THURSDAY, MAY 22, 1884

VESTIGES OF CREATION

Vestiges of Creation. By Robert Chambers, LL.D. Twelfth Edition, with an Introduction relating to the Authorship of the Work, by Alexander Ireland. (London: W. and R. Chambers, 1884.)

ALTHOUGH the authorship of this interesting book has been for some time a somewhat open secret, the public avowal of it is to be welcomed for more reasons than one. The mystery which for so long a time has been allowed to hang over the subject was itself a mystery to explain. For any one reading the "Vestiges" could scarcely suppose that the free-minded, open-hearted, and fearless, truth-seeking spirit which looks out upon us in every page could be deterred by any motives of a petty or puerile kind from fixing the stamp of his name upon his work—at any rate in some of the later of the numerous editions through which the book passed. This mystery is now explained. In his brief introduction to this, the twelfth, edition, Mr. Ireland gives us the whole history of the matter. It seems that Mr. Chambers desired to conceal the authorship in the first instance for a variety of reasons, all of which were laudable. The chief among these was that "he was his brother's partner in a publishing business in which the rule had been laid down from the beginning of their co-partnery to avoid as far as possible, in their publications, mixing themselves up with debatable questions in politics and theology." After the author's death this brother continued to put his veto upon any declaration of the authorship, and so the secret was held close. About this time last year, however, Dr. William Chambers died, and left Mr. Ireland, as he says, "the sole surviving possessor of the secret." Previous to his death William Chambers expressed a wish that the secret should never be divulged; but as Robert Chambers had left the matter to the discretion of Mr. Ireland, this gentleman very properly undertook to keep the secret during the lifetime of the surviving relative, but refused to promise that he would do so in the event of his being left its sole repository. It is, therefore, to his sagacity and good feeling that the public are now indebted for the final clearing away of all the cobwebs which have been allowed to grow around this matter.

Of course the interest of the book itself is now purely historical. But if we were asked to indicate what is the feature which most strikes us on reading it from end to end, we should say, its power of clear and logical reasoning. The author is obviously a literary man, as distinguished from a man of science. But he is a literary man who is diligent in getting up his facts after the manner of a barrister preparing a case. He does not wait to examine his facts, provided that they make a decent show of probability, and produce a striking effect in his argument. As a consequence, even in this expurgated edition, we meet with a number of gravely erroneous statements. But the point to which we desire to draw attention is this. Although the writer every now and then admits erroneous statements of fact on insufficient evidence, and although as a consequence he every now and then runs after some will-o'-the-wisp hypothesis, he never loses his logical balance; but, after his chase is over, he returns to his main argument as little out of breath as when he started. This, we think, is no small praise. If Chambers constructs his argument barrister-wise, he does so merely for the sake of presenting to judgment everything that has any appearance of being a fact; and on the whole he exercises a wise discretion in his estimate of the comparative value of the facts as proved or unproved.

The interest attaching to this remarkable work being now purely historical, it is impossible to avoid contrasting it with the still more remarkable work by which it was so soon to be eclipsed. When we do so, we have brought home to us more forcibly than ever by how enormous an interval the mind of Mr. Darwin was separated from all contemporary thought on the origin of species. It is not merely that he happened to have shed upon the whole subject the new light which arose with the great conception of survival of the fittest. Indeed, while reading some of Chambers' broadly-stated and yet closely-reasoned views upon "the fecundity of nature ordaining that her creatures shall ever be pressing upon the verge of the local means of subsistence"; the consequent tendency of individuals to overflow into other areas, "thus exposing themselves to new influences"; the opportunity that is thus afforded to any variety happening to arise on the newly colonised area, and happening also to be adapted to these new conditions, to perpetuate itself by heredity (pp. 226-27);—when we read such passages, we are led to wonder that, having gone all round the hypothesis of natural selection, Chambers should not have gone through it. But where we find the immense contrast between him and Darwin is in the different manner wherewith they have treated even the same lines of evidence concerning the *fact*, as distinguished from the *method*, of evolution. If we compare the chapters on geological and geographical distribution, on the mental constitution of animals, &c., with the corresponding chapters in the "Origin of Species" and "Descent of Man," we are led to marvel, perhaps more than we have ever marvelled, at the gigantic grip of Mr. Darwin's mind. It is not merely that he had incomparably larger stores of facts to draw upon, that he was a man of science as distinguished from a man of letters, and so forth. It is rather that he was head and shoulders above everybody else in sheer mass and force of thought. We have now become so accustomed to walk easily through the jungles where he, like an elephant, has opened the way, that it is difficult for the younger generation to realise the state of matters before the elephant appeared. But in the "Vestiges of Creation" we have the vestiges of these former things. We here see a man of very unusual strength as a writer, with no small diligence in accumulating evidence, and well equipped with the implements of logical method; we see him fighting manfully with all his might to cut his way in the direction where he is profoundly convinced that the truth must lie; and yet we see that he is overwhelmed with the immensity of his task. His work is now well worth surveying, if only to make us realise the nature of the difficulties with which at that same time his great successor was contending.

But, leaving now this unavoidable comparison aside, we shall give a few quotations from the book, in order to show at once the tone of thinking which more or less pervades the whole, and the pleasing style in which it is conveyed.

"There are some considerations on the very threshold of the question which appear to throw the balance of likelihood strongly on the side of natural causes, however difficult it may be to say what these causes were. The production of the organic world is, we see, mixed up with the production of the physical. It is mixed in the sense of actual connection and dependence, and it is mixed in regard to time, for the one class of phenomena commenced whenever the other had arrived at a point which favoured or admitted of it; life, as it were, *pressed in* as soon as there were suitable conditions, and, once it had commenced, the two classes of phenomena went on, hand in hand, together. It is surely very unlikely, *a priori*, that in two classes of phenomena, to all appearance perfectly coordinate, and for certain intimately connected, there should have been *two totally distinct modes of the exercise of the divine power*," &c. (p. 148).

"There is certainly no express reason to suppose that, although life had been imparted by natural means after the first cooling of the surface to a suitable temperature, it would have continued thereafter to be capable of being imparted in like manner. . . . We are rather to expect that the vital phenomena presented to our eye should mainly, if not entirely, be limited to a regular and unvarying succession of races by the ordinary means of generation. This, however, is no more an argument against a time when phenomena of the first kind prevailed, than it would be proof against the fact of a mature man having once been a growing youth that he is now seen growing no longer" (p. 168).

Notwithstanding this, however, the writer immediately begins coquetting with a number of very seductive facts and considerations in favour of spontaneous—or, as he more correctly terms it, "non-parental generation." In particular he lays great stress upon the "Crossian experiment" of producing acari by the action of a voltaic battery on a solution of silicate of potash. And here we have a very good special illustration of the difference between Chambers and Darwin. The former, as a literary man, states the experiments, weighs the evidence which they yield, and, without actually accepting the fact as proved, is on the whole strongly disposed to believe it. The latter, as a man of science, would have spent a lifetime in verifying so all-important a fact, even if the evidence of it had appeared to him of but a tenth part of the weight that it appeared to Chambers. Here, however, it is but fair to Chambers, as a literary man, to say that he does not in this place, or anywhere else, attach more than its due value to the evidence of any alleged fact. He merely gives the evidence for what it may be worth, and then passes on. Therefore he is careful to make it clear that whether or not all the considerations which he adduces in favour of "non-parental generation" are valid, the question of its actual occurrence is really a side issue, and does not affect the course of his general argument in favour of the evolution of species by way of "parental generation." This clearness of logical view is further and particularly well displayed in his consideration of Lamarck's theory touching the causes of the evolution of species: although Chambers is exceedingly anxious to find these causes, so that it might "appear as if the clouds were beginning to give way, and the light of simple, unpretending truth were about to break upon the great mystery," yet he critically puts his finger upon the weak points of the theory in question, and ends by dismissing it as inadequate to explain the facts (p. 233 *et seq.*).

One other quotation may be given as an example of the general common sense which the writer every now and then pours out, like a viscid secretion, wherewith to entangle and render helpless his opponents.

"It may be well to mark the credulity to which the adherents of immutability must here be reduced. They must believe that the Creator, having a particular regard to the fact of molluscan shells lying useless on the shore, formed, by special care or fiat, a family of crabs to occupy them. They must believe that the roughness of the caudal appendages, the development of suckers along the abdomen, the reduction of the two hind pairs of limbs, and the left pincer-claw, were all subjects for this special care, and were beyond the power of what an eminent geologist calls 'vulgar nature.' Surely the *Deus ex machinâ* was never more remarkably exemplified. See, on the other hand, how these facts are accounted for on the development theory. According to this new light, the hermit-crabs are simply a portion of some greater section of the crustacean class. Their peculiarities are modifications from the parent form, brought about in the course of generations, in consequence of an appetency which had led these creatures to seek a kind of shelter in turbinate shells" (p. 54).

It only remains to say that this, the no doubt final edition of the "Vestiges of Creation," is very prettily got up, and leaves nothing to be desired as to printing, &c. We feel, however, that it would have been well worth while to have had the reprint edited by some competent naturalist, who might have inserted footnotes to warn the general reader against the numerous pitfalls which are to be encountered on matters of fact. As it is, the general reader cannot possibly know what he is to accept as scientifically-established truth, and what he is to reject as superseded error. This we think is a pity in the interests of the book itself, because during its author's lifetime the successive editions were successively brought up to date in the matter of keeping pace with the progress of science. Lastly, in the appendix, written by the author himself in reply to criticisms, we must not fail to note the magnanimous temper, dignified style, and forcible reasoning, which contrast so favourably with the opposites of these things in the quotations which he has occasion to make from the more celebrated among his critics.

GEORGE J. ROMANES

NATTERER'S BRAZILIAN MAMMALS

Brasilische Saugethiere. Resultate von Johann Natterer's Reisen in den Jahren 1817 bis 1835. Dargestellt von August von Pelzeln. (Wien, 1883.)

THE collections of the celebrated Brazilian traveller and naturalist, Johann Natterer, owing to his untimely death shortly after his return to Europe, lay almost unnoticed for many years in the Imperial Cabinet at Vienna. At length Herr August von Pelzeln, after several years' unremitting study of the unrivalled collection of birds, published in 1871 his "Ornithologie Brasiliens"—well known to ornithologists as one of the most important authorities on the Brazilian avifauna. More recently the same laborious naturalist has devoted his attention to Natterer's mammals, and in the memoir now before us, of which the second part has just been issued, has given us an excellent summary of Natterer's discoveries in this class of animals.

During his ten journeys in the Brazilian Empire (of which the first was commenced at Rio in November 1817, and the last terminated at Parà in September 1835) Natterer collected no less than 1179 examples of mammals, all most carefully prepared and accurately labelled, with notes of sex, colours of soft parts, date, and locality. These are referred by von Pelzeln to 205 species, 73 of which were new to science when first obtained by this unrivalled collector.

Natterer had planned a general work on the mammals of Brazil, in conjunction with Andreas Wagner. After the former's untimely death in 1843, Wagner published descriptions of the new genera and species in Wiegmann's *Archiv* and other periodicals, and introduced notices of them into his well-known supplement to Schreber's "Saugethiere." But we have now for the first time a complete systematic account of the whole of Natterer's collection with exact localities.

As might have been expected, the dense forest-region mostly traversed by Natterer was especially productive of Quadrumana—the American group of this order being exclusively arboreal in their habits. No less than 265 specimens of American monkeys were obtained, referable to 45 species, 4 of which were new to science. Of Chiroptera, Natterer procured examples of 48 species, of which at least 25 were first discovered by him. It should be also noted that the very singular structure of the stomach of the bloodsucking *Desmodi*, first made known by Prof. Huxley in 1865, was, as is testified by his note-books, previously discovered by Natterer in 1828!

The Carnivores are not so numerous in the Brazilian forests as the two preceding orders. Only 17 species were met with by Natterer, and only one of these (*Lutra solitaria*) was first made known to us by his specimens. The Rodents, on the other hand, are very abundant in species as in individuals in this part of South America. Not less than 50 species are represented in Natterer's series, whereof 24 were previously unknown to science.

The Ungulates are not abundant in South America, the true Ruminants being only represented by some peculiar forms of the deer family (Cervidæ). Of these Natterer obtained examples referable to 5 species. Besides the deer the only Ungulates met with were a tapir (*Tapirus americanus*) and the two well-known species of peccary.

Of the Sirenia, Natterer met with a manatee high up the stream of the Amazons, in the Rio Negro, Rio Brancho, and Madeira, and maintains in his notes that the species which inhabits these far inland waters is quite different from the *Manatus americanus* of the South American coast. Natterer called it *Manatus inunguis*, from its nailless fingers, and sent home to the Imperial Cabinet of Vienna three complete specimens and several skulls. Of the Cetaceans, Natterer met with two species of dolphin in the Amazons and its tributaries. *Inia amazonica* was found in the Guaporé and Madeira, and two examples obtained, and a head of *Steno tucuxi* was brought home from Barra de Rio Negro. Interesting notes are given on the structure of both these little-known animals.

We now come to the Edentata, which, as is well known, are well represented in the Neotropical Region by the three families of sloths, armadillos, and anteaters. Of each of these peculiar forms Natterer obtained a fine series. Among the sloths the two-toed *Cholopus didactylus* was met with on the banks of the Rio Negro and its tributaries, while of the three-toed genus *Bradypus* examples were collected which are referred by Herr von Pelzeln to five species. Of armadillos, Natterer obtained examples of five species, including the giant *Cheloniscus gigas*; he likewise procured specimens of all the three known species of anteaters.

South America is also rich in the smaller opossums, which constitute the only family of extra-Australian Marsupials, and amongst them this assiduous collector reaped a rich harvest. Of 18 species of which he sent home specimens not less than 11 were previously unknown to science, and were mostly described by Andreas Wagner under Natterer's manuscript names. It may, indeed, be safely affirmed that no naturalist, unless our countryman, John Gould, in the case of his celebrated expedition to Australia, be a possible exception, has ever been equally successful with Johann Natterer in discoveries amongst the higher classes of animals, and it is probable that no future naturalist, however great be his industry, will ever surpass him in the number and variety of his discoveries or in the excellence of his specimens.

OUR BOOK SHELF

A Treatise on Chemistry. By H. E. Roscoe, F.R.S., and C. Schorlemmer, F.R.S., Professors of Chemistry in the Victoria University, Owens College, Manchester. Vol. III. Organic Chemistry, Part II. (London: Macmillan and Co., 1884.)

