is still the same Gorgon shield which prevents the West from pressing forward into the immoveable East. The cold current does not, however, always lie towards the East. The winter of 1834-35 gives a striking example of this.

The greatest observed cold at Berlin in January, February, and March, was 18°·5 Fahr.; the medium temperature of these three months was however 30°·875, 27°·5, and 22°·25 Fahr.; and what is still more striking, not ten days followed each other consecutively during this period, the mean temperature of which fell below the freezing point. That this phenomenon was occasioned by a southern current is therefore clear, the most significant wind of the north current, the NE., not having been once observed from the 1st of January to the 18th of March. During this time such a fearful degree of cold prevailed in America, that at the beginning of January the harbours of

Boston, Portland, New Bury, New Haven, Philadelphia, Baltimore, and Washington, were frozen over; and on the 3d, when the thermometer at Berlin stood all day and night above the freezing point, carts passed over the frozen Potomac.

The cold Easter of the year 1835 must be still in the remembrance of every one. Thick falls of snow gave a very winterly look to Good Friday, on the Banks of the Rhine, from Bonn to Mayence, although the peach and cherry trees were covered with blossom. In Berlin the wind blew from the SW., but without any snow. Generally the weather was much more stormy on the banks of the Rhine than at Berlin. It was still worse in England, where the cold set in on the Wednesday evening. It snowed as in December, and froze on the open plains during the daytime; the blossom, too, was much injured, for this severe cold had been preceded by beautiful spring weather. The waggons which entered London from the north on Good Friday were covered with snow. An unusual degree of cold was also universally felt in Italy. It was more severe in westerly countries than in the east, for it came from the west. Such phenomena as these repeat themselves generally after some time with diminished strength, then they suddenly cease, and winter is finally conquered.

If it be supposed that a cold winter always follows a hot summer, it is as much as to say that the current which flowed over the place of observation during the summer would flow in the same direction during the winter. That certainly would be much to gain from a current that is never arbitrarily confined to one bed.

During the hot summer of 1822, there was no ice to be had in Berlin, for the preceding winter had been so mild that they had not been able to collect any. The years 1811-19-22-34, which are celebrated as good vintage years, were preceded by mild winters or springs. On the contrary, the cold which lasted from January to June 1815, was followed by a period of scarcity of which Western Europe will long retain the remembrance. It was then that Odessa, which during that time enjoyed the mild temperature of Eastern Europe, became celebrated for its commerce; its annual exports of grain, from 1815 to 1817, increasing from 11 to 38 millions of roubles. The relative extreme of cold was experienced during that year in England, and America had also its share in the decrease of temperature. The west of Europe, therefore, looked to the east as a general source of supply during that period. The repetition of these relations in connection with England during the years 1837-38, during which time East Prussia had favourable weather, stands in direct association with the briskness of the discussion on the Corn-law question, for the more unshackled the commercial intercourse of nations becomes, so much the more impossible is it that a famine should take place; the trading resources of a country where scarcity prevails being used as the means of obtaining supplies from a country distinguished for temporary abundance.

*On Glacial Phenomena in Scotland and Parts of England.** By ROBERT CHAMBERS, Esq. F.R.S.E. Communicated by the Author.

The subject of ancient glacial phenomena having been much before the public a few years ago, I must entreat the Society to believe that I should not have sought their attention to it again, if I had not during the last three years seen reason to believe that it has as yet been but imperfectly presented, and that English geologists in general have arrived at conclusions regarding it which cannot be maintained.

It would detain us too long, and be in a great measure labour thrown away, to renew the combat with those who think that diluvial action in any form is sufficient to account for the phenomena in question. I can scarcely even pause to argue with those who hold that floating ice is the only agent required in the case. If the gentlemen who abide by such doctrines would examine the action of an existing glacier in the Alps, they would find that the effect upon the subjacent rocks is absolutely the same with the appearances of what are called polished and striated surfaces in these islands, where glaciers do not now exist. If they were to travel through Norway and Sweden, they would see such an extent of surface abraded, and an uniformity of striation observed over such large areas, that so light, partial, and irregular an action as that of floating masses of ice would appear totally inadequate to account for the effects. It need scarcely be insisted on, that opponents of theory are as much bound as theorists themselves to observe the ordinary rules of science, —namely, to argue on the unknown from the known, to look more carefully to distinctions than to resemblances, and to give no presumed agent too much to do. Now, I have seen what I consider an ice-polished surface crossed by a small runnel of water carrying minute gravel, and it was clearly observable that where the water crossed, the surface was changed,—became rougher and dimmer, something like the difference between chased and polished goldsmiths' work. I have examined the rocky beds of many mountain streams

* Read before the Royal Society of Edinburgh, Dec. 6 and 20, 1852.

accustomed to bring down all sizes of gravel, but never found in any instance those flowing outlines of abrasion which we see in the so-called glacial surfaces. There is a palpable enough difference, moreover, between the confused masses of mud and sand, mingled with rounded blocks, which are found in connection with polished surfaces, and the sorted materials, gravel, sand, and clay, which are indisputably attributed to watery action. I cannot entertain any doubt that, had these specialties in the respective effects of the two agents been carefully looked to, we should have had much less controversy on this subject, and we should by this time have arrived at results much more satisfactory.

With minds rightly prepared by observation of what ice actually does in the countries where it now works, I could no more expect to see these differences overlooked, than to find in ordinary life men attributing saw-dust to the action of a plane, or chips to the operation of a saw. As for icebergs, they have doubtless played a part, if not in the abrasion of rocks, at least in some of the associated phenomena of the superficial deposits; but to attribute to them the whole phenomena is utterly unwarrantable. If any man were to say, that because he can with some difficulty smooth a rough surface of wood with his thumb-nail, therefore his dining-tables must have been fashioned and polished by the joiner with that little instrument alone, I would consider him as advancing a theory fully as tenable as that which consists in attributing all the so-called glacial phenomena to icebergs. It is really, however, no want of charity to say that much of the opposition to glacial theories arises from an inadequate acquaintance with the phenomena of smoothed rocks and the various deposits laid over them, and an over-faithful attachment to, or misapplication of, certain theories of older date.

Ancient Moraines connected with Corries or small Valleys.

When proofs of ancient glacial action in Scotland were first looked for in 1840 by M. Agassiz and Dr Buckland, a great number of ancient moraines were announced in the middle and southern districts, as well as in the Highlands. There cannot, however, be the least doubt that both of these observers were misled by the novel features of our superficial formations, and in many instances mistook for results of glacial action what were in reality alluvial accumulations, most of them being those ancient deltas of mountain streams which are so often found where narrow side glens join the principal valleys.

Amongst the contemporary observations of Sir Charles Lyell, two objects are cited, which answer so entirely to the character of ancient terminal moraines that I cannot doubt their being of that character. They occur in the small elevated valleys on the skirts of the Grampians, which contain the Lochs Whorral and Brandy. "Loch Brandy," says Sir Charles, "is surrounded on three sides by lofty precipices of gneiss, while on the south it is bounded only by an enormous accumulation of sand, mud, and fragments of rocks, evidently derived from the cliffs which overhang the lake on the east, north, and west." We only can account for an accumulation of such a kind in such a position by supposing the action of a small local glacier. The two lochs are 1500 feet above the sea. Professor Ramsay has lately discovered lakes in North Wales formed by dams which he believes to be ancient moraines; and Mr Darwin has described similar objects as occurring in South America.

Professor J. D. Forbes's Observations on the Cuchullin Hills, published in 1845, included descriptions of the general glacial phenomena of that district, which are certainly of a most striking character, the whole central valley, in which Loch Coruisk lies, being shaven bare and striated, with a vast number of blocks scattered over the surface, many of them in situations where ice alone could have placed them. Yet it is remarkable that no true moraine exists in this glen; that is to say, no train or ridge of the rough detrital matter marking the sides or skirts of an ancient glacier. Professor Forbes describes one true and unmistakeable moraine as forming "an elongated semi-oval" round the mouth of a deep *corry* on the outside (westward) of the Cuchullin group. He also adverts, in less confident terms, to something of the same kind at the mouth of the Corry-na-briech,—a short abrupt valley, likewise looking outwards to the north-west,—

where, however, I failed to trace any object which realised to my mind the idea of a true moraine. When our associate Mr Maclaren, in 1849, gave us his accurate summary of Glacial Phenomena in Scotland, he justly remarked the *rarity of ancient moraines;* but he next year described to the British Association an object which he thought might prove to be of that kind, which he had found in Glen Messan, a small valley connected with the Holy Loch, on the Firth of Clyde.

Such may be said to be the present posture of this branch of our subject. I have now to enumerate a few ancient moraines which have come under my own attention in Scotland.

To the eastward of the Cuchullin group, and divided from it only by Glen Sligachan, a wild valley full of polished and striated surfaces, is the lofty mountain called Ben-Blaven. A short abrupt valley, called Corry-hashtel, cleaves its south side, terminating at the sea near the farm-house of Camusunary. About half way down this corry, on its west side, commences a long train of blocks, in three separate and distinct lines, followed farther down by three ridges of blocks mingled with mud, forming, beyond all question, the lateral moraines of an ancient glacier which had descended through Corry-hashtel, the outer line being the chronicle of its greatest magnitude, the second marking its limit after it had shrunk, and the third indicating its final condition. Another and still ruder corry, descending the east side of Ben-Blaven, with the lower summit of Garravine on the right, presents at its mouth two or three distinct ridges of blocks mingled with mud, which have evidently been the terminal moraines of a glacier once filling that corry, and which had experienced a similar shrinking. In this corry I found striated rocks.

In the savage alpine district extending along the west coast of Ross and Sutherlandshire, moraines of this kind are not uncommon. Indeed, in most of the high valleys of this desolate tract, we find rude masses of detrital matter which have evidently come, by means of glacial action, from the neighbouring hill sides; but I propose to specify only those which take an unmistakeably moraine form. On the south portion of the lofty old red sandstone hills of Applecross, there is a short but deep valley issuing upon the road, about three miles from Keeshorn. At the mouth of the valley, and near its rivulet, large spaces of bare rock are polished and striated, the striæ being from N. 30° W., and thus conformable, as is customary, to the major axis of the valley. Round the mouth of this valley are curving ridges forming true moraines.

In the valley in which Applecross House is situated, lumps, lines, and cones of similar detritus, generally bristling with large blocks, are scattered over a wide surface, and I found amongst these one decided set of curving ridges, having the concave of the curve turned in the most significant manner to a deep lofty recess in the side of the glen. These I consider as true moraines, the product of a glacier formed at some remote period in Corry Glas, the recess pointed to.

North of Loch Broom, on the west coast of Ross-shire, is a huge mountain named Ben More Coigach, of a triangular form, and having very precipitous sides. In a deep dark valley to the north of this mountain, a scene of extraordinary sterility and rudeness, I found a striking collection of hummocks and ridges of detrital matter, with some huge blocks perched on the summits of rocky eminences. At one deep precipitous corry towards the east, there was a regular curving ridge of detritus, rough with blocks, having the concave side of the curve turned towards the corry, from which it is not more than a quarter of a mile distant. This I also consider as a true moraine.

In Assynt, Sutherlandshire, the eastern slope of the mountain Canisp extends in a tolerably straight line for several miles from the east end of the loch. At two places there are slight hollows in the line of slope, and *apropos* to these there are moraines in the valley below, filling its breadth of a quarter of a mile, but partially demolished by the rivulet which seeks its way amongst them. In both of the hollows, the white quartz rock is polished, with *striæ* pointed straight down hill, clearly the effect of the glaciers which deposited the moraines. What strikingly affiliates the moraines or detrital ridges to the recesses in Canisp is the fact, that the outermost lines lie close under the *limestone* cliff on the other side of the valley, but nevertheless contain only masses of quartz derived from Canisp.

The only other detrital phenomenon of the kind here adverted to which I have to mention, is one in Glen Messan, a branch of the greater valley, containing the Holy Loch, in Argyleshire. Not far from the mouth of this glen, close above a place called Coruisk, where another branch glen joins it, there is a lofty mound of detrital matter, smooth in the surface, and covered with turf, forming a sort of barrier across the valley, but leaving an opening at the north extremity, through which runs the little river Messan. This, I suppose, is the moraine which Mr Maclaren introduced to the notice of the British Association in 1850. I do not presume to decide about the actual history of this remarkable and singular object, but would merely remark that some caution will be necessary before deciding that it is the moraine of a glacier which has descended Glen Messan, as, considering its relative situation, and remembering similar objects in the valleys of the Alps, it may be the left lateral moraine of the glacier of the branch glen which issues into Glen Messan close by. However this may be, there is an example of the true moraine in Glen Messan, about the origin of which there can be no mistake. It occurs at a place called Stronlonaig, about three miles above Coruisk. There is here a corry on the south side of the glen, a rude savage recess, enlivened only by a tumbling torrent. In the bottom of the glen, two short lines of moraine matter curve towards the mouth of the corry, but at such a distance that no watery action connected with the corry could account for them. Besides, between the ridges and the mouth of the corry, there is a *talus* of gravel, the separate and characteristic result of such watery action, and evidently of later origin. In short, there has first been a glacier in this corry, descending into Glen Messan, and leaving there two terminal moraines in succession; afterwards, this has passed away, and been succeeded by the present system of things, during which the rivulet has formed a *talus* of debris circumscribed by the inner moraine.

Ancient Glaciers in Limited Mountain Districts.

A short excursion in the Lake District of the North of England in April 1852, satisfied me that that district had been the seat of local glaciers, each of which moved down its respective valley, and I have since found that Mr Maclaren came to the same conclusion from what he observed in the same region in 1850. A few stray glacial phenomena had been previously observed in the district by Dr Buckland, Professor Phillips, Mr Bryce, and others.

Overlooking Skiddaw and Saddleback, which stand comparatively isolated, the mountains of the Lake Country form two or three centres of peculiar elevation, from which the valleys containing the lakes take their origin. The principal centre is at Scafell and Bowfell, from which Borrowdale descends to the north, the valley of Coniston Lake to the south, and Wastdale to the west, while to the south-east descend various minor vales which meet at the head of Grasmere, and are continued in the great valley of Windermere. The vale containing Thirlmere also has its head in this cluster of mountains. Another centre is formed by Kirkstone Fell, Rydal Head, and Helvellyn, whence descend the valley containing Ulleswater on the one hand, and the vales of Rydal and Kent on the other. Between the vales which meet at Grasmere, and that containing Thirlmere, there is a valley of passage, the summit of which at Dunmail Raise is 760 feet above the level of the sea.

In all of these valleys which have been examined by Mr Maclaren and myself, namely Borrowdale, the Ulleswater valley, those of Thirlmere, Grasmere, Windermere, and Kent, we have found unequivocal memorials of ancient glaciers descending in them respectively.

The chief of these memorials are prominent masses of rock by the sides of the valley, presenting rounded and polished surfaces towards its head, with rough faces downwards, the polished surfaces being farther grooved and striated in the direction of the valley, whatever that may be. Rocks so marked are particularly conspicuous near the site of the famous Bowderstone in Borrowdale. The lofty hummock on which that large mass has fallen from its parent cliff above, is itself partially abraded and smoothed by ancient ice. Various prominent masses at Lodore, at Grange, and on the west side of Derwentwater Lake, are in the same condition, none, however, so strikingly so as a platform of flat bare rock near the bridge at Grange, extending to the length of forty-two paces, and still retaining its original glassy polish and striation, notwithstanding its being subject to much wearing, in consequence of its proximity to a public road and to a farm-house. About a mile above this point, the extensive basin, embraced by the arms of Scafell and Bowfell, and which must have formed the gathering place of the snow forming the glacier of this valley, contracts into a comparatively narrow space, and there the polished surfaces are particularly conspicuous. Just above the point of contraction, these polished surfaces are slightly roughened, and bare masses of partially water-worn materials laid against them. I was at a loss to account for these facts, as the rivulet runs through a rocky channel forty or fifty feet below, until I observed that the passage for the river is through a chasm, the sides of which, angular and rough, are altogether in contrast to the neighbouring polished surfaces. It clearly appears, that, before the river had cut out this channel, it had formed a lake in the open valley above, and that to the action of this lake we are to attribute the slight roughening of the previously glacialised surfaces, and the accumulation of water-worn debris.

The abraded surfaces at Patterdale, in the Ulleswater valley, are scarcely less remarkable. Near the inn at the head of the lake, there is so much of this sterile surface presented, that the place reminded me much of certain parts of Sweden. The two partially-wooded islets near the head of the lake, rounded, shaven, polished, and only admitting vegetation in chinks, are exactly like the numberless *roches montonnées* which gem the Christiania-fiord, and, indeed, the whole of the sea-board of Norway. As in the case of Borrowdale, there is an extensive basin suitable for the collection of snow at the head of this valley, and hence we might expect a glacier of considerable magnitude. My observing glacialised surfaces fully 200 feet above the lake is not, therefore, surprising. Mr Maclaren speaks of a striated *vertical* face of rock on the west side of the deep narrow valley of Troutbeck, 500 feet above the bottom of that valley, indicating a glacier of still greater depth.

In the Thirlmere valley, for several miles down from the summit at Dunmail Raise, I could find no glacialised surfaces; but at length they became conspicuous at a place opposite Armboth, near the lower extremity of the lake. Between this place and Keswick, four miles from that town, I found a considerable surface, exposed in consequence of quarrying for road-metal. The whole was beautifully polished and striated, the direction of the striæ being a little west of magnetic north, and thus coincident with the major axis of the valley. In all of these cases, there are unequivocal appearances of a *stoss seite*, or exposed side to the south, or up the valley.

For some miles below Dunmail Raise, in the Grasmere valley, there are, in like manner, no abraded surfaces; but they present themselves on the north side of that lake, with striation pointing to N. 25° W., being the direction of the valley at that place; likewise in a low field south of Rydal, and in Dr Davy's garden, near Ambleside, where the direction, however, of the striæ is more easterly, and towards Rydal glen. On the high ground over which the bye-road passes between Grasmere and Skelwith Bridge, there are mammillated rocks, with striæ from N. 25° W., or nearly magnetic north, a direction from which it would be difficult for any such agent to come to such a place. At Birthwaite Railway Station, near the shore of Windermere, there is a large recently exposed surface, glacially polished, and bearing striæ of the same direction, being that of the valley of Windermere.

In the valley of the Kent, near Stavely, there are several examples of abraded surfaces, one of which has been accurately described by Mr Bryce. It is situated at a place called Jacob's Wood, and having only lately been exposed, it is in the finest possible condition. The slate (Lower Ludlow rocks) is here remarkably hard, insomuch that an attempt at quarrying it has had to be abandoned. A surface, fifty-three feet long by fifteen broad, is laid bare by the removal of a coarse brown detritus containing boulders. It presents four bosses, side by side, in the direction of the length, and the whole is beautifully polished, with finely-marked striation across the planes of stratification, being in the direction of N. 46° W., [Mr Bryce says N. 34° W.,] thus pointing towards the eminence forming the west side of the upper and more mountainous portion of the Kent valley.

A detritus of half-worn blocks mixed up with a brown mass of clay and sand, precisely resembling the moraine matter left at the sides and extremities of existing glaciers, is deposited in various parts of the Lake valleys, in immediate contact with the polished surfaces, and generally in the lee of eminences. It is generally where such matter has been excavated for the making and repairing of roads, that we find the best examples of polished surfaces, the detritus having served as a complete protection to the vitreous polish left by the abrading agent. As far as I have observed, the superficial matters do not anywhere, in the central parts of the Lake District, present the peculiar forms of either lateral or terminal moraines, except in one instance, in the Thirlmere valley, near its head at Dunmail Raise. There, in the angle between a side valley and the principal one, we find a long ridge of rough detritus with many large blocks, extending down the hill-face. An inexperienced observer would be at a loss to understand the relations in which such an object could stand towards any imaginable glacier hereabouts; but one who has seen the moraines of the Glacier des Bois and the Glacier d'Argentière in the Chamouni valley, would quickly perceive that this, in reality, is the right lateral moraine of the glacier which issued at this place into the Thirlmere valley, from one of the high glens which ascend into the mountain chain of Bowfell. Mr Maclaren's moraine in Glen Messan has been surmised as an object of precisely similar history.

Not far from the moraine just described, on the summit called Dunmail Raise, which is a valley of passage between two ordinary valleys, there is a great mass of detrital matter, through which the infant rills of the district have made deep passages, shewing the hugeness of the deposit. I regret that I did not examine this mass very carefully; but I am satisfied that it is a different kind of detritus from the brown moraine matter already described, most probably the blue boulder clay. It is very remarkable to find a different detritus in a situation obviously out of the reach of the glaciers of the valley system here described.

Dr Buckland, in 1840, announced objects in the vicinity of the lake country, which he believed to be moraines connected with its valleys. Thus he traced the spoils of the Patterdale and Ulleswater valley in "extensive moraines loaded with enormous blocks of porphyry and slate," in the vicinity of Penrith. At the vomitories of Long Sleddale and the Kentmere valley, he found "large and lofty piles of gravel." The districts of Furness, Ulverstone, and Dalton, to the south of the lake region, he described as "extensively covered with deep deposits of glacier origin." Dr Buckland had not been able to examine the western outskirts of the districts; but he believed that many hillocks laid down there in masses were remains of moraines. Seeing that the learned geologist, in the novelty of the investigation, mistook some alluvial accumulations in Scotland for ancient moraines, I cannot bring forward these observations as conclusive upon the subject; and I must regret that I have not been able to contribute any of my own. Now, however, that the valleys are known to have been filled by glaciers, it may be hoped that some local observers will institute an inquiry to ascertain whether their detrital spoils remain in definite forms at their vomitories, or have been carried away and dissipated over the neighbouring country.

From the whole phenomena, I infer that the lake country has at one time been the seat of a radiating system of glaciers. I regard it as a complete and well-defined example of *glacial action in a limited mountainous district*, where the direction and slope of the valleys clearly determine the ice-streams. It is easy to see how the spacious basins of elevated ground embosomed amongst the heights of Scafell and Bowfell on the one hand, and Helvellyn, Rydal Head, and Kirkstonefell on the other, formed the *berceaux* of the various glaciers of whose course we have described the memorials. And as such basins are necessary for the formation of glaciers, we can readily understand why no traces of glaciation are to be found in the higher parts of the valleys meeting at Dunmail Raise, as also why a mass of peculiar detritus is left there. That place had been out of the scope of the glaciers here spoken of, and its mass of detritus may be regarded as probably the result of some earlier operations.

From the descriptions which have been given us of the Snowdonian regions in North Wales by Dr Buckland, Mr Darwin, Professor Ramsay, and others, and from what I have seen of it myself, I entertain no doubt that it is another example of a *limited mountain district once occupied by local glaciers*. Seven valleys radiating from a centre of elevation present, along their sides and bottoms, rock faces which have been ground, smoothed, and striated by ice, the striæ being in each case parallel to the line of the valley. There are also in and about these valleys certain detrital masses which have been set down by several observers as the moraines connected with their ancient glaciers; but my own observations lead me to consider some of these as deficient in the characteristic form of moraines, and, as a general rule, the Snowdonian valleys may be said to be remarkably bare of detrital matter. While this is the case, the outer flanks of this group of mountains, and many high table-lands interspersed amongst them, are covered deeply with the "Northern Drift." That this, however, is the product of a different condition of things, and of an earlier epoch than that of the valley glaciers, appears to me proved by two facts, namely, that the connection of the sea with the origin of the drift is indicated by the shell deposits found in it, and that, as we learn from a late paper of Professor Ramsay, "small patches of it alone remain nestled amid the smaller bottoms of the hills." It hence appears that the glaciers have removed or swept out this drift from the valleys, while failing to disturb it on the high grounds and the outskirts of the mountain district. Mr Ramsay, with his usual acumen, has drawn this distinction, the importance of which will appear in a stronger light before we have done with the subject.

In Scotland, the mountain systems are too large to allow of our seeing any such well-defined examples of what may be called District Glaciation, as those cited from South Britain. The memorials of the action of ancient ice are, as is well known, abundant in our land of mountain and flood; and we shall presently endeavour to embrace them in a comprehensive sketch; but I am unable to select any particular district precisely comparable to the Lake country or the Snowdonian region, although, as has been seen, there are in various places proofs of still more narrowly local glaciation. It is, also, to be remarked that there are in several district valleys in Scotland, proofs of local glaciation on a larger scale than those already mentioned; but these I shall advert to in the comprehensive sketch which must now be attempted.

Proofs of a more General Glaciation in Scotland.

The examples of smoothed and striated rocks in Scotland, known up to 1849, were summed in an interesting paper by Mr Maclaren, read before this Society in April of that year. They were very numerous. He redescribed the remarkable example in Gairloch, originally discovered by himself in 1845. Instances were also cited from the neighbouring valleys of Loch Long, Loch Eck, and Loch Fyne; the direction of striæ being in all instances conformable to the direction of the valleys, namely, in the first three cases from NNW., and in the last NNE. Mr Maclaren described striated rocks in the valleys of Loch Earn and Loch Katrine, striæ directed from the west; along Loch Lubnaig, directed from the north; along the skirts of Demyat hill, and at Torwood, in the valley of the Forth, pointing from WNW.; and at numerous places in the lower parts of the valley of the Forth, about Edinburgh, and on the Pentland Hills, pointing generally from WSW. Our learned associate also adduced examples of the same phenomena, from the east end of Loch Awe in Argyleshire, from Loch Etive near Oban, from Loch Leven at Ballachulish, and from Glen Spean near Fort William, where the exposed sides were clearly towards the east, and the smoothing agent had of course a westerly direction. He, therefore, drew the inference that " the nucleus of this physical force, the common centre from which their agents moved, was in the group of mountains extending from Loch Goil northward to Loch Laggan, dividing the springs of the Spean, the Leven, and the Orchay, from those of the Spey, the Tay, the Earn, and the Forth." At the same time, Mr Maclaren candidly admitted that much remained to be done before adequate materials for a satisfactory theory were collected.

M. Charles Martins, in 1850, supported Mr Maclaren in his view of glaciers radiating out of the Highlands, and descending on the plains, as sufficient to produce the phenomena which are to be accounted for.

It seems, nevertheless, that both Mr Maclaren and M. Martins were aware of some features of the case which such a theory could not well account for. Mr Maclaren had himself discovered that the eminence between Loch Long and the Gairloch, 600 feet high, was as perfectly smoothed along the top, as was the bottom of either of the two valleys. Another even more startling fact, was that of a summit of the Pentlands, 1400 feet high, where Professor Fleming had found striæ identical in direction with those in the plains to the northward. Mr Maclaren had likewise observed in the valley of Westwater, which runs north and south at the western extremity of the Pentland range, near Dunsyre, and which is 800 or 900 feet above the sea, that striæ *crossed through it* in a direction from west to east, thus persevering in the normal direction of the district, in circumstances where, if anywhere, a divergence was to be expected. That any group of our Highland mountains, ranging as they do from 3000 to 3500 feet high, should have sent forth from their valleys, ranging far below that elevation, for so it must have been, a glacier which reached the area of Mid-Lothian, seventy miles off, in such volume and depth as to envelope a range of hills to the depth of 1400 feet, and in such unyielding force as there to cross a minor valley, 800 or 900 feet above the sea, without diverging in the least from its course, was certainly to be scarce expected by any one who was content to confine his view to what we see done by such ice-streams as now exist in the Alps. I, in some measure, intimated this objection to the British Association in 1850, when, professing to be unprepared for any theory on the subject, I held that one was wanting which would plausibly account for the Pentland phenomena, as also for the uniformity of striation on the front of the Fife hills, on the opposite side of the Forth valley, for I had been shewn markings at Cullelo quarry and near Burntisland, identical in direction with the various examples in Lothian, proving that the whole valley from the Lomonds to the Pentlands, and even beyond these hills, had been under one glacial agent, self-consistent throughout in its movement and operation.

The observations which I have been able to make since the Edinburgh meeting of the Association have served much to confirm me in the belief, that the views entertained up to that time, for the explanation of the glacial phenomena of Scotland, were far from being adequate to embrace the facts of the case.

It appears to me that previous observers have, in the first place, had too few facts to speculate upon, and have consequently pronounced as if certain local and partial phenomena, such as might arise in a limited Alpine region, were alone to be accounted for. They have also, from a similar limitedness of view, erred in attempting to explain the phenomena as a product of only one set of conditions existing at one point in time.

As to the real extent of the phenomena in Scotland, the difficulty is not so much to say where there *are* abraded and striated rocks, more or less covered by glacial detritus, as where such rocks *are not*. I have, since August 1850, found them along the whole range of the coast north of Argyleshire, namely, in Inverness-shire, and the counties of Ross, Sutherland, and Caithness. I have found them in the Isle of Skye, in situations independent of the Cuchullin Hills : in the island of Mull ; all along Loch Lomond, and Loch Katrine ; even the picturesque eminences which constitute the Trosachs being *roches montonnées*, with abraded faces to the west. I have likewise found them in Perthshire, Fife, and Aberdeenshire. They are reported from Ayrshire. I have found a large lateral moraine near Maxwellton House, in Kirkcudbright, and seen fine smoothings with striation on the surface of Corncockle Muir, in Dumfriesshire. When we add these situations to those previously ascertained, we see that glacial phenomena are so widely distributed, that it is making but a small demand on hypothesis to say, that we should find traces of ice everywhere, except at the utmost on the summits of the loftier hills, if all our rock-surfaces were exposed, and if all those actually exposed had been equally capable of retaining the impressions made by ice. In point of fact, we may see in every valley in the country, forms of the surface which, though changed by weathering and other agencies, it is easy to connect through a series of similar objects with indubitable glacial surfaces, so as to satisfy ourselves that these too have been glacialised. Thus, nothing is more common in the Highland valleys than rounded humps of upturned gneiss or mica-slate, with the strata shorn sharply through. In many instances, exposure has caused a weathering, the extent of which we may know to be one, two, or even three inches, by the prominence of quartz veins to that height. Near these, we often find, where a recent exposure has taken place, surfaces of the same rock, finely smoothed and striated. Other examples in all intermediate degrees of weathering can be detected, clearly shewing that the polished condition was originally that of all such rounded masses. Hence, even when there is a single case decided of polishing in a whole glen, we may see enough to prove that such was the original condition of the whole. So also, if we find sandstone of a certain considerable degree of hardness always presented prominently above the surface, as at Ravelston and Craigleith, in Mid Lothian, at Cullelo in Fife, and at Brora in Sutherlandshire, and always in these instances smoothed and striated even after long exposure, we may not unreasonably infer that other sandstone surfaces, in no respect of relative situation different, but comparatively soft, and tending to a blazy condition of the surface, would have been glacialised likewise, if of the proper consistence.

As our own neighbourhood is specially rich in the phenomena of polished and striated surfaces, I may dwell a little longer upon it, mentioning a few examples as yet unrecorded.

There are, as is well known, some vertical faces of the basaltic clinkstone of Edinburgh Castle rock, which have evidently been polished by some external application. Near this, in the foundation of the Corn Exchange in the Grassmarket, Mr David Page found the subjacent rock polished and striated. It is well remembered that, a few years ago, on the cutting out of the superficial detritus on the south shoulder of Arthur's Seat, above Sampson's Ribs, a spot 390 feet above the sea, the rock was found to form a kind of trough, the sides and bottom of which were polished and striated. In 1850, some cuttings at the St Margaret's station of the North British Railway, near Jock's Lodge, enabled me to ascertain that the north base of Arthur's Seat is smoothed and marked in precisely the same manner, namely, with striæ and groovings directed from a point south of west; while numerous rounded and striated boulders are interspersed through the superincumbent compact blue clay, There has lately been a similar exposure of the surface at the parting of the Bathgate and Edinburgh and Glasgow Railways at Ratho, and there likewise we see the rock polished and furrowed, while the striæ observe a similar direction. In East Lothian, I have found at Whitekirk, at Craig, at Fenton Town, and other places, instances of this phenomenon, additional to those previously detected in that county. Professor Fleming likewise detected glacial surfaces on the west front of North Berwick Law, near the base. The direction of the lines is generally very nearly uniform, namely, from one to two points south of west, being the general direction of the valley.

There is something in the general configuration of our district even more remarkable than in these polished surfaces. It is forty years since Sir James Hall observed the peculiar form of eminence which he called *crag-and-tail*, and of which he pointed out instances in the Abbey Craig and Stirling Castle rocks, in the hill of the Old Town of Edinburgh, and some others. It consisted, as is well known, of an abrupt face or cliff to the westward and a gentle slope to the eastward, the face being usually composed of some rock capable of presenting a powerful resistance to any denuding agent. Colonel Imrie found in the Campsie Hills and the Grampians a marked tendency to the same form, with the same arrangement. More than this, but quite in conformity with it, is a tendency in the surface of Lothian to a *ridge-and-trough* form, exemplified most strikingly in such groups of third-rate hills as those of Dalmahoy and Garleton, where the lines of both the heights and hollows are throughout very nearly the same. We see the same form on a subdued scale in the ground between Corstorphine Hill and Leith, which consists of a series of broad longitudinal swells, with slight hollows between. All of these ridges and hollows are in the same direction as the hills of crag-and-tail, and the whole conform to the direction of the striæ upon the rocks.

From such objects, it is but a step to extend our observations to the sides of those larger hills which bound valleys, as the Fife Lomonds and the Pentlands, where we very often find a remarkable form of surface, which may be described as *Mouldings*, extending longitudinally, but not always quite horizontally, along the slope, and clear in their cross sections of every kind of abruptness or inequality rising above the sectional outlines. Such mouldings are easily seen on the Pentlands from about Colinton; on the northern aspects of Arthur's Seat; under Dunearn summit in Fife; on Demyat from the valley below; on several parts of the Campsie Fells, particularly above Banton; on the hills to the south of Loch Vennachar and Loch Achray, in Perthshire; and on many other of the Scottish hills, but generally most clearly when the sun shines at a low angle along the slope. They are clearly attributable to the operation of the same agent, of which some other serrations or irregularities have fashioned the longitudinal ridges in the valley below; that is to say, more correctly, some stronger consistency of rock has in both cases presented a more than usual resistance to the planing agent. Now these markings are seen at great elevations among the hills, and but a small way from their summits; and the flowing sky-lines of the greater portion of our secondary hills are manifestly connected with them in respect of cause. Thus, when we eliminate cliffs and other rough parts as only exceptions, and the effect of subsequent weathering and other casual forces, a comprehensive eye cast over the mountain system of Scotland, has no difficulty in seeing the effects of a general abrading agent which has passed over and more or less moulded nearly the whole.

I am prepared, however, to shew proofs of a general abrasion in Scotland, compared to which the above can only be considered as adjuvant and subordinate.

Most students of geology will remember the striking description which Dr M'Culloch gives of the range of old red sandstone mountains which extends for fifty miles along the west coast of Ross and Sutherland. From a platform of upturned gneiss, undulating in outline, and between 200 or 300 and 1000 feet above the sea, rise these mountains isolatedly to the height of from 3000 to 3500 feet above the sea, with wide spaces between, in some of which lie lakes and estuaries. The strata being disposed at a low angle, it becomes evident that they are the relics of one wide-spread formation, out of which gaps have been cut by some external agent; and hitherto the district has been regarded as a striking example of the process of denudation, and often adverted to as such in elementary books, the agent usually presumed being water. Not one of these mountains, as far as I am aware, advances to the coast or abuts on the sea; but at Rhu Stor, in Sutherlandshire, a small low patch of the sandstone borders the coast and passes beneath the waves, which have cut it into very fantastic forms.

