The late Dr. Miller spoke as follows on the occasion above referred to:—"Gentlemen," he observed, "representing great branches of science, like the Astronomer Royal, were met by the Government with liberality; and scientific bodies, such as the Royal Society, when they made an application, after careful consideration of the objects they had in view, were also listened to with respect, and, in the majority of instances, their applications were granted. It appeared, therefore, that the great difficulty on the part of the Government was to be sure that what they expended was wisely laid out."

Dr. Miller, as Treasurer of the Royal Society, spoke with authority; he shared with the Astronomer Royal the error of imputing to Government a liberality towards science utterly inconsistent with that true economy for which they have, in so many other matters, earned high renown.

The whole transaction, considered as the latest notion in civilisation, is so ludicrous that it is difficult in speaking of it to do so seriously. It may be argued that Mr. Airy and Dr. Miller were perfectly correct in their picture of former Governments, but that our present Ministry act on different principles, and refuse to promote what their predecessors would have thought worthy objects. This hypothesis is so extremely disparaging to the Ministers of to-day, that I for one cannot adopt it. When the speeches I have cited were made I offered no reply, but I was far from assenting to the estimates of Government liberality to science in England given by Mr. Airy and Dr. Miller. I do not now for the first time say that, not only have English Governments, past and present, been backward in promoting science, but that no English Government has ever shown that it understood the value of science—how it should be promoted, or what were their duties respecting it. This inability to realise the requirements of Science is not confined to Governments—it largely pervades the most intelligent portion of the community—the whole governing class. For one man of high position and culture who comprehends the mode of advancing science, and the certain effects of advancing it, there are, not hundreds, but thousands, who have clear views regarding art, literature, and general education. Every man of wealth covers his walls with pictures and books, but how many equip a laboratory or an observatory? The knowledge of science which most educated men possess has been acquired by reading only, and their notions of what is needed to advance science, of the extent of field remaining still unoccupied, of the means requisite for cultivating it, and of the value of the produce, are, we find from every-day experience, exceedingly hazy.

The true explanation of the difference between the distinguished speakers and those who think with me I believe to be this—that the demands made upon the State by scientific men and bodies have hitherto been so moderate, so desultory, and so infrequent, that few of them could, with decency, be denied by men not utter barbarians. I am of opinion that the moderation of scientific men has been exceedingly detrimental to the nation, and utterly opposed to true economy. For it has led to the waste of the two most valuable gifts of Providence—the human intellect and the forces of nature. This moderation has encouraged the comfortable creed of English statesmen that private enterprise will do all that is needful, and that the utilisation of those two gifts forms no part of their national duties. But suddenly those who have suffered Government to hug itself in its inaction, and live in a fool's paradise of indifference to duties which they do not understand, are startled by their own teachings recoiling on themselves in a rebuff unequalled for its narrow-mindedness since the time of Galileo.

But a new school of scientific men is now astir, and this rebuff will quicken its energies and so do good. A Royal Commission on Science now sits, and at such a tribunal this wrong to Astronomy must be heard and judged. Let us hope that when next the sun is eclipsed, the darkness on the minds of men may not equal the darkness on the earth's face.

ALEX. STRANGE, Lieut.-Col.

The Geological Bearings of Recent Deep-Sea Explorations

YOUR report of the Proceedings of the Geological Section of the British Association (No. 51, p. 503) makes Sir Roderick Murchison say that "he hoped Mr. Jeffreys did not share the opinion of his colleague Dr. Carpenter, that their discoveries tended to upset modern geology." I have the authority of Sir Roderick to state, that he did not accuse me of any such absurdity; and that I

should find what he did say on that occasion, in dissent from some of the views put forth by Prof. Wyville Thomson and myself, fully expressed in his introductory address, of which he has given me a copy. As, however, he there attributes to a passage in a lecture which I delivered eighteen months since at the Royal Institution, a sense which I never meant it to convey, I shall be obliged by your allowing me to give a precise explanation of my meaning.

The passage cited by Sir Roderick is as follows:—"The facts I have now brought before you, still more the speculations which I have ventured to connect with them, may seem to unsettle much that has been generally accredited in Geological Science; and thus to diminish rather than to augment our stock of positive knowledge; but this is the necessary result of the introduction of a new idea into any department of scientific inquiry."