THE first part of this volume, treating of the hydrocarbons of the paraffin series, and the alcohols, ethers, bases, acids, &c., derived therefrom, has already been reviewed in this journal (vol. xxv. p. 50). The part now under consideration treats of a large number of compounds derived from the di-, tri-, tetra, and hex-atomic alcohol-radicals, and from the monatomic alcohol-radicals of the series C_nH_{2n-1}; also of the carbohydrates, sugar, starch, gum, cellulose, &c., and of the furfuryl, meconic acid, and uric acid derivatives. Many of these bodies, *e.g.* the carbohydrates, and oxalic, lactic, malic, tartaric, citric, and uric acids, are of great importance as constituents of vegetable and animal organisms, and for their applications in arts and manufactures. The extraction and purification of sugar, from the cane and from beet, are clearly and fully described in this volume, and illustrated by excellent woodcuts of the apparatus and machinery used; also the estimation of sugar in juices, &c., by the optical or polarimetric method. Descriptions and illustrations are also given of the manufacture of starch, of the uses of cellulose in its various forms, cotton, flax, hemp, &c., and of the manufacture of paper.

Altogether the part now under consideration forms a very valuable portion of Roscoe and Schorlemmer's "Treatise," and we hope that the publication of the remaining parts—which will treat of the benzene-derivatives or aromatic bodies, and of the proximate constituents of the animal organism—will not be long delayed. The portions already published afford a guarantee that the volume when finished will form one of the most complete treatises on Organic Chemistry yet published in the English language.

H. WATTS

LETTERS TO THE EDITOR

[The Editor does not hold himself responsible for opinions expressed by his correspondents. Neither can he undertake to return, or to correspond with the writers of, rejected manuscripts. No notice is taken of anonymous communications.

[The Editor urgently requests correspondents to keep their letters as short as possible. The pressure on his space is so great that it is impossible otherwise to insure the appearance even of communications containing interesting and novel facts.]

Geology of the Malayan Peninsula

IN some geological excursions made recently in the State of Perak, I met with some curious facts which may be of interest to many of your readers. I made boat journeys down the Perak River from Enggor to the mouth, then back again up the valley of the Kiuta, and then returning to the mouth of the Kampar, went up that stream as far as boats can go. The main chains dividing these ranges are all granitic, rising to peaks generally over 3000 but sometimes over 7500 feet high. The ranges are flanked by Lower Limestone ridges, forming detached hills about 1500 feet in elevation. The summits of these hills, as well as on the flanks, are pierced with caves, which contain a ferruginous clay with stream tin. The latter is evidently derived from granite, but as the limestone hills are quite isolated, and some miles away from the source of the ore, the denudation of the country must have been very great. Some of the caves with tin sand are 1000 feet above the plain, and have to be approached by steps cut in the face of a precipice. These small mines are rich enough to attract a few Malays and Chinese, who are the only inhabitants. The country is otherwise a dense jungle. The limestone is crystalline, without a trace of organism, though lines of stratification can still be traced. Tin is also found in the drift at the base of these hills, entangled as it is in the pinnacles and peaks of the underlying limestone.

There is evidence of extensive denudation in both the granite and limestone. There are no signs of any recent upheaval in any of this country, nor, as far as I have seen, anywhere in the Malayan Peninsula, from Keddah to Johore. The country is rich in tin, which has been only partially worked.

There is a palæozoic sandstone clay slate or gneissose formation lying between the limestone and granite. It is much decomposed, and gives rise to a red clay which goes generally by the name of laterite. It is not of great thickness, but is widely represented by outliers at the base of the main ranges, often capping small detached hills. At the junction of this rock with the granite is in my opinion the place where the great deposits of tin have taken place. Wherever such outliers have been denuded away the resulting drift has always been noticed by me as richest in stream tin. On such drifts are the richest mines of Perak, notably Larut, Kamunting, and Assam Kumban. I dont think this palæozoic formation has been previously noticed, but indeed the country is but little known geologically. The slates are very like the Ordovician rocks of Australia, in which so much gold has been found. J. E. TENISON-WOODS

Thaiping, Perak, April 17

The Marine Biological Station and a Coast Survey

ALLOW me to say in reference to your article advocating a Biological survey of the British coasts, that you are quite right in supposing that such a survey falls within the scope of this Association. As a first step in the direction of such a survey the Association proposes to establish a dredging station and observatory on the south coast. Later it will, it is to be hoped, be able to establish or to cooperate in the establishment of additional dredging stations on various parts of the coasts of the United Kingdom, and thus gradually complete a *thorough* (not a superficial) survey such as is needed. The Association will no doubt seek the aid of the Government when the proper time for doing so arrives. E. RAY LANKESTER

Secretary (*ad interim*) of the Marine Biological Association

Atlantic Ice and Mild Winters

THE influence of the Gulf Stream in ameliorating the climate of the United Kingdom and of the north-west corner of Europe up to 71° of north latitude is so well known and so generally acknowledged that no comments are required; but can we discover any force sufficiently powerful by which this great heating power may occasionally be so largely augmented as materially to influence our usual winter temperatures, by bringing to our shores not only a larger flow of warm water, but also impelling it to strike or come into closer contact with our coasts further to the south?

I have, in a desultory way, for a series of years noticed that as a rule mild winters in England were associated with much ice extending far south in the Atlantic. The past winter is a striking example of this. Floe-ice has been more than once met with by steamers in lat. 40° N. and in about the same degree of west longitude, as nearly as possible midway between New York and Ireland, and in the direct ship track between Jamaica and Liverpool. These conditions indicate an Arctic current of very much increased volume, extending something like 400 miles south and an equal or greater distance east of the position given to it on any of the current charts I have examined.

The natural effect of so large a flow of cold water from the north meeting the Gulf Stream at right angles would not only be to deflect the latter to the southward of its usual course, causing it to strike our shores further south, but also in much greater volume, because a larger supply is required to replace the increased quantity from the Arctic

The only specially cold winds we have had in the past winter and spring have been from the east, with one or two brief exceptions, when there were gales from west and north-west, during which the air, after leaving the Arctic current, *may have* passed so rapidly over the Gulf Stream that it had not time to acquire any great increase of heat.

As was to be expected from the extra quantity of ice on the west side of the Atlantic the winter weather was unusually cold and changeable in Canada and the United States, varying with the direction of the winds.

The meeting of the Arctic current and Gulf Stream has no doubt been seen thousands of times. I had the good fortune to witness it only once, and it reminded me—but on a far grander scale—of two great rivers having waters of different colours, joining each other at right angles, or nearly so, as I have noticed with the McKenzie and some of its tributaries.

We were coming from Portland (February 1860), and our excellent captain had kept far south of the usual track, to avoid ice, so that for several days we were steaming *in* or at the edge *of* the Gulf Stream. The meeting of the two currents with their eddies—miles wide—was clearly defined, the water to the north being beautifully clear and blue, whilst to the south it had a brown colour with a thin film of haze over it. As we crossed the eddies or "swirls" of current, temperatures were carefully taken, that of the clear water being many degrees lower—I have forgotten the exact difference—than the brown or Gulf Stream.

Probably this whole question may have already been gone into and fully discussed by others; if so, the details have not come under my notice. My chief object is to attract the attention of those who are much better qualified to deal satisfactorily with this interesting subject than I can pretend to be.

4, Addison Gardens, May 10 JOHN RAE

Right-sidedness

IN NATURE for March 20 (vol. xxix. p. 477) Mr. Wharton and Dr. Rae criticise my letter of the 13th on right-sidedness. In writing that letter I had no intention of starting a new subject, but only to remove one source of confusion from the subject of bias in walking. But since the subject is started, I will say a few words in reply.

Neither Mr. Wharton nor Dr. Rae seem to be perfectly normally constituted. Dr. Rae is left-handed, indeed left-sided, by inheritance (I suppose), and right-handed in some things by education. In his case, therefore, the phenomena are more complicated, but there is nothing at all inconsistent with my view or at all different from what I would expect.

Mr. Wharton is near-sighted; his two eyes are of different focal length, and his *left* eye is *much the stronger*. And yet "by unconscious preference" he uses the right eye for the microscope or telescope. Is it possible to have a stronger confirmation of my view?

But he says that if right-sidedness has its cause in the brain, then, since I am right-handed, I ought to be left-eyed, for paralysis of the right side is attended with blindness of the left eye, and *vice versâ*. Is this true in all cases? If Mr. Wharton would prove it, physiology would owe him a deep debt. We all know the complex and therefore delusive and often apparently contradictory character of the phenomena resulting from lesions of the brain, but I think the weight of experimental evidence (and surely this is more reliable than pathological) is the other way. Experiments on pigeons and dogs ("Dalton's Physiology," pp. 430 and 454) seem to show that lesions of the brain affect the opposite eye as well as the opposite side of the body. Anatomical structure also would lead us to expect this, for the fibres of the optic tracts cross over in the chiasma, in birds completely, and in mammals largely. But even if it were otherwise, I do not see that the question is materially affected. If right-sidedness is inherited, there must be, or must have been, some advantage in it; and there is no reason why inheritance should not have affected different sides of the brain for hand and for eye, if such were necessary to bring about the result.

Again, Mr. Wharton has the singular idea that because Europeans, who are a right-handed people, write from left to right, therefore Eastern nations who write from right to left must be left-handed! Obviously this does not follow. Many right-handed motions, such for example, as striking with a whip are from right to left, so that the contrary stroke, on account of its unfrequency, is called *backhanded*.

Lastly, Mr. Wharton alludes to the rules of boxing. The left hand is used mostly for striking, and the right for guarding. It would be well if some one acquainted with the subject would give us its history. My impression is that the present practice is comparatively recent, perhaps forty to fifty years old, and that formerly the right hand was used mostly for striking, and the left for guarding. I think, further, that even now the left is used more for feints and lighter blows, while the right is reserved for favourable opportunities to plant decisive blows.

Berkeley, Cal., April 23 JOSEPH LE CONTE

Dark Transit of Jupiter's First Satellite

ON May 18, at 8h., on observing Jupiter with my 10-inch reflector, p. 252, I saw three very dark spots—one near the planet's centre, and two others not far advanced upon the east limb. These I took to be the shadows of satellites, and on reference found that the shadows of Satellites I. and II. were really upon the planet; also Satellite I. itself. The latter was evidently the spot near the centre of the disk, and it appeared almost equally as black as the shadow. The satellite was situated close to the equatorial white spot, and in point of fact was projected upon the north-east borders of that object. The latter was estimated on the central meridian at 8h. 5m., so that its longitude, computed on the diurnal rate of 878°·46 (= rotation of 9h. 50m. 7·42s.), was 94°·3.

When near mid-transit, Satellite I., as regards its visible aspect, could hardly have been distinguished from its shadow, and I believe the very dark appearance of the satellite on this occasion to have been somewhat exceptional; for though I have observed a considerable number of its transits, I never saw it nearly so dark before. W. F. DENNING

Bristol, May 19

The Remarkable Sunsets

A COPY of NATURE (vol. xxix. p. 149) just received here contains an article on "Remarkable Sunsets" which were seen in all parts of the world during the latter days of November and the early days of December. It may interest your readers to know that precisely similar sunsets to those described in the paper referred to above occurred here for several days in December. The "rosy pink after-glow" immediately succeeded the sunset, and lasted from ten to fifteen minutes. The phenomenon considerably scared the Chinese, who feared it portended some evil to the Emperor. The winter has been remarkably mild and dry; the first fall of snow, a very heavy one, took place on March 1. This region is volcanic; we have occasional shocks of earthquake. ARTHUR SOWERBY

T'ai Ynen Fu, Shansi, North China, March 5

"Notes on Earthworms"

REFERRING to Mr. Hughes' communication to NATURE of May 15, p. 57, I myself to-day saw a small worm pursued by a black insect, also evidently the larva of one of the Carabidæ. I was attracted by observing the worm emerge from the ground and hurry quickly away. When about five inches from its burrow the larva came out of the same burrow, and briskly followed in a zigzag course, until it overtook its prey, which it then seized near the tail end and dragged under some loose earth. No doubt the worm had been pursued underground, and was endeavouring to make its escape. E. A. SWAN

224, Camberwell New Road, May 17

The Recent Earthquake

IN p. 57 of the last number of NATURE notice is taken of the lack of observation on the late earthquake in Central Kent, Surrey, or Sussex. In Tonbridge we have known of three instances in which it was certainly felt. On the morning of April 22 a lady in bed in a room on the first floor felt a push from the foot of the bed so strong that she asked her little girl, who was in the room, why she was shaking it so, which of course the child denied—the bedstead being of iron and too heavy for her to have moved; the vallance at the head of the bed swayed to and fro. The second instance we heard of was an Indian officer, who felt it, while standing leaning against his mantelpiece, directed about from north-north-east to south-south-west. The third instance was an invalid lady in bed on the first floor. M. I. PLARR

22, Hadlow Road, Tonbridge, Kent, May 19

Animal Intelligence

ONE night a loud knock was heard at the back door, and as the door could not be reached by any one outside the house except by getting over the garden wall, some alarm was caused. On the knock being impatiently repeated, the door was opened, and the cat ("Mrs. Muffins") walked in with great dignity. Since then she has never failed to make known her presence in the same way, always waiting after the first knock. Some weeks elapsed before it was ascertained how the knocking was produced, but at length it was discovered that a slip of wood which runs down the side of the door was loose at the bottom; this slip she pulls out with her paw, and then allows it to rebound. She is a very affectionate mother. Some time ago her mistress, by accident, hurt her kitten. "Mrs. Muffins" walked up to her and gave her two or three sharp slaps on the dress. To-day the same thing has occurred; but on this occasion, as the servant was the offender, "Mrs. Muffins" followed her into the kitchen to chastise her. I may also add that she has shown great intelligence in making her wants known to her friends. E. A. LONERGAN

AGRICULTURE IN THE UNITED STATES[1]

WE may learn many a good lesson by observing the admirable manner in which the various Boards of Agriculture discharge their duties in the United States. With a sound discretion the mutual influences of geology and agricultural practice are prudently considered in association with the investigations of the chemist and the records of the Census Office. In these respects the various States are greatly in advance of anything provided in the United Kingdom. We have our Geological Survey most carefully conducted, and the maps showing the solid geology of the country are excellent. In addition to these we have another series of geological maps showing the drifts covering up these rocks, but at this point we cease to follow the example set us in the United States. Aided as each individual State is by a series of experts, such as the State Botanist, the State Geologist, the State Entomologist, the State Chemist, and similar officials, we thereby find most valuable help rendered to the agriculture of the country. This assistance is rendered more effective by reason of the concerted action by which it is so generally characterised. Each scientist views any given subject from his own special standpoint, and the great advantage of concerted action is the more mellowed judgment which is thereby secured.