It seems to me entirely inadmissible that the sea has been the denuding agent in this case, and for the following reasons: —*First*, On the gneiss platform between the mountains and the coast, we do not see the fragments of sandstone which would be deposited there by such an operation. *Second*, We have at Holborn Head, in Caithness, and all along the coasts of Aberdeen and Forfarshire, cliffs of old red sandstone abutting on the waves, and worn by them into deep chasms and caves, with isolated columnar masses here and there left out at sea; but the faces of the mountains in question bear no trace of such operations.

On these mountains, however, at least such of them as I have examined in the district of Assynt and at Loch Maree in Ross-shire, and on the gneissic platform whereon they rest, there are abundant traces of glacial action. These are apt at first to appear of a confused and contradictory character; but all difficulty vanishes when we arrive at the idea of a local system of glaciers succeeding a system of things during which a more general glaciation took place, and substituting for the effects of that more general movement effects of its own; the key to much that has been perplexing in the investigation of this subject.

There is one of these mountains which attracts more observation than any other, on account of its extraordinary form, which has given it among sailors the name of Sugar Loaf, though it is properly called Suilvean (meaning *Ear Hill*). It extends in a narrow ridgy form for upwards of a mile, with sides so steep as to be inaccessible in most places (I measured an angle of 58° on one side, and found the precipice on the other absolutely vertical); the west end being also very steep, while the east slopes away in a tail. Seen at the west end, the hill looks like a lofty tower with a dome-shaped top, something not unlike the Eddystone Lighthouse,—a resemblance not a little helped by the palpable stratification, which has the appearance of a Titanic masonry. Another perfectly isolated mountain, called Stack, precisely resembles Suilvean, and these, from their position, may be considered as a front guard for the series towards the sea.

Behind that range is a series composed of Cuineag, Canisp, Coul More, and Coul Beg, which, with bold faces to the west, dip down on the east at an angle of about 9°, their lower slopes in that direction passing under another range of hills resting on a broad band of limestone. The backs or eastern slopes of all these hills are composed of quartz rock—sandstone metamorphosed into that character—and the bareness and whiteness of that peculiar surfacing gives them a very remarkable appearance. It becomes readily apparent that these quartz *carapaces*, as they may be called, are what has protected the hills from the utter demolition and removal which have befallen the matter once filling the great intervals between them.

Now, in this range of hills, there are phenomena of smoothing, striation, and detrital accumulations, which can only be accounted for on the supposition of there having been, besides a district glaciation in the valleys, like that of the Lake Country, *an earlier general glaciation* which has passed over the backs, if not the very summits of the hills.

The valley in which Loch Assynt lies, extending up into a spacious *bosom* of high ground inclosed by the summits of Ben Uie and Glasvean, has been the seat of a glacier originating in that bosom, and which had swept out to sea at Loch Inver and Rhu Stor. We see all along this course, smoothed rocks, with striæ in the line of the valley. In the higher parts, are moraines, one of them forming the barrier of a little lake. In the middle part, about Loch Assynt, are accumulations of moraine matter: while along the gneissic platform, towards Rhu Stor, are examples of long ridges, with the *stoss seite* to the east, and a lee side to west, attended by gatherings of moraine matter in the lee, containing, with many masses of the gneiss, some of the red sandstone, which may be presumed to have been brought from the skirts of Cuineag. When we go onward to the low patch of sandstone on the coast at Stor, we find fragments of the gneiss carried over it, still confirming a westerly movement at this place.

At the back or north side of the elevated ridge formed by Ben Uie and Glasvean, there is another valley called Glen Coul, which runs out to the westward, and is partly filled by the estuary of Kyle Skou. This has likewise been the seat of a local glacier, as appears from similar proofs; but it has been on a smaller scale, not having had such a spacious field for the collection of the proper material.

So much for the glaciation of this district, where there are bosoms amongst the hills and valleys running out from them, appropriate seats of local glaciers. But on the summits and high slopes of the hills, and on the portions of the gneissic platform not connected with valleys, there are traces of an independent and, I believe, earlier glaciation. On Cuineag and Canisp—on the former up to the height of 1700 or 1800 feet, and on the latter not much less, the quartz surfaces are marked with *black streakings*, which are the striæ peculiar to a singularly hard rock, and these run from about N. 60° W. with certain exceptions. One of these is at the base of the slope of Cuineag, where the streaks are from the direct north, apparently by reason of the turn which the agent has there received from the base of the adjacent hill. Another exception is at the hollow dividing the mass of the hill from its loftiest top, where another system of streakings comes in from the direct west, thus with the other set clipping the summit of the hill. It may be remarked that the dip of the strata on the backs of these hills is usually at a somewhat greater inclination than the outline of the surface, the resistance having been the stronger the nearer the bottom. There is a great quantity of quartz slabs strewed along the back of the hill, being the last fragments which have been torn up by the denuding agent, and many of the surfaces exposed have evidently undergone no attrition. This has afforded us an opportunity of observing the difference between an abraded surface and one which has undergone no abrasion, and it is very striking. The unabraded surface presents an inequality of outline, partaking of a tuberculated character, which is entirely wanting in one which has been subjected to the striating agent.

On a summit running south from Ben More, fully 1500 feet high, and four or five miles to the south-east of Cuineag, there are streakings on the quartz, observing the normal direction of this general movement, namely, about N. 60° W. What is most curious and significant, and settles the question of two systems and epochs of glaciation, is, the fact of there being upon Canisp, cross striæ connected with those local moraines at the base which were adverted to in the earlier part of this paper. The strong normal streaks athwart the hill from the north-west, a direction in which no local or limited mass of ice could move, are clearly chequered with fainter streaks produced by this simple down-hill movement, which happens to be from WSW. It may also be remarked that, on some other parts of the mountain, of no great elevation, there are down-hill streakings without any of those from the north-west. Such is likewise the case on the back of Coul More.

On the gneissic platform, between Coul More and Suilvean I found polished surfaces, striated from NW. to W.; and to the west and north of the latter mountain are markings in all respects similar. Such is the line of the major axis of Suilvean itself, and of many ridges and hollows of the gneiss, as may be partly observed from the Map; for such is the direction of many lakes which repose in these hollows, and which are laid down in maps. These are situations where no local glaciers could exist. They only could be marked by some glaciation more general than any we now see in operation.

At a particular stage in the investigation of this district, I thought that, there being proofs of so extensive a denudation in Assynt, by an abrading agent coming from the north-west, we ought to find extensive deposits of the detritus of the district in regions situated to the eastward. I therefore made an extensive detour, in order to pass along the valley containing Loch Shin, and looked carefully there for fragments of quartz and old red sandstone. Not a fragment was to be found. The mystery was, however, soon cleared up; for it became evident, from both striated surfaces and moraines, that this valley had been, like that of Loch Assynt and Glen Coul, the seat of a comparatively late local glacier, which necessarily had swept out every particle of earlier detritus.

It must now be observed, that the proofs of such a general extension and so deep a volume of mobile ice, are not confined to this district. Streaking, precisely the same as that of Cuineag and Canisp, exists at an elevation of at least 2000 feet, on the similar quartz mountain named Ben-Eay, south of Loch Maree, and forty miles from Assynt,—this striation being from NW., or thereabouts, and totally irrespective of the form of the hill. On free ground, between Gairloch and Poolewe, there is similar marking, with a direction from WNW. So also is there in the great elevated valley of passage across the island in Ross-shire,—the dreary Dirry More.

It seems to me that the whole phenomena can only be accounted for, by our supposing that there was, *first*, a general sweeping of the surface of this district by a deep flow of mobile ice, one great cause, if not the principal, of that enormous denudation which has been described, but of which the spoils, from the universality and power of the agent, were in a great measure carried away. *Second*, local, and certainly subærial glaciers, occupying certain valleys in the more elevated mountain systems, and producing moraines, composed of brown clay, sand, and blocks. The small glaciers first pointed to in this paper were perhaps of a still later date, when the mean temperature was not much below its present point.

The examples which have been cited do not, after all, refer to a very extensive district; but when we take a wider range of observation, we find phenomena which are for the most part in perfect harmony with those of the west coast of Assynt. Passing northward to Rhiconich, we find near that place striæ coming in from the coast, from the north-west, and passing across a high moor, with no regard whatever to the inequalities of the ground. A little farther north, at Loch Laxford, a fine surface is marked with striation from the north-west, being *across the valley in which it occurs*. At an opening in the bold gneissic coast which looks out upon the Pentland Firth, there is strong marking in a direction from NNW. The high desolate tract called Moen, between Loch Eribol and Tongue Bay, where there is nothing that could restrain or guide the movement of the ice, exhibits striation from N. 28° W. Striæ, in nearly the same direction, namely, N. 25° W., occur four miles to the east of Tongue Bay. On perfectly free ground, at Armadale, the markings point almost directly from the north. When we pass on to Caithness, where the country generally is of that rounded undulating character which speaks of glacial action, we find a few traces of striation, still from points between north and north-west, which is *directly transverse to a line pointing to the neighbouring hills.* At the Clynelish quarry, near Brora, in Sutherlandshire, the fine surface of smoothed sandstone, pointed out by Sir Roderick Murchison, exhibits striation from a point north of west. This pointing back to a valley out of which a local glacier may have come, and the gorge of which shews many moraine-like ridges, is perhaps not a true case; but if it be, the line of the striation is not much out of conformity. Striation of north-westerly direction is found in a valley near Loch Fleet, also at Invershin, and along the road to Assynt. So also is it found in the valley of the Shin, but with what I consider undoubted moraines, shewing at least a subsequent local glaciation.

I found only one example of remarkable divergence in Sutherlandshire, beyond the instances of undoubted local glaciation in Assynt, and this was in the valley in which Loch Eribol lies. The sides of this valley are composed of quartz rock, and the whole bears a great resemblance to the Gairloch. The quartz is everywhere smoothed down to a condition of the highest polish, excepting where some modern fracturing has taken place; and the striæ on this fine surface run between a point east of north, and one west of south, being precisely the direction of the valley. The probability is, however, that a glacier has descended this valley from the bosoms of the great eminences in the Dearrie Forest.

Far to the south of this district, in the valleys near the western extremity of the Great Glen, we have seen that there are markings, which Mr Maclaren has described as having a direction from the interior of the country towards the west coast; in which respect they differ from those now under our immediate notice. He particularly mentions some on the south side of Loch Awe, about a mile west from Dalmally Inn, where there are two small *crag-and-tail* hills, with striæ from ENE., and masses of stones and soil to the WSW. He also lays much force upon certain smoothings at and near Monessie, in Glen Spean, where the rough or protected sides are clearly down the valley, or to the west. Now, in several places connected with this valley, there are abraded rocks, with the rough sides in the opposite direction. Mr Milne Home has described one group at the opening of Loch Treig, and another at the junction of Glen Fintec with Glen Gluoy. I was with Mr Milne Home when these examples were discovered, and can testify to their genuineness. I also find, among my own memoranda, a note and sketch of another, which we had discovered at the head of Glen Glaster, with the smoothed side to the north-westward. Thus, in the very district containing the markings which Mr Maclaren, M. Martins, and Sir Roderick Murchison, have depended on as completing their proofs of a radiating arrangement, we see that there is a more widely-spread set of markings, more elevated in situation, and in conformity with the normal direction. Mr Maclaren also mentions smoothed rocks on Loch Etive, with striation, to his surprise, not conformable to the shore, and coming, as he thought, from ESE., or from Loch Awe, though hills of from 300 to 500 feet intervene. I have no doubt that if Mr Maclaren had seen the examples which exist in the far north, he would have regarded this as an example of that early general glaciation proceeding from the north-west, which we have shewn to be independent of even more considerable inequalities of ground than the hills of Loch Etive.

It happens that, at a place not many miles from Loch Etive, namely the Isle of Kerrera, opposite Oban, there are numerous smoothed surfaces dipping into the sea, with striation from N. 60° W., being nearly the same direction as Mr Maclaren's, WNW. If the agent moved on to S. 60° E., it would strike the shore at Oban; and if it went straight on, it must have passed over the high grounds which lie between that shore and Loch Awe. The question may arise, Did it not pass in the opposite direction ? One circumstance, not easily reconcileable with that idea, and otherwise highly curious, is, that on the high grounds above Tobermory, in Mull, twenty-five miles from Oban, there are striæ pointing from N. 60° W. No glacier proceeding from the hills above Oban could go straight on to this point, and leave marks on a hill two hundred feet high. But, when we see marks in the far north, as independent of unequal ground, and equally irrelative to the kind of grounds which feed glaciers, we have no room to doubt that these Mull and Oban markings belong to the same class.

The examples in the valleys of Loch Fine, Loch Eck, Loch Long, and Gairloch, which Mr Maclaren has cited, all with a southerly direction, may easily be interpreted as parts of this grand early system of glaciation, though perhaps partially affected by local glaciation at a later period. It has already been stated by Sir Roderick Murchison, that there is no imaginable centre for the issue of glaciers of the ordinary kind down the Gairloch. And the objection is one which apparently cannot be answered. Mr Maclaren has himself observed a fact irreconcileable with such a theory in the smoothing of the hills of 600 feet high, between Gairloch and Loch Long. I have myself observed, in the adjacent Holy Loch, that the striation, which is there from north to south, indicates an agent which has come slanting over the hill, between that valley and Loch Long,—an eminence of not less height.

Conformable also are the eastward markings of Strathearn, and the southward markings of Loch Lubnaig. I have lately observed that the valley of Loch Lomond is glacialised southwardly, the line of its length, *roches montonnées*, with striation, being conspicuous at Bealmaha, Rowandernnan, Luss, and Tarbert. Some islets near Luss are of this character, being precisely like the examples in Ulleswater. Those who are accustomed to affiliate glaciers exclusively to high mountains, would be somewhat surprised to see proofs of such a stream of ice having swept *laterally* along the base of Ben Lomond. At the same time, I am not sure that the valley of Loch Lomond has not been latterly filled with a local glacier descending from some of the elevated basins near its northern extremity, and which, by one of its moraines, may have formed the dam at its foot. A train of granite blocks traced by Mr Hopkins along the side of the loch to a northerly origin is a circumstance pleading strongly for such a theory.

One example of smoothed and striated rocks at Stronachlachar, near the head of Loch Katrine, is worthy of particular notice, as utterly destructive of the idea of exclusively local glaciers, and only to be explained by that of an agent wide-spread over the land, plastic, but pressing hard, and not readily yielding to any local obstruction. There is here striation ascending obliquely out of the loch, passing over a high jutting hill promontory, reappearing under compact clay, in low ground, at some distance from the loch, and everywhere maintaining precisely one direction, and that from NNW. To all appearance, the agent which produced these impressions came over a lofty range of hills from Balquidder, and passed on to cross a scarcely lower range, and descend into the valley of Loch Ard. There has also been, as already mentioned, an issue of glaciers by the south-east end of the lake, among the defiles of the Trosachs, part of the roughness of which is caused by a large moraine.

The descent of this great or general glacier into the south and east of Scotland can be traced at other points. A lofty and extensive sandstone plateau between Campsie and Glasgow, exhibits extensive smoothings, with striation from WNW. Eminences of trap in the valley of Strathblane have manifestly abraded faces to the north-west. There are clear marks of the passage of ice over the conglomerate skirts of Demyat, directed to ESE.; also, in the same direction over the sandstone at the Torwood, near Larbert. The line of the remarkable passages through the trap eminence at Stirling Castle is precisely conformable. Farther on, the agent gets a turn to the northward, bringing it into conformity with the line of the Forth valley; it continues to be from about W. 15° S., all along by Edinburgh and East Lothian, the only remarkable excess in this twist of movement being at Silvermine quarry, a lofty position to the south of Linlithgow, where it is as much as W. 45° S. On the lime stone here, over beautifully marked surfaces, lies a deep bed of the compact blue clay with blocks, which, besides being scattered through the mass, form a *zone* a good many feet down, a striking but not unexampled peculiarity.

From the south of the Pentland Hills and Lammermuir range, there are no reported examples of abraded or scratched surfaces, a fact apparently to be attributed to the splintery character of the Silurian hills of the south of Scotland. The general mammillated character of the outline of these hills is, however, very remarkable, from its resemblance to the configuration of ground on which we trace true ice markings. It is also to be noted that in Berwickshire, the masses inclosed in the boulder clay are from the west.*

* Mr D. Milne on Parallel Roads of Lochaber.

The views here advanced for a general glaciation are supported by facts from Scandinavia, which no theory of exclusively local glaciation, or of abrasion exclusively by floating ice, can possibly account for. M. Bohtlink, who examined the glacial phenomena of Scandinavia with great care, found there, as we have done in Scotland, many examples of striation in the direction of the valleys. But he also found on the intermediate heights the normal direction observed, sometimes at an angle of 50° to that of the valleys. This is precisely what I have found in Sutherlandshire. I have myself seen something of the glacial phenomena of Scandinavia, and fully believe that local glaciers once filled many of the valleys of that country. The moraines of the celebrated Gulbrandsdalen, at Mosshuus and Laurgard, which I have described elsewhere, are not to be mistaken. There are, moreover, in Lapland and Finland clear proofs of glaciers having run out to north-westward and north-eastward. But to rest content with the idea that the direction of *all* such action can be traced back to the great plateaux—which is the case of English geologists at this day—is to stand in a position which I am certain cannot be maintained. Take the following facts of my own observation, as only a selection of reasons which might be adduced for that conclusion.

In the very midst of the Scandinavian plateau, on the summit of 4000 feet elevation at Jerkind, and in the immediate neighbourhood of Sneehatte, the southern slope is abraded and polished almost to the top, with striæ between north-east and south-west—a line totally irrespective of all the great mountains of the district, such as Sneehatte, which it sweeps laterally. There is, in fact, no higher ground from which the required agent could descend to this spot: the effects have clearly been produced by an agent *crossing the chain.* There is, indeed, in the neighbouring valley of the Driv, an abrasion running downwards to the north, with a great lateral moraine at a considerable elevation along the mountain side; and this is the undoubted memorial of a local or valley glacier, easily traceable to the hollow grounds around Sneehatte. It is easy, however, to see that the markings at

Jerkind, being wholly unconnected with either more elevated ground in which an ordinary glacier could be formed, or with a valley in which it could be contained and directed, must have had a totally different history. Again, on the summit over which the road from Lavanger to Sundsvall passes, and the great connecting line between Norway and Sweden in that quarter, the *col* is a wide saddle-formed space, with only gentle heights on both sides, but crossed transversely by a group of low ridges. The whole of this space, composed of rocks of chlorite schist, is abraded by an agent which has been able to shear sharply through the upturned edges of the strata, leaving clear striæ to mark its course. Surprising to say, that course has not been across from west to east, as the road passes; neither has it been from north to south in the line of the little ridges; but it is athwart both of these lines of hollow, from north-west to north-east, and thus clearly has been independent of the form of the country. It is not till we see such demonstrations as these, that we can fully apprehend the weakness of the position which English geologists have been contented with for the last ten years, in believing that every thing may be accounted for by detached masses of floating ice, set in motion by currents.

It is a remarkable feature of the northern peninsula, that the descent from the great back bone of the country towards the west, constituting Norway, is by a series of comparatively short, steep, deep valleys, generally very bare, or only presenting certain alluvia in the lower and wider spaces towards the sea, while the slope towards the east, constituting Sweden, is gentle and open, with an enormous abundance of detrital accumulations spreading over all for many miles, from the flanks of the hills, where they reach to a great elevation. It was my fortune to pass across the Plateau from Norway into Sweden, and I felt myself to have been quite unprepared for the accumulations which I met with in the lee of the hills, immediately on descending from the bare striated *col* above described. The matter took the form of vast terraces, with promontories of the superior stretching into the inferior, and while the surface matter was always water-worn and water-laid, the interior, wherever laid open for road material, shewed of precisely the same character as the stuff constituting the moraines of the Alps. Now, it would be necessary for the exclusive advocates of a drift by floating ice radiating from mountain chains, to shew how there has been such a drift from one side of that of Scandinavia, while there is so little in the opposite direction. They would need to prove that this detrital accumulation in the lee of a mountain chain, is any thing different from the familiar phenomenon of a tail of debris in the lee of a second or third rate hill, or of an isolated rock, and ought not to be set down to the same cause; namely, the chain having been involved in a flow of ice, in some form, in some circumstances, which pressed hard upon and swept bare the hither side, but, passing with comparative lightness over what lay beyond, left there some of the solid matter with which it was charged.

It is also to be remarked how little help any such mountain chain as that of Scandinavia is really calculated to give us in explaining some of the phenomena. On the shores of the Gulf of Bothnia, and in Finland, where there are vast spaces finely polished, with striation from NW.; in the country near Stockholm; in the district between Christiania and Christiansand, and around Gottenburg, where the polished surfaces are equally extensive, but where the striation has a bend towards the south-west; we are many hundreds of miles from that presumed centre of action, and the intervening space presents an infinite number of minor obstructions, all of which, however, have been swept over by the agent, whatever it was. If glaciers proceeding from the plateau be presumed, we should require to know how any such agent descending from hills only half as high as the Swiss Alps could travel over twenty times the space, in a condition, too, necessarily attenuated, through the wideness of the country over which they must have spread. If ice-floes dragging detritus over the surface are presumed, it should be shewn how any such agent could be impelled over the submarine heights and hollows of such an extent of country, everywhere pressing as hard upon the sea-bottom as if its full weight were exercised upon it under subaerial circumstances.

The general glaciation of which we see traces in Scotland, finds a still more unequivocal parallel in the northern part of the American Continent. It is well known that there are proofs all over Canada, and to a point far south in the United States, as well as around Lakes Huron and Superior, of an abrading agent for the most part from the north-west.* Mountains of 2000 feet in height bear on their sides and tops striation in that direction ; while to the north-westward, no mountains of greater elevation to serve as gathering-places for glaciers can be pointed out. Scandinavia, indeed, would be in precisely the same circumstances as North America in respect of these phenomena, if there were no such lofty chain as the Dovre-Field to variegate its surface —hence that plateau may be presumed to be quite indifferent in the case, except as a proof of the grandeur of the agent which could over-ride such elevations.

Speculations on the Causes of the More General Glaciation.

When the phenomena of ancient glacial action in the region of the Alps were first observed by Messrs Charpentier, Venetz, and Agassiz, it was thought that the abrasion of Scandinavia, which had been described some years before and attributed to floods, might be accounted for by an extension of the polar ice over that region, and its movement southwards, under the influence of a principle of dilatation, supposed to reside within the glacier itself, and believed to be dependent on the infiltration of water into chinks and its subsequent freezing. This doctrine of dilatation has been, as is well known, very generally abandoned, in consequence of the demonstrations brought by Professor James Forbes in favour of his proposition, that "a glacier is an imperfect fluid, or a viscous body, which is urged down slopes of a cer-

* Sir Charles Lyell shews that the ordinary and natural course of icebergs borne by currents is from the NE. to SW.; and in his attempt to account for the glacial markings in America by that agent alone, he observes that the general direction is the same as that of the icebergs. But I find that, in Bigsby's map of the glacial phenomena of Northern America,* the direction in by far the greater number of the markings is from NW. to SE.

* Quarterly Jour. of Geol. Soc. April 1851.

tain inclination, by the mutual pressure of its parts." In the eagerness to give up this view of a possible cause, the very fact of the glacial abrasion of Scandinavia has been also given up by many, as if the two things had been essentially connected. At least, we have for some years heard little of the abrasion either of that region or of America. Most geologists seem to be content to regard the phenomena, in the reduced or restricted form in which they contemplate them, as capable of being produced by floating icebergs which had grazed the bottom of the sea in their voyage southward, when the land in that quarter was submerged, or by these agents joined to ice-floes and masses of detritus carried along by powerful currents.

I must profess myself unable to see the force of the logic which demands that certain phenomena should be regarded as non-existent, or reduced to some fraction of their actual extent, because one theory of the mode of operation of their assumed cause has been found untenable. Be the value or fate of the Dilatation Theory what it may, it can make no change in the fact, that all over Scandinavia, below a certain elevated point, the rocky surface, wherever it has been duly protected and is now exposed, or even in some instances where it has been exposed for ages, is found to be worn or shorn down to a flowing outline, is polished, furrowed, and striated, exactly as we see that the surfaces of elevated valleys in the Alps are worn, polished, and striated by the glaciers moving in them at the present day. This fact still remains to be accounted for; and if one line of speculation on its cause shall fail, the right course, I apprehend, is to look out for another.

It is remarkable that Professor Forbes himself has been far from giving countenance to any such consequence of the refutation of the Dilatation Theory.

It is, however, far more remarkable that the prevalent theories of English geologists on this subject are all based on data for which no tangible proof has ever been, or perhaps could be, adduced. One speaks of "large islands and bergs of floating ice which came from the north, and, as they grounded on the coast and on shoals, pushed along all the loose materials of sand and pebbles, broke off all angular and projecting points of rock, and when fragments of hard stone were frozen into their lower surfaces, scooped out grooves in the subjacent solid strata." Now, the floating and stranding of icebergs are familiar facts; but no one ever saw a sea-bottom worn or scratched by such an agent, or could prove that such an operation ever takes place, except at the utmost in a partial and casual manner. It is in the main a conjecture. Another was not long ago satisfied that "waves of translation," breaking away from centres where a sudden upheaval of the land had taken place, were sufficient to account for the phenomena, but appears to be now of opinion that glaciers, floating ice, and currents, have all been concerned in producing the effects, though still without addressing himself to, or admitting, the fact of the parallelism of striation over a large surface, which no such agents could have produced. Sir Roderick Murchison surmised that "the ice-floes and their detritus might be set in motion by the elevation of the Scandinavian continent, and the consequent breaking-up of the great glaciers on the northern shores of a sea which then covered all the flat regions of Russia." But this is an operation which has never been seen in nature, and, even though it were to take place, we hold that the ice and detritus, borne along in a wave of the sea, are still incompetent to produce the various effects of abrasion, polishing, and striation, which are to be accounted for. Besides, Sir Roderick would need to shew—what he has not attempted—that the British islands and Northern America had a similar northern mountain chain to send forth the ice-floes and detritus required in their cases. We have always been led to understand that it was a rule of scientific geology to refer ancient phenomena to causes which we see producing similar effects at the present day; but here the rule seems to be set aside in favour of a cause which has no known effects whatever.

It may be asked, can we seriously attach the least value to any theory which either ignores the great and palpable facts, or leaves them totally unaccounted for? Yet this is the character of the theories here referred to. I shall proceed to state a few only of the facts which are thus overlooked and slighted.

The first is the extent and direction of the operation of the agent in the North of Europe. In the central parts of Sweden, and the southern parts of Norway, there is but one system of mammillated rocks and of striation—this being from NNE. and NE. :—it involves hills of several hundred feet in height, and passes across and athwart valleys, with an absolute indifference to such irregularities. Now, no free sea could produce a uniformity of movement over so wide a space, or with such indifference to forms of the surface ; and, even if the abrupt elevation of the Scandinavian chain demanded by Sir Roderick Murchison were granted, the ice and detritus thrown off by that operation could never have so soon turned off in a different direction—first sweeping to the east and then returning towards the west.

In the second place, these theories altogether overlook certain peculiar minute features of the abraded surface, which are to be accounted for as well as the general fact of an abrasion having taken place. I would instance the perfect polishing and striation of the under faces of overhanging rocks, and of the sides of certain deep narrow channels—six feet deep sometimes, and little more than one foot wide. I may point still more particularly to a class of objects which abound in Sweden, in connection with glacialised surfaces. These are the celebrated Jettegryder, or Reisentopfes (Giants' Pots or Tubs). In the midst of a glacialised surface, perhaps on the side of a mountain, perhaps on the *col* or summit of a pass through a chain of mountains, we see a circular pit of three, six, ten, or more feet in depth, and three, six, or even eight feet in diameter, with sides and bottom worn quite as smooth as the parts of the surface near by. There is an evident connection between the pit and the neighbouring smoothings in respect of cause. Generally, we find a sort of channel running up to and into the pit, forming an indentation in its lip ; and in one instance at least, I observed that a moulding descended obliquely from this entrance down to the bottom, while striæ followed the same line, the whole sides indeed being marked by curious scoopings, and intermediate ridgings and other evident marks of a spirality, as well as inequality of pressure, in the direction of the excavating agent. At the bottom, rounded pebbles of the size of a playing bowl are sometimes found, objects that have clearly been concerned in the hollowing process. When an English geologist hears generally of circular pits in Scandinavia, he at once thinks of aqueous action; for limestone cliffs down which water descends in a cascade, are often found so hollowed. The presence of the pebbles at the bottom confirms him in the assimilation. But were he to inspect a real Giant's Pot, he would speedily see that it never could have been associated with a waterfall, and that it has strong characteristic peculiarities altogether apart from such honeycombing of cliffs as we find at cascades. Even in the character of the skin or surface of the rock, there is a difference. In short, it is evident that these pots have been fashioned by some plastic substance which has wound round the interior, come out again, and passed on,—a substance, however, so far mixed up or associated with water, as to allow of the loose stones generally to keep at or near the bottom, or at least within the pit. Such a plastic substance, with water continually permeating its body, is the ice of glaciers. It would be difficult, I apprehend, to shew that any floating or water-impelled ice could, in its sluggish rigid movement over a sea-bottom, send down a tongue to lick and scoop out so peculiar a hollow in the subjacent rock. Still more difficult would it be for those who regard the whole of the ancient glacial phenomena as *submarine*, to shew how cascades took place at the bottom of a sea! If the theory of these gentlemen thus puts on so burlesque an aspect, I must be permitted to say, the blame is their own, for all of these peculiar phenomena have been recognised and described for many years, and yet have been passed over by them as if they did not exist.

The great defect of the ice-floe theory is, after all, the weakness of the force which it implies. If we look the phenomena to be accounted for fully in the face, we shall see that a heavy forcible pressure, by a dense yet plastic substance, has been exercised—one which could grind and mould the surface of a large tract of country, variegated by considerable hills, by one movement. This could never be done by ice partially floating, or merely impelled by ordinary currents. While those who argue for the abrading powers of icebergs, can scarcely adduce a single example of that agency in nature, I can adduce negative facts of no small force against such an agency. At the falls of the copious river Glommen, in Norway, just above the cascade, the rock is seen striated under the water, *obliquely to the course of the river.* Now, this river must have upbreaks of ice every spring, filling its channel at this place with a tolerable representation of the ice-floes in question; yet no striæ are seen in that direction, and thousands of winters have failed to obliterate the original glacial markings in any perceptible degree. Many rivers of our own country have driftings of broken ice impelled down their channels with immense force at the end of every great frost; yet their rocky channels present irregularities which give them a totally different appearance from the abraded and striated surfaces. I was first impressed with this objection to the ice-floe theory on observing some rugged, or only slightly blunted points of rock starting up in the bed of the Tweed, near Peebles, where in my early days I have witnessed magnificent examples of the rush of river-ice so well described in Thomson's "Winter." This ice is, as is generally known, often impeded by grounding, and sometimes is carried gratingly over the channel of the river exactly in the manner of the ice-floes of the ocean; and, though the phenomenon is on a comparatively small scale, some memorials of abrasion might be expected, if ice carried by water were really capable of leaving any beyond the most trifling.

As an example of what may be called inadequate theories of the polished and striated surfaces, reference may be made to one lately started in Ireland, where, as is well known, such phenomena are fully as conspicuous as in Scotland. Mr Robert Mallet appears to be the real author of this theory, though Colonel Portlock claims to have suggested something similar about the same time. The main proposition is, that a detrital covering of the land, raised along with it at the time of elevation, slipped down its face into the sea, and even over surfaces beneath the sea level, thus producing upon the subjacent rock those phenomena of rounding, furrowing, and scratching, which have been attributed to the action of ice. Such a process, Mr Mallet conceives, may be going on beneath the sea, even at the present day. The only remark I feel called upon to make regarding this theory is, that, while few would deny that a mud-slide, land-slip, or other slipping of detrital matter, is competent, when it takes place, to abrade and scratch the subjacent faces of rock, the phenomena really to be accounted for—the extensive denudations, the abrasion of mountains and valleys in directions irrespective of the inclination of the ground, and the deposit of detrital accumulations over enormous surfaces with no general slope at all (as the valley between the Friths of Clyde and Forth)—are wholly beyond the imaginable scope of such an operation.

While thus sensible of how far any existing theory is from accounting for the whole phenomena, I am by no means possessed of any theory of my own, which I think fit to be immediately accepted and maintained, without future change or modification. I can only say that it seems to me unavoidable, that we suppose a mass of ice to have spread out, from the north generally to the south, ice viscous and moveable like that of subaërial glaciers, and like them sufficiently compact to possess great abrading force; and water has been concerned in connection with this ice, as evidenced by the character of the connected deposit of boulder clay; but as to the formation and movement of this supposed northern envelope, we are not yet in a position to speak positively. All we can do is to enter upon a few speculations in connection with these questions.

What will most likely be felt as the great difficulty, is the difference between the valley containing a modern glacier, attended as it is by a mean inclination of three, four, or more degrees, and a wide extent of country without retaining walls, and with only certain inequalities throughout its surface. We see, it will be said, how gravitation will produce a flow in the one case, but not in the other. The difficulty, after all, will be found to rest chiefly on this supposed necessity for the force of gravitation to pull a glacier along in its bed; for it so happens that the main effect of Professor Forbes's investigation, has been to impress such a notion, while the actual terms of his proposition are forgotten or overlooked. These were, that a glacier is "urged down a slope of a certain inclination, by the *mutual pressure of its parts*." As far as I can understand the views of our learned associate, there is a hydrostatical pressure from a column of the same material acting on a superior level, and thus pushing along what is at the lower level. Mr Forbes says, "Pure fluid pressure, or what is commonly called hydrostatical pressure, depends not at all for its energy upon the *slope* of the fluid, but merely upon the difference of *level* of the two connected parts or ends of the mass under consideration." It appears that the less fluid the body, the less is this the case, from the resistance which the viscosity presents; but, at the same time, the greater the viscosity, the more will the retardation due to friction be distributed throughout the mass; so that the sliding of the bottom of the fluid over its bed, will be the more facilitated. The glacier, of course, being a highly viscous body, will be comparatively slow to yield to the hydrostatical pressure of the more elevated parts; but it will, and does yield in a certain reduced degree, and its comparative viscosity ensures that its base shall not be left greatly behind its middle and superficial parts—that it must, in short, slide *bodily*, and so graze the bed or surface over which it moves.

The question occurs, over how small an inclination will a mass constituted in the manner of a glacier slide? We see glaciers in the Alps, moving at the rate of above two hundred yards in a year, over a bed with walls and impeding projections, which has a mean slope of 5°. Will it move at all over a very much smaller inclination? We have an answer on this point from Professor Forbes:—"Large and deep rivers," says he, "flow along a much smaller inclination than small and shallow ones. . . . The most certain analogy leads us to the same conclusion in the case of glaciers. We cannot, therefore, admit it to be any sufficient argument against the extension of ancient glaciers to the Jura, for example, that they have moved with a superficial slope of one degree, or in some parts even of a half or quarter that amount, whilst in existing glaciers the slope is seldom or never under 3°. The declivity requisite to insure a given velocity, bears a simple reference to the dimensions of a stream. A stream of twice the length, breadth, and depth of another, will flow on a declivity half as great, and one of ten times the dimension upon one-tenth of the slope."

If this be the simple principle concerned where there is a declivity, it is easy to see that a very small declination from the north to the south of Scandinavia, or of Northern America, would suffice to allow of a movement for the supposed general glaciers of those regions, seeing that there is tolerably clear evidence of these glaciers having been on a scale of volume immensely exceeding the glaciers of the Alps. Judging from the abrasions they have left on hills, and the height to which their detritus extends, they must have been several thousands of feet in depth.