Now I gave not the remotest hint of impugning those great doctrines of Stratigraphical and Palæontological succession, to which Sir Roderick refers as accepted by Uniformitarians, Catastrophists, and Evolutionists alike; my chief heresy being the indorsement of the doctrine of which my colleague, Prof. Wyville Thomson (himself a sound and accomplished Geologist), was the originator, "that we may be said to be still living in the Cretaceous Epoch." Our meaning was this:—There can now be no question that a formation, corresponding with the Chalk of the Cretaceous Epoch, alike in its material, and in the general character of its Fauna, is at present going on over a large part of the North Atlantic Sea-bed. This similarity is marked, not by the occurrence of a few types of life (like the Lingulæ and Terebratulidæ of the older formations, referred to by Sir Roderick Murchison), but by the persistence of those which constitute the formation itself, viz., the Globigerinæ, the Cocoliths and the Cocospheres; as also of numerous types of Echinodermata that were formerly considered as essentially Cretaceous, and of a great variety of those Sponges (including Xanthidia), and Foraminifera, whose abundance in the White Chalk is one of its most important features. The explorations carried on by the United States Coast Survey in the Gulf of Mexico have furnished results entirely coinciding with our own in many of these particulars.

Now it is, of course, quite open to any geologist to maintain that this Formation is a mere repetition of the Cretaceous, at a later date, under generally similar conditions. Such was, I presume, the idea of those who, several years before our researches began, had pointed out the conformity of the material of the Atlantic deposit with that of the old Chalk; and such had been my own belief, until Prof. Wyville Thomson suggested to me the probability of a continuity between the past and the present deposits, on the following ground:—The oscillations of the earth's crust, in the Northern part of the Northern Hemisphere,* during the whole Tertiary period, have not been shown anywhere to exceed 1,500, or at the most 1,800 feet, or 300 fathoms; and as the general depth of the North Atlantic Sea-bed ranges from twice to ten times that amount, there is no reason to suppose that the formation and accumulation of Globigerina-mud have been interrupted in any part of its duration. Now the termination of the Cretaceous Epoch is commonly regarded as having been marked by the elevation of the Cretaceous deposits of the European area into dry land; but there is no evidence that this change of level stopped the formation of Chalk in the deep sea elsewhere. On the contrary, according to the received doctrine of Geology, it is highly probable that coincidently with the elevation of the European area, there was a gradual subsidence of what is now the North Atlantic Sea-bed; so that the Globigerinæ and Cocoliths of the former area, with such accompanying types of animal life as could accommodate themselves to the change of conditions, would progressively spread themselves over the latter.

Now there is nothing more heterodox in this view than in M. Barrande's doctrine of "colonies," which is now, I believe, universally accepted as the explanation of a large and very important series of geological facts—the persistence, in certain outlying localities, of a Fauna characteristic of a formation stratigraphically inferior to that in which it presents itself. The only difference here is in the relative extent of the existing Cretaceous deposit in the North Atlantic, which may hold to that of Europe somewhat the relation that the English-speaking race which has colonised America does to that of the mother country, instead of

* This statement has been recently met by our friend Mr. J. Gwyn Jeffreys, who adverts to the well-known fact of the elevation of Tertiary strata in the South of Europe to 11,000 feet. But there is no evidence, so far as we know, of any such elevation in the latitude of Great Britain, or north of it.

that which the Norse-speaking Icelanders hold to the modern Scandinavians.

If the facts be as I have now stated them, the *onus probandi* seems to me to lie upon those who affirm that a complete stop was put to the formation of Chalk before the commencement of the Tertiary period. If, on the other hand, the continuity of the existing Chalk-deposit with that which formed the Chalk of Dover Cliffs be admitted, the question, whether we can be rightly said to be "still living in the Cretaceous Epoch" seems to me one of terms rather than of essentials.

That we could not expect to find the Cretaceous Fauna as a whole in our modern Chalk, is evident from the considerations admirably set forth in a parallel case by the President of the Linnean Society, in his last Annual Address.

The difference is undoubtedly most marked in the *Mollusca*; only one shell, the *Terebratulula caput-serpentis*, having at present been shown to be common to the Cretaceous and the Modern period. But the positive evidence of continuity afforded by the persistency of all the types which make the chalk, as well as of numerous forms of Echinoderms, Sponges, and Foraminifera which are among its characteristic inhabitants, appears to us to outweigh the negative evidence afforded by the larger amount of change that has taken place in the Molluscan Fauna, for which it would not be difficult to assign probable reasons.

Further, it is to be borne in mind that the successive beds of the Cretaceous formation differ from each other in a very marked manner; so that we could not expect to find, in any one deposit, more than a small part of that *ensemble* which is commonly spoken of as "the Cretaceous Fauna." What we mean by the expression to which Sir Roderick Murchison has taken exception, is simply that the facts and deductions we have brought together justify the assumption of the continuous prevalence of the same general Physical and Biological conditions, in the deep sea that separates the northern parts of the European and American continents, from the time when the Chalk of those continents was raised into dry land to the present date. This is perfectly compatible with those changes in the conditions of the shallower portions, which have given origin to the long succession of Tertiary deposits.