In the Report before us we have one of those happy blendings of science and practice which is so well calcu-

[1] "Geological Survey of Alabama, embracing an Account of the Agricultural Features of the State." By Eugene Allen Smith, Ph.D., State Geologist.

lated to benefit the district dealt with, and which, instead of insulting the practical man, gives him information which he gladly utilises. The Report commences with a general discussion upon the composition, mode of formation, and the properties of soils, and the changes produced by cultivation. In the second section, soil in its relation to vegetation is somewhat elaborately dealt with. In the third section, soil in its relations to animal life is very completely presented to the reader's attention. The question of the absorptive powers of soils is ably dealt with. "As to the cause, opinions vary, but closer study of the phenomena of absorption have led back to the pretty general acceptance of the explanation originally offered by Way, which, as expressed by Mayer ('Agrikultur Chemie'), is as follows:—'We find in the soil easily decomposable double silicates, the exact composition of which is unessential, which, along with alumina, always contain some other base, an alkali or an alkaline earth, or even several of these bases at the same time. These silicates have the property, under certain conditions, of exchanging their accessory ingredients (not the alumina). The artificial silicate of Way had the composition of a zeolite, and it remained only to experiment with naturally occurring zeolites, which was done by Eichhorn, Mulder, and others, with the result of showing . . . that they all possess the power of exchanging a portion of their original content of lime or soda for an equivalent of potash or ammonia; in other words, of absorbing the latter bases. . . . According to Mulder . . . while the fertility of soil does not depend exclusively upon these zeolites, yet its chemical activity is altogether determined thereby.'' These comments are the more noteworthy because there has been a tendency amongst some chemists to undervalue the importance of Way's discovery, but the testimony of practice is too strong for it to be altogether ignored.

An exceedingly important connection is shown between the production of cotton and the systems of management pursued in Alabama. Speaking of the Great Cotton Belt of Alabama, the Report points out that the soils upon this belt have been largely exhausted by improvident culture, cotton being planted year after year upon the same soils, without any attempt being made to maintain the fertility by the use of manures. In other parts of the State where cotton is produced a selection is generally made of the better soils, rotation of crops is more generally practised, and in some sections fertilisers are in more general use. This is largely occasioned by the relative proportions of the population and the capital they have at their command.

"The system of credits in the large cotton-producing regions prevails to such an extent that the whole cotton crop is usually mortgaged before it is gathered, and when we consider that the prices charged for provisions are at least 50 per cent. higher than regular market rates, . . . it will need very little calculation to show that the labourer will have the chances too greatly against him, even to be out of debt to his merchants, when he relies solely upon this crop to provide the money, and the exorbitant interest on the money advanced is not likely to be lessened so long as the merchants' risks continue to be as great as they are. Where the blacks are in excess of the whites there are the originally most fertile lands of the State. The natural advantages of the soils are, however, more than counterbalanced by the bad system prevailing in such sections, viz. large farms rented out in patches to labourers, who are too poor and too much in debt to merchants to have any interest in keeping up the fertility of the soil, or rather they lack the ability to keep it up, with the natural consequence of its rapid exhaustion and a product per acre on the best lands in the State lower than that which is realised from the very poorest. Where the two races are in nearly equal proportions . . . there is found the system of small farms, worked generally by the owners, a consequently better cultivation, a more general use of commercial fertilisers, a corresponding high product per acre, and a partial maintenance of the fertility of the soils."

The entire Report is literally crowded with interesting and most important details, such as skilled experts are likely to formulate for the guidance of higher officials and for the assistance of those engaged in the cultivation of the land. The well-organised system existing in the United States, whereby the causes of failure and success are rendered prominent, is doing great service to that country, for they clearly recognise the truth that the advancement of agriculture is a national duty, because just in proportion as additional wealth is thus created within the States, so do the people generally participate in the advantages thus secured.

BIRD SKELETONS[1]

THE author of this important work, shortly after his return from his explorations in New Guinea and the Moluccas, was appointed Director of the Royal Zoological Museum at Dresden, and under his care the last-named museum is fast becoming one of the leading institutions in Germany. During his travels in the East Dr. Meyer appears to have amassed a considerable amount of material for his projected work on the skeletons of birds, and now that five parts of the "Abbildungen" have appeared, we think it well to draw the attention of English naturalists to it, as it will undoubtedly prove to be one of the most interesting osteological works yet attempted. The skeletons are all contained in the Dresden Museum, and Dr. Meyer proposes to carry on the work until his material becomes exhausted; but we trust that all ornithologists who can aid the author in his excellent enterprise will not fail to do so.

The works on the osteology of birds are not numerous, and this important portion of ornithological study has been too much neglected and systematically overlooked. The chief English work has been the "Osteologia Avium" of the late Mr. Eyton, and there are, of course, Prof. Owen's well-known memoirs on the *Dinornis* and its allies, on the Great Auk, and a few scattered representations of skeletons here and there. France can boast of Prof. Milne-Edwards's splendid volumes on fossil birds in comparison with recent forms, as well as the fine series of illustrations in the "Histoire Naturelle de Madagascar" of M. Grandidier. In Germany Prof. Selencka, of Erlangen, commenced, in Bronn's "Classen und Ordnungen," a systematic treatise on the osteology of birds, but unfortunately he discontinued this useful work after the issue of a few parts. Dr. Meyer's labours therefore deserve the acknowledgment of all scientific men as being an attempt to fill up a gap in our knowledge of birds. There are probably eleven thousand species of birds described up to the present time, but the osteological characters of only a very small proportion of them have been noticed, and a very inconsiderable number of the three thousand genera have been illustrated. As Dr. Meyer only figures those species which have not been before represented, each illustration represents a new fact for science, and we trust that he will be able to continue to add to the already rich materials at his command, and bring to a successful conclusion the important task which he has set himself.

Dr. Meyer does not avail himself of the usual mode of illustration by lithography, but has had all the skeletons photographed from nature, and then reproduced by

[1] "Abbildungen von Vogel-Skeletten herausgeben mit Unterstützung der generaldirection der konigl, Sammlungen für Kunst und Wissenschaft in Dresden." Von Dr. A. B. Meyer. Parts 1 to 5, pp. 1 to 40, Plates 1 to 50. (Dresden: Published by the Author, 1879-1883.)

phototype. This process does not fade as a photograph is liable to do, but has the consistency of print with the appearance of a steel engraving. By an ingenious method adopted by the author only one side of the bird's skeleton is given in the plate, and thus the confusion which is often seen in osteological illustrations from the appearance of the opposite side of the skeleton in the picture is obviated. The plates, which have been executed in Dresden at Mr. Wilhelm Hoffmann's Art Institute, deserve great credit for their execution. The letterpress which accompanies the figures gives the distinguishing characters of the skeletons with their principal measurements.

It is proposed to issue at least two parts in the course of every year, each part to contain ten plates. Out of the number hitherto published we find illustrations of seventeen Parrots belonging to fourteen genera, amongst them being the rare *Dasyptilus pesqueti* from New Guinea, the smallest known Parrot, *Nasiterna pygmæa*, as well as the largest one, *Microglossus aterrimus*, both of which are from New Guinea; *Nestor meridionalis* and *Stringops habroptilus* from New Zealand, besides illustrations of members of the following genera:—*Eclectus*, *Cacatua*, *Cyclopsitta*, *Loriculus*, *Trichoglossus*, *Charmosyna*, *Brotogerys*, *Tanygnathus*, and *Eos*. Of Birds of Paradise illustrations are given of *Cicinnurus regius*, *Paradisea minor*, *Manucodia chalybeata* with its twisted windpipe, along with those of its allies. Other Birds of Paradise are promised by Dr. Meyer. Among the Pigeons are figured species of *Carpophaga*, *Otidiphaps*, *Œdirhinus* and *Ptilopus*, side by side with skeletons and skulls of some of the domestic races. Of Kingfishers figures of the skeletons of the genera *Cittura*, *Tanysiptera*, and *Sauromarptis* are furnished, and among others we find illustrations of such interesting genera as the following:—*Pelenopides*, *Meropogon*, *Collocalia*, *Heteralocha*, *Rallina*, *Scissirostrum*, *Streptocitta*, *Oriolus*, *Dicrurus*, *Lepidogrammus*, &c.

We must draw the special attention of our readers to the skeleton of a species of *Notornis* from New Zealand, which Dr. Meyer has figured in Plates 34 to 37. This skeleton was procured along with the skin of the bird in South Island, N.Z., in the year 1879, and has found its way to the Dresden Museum. Complete figures of the osteology of this interesting genus are here given for the first time. Our national collection contains two skins of *Notornis*, but no skeleton, only some fossil remains from the North Island having been described and figured in the year 1848 by Prof. Owen. From a comparison of the latter with the skeleton now in the Dresden Museum, Dr. Meyer has been induced to consider that the North Island species is distinct from that inhabiting the South Island, and as the name of *Notornis mantelli* was given by Owen to the former bird, the specimen in the British Museum which came from the South Island must bear the name of *Notornis hochstetteri*, as Dr. Meyer proposes to attach to it the name of the well-known New Zealand explorer, Prof. von Hochstetter of Vienna.

A comparison is instituted by Dr. Meyer between the skeletons of different species of *Porphyrio* and *Ocydromus*. Together with the skeleton of the Jungle-fowl (*Gallus bankiva*), which Dr. Meyer himself brought from Sangi Island, north of Celebes, and different species of grouse (amongst them that of *Tetrao medius*), we find representations of the skeletons of several domesticated races of fowls. The importance of the characters presented by the differences of the crania and other portions of the skeletons of domestic fowls and pigeons was long ago proved by Mr. Darwin, and as there were only certain portions of the skeletons figured by him, the material which Dr. Meyer has collected with great care offers to the student a better opportunity of going deeply into this subject.

R. B. S.

THE "POTÉTOMÈTRE," AN INSTRUMENT FOR MEASURING THE TRANSPIRATION OF WATER BY PLANTS

IN view of the interest now attaching to recent advances in vegetable physiology, it seems not unlikely that a description of the instrument bearing the above name, lately published by Moll (*Archives Néerlandaises*, t. xviii.), will serve a useful purpose.[1] The apparatus was designed to do away with certain sources of error in Sachs's older form of the instrument, described in his "Experimental-Physiologie"—errors chiefly due to the continual alteration of pressure during the progress of the experiment.

As shown in the diagram, the "potétomètre" consists essentially of a glass tube, *a d*, open at both ends, and blown out into a bulb near the lower end; an aperture also

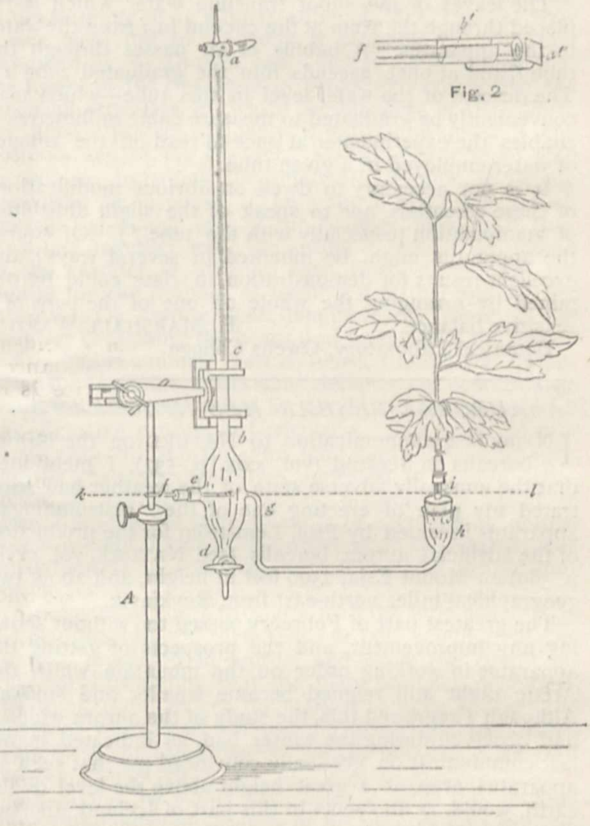


Fig. 2

Fig. 1

exists on either side of the bulb at or about its equator. The two ends of the main tube are governed by the stopcocks *a* and *d*, and the greater length of the tube is graduated. A perforated caoutchouc stopper is fitted into one aperture of the bulb *e*, and a tube, *g h*, fits hermetically to the other. This latter tube is dilated into a cup at *h* to receive the caoutchouc stopper, into which the end of the shoot to be experimented upon is properly fixed.

The fixing of the shoot is effected by caoutchouc and wire or silk, as shown at *i*, and must be performed so that the clean-cut end of the shoot is exactly at the level of a tube passing through the perforated stopper, *e*, of the bulb; this is easily managed, and is provided for by the bending of the tube *g h*. The tube *f*, passing horizontally through the caoutchouc stopper *e*, is intended to admit bubbles of air, and so equalise the pressure and at the same time afford a means of measuring the rapidity of the absorption of water by the transpiring shoot. This tube

[1] Especially also with reference to Mr. F. Darwin's description of his own ingenious instrument (see NATURE, May 8, p. 7).

(see Fig. 2, *f*) is a short piece of capillary glass tubing, to which is fixed a thin sheath of copper, *b'*, which slides on it, and supports a small plate of polished copper, *a'*, in such a manner that the latter can be held vertically at a small distance from the inner opening of the tube, and so regulate the size of the bubble of air to be directed upwards into the graduated tube *a b*.

The apparatus is filled by placing the lower end of the main tube under water, closing the tubes *f* and *i* (with caoutchouc tubing and clips), and opening the stopcocks *a* and *d*. Water is then sucked in from *a*, and the whole apparatus carefully filled. The cocks are then turned, and the cut end of the shoot fixed into *i*, as stated: care must be taken that no air remains under the cut end at *i*, and the end of the shoot must be at the level *k l*. This done, the tube *f* may then be opened.

The leaves of the shoot transpire water, which is replaced through the stem at the cut end in *i* from the water in the apparatus. A bubble of air passes through the tube *f*, and at once ascends into the graduated tube *a c*. The descent of the water-level in this tube—which may conveniently be graduated to measure cubic millimetres—enables the experimenter at once to read off the amount of water employed in a given time.

It is not necessary to dwell on obvious modifications of these essentials, nor to speak of the slight difficulties of manipulation (especially with the tube *f*). Of course the apparatus might be mounted in several ways; and excellent results for demonstration in class could be obtained by arranging the whole on one of the pans of a sensitive balance. H. MARSHALL WARD

Botanical Laboratory, Owens College

AURORAL RESEARCHES IN ICELAND

IN my last communication to NATURE on the aurora borealis in Iceland (vol. xxix. p. 537), I mentioned that the unusually adverse state of the weather had frustrated my plan of erecting one of the "utströmnings" apparatus invented by Prof. Lemström for the production of the artificial aurora borealis (see NATURE, vol. xxvii. p. 389) on Mount Esja, 2500 feet in height, and about two geographical miles north-east from Reykjavik.

The greatest part of February passed too without showing any improvement, and the prospects of getting the apparatus in working order on the mountain whilst the Arctic night still reigned became smaller and smaller. Although I regretted this, the study of the aurora which I had observed during the winter had, as indicated in my last communication, gradually convinced me that such an apparatus, even at a great height above the level of the earth, would, at all events in this part of Iceland, give but a negative result.

In spite of the favourable position of the island, the electrical forces, for which the aurora borealis is a visible indicator, appear to possess exceedingly little energy and intensity here, which has particularly been the case during the past few months. In consequence I came to the conclusion that should even all my arrangements be carried out to perfection there was little prospect of producing the "artificial" aurora borealis here.

On February 22, however, a change in the weather set in, and we had a few lovely days with a clear sky, no wind, and a pleasant temperature. Now, if ever, the time had come for realising my plan; and as the weather held for three entire days I fixed the departure for noon of the 25th.