But it appears as if it were not necessary that there should have been any sensible inclination of the general surface over which these supposed glaciers extended, if it be true, on the hydrostatical principle announced by Professor Forbes, that they would move under the influence of sufficient accumulations in any quarter, in the directions in which they found least resistance. Supposing such accumulations on circumpolar grounds, there would be a spreading movement to the south, liable to be affected to some extent by accidental impediments; in short, very much such a movement as the glacial phenomena of northern countries lead us to expect. To such an extension of the operations we now see, it is only further necessary that the meteorological conditions should have been such as to maintain the plasticity of the material; and this is a point on which we have assuredly no data that would at once and decisively negative the demands of the present theory.

The nearest approach that we are acquainted with in nature, to the case here supposed, appears to be that afforded by the phenomena of the land discovered by Sir James Ross in the 79th degree of south latitude. "The vessels were here stopped by a barrier of ice from 100 to 180 feet in height, and extending 300 miles from east to west. Beyond these ice-cliffs a chain of lofty mountains was discovered, rising from ten to twelve thousand feet in height, and covered with glaciers and ice-fields. From the sea-face of the frozen barrier reached by the vessels, huge masses were constantly breaking off, and floating northward, bearing with them fragments of rocks which had been derived from the mountains." Such is the description given. It appears that here was a tract of ice 300 miles in extent, moving outwards from land, with detritus. It must have been viscous ice, or it would have had no motion; although, at its extremities, where the fragments were breaking off, a more solid character may have been assumed. It seems to realise, on a very considerable scale, the extensive glacier-sheet demanded by the phenomena of abrasion in the opposite portion of the globe.

We have, from motives of convenience, withheld till now all but the most partial consideration of those superficial deposits which are so palpably connected with the present subject. It is obviously necessary that these should be explained in harmony with any theory of the abraded surfaces which we can expect to be received.

In Sweden, as far as my observations extended, the kind of matter usually found lying immediately upon the smoothed rocks, and in the lee of eminences, is a confused mixture of blocks of all sizes, imbedded in coarse sand and clay, with no sorting observable in any part. Very generally this mass is of a straw colour, and so exactly does it resemble the detritus found at the sides and skirts of existing glaciers, that I have been led to adopt for it the term *Moraine Matter*. It seems to be the direct and invariable effect of glaciation taking place on inclined ground under the atmosphere. This matter is, everywhere in Scandinavia, covered with beds of sorted gravel, sand, and clay, betokening a subsequent watery action, as if the masses had been submerged, and a partial change effected on and about them by that means. In many places, this alluvial or aqueous formation is presented in ridges called *ösar*, which traverse the country in determinate directions, often extending for many miles. Shells are found in the aqueous deposit, but never, as far as I have heard, in the subjacent moraine matter. Besides these formations, there is the still more superficial one of erratic blocks, which, affiliated to Sweden and Finland, extend southward into Denmark, Germany, and Russia, at least as far as the 50th parallel. These rocks are less worn than those of the lowest deposit, and yet are carried much farther. It is likewise of importance to observe, that they have been carried over the intervening line of the Valdai Hills, which rise from 800 to 1100 feet above the sea.

The superficial deposits of Northern America bear a general resemblance, in their important features, to those of Northern Europe.

In our island, the superficial deposits constitute a series, of which no fewer than six, if not seven, members have been described by some observers, though it is seldom that so many are present at one place.

One noted deposit very generally found resting on the rocks in Scotland, is the *Boulder Clay* (No. 1.) It consists of a remarkably compact menstruum of clay, blue, black, or of some lighter colour, totally impervious to water, and only assailable by the pickaxe; which breaks with irregular fracture; has no trace of lamination; and through which are interspersed blocks of all sizes, which have travelled from places within forty or fifty miles, usually rounded, often worn into a sort of sole on one side, presenting striæ or scratches. This deposit is found, in Mid-Lothian, nearly 1000 feet above the sea, and, in some places, is stated to be not less than 160 feet deep; shewing an amount and extent of operation for the abrading agent in which it took its rise, perfectly enormous. A railway cutting made in this deposit on Middleton Muir, in a situation not less than 700 feet above the sea, was about fifty feet thick.

In the valleys of the Forth and Clyde, where the boulder clay is very largely developed, the included blocks are all from the westward, the direction of the agent which has produced the furrowing and striation of the district. At several places, strata cropping out westward under the clay, have been found bending off back to the east, with the clay insinuated in the gap, clearly proving at once an east-going force, and a partially liquid state of the clay at the time of its deposition.

At Linksfield, near Elgin, there is a horizontal chink between a limestone bed and the superior oolite strata, from three to four feet deep, and this is filled for several hundred yards inward from its mouth with boulder clay, which has found an entrance from the *north-west*, and scratched the planes above and below, between which it has been insinuated.

In a few isolated situations, a bed of sand has been found between the boulder clay and the subjacent rocks, and Mr Milne Home mentions an instance in which some of the materials of this sand could be traced to an *easterly* situation.

The generally azoic character of the boulder clay is one of its most remarkable features. Besides a fragment of an elephant's tusk, represented as having been found in it by some workmen in 1820 at Cliftonhall, in Mid-Lothian, Mr Milne Home, who gave great attention to the formation and its history, had never, in 1838, heard of a single instance of organic matter found in connection with it. More recently, shells of the existing epoch have been found by Mr John Cleghorn, liberally scattered through its depths in Caithness; but they are all water-worn, and can, therefore, be only classed with the inorganic materials. Mr Smith of Jordanhill discovered shells in the like state in the boulder clay; and Mr Carrick Moore lately announced an entire valve of *Astarte compressa*, as being found by him in the same formation in Wigtonshire,—a solitary exception to the rule.

I have only within the last few days been made acquainted by Mr Hugh Miller, with a curious and, as yet, unrecorded feature of this mysterious deposit, as it occurs in our own neighbourhood. It is well known that between Leith and Portobello, and between Portobello and Fisherrow, there is a cliff of the boulder clay on which the sea is making perpetual aggressions. The beach in these places is partly composed of a rough though levelled platform of boulder clay, with some huge blocks resting on it here and there that have been washed out of the superior mass, now carried away. At several places the eye can detect a narrow train of blocks crossing the line of beach, somewhat like a quay or mole, but not more than a foot above the general level, and not at a right angle to the line of the coast. All of these blocks have flat sides uppermost, and all of these flat sides are striated in one direction,—namely, in that of the line of blocks. There are also some appearances of a hollow on the surfaces of these curious *pavements*, as Mr Miller calls them, as if some enormous wheel had run along the surface in that direction, and left in it a slight track. What is of the highest importance, the line of the blocks, and that of the striation, are from about WSW., both at Seafield and at Magdalen Bridge, (examples three miles apart,) this being the direction of the striation upon the fast rock throughout the whole of our district, so that the presumption for a community of cause becomes very strong. There is, in short, a surface of the boulder clay, deep down in the entire bed, which, to appearance, has been in precisely the same circumstances as the fast rock-surface below had previously been. It has had in its turn to sustain the weight and abrading force of the glacial agent, in whatever form it was applied; and the additional deposit of the boulder clay left over this surface, may be presumed to have been formed by the agent on that occasion.

Professor Fleming, to whose superior experience I am much beholden in this part of my subject, assures me that the deposit most generally found in our district over the boulder clay is a fine laminated clay, or silt, evidently derived from the preceding formation, in which it sometimes fills up considerable irregularities. This is the clay generally wrought for bricks and tiles throughout Scotland, so that we may be said to be indebted remotely to these glacial phenomena, both for the houses which shelter us, and the increase of food required by the exigencies of a large population.

The laminated clay is succeeded by, or perhaps we ought rather to say, associated with, an abundant formation of fine sand, disposed in beds, and intercalated with gravel. Very often there are interlacings of the sand and the clay, or curious nests of sand within the clay, shewing rapid and abrupt alternations of conditions in the sea, in which the whole had been formed. In this compound formation, as I venture to call it (No. 2), shells are found—*Mya truncata*, *Saxicava sulcata*, *Tellina calcarea*, *Astarte borealis*, *Cyprina islandica*, *Mytilus umbilicatus, Littorina littorea, Buccinum undatum, Natica clausa, Balanus sulcatus,* suggesting an arctic character in the sea of the period. Remains of large quadrupeds have also been found in this set of deposits. In the deep beds wrought for bricks at Portobello, large trees are reported as having been found by the workmen, and thought by them to be of oak; as also, bones "as thick as a man's thigh." They are likewise understood to have found hazel nuts lying on the surface of the deposit.

This evidently aqueous formation of a tranquil era, during which there had been dry land inhabited by the elephant, rhinoceros, stag, and other large mammalia, is succeeded by what Mr Milne Home calls the *coarse gravel* or *stony clay*, but what is more generally recognised in Scotland as the *till*, being the subsoil of many of our fields (No. 3). This formation may be described as a layer of rough stones, embedded in a light-coloured clay, not so thick as the boulder clay generally is, while the included blocks are also of smaller size. It has no laminæ, no organic remains, and has all the appearance of having been the product of violent agencies. It appears to be often confounded with the boulder clay, and thus has given rise to some serious mistakes regarding the arrangement of the superficial deposits. It is often, however, placed immediately over the surface of the rocks.

Over this again comes a new series of sand-beds (No. 4), containing thin layers of gravel, and fragments of coal,—a very wide-spread formation in our immediate neighbourhood, and throughout Scotland generally. Mr Milne Home found it at Blackshiels, 700 feet above the sea, and it probably exists at greater elevations. This very careful observer had not heard of any shells being ever found in it.

The same gentleman has described a raised beach which extends along the Firth of Forth, (No. 5,) rising from fifteen feet in the east, to about thirty in the west, above the level of the sea, in which he found beds of shells of existing species; and this appears, from his description, to be an intercalated formation, though probably represented by some of the shell-bearing beds found by Mr Smith of Jordanhill, and Mr John Craig, in the basin of the Clyde. The bed is one of exceeding value in the present disquisition, as it indicates that at this particular period, the relative level of sea and land, in our district at least, had been reduced from the high point denoted in the preceding formation, down to one not more than thirty feet above the present. It was a period, in short, of extensive dry land. As might be expected, the rivers had in this period worn out hollows in the solid structure of the country; amongst other such cuttings was that of the Water of Leith at the Dean, in our own neighbourhood. So, at least, Mr Milne Home infers, and with good reason, from finding on the sides of that hollow, a bed of the next formation.

This was a third boulder bed (No. 6), a drift of coarse gravel, connected with the well-known erratics, which, however, are very generally superficial. This formation must be regarded as, in our district, consequent upon a deep and abrupt re-immersion, for it spreads up to elevations even higher than the boulder clay. The long ridges of gravel, called in Scotland *kames*, and identical in character with the *ösar* of Sweden, and *eskers* of Ireland, belong to this formation; and the various ancient beaches which can be traced from several hundred feet above the sea, down to its present level, may be considered as the memorials of stages or pauses in the subsequent and final emergence of the land. The vegetable soil completes the entire series, being the product of historic times.

In the basin of the Clyde, there are some differences in the suite of deposits, though the general harmony is sufficiently clear. Mr John Craig describes the following series as existing at Glasgow:—

4. { Sand under Trongate.
   Laminated clays with recent marine shells; newer portion containing only fresh-water shells, as *physa*. }

3. Boulder till. (What are below appear at Bell's Park.)

2. Sand.

1. Lower boulder till.

The boulder till (No. 1), at Bell's Park, contains an abundance of worn and striated boulders, and the subjacent sandstone exposed in making the Caledonian Railway Station presented, within the last two years, a piece of polished and scratched surface, which, however, has since been quarried. The blocks are of granite, porphyritic traps, mica-slate, greywacke, red sandstone conglomerate, and quartzose rock, all of which are found in the Highlands many miles to the north-west; besides some less worn coal, sandstone, and carboniferous limestone, from the immediate neighbourhood of Glasgow.

In another situation, between Greenock and Port-Glasgow, Mr Smith of Jordanhill found the following deposits, which, as in the above case, we venture to assign to their relative places by numbers:*—

Vegetable soil.

3. Coarse gravel, two feet.

2. { Sand, ten feet.
A series of thin beds of sand, gravel, and clay, full of sea-shells; (33 species found at two visits).

1. Diluvium.

The same diligent observer has described a deposit of shells found at Airdrie, in digging a coal shaft, at a spot 524 feet above the sea:†—

3. Upper till.

2. Stratified clay, in connection with which the shells were found.

1. Lower till.

It must be admitted that there is some uncertainty in assigning these relations, the imperfection of the description making certainty for the present impossible.

The superficial formations of England have been described by various local observers, but with such a want of concert and relation, that it is extremely difficult to reduce them to any conformity even amongst themselves, much more to bring them into harmony with those of Scotland.

The region of Siluria—the south-east-looking slope of the hills of North Wales, and adjacent districts of Herefordshire, Worcestershire, and Salop—is described by Sir Roderick Murchison, as presenting a local drift—that is, a drift com-

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* Memoirs of Wernerian Soc., viii. † Quar. Jour. Geol. Soc., vi. 386.

posed of materials derived either from mountains forming the north-western limits of the country, or from rocks of the very district where the materials are found. "Not only the valleys, but various elevated *combs* and basin-shaped cavities, as well as the slopes and escarpments of hills, are strewed sometimes with boulders, coarse gravel, and clay, at others with finely comminuted materials. . . . In passing to the south-east, the coarse boulders disappear, and the gravel becomes more and more finely comminuted, shewing that the direction of the drift has been from the north-west." Connected with this drift are proofs of extensive denudation, such as the conical hills called the Pyons, lying five miles from the principal masses with which they were once connected, the valley of the Severn lying between,—and the lofty peak Pen-cerrig-calch, an outlier of the South Wales coal-field divided from its principal by an intervening valley twelve or fifteen hundred feet deep.

Sir Roderick further describes a central tract of Western England, composed of large portions of Lancashire, Cheshire, Shropshire, Staffordshire, Worcestershire, and Gloucestershire, where the local drift is overlaid by a drift which has come from the north, bearing fragments of granite and other rocks, of which the original position is comparatively distant, and in which are found deposits of shells of existing species. He conceives that Siluria had been dry land at the time when a northern sea-current deposited this higher and later drift.

The same northern drift lies in large masses on the north coast of North Wales, and in elevated portions of the Snowdonian region, where shells have been found in it at 1392 and 2200 feet above the sea; but, as has been remarked, it seems to have been swept out of the Snowdonian valleys by comparatively modern glaciers.

Professor Phillips describes the drift in a part of England more to the northward. Masses of the porphyritic granite of Shap Fell, and portions of other highly peculiar rocks belonging to the Lake country, have been carried "northward in the vale of the Eden to Carlisle, southward by the Lune and the Kent to the barren tract between Bolland Forest and the bay of Morecambe, and from the vicinity of Lancaster they are traced at intervals through the comparatively low country of Preston and Manchester, lying between the sea and the Yorkshire and Derbyshire hills, to the valley of the Trent, the plains of Cheshire and Staffordshire, and the vale of the Severn, where they occur of great magnitude. It thus appears that the Pennine chain, ranging north and south, acted as a great natural dam, limiting the eastward distribution of the blocks; but at Stainmoor, directly east of Shap Fells, a comparatively low part of the chain (1400 feet above the sea), granite from Shap Fell, which is 1500 feet, as well as sienitic rocks from Barrock Fell, which is 2200 feet, and red conglomeratic masses from Kirby Stephen, only 500 feet above the sea, have been drifted over the ridge. This great boundary passed, the blocks are scattered from Stainmoor, as from a new centre, to Darlington, Redcar, Stokesley, Osmotherly, Thirsk, and the whole front of the Hambleton hills; they have gone down the whole length of the vale of York, and by the base of the chalk wolds to the Humber." To the south of the point of passage here described, the boulders of the Lake district lie up against the Pennine chain "in enormous quantity, and in the most inextricable confusion, not to be explained by anything like the action of the sea on its coasts, even during the most violent storms."

In Norfolk, the series of superficial deposits is thus set down by Sir Charles Lyell:

3. Erratics.
2. Fresh-water deposits, with beds of lignite and submarine forests.
1. Unstratified clay or till, lying on the Norwich Crag.

Mr Trimmer describes the superficial deposits of the country between Congleton and Macclesfield, as follows:

3. Upper Erratics: sand and gravel; large northern boulders.
2. Till: "a red clay containing many small fragments having a northern origin, and much detritus derived

from the neighbouring chain." Contains scratched fragments, but these supposed to be local. Fragments of shells.

1. Sand, a deep bed, with erratic detritus.

At Weymouth, according to Sir Henry de la Beche,* the rocks, inclusive of the chalk, have been subjected to great disturbance, producing enormous faults; but the surface has subsequently been exposed to "a tremendous inundation, which has swept away all the rubbish and ruins of the elevated masses, and has excavated valleys of many hundred feet in depth on the surface of the strata that remain. Outlying summits composed of residuary portions of the strata which are continuous along the escarpments on the north and east of the valley of Bredy, indicate the original continuity of these strata over large portions of that district from which they have been removed."

In the district of Chatham and Rochester, according to Mr R. Dadd,† there is the following series of deposits above the upper chalk:

4. Alluvium.
3. Diluvium: from 6 to 10 feet thick; water-worn chalk, with unworn flints. Remains of deer, elephant, rhinoceros, &c.
2. London clay.
1. Plastic clay. Shells of *ostrea*, *cyclas*, and *cerithium*.

Amidst the obscurities produced by the want of a uniform nomenclature, it is easy to see that the till, diluvium, and northern drift are all one formation, identical with the till or second boulder clay of Scotland. In the Silurian region there is a lower drift, marked, like the lower or true boulder clay of Scotland, by the comparatively local character of the detritus, and which may be presumed to be contemporary with that formation. Over the till or northern drift, again, there are other deposits of a tranquil ocean, as in Scotland. There are also, as in Scotland, about this part of the series, remains of land vegetation. Subsequently come large un-

* Geol. Proceedings, i., 220. † Ibid., i., 482.

worn northern erratics, generally occupying a superficial position. Thus the sequence of events seems the same over the island, though all are not everywhere expressed,—a result which no geologist will have any difficulty in accounting for.

It must be evident, when the whole subject of the superficial deposits is thus analysed, that the vague general view which is often taken of it by geologists, is one which can only be entertained in defiance of facts. It is placed beyond all question, that these deposits form the record, not of one epoch, when our land was under a glacial sea charged with icebergs, but of a succession of conditions in which the land sunk and rose, and sunk and rose again, and during which phenomena of very various character took place. It is not possible, in the present state of the investigation, to speak with precision of this succession of conditions and phenomena; but I may venture to point out what the facts suggest in the case, so far as we are yet acquainted with them, leaving to future inquirers to make such modifications of my provisional view of the matter as may appear necessary.

The more general glaciation which has here been described, with its attendant memorial of a detritus of striated local blocks and clay, points to a wide extension of the circumpolar ice, and a southern movement of that envelope, in the course of which the surface was abraded and the detritus produced. This icy sheet is shewn, however, not to have been everywhere in precisely the same condition as a glacier of the Alps, for there is a difference in the character of its detritus. The boulder clay indicates a comparatively fluid state of the ice, whether from passing across shallow seas, as it may have often done, or simply because the water which itself produced rested amongst its particles, instead of being drained away, as it always is, in a valley glacier. There being in the detritus of this glaciation no far transported blocks, I attribute to the severity of the attrition to which they were subjected. With this glaciation, moreover, is connected much of that denudation which has hitherto been attributed exclusively to floods.

After this glacial period, the land had been partly submerged; those parts which remained above the waves were the residence of the large mammalia, while under the waters there took place deposits of plastic clay, washed off from the boulder clay, alternating with beds of sand, of which the materials were obtained from the hills.

Next succeeded a new cold period, in which the masses of the land produced glaciers descending with their subaërial detritus into the sea, as we see at this day in Spitzbergen. Borne along in determinate directions by currents, the ice-borne detritus was strewed along the sea-bottom, so as to form the *till* of Scotland, the *drift* of England, and the corresponding deposits of Northern Europe and America.

This also passed away, giving place to renewed deposits of sand and gravel under an ordinary sea.

Then was a period of larger extent of dry land,—larger, even, than what now exists. Districts now little above the level of the sea, and some a little below it, were then so far elevated as to be subjected to a comparatively severe temperature. What are now low grounds in Hampshire, bore the coniferæ and other trees now proper to the Scottish hills. Snowdonia, the Lake Country, Assynt, the Cuchullin Hills, and other districts in Scotland, were the seats of glaciers like those now existing in the Alps, by which the detritus of an earlier cold period were swept out of the valleys forming their beds.

Then came another deep submergence, attended still by great cold. Masses of ice floating away from the insulated hills, bore off large blocks in the direction of the prevalent currents, and thus the Criffel granite became strewed in Cumberland, and the Shap granite was transported to the plains of Salop and the vale of York.

The emergence consequent upon this state of things, still attended by a low temperature and a transportation of erratics, was by stages, to which must be attributed the ancient beaches now traceable over the face of the country.

Perhaps the most valuable effect of the facts here adduced is in the light which they throw upon the great, but hitherto mysterious processes of denudation and the formation of valleys. To suppose water capable of cutting out all the wide and deep spaces which exist between the principal masses of certain formations and their outliers, has always appeared to me a violent supposition, and one with which we could not rest. When, surveying the Old Red Sandstone district of Sutherland and Ross shires, I found the enormous relics of that formation, and the vast spaces left between them, marked with the traces of an agent possessed of much higher mechanical force, I felt how much more satisfactory it would be to regard *that* as the great denudator, though certainly not to the exclusion of water, the wearing force of which is everywhere conspicuous within its own limits. To the south of Lake Wenern, in Sweden, there is a series of hills, of about 700 feet high, composed of horizontal transition strata, and the gneiss surfaces between are all polished.* This is a case perfectly parallel to that of the Ross-shire mountains, and doubtless many other instances might be found. Valleys are generally formed in the lines of ancient breaks or faults. Such is the case with the valleys of the Lake Country. But as Mr Hopkins remarks—"The inspection of a model in which heights and distances are on the same scale, must make it apparent that the actual *widths* of the valleys in question could not possibly be derived from the fractures in which we may conceive them to have originated."† It is equally evident that after certain longitudinal and descending hollows had been formed by fracture, these, becoming the seats of moving ice, would in time be widened to the extent which we now behold.

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* Bohtlink; Edin. New Phil. Jour., Oct. 1841.

† Quar. Jour. Geol. Society, iv., 86.

Meteorological Observations taken at the Ordnance Survey Office, 13 *Royal Circus, Edinburgh, during the Year* 1852; 130 *feet above the mean level of the sea.* Communicated by Captain JAMES, Royal Engineers.

From Daily Observations.	Hours of Observation.	Jan.	Feb.	March.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Means of the Year.
Mean height of the barometer at the temperature of 32°, and corrected for altitude above the mean level of the sea for each month, and for the year, ...	9 A.M.	29·462	29·870	30·212	30·168	29·917	29·629	29·977	29·746	29·939	29·822	29·496	29·408	29·804
	3 P.M.	29·356	29·867	30·186	30·139	29·903	29·614	29·972	29·728	29·919	29·805	29·480	29·426	29·783
Mean temperature of the air for each month, and for the year, at 9 A.M. and 3 P.M.	9 A.M.	40·8	40·9	42·6	46·7	51·9	55·9	63·2	60·6	53·9	46·9	42·8	43·1	49·1
	3 P.M.	42·1	43·1	45·5	52·9	55·4	58·8	68·0	64·6	57·7	49·9	45·1	43·9	53·3
Approximate mean temperature of the air from the means of daily observations of self-registering max. and min. thermometer, ...	Max.	44·9	45·5	46·1	53·8	57·5	61·3	70·8	67·0	59·4	51·5	47·5	47·1	54·4
	Min.	36·2	34·1	36·4	40·1	45·5	49·5	57·4	55·0	48·8	42·1	38·3	38·2	43·5
	Mean	41·0	39·8	41·2	46·9	51·5	55·4	64·1	61·0	54·1	46·8	42·1	42·6	48·95
Mean temperature of evaporation, from observations of wet bulb thermometers for each month, and for the year, ...	9 A.M.	38·3	37·9	39·0	43·0	47·4	52·1	59·0	59·3	50·7	44·6	40·9	41·4	46·1
	3 P.M.	40·2	39·6	40·6	46·5	49·3	53·9	61·8	58·9	53·2	46·4	42·4	44·2	47·1
Meau temperature of the dew point, calculated from observations of the temperature of the air, and of evaporation, ...	9 A.M.	36·1	37·9	35·3	38·5	42·5	48·2	56·3	54·0	47·8	41·9	38·5	39·4	43·0
	3 P.M.	37·8	35·5	37·7	40·2	43·7	46·0	58·2	55·3	48·5	42·9	40·1	42·0	43·7
Elastic force of vapour, calculated from mean temperature of dew point, for each month, ...	9 A.M.	0·226	0·217	0·220	0·257	0·298	0·363	0·461	0·502	0·349	0·281	0·252	0·262	0·290
	3 P.M.	0·243	0·224	0·222	0·264	0·317	0·380	0·496	0·450	0·367	0·293	0·262	0·261	0·288
Mean humidity of the air, calculated from temperature of dew point, 1·000 = complete saturation,...........	9 A.M.	0·864	0·809	0·812	0·766	0·730	0·783	0·795	0·808	0·820	0·845	0·857	0·880	0·814
	3 P.M.	0·865	0·770	0·761	0·661	0·674	0.751	0·733	0·749	0·738	0·791	0·840	0·870	0·767
Total quantity of rain in inches, at 65 ft. 10 in. above the ground for each month, and for the year, ...		2·74	2·08	0·61	0·42	1·66	2·79	1·90	3·91	2·03	2·11	3·27	5·60	29·120
	Direction.	Number of Days from Each Point.												
Direction of the Wind at 9 A.M. during each month, and during the year,...............	N.	2	4	3	9	2	1	—	3	3	3	2	—	32
	NE.	—	1	2	2	6	1	1	—	3	2	—	—	18
	E.	—	—	4	4	6	3	5	4	4	4	3	3	40
	SE.	2	2	6	9	3	6	1	3	3	4	7	5	51
	S.	11	4	7	—	—	2	4	3	5	2	1	4	43
	SW.	8	5	2	2	8	10	8	9	1	4	8	11	76
	W.	6	11	7	3	3	4	7	7	7	8	9	8	80
	NW.	2	2	—	1	8	3	5	2	4	4	—	—	26

Remarks.

1. *Barometric Pressure.*—

The Maximum height observed was on the 7th March, at 9 A.M. ....=30·612

The Minimum height observed was on the 27th December, at 9 A.M. ....=27·895

Extreme range during the year,... = 2·717

So great a depression of the barometer has not occurred since January 1839. On the 13th of that month, Mr Adie informs me the height corrected for altitude was 27·53, when, as on the 27th December last, there was a violent storm, which, from observations made, was no doubt a rotatory storm. The depression observed by Mr Adie was the greatest (as far as I can learn) which has ever been recorded in Edinburgh.

It will be observed that the mean height of the barometer at 9 A.M., for each month, is higher than the mean height at 3 P.M., with the exception of the month of December. This abnormal result was caused by the sudden rise of the barometer on the 27th between those hours, amounting to ·419, which, on the mean of the month, overpowered the difference due to the influence of temperature at the hours of observation, though it very slightly affected the means for the year.

It will also be observed that the mean height was greatest in March, closely following the lowest mean temperature of the air, and that the mean height was lowest in August, closely following the highest mean temperature. This fact, coupled with the fact that the barometer is always higher at 9 A.M. than at 3 P.M., whilst the temperature of the air is always lower in the morning than in the afternoon, seems to prove that the effect of an increase of temperature, by causing the air to expand and become specifically lighter, produces a corresponding depression in the barometer; but as the amount of vapour in the air, and the influence of clouds and currents in the upper strata of the atmosphere constantly disturbs the effect of increased or decreased temperature at the surface of the earth, we are not able to express *numerically* the effect of any increase or decrease in the temperature of the air upon the barometer ; but it has been shewn by Colonel Sabine, that when the pressure due to the amount of vapour in the air is deducted from the height of the barometer, that the influence of temperature upon the *dry air* is to produce a daily maximum and minimum, coinciding nearly with the coldest and the warmest hours.

2. *Temperature of the air.*—

The maximum temperature registered on the 4th July, ...=81°·5

The minimum temperature registered on the 19th February, ...=26°·0

Extreme range during the year,......=55°·5

The approximate mean temperature of the air for the year =48°·95, which is probably 2° or 3° higher than the mean temperature of the air in the neighbourhood, in places beyond the influence of the heat and shelter of the houses.

3. *Humidity.*—The degree of humidity of the air has so sensible an effect upon health, particularly on persons with delicate lungs, or those subject to irritability of the skin, that it is much to be wondered at that medical men in general have paid so little attention to it, and more especially as the instrument for measuring the humidity of the air in any room is so simple and inexpensive. The gardener knows it is not sufficient that his greenhouse should be kept at a certain temperature, but takes care that his plants shall have also the requisite degree of moisture in the air ; without this the plants droop; and beyond doubt there is a certain degree of moisture which is also necessary to the health of man. Every sick room therefore should have a dry and wet bulb hygrometer ; and if the medical man considers that the temperature should be preserved at 60°, then the wet bulb thermometer should indicate 55°, which would shew the air to be ·75, or three-fourths saturated with moisture.

The amount of moisture might be regulated by exposing a larger or smaller surface of water to evaporate, for which the numerous vases and other ornamental vessels usually found in drawing rooms would be found available.

4. *Rain.*—The greatest quantity of rain which fell in one day during the year was 1·37 inches, on the 24th August; this is one-third more than fell during the entire months of March and April.

5. *Wind.*—It will be seen from the table of the direction of the wind, that it blows at 9 A.M. $2\frac{1}{4}$ times more frequently from the W. to S. arc than from the E. to N. arc; the numbers being 199 days from the SW. arc, and 90 days from the NE. arc, and that the NE. winds are the least prevalent throughout the year, occurring principally in the spring and autumn.

On the Valuation of Indigo. By Dr FREDERICK PENNY, F.C.S., Professor of Chemistry in the Andersonian University, Glasgow.

Several methods have been employed for estimating the comparative value of commercial indigo.

The colorimetric processes with chlorine, proposed by Berthollet, and first practically applied by Descroizilles, have been most extensively tried, and have been fully described by Berzelius,* Chevreul,† Schlumberger,‡ Schubart,§ Persoz, || and others. In these processes chlorine-water or bleaching-powder was used as the source of the chlorine.

Bolley ¶ has proposed chlorate of potash and hydrochloric acid as the source of chlorine, and has reported very favourably of the results obtained by operating upon specimens of various qualities.

Some chemists consider that the only method of accurately determining the value of this article consists in removing the

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* Traité de Chimie.
† Leçons de Chimie appliquée à la Teinture.
‡ Bullet. de la Soc. Industr. xv. 277.
§ Tech. Chimie.
|| Traité de l'Impression des Tissus.
¶ Ann. Ch. Pharm. 1850.

various impurities by the successive action of diluted acid, caustic alkali, alcohol and water, and then ascertaining the quantity of indigo-blue that remains, the ash being deducted in the usual manner. Others, again, prefer the process of reducing the indigo-blue by deoxidizing agents, and afterwards precipitating and collecting it in the pure state. This method was, about the commencement of the present century, adopted by Pringle,* who employed the well-known materials, sulphate of iron and lime, as the reducing and dissolving agents, and separated the indigo-blue from the clarified solution with hydrochloric acid. The operations involved in this process are exceedingly tedious, and in consequence of the peculiar property which reduced indigo has of forming two distinct combinations with lime, the one soluble, and the other insoluble (a fact not known to Pringle); the results afforded by it are not always satisfactory.

Dana † has recommended another method, based, however, on the same principles. It consists in boiling the indigo in caustic soda, and cautiously adding protochloride of tin until the indigo-blue is completely reduced and dissolved; the clear solution is then precipitated by bichromate of potash, and the precipitate being well washed with dilute hydrochloric acid, is dried and weighed.

Fritzche ‡ has suggested cane-sugar, alcohol, and caustic soda for the reduction and solution of the indigo-blue. His process, which appears, however, to be better adapted for the preparation of pure indigo, than for testing its value, has been repeated and favourably spoken of by Marchand; and Berzelius says, that it surpasses all other methods that have been employed for obtaining indigo-blue in a state of purity.

Chevreul's method of dyeing cotton until the indigo-solution is exhausted is obviously very objectionable.

Reinsch,§ after trying various modes, prefers that of dissolving a grain and a half of the indigo in concentrated sulphuric acid, and then estimating its comparative value by the

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* Annales des Arts et Manufac. vi., 214–239.

† J. pr. Chem. xxvi., 398.

‡ J. pr. Chem. xxviii. 16.

§ Jahrb. prak. Pharm.

quantity of water required to be added to reduce the colour of the solution to a certain shade. This process, which is simple and convenient, is in every respect similar to that long since applied by Ure,* though Persoz † ascribes it to Houton-Labillardière.

The advantages and disadvantages of these processes have been so fully discussed by Bolley in his paper, before referred to, that it is unnecessary, I conceive, to make any further comment on their respective merits.

The method I have now to propose, is based upon the circumstance that indigo-blue in presence of hydrochloric acid, is decolorised by bichromate of potash. This salt has long been used for discharging indigo-blue and other colours in the printing of textile fabrics, as well as for bleaching oils, fats, and several other substances. In employing it for estimating the comparative value of commercial indigo, the necessary manipulations are extremely simple.

Ten grains of the sample, in very fine powder, are carefully triturated with two drachms by measure of fuming sulphuric acid, and the mixture being excluded from the air is allowed to digest with occasional stirring for twelve or fourteen hours. A small flat-bottomed flask with a tightly fitting cork, is a very convenient vessel for this operation. Some pieces of broken glass should however be thrown in to facilitate the contact of the indigo and acid during the agitation, and thus to prevent the aggregation of the former into small clots, which the acid by itself cannot penetrate. If a small capsule or test-glass be used, it should be covered, during the digestion, with an air-tight gas-jar. It will also be found advantageous to place the mixture in a warm situation, say between 70° and 80° F., that the action of the acid may be fully developed; a higher temperature than this must be avoided, as sulphurous acid is liable to be produced, and the trial in consequence completely vitiated. Great care must be taken to insure the perfect solution of the indigo-blue in the acid. This result being accomplished, the solution is poured slowly, with constant stirring, into a pint of water contained in a

* J. Roy. Inst., 1830. † Traité des Tissus, i. 434.

basin, and $\frac{3}{4}$ of a volume ounce of strong hydrochloric acid immediately added, the flask or capsule being rinsed clean with water.

An alkalimeter of 100 equal measures, is now made up in the usual way with $7\frac{1}{2}$ grains of dry and pure bichromate of potash, and the solution added in small successive portions to the diluted sulphate of indigo in the basin, until a drop of the mixture, on being let fall on a white slab or slip of bibulous paper, presents a distinct light brown or ochre shade, unmixed with any blue or green. The process is then finished; the number of measures of bichromate used is read off, and this number shews the comparative value of the indigo subjected to the trial.

In applying the test-drop to the bibulous paper, the best results are obtained by bringing the end of a glass rod into contact with the indigo-solution, and then gently pressing it against the surface of the paper. The stain thus produced will be circular, and conveniently localised to a small space. By using bibulous paper, it will also be found much easier to recognise the last traces of the blue colour than when a slab is employed, and the results, when dry, may be preserved unchanged, for reference or comparison.