Passing from this topic, I now proceed to other points on which the researches of Prof. Wyville Thomson and myself appear to us to invalidate Geological doctrines that have gained general currency.

Up to the commencement of the recent exploration of the Deep Sea bottom by means of the Dredge, the doctrine propounded by Prof. Edward Forbes as to the limitation of Animal Life to a depth of 300 or 400 fathoms, and the consequently *asotic* character of all deposits formed at depths exceeding that amount, was generally accepted by Geologists; partly on account of the deservedly high authority of its originator, and partly because it appeared to afford a simple explanation of phenomena which had long perplexed Geologists and Palæontologists, viz., the occurrence at various epochs of vast accumulations of sedimentary strata apparently altogether devoid of organic remains. The indications obtained by the Sounding apparatus, of the existence, not merely of humble Foraminifera, but of Annelids, Echinoderms and Crustacea, at depths far exceeding Edward Forbes's limits, were not generally accepted, either by Zoologists or Palæontologists, as indicating the presence of a varied and abundant Fauna on the ocean bottom; for although Dr. Wallich, with a sagacity to which I have uniformly endeavoured to do full justice, had argued that they should be, it was specially noticed that these researches gave no evidence of the existence, at great depths, either of Mollusks or of Zoophytes—the two groups whose fossil remains are usually of the highest Palæontological significance.

Now the Dredgings which were carried down in the *Lightning* Expedition of 1869 to 650 fathoms, and in the *Porcupine* Expedition of 1869 to 2,435 fathoms, have established beyond all reasonable question that a varied and abundant Fauna may exist on the sea-bottom without any limit as to *depth* and *pressure*; and they have further rendered it probable that, putting aside those Animals which are necessarily restricted by the nature of their food to the depth to which living Vegetation extends, a large proportion may accommodate themselves by gradual modification to any amount of *change* in depth and pressure; so that the assumption that the occurrence of particular types is significant of the depth at which a formation was deposited, can no longer be upheld, except in the case of animals essentially littoral. For example, no doctrine has been more generally accepted than that of the limitation of the Pedunculate Crinoids to compara-

tively shallow water; the large West Indian representatives of that group being found growing on coral reefs, and a like *habitat* having obviously been peopled by them in the Carboniferous epoch. Yet, in the *Porcupine* dredgings of the present year, a large Pentacrinus, closely allied to the West Indian species, has been obtained near the coast of Portugal from a depth of about 800 fathoms; and the little Rhizocrinus, with another small Apiocrinoid, which I hope soon to describe under the name of Wyvillocrinus, were found last year, the former at 862 fathoms, the latter at 2,435.

Further, the *Lightning* and the *Porcupine* dredgings have fully established the position that the distribution of marine life is much more closely related to the *temperature* of the ocean-bottom, than to its depth. This is most clearly evidenced by the results of the careful exploration of the Channel of from 500 to 650 fathoms depth, which separates the plateau that supports the northern extremity of Scotland from the Faroe Banks. For we have shown that, whilst the *surface*-temperature of this Channel is everywhere nearly the same, and indicates a derivation of its upper stratum from a warmer source, a considerable part of the deeper portion of this Channel is covered by a *frigid stream*, bringing a temperature as low as 29.5° from the Arctic Ocean; this stream having in some places a depth of 2,000 feet. Thus the bottom of this Channel is divided into a *warm area*, on which the bottom-temperature at depths of from 500 to 600 fathoms is about 45°, and a *cold area* on which the bottom-temperature at like depths is 30°, or even lower. We have traced these two areas at corresponding depths within about twenty miles of each other; and where the bottom was unequal,—the slope of the plateau at the edge of the cold area, or of a bank in its midst, raising its bottom out of the *cold* stream into the *warm* which overlies it—a difference of 18.5° was found within *eight miles*. No contrast could well be more striking than that which presented itself between the Faunæ of these two areas. The Globigerina-mud was rigorously limited to the *warm*; and of the animals living on its surface a large proportion were characteristic of the warmer-temperate seas. The bottom of the *cold* area consisted of sand and stones; and of the animals which were abundantly distributed over it, a large proportion were essentially Boreal. In the shallower portions of the cold area, where an intermediate bottom temperature prevailed, an intermixture of the two Faunæ, corresponding with the border position of this area between the Temperate and the Boreal provinces, was readily traceable.