I was fortunate enough to be able to make the journey in pleasant company, two of the burghers of the town and two Englishmen engaged at some sulphur mines in the vicinity volunteering to accompany me to the top of the mountain. We started at about 10 a.m. in a large sailing boat, with the poles, wires, and the rest of the apparatus.

In about three hours we landed at the foot of Esja, and took up our quarters in the farm Mogilsau, from whence I despatched the crew in every direction to call up all able-bodied men to assist in bringing the materials up to the top. Already the same afternoon I had ten of the poles carried up to a height of about 1500 feet.

The next morning broke clear and fine, promising a day as fine as the previous one. I had then sixteen men at my disposal. They began work at 6 a.m., carrying the heavy things up the mountain, and at 9 the last were taken out of the boat, and we all followed upwards.

We ascended from the southern side of the mountain about two miles in length. Only now and then we found snow, otherwise the ground consisted of sand and gravel mixed with boulders. The incline is not very great at first, but at times hills and ridges are encountered which tax the muscles and the lungs severely enough. However, the first 2000 feet of the road were not difficult or dangerous; in fact the only part which could be called so were the last 500 to 600 feet. Here the mountain rises abruptly (Esja is formed in terraces), and was covered with a thin layer of snow having a dangerous ice-coating. It was impossible to proceed here without first having hewn steps in the ice.

At 11.20 we mounted the crest of Esja. The mountain stretched snowy-white to all sides as level as a floor. It brought to my mind my ascent of the North Cape last summer. There was a slight breeze blowing which made the air feel chilly. The thermometer showed in the sun at 1 p.m. $-$ 1·2°, at 2 $-$ 0·2°, and at 3, in the shade, $-$ 3·2° Cels.

Every hand now became busy with erecting the apparatus. The layer of snow on the surface of the mountain was not thick enough to support the poles, and as the ground was frozen hard, they were—thirty-one in number—raised in cairns of large boulders, of which there were great quantities on the edge of the plateau. The poles being raised, the copper wires, along which there were fixed more than a thousand fine points, were suspended over the insulators on their tops. The wires were 850 feet in length, and the poles were erected in such a manner that square spiral slings were formed, having a distance of 6 feet from each other. The total surface area of the "utströmnings" apparatus is therefore 4100 square feet.

The work of erecting the apparatus occupied about four hours, and from the four barometrical observations I had an opportunity of making during the time—in conjunction with those which were, at my request, simultaneously, and with a similar instrument, effected at Reykjavik—I have fixed the height at which the apparatus stands at 2616 feet.

At 3.30 the descent began. The first part of this was far more risky than the ascent, as the steps cut became worn down and new ones had to be made. Simultaneously a very strong copper wire, carefully insulated by layers of canvas and indiarubber—the insulation being 6 mm. in diameter—was brought down the mountain by the shortest road, as far as it reached.

The next morning welcomed us with wind and heavy clouds, with a rapidly-falling barometer. The remaining poles were now brought up the mountain, and the bare telegraph wire, 3200 feet in length, carried to the spot where the insulated conductor ended. Both wires were connected in the most careful and exact manner, and the bare wire laid down as an ordinary telegraph wire on poles with insulators as far as it went. I had expected from its great length that it would reach down to the foot of the mountain, but it did not; it only reached to a height of 714 feet. When the wires in increasing rain and wind were laid out, I connected the end with two zinc disks one of which was placed in a small waterfall with heavy stones on it, and the other buried in the earth. When, finally, I had by means of a telephone and a galvanic element, conclusively ascertained that the conductor was in perfect working order right up to the top of the mountain, we began the descent and the return journey as rapidly as possible. We had no other choice, as the storm and rain which every moment increased precluded every possibility of doing more at that time. I had, however, some consolation in what already was done, my apparatus standing 1900 feet above the disks.

I left all the instruments to be used in connection with the experiments at Mogilsau in hopes that the weather would soon improve and allow me to return. The journey to Reykjavik was performed in a downpour of rain and a great storm.

As I had anticipated, the "utströmnings" apparatus has up to the present shown no signs of life whatever. I can see it plainly with a good telescope from my residence, and thus ascertain that it is in perfect order. In addition, I have just received a message from Mogilsau, informing me that the lower part is in perfect order too. Still during the few favourable nights we have as yet experienced not the slightest luminosity has appeared above the point in question.

If this be a negative result, it is a result, nevertheless, of considerable scientific interest.

The aurora borealis here has during the last few months been far more distinct in its appearance than during the first half of the winter. There is certainly, when the sky is sufficiently free from clouds, here and there a faint indication that the phenomenon does still exist, but such signs of life are very weak and limited.

I have at present no knowledge whether the aurora borealis has displayed less activity in other quarters of the globe during the winter than is generally the case, as letters take a long time from and to this island, but the Reykjavik people contend that the phenomenon displays usually far more energy and intensity than has been the case this winter. I am at present inquiring in various parts of the island whether the absence of the aurora borealis this winter has been noticed as generally remarkable, or its appearance is the usual one in Iceland.

In my last communication to NATURE I intended to have mentioned that I was curious to know what the effect would be of a sufficiently strong aurora covering the moon's disk. During the winter I have had several opportunities of observing auroræ projecting over the disk of the moon when full, but nothing more unusual is seen than the light of the aurora borealis disappearing within a radius of 5° to 10° around the moon. But in the appearance of the latter there is no difference.

Reykjavik, March SOPHUS TROMHOLT

A CARNIVOROUS PLANT PREYING ON VERTEBRATA

AN interesting discovery has been made during the last week by Mr. G. E. Simms, son of a well-known tradesman of Oxford. It is that the bladder-traps of *Utricularia vulgaris* are capable of catching newly-hatched fish and killing them. Mr. Simms brought to me for examination a specimen of Utricularia in a glass vessel, in which were numerous young roach newly hatched from a mass of spawn lying at the bottom. Numbers of these young fish were seen dead, held fast in the jaws of the bladder-traps of the plant. I had never seen Utricularia before, and am indebted to my colleague Prof. Burdon Sanderson for the identification of the plant and a reference to Cohn's researches on it. Mr. Simms supplied me with a fresh specimen of Utricularia in a vessel with fresh young fish and spawn, and in about six hours more than a dozen of the fish were found entrapped. Most are caught by the head, and when this is the case the head is usually pushed as far into the bladder as possible till the snout touches its hinder wall. The two dark black eyes of the fish then show out conspicuously through the wall of the bladder. Rarely a specimen is seen caught only by the tip of the snout. By no means a few of the fish are, however, captured by the tail, which is swallowed, so to speak, to a greater or less distance, and I have one specimen in which the fish is caught by the yelk sac. Three or four instances were observed in which a fish had its head swallowed by one bladder-trap, and its tail by another adjacent one, the body of the fish forming a connecting bar between the two bladders.

I have not been able to see a fish in the actual process of being trapped, nor to find one recently caught, and showing by motion of the fore part of its body signs of life. All those trapped were found already dead, but I have had no opportunity of prolonged observation, and it will be remembered that Mr. Darwin, in his account of the trapping of Crustacea, worms, &c., by Utricularia, states that he was not able to observe the actual occurrence of the trapping of an animal, although Mrs. Treat of New Jersey often did so. I think it probable that the fact described by Mr. Darwin, and which is easily verified, that the longer of the two pairs of projections composing the quadrifid processes by which the bladders of Utricularia are lined "project obliquely inwards and towards the posterior end of the bladder," has something to do with mechanism by which the small fish become so deeply swallowed so to speak. The oblique processes, set all towards the hinder end of the bladder, look as if they must act together with the spring valves of the mouth of the bladder in utilising each fresh struggle of the captive for the purpose of pushing it further and further inwards. On cutting open longitudinally some of the bladders containing the heads and foreparts of the bodies of fish, and examining their contents, I found the tissues of the fish in a more or less slimy deliquescent condition, no doubt from decomposition, for Mr. Darwin failed to detect any digestive process in Utricularia. The quadrifid processes were bathed in the slimy semi-fluid animal substance, and the processes themselves appeared to contain abundance of fine granular matter, possibly the result of absorption, but the large quantity of surrounding animal matter present rendered the observation uncertain. The usual swarms of Infusoria were present in the decomposing matter.

Specimens of the Utricularia with the little fish fast in the bladder-trap, and their heads or tails hanging out, can be well preserved in spirits, and show the conditions well, notwithstanding that the plant becomes colourless, and there is no longer the marked contrast between the glistening white dead fish and the green bladders, which in the fresh condition renders the combination of the trap and prey conspicuous.

Mr. Simms, by whose permission I write this, intends shortly to publish an account of his observations himself. I have advised him to endeavour to prepare spirit specimens of Utricularia plants with numerous trapped fish *in situ* for sale to those interested in the matter who may care to apply for them. His address is 37, Broad Street, Oxford. H. N. MOSELEY

NOTES

M. PASTEUR read to the Academy of Sciences on Monday an account of his experiments on rabies. He maintains that he has twenty dogs which he has rendered insusceptible to the disease, and which, with twenty ordinary dogs, he is prepared to have bitten by a number of dogs in a rabid state. A Commission has been appointed by the French Government to test M. Pasteur's conclusions, the immense importance of which, if established, must be evident to every one. Eminent physiologists maintain, however, that M. Pasteur is far from having proved his position, and that it would be rash to give any positive opinion upon the subject until the experiment which he suggests has been made. We await the full report of M. Pasteur's paper before saying more upon it. The following are the members of the Government Commission:—Dr. Beclard, the Dean of the Paris Faculty; M. Paul Bert, Professor of General Physiology at the Faculty of Sciences; M. Bouley, Professor of Comparative Pathology at the Museum of Natural History; Dr. Villemin, Professor of Clinical Surgery at the Military Pharmacy; Dr. Vulpian, Professor of Comparative and Experimental Pathology at the Paris Faculty of Medicine; and M. Tisserand, Director of the Agricultural Department.

PROF. HUXLEY has undertaken to be President of the Marine Biological Association. It is stated that Plymouth will probably be selected as the site of the first laboratory and experimental station erected by the Association. The Duke of Argyll, the Duke of Sutherland, and Dr. Gwyn Jeffreys, F.R.S., have given their names as vice-presidents. Mr. Chamberlain has joined the Association, and subscribed twenty guineas towards building the sea-coast laboratory. Mr. Thomasson, M.P. for Bolton, has subscribed 100*l.*

WE understand that the Scottish Fishery Board have obtained sufficient funds to enable Prof. McIntosh to carry on a number of important preliminary inquiries at St. Andrew's as to the possibility of increasing by artificial means the supply of flat-fish, and also as to the spawning habits and life-history of food fishes in general. This work is in the meantime being carried on in a temporary building which for some time served as a hospital. It is hoped, however, that when the importance of the work and the many advantages which St. Andrew's offers for a marine station are recognised, that both in the interest of science and by way of developing further the great fishing industry, a well-equipped laboratory and hatching station will be provided. Dr. McIntosh has already succeeded in hatching from artificially fertilised eggs the flounder, whiting, haddock, and cod, and in determining the nature of the eggs of the gurnard and other fish. Prof. Hubrecht of Utrecht is expected to work at the St. Andrew's Marine Station during the autumn.

THE Davis Lectures upon zoological subjects will be given in the lecture-room in the Zoological Society's Gardens, Regent's Park, on Thursdays, at 5 p.m., commencing June 5, as follows:—June 5, Man, zoologically considered, by Prof. Flower, LL.D., F.R.S.; June 12, Hands and feet, by Prof. Mivart, F.R.S.; June 19, Instinct, by G. J. Romanes, LL.D., F.R.S.; June 26, Hedgehogs, moles, and shrews, by Prof. Parker, F.R.S.; July 3, Dogs, ancient and modern, by J. E. Harting, F.L.S.; July 10, Birds' nests, by Henry Seebohm, F.L.S.; July 17, Reptiles, by P. L. Sclater, F.R.S.

THE Municipal Council of Paris has, at the instigation of the Société d'Anthropologie, given its sanction to the projected erection of a monument to Paul Broca. The spot chosen is a triangular plot of ground on the Boulevard Saint-Germain, immediately opposite the entrance gate of the new wing of the École de Médecine. A Commission has been appointed to decide upon the terms and conditions to be observed by those who desire to enter into the competition shortly to be opened for the honour of executing the work.

THE eighth meeting of the French National Congress of Geography will open on August 8 at Toulouse, where the local Geographical Society is organising an international exhibition, to be held from June 1 to August 15.

IN reference to his "Prize Records of Family Faculties" Mr. F. Galton writes to the *Times*:—"Permit me, as the last day for sending in the records has just gone by, to send you a brief estimate of the value of the response to my offer, so far as a very hasty inspection warrants. This value has far exceeded my expectations. I have received very little trash, and upwards of 150 good records of different families. Many of these are admirably drawn up; concise, full of information, and offering numerous opportunities of verification. As each of these returns refers to fourteen direct ancestors of the children of the family, and to many of the brothers and sisters of each of them, the mass of anthropological material may be inferred. It certainly refers to more than 5000 persons, and as the data are all entered in my bound tabular forms, the records form a long row of thin quarto volumes, severally labelled, and easily accessible. It is a unique anthropological collection. The writers are chiefly persons of the upper and middle classes of society; they are male and female in nearly equal proportions, and the two sexes write equally well, so far as I can thus far judge. The letters that accompanied the records are full and friendly, expressing a trust that I can assure them will not be misplaced of my treating the information as strictly confidential. In many cases they express the great interest that the inquiry into their own family history has been to them. Permit me to add that I do not think it possible to determine the prizes in much less than two months, and that besides publishing the awards I propose to send a copy of them to the private address of every substantial competitor."

NO. 16 of the Bibliographical Contributions of the Library of Harvard University consists of a classified index to the maps in *Petermann's Geographische Mittheilungen*, 1855-81, by Mr. Richard Bliss. The index consists of 1340 entries, and has evidently been made with the greatest care. Mr. Bliss has done a work of great utility.

IN two papers entitled "Le Ceneri dei Volcani di Giava supposta Causa dei Bagliori Crepuscolari," and "L'Isola di Giava ed i Crepuscoli del Novembre e Decembre 1883," recently published at Vicenza, Alvise G. Mocenigo discusses the various theories put forward to explain the late remarkable crepuscular lights that have been observed in every part of the world. He thinks the phenomena should probably be attributed to extra-telluric, interplanetary, or cosmic conditions naturally recurring only at long intervals, and which may possibly have never before arisen since the appearance of man on the earth.