It is advisable to keep the indigo-solution gently heated while the chrome-liquor is being added; and it is essentially necessary that the mixture should be well stirred after each addition. Several measures of the chrome-solution may at first be poured in without risk of error, but towards the conclusion, the liquor must be added very slowly and with great care, as one or two drops will then be found to produce a very decided effect. The characteristic changes of colour which the mixture undergoes during the addition of the chrome-solution, will distinctly indicate the approach of the process towards conclusion. The blue colour of the solution gradually diminishes in intensity, becoming perceptibly lighter and lighter, and after a time it acquires a greenish shade, which soon changes to greenish-brown, and almost immediately to light ochre-brown.

I have tried this process very carefully upon pure indigo, prepared according to Fritzche's method. The mean of three experiments, which gave results almost identically the same, shewed that 10 grains of pure indigo require very nearly 7½ grains of bichromate of potash; and I have accordingly taken this quantity of the salt for solution in the alkalimeter.

The following table contains the results of trials upon three series of specimens of commercial indigo, and includes likewise the price of each sample, and the amount of ash left after careful incineration, as well as the moisture expelled at 212°. The first series of samples was obtained from an indigo broker in London; the second from Messrs C. Tennant and Co., Glasgow; and the third from Messrs R. and I. Henderson, Glasgow.

FIRST SERIES.

SPECIMENS.	Price, 1851. s. d.	Alkalimeter measures consumed.	Ash per cent.	Water per cent.
East Indian . .	6 4	68	4·5	5.0
" " . .	6 0	66	5·8	6·0
" " . .	5 9	64	8·1	8·0
" " . .	5 6	54	11·0	7·0
" " . .	4 9	51½	7·2	7·5
" " . .	4 8	54	3·6	7·0
" " . .	4 4	45	14·0	8·4
Spanish . . .	4 3	55	12·3	6 0
" . . .	3 10	50	13·0	7·0
" . . .	3 6	44½	19·0	5·5
" . . .	2 10	28	33·4	4·5

SECOND SERIES.

SPECIMENS.	Price, 1851. s. d.	Alkalimeter measures consumed.	Ash per cent.	Water per cent.
Bengal . . .	5 0	64	5·9	4·0
" . . .	4 9	47	24·6	5·0
Benares . . .	4 6	45	20·7	8·4
Guatemala . .	4 3	50	16·0	6 5
Madras . . .	3 8	41	10·6	6·7
Oude . . .	3 8	46	6·3	8·5
Carraccas . . .	3 6	52½	16 2	6·4
Madras . . .	2 9	35	33·3	6·0

THIRD SERIES.

SPECIMENS.	Price, 1852.		Alkalimeter measures consumed.	Ash per cent.	Water per cent.
	s.	d.			
Java	5	6	63½	5·4	4.8
Bengal	4	10	59½	7·5	5·0
,, ...	4	0	56	11.0	5·3
,, ...	3	4	45½	14·0	7·2
,, ...	1	6	24	44·4	4·4
Manilla, . . .	3	4	35½	28·0	5·0
" . . .	2	0	26½	50·0	5·4

The results in these tables clearly shew the uncertainty, and in several instances the positive inaccuracy, of the common methods at present employed by commercial men for estimating the true value of this article. The indications of quality afforded by colour, fracture, texture, coppery hue when rubbed, cleanliness, weight, and other characters, should always, in my opinion, be confirmed by the application of a simple chemical process, such as I have here described. The objection, on the score of the time consumed, so strongly urged against many of the other methods, is certainly not chargeable against this; for, by steeping the indigo in the acid over-night, twenty or thirty samples at least could be easily tested in a day, and at a trifling expense.

I may mention that there was recently sent me for examination, a specimen of indigo, offered in Glasgow as refined indigo, at 10s. per lb. It gave 9 per cent. of ash, and 2½ per cent. of moisture; and 10 grains, when dissolved in sulphuric acid, consumed 82 measures of the bichromate of potash solution. It is in very fine powder, with a deep coppery-blue colour. Assuming its quality and purity to be uniform, it would unquestionably be more economical, even at the high price of 10s. per lb., than much of the indigo at present sold. Its tinctorial powers could be relied on; and, from the circumstance of its being finely pulverized, it obviously admits of being rigorously tested by the bichromate process.

The method here proposed is open, I am well aware, to some of the many objections that have been advanced against the well-known chlorine process. It is quite obvious, for instance, that unless particular care is taken in dissolving the indigo in the sulphuric acid, not only is a part of it liable to escape solution, and proper estimation, but, in the case of inferior indigo, sulphurous acid may be produced, which would of course involve a larger consumption of the bichromate of potash than the indigo-blue itself would require. It may also be objected that bichromate of potash, in the presence of hydrochloric acid, will act upon the other constituents of ordinary indigo; but, so far as I have been able to judge from a very extensive course of experiments upon a great variety of specimens, the amount of these influences is extremely slight, and altogether inappreciable when the process is executed with proper care. The same opinion has been expressed by Berzelius and Schlumberger regarding the chlorine process; and it is further supported by the fact, that indigo containing a large proportion of brown and other colouring matters, consumes a very small quantity only of the bichromate. While, therefore, this process has no pretensions to supply scientific men with the means of determining the actual amount of pure indigo-blue in samples of commercial indigo, it is, in my opinion, admirably adapted for ascertaining their relative values, being in many respects superior to those which have hitherto been proposed.

The bichromate of potash possesses, in an eminent degree, all the qualities requisite for a trustworthy agent of valuation, being easy of purification, unchangeable by keeping, and of uniform composition.

On the Origin of Stratification. By D. A. Wells, Esq., of Cambridge, United States, North America.

The general idea respecting the origin or cause of stratification as expressed in geological text-books, or as inferred from the writings of geologists, seems to be this: that strata, or the so-called divisions of sedimentary matter, have been produced either by an interruption of deposition, or a change in the quality of the material deposited. This idea is well illustrated by the deposition of matter by tides or inundations, its subsequent consolidation, and a renewed deposition on the plane of the former deposit. That such is really the cause of stratification in many cases, I do not dispute; but that there are other causes which tend to produce, and have produced, stratification equally extensive and varied, is, I think, clearly shewn by the following observations :—

My attention was first drawn to the subject during the past summer, while engaged in the analysis of soils. By the process adopted, the soil was washed upon a filter for a considerable number of days, in some cases for a period as long as two weeks, and subsequently dried at a temperature of 250° F. The residue of the soil left upon the filter, consisting chiefly of silica and alumina, was found, after drying, in every instance, to be more or less stratified, and that too by divisional planes, in some cases not at all coincident with any division of the materials, lthough this is apt to take place. The strata so produced were in some instances exceedingly perfect and beautiful, not altogether horizontal, but slightly curved, and in some degree conforming to the shape of the funnel. The production of laminæ was also noticed, especially by the cleavage of the strata produced, into delicate, thin, parallel plates, when moistened with water. These arrangements, it is evident, were not caused by any interruption and renewal of the matter deposited, or by any change in the quality of the particles deposited, but from two other causes entirely distinct, and which I conceive to be these :—First, from a tendency in earthy matter, subjected to the filtering, soaking, and washing of water, for a considerable period, to arrange itself according to its degree of fineness, and thus form strata; and secondly, from a tendency in earthy matter, consolidated both by water and subsequent exsiccation, to divide, independently of the fineness or quality of its component particles, into strata and laminæ. The tendency of this earthy matter is generally to divide along the lines formed by the arrangement of the particles according to their nature or quality: this is not, however, always the case, as was proved by the observations noted, and which is also conclusively shewn by the examination of almost any stratified rocks.

In the valley of the Connecticut, where the sandstones remain unaltered in any great degree by heat or dislocation, the stratification produced by the several causes may be clearly seen and studied. On the western edge of this deposit, we have rocks composed of strata, which would at once be referred to the action of tides or inundations by the most inexperienced observer. The strata here vary from one tenth of an inch to one inch in thickness; they are also covered with mud-cracks, and the various markings which are usually found upon a shore or beach. In other portions of the valley, we have strata divisions occasioned by the lines which separate materials differing either in quality or nature, as in the shales from the sandstone, the coarse conglomerates from the fine sandstone, or the highly bituminous shales from those less bituminous. And then upon the extreme eastern edge of this sandstone deposit, we find strata, the leaves of which measure from one to two, and in some instances, three feet in thickness, each embracing in itself matter ranging from a coarse conglomerate to the finest sand; and yet none of these, within the limits of the particular strata in which they are included, exhibit the slightest tendency to break or divide in any one direction more than another.

The observations here stated, I am happy to find, have been also noticed to some extent by others conversant with the subject of stratification. Sawdust, subjected to the filtering action of water, has been observed by Professor Agassiz to assume a regular stratified appearance. The same has also been noticed by Dr Hayes of Boston, in the vats into which clay, used for the manufacture of alum, is washed. I have also noticed regular stratification in the dried deposit of a puddle in the streets, where no apparent change in the character of the materials deposited could be noticed, and when there was certainly no interruption of deposition.

If the divisions of stratification which I have thus pointed out be admitted, it is not improbable that many cases of what are now considered disturbed and tilted strata are none other than their normal condition.

Dr Emmons remarked that he agreed entirely with the views brought forward by Mr Wells, and referred to cases of clay beds, in which certain strata were contorted and inclined, apparently from forces acting laterally, or from below; but which forces, from the undisturbed condition of the surrounding beds, could not have acted in such a manner as to have produced the disturbance referred to: they must therefore be accounted for by peculiarities or changes in the method of deposition, and by subsequent changes.

Professor Hall stated that he had also accumulated considerable evidence in regard to this subject, and regarded it as highly important in a geological point of view.—(*Proceedings of the American Association for the Advancement of Science.*)

Relation of the Chemical Constitution of Bodies to Light. By Professor E. N. Horsford, of Harvard.

Professor Horsford called attention first to the well-known facts that the colour of the hair on animals varied, and was more intense on certain portions of the body. The metals also had colours which were affected by their composition. The change of their colour in summer and winter was also a well-known fact. He enumerated many metals which changed their tints by the simple process of heating. These were phenomena which ought to be investigated by means of chemistry. The change of tint is without change in chemical composition. The law appears to be that metals pass from a lighter to a darker tint. The loss of water causes a change from a lighter to a darker tint. In charring wood, we have a change from a lighter to a darker tint. He illustrated on the black board that blackness was the natural colour of all non-gaseous bodies; and he cited the series of compounds of gold, silver, nickel, platinum, tin, and other metals. He illustrated how the compounds of the several metals, as they became more divided in their molecular structure, varied. He exemplified them by the series of compounds of lead with oxygen, in which, as the oxygen prevailed, the colours became lighter. This was in keeping with discoveries made by Liebig, and other eminent chemists whom he named.

Dr Draper had found the tints to vary in the order in which the metals had certain affinities, as in barium, strontium, and calcium: he thought it was due to the metals which were at the base.

Blackness is appropriate to extreme dissolution; and, in this connection, it was worthy of remark that many nations had chosen that colour to express extreme grief.

The conclusions of Prof. Horsford were, that the colour of bodies depends upon the extent of the surface of their smaller particles, or groups of atoms. Transparency depends upon the arrangement of lesser atoms in certain order, constituting large groups. Whiteness depends upon such extent of surface of the groups of atoms as shall reflect all light, or upon such number of these plates produced by pulverizing transparent bodies as will reflect all the light. Blackness depends upon the subdivision of groups to such minuteness that they no longer reflect light, or, by producing interference, destroy it. Heat, by subdivision, causes darker shades. He also observed, in a note, that there seem to be successive scales of colours produced by heat.

Professor Smith, of Louisiana, did not agree with Professor Horsford in some of his conclusions, and shewed that there were numerous exceptions in the mineral kingdom. There has recently been discovered the amorphous or black diamond. The diamond is generally supposed to be a clear, transparent substance; yet here was a specimen of a black variety, which was proved by the investigations of Dufresnoy to contain 98 per cent. of carbon. The colour of this variety of diamond proceeded entirely from molecular structure.—(*Proceedings of the American Association for the Advancement of Science.*)

Notes on the Distribution of Animals available as Food in the Arctic Regions. By AUGUSTUS PETERMANN, Esq., F.R.G.S., &c.

The occurrence of animals in the Arctic regions, and its bearing on the missing expedition under Sir John Franklin, is a subject which has of late excited a good deal of interest, and has giving rise to the most conflicting and contradictory opinions: some maintaining the existing of animals in the Arctic regions in great numbers, affording abundance of food to man; others as stoutly insisting upon the extreme scarcity, if not total absence, of them.

On entering, however, into an analysis of all that has been said and written on this point, it appears that a too confined view has been generally taken of the subject. Individual observations in certain localities have been separately considered and reasoned upon for the entire region, and these localities only related to a comparatively small space on the American side, the whole Asiatic side of the Polar basin not being taken into account at all. Again, it has been commonly assumed that with ascending latitudes temperature descended, and animal and vegetable life decreased, attaining their minima at the Pole. Nothing could be more fallacious than such an hypothesis in a region where the temperature corresponds less with latitude than in any other part of the globe. When, therefore, the shores and waters of Wellington Channel were found to be "teeming with animal life," it was regarded as a wonderful fact that more animals should be found in that region than in those to the south of it; whereas this fact would seem to find an explanation when connected with other physical features. Indeed, the consideration of isolated facts alone can lead to no correct result; and it is only when the various natural features are compared and considered in their relative bearing, that the laws which govern nature can be traced and discovered. It is in this manner only that Physical Geography becomes a really useful and practical science.

In the following outline it is attempted to take a comprehensive, though rapid, glance of the distribution of animals within the Arctic regions generally, and to inquire into the causes of certain apparent abnormities.

I will, in the first place, proceed to indicate the regions to which these remarks refer; those, namely, which comprise the Arctic fauna. On this point I have adopted narrower limits than other authors, inasmuch as I have taken the northern limit of woods as the southern boundary of the region under consideration. It is true that some Arctic animals, like the reindeer, are found to the south of this line—still these are not exclusively Arctic in their character, and they are also, more or less, of migratory habits. The ice-fox, a beautiful little animal, well known to Arctic voyagers, and decidedly of Arctic character, does not in general extend to the south of the line assumed ;* which also coincides with the extreme northern limit of the reptiles, and corresponds pretty closely with the line of 50°, mean summer temperature. The region thus comprises Iceland, Spitzbergen, Nova Zembla, the extreme northern shores of Europe and Asia, with the north-eastern extremity of the latter, including also the sea of Kamtschatka and the Aleutian Islands, but excluding the peninsula of Kamtschatka. On the American side it comprises a considerable portion of British North America, the northern part of Labrador, and the whole of Greenland.

Though several classes of the animal creation—as, for example, the reptiles—are entirely wanting in this region, those of the mammals, birds, and fishes, at least bear comparison, both as to number and size, with those of the tropics,†

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* The only exception, I believe, where the Arctic fox ranges southward within the wooded district occurs in North America round Hudson Bay. This is owing to its habit of keeping as much as possible on the coast in migrating to the south ; thus, while they extend along the shore of Hudson Bay to about 50° N. lat., towards the centre of the continent they are very scarce, even in lat. 61°, and in lat. 65° they are only seen in winter, and then not in numbers.—(See Richardson, *Fauna Boreali Americana*, p. 87.) Throughout the whole of the Asiatic and European north the range of the ice-fox is nowhere found to be within the wooded region, as Baer has shewn in his masterly account of the distribution of this animal.—(See *Bullet. Scientif. publiée par l'Acad. Imp. de St Pétersbourg*, tom. ix. p. 89.)

† Though the number of *species* is decidedly inferior, the immense multitudes of *individuals* compensate for this deficiency. Some years ago I wrote with regard to this point—" If we were to conclude from a large number of species that there must be a large number of individuals, we should come to erroneous conclusions ; for such is frequently not the case. The Arctic and tropical countries furnish an excellent example, at least in their Mammalian and Ornithological Faunas. We need only refer to the crowds of birds which hover over the islands and shores of the north, or to the inconceivable myriads of penguins met with by Ross on the Antarctic lands, where there was not even the smallest appearance of vegetation ; and, among the quadrupeds, to the thousands of fur animals that are annually killed in the Arctic regions. Wrangell gives a fine description of animal life in the Kolyma district of Siberia, one of the coldest regions of the globe : the poverty of vegetation is

— the lion, the elephant, the hippopotamus, and others, being not more notable in the latter respect than the polar bear, the musk ox, the walrus, and, above all, the whale. Besides these, there are the moose, the reindeer, the wolf, the polar hare, the seal, and various smaller quadrupeds. The birds consist chiefly of an immense number of aquatic species. Of fishes, the salmon, salmon-trout, and herring are the principal, the latter especially occurring in such myriads as to surpass everything of the kind met with in tropical countries. Nearly all these animals furnish wholesome food for man. They are, with few exceptions, distributed over the entire region. The number in which they occur is very different in different parts. Thus, on the American side we find the animals increase in number from E. to W.—on the shores of Davis Strait, Baffin Bay, Lancaster Sound, Regent Inlet, fewer are met with than in Boothia Felix and the Parry Group. The abundance of animal life in Melville Island and Victoria Channel is probably not surpassed in any part of the American side. Proceeding westward to the Russian possessions, we find considerable numbers of animals all round and within the sea of Kamtschatka, as also to the north of Behring Strait. The yearly produce of the Russian Fur Company in America is immense, and formerly it was much greater. Pribylow, when discovering the islands named after him, collected within two years 2000 skins of sea otters, 40,000 sea bears (Ursine seals), 6000 dark ice foxes, and 1000 pood of walrus teeth. Lütke, in his Voyage round the World, mentions that, in the year

strongly contrasted with the rich abundance of animals; countless herds of reindeer, elks, black bears, foxes, sables, and grey squirrels, fill the upland forests; stone foxes and wolves roam over the low grounds. Enormous flights of swans, geese, and ducks, arrive in spring, and seek deserts, where they may moult and build their nests in safety. Eagles, owls, and gulls pursue their prey along the sea-coast; ptarmigans in troops among the bushes, and little snipes are busy along the brooks and in the morasses. Baer also relates that a walrus hunter on the rocks of *Nova Zembla* caught in a few hours 30,000 lemmings. On the other hand, in Australia, and other regions of the tropical and temperate zones, a traveller will frequently journey for weeks together, and pass over hundreds of miles of country, without meeting with a single quadruped."—See *Atlas of Physical Geography*, by Petermann and Milner, p. 130.

1803, 800,000 skins of the Ursine seal alone were accumulated in Unalaska, one of the depôts of the Russian Fur Company; 700,000 of these skins were thrown into the sea, partly because they were badly prepared, partly in order to keep up the prices. In the Polar Sea to the north of Behring Strait, as is well known, the number of whales found is prodigious; during the last three years American whalers, at the rate of 150 every year, having been employed in that small portion of the ocean. But in no other part of the Arctic zoological region is animal life so abundant as in the north-eastern portion of Siberia, especially between the rivers Kolyma and Lena. A description of the Kolyma district has already been given in the preceding remarks, to which the following particulars may now be added. The first animals that make their appearance after the dreary winter are large flights of swans, geese, ducks, and snipes: these are killed by old and young; fish also begin to be taken in nets and baskets placed under the ice. In June, however, when the rivers open, the fish pour in in immense numbers. At the beginning of the present century several thousand geese were sometimes killed in one day at the mouth of the Kolyma; about twenty years later, when Admiral Wrangell visited that place, the numbers had somewhat decreased, and it was then called a good season when 1000 geese, 5000 ducks, and 200 swans were killed. Reindeer hunting forms the next occupation of the inhabitants. About the same time the shoals of herrings begin to ascend the rivers, and the multitudes of these fish are often such, that in three or four days 40,000 may be taken with a single net. On the banks of the river Indigirka the number of swans and geese resorting there in the moulting season is said to be much greater even than on the Kolyma. West of the Lena, and along the whole of the Siberian shores as far as Nova Zembla, and including that island, animal life presents a great contrast to the preceding portion, as it is nowhere found in such abundance as in the districts already described, and in many parts it is extremely scarce. Spitzbergen, although possessing considerable numbers of animals, especially reindeer of the best description, is greatly inferior to north-eastern Siberia in that respect.

Having now completed this circumpolar view of the distribution of animals, its causes remain to be considered.

The development of vegetable and animal life in the Arctic regions chiefly depends on the warmth of two or three, or even one summer month; and it may be in general assumed that where the summer warmth is the highest, there plants and animals will be found in greater number and bulk than in other regions where the temperature is lower. This assumption is found to be correct as far as actual observations have been extended. The distribution of temperature in the Arctic regions and its causes I have elsewhere* discussed; in this place the summer temperature only requires to be considered. To afford, however, the elements of a complete view of the distribution of temperature within the frigid zone, I have collected the observations made at various points, including some interesting stations not strictly belonging to the Arctic regions: these results are given in the Table (pp. 306, 307) and enumerated with respect to latitude.

According to Sir John Richardson, terrestrial animalsare abundant in the polar regions for two short summer months only. Birds fly to the north to perform the functions of incubation and rearing their young, which done, old and young, with the exception of some scattered flocks of dovekies, desert their breeding-places, and with the frost wing their way southwards. Reindeer, musk-oxen, and the beasts of prey which follow in their train, do not quit the continent to visit the Polar islands until the thaw has made some progress in thinning the snowy covering of the pastures, and they return towards the woodlands again as soon as the sea is fast, or sooner, if the straits which separate their summer haunts from the main are narrow enough for them to swim across. The temperature of the month of July, which corresponds with the summit of the summer, appears to be a pretty sure index of the occurrence or abundance of animals in those regions. The following table exhibits the places of

* See Petermann's "Search for Franklin," 1852.

the lowest mean July temperature of the American half of of the Arctic regions, being all below 40° :—

		° ′		°
Winter Islands . . .	(latitude	66 11)	. .	35·4
Port Bowen	("	73 14)	. .	36·6
Assistance Harbour .	("	74 40)	. .	37·8
Igloolik	("	69 21)	. .	39·1

Observations made on board of vessels navigating Baffin Bay and Hudson Strait give the following additional re-results :*—

	Mean Latitude.		Mean Longitude.		Mean Temperature of July.
	°	′	°	′	°
Baffin Bay . .	70	0	59	0	33·5
Baffin Bay . .	70	0	58	0	34·8
Baffin Bay . .	75	5	59	4	34·9
Hudson Strait .	63	0	77	0	35·3

An elliptical curve drawn round the foregoing points, having as its axis a line extending from the entrance to Hudson Strait to Assistance Bay, and including Davis Strait, Baffin Bay, Lancaster Sound, Barrow Strait, Prince Regent Inlet, Boothia Gulf, Fox Channel, with the land between, comprises the coldest regions on the American side. This region is precisely that in which the fewest numbers of animals have been met with. Beyond it, even to the N., where the July temperature—as in Melville Island—has been found to increase, there the animals also have been found in greater numbers. Dr Sutherland, in his valuable work already quoted, gives some interesting remarks on this head. He says,† " That deer are more abundant on the N. side of Cornwallis Island, adjacent to Barrow Strait, no person need doubt; for Captain Penny's and Mr Goodsir's travelling reports contain frequent allusions to the numbe s

* As given by Dr Sutherland in his " Journal of a Voyage to Baffin Bay and Barrow Strait." See Appendix, p. clxxvi.

† " Journal of a Voyage to Baffin Bay and Barrow Strait," Introduction, p. xxxii.

of these animals that were seen there; while not one, so far as I know, was ever seen during the whole year in any of the frequent excursions made from the ships in Assistance Bay." Again: "It will be rather peculiar if we find that these animals take towards the N. side of Cornwallis Island as the winter approaches, that they may share the modifying effect which the open water in Queen's Channel must have upon the atmosphere in its vicinity; and it will appear at variance with the generally received opinion that these animals migrate southward on the approach of winter." It would have been interesting if a series of observations of the temperature in the regions referred to by Dr Sutherland could have been made, so as to draw a comparison in that respect with Assistance Bay.

In Wolstenholme Sound, at the head of Baffin Bay, though having a July temperature of 40° 5′, a comparatively small number of animals were observed by the expedition of the "North Star." This is a point, however, from which animals can easily migrate to the S. or N.; and if the temperature be higher farther N. during the summer, as is highly probable, they unquestionably would extend their migration in that direction. Dr Sutherland has an interesting remark bearing on the point:—

"The Esquimaux lad whom Captain Ommanney took on board H.M.S. 'Assistance,' at Cape York, says that the Esquimaux who inhabit the coast in the vicinity of Whale Sound, at the top of Baffin Bay, clothe themselves with the skin of the musk-ox (umingmak). This statement, if true, would lead one to the idea that the musk-ox inhabits still more northern regions than Melville Island—regions whence they cannot return into a more southern latitude with the close of the season, owing to the open water in the top of Baffin Bay throughout the whole winter. And moreover, it may lead to the inference that such regions as can maintain the musk-ox throughout the year in so high a latitude as 77° and upwards, must present features with respect to temperature which are peculiar only to regions in the vicinity of an extensive sea."

On the Asiatic half of the Arctic regions the July temperature stands as follows:—

Spitzbergen, NW. extremity . .	(latitude 80 00) . .	36·0
Nova Zembla, Karische Pforte .	(" 70 37) . .	36·3
Ditto, Seichte Bay	(" 74 00) . .	37·7
Ditto, Matothkin Shar	(" 73 00) . .	40·0
Spitzbergen, Hecla Cove	(" 79 55) . .	40·2
Kovennoy Filipovskoy	(" 71 05) . .	48·8
Ust Yansk	(" 70 58) . .	58·6
Nishne Kolymsk	(" 68 32) . .	61·0

In this region the influence of the temperature is still more striking, as it has been shewn that north-eastern Siberia, comprising the warmest stations in the foregoing list, exhibits not only the greatest amount of animal life in northern Siberia, but throughout the whole of the Arctic regions, although in winter it is the coldest on the face of the globe. It will be seen, by comparing the two tables of the July temperature, that Winter Island is the coldest of all stations; and this is likewise the case with the mean of the three summer months. This place is consequently the pole of cold of the northern hemisphere during the summer; and Mr Berthold Seemann, the naturalist of H.M.S. *Herald*, informs me that it it is likewise the phytological North Pole, namely, that point which possesses the smallest number of genera and species of plants, and whence the number increases in every direction. While thus in Winter Island the most scanty vegetation is found, in north-eastern Siberia, in a corresponding latitude, noble forests are known to thrive in considerable extent. It is curious to remember that already that distinguished navigator Frobisher, nearly three hundred years ago, in describing the country round the Strait named after him, says that under a latitude of 62° it was colder there than in Wardöhuus in Europe, in latitude 70½°, the former being comprised in the district I have shewn to be the coldest in summer in the Arctic regions, as far as our present knowledge extends. It is much to be regretted that the efforts of the numerous Arctic expeditions in this century—in the hope to effect the so-called "North-western" passage—should have been almost exclusively directed and accumulated upon that region,—the most desolate, and, perhaps, the most uninteresting, as well as the most difficult and dangerous portion of the Frigid Zone.

Without going further into detail, I will merely add a few words as to the bearing of the foregoing observations on Sir John Franklin's Expedition.

The general opinion is that the missing vessels have been arrested somewhere between Wellington Channel and Behring Strait and the Siberian shores. Most probably their position is nearer to the latter than to the former points. As these three regions abound in animal life, we may fairly conclude that the intervening portion partakes of the same character, and moreover, that the further Sir John Franklin may have got away from Wellington Channel, and the nearer he may have approached the north-eastern portion of Asia, the more he will have found the animals to increase in number. The direction of the isothermal lines corroborates this assumption, as they are indicative of a higher summer temperature in that region than in any other within the Polar basin. Those countries being probably uninhabited by man, the animals there would have continued unthinned by the wholesale massacres by which myriads are destroyed for the sake only of their skins or teeth.

An interesting fact was mentioned in this Society by Lieutenant Osborn, namely, that Captain Penny, in September 1850, had seen enormous numbers of whales running southwards from under the ice in Wellington Channel. We know this to be also the case in the Spitzbergen Sea every spring, and that these animals are numerous along the Siberian coasts. This not only tends to prove the existence of one, or perhaps two, Polar Seas, more or less open throughout the year, but also that these seas abound in animal life, as to satisfy enormous numbers of whales a large amount of food is required. And it is well known among the Tchuktchi, on the north-eastern coasts of Siberia,—where land to the N. is said to exist in contiguity and probably connected with the lands discovered by Captain Kellett,—that herds of reindeer migrate between those lands and the continents.

Taking all these facts into consideration, the conclusion seems to be a reasonable one, that Franklin, ever since entering Wellington Channel, has found himself in that portion of the Arctic regions where animals probably exist in greater plenty than in any other. Under these circumstances alone his party could exist as well as other inhabitants of the Polar regions; but we must not forget that, in addition to the natural resources, they would in their vessels possess more comfortable and substantial houses than any of the native inhabitants.

So far as food is concerned, reasonable hope therefore may be entertained that the missing Expedition would not altogether suffer by the want of it;—their fate, however, depends upon other circumstances as well, among which, that dire scourge of mariners, the scurvy, is probably more to be feared than any other.

My authorities have been the works of the various expeditions undertaken in the Arctic regions by the English, Russian, Dutch, and other nations; the zoological accounts of Richardson, Baer, Wrangell, and others; also the valuable papers on the distribution of mammals by Dr Wagner. The meteorological data are chiefly derived from Dove's tables, and the works of Richardson, Sutherland, Middendorf, and others.

THERMOMETRICAL OBSERVATIONS in the ARCTIC

	—	Lat. N.	Long. W.	Elev.	Jan.	Feb.	March.	April.	May.	June.	July.	Aug.
	Lat. 80° to 75°.	° ′	° ′	Feet.								
1	Spitzbergen . . .	80 0	– 10 0	...	...	...	...	...	...	33·71	35·98	33·80
2	Hecla Cove . . .	79 55	16 49	...	...	...	...	...	...	35·86	40·17	38·40
3	Greenland Sea . .	78 0	...	...	...	...	...	14·23	22·52	31·37	37·00	...
4	Wolstenholme Sound	76 33	30 0	...	–25·07	–34·02	–17·47	– 3·74	25·82	39·73	40·52	33·6
	Lat. 75° to 70°.											
5	Melville Island .	74 47	110 48	...	–31·28	–32·45	–18·19	– 8·21	16·82	36·21	42.45	32·5
6	Assistance Bay . .	74 40	94 16	...	–29·	–29·8	–22·4	– 3·2	12·1	34·3	37·8	35·6
7	Novaia Zemlia (Seichte Bay).	74 0	58 0	...	9·32	10·29	10·38	10·69	24·30	34·41	37·67	37·7
8	Port Bowen . . .	73 14	88 56	...	–28·91	–27·32	–28·38	– 6·50	17·57	36·12	36·55	30·5
9	Novaïa Zemlia (Matothkin Shar).	73 0	– 57 20	...	4·28	– 7·74	4·46	8·26	19·74	34·57	39·97	40·9
10	North Cape, Island of Mageroe.	71 10	– 26 1	...	22·08	23·16	24·75	30·02	34·07	40·15	46·60	43.7
11	Kovennoi Filipovskoi	71 5	–118 0	...	...	...	...	– 4· ‖	16·0	35·1	48·8	51·3
12	Ustyansk . . .	70 58	–138 24	...	–39·48	–31·18	– 4·05	6·75	27·95	47·55	58·60	44·0
13	Novaïa Zemlia, Karische Pforte.	70 37	– 57 47	...	2·88	0·09	–10·68	3·13	17·51	32·95	36·30	37·5
	Lat. 70° to 65°.											
14	Boothia Felix . .	69 59	92 1	...	–28·69	–32.02	–28·68	– 2·59	15·65	34·16	41·26	38·6
15	Igloolik	69 21	81 53	...	–16·13	–19·58	–19·01	– 0·85	25·14	32·16	39·09	33·8
16	Nishne Kolymsk .	68 32	–160 56	...	–31·27	–22·59	– 6·70	15·51	42·96	50·	61·? ‡	...
17	Kotzebue Sound .	68 0	163 0	...	...	...	...	...	...	...	52·33	43·
18	Fort Confidence .	66 54	118 49	500	–21·57	–21·52	–20·21	– 4·71	...	...	...	...
19	Fort Hope . . .	66 32	86 56	...	–29·32	–26·68	–28·10	– 3·95	17·88	31·38	41·46	46·8
20	Eyafiord	66 30	20 30	...	25·70	18·50	20·66	27·50	36·14	43·52	46·94	46·9
21	Winter Island . .	66 11	83 11	...	–23·17	–23·99	–10·72	6·48	23·29	23·17	35·36	36·8
22	Yukon	66 0	147 0	200?	–26·85	–26·44	–11·16	12·66	41·24	53·49	65·75	59·9
23	Fort Franklin . .	65 12	123 13	500	–23·33	–16·75	– 5·38	12·35	35·18	48·02	52·10	50·5
	Lat. 65° to 60°.											
24	Archangel . . .	64 32	– 40 33	...	6·57	9·23	21·90	31·39	41·68	55·18	60·82	57·5
25	Fort Enterprise .	64 28	113 06	850	–15·57	–25·88	–13·48	5·78	31·20	...	...	...
26	Godhaab	64 10	52 24	...	12·38	12·56	15·60	22·01	32·16	39·09	41·92	40·8
27	New Herrnhut . .	64 10	52 40	...	9·05	22·10	21·65	24·80	32·	40·10	40·33	37·4
28	Reykiavig	64 8	21 55	...	29·82	28·31	29·86	36·46	44·80	51·58	56·19	52·8
29	Fort Reliance . .	62 46	109 0	650	–25·00	–18·84	– 6·14	8·23	36·03	...	...	...
30	Yakutsk	62 1	–129 44	...	–45·47	–28·86	– 6·43	16·36	36·91	58·28	68·79	58·1
31	Fort Simpson . .	61 51	121 51	400	–12·54	– 9·06	5·55	26·28	48·16	63·64	60·97	53·8
32	Felly Banks . . .	61 30	130 0	1400	–21·95	–14·73	– 0·99	20·44	...	...	...	...
33	Fort Resolution .	61 10	113 51	500	0·42	–25·00	9 95	12·88	40·14	...	...	...
34	Lichtenau	60 35	46	...	19·74	23·	27·63	32·43	39·27	43·09	45·37	41·0
	Lat. 60° to 55°.											
35	Friedrichsthal . .	60	45	...	19·62	18·72	22·10	27·50	...	...	...	...
36	Petersburgh . . .	59 56	– 30 18	...	14·74	18·68	25·50	37·18	48·52	59·95	63·91	61·1
37	Fort Churchill . .	59 02	93 10	20	–21·21	– 7.31	– 4·63	16·29	28·42	44·69	56·80	53·3
38	Fort Chepewyan .	58 43	118 20	700	– 8·76	– 4·01	3·08	19·80	45·40	55·00	63·00	58·1
39	Hebron	58 0	64 0	...	– 5·24	– 5·31	4·62	16·83	33·01	36·61	43·57	49·1
40	Okak	57 30	66 0	...	2·15	1·95	8·25	29·0	38·25	44·65	51·65	52·0
41	Nain	57 10	61 50	...	0·95	3·51	7·52	29 97	36·23	42·53	50·18	50·9
42	Sitka	57 3	135 18	...	34·18	33·00	38·01	40·64	48·18	53·83	57·11	57·7
43	York Factory . .	57 0	92 26	20	– 5·12	– 6·60	4·77	19·21	33·53	47·67	59·99	54·8
	Lat. 55° to 47°.											
44	Oxford House . .	54 55	96 28	400	–22·06	– 1·90	8·57	28·62	38·01	...	...	...
45	Cumberland House	53 57	102 17	...	–13·2	– 1·1	12·1	35·	50·	58·8	61·8	56·2
46	Illuluk	53 52	166 25	...	34·27	32·47	31·82	34·16	39·25	44·98	49·55	54·8
47	Rupert House . .	51 21	83 40	20?	– 4·09	– 0·68	7·64	21·05	41·51	...	...	..
48	St John's	47 34	52 28	...	23·34	20·88	24 18	33·40	39·30	48·02	56·16	57·8
	London (for comparison).	51 30	0 5	...	37·2	40·1	42·5	46·9	53·5	58·7	62·4	62·1