Here, then, we have the remarkable fact that two deposits may be taking place within a few miles of each other, at the same depth and on the same Geological horizon (the area of one penetrating, so to speak, the area of the other), of which not only the Mineral character but the Fauna are alike different;—that difference being due on the one hand to the direction of the current which has furnished their materials, and on the other to the temperature of the water brought by that current. If the *cold* area were to be raised above the surface, so that the deposit at present in progress upon its bottom should become the subject of examination, by some Geologist of the future, he would find this to consist of a Sandstone formed by the disintegration of older rocks, the Fauna of which would in great degree bear a Boreal character: whilst if a portion of the *warm* area were elevated at the same time, the Geologist would be perplexed by the stratigraphical continuity with the preceding of a Cretaceous formation, the production of which entirely depends upon the extensive development of the humblest forms of animal life under the influence of a higher temperature, and which includes not only an extraordinary abundance of Sponges, but a great variety of other animal remains, several of them belonging to the warmer-temperate regions. He would naturally suppose these widely different climatic conditions to have prevailed at different periods, and would probably have had recourse to the hypothesis of a "fault" to account for the phenomenon. And yet these Formations have been shown to be going on together, at corresponding depths, over wide contiguous areas of the sea-bottom; in virtue solely of the fact that one area is traversed by an Equatorial, and the other by a Polar current. Further, in the midst of the land formed by the elevation of the Cold area, our Geologist would find hills some 1,800 feet high, covered with a Sandstone continuous with that of the land from which they rise, but rich in remains of animals belonging to a more temperate province; and might easily fall into the mistake of supposing that two such different Faunæ occurring at different levels must indicate two distinct climates separated in time; instead of indicating, as they

have been shown to do, two contemporaneous but dissimilar climates, separated only by a few miles horizontally and by 300 fathoms vertically.

But further: the Temperature-soundings taken in the *Porcupine* Expeditions of 1869 and 1870 have conclusively shown that a temperature as low as $36^{\circ}5'$ prevails over the deeper parts of the North Atlantic sea-bed; this reduction being due to the pervasion of Arctic and Antarctic waters, which come to replace the superficial flow of Equatorial water (as in the Gulf Stream and other currents) towards the Polar areas. In conformity with this depression of temperature, many species of Mollusca, Crustacea, and Echinodermata, formerly supposed to be purely Arctic, have been found to range southwards in deep water as far as the Straits of Gibraltar; and we have shown it to be highly probable that an extension of the same mode of exploration would bring them up from the abysses of even intertropical seas, over which a similar climate prevails, and that an actual continuity may thus be found to exist between the Arctic and the Antarctic Fauna. This idea was well put forth some years since by our excellent friend Prof. Lovén, of Stockholm, in his discussion of the results of the deep-sea dredgings executed by the Swedish Spitzbergen Expedition of 1861, under Torell. "Considering," he says, "the power of endurance in these lower marine animals, and recollecting the facts, that properly Arctic species which live also on the coast of Europe, are generally found there at greater depths than in their proper home, and that certain Antarctic species very closely agree with Arctic species, the idea occurs that, while in our own seas and those of warm climates, the surface, the coast line, and the lesser depths are peopled with a rich and varied Fauna, there exists in the great Atlantic depression, perhaps in all the abysses of our globe, and continued from Pole to Pole, a Fauna of the same general character, thriving under severe conditions, and approaching the surface where none but such exist in the coldest seas."

But whilst the question of Deep-sea Temperature is one of the greatest Biological interest, its determination is of even greater importance to the Geologist, as affecting his interpretation of the phenomena on which his belief in a former general prevalence of a Glacial climate is founded. For if a Glacial temperature should be found now to prevail, and types of Animal life conformable thereto should prove to be diffused, over the deeper portion of the *existing* Sea-bed in all parts of the globe, it is obvious that the same may have been the case at *any* Geological epoch; for there must have been deep seas in all periods, and the Physical forces which maintain the oceanic circulation at the present time must have been always in operation, though modified in their local action by the distribution of land and water existing at any particular date. And as the elevation of the present deep-sea bed of even the Intertropical oceanic area would (if we have correctly interpreted the results of our own and others' observations) offer to the study of the Geologist of the future a deposit characterised by the presence of Polar types, so must the Geologist of the present hesitate in regarding the occurrence of Boreal types in any marine deposit as adequate evidence *per se* of the general extension of Glacial action into temperate or tropical regions. At any rate, it may be considered as having been now placed beyond reasonable doubt, that a Glacial Submarine climate may prevail over any area, without having any relation whatever to the Terrestrial climate of that area.