THE Mitchell Library at Glasgow still labours under that most satisfactory of difficulties—want of room in which to carry on the amount of work it could otherwise do. Seldom has this want been more heavily felt than here, where not one-tenth of its founder's bequest of 70,000*l.* has yet been expended, while an additional legacy of 11,500*l.*, exceeding the entire expenditure in books hitherto, lies unused for sheer want of space to make available any such treasures as it would secure. The moderate increase of between 4 and 5 per cent. in its total issues of books is reasonably attributed to this limitation. Glasgow has not yet adopted the Free Libraries Act, but the Corporation has placed the complete publications of the Patent Office at another library founded by Walter Stirling, a merchant of that city, in 1791. As a reference library this also is free, and a recent reorganisation has reduced the subscription to its circulating department to 10*s.* 6*d.* a year, or half that where four members of a firm enter together. This arrangement has led to a large increase of readers at both branches of this library, but that has not interfered with the use made of the Mitchell Library, and it is satisfactory to find in the Report of the latter a notice in large type referring all persons who wish to take books home to the moderate terms of the sister establishment. Still the subscribers to the latter form but a small fraction of the numbers who would be sure to avail themselves of rate-supported libraries in a great town like Glasgow, and the Mitchell Report strongly and wisely urges the adoption of the Act.

VISITORS to Canada during the forthcoming meeting of the British Association will find many useful hints and considerable practical guidance in Mr. T. Greenwood's "Tour in the United States and Canada." Mr. Greenwood went out and back in six weeks, and evidently made good use of his time.

THE demonstration by Dr. Herbert Carpenter of some points in the minute anatomy of Crinoids at the last meeting of the

Royal Microscopical Society was of great interest, and gave promise that his forthcoming *Challenger* Report will be of high importance as a contribution to the morphology of these Echinoderms. His exhibition of microscopic preparations of the system of cords which he and his father assert to be of a nervous nature was supplemented by an interesting account by Dr. Carpenter, C.B., of the observations and experiments which had led to the conviction as to their nervous nature, which is gradually being accepted by other investigators.

M. Mascart, Professor at the College of France, will give a discourse at the Royal Institution on Friday evening, May 30, the subject being "Sur les Couleurs."

We regret to learn of the death of Mr. Henry Baden Pritchard, whose name has been so long connected with the *Photographic News*, and with the photographic world in general.

A strong earthquake shock causing some damage was felt last week at Panderma and Erdek in the province of Broussa, Asia Minor. Two slight shocks, unattended by any damage, have occurred at Balikesri in the same province.

At a meeting of the Governors of North Wales University, held last week at Bangor, Mr. Henry Rudolf Reichel, M.A., Fellow of All Souls College, Oxford, was elected Principal of the College.

That the railway should be the means of enriching the flora of a district seems strange. This has, however, been shown to be the case in Arbrå parish, in the province of Helsingland, Sweden. Thus, since the extension of the Great Northern main line into this province in 1878, no less than seven new species of plants have immigrated along the line. They are *Galium mollugo*, *Plantago lanceolata*, *Euphorbia helioscopia*, *Dactylis glomerata*, *Bunias orientalis*, *Avena fatua*, and an American importation, *Rudbeckia hirta* (L.). That these must owe their introduction to the railway is clearly demonstrated by the fact that in spite of the closest scrutiny these plants have never before been found in this district, and that they are even now confined to the railway embankment and its immediate vicinity. The four first-named have, in all probability, only come from the parishes south of Arbrå, but the *Bunias orientalis* and *Avena fatua* have no doubt travelled along the line all the way from the province of Gestrikland, to whose flora they belong. The last-named, *Rudbeckia hirta*, which hails from the eastern part of the United States, seems to follow in the track of the navvy in the whole of Northern Sweden. In the summer of 1880 it was seen some ten miles south of Bollnäs station; in 1882 it appeared for the first time at Arbrå, about twenty miles further up the railway line; and last year it had travelled as far as Torps parish, in the province of Medelpad, *i.e.* a distance in four years of about one degree.

A correspondent writes in reference to Prof. McKenny Hughes' article on earthworms, that the worst consequence of the sea going over the walls in the Somerset low grounds is that it kills the worms, thousands of which come to the surface and die in agony, and the farmers are very sensible of the evil done to the land for a long time afterwards.

Messrs. Crosby Lockwood and Co. inform us that they will shortly publish "A Treatise on Earthy and other Minerals and Mining," by D. C. Davies, F.G.S. The work, which is uniform with and forms a companion volume to the same author's "Treatise on Metalliferous Minerals and Mining," will be fully illustrated. The same publishers announce a work on an entirely new subject, viz. "Stone-working Machinery, and the Rapid and Economical Conversion of Stone, with Hints on the Arrangement and Management of Stone-Works," by M. Powis Bale, M.Inst.M.E., A.M.Inst.C.E. Messrs. Crosby Lockwood and Co. also announce "The Blowpipe in Chemistry, Mineralogy, and Geology," by Lieut.-Col. Ross.

The additions to the Zoological Society's Gardens during the past week include a Hodgson's Partridge (*Perdix hodgsoniæ*), presented by Mr. W. Jamrach; a Bonnet Monkey (*Macacus radiatus*), presented by Mr. A. King; two Japanese Pheasants (*Phasianus versicolor*), two Egyptian Geese (*Chenalopex ægyptiaca*), a White American Crane (*Grus americana*), thirteen Green Lizards (*Lacerta viridis*), purchased; two Common Vipers, presented by Mr. W. H. B. Pain; a Common Partridge (*Perdix cinerea*), presented by Mr. R. Steele; a Banded Ichneumon (*Herpestes fasciatus*), presented by Master Adams; twelve Variegated Sheldrakes (*Tadorna variegata*), four Soft-billed Ducks (*Hymenolæmus malacorhynchus*), a Bernicle Goose (*Bernicla leucopsis*), an Argentine Tortoise (*Testudo argentina*), presented by Mr. Wm. Petty.

OUR ASTRONOMICAL COLUMN

A New Comet of Short Period.—M. Schulhof of Paris has lately ascertained that the observations of the third comet of 1858 (a very limited number) are closely represented by an elliptical orbit with a period of about six years and a half. The comet in question was discovered by Mr. H. P. Tuttle at the Observatory of Cambridge, Mass., on the evening of May 2; it was observed there until May 12, and likewise at Ann Arbor by the late Prof. Watson from May 9 until June 1. Eight observations in all are available for the calculation of the orbit, and upon these M. Schulhof bases four positions, from which he deduces the following elements:—

Perihelion passage, 1858 May 2·96719 G.M.T.

	°	′	″
Longitude of perihelion	200	46	27·1
,, ascending node	175	4	8·5
Inclination	19	30	2·0
Angle of eccentricity	41	21	5·2
Mean daily sidereal motion	536″·881		

From these elements we find—

Eccentricity	0·660676	Perihelion distance	1·1950
Semi-axis major ...	3·5217	Revolution ...	6·609 years
,, minor ...	2·6436		

M. Schulhof finds the limits for the mean daily motion 612″ and 470″ corresponding to periods of 5·80 and 7·55 years.

With such elements the comet must approach very near to the orbit of Jupiter, as is the case with nearly all the comets of the short-period group: and with the most probable period (6·6 years) would come into close proximity to the planet in 1879 and 1880. It unfortunately happens that an endeavour to identify this comet with any one of the imperfectly observed comets of past times, or with missing nebulous objects, has so far been fruitless, and hence much uncertainty remains as to the true length of the revolution, but M. Schulhof has prepared sweeping-ephemerides, of which a part is printed in No. 2590 of the *Astronomische Nachrichten*: it contains the sweeping-line for every fourth degree of the sun's true longitude from 40° to 104°. At the time of discovery in 1858 the comet was a very faint object in the comet-seeker, and continued faint during the month that it was observed. To this circumstance and unfavourable weather is attributed its not having been seen at Washington: it was not observed in Europe. Parabolic elements were computed by Profs. Hall and Watson, but no suspicion of periodicity could have arisen from the results of their calculations beyond what comparatively small inclination and direct motion might have suggested; indeed we believe it is somewhere upon record that Prof. Hall considered the tendency was rather towards a hyperbolic orbit. M. Schulhof's merit in drawing the attention of astronomers to the real nature of the comet's path is so much the greater.

Could reliance be placed upon the period given by the few observations in our possession as the most probable one, a return to perihelion might be expected in October next, but as already remarked such period would have brought the comet into close proximity to the planet Jupiter in 1879-80, and the next perihelion passage might be considerably affected thereby. Further, it is to be remarked that with perihelion passage in the middle of October there would be little or no chance of recovering the comet.

The comet's heliocentric equatorial-coordinates at perihelion are—

$x \ldots -1{\cdot}1148 \quad y \ldots -0{\cdot}4305 \quad z \ldots +0{\cdot}0018.$

If we combine these with the sun's coordinates, X, Y, Z, in the *Nautical Almanac*, we readily obtain an idea as to the chances of finding the comet, according to different assumed dates of arrival at perihelion. The most advantageous conditions are presented when this falls about the middle of April. If we assume April 11, the R.A. is found to be 208°, N.P.D. 54°, and the intensity of light 11·05, which is four times greater than on the date of the comet's discovery by Tuttle in 1858. As it was then extremely faint, its rediscovery may be a matter of difficulty. We have already one "Tuttle's comet," of short period, and it may perhaps occur to astronomers that the third of 1858 will be aptly named *Schulhof's comet*.

CHEMICAL NOTES

POTILITZIN has recently (*Ber.*, xvii. 276) made some interesting observations on the hydration and dehydration of cobalt chloride. He shows that, besides the already known hydrate $CoCl_2 . 6H_2O$, there exist two hydrates, $CoCl_2 . 2H_2O$ and $CoCl_2 . H_2O$, the former being rose-red in colour, and the latter dark violet. When the dehydrated salt is heated to about 100°, it parts with water, which is again absorbed on cooling. When an aqueous solution of the ordinary hexhydrated salt is heated, or is mixed with a dehydrating agent, the colour changes from pink to blue or dark violet. Potilitzin shows that this change, which he proves to be due to partial decomposition of the hexhydrated salt, may be brought about without raising temperature by the capillary action of unsized paper or a porous plate of stucco.

TOLLENS has made experiments on the sugar-like substance obtained by the action of alkalies on an aqueous solution of formaldehyde. He oxidises methylic alcohol by air in presence of platinum foil at 54°–55°, and distils; he then treats the crude distillate with baryta water, and so obtains a yellowish precipitate, which, when freed from barium, yields an amorphous syrup that reduces Fehling's solution, and gives results on analysis approximating to the formula $C_6H_{10}O_5$. This syrup is optically inactive, and does not undergo fermentation; on treatment with sulphuric acid, it gives formic and lactic acids (*Landw. Versuchs-Stat.*, xxix. 355).

KANNONIKOW (*Ber.*, xvii. p. 157, *abstracts*) attempts to measure the refraction-equivalents of various metals by deducting the refraction-equivalents of salts of these metals with organic acids (determined with aqueous solutions of the salts) from the refraction-equivalents of the acids themselves. So far as his results go, they appear to indicate that the refraction-equivalents vary periodically with variations in the atomic weights of the metals.

MM. NILSON AND PETTERSON have prepared pure beryllium chloride by heating the metal in perfectly dry hydrochloric acid gas, and have determined the density of the vapour of this compound. Beryllium chloride can be volatilised without decomposition in an atmosphere of dry nitrogen or carbon dioxide, provided every trace of air is excluded. The density of the gaseous compound for the temperature-interval 686°–812° agrees with that calculated from the formula $BeCl_2$ (Be = 9·1). The question as to the value to be assigned to the atomic weight of beryllium, which has been so much discussed of late, appears to be now finally settled in favour of the number deduced by applying the periodic law to the study of the properties of this metal and its compounds (*Ber.* xvii. 987).

CONTINUING the researches of Krämers, Prof. Mendeléeff has shown at a recent meeting of the Russian Chemical Society (*Journal* of the Society, vol. xvi. fasc. 2) that the densities of solutions of salts increase together with the increase of their molecular weights. Thus if we take the series of salts HCl, LiCl, NaCl, KCl, . . . $BaCl_2$, $SnCl_4$, $HgCl_4$, and Fe_2Cl_6, the molecular weights of which are respectively 36·5, 42·5, 58·5, 74·5, . . . 208, 259, 271, and 325, the densities of their solutions in 100 parts of water, at 15° to 20°, are: 1·010, 1·014, 1·023, 1·025, . . . 1·098, 1·106, 1·128 (calculated), and 1·134. The densities increase as the molecular weights increase; but if we take, instead of the molecular weights, the weights of their equivalents, or those of the equivalents of metals, the regularity of increase disappears. Prof. Mendeléeff adds that the above is true, not only with regard to chlorides, but also with regard to the salts of bromine and iodine, and many others. Reserving to himself further to pursue his researches in this way, Prof. Mendeléeff points out the following relation:—If the molecular weight of the dissolved body be M, and the solution be represented by $nM + 100\,H_2O$ (where n represents the number of molecules), the density, D, of the solution may be expressed for many bodies by the following equation:— $\left(\frac{n}{D - D_0}\right)^k = A + Bn$, where D_0 is the density of water, and k is equal to unity, or very near to it. This equation must be considered, however, only as preliminary, ulterior researches promising to give a more general formula. A and B are two constants, which vary with the temperature. Thus, for HCl at 0° (the density of water at 4° being taken = 1), $A = 94{\cdot}5$ and $B = 1{\cdot}725$; at 20°, $A = 102{\cdot}2$, and $B = 1{\cdot}80$; at 40° $A = 106{\cdot}2$, and $B = 1{\cdot}85$; at 60° $A = 105{\cdot}2$, and $B = 2{\cdot}05$; at 80° $A = 100{\cdot}6$, and $B = 2{\cdot}25$; and at 100° $A = 94{\cdot}5$, and $B = 2{\cdot}55$, the coefficient k being in all cases equal to unity.

ON THE NOMENCLATURE, ORIGIN, AND DISTRIBUTION OF DEEP-SEA DEPOSITS[1]

Introduction

THE sea is unquestionably the most powerful dynamic agent on the surface of the globe, and its effects are deeply imprinted on the external crust of our planet; but among the sedimentary deposits which are attributed to its action, and among the effects which it has wrought on the surface features of the earth, the attention of geologists has, till within quite recent times, been principally directed to the phenomena which take place in the immediate vicinity of the land. It is incontestable that the action of the sea along coasts and in shallow water has played the largest part in the formation and accumulation of those marine sediments which, so far as we can observe, form the principal strata of the solid crust of the globe; and it has been from an attentive study of the phenomena which take place along the shores of modern seas that we have been able to reconstruct in some degree the conditions under which the marine deposits of ancient times were laid down.

Attention has been paid only in a very limited degree to deposits of the same order, and, for the greater part, of the same origin, which differ from the sands and gravels of the shores and shallow waters only by a lesser size of the grains, and by the fact that they are laid down at a greater distance from the land and in deeper water. And still less attention has been paid to those true deep-sea deposits which are only known through systematic submarine investigations. One might well ask what deposits are now taking place, or have in past ages taken place, at the bottom of the great oceans at points far removed from land, and in regions where the erosive and transporting action of water has little or no influence. Without denying that the action of the tidal waves can, under certain special conditions, exert an erosive and transporting power at great depths in the ocean, especially on submerged peaks and barriers, it is none the less certain that these are exceptional cases, and that the action of waves is almost exclusively confined to the coasts of emerged land. There are in the Pacific immense stretches of thousands of miles where we do not encounter any land, and in the Atlantic we have similar conditions. What takes place in these vast regions where the waves exercise no mechanical action on any solid object? We are about to answer this question by reference to the facts which an examination of deep-sea sediments has furnished.