The longitudes are East when – is prefixed, and West when there is no sign.——* Difference of the hottest
Land.'——S., Sutherland, 'Journal of a voyage to Baffin Bay and Barrow Straits.'——M., Middendorf, 'Reise
tions are from Dove (17th and 18th Reports British Association, 1847 & 48).——‡ By interpolation.——§ From

Regions, arranged according to Latitude.

pt.	Oct.	Nov.	Dec.	Winter.	Spring.	Sum.	Aut.	Year.	Differ. H. & C. Months. *	Differ S. & W. †	No. of Yrs.	Hour of Observation.	Authorities.
.	...	...	...	...	...	34·52	...	...	...	...	⅓	2-hourly.	
.	...	...	...	...	...	38·15	...	...	...	...	...	hourly.	
.	...	...	...	...	...	...	...	...	...	...	3	d. extr.	
·76	11·32	–18·60	–27·05	–28·53	1·59	37·97	6·55	4·54	74.54	66·50	1	6 times.	R.
·52	– 2·83	–21·14	–21·62	–28·45	– 3·19	37·08	– 0·48	1·24	74·90	65·53	1	2-hourly.	
·3	1·5	– 6·7	–21·4	–26·73	– 4·50	35·90	5·37	2·5	67·6	62·63	1	3 hourly.	S.
·01	23·79	9·63	9·72	9·78	15·12	36·60	21·48	20·74	28·:0	26·82	1	2-hourly.	
88	10·85	– 5·00	–19·05	–25·09	– 5·77	34·40	10·58	3·53	65·46	59·49	1	2-hourly.	
08	22·26	8·73	– 3·42	– 2·29	10·82	38·49	20·69	16·93	48·67	40·78	1	2-hourly.	
60	32·	25·77	25·74	23·66	29·61	43·48	31·79	32·14	24·52	19·82	1	...	
8	19·0¶	...	...	...	...	45·0	...	...	...	...	½	...	M.
25	–18·58	–25·24	–37·03	–35·90	10·22	50 26	8·52	4·01	98·08	86·16	2	8, 12, 4, 12.	
02	20·28	3·24	12·42	3·21	3·32	35·59	17·85	14·99	48·19	32·38	1	2-hourly.	
41	9·07	– 5·41	–22·43	–27·71	– 5·21	38·04	9·69	3·70	73·28	65·75	2½	hourly.	
09	13·72	–18·65	–28·25	–31·32	1·76	35·04	6·72	5·55	67·34	56·36	1	2-hourly.	
07	0·30	–16·71	–23·60	–25·82	17·26	...	1·52	...	92 ? ‡	...	2	8, 8.	
04	...	...	...	...	...	...	...	...	...	...	¼	daily extr.	
	19·43	– 3·68	–38·69	–27·26	...	...	...	9· ?	...	...	7/12	15 to 17 times.	R.
7	12·56	0·68	–19·27	–25·09	– 4·73	39·59	13·93	5·96	75·64	64·68	1	8 times.	R.
6	34·34	25·88	18·32	20·84	28·10	45·80	34·46	32·30	28·62	24·96	2	...	
1	13·25	7·88	–14·24	–20·47	6·35	31·80	17·58	8·82	60·85	52·27	1	2-hourly.	
6	21·60	– 8·28	–18·43	–23·80	56·73	14·60	17·37	14·58	92·60	80·53	1	6, 6.	R.
0	22·47	– 0·11	–10·88	–17·00	50·41	12·69	21·15	17·75	74·43	67·41	2	6 times.	R.
2	35·22	22·62	12·51	9·43	31·66	57·85	35·15	33·53	54·78	48·42	18	7, 2, 9.	
9	21·75	– 1·70	–30·54	–24·00	55· ?	23 50	17·21	17·94	? 86·88	79 ?	3	...	R.
5	29·84	21·94	17·49	14·14	23·26	40·62	29·14	26·79	29·54	26·48	13½	10, 10.	
3	32·90	15·80	11·75	14·30	26·15	39·28	26·50	26·83	31·28	24·48	1	...	
5	36·91	30·45	29·41	29·18	37·04	53·54	37·94	39·43	27·88	24·36	14½	d. extr.	
	20·70	13·44	–17·07	–16·97	...	12·21	...	16· ?	...	...	⅔	15 times.	
1	16·59	–22·41	–34·78	–36·37	15·61	61·72	12·76	13·43	114·26	98·09	2	5 times.	R.
	24·28	8·53	– 8·36	–10·	59·48	26·66	27·34	25·75	76·18	69·48	2½	8, 8.	
	...	...	–13·98	–16·88	...	...	...	...	...	...	5/12	3 times.	I.
	26·06	12·04	– 2·59	– 8·09	...	20·99	...	21· ?	...	...	⅔	8, 8.	R.
	35·58	26·13	22·41	21·72	33·11	43·18	33·80	32·95	25·63	41·46	2	...	R.
	32·45	35·15	29·75	22·70	...	...	...	...	...	...	...	...	
	41·38	30·38	22·57	18·66	37·06	61·68	41·02	39·61	49·17	43·02	13	7, 2, 9.	
	26·50	3·32	–14·00	–14·17	51·63	13·36	21·95	18·19	78·01	65·80	1	3 times.	I.
	33·00	19·13	2·76	– 3·34	58·70	22·76	31·89	27·52	71·76	62·04	3½	8, 8.	
	29·43	23·58	5·18	– 1·79	18·15	43·09	30·62	22 52	54·41	44·88	2	...	R.
	31·15	22·4	8·45	4·18	25·17	49·43	32·67	27·86	60·45	...	2	8, 12, 4, 8.	
	33·98	26·51	6·51	3·66	24·57	47·90	35·16	27·82	50·04	44·24	3	8, 12, 4, 8.	
	46·63	42·89	36·32	34·74	42·28	56·24	48·49	45·44	24·19	21·50	2½	red.	
	33·43	25·17	3·73	– 2·53	19·17	52·07	33·50	25·63	66·59	54·60	1	3 times.	R.
	17·53	13·29	–23·06	– 0·82	7·51	...	...	...	...	...	⅔	7, 8.	R.
	36·9	13·	3·2	– 3·70	32·37	58·93	32·30	29·98	75·00	62·63	1	...	
	42·73	35 17	33·94	33·56	35·08	49·78	37·32	38·94	23·	16·22	1¾	8, 1, 9.	
	34·80	23 33	15·59	0·14	0·78	...	..	...	...	...	⅔	3 times.	R.
	44·50	33 98	25·32	23 18	32·29	54·01	43·84	38·33	36·98	30·83	5	daily extr.	
	50·7	44 0	40·4	39·23	47·63	61·07	50·73	49·7	25·2	21·84	65	red	T.

oldest months.——† Difference of Summer and Winter.——R., Richardson, 'Boat-Voyage through Rupert's äussersten Norden und Osten Sibiriens.'——T., Transactions Royal Society.——The rest of the Observa-vations to the 19th Aug. only.——‖ 25--30 April.——¶ 1 - 26 October.

The Effect of Heat on the Perpendicularity of Bunker Hill Monument. By Prof. E. N. HORSFORD, of Harvard, North America.

Soon after the pendulum was placed in Bunker Hill Monument, it was observed that the ball when at rest was not always over the same point in the floor. The careful consideration of all the conditions of this fact resulted in ascribing it to the unequal expansion of the sides of the monument, in consequence of unequal exposure to the sun.

A brief description of the present condition of the monument will aid in understanding the mode of observation pursued.

The obelisk, thirty feet square at the base, rises, gradually lessening, to a pyramidal summit, two hundred and twenty-one feet. Within is a circular well, seven feet in diameter at the bottom, and five at the top, where it opens into a chamber or observatory. The chamber is approached by a winding stairway. In the centre of the roof of the chamber is an iron staple which was securely fixed at the time of placing the capstone. It served at first to support machinery for carrying visitors up and down. From this staple, which is over the centre of the open space or well, the pendulum is suspended by means of a screw clamp.

From a point in the floor directly below the index attached to the ball, circles were described and graduated, and radii drawn.

On the day following the graduation, the index was found to be on the one side of the centre of the circle. As the screw clamp first employed did not admit of adjustment, a new apparatus, with the necessary modifications, were substituted, and the ball brought precisely over the centre of the graduated circle.

A few hours later, it was found out of the centre.

Upon observing more carefully, it was found during clear days that the motion of the ball in the morning was to the westward, at noon to the northwest, and at evening to the east. It was further observed that on days when the sun was obscured by clouds, that no motion of the ball or its index point occurred. It was still further observed on one occasion, during a sudden shower, accompanied with strong wind from the southeast, at about three o'clock in the afternoon, to move in the space of a very few minutes a quarter of an inch to the eastward. Observations at seven o'clock in the morning, at twelve o'clock at noon, and at seven o'clock in the afternoon, were recorded through several weeks, and no doubt remains that a cause coincident with the sun in its progress produced the variation of the perdendicular in the monument.

A fact already hinted at, further confirmed this conclusion. The extreme departure of the ball from the centre was to the west of northwest; not to the north, as might at first glance be supposed. The explanation is found in the position of the monument. Its sides do not face the cardinal points, but are inclined about 20°. The expansion of a single side would produce inclination in a direction perpendicular to the side. The expansion of two adjacent sides would produce inclination in the direction of the diagonal. In the morning the shaft is inclined to the westward. At noon it is inclined but a little to the north of west. In the progress of the afternoon, it sweeps over twice the amount of movement in the morning; describing, in the twelve hours of observation, an arc of an ellipse.

During the night it sets back to the centre, and before seven o'clock in the morning, has already moved westward.

The greatest diameter of the irregular ellipse, described by the index in twenty-four hours, is ordinarily less than half an inch, while the least was less than a quarter of an inch.

It would not be difficult to find the expansion of the granite to which this movement of the ball corresponds. In the simpler case of a rectangular shaft, the departure of the ball from the centre would be the versed sine of an arc (the side of the shaft), of which the pendulum was the sine. The difference between the arc and sine would be the expansion of the granite.

The heat of the sun penetrates to but a moderate depth. This is evident from the prompt movement of the column when a shower falls only upon the more highly-heated sides, and also from the ready change in inclination as the day advances.

The effects here observed, and which are now recorded from day to day, taken in connection with the meteorological record of Boston, Charlestown, and Cambridge, cannot fail to be of high interest.

The expansion of granite by heat had before been observed. Mr Bond, the director of the Cambridge Observatory, noticed its effect on his transit instrument erected in the temporary establishment at the corner of Quincy and Harvard streets. The instrument rested on two granite pillars. In the morning of a clear day, his meridian mark on a distant hill would be found east of the meridian line as indicated by his instrument; at noon, or a little past, coincident with it; and at evening west of it.

Engineers have observed it in long walls of masonry. It can scarely be doubted that we have memorials of it in the ruins of Baalbec and Pæstum, of Nimrod and Stonehenge; nor can we question that it has played a large part in the destruction of cliffs, or the splitting of mountain masses.

The mode of observation at the monument is this: On either side, about three-quarters of a inch from the centre, under the index of the ball, two slender needles have been driven into the floor, leaving not more than the sixteenth of an inch above. These are made by pressure to pierce a card of thin drawing paper, which is kept from warping by slender bars of lead. When fixed the north and south and east and west lines are transversed in pencil mark from the floor to the paper. After bringing the ball to rest, in which the observer is aided by a contrivance enabling him to steady his hands, a dot is made with a pencil immediately under the index point, which is about the sixteenth of an inch above the paper. At the close of the day, the card, previously dated, is removed, and another takes its place for the observation of the next day.

It is a grateful duty to state that the expense of the necessary fixtures at the monument for the pendulum experiment, of which advantage has been taken in the observations here referred to, has been incurred by the Massachusetts

Charitable Mechanics' Association. The enlightened liberality of the directors of this association is only equalled by the generous and efficient co-operation of the officers of the Bunker Hill Monument Association.—(*Proceedings of the American Association for the Advancement of Science.*)

On the Geological Distribution of Marine Animals. By Professor Edward Forbes.

Professor Forbes, in his Map of the Geological Distribution of Marine Life, and on the Homoiozoic Belts, shews the provinces under which animals and vegetables are assembled, and these provinces are delineated so as to shew their peculiarities, relations, and contrasts. The character of each is marked by the entire assemblage of organised beings, constituting its population, a considerable portion in most cases being peculiar, and a still larger number of species having their areas of maximum development within it. The several provinces vary greatly in extent, some being very small and some very large. The northern and southern limits of each province correspond with the boundaries of a latitudinal belt, to which, on account of similarity of organic features, presented through its extension, the name of *Homoiozoic* is proposed to be applied. Nine of these belts are distinguished, of which one is unique, central, and equatorial, and four in the northern hemisphere represent as many in the southern. The boundaries of the belts on land appear to correspond with the isotherm of the months in which there is the greatest vivacity of animal and vegetable life. The Homoiozoic belts are not of equal breadth in all parts; the polar belts include only a single province in each, the other severally include many provinces. There are twenty-five provinces. 1. Arctic; 2. Boreal; 3. Celtic; 4. Lusitanian; 5. Mediterranean; 6. West African; 7. South African; 8. Indo Pacific; 9. Australian; 10. Japonian; 11. Mantchourian; 12. Ochotyian; 13 Sitchian; 14. Oregonian; 15. Californian; 16. Panamian; 17. Peruvian; 18. Araucanian; 19. Fuegian; 20. Antarctic; 21. East Patagonian; 22. Urugavian; 23. Caribbean; 24. Carolinian; 25.

Virginian.—(For an account of Professor Forbes's regions of depths, *vide* vols. 50, 51, and 52, Edin. New Phil. Journal.)

On the Change of Temperature in Europe, and the Variation of the Magnetic Needle. By Mr G. A. Rowell.* With a Map.

From the attention now given to the effects of glaciers in producing geological phenomena, much interest has been excited as to the cause which has brought about the change of temperature in Europe since the glacial period.

This change of temperature is, I believe, intimately connected with the change of declination of the needle, and in the theory which I first submitted to this Society in 1839, on the cause of terrestrial magnetism, I attributed the change of declination in this hemisphere to a decrease of temperature in the higher latitudes of America, or to an increase of temperature in those of Europe and Asia. In a recent communication on Scandinavia, allusion has been made to several geological facts, which are, I believe, connected with the cause of these changes. I trust, therefore, I have chosen a proper time to bring the subject under the consideration of this Society, as I hope to shew the causes of this change of temperature, and also the probability that these causes have been in operation to a sufficiently recent time, to account for the variation of the needle.

Before I proceed further, I will describe the accompanying Map, as I shall have to refer to it often.

The lines of equal magnetic intensity are shewn by the broken lines; these are taken from Col. Sabine's maps, in the Sixth Report of the British Association. The point of greatest intensity is shewn by the spot at 52° 19′ north latitude, 92° west longitude; the intensity decreasing from this point as shewn by the lines 1.7 — 1.6 — 1.5 — 1.4 The American magnetic pole, according to Sir James Ross, is in north latitude 70° 51′, west longitude 96° 46′. The Asiatic magnetic pole, according to Hansteen's observations, is in

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* Read before the Ashmolean Society, January 31, 1853.

Lithog. by W. & A. K. Johnston Edin.

85° north latitude, 116° east longitude. The plain lines shew the isothermal lines of 5°, 10°, 20°, 30°, and 40° of temperature; the dotted line is the line of maximum temperature. This is not an isothermal line, as it varies from less than 80° to more than 85° of mean temperature. These lines are all from Johnston's Physical Atlas.

As few persons are acquainted with the theory I propose on the cause of terrestrial magnetism, it will be necessary to explain it; but I shall do so in as brief a manner as possible.

As the trade-winds are caused by the cold and condensed air from high latitudes pressing onward and raising the warmer and lighter air in the tropical regions, the air thus raised must flow back again in an upper current towards the colder regions, to keep an equilibrium. Thus the air is in constant circulation from the colder to the warmer regions along the earth's surface, and from the warmer to the colder above.

It is well known that during evaporation electricity is carried off, and the water from which the vapour has arisen is left in a negative state; it follows, therefore, that the tropical regions must always be in a negative state, owing to the vapour and its electricity being carried from thence by the rising air; and the vapour and its electricity carried by the upper current to the polar regions must render those parts positively electrified, and it is to the rush of electricity from the positive to the negative parts of the earth that I attribute the direction of the needle.

The cause of the magnetic poles in this hemisphere I believe to be the vast quantities of ice blocked up both in winter and summer above the two continents, thus keeping those parts constantly colder than any other parts in the same latitudes; consequently these centres or poles of cold are the magnetic poles. For as the density of the air increases with the degree of cold, it follows that there must be more air flow from these coldest parts towards the warmer regions than from any other district; consequently there must be a greater flow of the upper currents of air with its vapour and electricity, from the warmer regions to these coldest parts, than to any other.

Now, if the point of greatest cold were at the terrestrial pole, and the temperature and evaporation increased regularly from thence to the equator, the electricity would pass off from the pole towards the warmer parts of the earth, directly in the lines of longitude, and there would be no declination of the needle except that caused by the greater evaporation, where the sun may be above the horizon. But as the poles of cold are at a distance from the terrestrial pole, as there is more electricity received at these parts than in others in the same latitudes, the electricity cannot all pass off in the lines of longitude, but must diverge eastward and westward of them, to gain its equilibrium in passing off towards the more negative parts of the earth, and thus cause the declination of the needle as the currents of electricity from the frigid to the tropical regions in every meridian must, in some degree, be affected by the divergences of the currents from the magnetic poles. As I consider the poles of cold and magnetic poles identical, I shall use the terms as synonymous.

The lines of equal intensity of magnetism by no means correspond with the parallels of latitude. If we trace the line 1.5, it has its highest northern limit, *i. e.* 73° north latitude, at about 10° east longitude. To the westward it descends through Iceland, passes west of the Azores, and reaches its lowest latitude, 23° north, in the Gulf of Mexico; it then rises again, and about 20° west of Behring's Strait has its second highest latitude 53°; it declines again to 41° in the meridian of the Asiatic pole, from whence it rises again to its highest northern limit. The course of this line shews the great intensity of the American pole as compared with the Asiatic. The declination of the needle also shews the different effects of the two poles, as the declination apparently caused by the Asiatic pole does not extend over more than about 100° of longitude; whilst the declination of the needle over the remaining 260° seems to be affected in some measure by the American pole. This difference in the intensity of the influence of the poles may arise from the American pole being the coldest, or from the air forming the upper current to that pole, being more loaded with vapour, and consequently electricity, than the current flowing to the Asiatic pole; or it may be caused by the ice in America being blocked up at much lower latitudes than in Asia, thus producing in a greater degree those currents of air, vapour, and electricity, to which I attribute magnetic phenomena.

It may be observed, that the point of greatest intensity is between Hudson's Bay and the Gulf of Mexico, and that the lines shew the great intensity from the American pole in the direction of the warm equatorial seas between Africa and America.

The intensity of effect from the Asiatic pole seems to be influenced by like causes, as it is directed towards the Indian Ocean, where the line of maximum temperature has its greatest northern latitude, *i. e.*, 12° 30′, and where the temperature of that line is at the highest, viz. 85½° of Fahrenheit, and consequently where the evaporation is greatest. Thus, in both cases the greatest intensity is from the poles towards the nearest parts where the evaporation is great.

In the meridian, where the intensity is the least, we find no such pole of cold, and the tropical region is occupied by Africa, consequently the rate of evaporation is low; and in the meridian of Behring's Straits the Arctic Sea is open, and the line of maximum temperature is about 7° south of the equator, so that this line is nearly 20° farther to the south in that meridian than it is in the Indian Ocean, and the temperature lower.

The lines of equal temperature follow the same general direction as the lines of magnetic intensity, shewing that they are both influenced by the same cause, viz. the two great centres or poles of cold; and generally in the meridians where the temperature is highest, the intensity of magnetism is the least, and where the temperature is lowest the intensity is greatest. The lines of equal temperature do not differ so much from the parallels of latitude as the lines of magnetic intensity, but yet the difference is great, especially in high northern latitudes.

Taking the line of mean temperature of 30° of Fahrenheit, it has its highest limit rather north-west of the North Cape, *i. e.* about 72° of north latitude. Passing westward it descends to the 54th degree of latitude, and shews a mean temperature of 20° lower in the eastern parts of America, when compared with the same latitudes in Iceland, England, and the north-western parts of Europe.

This difference of temperature is generally attributed to the effects of the Gulf Stream; but although there is high authority for this opinion, I venture to suggest that other causes operate in a much greater degree in producing this phenomenon. That the temperature of the Atlantic Ocean has some effect I do not deny, but the proofs of a continuation of the Gulf Stream, or of there being any stream from the Atlantic into the Arctic Sea, are very meagre, chiefly, I believe, depending on the fact, that plants from the Gulf of Mexico and the West Indian Islands are occasionally found on the shores of England, Iceland, Norway, &c.; but when we consider the vast quantity of such materials brought by the Gulf Stream into the midst of the Atlantic, it is reasonable to suppose that the whole of its shores must occasionally have some of these things thrown on them by storms, &c. I am not aware that the Gulf Stream can be traced farther north than the 49th degree of latitude, and the fact that a bottle thrown into the sea by Sir W. E. Parry, in latitude 53° 13′ north, longitude 46° 55′ west, was picked up on the shore of Teneriffe, seems to support this idea, as it must have crossed the direction of this supposed stream.

It is a very general opinion that the western sides of continents are always warmer than the eastern; but this is not supported by facts, as the temperature of Africa is lowest on the western side, and the same is the case with the whole of America, from the 30th degree of north latitude to Cape Horn.

I beg to suggest, that the principal cause of the unequal distribution of temperature in high northern latitudes is the blocking up of the ice in the seas above the Asiatic and American continents, thus making those parts the poles of cold, whilst the Arctic Sea being open from Norway to Greenland no such accumulation of ice can take place there, consequently the temperature is higher there than in any other parts in this hemisphere in the same parallels of latitude.

The opening into the Arctic Sea through Behring's Strait produces similar effects in those regions, but in a lesser degree. It is true that the isothermal lines in the North Pacific Ocean have not their highest northern limits in the meridian of the Strait, but to the east of it; this fact supports the theory, as the high temperature of the western parts of North America may fairly be attributed to the great height of the Rocky Mountains intercepting the cold breezes from Hudson's Bay and the frozen seas above it.

With respect to the changes of temperature which have taken place in Europe, it is evident, from glacial marks and deposits in Switzerland, Scotland, and in almost the whole of North-Western Europe, that the temperature of these regions has been much lower than at the present time. I will not attempt to give an opinion as to the depression of temperature which would produce such an extent of glaciers; but M. Charles Martins, in an article* "on the Ancient Extent of the Glaciers of Chamounix," calculated that a mean temperature similar to that of the northern part of the State of New York, by lowering the line of perpetual snow, and enlarging the area for its accumulation, would be quite sufficient to account for the extent of ancient glaciers in the district around Mont Blanc. On this authority, therefore, I conclude that the extent of ancient glaciers in Europe may be accounted for by a temperature such as now prevails in similar latitudes in the eastern parts of America.

It has been suggested, that a change in the direction of the Gulf Stream may have been the cause of the change of temperature since the glacial period; this cause alone seems insufficient to produce such effects, and the supposition of any change in the course of the Gulf Stream is purely hypothetical.

I submit that this change of temperature may be fairly attributed to geological changes, of which we have evidence at the present time. I believe the low temperature of the

* Edinburgh New Philosophical Journal, No. 85.

eastern parts of America, from the 40th to the 65th degree of latitude, is caused by the vast quantities of ice blocked up in Hudson's Bay, as it is a large sea open to receive the icebergs from more northern regions, and cut off from communication with the warmer waters of the Atlantic Ocean, the only opening into it being Hudson's Strait, from whence the current sets into the Atlantic.

I will endeavour to shew that there are fair grounds for assuming, that very similar circumstances prevailed in Europe in recent geological times, and consequently it had a like depressed temperature. I believe it is now considered proved, that since the creation of races of animals at present existing, England and the Continent were connected by dry land. If, then, we consider the British Channel to have no existence, the German Ocean would form a sea similar in latitude to Hudson's Bay. We have farther the facts given by Sir R. Murchison, in his paper "On the Superficial Detritus of Sweden," which shew, that since the southern part of Sweden was inhabited by man, the more northern parts and neighbouring districts were covered by water: that previous to the elevation of this land, the last geological change was the distribution, by means of icebergs, of innumerable distinct angular blocks of stone over these districts. That these icebergs must have been immense is shewn by the size of some of the stones which have been so distributed, one measured by Sir R. Murchison was 40 feet long, 23 feet wide, and 25 feet high, and another was still larger.

From the nature of these stones, it is evident that they have all been carried from north to south, shewing that the current was in that direction; proving also that these regions were then open to the Frigid Ocean; and as this current was from north to south, it is fair to assume that it found its way into the German Ocean, and thence into the Atlantic.

If I have taken a fair view of these subjects, the condition of North-Western Europe at that time was very similar to that which now prevails in the north-eastern parts of America, Great Britain representing Labrador, Norway standing for Cumberland Island, the German Ocean, with its connection with the Baltic and Frigid Seas, forming another Hudson's Bay, the current from the Baltic and the German Ocean passing into the Atlantic, between Norway and the Shetland Islands, taking the place of the cold stream from Hudson's Strait.

It is to these circumstances I attribute the depression of temperature during the glacial period, and the subsequent rise of temperature to the German Ocean becoming open to the Atlantic, and the descent of icebergs from the Arctic regions into the Baltic being prevented by the elevation of land in the north of Europe.

I will now endeavour to shew the probability that the variation in the declination of the needle has been caused by this change of temperature.

All the earliest observations on the needle shew that Europe was at that time within the influence of the European or Asiatic pole, as the declination was eastward. Columbus is said to have been the first European who observed a western declination. When on his voyage of discovery to America in 1592, he found the eastern declination become less and less,—near the Azores he crossed the line of no declination, and then found it become westward. Now, as there are two magnetic poles in this hemisphere, there must be a line of no declination where the influences of the two poles are equal; and it is obvious that it was this line of no declination which Columbus crossed, as the declination on each side diverged from it. In 1657 this line had passed eastward, and there was no declination in London,—at this time the declination was still eastward at Paris. In 1666, *i.e.* nine years later, it was at Paris, and the declination in London had become eastward,—since that time it has gone farther and farther eastward, and is now about 43° east longitude. Nearly all Europe has thus become under the influence of the American pole, and the declination in London has gradually changed from 11° 15′ east in 1580, to 24° 30′ west, in the early part of the present century, since which time no change of importance has taken place.

During the time these changes of declination occurred in Europe, no change of importance was observed in America, and *there is positive proof, that in Jamaica, from* 1660 *to*

1806 *the declination did not vary in the slightest degree,* although in London, during those years, it amounted to full 24°. This fact is important, as it shews that the American pole, during those years, has not shifted its position, and that the cause of the variation must be connected with the old continent.

In accordance with the theory of magnetism, I have explained, the change of declination may be fairly accounted for, either by the cold of the Asiatic pole decreasing in intensity, or by an elevation of temperature in Europe driving the centre or pole of cold farther towards the east; and there can be no doubt that both these circumstances followed the geological changes I have alluded to.

It may be difficult to prove that a change of declination, which has been going on up to the present century, can be owing to geological phenomena, which occurred so long previous, but I hope to shew that there are fair grounds for such an opinion.

Assuming that during the glacial period the condition of Europe was similar to that of America at the present time, we may conclude that ice extended from the shores of Norway, Scotland, Iceland, &c., in a similar way to what it now does from Greenland, Cumberland Island, and Labrador. (The extent of ice from these shores is given in Johnston's Atlas, and is shewn in the Map). The Arctic Sea must, therefore, at that time, have been blocked up with ice much more than at present, consequently the Asiatic pole of cold could not then have been in its present position, but was probably situate about Nova Zembla; and if so, it must since that time have receded more than 40° of longitude towards the east.

This change of position will account for the change of declination in Western Europe, as the Asiatic pole is now chiefly affected by the evaporation from the Indian Ocean, and quite removed from the influence of evaporation from the warmer parts of the Atlantic. It is impossible to prove how long was required to produce these results, after the geological changes to which I have alluded; to arrive at a fair conclusion on the subject, it may be well to suppose similar changes to take place in America at this time: the question for consideration would then be;—If by some geological phenomenon the southern parts of Hudson's Bay became exposed to the Atlantic Ocean by an opening similar to the British Channel, and from the 66th to the 70th degree of latitude the land was upheaved so as to cut off all communication from the Arctic Seas, how long a time, under these circumstances, would it require for the whole of the north-eastern parts of America, together with the neighbouring Arctic regions, to arrive at the highest temperature they would ultimately acquire in consequence of these changes? For as long as any elevation of temperature was going on, so long would the pole of cold continue to recede towards the west; so long, also, would the variation of the needle go on, and the line of no declination would move from its present situation, near St Petersburg, towards the west. England might thus again be brought under the influence of the Asiatic pole, and the needle throughout Europe again have an eastern declination.

In considering this subject, it is necessary to bear in mind how slowly heat is conducted by some earths, and also the fact, that 140 degrees of heat are absorbed by ice in melting without any increase of temperature. Many proofs might be given of the slow transmission of heat through earth, but I will only refer to one, as stated by Mr Nasmyth, in the Journal of the Geological Society, vol. iii., p. 233. "The instance in question" (says that gentleman), "was that of a large plate-iron pot, containing 11 tons of white-hot melted cast-iron—a temperature so high as to be quite beyond all thermometric certainty, but well known to be the highest intensity of furnace heat, being quite equal to that of welding hot iron.

"This vast mass of white-hot melted cast-iron, stood in the pot for upwards of 20 minutes, and but for a thin coating of clay and sand, of about half an inch thick, would have soon melted the bottom and sides of the pot.

"This half-inch thickness of mineral substance, however, was quite sufficient to prevent the conduction of the heat to the exterior; so completely so, that after this mass of hot iron had remained for upwards of 20 minutes in the pot, you could place your hand on the side of the vessel without feeling any inconvenient degree of heat; and so slowly and imperfectly does this thin lining of half an inch of clay and sand permit the heat to pass outwards, that the entire mass might rest there till it became cool ere the outside of the pot would have reached a temperature high enough to carbonize wood in contact with it."

With such facts as these, I think it fair to assume that, after the geological change I have supposed, thousands of years must pass ere the parts of America to which I have alluded could obtain their highest degree of temperature: for if half an inch of clay and sand thus intercepts the communication of so high a temperature as that of 11 tons of white-hot cast-iron, how can we estimate the time it would require for thousands of square miles of frozen land and sea to become elevated in temperature even a few degrees.

Bringing these reasonings and facts to bear on the question of the change of temperature in Europe, I submit that there are fair grounds for attributing the change of declination to this change of temperature. For although the opening of the British Channel may date too far back to support this opinion, there are ample proofs that the connection of the Baltic with the Frigid Ocean, and the elevation of parts of Sweden, have been much more recent; and these were the principal causes of the change of temperature in the north of Europe.

It has been shewn by Professor Nilsson that the northern parts of Sweden formed the bottom of a sea after the southern part was inhabited by man. The land since then has been elevated some hundreds of feet, but the fact that there are no dislocations of strata, shews that this elevation of land has been gradual, and even at the present time an elevation is going on in various parts of Sweden. Dr Daubeny, in his recent communication on Scandinavia, alluded to this fact, and, amongst other authors on the subject, Professor Nilsson states that the elevation of the coast of Sweden has been going on gradually during the last 300 years at the rate of two feet in the century.

In proof of the recent connection of the Baltic with the

Arctic Sea, Professor Forchhammer may be cited. He says—"The Gulf of Bothnia has been connected with the White Sea, where, in the neighbourhood of Uleburg, a considerable depression towards its shores may be observed, a complete water communication existing from the White Sea through the Gulf of Bothnia and the northern parts of the Ost Sea to the Cattegat;" and adds in a note, that between the Gulf of Bothnia and the White Sea, "*a communication by water was kept up in the time of flood, even so lately as at the commencement of the last century.*"

Some effects may be attributed to the elevation of land now going on, which, together with increased cultivation and drainage, must tend to an elevation of temperature even at the present time.

In submitting these theories to the consideration of this Society, I am aware that I can only support them by probabilities; but as the change of temperature in Europe, and the variation of the needle are subjects on which no theories have been adopted, I have some hope that the opinions I have advanced may be thought worthy of farther consideration.

The Paragenetic Relations of Minerals. *

The natural association of mineral species has long attracted attention, and although since the time of Werner it has been made the basis upon which distinctions between rocks are established, still the subject has not been investigated so fully as it would appear to deserve. Minerals which occur together are enumerated in the description of one or other of them, but no adequate account is given of the mode of association, and their relations of date are even still less regarded.

Professor Breithaupt has for several years especially

* Die Paragenesis der Mineralien. Mineralogisch, geognostisch und chemisch beleuchtet mit besonderer Rücksicht auf Bergbau. Von A. Breithaupt. Freiberg, 1849.

directed his attention to these points, and has arrived at a number of very interesting results. Of these, and the inferences he draws from them, his general views, and the arguments by which he supports them, it is the purpose of the following pages to give some account. By the paragenesis of minerals he understands the more or less definite mode of association, by means of which he endeavours to determine their relative age; and he has conducted his observations from the point of view expressed in a remark of Dolomieu's, that every stone must have some connection with the general history of our globe, and although individually it may possess but little interest, still in its relations to others it may lead to important discoveries; further, that it is the study of the most common and most universal minerals, and from which valuable results may chiefly be anticipated. He in the first place brings forward some facts which are sufficient to shew that the paragenetic relations of minerals are deserving of being studied not only by the mineralogist but perhaps still more so by the geologist and the chemist.

In some instances the existence of a mineral species appears to depend upon the co or pre-existence of another mineral. Thus among epidotes, which are tolerably abundant, manganesian epidote occurs only in association with heterocline, consisting chiefly of oxide of manganese; and among the titanites, which are still more frequent, greenovite occurs at St Marcel in Piedmont, only together with the above two minerals. Basaltine is the only amphibole, semeline the only titanite, melanite the only garnet, and hyacinth the only zircon which occur in trachytic basalt or phonolite. Rhodizite has hitherto only been met with upon turmalin. There are again other minerals, whose existence may safely be said to depend upon the pre-existence of copper pyrites; thus bismuthine, linneite and cobalt glance. Magnetic pyrites very generally accompanies copper pyrites, which is in this instance the most recent. It is perhaps still more remarkable, that all larger masses of variegated copper pyrites are accompanied by the more recently-formed copper pyrites, and the larger masses of copper pyrites by the still more recent iron pyrites. These facts shew that there are uniformities in the association of minerals worthy of being investigated.