These views are offered by us with the more confidence, since they are in harmony with the deductions already drawn by Geologists of eminence from facts observed by them. Thus I find on my return from the Mediterranean a letter from Principal Dawson, of Montreal, from which I am sure he would permit me to make public the following extract:—

"... In reading your recent interesting publications on the Life of the Deep Sea, it occurred to me to mention to you that the fact which you have proved on the European coast, as to the existence and action of cold Arctic currents on the bottom of the ocean, was affirmed by me years ago for the American coast, on geological and geographical evidence, and was applied to the explanation of the Post-pliocene climate. On the American coast we have the cold currents in shallower water than you have now; though in the Post-pliocene you had them in shallow water also. It is true that the Glacial theories of Agassiz and others have prevented the proper amount of attention to these facts; but I have insisted on them again and again, and fully believe that the varying distribution of the cold and warm currents, depending on the elevation and depression of the

sea bottom, will account for most of the differences of climate indicated by fossils and boulders from the Laurentian to the Modern period. I have some new and unpublished facts on this subject, which I intend to bring out in connection with the work I am now doing with the help of your brother, in the Post-pliocene geology of Canada."

In conclusion, I venture to anticipate that the words with which I concluded my lecture at the Royal Institution, "On the Results obtained in the *Lightning* Expedition of 1868," will be found to have been fully justified by those of the "*Porcupine* Expeditions" of 1869 and 1870; and that whatever may be thought of the notion that "we are still living in the Cretaceous epoch," we have furnished adequate proof that the formation of Glacial beds was not limited to any special Geological period, but that they are now, and have been through all time, in course of deposition:—"The facts I have now brought before you, still more the speculations which I have ventured to connect with them, may seem to unsettle much that has been generally accredited in Geological Science, and thus to diminish rather than to augment our stock of positive knowledge; but this is the necessary result of the introduction of a new idea into any department of scientific inquiry. Like the flood which tests the security of every foundation that stands in the way of its onward rush, overthrowing the house built only on the sand, but leaving unharmed the edifice which rests secure on the solid rock, so does a new method of research, a new series of facts, or a new application of facts previously known, come to bear with impetuous force on a whole fabric of doctrine, and subject it to an undermining power which nothing can resist, save that which rests on the solid rock of Truth. And it is here that the Moral value of Scientific study, pursued in a spirit worthy of its elevated aims, pre-eminently shows itself. For, as was grandly said by Schiller in his admirable contrast between the Trader in Science and the true Philosopher, 'New discoveries in the field of his activity which depress the one, enrapture the other. Perhaps they fill a chasm which the growth of his ideas had rendered more wide and unseemly; or they place the last stone, the only one wanting, to the completion of the structure of his ideas. But even should they shiver it into ruins, should a new series of ideas, a new aspect of nature, a newly-discovered law in the physical world, overthrow the whole fabric of his knowledge, *he has always loved truth better than his system*, and gladly will he exchange her old and defective form for a new and fairer one.'"

WILLIAM B. CARPENTER

On a Method of Ascertaining the Rate of Ascent of Fluid in Plants

WHEN conducting a series of physiological experiments on the transpiration of fluid by leaves, it became a matter of importance to determine the rapidity of ascent of fluid. My colleague, Prof. Church, had suggested for another series of experiments the use of lithium citrate, a salt easily taken up by plants, and one which can be detected with the greatest readiness by means of the spectroscope. Preference was given to the citrate, because of its containing an organic acid, and on this account not likely to meet with any obstruction to its passage from the tissues. This method I have used with great success. In one experiment the fluid had risen nine inches in thirty minutes, in another five and a half inches in ten minutes. This method is greatly superior to the use of colouring matters, which seem to experience considerable resistance in their passage through the vessels. Full particulars of these and numerous other experiments in the same direction will shortly be published. W. R. M'NAB, M.D.

Royal Agricultural College, Cirencester, Oct. 20

The Aurora Borealis

HAVING read the two accounts of Aurora Borealis in this week's number of NATURE, I hope the following brief account of the very beautiful one that occurred here may not prove uninteresting. On Friday, the 14th Oct. at 8.15 p.m., I noticed a bright appearance towards the north-west, somewhat resembling the moon rising, and on going to the front of the house which faced the north, saw that the whole of the horizon from west to south-east was lit up with a bluish white light. Gradually long streaks of the same colour stretched themselves up almost to the zenith, and then a blood-coloured light formed the higher portions, while the lower kept the bluish white colour already noticed.