A study of the sediments recently collected in the deep sea shows that their nature and mode of formation, as well as their geographical and bathymetrical distribution, permit deductions to be made which have a great and increasing importance from a geological point of view. In making known the composition of these deposits and their distribution, the first outlines of a geological map of the bottom of the ocean will be sketched.

This is not the place to give a detailed history of the various contributions to our knowledge of the terrigenous deposits in deep water near land, or of those true deep-sea deposits far removed from land, which may be said to form the special subject of this communication. From the time of the first expeditions under-

[1] A Paper read before the Royal Society of Edinburgh by John Murray and A. Renard. Communicated by John Murray

taken with a view of ascertaining the depth of the ocean, small quantities of mud have been collected by the sounding lead and briefly described. We may recall in this connection the experiments of Ross and the observations of Hooker and Maury. These investigations, made with more or less imperfect appliances, immediately fixed the attention, without however giving sufficient information on which to establish any general conclusions as to the nature of the deposits or their distribution in the depths of the sea.

When systematic soundings were undertaken with a view of establishing telegraphic communication between Europe and America, the attention of many distinguished men was directed to the importance, in a biological and geological sense, of the specimens of mud brought up from great depths. The observations of Wallich, Huxley, Agassiz, Baily, Pourtalès, Carpenter, Thomson, and many others, while not neglecting mineralogical and chemical composition, deal with this only in a subordinate manner. The small quantities of each specimen at their command, and the limited areas from which they were collected, did not permit the establishment of any general laws as to their composition or geographical and bathymetrical distribution. These early researches, however, directed attention to the geological importance of deep-sea deposits, and prepared the way for the expeditions organised with the special object of a scientific exploration of the great ocean basins.

The expedition of the *Challenger* takes the first rank in these investigations. During that expedition a large amount of material was collected and brought to England for fuller study under the charge of Mr. Murray, who has in several preliminary papers pointed out the composition and varieties of deposits which are now forming over the floor of the great oceans. In order to arrive at results as general as possible, it was resolved to investigate the subject from the biological, mineralogical, and chemical points of view, and M. Renard was associated with Mr. Murray in the work. In addition to the valuable collections and observations made by the *Challenger*, we have had for examination material collected by other British ships, such as the *Porcupine*, *Bulldog*, *Valorous*, *Nassau*, *Swallow*, *Dove*; and, through Prof. Mohn, by the Norwegian North Atlantic Expedition. Again, through the liberality of the United States Coast Survey and Mr. A. Agassiz, the material amassed in the splendid series of soundings taken by the American ships *Tuscarora*, *Blake*, and *Gettysburg*, were placed in our hands. The results at which we have arrived may therefore be said to have been derived from a study of all the important available material.

The work connected with the examination and description of these large collections is not yet completed, but it is sufficiently advanced to permit some general conclusions to be drawn which appear to be of considerable importance. In addition to descriptions and results, we shall briefly state the methods we have adopted in the study. All the details of our research will be given in the Report on the Deep-Sea Deposits in the *Challenger* series, which will be accompanied by charts indicating the distribution, plates showing the principal types of deposits as seen by the microscope, and numerous analyses giving the chemical composition and its relation to the mineralogical composition. The description of each sediment will be accompanied by an enumeration of the organisms dredged with the sample, so as to furnish all the biological and mineralogical information which we possess on deep-sea deposits, and finally, we shall endeavour to establish general conclusions which can only be indicated at present.

Before entering on the subject, we believe it right to point out the difficulties which necessarily accompany such a research as the one now under consideration, difficulties which arise often in part from the small quantity of the substance at our disposal, but also from the very nature of the deposit. Since we have endeavoured to determine, with great exactitude, the composition of the deposit at any given point, we have, whenever possible, taken the sample collected in the sounding-tube. That procured by the trawl or dredge, although usually much larger, is not considered so satisfactory on account of the washing and sorting to which the deposit has been subjected while being hauled through a great depth of water. We have, however, always examined carefully the contents of these instruments, although we do not think the material gives such a just idea of the deposit as the sample collected by the sounding-tube. The material collected by the last-named instrument has been taken as the basis of our investigations, although the small quantity often gives to it an inherent difficulty. It was the small quantity of substance collected by the sounding-tube in early expeditions which prevented the first observers from arriving at any definite results ; but when such small samples are supplemented by occasional large hauls from the dredge or trawl, they become much more valuable and indicative of the nature of the deposit as a whole. Not only the scantiness of the material, but the small size of the grains, which in most instances make up deep-sea deposits, render the determinations difficult. In spite of the improvements recently effected in the microscopical examination of minerals, it is impossible to apply all the optical resources of the instrument to the determination of the species of extremely fine, loose, and fractured particles. Again, the examination of these deposits is rendered difficult by the presence of a large quantity of amorphous mineral matter, and of shells, skeletons, and minute particles of organic origin. It is also to be observed that we have not to deal with pure and unaltered mineral fragments, but with particles upon which the chemical action of the sea has wrought great changes, and more or less destroyed their distinctive characters.

What still further complicates these researches is the endeavour to discover the origin of the heterogeneous materials which make up the deposits. These have been subjected to the influence of a great number of agents of some of which our knowledge is to a great extent still in its infancy. We must take into account a large number of agents and processes, such as ocean currents ; the distribution of temperature in the water at the surface and at the bottom ; the distribution of organisms as dependent on temperature and specific gravity of the water ; the influence of aërial currents ; the carrying power of rivers ; the limit of transport by waves ; the eruptions of aërial and submarine volcanoes ; the effect of glaciers in transporting mineral particles, and, when melting, influencing the specific gravity of the water, which in turn affects the animal and plant life of the surface. It is necessary to study the chemical reactions which take place in great depths ; in short, to call to our aid all the assistance which the physical and biological sciences can furnish. It will thus be understood that the task, like all first attempts in a new field, is one of exceptional difficulty, and demands continued effort to carry it to a successful issue.

In presenting a short *résumé* of our methods, of the nomenclature we have adopted, and of the investigation into the origin of the deposits in the deep sea and deeper parts of the littoral zones, we offer it as a sketch of our research, prepared to modify the arrangements in any way which an intelligent criticism may suggest.

Before proceeding to a description of methods and of the varieties of deposits, with their distribution in modern oceans, we will briefly enumerate the materials which our examination has shown take part in the formation of these deposits, state the origin of these materials, and the agents concerned in their deposition, distribution, and modification.

Materials.—The materials which unite to form the deposits which we have to describe may be divided into two groups, viewed in relation to their origin, viz., mineral and organic.

The mineral particles carried into the ocean have a different form and size, according to the agents which have been concerned in their transport. Generally speaking, their size diminishes with distance from the coast, but here we limit our remarks to the mineralogical character of the particles. We find isolated fragments of rocks and minerals coming from the crystalline and schisto-crystalline series, and from the clastic and sedimentary formations ; according to the nature of the nearest coasts they belong to granite, diorite, diabase, porphyry, &c. ; crystalline schists, ancient limestones, and the sedimentary rocks of all geological ages, with the minerals which come from their disintegration, such as quartz, monoclinic and triclinic feldspars, hornblende, augite, rhombic pyroxene, olivine, muscovite, biotite, titanic and magnetic iron, tourmaline, garnet, epidote, and other secondary minerals. The trituration and decomposition of these rocks and minerals give rise to materials more or less amorphous and without distinctive characters, but the origin of which is indicated by association with the rocks and minerals just mentioned.

Although the debris of continental land to which we have just referred plays the most important *rôle* in the immediate vicinity of shores, yet our researches show beyond doubt that when we pass out towards the central parts of the great ocean basins, the debris of continental rocks gradually disappears from the deposits, and its place is taken by materials derived from modern volcanic rocks, such as basalts, trachytes, augite-andesites, and vitreous varieties of these lithological families, for instance, pumice, and loose, incoherent, volcanic particles of recent eruptions, with their characteristic minerals. All these mineral substances being usually extremely fine or areolar in structure, are easily attacked by the sea water at the place where they are deposited. This chemical action brings about an alteration of the minerals and vitreous fragments, which soon passes into complete decomposition, and in special circumstances gives rise to the formation of secondary products. In some places the bottom of the sea is covered with deposits due to this chemical action, principal among which is clayey matter, associated with which there are often concretions composed of manganese and iron. In other regions the reactions which result in the formation of argillaceous matter from volcanic products give rise also to the formation of zeolites.

Among other products arising from chemical action, probably combined with the activity of organic matter, may be mentioned the formation of glauconite and phosphatic nodules, with, in some rare and doubtful examples, the deposition of silica. The decomposition of the tissues, shells, and skeletons of organisms adds small quantities of iron, fluorine, and phosphoric acid to the inorganic constituents of the deep-sea deposits.

Finally, we must mention extra-terrestrial substances in the form of cosmic dust.

We now pass to the consideration of the *rôle* played by organisms in the formation of marine deposits. Organisms living at the surface of the ocean, along the coasts, and at the bottom of the sea are continually extracting the lime, magnesia, and silica held in solution in sea water. The shells and skeletons of these, after the death of the animals and plants, accumulate at the bottom and give rise to calcareous and siliceous deposits. The calcareous deposits are made up of the remains of coccospheres, rhabdospheres, pelagic and deep-sea Foraminifera, pelagic and deep-sea Mollusks, Corals, Alcyonarians, Polyzoa, Echinoderms, Annelids, Fish, and other organisms. The siliceous deposits are formed principally of frustules of Diatoms, skeletons of Radiolarians, and spicules of Sponges.

While the minute pelagic and deep-sea organisms above mentioned play by far the most important part in the formation of deep-sea deposits, the influence of Vertebrates is recognisable only in a very slight degree in some special regions by the presence of large numbers of sharks' teeth, and the ear-bones and a few other bones of whales. The otoliths of fish are usually present in the deposits, but, with the exception of two vertebræ and a scapula, no other bones of fish have been detected in the large amount of material we have examined.

Agents.—Having passed in review the various materials which go to the formation of deposits in the deep water immediately surrounding the land and in the truly oceanic areas, attention must now be directed to the agents which are concerned in the transport and distribution of these, and to the sphere of their action. The relations existing between the organic and inorganic elements of deposits to which we have just referred, and the laws which determine their distribution, will be pointed out at the same time.

The fluids which envelop the solid crust of the globe are incessantly at work disintegrating the materials of the land, which, becoming loose and transportable, are carried away, sometimes by the atmosphere, sometimes by water, to lower regions, and are eventually borne to the ocean in the form of solid particles or as matter in solution. The atmosphere when agitated, after having broken up the solid rock, transports the particles from the continents, and in some regions carries them far out to sea, where they form an appreciable portion of the deposit; as, for instance, off the west coast of North Africa and the south-west coast of Australia. Again, in times of volcanic eruptions, the dust and scoria which are shot into the air are carried immense distances by winds and atmospheric currents, and no small portion eventually falls into the sea.

Water is, however, the most powerful agent concerned in the formation and distribution of marine sediments. Running water corrodes the surface of the land, and carries the triturated fragments down into the ocean. The waters of the ocean, in the form of waves and tides, attack the coasts and distribute the debris at a lower level. Independently of the action of waves, there exist along most coasts currents, more or less constant, which have an effect in removing sand, gravel, and pebbles further from their origin. Generally, terrestrial matters appear to be distributed by these means to a distance of one or two hundred miles from the coast. Waves and currents probably have no erosive or transporting power at depths greater than 200 or 300 fathoms, and even at such depths it is necessary that there should be some local and special conditions in order that the agitated water may produce any mechanical effect. However, it is not improbable that, by a peculiar configuration of the bottom and ridges among oceanic islands, the deposit on a ridge may be disturbed by the tidal wave even at 1000 fathoms; and this may be the cause of the hard ground sometimes met with in such positions. By observations off the coast of France it has been shown that fine mud is at times disturbed at a depth of 150 fathoms; but, while admitting that this is the case on exposed coasts, the majority of observations indicate that beyond 100 fathoms it is an oscillation of the water, rather than a movement capable of exerting any geological action, which concerns us in this connection.

Although the great oceanic currents have no direct influence upon the bottom, yet they have a very important indirect effect on deposits, because the organisms which live in the warm equatorial currents form a very large part of the sediment being deposited there, and this in consequence differs greatly from the deposits forming in regions where the surface water is colder. In the same way a high or low specific gravity of the surface water has an important bearing on the animal and vegetable life of the ocean, and this in its turn affects the character of the deposits.

The thermometric observations of the *Challenger* show that a slow movement of cold water must take place in all the greater depths of the ocean from the poles, but particularly from the southern pole, towards the equator. It could be shown from many lines of argument that this extremely slow massive movement of the water can have no direct influence on the distribution of marine sediments.

Glaciers, which eventually become icebergs that are carried far out to sea by currents, transport detrital matter from the land to the ocean, and thus modify in the Arctic and Antarctic regions the deposits taking place in the regions affected by them. The detritus from icebergs in the Atlantic can be traced as far south as latitude 36° off the American coast, and in the southern hemisphere as far north as latitude 40°.

The fact that sea water retains fine matter in suspension for a much shorter time than fresh water should be referred to here as having an important influence in limiting the distribution of fine argillaceous and other materials borne down to the sea by rivers, thus giving a distinctive character to deposits forming near land.

We have pointed out the influence of temperature and salinity upon the distribution of the surface organisms whose skeletons form a large part of some oceanic deposits, and may state also that the bathymetrical distribution of calcareous organisms is influenced by the chemical action of sea water. We will return to these influences presently when describing the distribution of the various kinds of deposits and their reciprocal relations, especially in those regions of the deep sea far removed from the mechanical action of rivers, waves, and superficial currents. The action of life as a geological agent has been indicated under the heading *Materials*.

Methods.—We give here an example showing the order followed in describing the deposits examined:—

Station 338; lat. 21° 15′ S., long. 14° 2′ W.; March 21, 1876; surface temperature 76°·5, bottom temperature 36°·5, depth 1990 fathoms.

GLOBIGERINA OOZE, white with slight rosy tinge when wet; granular, homogeneous, and very slightly coherent when dry; resembles chalk.

i. *Carbonate of Calcium*, 90·38 per cent., consists of pelagic Foraminifera (80 per cent.); coccoliths and rhabdoliths (9 per cent.); Miliolas, Discorbinas, and other Foraminifera, Ostracode valves, fragments of Echini spines, and one or two small fragments of Pteropods (1·38 per cent.).

ii. *Residue*, 9·62 per cent., reddish brown; consists of—

1. *Minerals* [1·62] m. di. 0·45 mm., fragments of feldspar, hornblende, magnetite, magnetic spherules, a few small grains of manganese, and pumice.