The paragenetic phenomena met with in druses, further indicate that the deposition of some more recent minerals has taken place more readily upon certain of the pre-existing minerals than upon others, as if there had been an unequal attraction. For instance, in the druses in greisen at the Zinnwald, the tungsten is more frequently implanted upon the smoke quartz than upon the mica. In the lode druses of the Friedrich August mine at Freiberg, the calc spar deposited upon surfaces consisting of iron pyrites and heavy spar, seems to have been attracted more by the latter than the former mineral. In the mine Beschert Glück pyrargyrite, occurring in druses of galena and polytelite, is found almost only upon the latter.

The association of minerals likewise seems to determine the form in which one of them appears. The galena occurring in druses near Freiberg is, when accompanied by diallogite, always in irregular rounded crystals, calc spar accompanying copper pyrites, probably always presents the most ordinary scalenohedron as the predominating form, and the calc spar upon iron pyrites is invariably in flat rhombohedric crystals.

Another striking circumstance is, that the minerals occurring together in a particular district or formation, possess a certain marked physiognomy, so easily recognisable that the localities of hand specimens may be determined by it. The amphiboles, pyroxenes, epidotes, &c. of Arendal, and the same minerals from New York and New Jersey, the older galena and zinc blende formations of Freiberg and those of Cumberland, as well as the minerals occurring in the lodes of Andreasberg (Harz) are sufficient illustrations of these peculiarities.

Certain associations of minerals belonging to the same genus, sometimes admit of the establishment of specific differences between them. In a trachytic rock at Laach in Rhenish Prussia, there occur nosean, sodalite, and leucite, imbedded in a porphyritic manner. These three minerals having been formed at the same time and under the same conditions, it may be inferred that they do not belong to one species. In the same manner antholite, anthophylite, and a dark green hornblende, with their characteristic peculiarities, occur in immediate contiguity at Kienrud in Norway.

In relation to mining, Professor Breithaupt is of opinion that the study of the phenomena of paragenesis will be of great importance by leading to a knowledge of the conditions, under which the ores of the useful metals occur, so as eventually to do away with the element of chance, or the reliance upon mere empirical rules, and to substitute in their place a scientific system of mining operations. Although, as he admits, this result is undoubtedly very remote, he considers it time that the by no means inconsiderable number of known facts should be collected, systematised, and their universality tested, in order to obtain some positive basis for its future achievement. One of the most important points in such an undertaking, is the progressive development of one inorganic mass from another—the accurate determination of relations of date, both as regards geological formations and individual minerals. He expresses his conviction, that as observation extends, it will become more obvious that the association of minerals has its definite laws—that there exists, so to speak, a certain economy of inorganic nature, whose investigation will be no less attractive than practically useful. It will then be seen that the same uniformities of association present themselves under very different circumstances, in mixed rocks, as well as in isolated deposits, in vesicular cavities, as well as in lodes.

It is here necessary to call attention to the fact, that minerals present two distinct kinds of structure—the crystalline and the non-crystalline. Although in many compact amorphous minerals, the ultimate molecules may be crystalline both in structure and form, there are others whose structure is unquestionably of a different character, for instance, opal and obsidian. Again, of the non-crystalline minerals there are at least two classes, of which the above substances may be taken as the types. Obsidian bears all the characters of a vitreous mass resulting from igneous fusion, and there is other evidence which strongly favours the opinion that it originated in this way. The opaline structure is equally peculiar, and more frequent, in minerals, than the vitreous. It would appear that those bodies which have an opaline structure, frequently present indications of having been originally in a plastic state; indeed, opal itself has actually been found so.

Without taking into account those minerals which may have been formed from solutions, there is an abundance of facts which fairly admit of the inference that the substance of a very great number of minerals possessed at some period of their existence a certain degree of internal mobility, being either liquid, viscous, or plastic, although opinions differ as to the precise nature of this former state.*

Fuchs is of opinion, that entire masses of rock have been in this state, and that the metamorphism of rocks is essentially connected with such a softening. The curvature in the axes of crystals, the partial fracture, contortion and separation of crystalline minerals as it were into slices, as in the garnets, in some schistose rocks, are favourable to this view. Some quartzose rocks consist of angular fragments cemented together by amorphous quartz, and it is not improbable that the fragments have been formed by the contraction of gelatinous or plastic silica, and that the cement has been subsequently introduced in a plastic state.

Moreover, crystalline substances may, without losing their solidity, experience an alteration of structure, as in the conversion of arragonite into calcite, and there is in many instances a remarkable fact of paragenesis connected with the calcite, which has originated in this way. Crystals of celestine are found upon it, which would appear to indicate that sulphuric acid has had some share in the change. Stromeyer's investigations have shewn, that arragonite generally contains strontia; and as celestine is always accompanied by

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* In a physical point of view, it is probable that the molecular structure of bodies depends mainly upon the conditions under which solidification takes place, and any inferences which may be drawn from the structure of minerals, would appear to refer rather to those conditions than to the former state of the masses from which they were formed.

calcite or limestone, and is always of more recent formation than these, it has possibly originated in all cases from strontiferous arragonite. The sulphuric acid may have been derived from the decomposition of iron pyrites.

The association of minerals does not always indicate their simultaneous formation. The granular rocks appear to afford the best evidence of this; for while, in some cases, minerals implanted upon each other differ very little in date, in others a very long interval may have elapsed between their respective formations. The simultaneous formation of different mineral species is indicated by their regular twin growth, by juxtaposition, as in disthene and staurolite from St Gothard; dolomite, ripidolite, and a green amphibole, (Pfitschthal, Tyrol) perhaps also in graphic granite, although in the druses, of the three constituents pegmatolite appears to be oldest, mica most recent, and quartz intermediate. When minerals present mutual impressions, such as Fournet has observed in the garnet and mica near Lyons, this circumstance is evidence of their simultaneous formation. In most cases, the date of minerals which present a twin-growth by superposition, is not precisely the same; thus the hexagonites haplotypicus is rather older than the rutile with which it is compounded (Tavetschthal, Switzerland). The same is the case with the regular twin-crystals of iron pyrites, and spear pyrites (Litmitz, Bohemia); the twin crystals of chlorite upon and with magnetite (Fahlun, Sweden). It ought likewise to be considered as a universal rule of superposition, at least with regard to varieties of the same species, that the non-crystalline, or least crystalline variety is followed by the crystalline; instances of this are furnished by compact and fibrous brown iron ore; hornstone and quartz crystals; allochroite and garnets.

Among the more uniform mixed rocks a certain geognostic relation is presented by the minerals constituting those which possess a granular, schistose, or porphyritic structure. With regard to the phenomena of paragenesis, these rocks may be divided into two classes:—

I. Those consisting of silicates, one of which is almost always a felsite, rarely replaced by nepheline.

II. Those consisting of silicates with quartz.

This distinction is of great importance in the study of eruptive rocks, and in relation to the association of some minerals quite essential, indicating likewise the presence or absence of others. The most frequent of such silicates belong to the genera felsite, pyroxene, amphibole, phengite, astrite, &c. The felsites are especially important both on account of their greater frequency, and because they include trisilicates as well as bisilicates almost entirely destitute of metallic oxides and magnesia, but rich in alumina and alkalies. Together with these there occur in the first class of rocks pyroxenes and amphiboles containing much iron, though scarcely any alumina or alkalies.

It must not be forgotten that some pyroxenes and amphiboles are similar in composition, and in such cases may be regarded as dimorphous bodies. Indeed, bronzite and anthophyllite are identical in composition, corresponding with the formula $Fe\ O\ Si\ O_3 + 3\ Mg\ O,\ 2\ Si\ O_3$. It is therefore possible that certain eruptive masses may have yielded either diabase or diorite, according to the prevailing conditions. Mitscherlich has actually obtained crystals of pyroxene by fusing amphibole; and G. Rose has shewn that crystals occur, consisting of a nucleus of pyroxene and an envelope of amphibole. In connection with this point, it is worthy of remark that some species of pyroxene occur only in rocks of volcanic, or undoubtedly igneous origin, such as basalt, lava, &c., while others do not occur; and in the former case, the pyroxenes are accompanied by astrites, but never by phengites. In such rocks, pyroxene and amphibole are indeed sometimes met with together, but the occurrence of amphibole is then limited to one species—basaltic amphibole,—which is essentially distinct.

In the rocks consisting of silicates with quartz, for the most part the oldest known rocks, associations of such minerals are observed, as, in the present state of science, can scarcely be regarded as of simultaneous formation. Whenever quartz is present as an essential constituent, pyroxenes are not found, with the single exception of spodumene, which although mineralogically belonging to this genus, differs widely in chemical composition from all the other members, inasmuch as alumina is an essential constituent.

It is in the study of these more ancient rocks, as in that of the early history of Man, that the greatest mystery, the greatest difficulties are encountered, and the progress of observation would appear to prove not only that the conditions under which they were formed were widely different from those which now prevail, but also that these rocks have experienced many successive alterations.

With regard to porphyritic rocks, Werner entertained the opinion that the imbedded crystals were of earlier formation than the matrix; however the contrary appears, with very trifling exceptions, more probable, and for the following reasons:—

1. The occurrence of crystals which contain nuclei of the mass in which they are imbedded.—This is the case with the large rhombohedrons of magnesite occurring in the talcose slate of the Tyrol. Crystals of leucite, from the old Vesuvian lavas, not unfrequently contain the same lava in their interior. The twin-crystals of pegmatolite from Elbogen, Bohemia, contain not only scales of phengite and granules of quartz, but nuclei of granite, presenting exactly the same appearance as the surrounding rock. Very finely developed crystals of iron pyrites from Osterode, Harz, with smooth surfaces, contain nuclei of the gypsum in which they lie, and large groups of iron pyrites crystals frequently contain in their centre some of the clay by which they are surrounded. In the hornstones of Schneeberg (Saxony) hexahedrons of tin white cobalt or smaltine occur with nuclei of the same hornstone. Some pseudomorphous minerals constitute an exception to this general rule; thus when an envelope of red hæmatite has been formed over calcite, assuming its scalenohedron form, and the latter mineral has been subsequently removed, and red hæmatite deposited in its place. But in this instance the pseudomorph was at a certain period hollow. Again, at Rothenberg (Saxony), the fluorspar formerly existing, and of which not a trace is now found, was first covered with fibrous red hæmatite, and then by some means removed, leaving a hollow cast, which was afterwards filled with quartz. Some-

times it is difficult, without collateral evidence, to tell which part of a pseudomorphous mineral was formed first, as in the case of rhombohedrons of compact brown iron ore, resulting from the alteration of spathic iron, and covered with a thick crust of malachite. The latter, however, being a derivative of copper pyrites must be more recent than the brown iron ore, because in the same lode copper pyrites is found implanted upon spathic iron.

2. The occurrence in sedimentary strata of crystals, presenting such sharpness in their edges that they have obviously not been deposited as detritus, but formed upon the spot.—Near Meissen, sharply-defined crystals of iron pyrites occur in clay, together with water-worn fragments of quartz, and generally contain a nucleus of carbon. It is probable that they have been produced from ferrugineous solutions by the reducing agency of carbonaceous matter.

Where large groups or masses of iron pyrites occur imbedded in stratified rocks, a curvature of the lines of stratification may frequently be observed immediately around them, to all appearance resulting from the formation of the pyrites on the spot. In the brown coal-formation, iron pyrites occurs chiefly where the coal-seams are in contact with large masses of clay. As might be expected, a carbonaceous nucleus cannot always be found in iron pyrites, but a nucleus of hepatic pyrites is frequent, and this contains sulphuret of carbon. Again, other than carbonaceous nuclei occur in iron pyrites. In the alluvium at Meronitz (Bohemia), the iron pyrites contains nuclei of pyrope, and in perfectly developed dodecahedrons of pyrites, nuclei of transparent quartz have been found.

This porphyritic formation of iron pyrites sufficiently proves the segregation of particular substances in rocks. It is not confined merely to deposits of clay, but may be observed even in the oldest schistose rocks. In some varieties of clay slate, the imbedded crystals of iron pyrites are covered, especially on one side, by a layer of fibrous quartz, which must have been deposited after the formation of the pyrites; and this fact furnishes additional evidence that these two minerals have an attraction for each other. The Devonian slates of the Eifel present abundant examples of this mode of occurrence, and the curvature in the surrounding layers of rock may be easily recognised. Sometimes the pyrites has been completely removed, its former existence being indicated only by hexahedral cavities, and then the fibrous character of the quartz is more prominent. It is probable that iron pyrites is very extensively disseminated throughout some schistose rocks, for the stagnant water in slate quarries frequently contains sulphate of iron.

If, then, it is satisfactorily proved that the porphyritic formation of iron pyrites has taken place subsequently to the formation of the strata in which it occurs, there appears to be no reason why we should not consider other crystalline minerals present in the same rocks, and sometimes in immediate proximity to the pyrites, to have been formed in a similar manner. In some of the most ancient slates octohedrons of magnetic iron occur together with the pyrites, and even the granular rocks of eruptive and plutonic origin present analogous facts. In the granite of Saubersdorf (Voigtland) the iron pyrites is partially decomposed, and converted into crystallised specular iron, the granite itself being somewhat disintegrated. In the syenite of Zschitschewig, titanite is imbedded together with pyrites. It is, however, inconsistent with chemical principles to suppose that bisulphuret of iron existed in a melted eruptive mass; in melting processes only mono- and sub-sulphurets are formed, and this renders it still more probable that the pyrites is of more recent formation than its matrix, likewise proving either that these rocks were not formed at any very high temperature, or had cooled considerably when the formation of pyrites took place.

Bunsen's observations in Iceland would appear to prove that the formation of iron pyrites in clay may sometimes be owing to other causes than those above mentioned. The principal gases associated with the exhalations of vapour in that island, are sulphuretted hydrogen and sulphurous acid, their mutual decomposition giving rise to the sublimation of immense masses of sulphur. When the sulphuretted hydrogen is in excess, the oxide of iron is converted, under the influence of alkaline sulphurets, into pyrites which remains imbedded in the clay.

As the principal object in the present instance is to prove that the formation of imbedded minerals is subsequent to that of their matrices, attention has been especially directed to one mineral alone. There are, however, two others of especial importance which occur in the same manner—gypsum and quartz—the former occurs in sharply-defined crystals in alluvial clays, shale, and even in the schistose and stratified clay iron ore of Yorkshire, &c. The absence of all traces of friction upon these very soft crystals does not, for a moment, admit of the supposition that they were deposited in a detrital manner, or with the matter of the sedimentary strata. It is indeed probable that, in some cases, their formation may have been owing to the presence of iron pyrites, and have taken place in the manner pointed out by Hausmann.*

Quartz being the mineral which principally gives the peculiarity of structure to the oldest and most frequent porphyritic rock, some mention of its mode of occurrence in more recent rocks may not be without interest. At Pösneck (Thuringia), millions of very small and extremely sharp-edged diploheders of quartz occur in a marl belonging to a more recent period than the zechstein group. In a marly and compact limestone at Pforzheim, in Baden, larger crystals are found, which singularly enough contain some sulphur. Quartz crystals likewise occur in the gypsum of Gräfintonna (Thuringia), and of St Jago di Compostella (Spain). Even some of the particles of sandstones are not invariably water-worn fragments, but sometimes actual crystals, as in the quader-sandstone of the Tharander Wald (Saxony).

Another singular fact is the occurrence of small druses of felsite in the clay-stone of Floha (Saxony), together with the same mineral imbedded in a porphyritic manner. This would appear to admit of the inference, that imbedded felsite is, at least in some instances, more recent than its matrix.

3. It often happens that one mineral imbedded in another,

* Bemerkungen über anhydrite und Karstenit, 1847, p. 25.

which serves as a matrix, occurs implanted upon it in druses.

In the Zillerthal (Tyrol), pistacite occurs imbedded in mica (astrite) slate, and in the same locality fine specimens of green epidote are found upon ripidolite. Chondrodite occurs in many places in saccharoid limestone and calcite; but in the druses in the masses ejected from Vesuvius, it is implanted upon calcite. Zeilanite likewise occurs imbedded in calcite, and in the above druses upon it. Yellow titanite occurs imbedded in chlorite at the Zillerthal (Tyrol), and at St Gothard, implanted upon it. Brown titanite occurs imbedded in hornblende slate at the Stubeithal (Tyrol), and in the well-known druses of common hornblende from Arendal (Norway), it is implanted upon this mineral.

The porphyritic occurrence of iron pyrites in copper pyrites is remarkably frequent, especially when the latter is in large masses. Sometimes the iron pyrites is quite porous, and only partially occupies the cavity in the copper pyrites. When these minerals are associated in druses, the copper pyrites always appears as the oldest of the two. Pseudomorphous iron pyrites, after copper pyrites, presents an apparent exception to this rule, but it must be remembered that pseudomorphs are in some sort abnormal products. There are, however, some real exceptions, though few in number.

Copper glance is in many instances followed by erubescite and iron pyrites, a fact which perhaps admits of explanation upon chemical principles. If, for example, a solution conaining oxide of copper and peroxide of iron, is acted upon by sulphuretted hydrogen, sulphuret of copper is first formed, while the peroxide of iron must be reduced to protoxide before a bisulphuret can be formed; and during this time it is readily conceivable that compounds of the sulphurets of iron and copper may be formed.

The most direct illustrations of this third proposition are furnished by those instances in which minerals occur imbedded in a rock, and at the same time implanted upon it in veins, sometimes even filling the fissures.

Thin plates and laminæ of talc occur imbedded separately in the chlorite slate of the Zillerthal (Tyrol); and this talc is found filling veins in the same rock. Astrite occurs both in and upon the finely granular calcite of the masses ejected from Vesuvius. The porphyry of Scharfefstein (Saxony) contains imbedded pistacite, and is likewise traversed by veins of the same mineral. It is also remarkable that the imbedded crystals are deposited around small nuclei of iron pyrites, and where epidote and iron pyrites are associated in druses, as at Arendal, the latter is always underneath. According to Haidinger, epidotes occurs in other places, as relatively very recent products. G. Rose states that the chlorospinel of Slatoust is both imbedded and in veins in the talcose slate. At Achmatowsk (Siberia), crystals of the same red garnet are imbedded in and implanted upon ripidolite. In the serpentine of Dobschau (Hungary), a garnet of bright green colour is both imbedded and implanted upon the walls of the fissures. Tourmaline crystals occur imbedded in talcose and mica slate; and where there are veins in these rocks, the tourmaline forms druses upon them. Crystals of cassiterite are imbedded in the felsite of the tin lodes at Marienberg (Saxony), and occur upon crystals of the same felsite. An arsenical pyrites, containing 0·8 to 0·9 per cent. of nickel,* occurs in chlorite slate near Sparnberg, in the same manner as the above-mentioned talc. Imbedded crystals of metallic copper occur in compact brown iron ore (Siberia) and plates of copper in the fissures.

Similar phenomena present themselves in essentially mixed rocks,—thus nepheline and apatite occur together imbedded in the granite of Miask (Siberia), in the syenite of Fredrikswärn (Norway), and in the veins of graystone at Capo di Bovo, likewise in the small druses of the nepheline rock at Meigen (Darmstadt), in Saxony, and in the volcanic felsite rock of the lake of Laach.

Cassiterite, beryl, columbite, and the several species of tantalites occur imbedded in granite, while in the druses and veins they are implanted upon the constituents of this rock. Beryl is found without columbite and tantalite, and these are

* Breithaupt has found nickel in most arsenical pyrites, which are associated with chlorite minerals.

more recent than it; but, as Nördenskjöld first pointed out, they never occur without beryl. It cannot therefore be doubted that their presence depends upon the pre-existence of beryl.

Iron pyrites, arsenical pyrites, galena, and zinc blende—the most frequent minerals in the Freiberg lodes, impregnate the adjoining gneiss to a distance of several fathoms. Although the walls of the lode fissures presented an abundant surface for their deposition, a considerable transfer of these substances from the lodes into the adjoining rock is sometimes unquestionable, and in this case the rock is generally disintegrated. Frequently the mispikel occurs imbedded in the gneiss, at a distance of 15 to 20 feet from the lode, in such quantity as to be advantageously worked. The gneiss is then converted into talc, or a very analogous substance.

The occurrence of calcite, both imbedded and in small veins, in the zechstein of Saalfeld, is a phenomenon which should probably be included among the above.

It may not be inappropriate here to make some mention of the artificial crystals obtained in smelting processes. The beautiful homogeneous and vitreous slags, from Hockeroda and Luisenthal, contain tabular, tetragonal-prismatic crystals, of a substance closely resembling idocrase, both imbedded and forming druses, in the larger vesicular cavities. Hexagonal-prismatic crystals, resembling nepheline, occur in the same manner in the slag from the Rothenthal at Osterode (Harz).

4. Some imbedded minerals are undoubtedly products of the decomposition of the mass in which they are inclosed, and are therefore more recent than it.

In the brown coal of Artern (Thuringia), mellite and sulphur occur in separate crystals and groups. At Luschetz (Bohemia), mellite and oxalite occur in a similar manner. Bischof considers that the carbonaceous matter of the coal has reduced sulphate of lime, and that subsequent contact of the sulphuret with sulphuric acid, resulting from the oxidation of pyrites has reproduced gypsum, with evolution of sulphuretted hydrogen, which, with oxygen, yielded water and sulphur. However, the sulphur in the brown coal of

Langenbogen (Prussia) is very probably a product of sublimation. The spherical masses of hydrated pyrites, covered with an envelope of gypsum, the crystal points of which are turned inwards, have decomposed with considerable evolution of heat. The sulphate of iron has been washed away, and the masses are now hollow, with the surplus sulphur, resulting from the decomposition, upon the points of the gypsum crystals. The heating of the pyrites has in this case been so great, that the coal immediately surrounding the gypsum has been converted into a species of anthracite.

It is not improbable that analogous changes may have taken place in other rocks possessing a porphyritic structure, but the difficulty here is, that we do not know what was the condition of the matrix previous to the formation of the imbedded crystals. Graphite occurs imbedded in the sandstone of Charlottenbrunn (Siberia), and it is very probably a product of the alteration of organic remains at some period after the formation of the rock. When it is remembered that some of the mixed rocks must be regarded as really metamorphic, the fourth proposition will appear applicable to a much greater number of facts, although it may not always be possible to furnish positive explanations of them.

5. Certain minerals occur imbedded in the older rocks, only where they are in contact with more recent eruptive rocks.

Several geologists state that the occurrence of the very frequently associated minerals, kyanite and staurolite, is limited, in the older schistose rocks, to those spots where they are in contact with granite, or some analogous rock. Here, then, the porphyritic separation of crystals is obviously owing to the influence of the more recent upon the older rock. It cannot be doubted that an essential part of the change consisted in a chemical readjustment of the atoms. Andalusite, which, according to Bunsen, is specifically identical with chiastolite, likewise occurs in mica and clay slates, under precisely similar circumstances. It has been found very fine in the clay slate of the Whealkind mine, at the surface of contact with granite, the clay slate at the same time being remarkably hard. The same phenomenon presents itself near the mica slate and gneiss at Munzig (Saxony), and chiastolite occurs in the clay-slate at Gefrees (Bavaria), close to granite.

At Treuen (Saxony), the so-called "Fruchtschiefer" occurs, surrounding a spheroidal mass of granite, and a perfectly similar-shaped black amphibole, with garnets, occurs at Airolo (Switzerland), so that it may be inferred that the indistinct and decomposed crystals in the "Fruchtschiefer" were formerly amphibole. The same kind of slate occurs at Schneeberg, near the granite; and in the mines at that place it has been found that the clay-slate is harder and more siliceous near the granite, this contact phenomenon even extending into the slate to a distance of 800 feet from the granite. This fact is alone sufficient to shew to what a distance the atoms of relatively recent rock may be transferred into an older one with which it comes in contact. The horn-slate, which forms a kind of mantle round the granite of the Brocken, affords almost precisely the same evidence. These altered, and in part essentially hardened slates, do not always present evident porphyritic inclosures, but they probably exist as microscopic particles, or the slate has been otherwise chemically altered.

It is probable that the alterations which rocks have suffered under the influence of more recently-formed rocks rarely consisted in merely mechanical modifications of the molecular aggregation; they appear rather to have been far more deeply seated, to have been more or less chemical. In this point of view, the theory put forward by Von Buch, that, under certain circumstances, dolomite may have originated from limestone by the action of melaphyr, comes within the bounds of possibility, and, under one condition, acquires much probability.

The mica-slate of Scharfenstein (Erzgebirge) is remarkably altered in contact with the porphyry which traverses it, being converted into gneiss for short distances. In this instance felsite has been transferred from the porphyry into the mica-slate, which might, indeed, be termed porphyritic, were it not customary to call a schistose mixture of felsite, quartz, and mica, gneiss.

The above mentioned transfer of mispikel, from a lode into gneiss, is an analogous fact, the more recent lode mass having acted upon a pre-existing rock, in the same way as a more recent rock mass. A number of other instances might be brought forward, but as there are no facts at variance with this proposition, it is unnecessary.

6. When the crystalline variety of a mineral is associated with the compact variety, the former is always the most recent.

Many porphyries consist of a mixture of compact felsite, with imbedded crystals of cleavable felsite. There is, therefore, no reason to deny that the latter are of more recent formation than their matrix. In granular or slaty mixed rocks large crystals, of some one or more constituents, are sometimes imbedded, communicating to the rock a porphyritic character; and there can be little doubt that such crystals are of more recent date, for not only do they contain nuclei of the rock in which they lie, but in the slaty rocks, the curvature of the layers surrounding the crystals is likewise to be observed, as in the gneiss of Schwartzenberg (Saxony).

Many minerals occur imbedded in the form, not of crystals but of nodules. In other respects they correspond precisely with the inclosures in porphyritic rocks, and there is no doubt that they have often originated in a similar manner. This is very evident in the case of iron pyrites, which frequently occurs, both in nodules and crystals, in the same bed of clay. Nodular iron pyrites occurs in all rocks up to the clay-slate. It is probable that many other nodular minerals must be regarded as of later formation than the masses in which they lie, although water-worn fragments are also imbedded in this shape. Again, agate occurs in the form of nodules, although it has been formed in a very different manner. Consequently very great caution must be exercised in forming any inferences with regard to the origin of imbedded nodules. Nodular minerals are sometimes associated with imbedded crystals, and this is then additional evidence in favour of their analogous origin, thus sphærulite occurs in pitchstone, pearlstone, and obsidian, together with crystals of astrite and felsite. The nodules of azurite, in the marl and sandstone of Miedezana

Gora (Poland), are remarkable, inasmuch as they are hollow, and lined with crystals, like amethyst balls. There can be no doubt that the formation of these crystals was attended by a contraction of volume, and commenced from the periphery of the nodules.

Nodular masses of limestone are very common in transition rocks, especially slate ; at Obernitz (Thuringia), they are so numerous as apparently to form beds. Marl strata sometimes contain nodules of very hard limestone or dolomite, traversed by veins of calcite, perhaps accompanied by celestine. Argillaceous spharosiderite would appear to have been formed by a segregation of carbonate of iron, after the formation of sedimentary rocks. Freiesleben states likewise, that the crystalline spathic iron of the Mansfeld district has in some places an oolitic structure. It must, however, be expressly stated, that both limestone and spharosiderite, when exposed to the atmospheric influence, assume a nodular structure, and this remark applies also to some sandstones, grauwackes, &c,

Heavy spar occurs in nodules in clay; yellow iron ore in the brown coal formation of Bohemia. At Miask (Siberia), the variety of chrysophan, called xanthophillite, occurs in nodules, generally surrounded by magnetic iron ; the crystals point towards the interior, which is either hollow, or filled with a light green mineral resembling serpentine. Nodules of green epidote occur in a gray compact limestone, in the Banat. Quartz occurs in nodular masses, more rarely crystalline than uncrystalline. Crystalline nodules of quartz, which cannot be regarded as detrital, occur in the mica-slate of the Erzgebirge. The Jura limestone at Eichstadt (Bavaria) contains balls of hornstone, sometimes of considerable size, presenting in their interior concentric-coloured streaks, and even concentric layers and fissures, the latter containing crystallised quartz. It is further interesting to observe, that the greater number of fossils in the chalk consist of flint, and that the larger nodules of this substance are particularly rich in animal remains. It is probable that the formerly existing organic matter had some share in determining the segregation of the silica, as it appears collected round the fossils.

Olivine is much more frequently imbedded in basalt in nodules than in separate crystals. These masses consist of crystalline granular fragments, sometimes mixed with augite and bronzite. As in basaltic tuffs, similar nodules of olivine are found, which, on account of their less coherent granular structure, may be easily broken down, there is the greater reason to regard them as subsequent productions, because no small particles or angular fragments are found near the large nodules.

At Charkow, Swoszowice, and other parts of Poland, amorphous sulphur occurs in nodules in marl; and where the marl has been converted into compact limestone, it presents vesicular cavities, containing crystallised sulphur and calcite.

In the case of all these nodular formations, it may be assumed that there has been a segregation of the particles of the minerals, for it would be difficult to suppose that they were accidentally deposited in the manner they now occur; and moreover, many such nodules contain small nuclei of the substance in which they are imbedded.

(To be continued.)

Some remarks on the probable present condition of the Planets Jupiter and Saturn; in reference to Temperature, &c. By JAMES NASMYTH, Esq.*

The remarkable appearances which characterise the aspect of the planets *Jupiter* and *Saturn*, as revealed by the aid of very powerful and excellent telescopes, have induced some reflections on the subject of their probable present condition as to temperature. With a view to excite more special and careful observation of the phenomenon in question, and promote discussion on this interesting subject, I have been tempted to hazard the following remarks, which may perhaps prove acceptable to some of the members of the Royal Astronomical Society.

In a former communication, in reference to the structure

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* Read at the Meeting of the Royal Astronomical Society.

and condition of the lunar surface, I made some remarks on the principle, which, as it appears to me, gives the law to the comparative rate of cooling of the planets, namely, that while the heat-retaining quality was due to the mass of the planet, the heat-dispensing property was governed by its surface; and as the former increases as the *cube* of the diameter of the planet, while the latter increases only as the *square* of its diameter, we thus find that the length of time which would be required by such enormous planets as *Jupiter* and *Saturn* to cool down from the original molten and incandescent condition to such a temperature as would be fitted to permit their oceanic matter to permanently descend and rest upon their surface, would be vastly longer than in the case of such a comparatively small planet as the earth.

Adopting the results which geological research has so clearly established as respects the original molten condition of the earth, as our guide to a knowledge of the condition of all the other planets, it appears to me that we may in this way be led to some very remarkable and interesting conclusions in reference to the probable present condition of such enormous planets as *Jupiter* and *Saturn*, tending to explain certain phenomena in respect to their aspect.

Assuming as established the original molten condition of the earth, and going very far back into the remote and primitive periods of the earth's geological history, we may find glimpses of the cause of those tremendous deluges, of which geological phenomena afford such striking evidence,* and by

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* The deluges here alluded to are quite distinct from those which have so frequently, during various periods of the earth's geological history, swept over vast portions of its surface, and of whose tremendous violence we have such clear evidence, in the denudation of the hardest rocks, the debris of which has yielded the material of nearly every sedimentary formation, from the period of the old red sandstone formation upwards.

These vast and often repeated deluges I consider to have resulted from mighty incursions of the ocean, over vast continents, till then forming the dry portion of the earth's surface, but which (by the retreat of the earth's substance from below, resulting from the progressive contraction, consequent on the gradual cooling of the sub-surface matter) must have again and again permitted extensive portions of the solid crust of the earth to suddenly crush down, like an whose peculiar dissolving and disintegrating action on the igneous formations which at that early period of the earth's history must have formed the only material of its crust, and may in that respect obtain some insight into the source whence the material which formed the first sedimentary strata was derived. If we only carry our minds back to that early period of the earth's geological history, where the temperature of its surface was so high as that no water in its *fluid* form could rest upon it, and follow its condition from such non-oceanic state to that period at which, by reason of the comparatively cooled-down condition of its surface, it began to be visited by partial and transient descents of the ocean, which had till then existed only in the form of a vast vapour envelope to the earth, we shall find in such considerations, not only the most sublime subject of reflection, in reference to the primitive condition of our globe, but also, as it appears to me, a very legitimate basis on which to rest our speculations in regard to the probable present condition of *Jupiter* and *Saturn*,—both of which great planets, I strongly incline to consider for the reasons before stated, are yet in

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over-loaded ill-supported floor, and so permit the ocean to rush in with fearful violence, and occupy the place of the so submerged continent.

Judging from the facts which geological phenomena yield us in abundance, these incursions of the ocean must have been sudden, violent, and of frequent occurrence.

The sudden sinking down of a continent to the extent of 1000 feet in depth, would be but an insignificant adjustment of the crust of the earth, to the retreating or contracting interior, as compared to the actual diameter of the earth (being only about one four-thousandth part of its diameter), but yet such a subsidence occurring to any portion of a continent near the sea, would occasion a rush of waters over its surface, amply sufficient to perform all the feats of violence and denudation (of the occurrence and action of which we have most palpable evidence), which have taken place during many successive periods of the earth's geological history, not only in the vast accumulations of debris, caused by these violent incursions of the ocean, but also in the prodigious dislocations of strata, which have resulted from the crushing down of the crust of the earth, in its attempts to follow down and fill up the void or hollow spaces caused by the contracting and retreating nucleus, which as before said, I consider to be the true cause of this class of deluges, the tremendous violence of which has yielded the old red sandstone, and all other sandstones, conglomerates, boulders, gravel, sand, and clay.

so hot a condition, as not only not to permit of the permanent descent of their oceanic matter, but to cause such to exist suspended as a vast vapour envelope, subject to incessant disturbances by reason of the abortive attempts which such vapour envelope may make in temporary and partial descents upon the hissing-hot surface of the planet.

Recurring again to this early period of the earth's geological history, when it was surrounded with a vast envelope of vapour, consisting of all the water which now forms the ocean. The exterior portion of this vapour envelope must, by reason of the radiation of its heat into space, have been continually descending in the form of deluges of hot water upon the red-hot surface of the earth. Such an action as this must have produced atmospheric commotions of the most fearful character: and towards the latter days of this state of things, when considerable portions of what was afterwards to form our ocean came down in torrents of water upon the then thin solid crust of the earth, the sudden contraction which such transient visits of the ocean must have produced on the crust of the earth would be followed by tremendous contortions of its surface, and belchings forth of the yet molten matter from beneath, such as yield legitimate material for the imagination, and the most sublime subject for reflection. The extraordinary contortions and confusion which characterise the more primitive sedimentary strata, such as the gneiss, schist, and mica slate, in so very remarkable a degree, shadow forth the state of things which must have existed during that period, when the ocean held a very disputed residence on the surface of the earth.

Could the earth have been viewed at this era of its geological history from such a distance as the planet *Mars*, I doubt not it would have yielded an aspect in no respect very dissimilar to that which we now observe in the case of *Jupiter*: namely, that while the actual body of the earth would have been hid by the vast vapour envelope then surrounding it, the tremendous convulsions going on within this veil would have been indicated by streaks and disruptions on the surface, which would be mottled over with markings such as we observe in the case of the entire surface of *Jupiter*: and by reason of the belchings forth of the monstrous volcanoes which at that period must have been so tremendously active on the earth, the vapour envelope would be most probably marked here and there with just such dingy and black-and-white patches, as form such remarkable features about the equatorial region of *Jupiter*—probably the result of volcanic matter, such as ashes, &c.—which the volcanoes about his equator may from time to time vomit forth, and send so far up into the cloudy atmosphere as to appear on the exterior, and so cause those remarkable features which so often manifest themselves on the outward surface of his vapour envelope; for I doubt if we have ever yet seen the body of *Jupiter*, which will probably remain veiled from mortal eyes for countless ages to come, or until he be so cooled down as to permit of a permanent residence on his surface, of his ocean, that is to be.

In applying these views to *Saturn*, it occurs to me that we may obtain some glimpses into the nature of those causes which have induced, and are now apparently inducing, those changes in respect to the aspect of his rings, which have, more especially of late, attracted so much attention. If *Saturn* also be so hot, that his future ocean is suspended as a vast vapour envelope around him, it is possible, I conceive, that some portion of this vapour may migrate, by reason of the peculiar electrical conditions which it is probable his rings may be in, in respect to the body of the planet; and that such migration of vapour in an intensely frozen state, as it must be in such situation, may not only appear from time to time, as the present *phantom ring* does, but also encrust the inner portion of the interior old ring with such vast coatings of hoar-frost as to cause the remarkable *whiteness* which so peculiarly distinguishes that portion of his rings. In fact, such are the extraordinary phenomena presented by this planet, that one is led to hazard a conjecture or two on the subject; and, I trust, such as I have now the pleasure to offer may meet with a kind reception from the Royal Astronomical Society.

13*th January* 1853.

Captain H. DENHAM, F.R.S., *on Deep Sea Soundings obtained in lat.* 36° 49′ *S., long.* 37.°6 *W.*

The following extracts from a letter received from Captain H. M. Denham, dated H.M.S. *Herald*, 29th of November 1852, Table Bay, Cape of Good Hope, give the results of some interesting experiments on the depth and temperature of the sea in the South Atlantic Ocean. The position, it will be seen, is in about the parallel of the mouth of the river Plata, and about half way between the American continent and Tristan d'Acunha. We have recorded similar experiments of Captain Sir James Ross, Sir Edward Belcher, and Captain E. Barnett. This, however, is far beyond any of theirs.

The following are references to our volumes for accounts of deep soundings:

1840—pp. 347, 507, Sir James Ross, 2426, 27° 4′ S., 17° 5′ W.; 2677, 33° 3′ S., 9° 1′ E.

1843—p. 796, Sir E. Belcher, 3065, 0° 4′ N., 10° 6′ W.; 1620, 4° 2′ S., 9° 6′ W.

1849—p. 121, Captain Barnett, 41° 2′ N., 44° 3′ W.; 3700 attempted, broke for want of more by effects of current.

1850—p. 699, American soundings, East of Bermuda.

1851—p. 275, Lieut. Gouldsborough, U.S.N., 3100, 28° 3′ S., 29° 3′ W.; p. 433, Commander J. Adams, from a New York paper, but unauthenticated by any other document we have seen, deepest being 5500 fathoms, in 32° 1′ N., 44° 8′ W.

H.M.S. *Herald*, as follows (7706 fathoms), obtained in lat. 36° 49′ S., long. 37° 6′ W., on her exploring voyage to the South Seas, under the command of Captain H. M. Denham, F.R.S. 30th October 1852.

The following is the extract of the letter referred to:—

"We reached the lat. of 36° 49′ S,, and long. 37° 6′ W., on the 30th of October, when the fineness of the weather permitted me to employ the 15,000 fathoms of sounding line which Commodore M'Keever, of the United States Navy, had very generously presented to me, and we had the gratification of obtaining the (I believe) unprecedented sounding of 7706 fathoms, equal to 8¾ English miles, the particulars of which I have tabulated as enclosed.

"Such was the apparent increase of the magnetic variation as we proceeded eastward, on the parallel of 37° S., that the effecting a landing on Tristan d'Acunha to test the actual amount, free from any local disturbances of the ship, appeared to me an essential step. Availing myself, therefore, of the tranquil state of the weather, on the day of sighting it (12th November), I effected a landing on the island, with the necessary instruments for settling the longitude, as well as the variation of the compass, and the shore data at once confirmed what had been indicated afloat, viz., that the variation has doubled in amount since 1813, being now in that vicinity 20° 4′ W., instead of 9° 51′ W.

"I took the opportunity of another calm day to ascertain the temperature of the sea at 900 and at 1000 fathoms. At both depths it proved the same, viz., 40° of Fahrenheit, whilst near the surface it was 58°. At the same time I employed means for tracing the depth to which the sun's rays penetrated, and found it to be 66 feet."

As we considered the foregoing statement would have been imperfect unless accompanied by particulars of this interesting proceeding, contained in Captain Denham's letter to the Hydrographer, Sir Francis Beaufort, it is with much satisfaction that with his permission we are enabled to add to it the following extract:—

"I must not omit, even in this, to allude to the generous offering to our expedition of 15,000 fathoms of sounding line by Commodore M'Keever, of the United States Navy, whose broad pendant was flying on board the *Congress* frigate at Rio. He was not content with presenting me with books, &c., but having observed that he had something *in our way*, sent me, the day before he sailed, 10,000 fathoms on one reel, and 5000 on another, of most admirably adapted line for experimenting in deep deep-sea casts. Without compunction as to ships' stores, I determined to hazard the 10,000 fathoms (beautifully laid up, or grafted into one length) the very first opportunity; and we as assuredly did get to the bottom at 7706 fathoms, as not actually bringing up a sample can permit me to say, for I and Lieut. Hutchison, in separate boats, with our own hands, drew the plummet up 50 fathoms several times, and after it had renewed its descent with the same velocity it had done during the last hundred fathoms, it landed on each occasion abruptly to the original mark to a fathom, and would not take a turn more off the reel. By its parting at 140 fathoms from the surface, we lost a Six's thermometer, which I had bent on at 3000 fathoms. With the remainder of the line I have obtained some 500's, when our own lines could not have been employed to that extent; and on two occasions between Tristan d'Acunha and this (Cape of Good Hope), I obtained 900 and 1500 fathoms with thermometers attached, saving them each time, and shewing that 40° is the minimum temperature after 200, where it averages 50 and 52, no matter what the surface temperature may be. I have still 5000 fathoms to play upon, before reeling up spunyarn again, which from our junk I had done to the length of 8 miles before I had the present."

We have no doubt the worthy Commodore will be much gratified with this disposal of his line. We need scarcely assure him that such generous marks of friendly feeling cannot fail to be appreciated, and particularly so when it is considered that he was giving away the means by which he himself might have gained the credit of finding the greatest depth of the ocean yet attained. But noble minds are above such personalities. The bottom was reached, and that was sufficient.

We shall leave our readers to form their own conclusions on the experiment, as to the up and down depth, as a seaman would say. But we may add, that although the experiment was made in a favourable part of the South Atlantic Ocean, we cannot suppose it possible that the ship would remain for the nine hours during which it lasted in a vertical position immediately over the lead, although nothing is said by Captain Denham as to the direction in which the line grows as the ship drifts while the operation is going forward, nor whether the boats and the ship were separated by the effect of any current. We by no means impugn the statement that bottom was reached when 8¾ statute miles were out, but should like to know whether or not some deduction should be made for drift, and what that should be, before an up and down depth can be asserted.—Ed. *N. M.*

A Table shewing the Rate at which the 9 lb. Plummet (11·5 *by* 1·7 *inches*) *descended with a Line of* 1-10*th of an inch diameter* (*and weighing, when dry*, 1 *lb. per* 100 *fathoms*), *through a depth of nearly* 9 *English miles of Ocean Water, at which depth it apparently reached the bottom.*

Successive Depths.	Notation. h.	m.	s.	Interval ℘ 100 Fathoms. h.	m.	s.	Interval ℘ 1000 Fathoms. h.	m.	s.
Immersion	8	30	45						
100 Fms.		32	15		1	30			
200 ...		34	20		2	5			
300 ...		36	45		2	25			
400 ...		39	15		2	30			
500 ...		42	4		2	49			
600 ...		45	0		2	56			
700 ...		48	0		3	0			
800 ...		51	5		3	5			
900 ...		54	20		3	15			
1000 ...		58	0		3	40	0	27	15
1100 ...	9	1	50		3	50			
1200 ...		5	45		3	55			
1300 ...		9	30		3	45			
1400 ...		12	45		3	15			
1500 ...		16	40		3	55			
1600 ...		20	40		4	0			
1700 ...		24	50		4	10			
1800 ...		29	0		4	10			
1900 ...		33	15		4	15			
2000 ...		37	40		4	25	0	39	40
2100 ...		42	0		4	20			
2200 ...		46	30		4	30			
2300 ...		51	0		4	30			
2400 ...		55	30		4	30			
2500 ...	10	0	5		4	35			
2600 ...		4	45		4	40			
2700 ...		9	45		5	0			
2800 ...		14	50		5	5			
2900 ...		20	10		5	20			
3000 ...		25	50		5	40	0	48	10
3100 ...		30	15		4	25			
3200 ...		36	15		6	0			
3300 ...		43	10		6	55			
3400 ...		50	40		7	30			
3500 ...		58	45		8	5			
3600 ...	11	6	50		8	5			
3700 ...		14	45		7	45			
3800 ...		22	30		7	45			
3900 ...		31	10		8	40			

Successive Depths.	Notation. h.	m.	s.	Interval ℘ 100 Fathoms. h.	m.	s.	Interval ℘ 1000 Fathoms. h.	m.	s.
4000 Fms.	11	39	29		8	19	1	13	39
4100 ...		49	10		9	41			
4200 ...		57	45		8	35			
4300 ...	12	6	10		8	25			
4400 ...		14	45		8	5			
4500 ...		21	40		7	25			
4600 ...		31	5		9	25			
4700 ...		40	10		9	5			
4800 ...		48	35		8	25			
4900 ...		57	10		8	35			
5000 ...	1	6	35		9	25	1	27	6
5100 ...		17	55		11	20			
5200 ...		27	0		9	5			
5300 ...		36	25		9	25			
5400 ...		45	55		9	30			
5500 ...		56	15		10	20			
5600 ...	2	6	55		10	10			
5700 ...		19	40		12	45			
5800 ...		30	15		10	35			
5900 ...		40	55		10	46			
6000 ...		52	0		11	5	1	45	25
6100 ...	3	5	10		11	10			
6200 ...		14	40		9	30			
6300 ...		25	20		10	40			
6400 ...		37	55		12	35			
6500 ...		48	0		10	5			
6600 ...		57	50		9	50			
6700 ...	4	8	0		10	10			
6800 ...		19	15		11	15			
6900 ...		30	45		11	30			
7000 ...		41	15		10	30	1	49	15
7100 ...		52	15		11	0			
7200 ...	5	1	50		9	35			
7300 ...		11	40		9	50			
7400 ...		24	10		12	30			
7500 ...		34	20		10	10			
7600 ...		44	22		10	2			
7700 ...		55	30		11	8	1	14	15
Total Interval,							9	24	45

Total fathoms, 7706 = 15,412 yards = 8¾ English miles.

NOTE.—This line could sustain 72 lb. in air, at a suspension of one fathom; but as the 7706 fathoms weighed 77 lb. (in addition to the plummet) became weighted one-half more by saturation (equal to 115 lb.), it could not bring up the plummet again to exhibit to us the nature of the bottom; it broke, whilst carefully reeling it in, at 140 fathoms below the water line.

H. M. DENHAM, Captain, R.N.

Astronomical Observations made with Airy's Zenith Sector, from 1842 *to* 1850, *in the determination of the Latitudes of various Trigonometrical Stations used in the Ordnance Survey of the British Isles. Edited by Captain Yolland, R.E., under the direction of Lieutenant-Colonel Lewis A. Hall, Royal Engineers, Superintendent of the Ordnance Survey, and published by order of the Master-General and Board of Ordnance.*

This is a ponderous quarto volume containing 52 pages of letterpress, and 1009 pages of figures and numerical results, as a contribution towards an exact knowledge of the latitudes of twenty-six stations on the Ordnance Survey of Great Britain. It will doubtless be very favourably received by the scientific public, and is an excellent specimen of the searching manner in, and practical skill with, which this great operation is now being carried on; while persons in general will see, from the voluminous extent to which the observations and calculations in this one department have necessarily expanded,—how essential it is that the whole should be conducted by the Imperial Government.

As the attention of persons in our neighbourhood has lately been attracted almost wholly to questions of the best scale for the maps of the survey, we may as well remind them, that to make a sensibly perfect map of the whole country on any of the scales proposed, two descriptions of operations are necessary; one consisting of terrestrial determinations of distances in feet and inches by means of measured base lines and triangles; the other, of astronomical observations, in terms of latitude and longitude, to fix the part of the globe wherein the surveyed may be situated;* and to furnish, by being compared

* It used to be objected against the old one-inch maps of the Ordnance Survey, that however accurately the fields and villages might be laid down thereon, there was nothing to shew in what part of the world the places might be situated; *i. e.*, there were no markings of latitude and longitude on the sides of the sheet, as had from the first been introduced in the government maps of France. With their usual readiness to meet all the rational requirements of

with the linear result, and with similar operations in other parts of the world, certain coefficients, relativeto the size and shape of the earth, and necessary to be employed in all the calculations of the base lines and triangles of the terrestrial measure.

Of these coefficients, the most important is the quantity of *compression* of the earth, which is derived with the greatest accuracy by comparing together measured lengths of the meridian in different latitudes; and the practical operation consists in each country in determining astronomically the differences of latitude of two stations, and then from their measured distance asunder in feet, and their bearing the one from the other, ascertaining the angular space between them on the meridian, as viewed from near* the centre of the earth, and so deducing as it is popularly termed, *the length of a degree of the meridian.*

Of the two proceedings, the *terrestrial* admits of being performed with far greater accuracy than the *astronomical.* Thus the length of 60 miles, for example, as calculated from the carefully measured base lines and angles of the Ordnance Survey, may be determined with certainty to considerably under one foot; and this will be equivalent to one-hun-

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the public, the omission has been supplied by the English officers in the recent maps on the six-inch scale; though to insert the points to such exactness that they may be depended on to the full extent of the terrestrial accuracy of the paper will be shewn presently to be a far more difficult matter than the objectors were probably aware of.

* From *near* to, not *at*, the centre of the earth, by reason of the spheroidal character of its figure; which causes the direction of gravity in various parts of the surface to point, not to one and the same internal spot, but to the locus of a curve depending on the amount of compression; and thus it is that as we travel from the equator toward the Poles, the radius of *curvature* and the length of a degree on the surface *increase,* while the distance from the centre decreases. Hence may arise two different modes of reckoning Latitude, one by a practical astronomical operation on the surface; and the other by a theoretic reference to the centre of the world, and is deduced by calculation from the former, combined with a knowledge of the ellipticity. This theoretic, or as it is called Geocentric Latitude, is proper to be employed in certain astronomical calculations; but the former is that which is more generally used, and known as "Latitude," and will be alone considered in the course of this notice.

dredth only of a second of a degree of latitude. But the astronomical determination, on the other hand, even with the best existing instruments and methods yet invented by man, can hardly be brought within several tenths of a second ; so great are the practical difficulties which beset the subject.

All possible means and appliances should therefore be employed, and even exhausted, in improving the accuracy of the *astronomical* determinations of the latitudes of the terminal points; and these when once well known, allow of the latitudes of any and all the other points in the country being computed from the terrestrial measurement with equal accuracy, and of being duly inserted in the margin of the maps. Not only, therefore, our knowledge of the compression of the earth depends on these terminal points, but also the latitudes of every place in the country, and the indications of every single sheet of the thousands of which the survey consists. The lines of latitude and longitude extending over a country are in fact an astronomical network, all the lines of which are obtained by computation from, and hinge on, the two or three stations, at which alone it has been possible to get the long and troublesome series of astronomical observations well performed. With any errors in the so determined positions of those spots, every other in the whole length and breadth of the land are out also ; and a greater uncertainty still is introduced into the results for the size and shape of the earth ; which again reacts prejudicially on the correctness of the formula employed in the calculations of all the triangles of the terrestrial portion of the survey. Hence the devotion of 1000 pages of closely-printed figures to the observations for determining the astronomical latitudes of a very limited number of places in the country.

Were *perfect* observation possible, two stations would have been enough in Great Britian, one in the extreme south, and the other in the extreme north. But as such a comfortable state of things can exist nowhere under the sun, the whole meridian length has been divided into several parts, and there are meridian lengths also taken on either side of the kingdom, so as to have as many separate results as possible ;

and moreover, at each intended station, observations have been made at several spots round about it, so as practically to ascertain whether there be any local attraction in the neighbourhood that might prejudice the results.

In this way the number of stations observed, has been increased to 26, extending from Saint Agnes in the Scilly Islands, in 49° 53′, to Saxavord in North Shetland, in 60° 49′ N. lat.

The first step in this inquiry was, of course, to get a good astronomical instrument, and the zenith sector made by Ramsden for the Ordnance having been destroyed in the fire at the Tower in 1840, application was made to the Astronomer Royal, G. B. Airy, Esq., to furnish a design for a new one, with any improvements he could suggest.

The result of this was the instrument employed, wherein the following capital improvements were introduced over all other previous zenith sectors—1*st*, the whole being made of metal, and in large pieces with few adjustments; 2*d*, A double graduated arc, or readings, and with micrometer microscopes, at either end of the telescope, which turned on an axis in the *middle* of its length; 3*d*, Levels were employed for the zero point in place of the old plumblines; and 4*th*, The whole arrangement was such as to admit of the double observations, face E. and face W., being made at the same transit.

The length of the telescope was 46 inches, the diameter of the object-glass 3·75 inches; the magnifying power usually employed 70; and the weight of the whole instrument, 10 cwt.

This was screened from the weather by a portable wooden building, covered with canvass, and having an observing slit in the roof, and weighing 23 cwt.

From 1842 to 1844 the observations were made by commissioned officers, Captains Hornby, and Driscoll Gosset, R.E., but subsequently, when the *modus operandi* was well settled, they were made and computed by non-commissioned officers, under charge of Captain Yolland, R.E.

On the average, 800 observations of stars were taken at each station, and each observation is given in the body of the work, nearly as read off from the instrument itself, with all the necessary elements for its reduction, and the principal steps of the reduction performed, are also given, up to the complete result for latitude by each observation.

In the subsequent part of the work, these quantities are collated together, and special corrections applied for certain instrumental peculiarities explained in the Introduction, and for errors of assumed declination of the stars observed, which being 491 in number, and confined between the parallels of 38° and 68° N. decl., necessarily included many small stars whose places had not previously been well fixed by any astronomer.

In the concluding part of the Introduction, the final results are considered, and being compared with the geodetical calculations, when the stations are but a few miles apart, some most startling conclusions are arrived at; shewing that the latitudes of places are affected by many more causes than most men's philosophy has hitherto taken account of. For while the probable error of the astronomical determinations is hardly so much as ±″·2, their differences from the geodetical, are often ten to twenty times as great: nay, in one instance, amount to the immense quantity of 9″·48.

The number of discordances is at the same time no less remarkable than their individual amount; and amongst the twenty-six stations observed are found all the following instances:—

	Lat.			Lat.	Discordance.
	° ′			° ′	″
St Agnes, . .	49 53	and	Goonhilly Down,	50 2	−1·60
Southampton, .	50 54	...	Boniface Down,	50 36	+1·23
... .	...	...	Week Down, .	50 36	+1·45
... .	...	...	Dunnose, . .	50 37	+3·71
... .	...	...	Port Valley, .	50 39	+0·42
... .	...	...	Black Down, .	50 41	−1·10
Hungry Hill, .	51 41	..	Feaghmaan, .	51 55	−3·73
Forth Mountain,	52 56	...	Precelly, . .	51 56	+0·60
Tawnymore, .	54 17	...	Lough Foyle, .	55 2	+3·20
Ben Heynish, .	56 27	...	Ben Lomond, .	56 11	+3·71
Cowhythe, . .	57 41	...	Great Stirling,	57 27	−9·48
North Rona, .	59 7	...	Monach, . .	58 21	−0·30
... .	59 7	...	Ben Hutich, .	58 32	+3·87
Balta, . . .	60 44	...	Saxavord, . .	60 49	−2·03

The − sign shewing that the geodetical is less than the astronomical amplitude.

"What great events do flow from little things," says an old comic writer, but the few numbers above are a veritable Pandora's box of trouble, likely to make every surveyor and geodesist throughout the earth to tremble, when considering the consequences which must certainly follow. That "nothing was given to man without great labour," was a proverb in the time of the Romans, and if true in ordinary matters, how much more pointed and impressive does it become when pushing scientific affairs to the utmost attainable degree of accuracy. To determine the latitude of a place to 30″ is easy enough; to 15″, is not difficult; but to 1″, the difficulty is increased a thousand fold, nay, every property of Nature and of matter seem to combine to prevent our discovering this secret of the world. With a proposed accuracy of 1″, still more if 0″·1 or 0″·01 be insisted on, an account must be taken, and an explanation rendered of the above discordances, preparatory to any hope of their being eliminated from the determinations for latitude.

It is easy to attribute the discrepances to "local attraction," but that is merely giving the difficulty a name; and the question still remains as to how a numerical correction can be obtained. It is by no means the first time that such a disturbing cause has been suspected, but previously observations have been conducted at so few stations, or have been liable to such great uncertainties from error of observer and instrument, that little attention has been paid to the allegation. Actual mountains have however been generally allowed to possess a sensible influence in this way; and then the observing places have usually been picked out at the greatest practicable distance from such questionable neighbours.

Such, we conclude, were the precautions taken with the ordnance stations; and certainly they are more numerous, and better and more uniformly observed, we believe, than any previous set that can be brought to bear on this question. The probable error of observation is here so small as for the time to disappear; and yet there are discordances of a greater amount than ever before known, and therefore plainly and surely attributable to local attraction, whatever that may be. The accusation, in fact, against mother earth is fully proved, and must be proceeded with.

Now this abnormal attraction can be only that of gravitation, which depends solely on weight; as, for instance, a pound of gold, a pound of stone, and a pound of ice, placed at equal distances from each other, will act each on the other with precisely similar gravitating forces. If therefore the weight and distance of a mountain be known, its effect on the plumb-line can be computed; and the first question is, whether the observed deviations can be completely explained by such visible and tangible excrescences on the surface of the earth, or whether they be owing to some heterogeneous construction beneath it? If the former be the case, the elimination is comparatively easy but laborious, for the mountain can in time be measured; there it is; but in the latter case, where is it, *i.e.*, the attracting body, or bodies?

At one of their trigonometrical points in Peru, the savants of Louis XIV. found an attraction in the mass of the Andes to the amount of 7″: and more recently Mr Maclear found the attraction of Table Mountain equal to 3″, and that of Piket Berg equal to 2″, at the stations employed by a former measurer of an arc of the meridian in South Africa. In his own determinations therefore, Mr Maclear left the sheltered valleys around the foot of a mountain, and preferred all the inconveniences of placing his instrument on the exposed summit: for there, having the mountain beneath his feet, its attraction acted,—in so far as its mass was uniformly disposed about its culminating point,—in the direction of that of the earth, and therefore could produce no deviation from the vertical.

But in England and Scotland, there are no mountain ranges like the Andes; nay, in the neighbourhood of the survey terminal stations, there are no masses comparable to Table Mountain or to Piket Berg; and yet the effects of local attraction at many of the stations are greater than were observed in the actual neighbourhood of those giant ranges. The known configuration of the surface of the dry land therefore will not explain completely all the difficulties, nor will any probable shape that may be given to the land under the neighbouring seas.

Magnetic and electric affinities, it need hardly be observed, are altogether powerless here; and so we are driven to the only remaining hypothesis, viz., vast caverns underneath the surface of the earth in certain spots; or, perhaps, immense masses of rock or metal of much less, and in other places, of much greater density and specific gravity, than the neighbouring material. But whether holes or masses, or veins or dikes, they must be something mighty in size, and by no means very distant, to produce such great, but at the same time, irregular, effects.

These discordances too appearing so very generally in the case before us, and acting of course on the longitude as well as the latitude, must render uncertain the astronomical elements of position of *all* places yet observed, by any instruments, in other countries as well as this; for in no place has any correction for local attraction, under as well as above the surface, ever been applied, or indeed obtained, or attempted. The multitudinous measures necessary for the purpose are still to be made.

Hitherto men have fancied, or at least appear by their conduct, with the slight exception already noticed, to have laid the flattering unction to their souls, that to determine the true astronomical position of a spot, they had merely to improve their instruments, and multiply their observations of the stars. But now it is shewn that there is another cause at work, which the above proceedings do not touch. In fact, even if we had a *perfect* astronomical instrument, and if angels were to observe with it, still the results would be in error by the full amount of the "local attraction;" and that may be far too large to be passed quietly by.

Our public observatories will not be affected by the anomaly, so far as their researches in cosmical astronomy are concerned; it will only be of importance in geographical astronomy. But it will both greatly affect all existing measures of arcs of the meridian, and greatly trouble the mapmakers. How, for example, shall they draw the parallels of latitude through Great Stirling and Cowhythe, when there exists an anomaly there of $9''\cdot5$, equal to one inch on the 6-inch-to-a-mile maps; and as yet there is nothing to shew on which side of either place, or whereabouts in the country the seat of disturbance, and its maximum effect, may be!

In fact, notwithstanding what the French have been in the habit of doing with their maps, and what the croakers complained of the Government not doing here, science is not far advanced enough to be able to insert the astronomical latitudes and longitudes with sensible accuracy on large sized maps. If, then, we see parallels of latitude represented by simple *straight* lines, we may be *certain* that they are wrong, *i. e.*, they do not represent what a perfect astronomical instrument would shew at one place, or a terrestrial measure give at another, and this, too, by a quantity that would permit any amateur, with small observing means, to detect apparently gross errors in the National Survey.

The volume, therefore, published by the Ordnance, opens a new and most important and difficult question, rather than it settles the latitudes of the trigonometrical stations. Further steps must, consequently, be taken in the research; and means must be found of reducing, in all cases, what we may term the *apparent*, to the *true* astronomical latitude and longitude. The present book is an exceedingly good one as far as it goes, and it is not the fault of the authors that the case to be investigated has proved more difficult than had been anticipated, by reason of the influence of occult natural causes; nor is it at all to their discredit, if haply with the rapidly advancing improvements in astronomical instruments and methods, some more perfect instrument still to that which they employed, may now be contrived. Their work is a great advance on all that has previously proceeded out of their office, and we must particularly admire the honesty with which all the original observations are given, together with the elements for their reduction, so that any person may verify the computations; a method of publication, the example for which was mainly set by the present Astronomer Royal; and who appears to have advised all the proceedings in the present case.

The men who have satisfactorily carried on the work thus far are doubtless the best to continue its prosecution, and we hope will do so, and have full means afforded them for following it out, through all its ramifications. Meanwhile the perusal of their record of the past, would seem to suggest,—if we rightly understand the numerous circumstances therein detailed,—the propriety of a few remarks for the future, something as follows:—

First,—Of the instrument.

The one in question, though a great advance on all previous zenith sectors, still was a zenith sector, and was affected by some of their natural errors,—errors which have driven them out of all astronomical observatories, and have occasioned in this example, the necessity of applying a very ugly and rather arbitrary correction to all the results, depending on the expansion of the arc by being squeezed out under the vertical pressure of the pivot screw at the top of the instrument; which screw at each station was turned different quantities to make more or less squeezing, according to the judgment or memory of the observer. The horizontal axis of the telescope, moreover, was very short, and being unbalanced, tended to wear unequally; while the levels, being all on one side of the vertical axis, would all be *similarly* affected by centrifugal motion in turning the instrument round, and might all, therefore, shew too great or too small a reading, by the amount of the retardation of the bubble by friction.

We should be inclined, indeed, in the present day, to reform sectors and levels altogether, by having a transit *circle*, and obtaining the zero point with the collimating eyepiece.

A single observation at each meridian transit, would then give a complete result, and with much greater ease and probable accuracy, than when two observations have to be taken, and a large instrument reversed and reset all in a few seconds, with the stars, too, already beginning to describe downward paths, by reason of their distance from the meridian.

The prime-vertical transit instrument, has become a favourite for these purposes on the Continent; but although it may give very concordant and apparently accurate results, yet in the shape in which it is there manufactured, it must be liable to so much flexure, and in a vital direction to the integrity of the observations, that their absolute accuracy may be always doubted.

In the form of the ordinary transit, *i. e.*, with a double axis, it may do better; though there is even then great doubt if the level ever can be ascertained as exactly as it should be; and after all, each observation occupies so very great a length of time, as to admit of but very few being taken during a night; and those may be so seriously interfered with by the abundant clouds of this climate, that a practical man may well prefer a graduated circle in the Meridian.

Second,—Of the mode of observing, and reducing the observations.

Each observation before us is made to give an independent latitude, and this is therefore loaded, not only with the instrumental errors in measuring the zenith distances, but also with the tabular errors of the star's declination, and what is much more uncertain, its proper motion. The prejudicial consequence of this appears in the columns on the right hand pages giving the observed zenith distances and the computed latitudes, in which latter the discordances are often double the amount of the former.

Uncertainties of refraction are certainly mixed up in the latitude results; but as the zenith distance is always small, there can never be any notable effect from that cause; yet we should like, in any future work, to see a discussion of the value of the constant of refraction; for it would doubtless be found to vary at the different altitudes above the sea, and in the contrasting physical circumstances of the several stations.

The greater part, then, of the increase of the discordances amongst the latitudes over the zenith distances, must rest with errors in the assumed values of the places and proper motions of the stars of comparison; and an easy way of remedying this difficulty is to have two instruments: keeping one always at a standard station, and having the same stars observed at the same times, with the stationary and with the travelling instrument: a method much practised by Mr Maclear in his excellent repetition of the South African arc.

Thirdly, we may observe, that while we should prefer, at the beginning of the volume, to see entered the *very identical* numbers read off from the instrument, without, as here, being reduced from divisions of the micrometer to seconds of space; we should also like to see at the close, some investigation into the *probable errors* of the final results. These numbers are given to hundredths of a second, but when we examine the components, and find one star giving a result many whole seconds from another, and all the southern stars having a perverse discordance to all the northern ones, we evidently cannot depend for certain on the last hundredth. To within how many hundredths of a second, then, can we depend ±? What is the real breadth of the foundation on which we can securely build a superstructure of theory and inference, free from the effects of error of observation?

This quantity should be obtained with observations for latitude and for longitude also, wherever there may exist so perfect a means as the electric telegraph for communicating time between two stations. The next step will then be to determine in each case the configuration of the neighbouring ground, by careful contouring (a superb mode, by the way, of settling the levels of a country for engineering and other operations, though discountenanced by the late Committee of the House of Commons): and with the size of the hillocks so ascertained, and with the nearest approach that can be made to a knowledge of their specific gravity, their attraction may be computed.

Then according to the character of the residual quantity, obtained by applying the computed to the observed attraction, deduced by comparison of one with many stations,—further astronomical observations should be instituted at various places, until all the sources of local attraction, and the means of computing their effects for all distances, shall have been discovered.

So far for the elimination of the disturbing effects of the attraction of the mountainous masses. But that having been ascertained sufficiently well for practical purposes; it is hoped that then the important scientific and physical result of the *weight* of the world will occupy the attention of the surveying department. So long a time has occurred since Dr Maskelyne tried the great experiment on Mount Schehallion, that much advantage might result from repeating his measures again, both terrestrial and astronomical, with improved means: especially adding observations for longitude as well as for latitude; and so observing on four sides of the mountain. But inasmuch as the geologic construction of Schehallion is very heterogeneous and uncertain, it might be better to search out some hill of more uniform constitution; and such, according to the experienced testimony of Professor Jameson, may be met with amongst the mountains of Sutherland, some of which are of quartz from top to bottom.

C. P. S.

Notes on the Scales of the Government Survey of Scotland.

The scales upon which the Government Survey of Scotland should be engraved and published, having naturally excited great interest, and given rise to much diversity of opinion, we have endeavoured to collect some precise information as to the progress, up to the present time, which has been made in this great National work, and the special purposes for which it is designed.

The Government, or, as it is called, the Ordnance Survey of England and Wales, had, up to the year 1824, been published on the scale of one inch to the mile; and the whole country, with the exception of the six northern counties, was finished upon this scale, and has given great satisfaction to the country, as we learn, from the evidence of several eminent civil engineers, and geologists, to whom it has been found of great value in many important works upon which they have been engaged. But in the year 1824, the whole surveying force of the Ordnance was transferred to Ireland, and as the survey there was designed to form the basis of a general valuation of the country, for which the scale of one inch to a mile was much too small, the Government directed, after a very mature consideration of the subject, that the scale of the county maps of Ireland should be on the scale of six inches to a mile, and that the large towns should be drawn on the scale of sixty inches to a mile, and that a general map on the scale of one inch to the mile, like that of England, should be prepared by reducing the six-inch maps to that scale. These orders were consequently carried into effect, and the whole kingdom has been engraved and published on the six-inch scale, and the one-inch general map is now in progress, On the completion of the survey of Ireland in 1845, that of England was resumed, and that of Scotland commenced, and in consequence of the very great advantages which the survey of Ireland had conferred on that country beyond the special object for which it was designed, the Government decided that, in the progress of the survey of Great Britain, the same series of maps should be published, as had been in Ireland—and in consequence the counties of Yorkshire and Lancashire, Wigtownshire, Kirkcudbrightshire, Edinburghshire, and Haddingtonshire, have been drawn, and the first four counties completely engraved on the six-inch scale, whilst the survey is proceeding in Durham and Fife. We also learn that the primary triangulation of the whole United Kingdom is now complete, and the measurement of the arc of the meridian, from Dunnose in the Isle of Wight, to Balta in the Shetland Islands, is in course of publication.

The progress of the survey of Scotland, which was necessarily slow in consequence of the small sums granted for the service, having created much dissatisfaction, and many eminent persons having expressed an opinion that a survey on the scale of six inches to a mile was not required for Scotland, a Committee of the House of Commons was appointed in 1851 to report upon this subject.

The report of this Committee, and the evidence of the numerous witnesses examined, contains much valuable and detailed information, but much diversity of opinion between the several witnesses; Sir R. Murchison, Lord Monteagle, Mr Stephenson, Mr Locke, and Mr Brunel, being of opinion that the one-inch scale, like that of the southern counties of England, was all that was required for Scotland; whilst, on the other hand, Mr Griffiths, under whom the valuation of the whole of Ireland was conducted, and Sir John Macneill, the engineer to the Railway Commissioners of Ireland, and all the Ordnance officers, were of opinion that the scale should be six inches to a mile, like that of Ireland.

The following are the recommendations of the Committee:

1. That the six-inch scale be abandoned.
2. That the system of contouring be abandoned.

3. That the survey and plotting on the two-inch scale be proceeded with as rapidly as is consistent with accuracy, with the view to the publication within ten years of a one-inch map, shaded and engraved in a manner similar to the Ordnance one-inch map of England.

Orders in conformity with these recommendations were given to the Ordnance officers, and in the summer of last year, the survey for the one-inch scale was proceeded with, but as soon as this change became known to the public, great dissatisfaction was very generally expressed, and numerous influential meetings were held in several counties, in Edinburgh, Glasgow, and many of the principal towns, to memorialize the Government to proceed with the survey of Scotland as as they had begun it. On the receipt of these memorials, the Chancellor of the Exchequer (Mr Disraeli) ordered the survey for the one-inch scale to be discontinued, and the counties of Haddington and Fife to be surveyed on the six-inch scale, and that no other county should be taken up "till this important subject shall have received further investigation."