2. *Siliceous Organisms* [1·00], Radiolarians, spicules of Sponges, and imperfect casts of Foraminifera.

3. *Fine Washings* [7·00], Argillaceous matter with small mineral particles and fragments of pumice and siliceous organisms.

The description of the deposits has been made upon this plan, which was adopted after many trials and much consideration.

This is not the place to give the reasons which have guided us in adopting this mode of description, or to give in detail the methods that we have systematically employed for all the sediments which we are engaged in describing. These will be fully given in the introduction to our *Challenger* Report. We limit ourselves here to explaining the meanings and arrangement of terms and abbreviations, so that the method may be understood and made available for others.

The description commences by indicating the kind of deposit (red clay, blue mud, Globigerina ooze, &c.), with the macroscopic characters of the deposit, when wet or dry.

We have always endeavoured to give a complete chemical analysis of the deposit, but when it was impossible to do this we have always determined the amount of *Carbonate of Calcium.* This determination was generally made by estimating the carbonic acid. We usually took a gramme of a mean sample of the substance for this purpose, using weak and cold hydrochloric acid. However, as the deposits often contain carbonates of magnesia and iron as well, the results calculated by associating the carbonic acid with the lime are not perfectly exact, but these carbonates of magnesia and iron are almost always in very small proportion, and the process is, we think, sufficiently accurate, for, owing to the sorting of the elements which goes on during collection and carriage, no two samples from the same station give exactly the same percentage. The number which follows the words "*Carbonate of Calcium*" indicates the percentage of $CaCO_3$; we then give the general designations of the principal calcareous organisms in the deposit.

The part insoluble in the hydrochloric acid, after the determination of the carbonic acid, is designated in our descriptions "*Residue.*" The number placed after this word indicates its percentage in the deposit; then follow the colour and principal physical properties. This residue is washed and submitted to decantations, which separate the several constituents according to their density; these form three groups—(1) *Minerals*, (2) *Siliceous Organisms*, (3) *Fine Washings*.

1. *Minerals.*—The number within brackets indicates the percentage of particular minerals and fragments of rocks. This number is the result of an approximate evaluation, of which we will give the basis in our report. As it is important to determine the dimensions of the grains of minerals which constitute the deposit, we give, after the contraction *m. di.*, their mean diameter in millimetres. We give next the form of the grains, if they are rounded or angular, &c.; then the enumeration of the species of minerals and rocks. In this enumeration we have placed the minerals in the order of the importance of the *rôle* which they play in the deposit. The specific determinations have been made with the mineralogical microscope in parallel or convergent polarised light.

2. *Siliceous Organisms.*—The number between brackets indicates the percentage of siliceous organic remains; we obtain it in the same manner as that placed after the word *Minerals*. The siliceous organisms and their fragments are examined with the microscope and determined. We have also placed under this heading the glauconitic casts of the Foraminifera and other calcareous organisms.

3. *Fine Washings.*—We designate by this name the particles which, resting in suspension, pass with the first decantation. They are about 0·05 mm. or less in diameter. We have been unable to arrange this microscopic matter under the category of *Minerals*, for, owing to its minute and fragmentary nature, it is impossible to determine the species. We have always found that the *Fine Washings* increase in quantity as the deposit passes to a clay, and it is from this point of view that the subdivision has its *raison d'être.* We often designate the lightest particles by the name argillaceous matter, but usually there are associated with this very small particles of indeterminable minerals and fragments of siliceous organisms. The number within brackets which follows the words *Fine Washings* is obtained in the same manner as those placed after *Minerals* and *Siliceous Organisms*.

These few words will suffice to render the descriptions intelligible. Greater details will be given, as already stated, in the *Challenger* Report. It may be added that in the majority of cases we have solidified the sediments and formed them into thin slides for microscopic examination, and that at all times the examination by transmitted light has been carried on at the same time as the examination by reflected light. Each description is followed by notes upon the dredging or sounding, upon the animals collected, and a discussion of the analysis whenever a complete analysis has been made, which is always the case with typical samples of the deposits.

Kinds of Deposits.—We now proceed to the description of the various types of deposits into which it is proposed to divide the marine formations that are now taking place in the deeper water of the various oceans and seas. We will speak first of those which are met with in the deeper water of inland seas, and around the coasts of continents and islands, and afterwards of those which are found in the abysmal regions of the great oceans. Those coast formations which are being laid down on the shores, or in very shallow water, and which have been somewhat carefully described previous to the recent deep-sea explorations, are here neglected.

A study of the collections made by the *Challenger* and other expeditions show—

(1) That in the deeper water around continents and islands which are neither of volcanic nor coral origin, the sediments are essentially composed of a mixture of sandy and amorphous matter, with a few remains of surface organisms, to which we give the name of *muds*, and which may be distinguished macroscopically by their colour. We distinguish them by the names, *blue*, *red*, and *green muds*.

(2) Around volcanic islands the deposits are chiefly composed of mineral fragments derived from the decomposition of volcanic rocks. These, according to the size of the grains, are called *volcanic muds or sands*.

(3) Near coral islands and along shores fringed by coral reefs, the deposits are calcareous, derived chiefly from the disintegration of the neighbouring reefs, but they receive large additions from shells and skeletons of pelagic organisms, as well as from animals living at the bottom. These are named, according to circumstances, *coral or coralline muds and sands*.

Let us now see what are the chief characteristics of each of these deposits.

Blue mud is the most extensive deposit now forming around the great continents and continental islands, and in all inclosed or partially inclosed seas. It is characterised by a slaty colour which passes in most cases into a thin layer of a reddish colour at the upper surface. These deposits are coloured blue by organic matter in a state of decomposition, and frequently give off an odour of sulphuretted hydrogen. When dried, a blue mud is grayish in colour, and rarely or never has the plasticity and compactness of a true clay. It is finely granular, and occasionally contains fragments of rocks 2 cm. in diameter; generally, however, the minerals, which are derived from the continents, and are found mixed up with the muddy matter in these deposits, have a diameter of 0·5 mm. and less. Quartz particles, often rounded, play the principal part, next come mica, feldspar, augite, hornblende, and all the mineral species which come from the disintegration of the neighbouring lands, or the lands traversed by rivers which enter the sea near the place where the specimens have been collected. These minerals make up the principal and characteristic portion of blue muds, sometimes forming 80 per cent of the whole deposit. Glauconite, though generally present, is never abundant in blue muds. The remains of calcareous organisms are at times quite absent, but occasionally they form over 50 per cent. The latter is the case when the specimen is taken at a considerable distance from the coast and at a moderate depth. These calcareous fragments consist of bottom-living and pelagic Foraminifera, Mollusks, Polyzoa, Serpulæ, Echinoderms, Alcyonarian-spicules, Corals, &c. The remains of Diatoms and Radiolarians are usually present. Generally speaking, as we approach the shore the pelagic organisms disappear; and on the contrary, as we proceed seawards, the size of the mineral grains diminishes, and the remains of shore and coast organisms give place to pelagic ones, till finally a blue mud passes into a true deep-sea deposit. In those regions of the ocean affected with floating ice, the colour of these deposits becomes gray rather than blue at great distances from land, and is further modified by the presence of a greater or less abundance of glaciated blocks and fragments of quartz.

Green Muds and Sands.—As regards their orgin, composition, and distribution near the shores of continental land, these muds and sands resemble the blue muds. They are largely composed of argillaceous matter and mineral particles of the same size and nature as in the blue muds. Their chief characteristic is the presence of a considerable quantity of glauconitic grains, either isolated or united into concretions. In the latter case the grains are cemented together by a brown argillaceous matter, and include, besides quartz, feldspars, phosphate of lime, and other minerals, more or less altered. The Foraminifera and fragments of Echinoderms and other organisms in these muds are frequently filled with glauconitic substance, and beautiful casts of these organisms remain after treatment with weak acid. At times there are few calcareous organisms in these deposits, and at other times the remains of Diatoms and Radiolarians are abundant. When these muds are dried they become earthy and of a gray-green colour. They frequently give out a sulphuretted hydrogen odour. The green colour appears sometimes to be due to the presence of organic matter, probably of vegetable origin, and to the reduction of peroxide of iron to protoxide under its influence. The *green sands* differ from the muds only in the comparative absence of the argillaceous and other amorphous matter, and by the more important part played by the grains of glauconite, which chiefly give the green colour to these sands.

Red Muds.—In some localities, as for instance off the Brazilian coast of America, the deposits differ from blue muds by the large quantity of ochreous matter brought down by the rivers and deposited along the coast. The ferruginous particles when mixed up with the argillaceous matter give the whole deposit a reddish colour. These deposits, rich in iron in the state of limonite, do not appear to contain any traces of glauconite, and have relatively few remains of siliceous organisms.

Volcanic Muds and Sands.—The muds and sands around volcanic islands are black or gray; when dried they are rarely coherent. The mineral particles are generally fragmentary, and consist of lapilli of the basic and acid series of modern volcanic rocks, which are scoriaceous or compact, vitreous or crystalline, and usually present traces of alteration. The minerals are sometimes isolated, sometimes surrounded by their matrix, and consist principally of plagioclases, sanadin, amphibole, pyroxene, biotite, olivine, and magnetic iron; the size of the particles diminishes with distance from the shore, but the mean diameter is generally 0·5 mm. Glauconite does not appear to be present in these deposits, and quartz is also very rare or absent. The fragments of shells and rocks are frequently covered with a coating of peroxide of manganese. Shells of calcareous organisms are often present in great abundance, and render the deposit of a lighter colour. The remains of Diatoms and Radiolarians are usually present.

Coral Muds.—These muds frequently contain as much as 95 per cent. of carbonate of lime, which consists of fragments of Corals, calcareous Algæ, Foraminifera, Serpulæ, Mollusks, and remains of other lime-secreting organisms. There is a large amount of amorphous calcareous matter, which gives the deposit a sticky and chalky character. The particles may be of all sizes according to the distance from the reefs, the mean diameter being 1 to 2 mm., but occasionally there are large blocks of coral and large calcareous concretions; the particles are white and red. Remains of siliceous organisms seldom make up over 2 or 3 per cent. of a typical coral mud. The *residue* consists usually of a small amount of argillaceous matter, with a few fragments of feldspar and other volcanic minerals; but off barrier and fringing reefs facing continents we may have a great variety of rocks and minerals. Beyond a depth of 1000 fathoms off coral islands the debris of the reefs begins to diminish, and the remains of pelagic organisms to increase; the deposit becomes more argillaceous, of a reddish or rose colour, and gradually passes into a Globigerina ooze or red clay. *Coral Sands* contain much less amorphous matter than coral muds, but in other respects they are similar, the sands being usually found nearer the reefs and in shallower water than the muds, except inside lagoons. In some regions the remains of calcareous algæ predominate, and in these cases the name *coralline mud or sand* is employed to point out the distinction.

Such is a rapid view of the deposits found in the deeper waters of the littoral zones, where the debris from the neighbouring land plays the most important part in the formation of muds and sands.

When, however, we pass beyond a distance of about 200 miles from land, we find that the deposits are characterised by the great abundance of fragmentary volcanic materials which have usually undergone great alteration, and by the enormous abundance of the shells and skeletons of minute pelagic organisms which have fallen to the bottom from the surface waters. These true deep-sea deposits may be divided into those in which the organic elements predominate, and those in which the mineral constituents play the chief part. We shall commence with the former.

(*To be continued.*)

THE TWO MANNERS OF MOTION OF WATER[1]

IT has long been a matter of very general regret with those who are interested in natural philosophy that in spite of the most strenuous efforts of the ablest mathematicians the theory of fluid motion fits very ill with the actual behaviour of fluids, and this for unexplained reasons. The theory itself appears to be very tolerably complete, and affords the means of calculating the results to be expected in almost every case of fluid motion, but while in many cases the theoretical results agree with those actually obtained, in other cases they are altogether different.

If we take a small body, such as a raindrop, moving through the air, the theory gives us the true law of resistance; but if we take a large body, such as a ship moving through the water, the theoretical law of resistance is altogether out; and what is the most unsatisfactory part of the matter is that the theory affords no clue to the reason why it should apply to the one class more than to the other.

When seven years ago I had the honour of lecturing in this room on the then novel subject of vortex motion, I ventured to insist that the reason why such ill success had attended our theoretical efforts was because, owing to the uniform clearness or opacity of water and air, we can see nothing of the internal motion, and while exhibiting the phenomena of vortex rings in water, rendered strikingly apparent by partially colouring the water, but otherwise as strikingly invisible, I ventured to predict that the more general application of this method, which I may call the method of colour-bands, would reveal clues to those mysteries of fluid motion which had baffled philosophy.

To-night I venture to claim what is at all events a partial verification of that prediction. The fact that we can see as far into fluids as into solids naturally raises the question why the same success should not have been obtained in the case of the theory of fluids as in that of solids. The answer is plain enough. As a rule there is no internal motion in solid bodies, and hence our theory, based on the assumption of relative internal rest, applies to all cases. It is not, however, impossible that an at all events seemingly solid body should have internal motion, and a simple experiment will show that if a class of such bodies existed they would apparently have disobeyed the laws of motion.

These two wooden cubes are apparently just alike, each has a string tied to it. Now if a ball is suspended by a string you all know that it hangs vertically below the point of suspension, or swings like a pendulum; you see this one does so, the other you see behaves quite differently, turning up sideways. The effect is very striking so long as you do not know the cause. There is a heavy revolving wheel inside which makes it behave like a top.

Now what I wish you to see is that had such bodies been a work of Nature so that we could not see what was going on—if, for instance, apples were of this nature while pears were what they are, the laws of motion would not have been discovered, or if discovered for pears would not have applied to apples, and so would hardly have been thought satisfactory.

Such is the case with fluids. Here are two vessels of water which appear exactly similar, even more so than the solids, because you can see right through them, and there is nothing unreasonable in supposing that the same laws of motion would apply to both vessels. The application of the method of colour-bands, however, reveals a secret—the water of the one is at rest while that in the other is in a high state of agitation.

I am speaking of the two manners of motion of water—not because there are only two motions possible: looked at by their general appearance the motions of water are infinite in number; but what it is my object to make clear to-night is that all the various phenomena of moving water may be divided into two broadly distinct classes, not according to what with uniform fluids are their apparent motions, but according to what are the internal motions of the fluids which are invisible with clear fluids but which become visible with colour-bands.