It is greatly to be regretted that so much time and money should have been lost, but it was obviously better to stop the work for the small scale at once, than to allow it to proceed, and produce dissatisfaction in the country, with the prospect of eventually losing more time and money on a work not calculated to meet the wants of the Government, and the country at large.

Most of the memorials have appeared in the journals of the day, but we select that from the gentlemen of Dumfriesshire, as expressing what appears to us to be the general feeling of the people of Scotland upon this subject.

"To the Honourable the Lords Commissioners of Her Majesty's Treasury, the humble memorial of the Commissioners of Supply of the County of Dumfries,

"Sheweth,—That the memorialists had under consideration at their annual meeting held in April last, which was numerously attended, the subject of the Ordnance Survey of Scotland, when they had occasion to express their regret at the delay which has taken place in the prosecution of it; and on the motion of Sir William Jardine of Applegarth, it was unanimously resolved to urge the Board of Ordnance to proceed with its completion, with as little further delay as possible, and that upon a scale of *six* inches to a mile.

" This resolution was accordingly communicated to the board; but the memorialists were informed that it rests with your Lordships alone to set aside or modify the present arrangement for completing what remains of the survey on a scale of *one* inch to a mile.

" The one-inch scale being considered by the memorialists so entirely useless for all practical purposes, the matter was again brought forward at their Michaelmas meeting, held on 5th October last, when (in consequence of the above information) it was resolved, on the motion of his Grace the Duke of Buccleuch and Queensberry, to present this memorial to your Lordships in support of the early completion of the survey of Scotland on the large scale; at the same time, calling attention to the peculiar advantages which a survey of the county of Dumfries on this scale would confer, as in comparison with one on the reduced scale.

" The memorialists are humbly of opinion, that six-inch maps of the counties of Scotland would be much more useful for all *public*, *local*, and *private* purposes, than plans on the one-inch scale; and indeed, that the latter would be even of less service than plans already existing; while the difference of cost, having regard to the superior advantages of the large plans, would not be so great as to justify a departure from the system pursued in the survey of the United Kingdom up to a very recent period.

" The larger maps, with the levels inserted upon them, would be highly useful for all purposes connected with engineering; the formation of railways, canals, roads; the conveyance of water to towns; sewerage; the reclamation of marshes; and the improvement of waste lands; the collection of *correct* agricultural, mineral, and other statistics, including a *correct* census; the procuring of *correct* geological and hydrographical surveys; the valuation of property in reference to sales and to public and parish assessments; the management of estates; the identification and registration of different properties, and in various other ways; for most of which purposes the smaller maps would be of comparatively little use, and for the more important would be of no service whatever.

"The larger map would not merely be valuable for present purposes; as an authentic record of the state of the country, and the boundaries of properties, parishes, and counties, it would in after ages be regarded with interest, and be found of great use in tracing the progress of improvement and the changes occurring in the course of time.

"The memorialists have respectfully to submit that there is no valid reason why Scotland should not have the benefit of a national survey on the enlarged scale. She contributed a proportion of the expense of the survey of the sister countries. There are extensive tracts of as wild country in Ireland as in Scotland, and upon the utility of surveying the former country on the large scale, the argument that large plans of such waste grounds were unnecessary was never raised. It appears to the memorialists, therefore, that it would be unjust to give Scotland inferior maps on the ground of expense. Besides, it is of manifest importance, in a national point of view, to have uniform connected maps, applicable to the entire United Kingdom."

These memorials would seem to have decided the Government to give to Scotland the benefit of a survey not inferior to that of Ireland; and we see, by a correspondence recently published between Sir Charles Trevelyan and Major Larcon, R.E., the present Under-secretary for Ireland, to whose energy and ability the perfection of the agricultural statistics of that country is mainly due, that the question of the best scales for the survey of Scotland is still under consideration. Major Larcon is asked if the six-inch survey of Ireland has fulfilled the objects for which it was designed, and whether, if the survey of that country had to be done over again, he would propose a larger scale; to this he replies, that the survey has fulfilled all the objects expected from it, and that he should recommend the same scale if the work had to be gone over again, and recommends that it should be extended to the whole of Scotland. Mr Griffiths, to whom these replies were communicated, concurs fully in these views, which are in accordance with the evidence he gave before the Parliamentary Committee of 1851.

We therefore confidently hope that the survey will now proceed without further interruption and delays. We have seen with great satisfaction that an additional grant of £10,000 appears in the Ordnance estimates for this year, making the grant for this year £35,000 for the survey of Scotland—a sum which will enable the Ordnance officers to proceed rapidly in their work, and give employment to a numerous body of assistants from our population. E.

On a Quartziferous Variety of Trachyte, found in Iceland. By THEODOR KJERULF, of Christiania. Communicated for the Edin. New Phil. Journal.

Amongst the trachytic formations of Iceland, which appear from the investigations of Bunsen to exhibit, along with the greatest mineralogical differences, a remarkable chemical agreement, and which, in a paper inserted in the twenty-third volume of Poggendorff's Annalen, he terms "normal trachytic," there are some which are characterised by the occurrence of interspersed quartz and rock crystal. These, as well as the other trachytes of Iceland, belong to Abich's "trachytic porphyries," with which they harmonize, not only in their chemical composition, but also in the circumstance of their assuming, for most part, a porphyritic appearance by the interspersion of minute lustrous lamella of felspar. In the rocks referred to in the following paper, which belong to these formations, these felspar secretions are absent, although in them likewise the rock presents a porphyritic appearance, from being interspersed with quartz. We might give it the appellation of quartziferous trachytic porphyry. The mass appears decomposed, almost friable, and in colour varying from light green to yellowish red. In similar varieties of trachyte, the mass being the same, but quartz being absent, there could be distinguished small spicula of iron pyrites, which seemed to indicate a subterraneous formation by the disengagement of sulphureous vapours from fissures (Fumarolenwirkung). In the present rocks, however, I could not, even with the assistance of a lens, detect iron pyrites, with anything like certainty, although that variety 2 exhibited traces of sulphuric acid and spicula, resembling hydrous oxide of iron.

The materials for the investigations of which the results are here communicated, were collected by myself on the spot, during a journey to Iceland, in the summer of 1850, and the analyses themselves, were conducted according to the method followed by Professor Bunsen, and communicated by Dr Streng (Bietrag zur Theorie der vulkanischen Gesteinsbildung, Bresl., 1852.) In the environs of the Baula, a mountain from which so much instruction may be derived in regard to the trachyte of Iceland, I could not, after the most careful search, discover any of the quartziferous rocks. These I have observed only, not under the most favourable circumstances for observation, at Kalmanstunga in the western, and at Trollakirkja, in the northern, parts of the island. At Kalmanstunga, at the declivity of the mountain which stretches towards Koita, there is an alternation of numberless varieties of trachyte, compact, earthy, nodular, breccious; and it is amongst the fragments of the latter, that at the declivity in question, the quartziferous porphyritic trachyte is found. The contiguous rock and the junction of the two are, unfortunately, concealed from observation by heaps of rubbish. As far as could be recognised, the whole composed a veniform mass (eine stock =oder gangförmige masse), which might probably extend over Tunga to the trachyte cliffs of the Nordlingafljot. It should also be mentioned that the trachyte mountain in the neighbourhood of the above-mentioned locality, has been broken through by a basaltic mass, which can be recognised at a considerable distance by its beautiful columns. The second variety subjected to analysis is from the northern district of the island, where the road from Fagranes to the Skagafjordr leads through the narrow valley of Vidadalr towards Grimstungur. Right across the valley, where it stretches in a southerly direction, there runs down from the mountain of Trollakirkja a vein of quartziferous trachytic porphyry, but here likewise the line of junction with the adjoining rock, which was a common dark augitic and palagonitic rock disposed in beds, was nowhere to be observed; even the thickness of the vein itself, which seemed to run from 6 to 14 feet, could scarcely be determined. A dark green vitreous rock of junction (Contactgestein), which is found at the Baula as well as almost everywhere else in Iceland, where the trachyte separates from an augitic or tuff rock, was not observed here, but may very possibly have been concealed under the loose rubbish, which the unfavourable state of the weather unfortunately put it out of my power to subject to a very close examination.

The rock No. 1, is composed of a greenish mass in which are imbedded small white globular particles, very distinctly separated from the matrix. These globules are either entirely filled with a hard white quartzose mass, or else they form a globular crust, of which the internal cavity is occupied with beautifully transparent points of rock crystals. The rock No. 2, appears to be more decomposed than the former; the mass, which is of a light yellow reddish colour, is almost friable, and the quartz crystals are found distributed in more irregular cavities. On comparing the two varieties, they seem to exhibit different phases of the same process of decomposition; the globules disappearing and giving place to cavities, as the matrix itself becomes more friable. The reddish powder of No. 2, after being digested for a short time in concentrated muriatic acid, totally loses its colour, and becomes snow-white.

The composition of these two varieties, as appearing on analysis, calculated on the anhydrous substance, is as follows:—No. 1 losing 1·847 per cent., and No. 2 losing 1·656 per cent., by being brought to a red heat.

	No. 1.	No. 2.
Silica, ...	78·149	81·364
Alumina, . . .	11·522	10·241
Oxide of iron, . .	1·655	1·931
Lime, ...	0·465	0·301
Magnesia, . . . }	0·067	0·058
Protoxide of manganese, }		0·076
Potassa, . . .	2·898	4·878
Soda, ...	4·195	2·030
	98·951	100·879

Or, to afford readier means of comparison with the composition of normal trachyte, it may be calculated at 100, and with protoxide of iron, as follows:—

	Normal Trachyte.	No. 1.	No. 2.
Silica, ...	76·67	79·11	80·81
Alumina, ...	14·23	11·67	10·17
Protoxide of iron, . .		1·51	1·73
Lime, ...	1·44	0·47	0·30
Magnesia, . . .	0·28	0·07	0·14
Potassa, ...	3·20	2·93	4·84
Soda, ...	4·18	4·24	2·01
	100·00	100·00	100·00

Thus we have very nearly the composition of normal trachyte,—the proportion of silica being somewhat larger, especially in the variety in which decomposition has proceeded farthest.

In order to check the analysis, I endeavoured, with No. 2, which presented most facility for the purpose, to ascertain the per centage of quartz crystals. A certain quantity, after being weighed, was gently crushed, and water being afterwards poured over it, the light supernatant particles of the mass were removed, and the residuum dried and strongly heated: the quartz crystals, which could then be easily distinguished, were separated mechanically from the small reddish fragments of trachyte, and from a few particles of white quartz. The result was 2·9, or 3 per cent. In this experiment, which was very carefully performed, I cannot imagine that there was room for an error of more than one per cent. loss at the utmost, so that the proportion of quartz cannot possibly exceed 4 per cent.

The question now arises, whether this excess of silica has been conveyed into the rock by infiltration, or whether it has proceeded from a partial elimination of its basic constituents. The answer to this question is, geognostically, of some interest. If we take as our basis the composition of normal trachyte,—and from the local relations of the porphyritic varieties with other trachytic rocks at Kalmanstunga, it seems exceedingly probable that the former have been formed from the latter. We are able, either on the one hand, upon the supposition of an infiltration of silica into what was originally a mass of normal trachyte; or, on the other hand, upon the supposition of a partial elimination of the bases, to arrive by calculation, at compositions nearly identical with No. 2. For, if to 5 portions of normal trachyte we assume the infiltration of 1 portion of silica, the composition 3 will be the result; and we obtain the composition 4, if, of 8 portions of undecomposed trachyte, 2 portions undergo alteration in such a manner as that their contained bases are, by the action of volcanic vapours (Fumarolenthätigkeit), eliminated in the form of sulphuric salts,—their silica at same time remaining:—

	No. 3.	No. 4.	No. 5.
Silica, ...	80·56	80·76	80·22
Alumina and protoxide of iron,	11·86	11·98	12·27
Lime, ...	1·20	1·21	0·31
Magnesia, . . .	0·23	0·24	0·14
Alkalies, ...	6·15	5·78	7·06
	100·00	100·00	100·00

Thus, it might seem as if the question were incapable of solution. But the alternative is really decided by the observation, that in No. 2 there is contained not more than 3–4 per cent. of *free* silica. In the calculated composition 3, in which 1 portion of quartz becomes added to 5 portions of normal trachyte, there would be required, not 3 or 4 per cent., but no less than 16·66 per cent. of free silicic acid. Where, again, (in 4) 0·2 of the whole mass is conceived to have been decomposed in the above manner, there remains just 3 per cent. of free silicic acid, which might very readily appear in the form of quartz and rock-crystal. Farther, if No. 2 had arisen under the influence of a process of infiltration, the result of its composition must, after subtracting the 3 per cent. quartz, have been identical with that of normal trachyte. Such a calculation, however, gives as its result, not the composition of normal trachyte, but one containing a larger amount of silica (5).

If, then, an elimination of bases have actually taken place in 1 and 2, it may be anticipated that this process will not have extended in a precisely similar degree to the whole constituents. Now this inequality will actually appear, if we calculate the composition of normal trachyte and that of the varieties 1 and 2, without reference to the silica, for like quantities of one of the bases, *e. g.*, the alumina :—

	For Normal Trachyte.	For 1.	For 2.
Alumina and protoxide of iron,	100·00	100·00	100·00
Lime, ...	10·11	3·56	2·51
Magnesia, ...	1·81	0·53	1·18
Alkalies, ...	52·88	54·40	57·56

For these reasons, as well as from the external appearance of the rock, which of itself indicates the operation of volcanic gases (Fumarolenwirkung), I think we are entitled to conclude that the quartz, which we so unexpectedly find in this trachyte, is derived, not from the infiltration, but from the secretion of silica. Almost everywhere in Iceland, where trachytes occur, I have observed amongst them compact and earthy varieties, resembling the fumerollė clay, frequently along with spicula of iron pyrites,—as near the Baula, at the Indridastadir, near Skorradalsvatn, at the Illvidrishnukr, in the northern district of the island, not far from where variety 2 is found. The analysis of the trachyte of Langarfjall, at the Geisir, which continues to be decomposed by the influence of fumerolles, exhibits a similar elimination of bases, especially a striking diminution of the alkalies. It is not improbable that, whilst the silica secreted in 2, in the course of the partial decomposition, remained in the rock ; of the liberated bases, the alkalies, and about half the alumina, were eliminated in the form of alum, the other half of the alumina, together with the whole lime and magnesia, being eliminated in the form of sulphuric salts.*

* Liebig's Annalen der Chemie, &c., vol. lxxxv., part 3.

Biography of the celebrated Naturalist, Baron Leopold von Buch. Communicated for the Philosophical Journal.

Berlin, March 6.—Leopold von Buch is dead. He expired on the 4th instant, at two o'clock afternoon, after a short illness. The once so active pedestrian, who even in his old age used, when on geological excursions, by the extraordinary amount of fatigue which he underwent, to put many a junior to the blush, had of late been exhibiting, physically although not intellectually, distinct signs of advancing age. In him Germany loses not merely one of the most famous of her literati, but one of those rare and extraordinary men on whom the world, with its gifts and external distinctions, has nothing in its power to bestow. Leopold von Buch was totally absorbed in his science—in the most unselfish efforts after the attainment of truth. One must have seen and known him in order to be able to comprehend the strength of his character—a character which, from that very quality—especially in such an atmosphere as Berlin—could not fail to be distinguished by some oddities.

Buch was born, not, as has been commonly stated, in 1777, but on the 26th of April 1774, and was a contemporary student with Alexander von Humboldt in the Mining Academy of Freiberg. Of all Werner's pupils it is he who has contributed the most to the progress of geology, and who can be most aptly compared with the Comte de Saussure, whom he not merely equalled in the comprehensiveness of his mineralogical and physical knowledge, in acuteness, in talent for observation, and in unwearied zeal, but also resembled in another respect: already in the possession of a fortune equal to his wants, he gave himself wholly to science, without the least reference to personal advantage, or its application to the practical purposes of life.

In the year 1797 he published a little work under the title of "An Attempt at a Mineralogical Description of Landeck in Silesia" (Versuch einer mineralogischen Beschreibung von Landeck), which was a perfect model of clear and simple exposition, and of concise and perspicuous description. In the same year he quitted the north of Germany, different portions of which he had already examined, of course under the influence of those neptunistic views which he had imbibed from Werner, and directed his footsteps to the Alps, of which he may, in a scientific point of view, be regarded as the Columbus.

In examining the district of Salzburg, so rich in natural beauties and in striking geognostic phenomena, he enjoyed the congenial companionship of Humboldt. Of this profitable intercourse there remains an imperishable monument in the description of Salzburg, which may be regarded as a model of description of great mountain regions.

In the spring of 1798 he instituted the first careful inquiry into the central alpine chain through the Tyrol; and from thence, after long impediments, arising from the continuous wars of the French Republic, he succeeded in February 1799 in reaching Naples. Here he directed his attention to the study of Mount Vesuvius, and it was the phenomena of this volcano that first awakened doubts in his mind with regard to the soundness of Werner's doctrines. An old Neapolitan still boasts with delight of having been the guide of Buch and Humboldt through the lava ruins.

But it was not until the year 1805 that Buch had an opportunity, in company of Humboldt and Gay-Lussac, of witnessing a great eruption. He then found himself enabled to correct a number of erroneous views, hitherto generally entertained, with regard to the activity and products of volcanoes. His mind had been prepared for the subject by a previous journey through the south of France. In the year 1802 he had examined the extinct volcanoes in the district of Auvergne, and discovered that the volcanoes break out from the granite; but, cautious inquirer as he was, he did not consider this as sufficient to overthrow the Wernerian theory. Recognizing the extraordinary scientific importance of a remarkable phenomenon, he was too cautious to make it the basis of a universal law; and it was not until after more extended inquiry, and the accumulation of new facts, that he allowed himself to assign a similar mode of origin to the German basalts. The fruit of his inquiries appeared in his "Geognostical observations during travels through Germany and

Italy" (Geognostische Beobachtungen auf Reisen durch Deutschland und Italien), 1802-1809.

Two full years—from 1806 to 1808—were passed by him in Scandinavia, where he found, to his extreme surprise, that granite, which had hitherto, in conformity with the views of Werner, been regarded as indubitably a primary rock, was to be met with betwixt younger formations. He was the first to ascertain the fact that the whole continental part of Sweden is undergoing a continuous but very slow upheaval. On his return home he passed through Lapland ("Travels through Norway and Lapland,"—Reise durch Norwegen, &c., 1810).

In company with the Norwegian botanist Smith, who afterwards met his death in the unlucky English expedition to Congo, he made arrangements in England, which he had embraced this opportunity of visiting, for a voyage of discovery to the Canary Islands. In April 1815 the two naturalists landed in Madeira, and Buch was not long in recognising an axiom of the utmost weight for the theory of volcanoes, namely, that as the whole Canary Islands are collectively the work of a volcanic action on its grandest scale, so the other islands of the ocean had a similar origin, and the groups of islands of the South Sea are the remains of a pre-existing continent. The volcanoes on the earth's surface are for the most part collected in series that frequently stand in certain relations to each other, and result from immense fissures through which subterranean forces effected a passage for themselves. These fissures follow the direction of promontories. The Lipari Islands, Etna, Iceland, the Azores, the Canaries, are to be regarded as central volcanoes. The contradistinction of craters of elevation and craters of eruption, which afforded a peculiar explanation of very interesting volcanic phenomena, met with determined opposition, and one of the strongest opponents was Buch's own principal scholar —whose early death was a severe loss to science—the justly regretted Hofmann, who, in the course of his travels through Sicily, had the good fortune, when at Sciacca, to be able to observe the origin of a small volcanic island. The "Physical Description of the Canary Islands" (Physische Beschreibung der Canariochen Inseln), has now become exceedingly rare.

Buch, during his stay in the British Islands, made minute observations upon the Hebrides, and the Giant's Causeway in the county of Antrim; and afterwards, in the Alps, he directed his attention to the study of porphyries. His explanation of dolomite has lately met with much and partly well-grounded opposition. How conscientiously he pursued his labours may be perceived from the circumstance that in his old age he made a second journey to Norway, in order to observe some facts bearing upon the transition of primary rocks.

The essential aim of Buch's labours had always been to invest the science of geology with a universal and organic character, by comprehending all its elements in one vast whole—the geognostic and physical relations of the earth's surface, temperature, soil, plants: at a later period of his life he enriched it by a profound study of petrifactions. He gave a direction to palæontology, by means of which it became possible to draw from the remains of an extinct animal creation the most important conclusions with regard to the process of formation of the earth's crust. This merit will remain, even though geology may resume the path of chemical analysis. But Germany may be especially proud of the very excellent geological map which she owes to the illustrious deceased; and when his miscellaneous writings, and particularly those minor compositions which are now lying scattered through the Transactions of academies, become, by being collected—as no doubt they will be—accessible to the general reader, the noble language and scientific method by which every line that Buch wrote was distinguished, will become duly appreciated. In a work on Volcanoes which is now passing through the press, Alexander von Humboldt has unconsciously erected a worthy monument to his illustrious friend.

Abstract of the Meteorological Register at Rangoon for September 1852. Communicated by Dr ALEXANDER CHRISTISON.

Thermometer at Sunrise.				Do. 9 A.M.			Do. Noon.			Do. 3 P.M.			Do. Sunset.			Do. 9 P.M.		
	M	Min.	Mean of 30 Observats.	Max.	Min.	Mean of 26 Observats.	Max.	Min.	Mean of 29 Observats.	Max.	Min.	Mean of 25 Observats.	Max.	Min.	Mean of 8 Observats.	Max.	Min.	Mean of 24 Observats.
Wet Bulb.	78°	74°	76°·25	79°·5	76°	78°·25	84°	76°	78°·724	81°	75°	78°·42	78°·5	75°	76°·628	81°	76°	77°·167
Dry Bulb.	81°	76°	77°·584	84°	76°	81°·289	90°	76°	83° 431	91°	77°	82°·98	81°	77°	78°·938	83°·5	75°·5	78°·855
Barometer at Sunrise.				Do. 9 A.M.			Do. Noon.			Do. 3 P.M.			Do. Sunset.			Do. 9 P.M.		
	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.
	30·07	29·97	30·0107	30·10	29·98	30·034	30·05	29·93	30·001	30·05	29·91	29·9892	30·01	29·92	29·971	30·07	29·96	30·022

Quantity of rain this month 13·07 inches—fell on 21 days. This month has been drier than the former. The latter part of it has been fine, and very hot. Wind very unsteady, in all quarters of the compass; occasionally squally; a few thunder-storms during the latter part of the month; atmosphere much drier,—the wet and dry bulbs indicating greater evaporation. On the 21st the kites returned, not having been seen since the rains began.

The mean temperature of the dry bulb thermometer, during May, June, July, August, September (the rainy season), has been 80°·2809,—the result of the average of six observations daily during that period. Total rain, 79·71 inches.

(Signed) J. FAYRER.

On the Reduction in the Height of Waves after Passing into Harbours. In a Letter to Professor Jameson. By THOMAS STEVENSON, Esq., Civil Engineer.

Edinburgh, 84 George Street,
16th March 1853.

DEAR SIR,—In your number for October last I gave an approximate formula for the law of increase in the height of waves due to their distance from the windward shore; and I have now to trouble you with another formula relating to the subject of harbours.

The great object of constructing harbours is, by lowering the height of the waves to preserve the tranquillity of the area of water which is included by the piers, and this property is variously possessed by harbours of different forms, and depends much upon the shape of the entrance and the relation between the direction of its opening and that of the line of *maximum exposure*. It may here be observed, that when there is an inner harbour, or *stilling basin*, the elliptical form seems to me the most promising. If one focus be supposed to be on the middle line of the entrance, and to coincide with the point from which the waves radiate, as from a centre, when they expand into the interior of the harbour; and if the other focus is situated *inland* of high-water mark, the waves will all tend to reassemble at the landward focus, and on their way will be destroyed by breaking on the beach. For it is a well-known property of the ellipse, that, if two *radii vectores* be drawn from the two foci to any point in the curve, they will make equal angles with the tangent at that point, and as the angles of incidence and reflection of a wave from any obstacle are practically equal, each wave will obviously be concentrated at the focus opposite to that from which it emanated.

Irrespective of the considerations mentioned above, the *reductive power* of a harbour will be dependent on the relation between the breadth and depth of the entrance, and the form and capacity of the area within. Where the piers are high enough to screen the inner area from the wind, where the depth is uniform and the quay walls are vertical, the following formula may be tried for cases in which D is not less than 50 feet:—

H = height in feet of waves in the open sea.

x = reduced height of waves in feet at place of observation in the interior of the harbour.

b = breadth of entrance to harbour in feet.

B = breadth of harbour at place of observation in feet.

D = distance from mouth of harbour to place of observation in feet.

$$x = H \left\{ \frac{\sqrt{B\,b}}{B} - \frac{1}{50}\,\frac{B + \sqrt{B\,b}}{B}\,\sqrt[4]{D} \right\}$$

This formula I have found to give good approximations at several harbours where the heights of the waves were registered. When H is assumed as unity, x will represent the reductive power of the harbour.—I am, yours faithfully,

THOMAS STEVENSON.

Professor JAMESON.

SCIENTIFIC INTELLIGENCE.

GEOLOGY AND GEOGRAPHY.

1. *Extent of Glaciers in the Polar Regions.*—On every side of the southern pole, on every meridian of the great South Sea, the seaman meets icebergs. Not so in the north. In the 360° of longitude, which intersects the parallel of 70° north (about which parallel the coasts of America, Europe, and Asia, will be found to lie), icebergs are only found over an extent of some 50° of longitude, and this is immediately in and about Greenland and Baffin's Bay. In fact, for 1375 miles of longitude we have icebergs, and then for 7635 geographical miles none are met with. This interesting fact is, in my opinion, most cheering, and points strongly to the possibility that no extensive land exists about our northern pole,—a supposition which is borne out by the fact, that the vast ice-fields off Spitzbergen shew no symptoms of ever having been in contact with sand or gravel. Of course, the more firmly we can bring ourselves to believe in the existence of an ocean-road leading to Behring's Straits, the better heart

we shall feel in searching the various tortuous channels, and different islands with which, doubtless, Franklin's route has been beset. It was not, therefore, without deep interest that I passed the boundary which nature had set in the west to the existence of icebergs, and endeavoured to form a correct idea of the cause of such a phenomenon.—(*Osborne's Arctic Journal*, p. 94.)

2. *Faroe Islands.—Sir Walter C. Trevelyan to Professor Jameson*, —25*th February* 1853. My Dear Sir, As you have sometimes thought notices from the Faroe Islands of sufficient interest to insert in your Journal, I now send you an extract from a letter I lately received, which you may, perhaps, like to publish in your next Number.

"Faroe Islands,
24*th December* 1852.

"Turnips have been too little used here, but if the potato disease continues, and it has been worse this season, I am sure they will be more cultivated. As the potatoes failed, the inhabitants would have been badly off, but abundance 'of whales' (Delphinus Tursio) having been caught last season, in some way made up for the loss. More than 2000 whales were killed in different places. In one harbour (Westmanhavn) we take them in a large net, in which more than 300 have been caught at one time. The net is made of ropes, 200 fathoms long and ten fathoms deep, it is of sufficient strength, but the whales sometimes escape under it.

"From the year 1819 to 1843, there were killed in Westmanhavn not more than 280 whales, although many shoals of them visited the harbour every year, in some years more than 1000. From June 1, 1843, when the net was first used, up to this time, we have caught 2200 in Westmanhavn alone. Each whale being valued at an average to produce thirty gallons of oil, makes the value gained to be about £4000, besides the flesh, which furnishes abundance of wholesome food."

ZOOLOGY.

3. *Numerical List of Species of Animals.*—Of the number of distinct specific forms of animals at present existing upon the earth's surface, it is scarcely possible to form even an approximate estimate: since, although we may be probably not far wrong in our calculation of the number of existing species, in certain classes which have been especially studied (such as those of mammals and birds), and of which by far the greater part are certainly known to us; it is at least equally probable that our present acquaintance is limited (from various causes) to a very small proportion of other classes, whose total amount, therefore, we can do little more than guess at. The number of species of *mammals* known to naturalists is about 1700; and it is probable that scarcely 300 more remain to be discovered. Of

birds, about 8000 species are certainly known; and to these we may perhaps add 4000 for those not yet discovered, or not yet clearly distinguished. Of *reptiles*, about 1200 species are known; but it is probable that the proportion not yet discovered is larger, and that for this we should add at least 800 species. Of fishes about 8000 species are known; and to these, also, numerous additions may be expected, probably at least 4000 species. Thus of vertebrated animals alone, nearly 19,000 species are known, and 9000 more are probably in existence. The number of *mollusks* has been hitherto reckoned chiefly by that of the *shells* contained in collections, no account being taken of any but the testaceous species. Of these about 15,000 species have been collected; and probably at least as many more yet unknown to the conchologist. But the number of "naked" or shell-less mollusks is undoubtedly extremely large; and of these it is probable that only a small proportion are yet known.* The class of insects far outnumbers all the preceding, both as to number of species already known, and still more as to the number of whose existence we have presumptive evidence. It is certain that at least 150,000 species are at present to be found in collections; and that these do not by any means include the total number existing even in the countries whose entomology has been best explored. So little, in fact, is this the case, that if anything like the same proportion holds good elsewhere between flowering plants and insects, as obtains in our own country (namely at least ten species of insects to every species of flowering plant), we should have to estimate the total number of existing species of insects at little less than *two millions*. In regard to none of the inferior classes, have we at present adequate means of forming any estimate whatever.—(*Carpenter's Principles of General and Comparative Physiology*, p. 239.)

4. *Dr Hamilton on the Guano Birds of the Lobos Islands.*—Along the sea-coast of Peru and Bolivia, within the tropic of Capricorn, countless numbers of aquatic fowls exist which live on fish, and whose excretions are exceedingly fertilizing. In some localities, the number of guanas is enormous, so that when alarmed by discharges of fire-arms, or otherwise, they rise from their resting-places in such masses as cannot be supposed by those who have never seen these birds darkening the air like a cloud. Guano producers change their habitation when continuously disturbed, but they do not permanently leave a locality which has long been frequented by them in consequence of a temporary alarm; for, in such a case, they soon return to their old haunts, and totally abandon them only when teased by

* Thus, of the tribe of Nudibranchiate Gasteropods, only about a dozen species were formerly known as inhabiting the coast of Britain; but in the beautiful monograph of Messrs Alder and Hancock (in course of publication by the Ray Society), more than a hundred species will be described.

lasting annoyances. The ocean on the west coast of South America, within the tropics, teems with fish, the quantity seeming exhaustless, and guanas equally abound, so that their egesta is gradually accumulating somewhere either on or off that desert land, and now has become an object sought after, not only by the Peruvian mountaineer, but by the merchant, shipowner, and statesman.

5. *The Cod Fish of the Whale Fish Islands.*—" We are preparing," says Mr Snow, in his Journal in the Arctic Seas, " in calling at Whale Fish Islands, at which place it was hoped we should be on the following day, if the wind continued the same.

" Our dinner this day was greatly impoved by some *cod fish* that had been caught in the morning, before the wind sprung up. It was excellent eating, and I believe the fish is considered of sufficient worth and goodness to have a few vessels from Scotland employed in catching and importing them. There is one particular place on this coast where they are said to be very numerous, and some small ships have made it an excellent trade."—(*Mr W. Parker Snow's Journal in the Arctic Seas*, p. 60.)

6. *Electricity applied to the capture of Whales.*—The most prominent features of this new method are thus described :—Every whale at the moment of being struck by the harpoon is rendered powerless, as by a stroke of lightning ; and, therefore, his subsequent escape or loss, except by sinking, is wholly impracticable, and the process of lancing and securing him is entirely unattended with danger. The arduous labour involved in a long chase in the capture of a whale is superseded, and, consequently, the inconvenience and danger of the boats losing sight of or becoming separated from the ship is avoided. One or two boats only would be required to be lowered at a time, and therefore a less number both of officers and seamen than heretofore employed would be ample for the purpose of the voyage. The electricity is conveyed to the body of the whale from an electro-galvanic battery contained in the boat, by means of a metallic wire attached to the harpoon, and so arranged as to reconduct the electric current from the whale through the sea to the machine. The machine itself is simple and compact in construction, enclosed in a strong chest weighing about 360 lb., and occupying a space in the boat of about $3\frac{1}{2}$ feet long, by 2 feet in width, and the same in height. It is capable of throwing into the body of the whale eight tremendous strokes of electricity in a second, or 950 strokes in a minute, paralysing, in an instant, the muscles of the whale, and depriving it of all power of motion, if not actually of life.—(*Year Book of Facts*, p. 141.)

7. *Preservation of Eggs.*—Eggs immersed while fresh in milk of lime will keep in it for years, doubtless because the carbonate of lime formed by the carbonic acid, evolved from the egg, completely stops up the pores of the shell. On pulling down a sacristy in the

neighbourhood of *Lago Maggiore*, eggs were found quite fresh, after having been surrounded with mortar and enclosed in a wall for 300 years.—(*Hand-Book of Chemistry*, vol. vii. *of the Cavendish Society*, p. 116.)

BOTANY.

8. *The Genus Nostoc.*—Dr Joseph Hooker has read to the Linnæan Society a paper on the genus *Nostoc* of botanists, more especially on a species brought by Dr Sutherland from the North Pole, during the late expedition in search of Sir John Franklin, under Captain Penny. The plant was found in great abundance in the ocean, and resembled the *Nostoc commune* of botanists. It was in sufficient quantities to be used as diet; and Dr Sutherland having eaten some of it, pronounced it more agreeable and nutritious than the *Tripe de Roche*. Specimens of this plant had been sent to Mr Berkeley; and, from certain points in structure, he considered it a new plant, and referred it provisionally to the genus Hormosiphon, under the name of *H. arcticus*. Dr Hooker also gave an account of a species of *Nostoc* which he had discovered in Thibet, and of another in China, which seemed identical with the one brought from the North Pole. The *Tripe de Roche* has lately been found in West Canada.—(*Year Book of Facts*, 1853, p. 223.)

9. *Preservation of Vegetables.*—A cask provided with a door is three-fourths filled with sorrel, lettuce, endive, chicory (even if rancid), or asparagus; and a piece of rag steeped in sulphur, and attached to the end of a wire, is set on fire and introduced through the door, the contamination of the vegetables, by the falling down of the burnt matter, being prevented by laying a board upon them; the door is then closed, and the cask agitated to accelerate the absorption of the sulphurous acid. The sulphuring is twice more performed in the same manner, and the vegetables, together with the liquid which has oozed from them, are put into stoneware jars, which are then merely tied round with parchment and put into a cellar. Vegetables thus treated keep well till the April of the following year. They do not, however, soften so quickly in water as fresh vegetables, and must therefore, before boiling, be soaked in cold water for some hours (asparagus in April for twenty-four hours). During the boiling, which generally does not last longer than with fresh vegetables, the sulphurous acid is given off. This method is applicable only to tender vegetables, which easily soften in boiling. —(*Leopold Gmelin's Hand-Book of Chemistry*, vol. iii. *of the Cavendish Society*, p. 116.)

By the Patent Law Amendment Act of 1852 (15 *and* 16 *Vict., cap.* 83), *it was provided, that Transcripts of all Patents should be transmitted to the Office of Director of Chancery in Scotland to be recorded, where they would be open to the inspection of the Public ; but that provision has never been complied with. And it is believed that there is a Bill now introduced into the House of Lords for the repeal of such a provision.*

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BRITISH MUSEUM NATURAL HISTORY

ERRATA IN VOL. LI

Page 84, throughout the article on Self-Registering Thermometer, *for* Sikes' *read* Six's

EDINBURGH:
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