The phenomena to be shown will, I hope, have some interest in themselves, but their intrinsic interest is as nothing compared to their philosophical interest. On this, however, I can but slightly touch. I have already pointed out that the problems of fluid motion may be divided into two classes, those in which the theoretical results agree with the experimental and those in which they are altogether different. Now what makes the recognition

1 Lecture at the Royal Institution on Friday, March 28, by Prof. Osborne Reynolds, F.R.S.

of the two manners of internal motion of fluids so important is that all those problems to which the theory fits belong to the one class of internal motions. The point before us to-night is simple enough, and may be well expressed by analogy. Most of us have more or less familiarity with the motion of troops, and we can well understand that there exists a science of military tactics which treats of the best manœuvres to meet particular circumstances. Suppose this science proceeds on the assumption that the discipline of the troops is perfect, and hence takes no account of such moral effects as may be produced by the presence of an enemy. Such a theory would stand in the same relation to the movements of troops as that of hydrodynamics does to the movements of water. For although only disciplined motion may be recognised in military tactics, troops have another manner of motion when anything disturbs their order. And this is precisely how it is with water: it will move in a perfectly direct, disciplined manner under some circumstances, while under others it becomes a mass of eddies and cross streams, which may be well likened to a whirling struggling mob, where each individual element is obstructing the others. Nor does the analogy end here. The circumstances which determine whether the motion of troops shall be a march or a scramble are closely analogous to those which determine whether the motion of water shall be direct or sinuous. In both cases there is a certain influence necessary for order: with troops, it is discipline; with water, it is viscosity or treaclyness. The better the discipline of the troops, or the more treacly the fluid, the less likely is steady motion to be disturbed under any circumstances. On the other hand, speed and size are in both cases influences conducive to unsteadiness. The larger the army and the more rapid the evolutions the greater the chance of disorder; so with fluid, the larger the channel and the greater the velocity the more chance of eddies. With troops some evolutions are much more difficult to effect with steadiness than others, and some evolutions which would be perfectly safe on parade would be sheer madness in the presence of an enemy. It is much the same with water.

One of my chief objects in introducing this analogy is to illustrate the fact that even while executing manœuvres in a steady manner there may be a fundamental difference in the condition of the fluid. This is easily realised in the case of troops, difficult and easy manœuvres may be executed in equally steady manners if all goes well, but the conditions of the moving troops are essentially different, for while in the one case any slight disarrangement would be easily rectified, in the other it would inevitably lead to a scramble. The source of such a change in the manner of motion may be ascribed either to the delicacy of the manœuvre or to the upsetting disarrangement, but as a matter of fact both these causes are necessary. In the case of extreme delicacy an indefinitely small disturbance, such as is always to be counted upon, will effect the change. Under these circumstances we may well describe the condition of the troops in the simple manœuvre as stable, while that in the difficult manœuvre is unstable, *i.e.* will break down on the smallest disarrangement. The small disarrangement is the immediate cause of the breakdown in the same sense as the sound of a voice is sometimes the cause of an avalanche, but since such disarrangement is certain to occur a condition of instability is the real cause of the change.

All this is exactly true for the motion of water. Supposing no disarrangement, the water would move in the manner indicated in the theory, just as if there were no disturbance an egg would stand on its end, but as there is always some slight disturbance it is only when the condition of steady motion is more or less stable that it can exist. In addition then to the theories either of military tactics or of hydrodynamics, it is necessary to know under what circumstances the manœuvres of which they treat are stable or unstable. It is in definitely separating these that the method of colour-bands has done good service, which will remove the discredit in which the theory of hydrodynamics has been held.

In the first place it has shown that the property of viscosity or treaclyness possessed more or less by all fluids is the general influence conducive to steadiness, while, on the other hand, space and velocity have the counter influence. Also that the effect of these influences is subject to a perfectly definite law, which is that a particular evolution becomes unstable for a definite value of the viscosity divided by the product of the velocity and space. This law explains a vast number of phenomena which have hitherto appeared paradoxical. One general conclusion is that with sufficiently slow motion all manners of motion are stable.

The effect of viscosity is well shown by introducing a band of coloured water across a beaker filled with clear water at rest. Then, when all is quite still, turn the beaker about its axis. The glass turns, but not the water, except that which is quite close to the glass. The coloured water which is close to the glass is drawn out into what looks like a long smear, but it is not a smear. It is simply a colour-band extending from the point in which the colour touched the glass in a spiral manner inwards; showing that the viscosity is slowly communicating the motion of the glass to the water within. To show this it is only necessary to turn the beaker back, and the smear closes up until the colour-band assumes its radial position. Throughout this evolution the motion has been quite steady—quite according to the theory.

When water flows steadily, it flows in streams. Water flowing along a pipe is such a stream. This is bounded by the solid surface of the pipe, but if the water is flowing steadily we can imagine the water to be divided by ideal tubes into a faggot of indefinitely small streams, any one of which may be coloured without altering its motion, just as one column of infantry may be distinguished from another by colour.

If there is internal motion, it is clear that we cannot consider the whole stream bounded by the pipe as a faggot of elementary streams, as the water is continually crossing the pipe from one side to another, any more than we can distinguish the streaks of colour in a human stream in the corridor of a theatre.

Solid walls are not necessary to form a stream. The jets from a fountain or the cascade in Niagara are streams bounded by free surfaces. A river is a stream half bounded by a solid surface. Streams may be parallel, as in a pipe; converging or diverging, as in conical pipes; or they may be straight and curved. All these circumstances have their influence on stability in the manner indicated in the accompanying diagram.

CIRCUMSTANCES CONDUCIVE TO

Direct or Steady Motion	*Sinuous or Unsteady Motion*
(1) Viscosity or fluid friction which continually destroys disturbance. Thus treacle is steadier than water.	(5) Particular variation of velocity across the stream, as when a stream flows through still water.
(2) A free bounding surface.	(6) Solid bounding walls.
(3) Converging solid boundaries.	(7) Diverging solid bounding walls.
(4) Curvature of the streams with the velocity greatest on the outside.	(8) Curvature with the velocity greatest on the inside.

It has for a long time been noticed that a stream of fluid through fluid otherwise at rest is in an unstable condition. It is this instability which renders flames and jets sensitive to the slight disarrangement caused by sound.

I have here a glass vessel of clean water in front of the lantern, so that any colour-bands will be projected on to the screen. You see the ends of two vertical tubes facing each other: nothing is flowing through these tubes, and the water in the vessel is at rest. I now open two taps, so as to allow a steady stream of coloured water to enter at the lower pipe, water flowing out at the upper. The water enters quite steadily, forms a sort of vortex ring at the end, which proceeds across the vessel, and passes out at the lower pipe. The coloured stream then extends straight across the vessel, and fills both pipes: you see no motion; it looks like a red glass rod. The red water is, however, flowing slowly, so slowly that viscosity is paramount, and hence the stream is steady. As the speed is increased, a certain wriggling, sinuous motion appears in the column; a little faster and the column breaks up into beautiful and well-defined eddies, and spreads into the surrounding water, which, becoming opaque with colour, gradually draws a veil over the experiment. The final breaking up of the column was doubtless determined by some slight vibration in the apparatus, but such vibration, which is always going on, will not affect the stream until it is in a sufficiently unstable condition. The same is true of all streams bounded by standing water.

If the motion is sufficiently slow, according to the size of the stream and the viscosity, the stream is steady and stable. Then at a certain critical velocity, determined by the ratio of the viscosity of the water to the diameter of the stream, the stream becomes unstable. So that under any conditions which involve a stream through surrounding water, the motion becomes unstable at sufficiently great velocities.

Now one of the most noticeable facts in experimental hydrodynamics is the difference in the way in which water flows along contracting and expanding channels. Such channels are now projected on the screen, surrounded and filled with clean, still water. The mouth of the tube at which the water enters is wide; the tube then contracts for some way, then expands again gradually until it is as wide as at the mouth. At present nothing is to be seen of what is going on. On colouring one of the elementary streams, however, outside the mouth, a colour-band is formed. This colour-band is drawn in with the surrounding water, and shows what is going on. It enters quite steadily, preserving its clear streak-like character until it has reached the neck, where convergence ceases; then on entering the expanding channel it is altogether broken up into eddies. Thus the motion is direct and steady in the contracting tube, sinuous in the expanding.

The theory of hydrodynamics affords no clue to the cause of this difference, and even as seen by the method of colour-bands the reason for the sinuous motion is not obvious. If the current be started suddenly at the first instant, the motion is the same in both parts of the channel. Its changing in the expanding pipe seemed to imply that there the motion is unstable. If this were so, it ought to appear from the theory. I am ashamed to think of the time spent in trying to make this out from the theory without any result. I then had recourse to the method of colour again, and found that there is an intermediate stage.

When the tap is first opened, the immediately ensuing motion is nearly the same in both parts; but, while that in the contracting tube maintains its character, that in the expanding changes its character: a vortex ring is formed which, moving forwards, leaves the motion behind that of a parallel stream through the surrounding water. When the motion is sufficiently slow, the stream is stable, as already explained; there is then direct motion in both the contracting and expanding portions of the tube, but these are not similar, the first being a faggot of similar elementary contracting streams, the latter being that of one parallel stream through surrounding fluid. The first is a stable form, the second an unstable, and on increasing the velocity the first remains, while the second breaks down, and, as before, the expanding tube is filled with eddies. This experiment is typical of a large class of motions. Whenever fluid flows through a narrow neck, as it approaches the neck it is steady, after passing the neck it is sinuous. The same is produced by an obstacle in the middle of a stream, and virtually the same by the motion of a solid through the water.

The object projected on the screen is not unlike a ship. Here the ship is fixed and the water flowing past it, but the effect would be the same were the ship moving through the water. In the front of the ship the stream is steady, so long as it contracts, until it has passed the middle; you then see the eddies formed as the streams expand again round the stern. It is these eddies which account for the difference between the actual and theoretical resistance of ships.

It appears then that the motion in the expanding channel is sinuous, because the only steady motion is that of a stream through still water. Numerous cases in which the motion is sinuous may be explained in the same way, but not all. If we have a parallel channel, neither contracting or expanding, the steady moving streams will be a faggot of steady parallel elementary streams all in motion but having different velocities, those in the middle moving the fastest. Here we have a stream but not through standing water. When this investigation began, it was not known whether such a stream was ever steady; but there was a well-known anomaly in the resistance encountered in parallel channels. In rivers and all pipes of sensible size experience had shown that the resistance increased as the square of the velocity, whereas in very small pipes, such as represent the smaller veins in animals, Poiseuille had proved that the resistance increased as the velocity. Thus since the resistance would be as the square of the velocity with sinuous motion, and as the velocity in the case of direct motion, it appeared that the discrepancy would be accounted for if it could be shown that the motion becomes unstable at sufficiently large velocities according to the size of the pipe. This has been done. You see on the screen a pipe with its end open. It is surrounded by water, and by opening a tap I can draw the water through it. This makes no difference to the appearance until I colour one of the elementary streams, when you see a beautiful streak of colour extend all along the pipe. So far the stream has been running steadily, and it appears quite stable. As the speed increases the colour-band naturally becomes finer, but on reaching a certain speed the colour-band becomes unsteady and mixes with the surrounding fluid filling the pipe. This sinuous motion comes on at a definite velocity; diminish the velocity ever so little, the band becomes straight and clear, increase it again and it breaks up. This critical speed depends on the size of the tube in the exact inverse ratio, the smaller the tube the greater the velocity. Also the more viscous the fluid the greater the velocity.

We have here then not only a complete explanation of the difference in the laws of resistance generally experienced and that found by Poiseuille, but also we have complete evidence of the instability of steady streams flowing between solid surfaces. The cause of this instability is not yet completely ascertained, but this much is certain, that while lateral stiffness in the walls of the tube is unimportant, inextensibility or tangential rigidity is essential to the creation of eddies. I cannot show you this, because the only way in which we can produce the necessary condition is by wind blowing over the surface of water. When the wind blows over water it imparts motion to the surface of the water just as a moving solid surface. Moving in this way the water is not susceptible of eddies, it is unstable, but the result is waves. This is proved by a very old experiment, which has recently attracted considerable notice. If oil be put on the surface it spreads out into an indefinitely thin sheet with only one of the characteristics of a solid surface, it offers resistance, very slight, but still resistance to extension or contraction. This resistance, slight as it is, is sufficient to entirely alter the character of the motion. It renders the motion of the water unstable internally, and instead of waves what the wind does is to produce eddies beneath the surface. To those who have observed the phenomenon of oil preventing waves there is probably nothing more striking throughout the region of mechanics. A film of oil so thin that we have no means of illustrating its thickness, and which cannot be perceived except by its effects—which possesses no mechanical properties that can be made apparent to our senses—is yet able to prevent an action involving forces the strongest that we can conceive, able to upset our ships and destroy our coasts. This, however, becomes intelligible when we perceive that the action of the oil is not to calm the sea by sheer force, but merely, as by its moral force, to alter the manner of motion produced by the action of the wind from that of the terrible waves on the surface into the harmless eddies below. The wind brings the water into a highly unstable condition, into what morally we should call a condition of great excitement; the oil by an influence we cannot perceive directs this excitement. This influence, although insensibly small, is however now proved to be of a mechanical kind, and to me it seems that this instance of one of the most powerful mechanical actions of which the forces of Nature are capable being entirely controlled by a mechanical force so slight as to be imperceptible does away with every argument against strictly mechanical sources for what we may call mental and moral forces.

But to return to the instability in parallel channels. This has been the most complete as well as the most definite result of the method of colour-bands. The circumstances are such as render definite experiments possible; these have been made and reveal a definite law of instability, which law has been tested by reference to all the numerous and important experiments that have been recorded with reference to the law of resistance in pipes, whence it appears that the change in the variation of the resistance from the velocity to the square of the velocity agrees as regards the velocity at which it occurs with the change from stability to instability. It is thus shown that water behaves in exactly the same manner, whether the channel is, as in Poiseuille's experiments, of the size of a hair, or whether it be the size of a water main or of the Mississippi. The only difference being that in order that the motions may be compared the velocities must be inversely as the size of the channels. This is not the only point explained.

If we consider other fluids than water, some fluids like oil or treacle apparently flow more slowly and steadily than water; this however is only in smaller channels. The velocity at which sinuous motion commences increases with the viscosity. Thus while water in ordinary streams is always above its critical velocity and the motion sinuous, the motion of treacle in such streams as we see is below its critical velocity and the motion is steady. But if Nature had produced rivers of treacle the size of the Thames the treacle would have flowed as easily as water. Thus in the lava streams from a volcano, although looked at closely the lava has the consistency of a pudding, in the large and rapid streams down the mountain side the lava flows with eddies like water.

There is now only one experiment left. This relates to the effect of curvature in the streams on the stability of the motion. Here again we see the whole effect altered by apparently a very slight cause. If the water be flowing in a bent channel in steady streams, the question as to whether the motion will be stable or not turns on the variation of the velocity across the channel. In front of the lantern is a cylinder with glass ends, so that the light passes through in the direction of the axis. The cylinder is full of water, the disk of light on the screen being the light which passes through this water, and is bounded by the circular walls of the cylinder. By means of two tubes temporarily attached, a stream of colour is introduced so as to form a colour-band right across the cylinder, extending from wall to wall; the motion is very slow, and, the taps being closed and the tubes removed, the colour-band is practically stationary. The vessel is now caused to revolve about its axis. At first only the walls of the cylinder move, but the colour-band shows that the water gradually takes up the motion, the streak being wound off at the ends into two spiral lines, but otherwise remaining still and vertical; when the streak is all wound off and the spirals meet in the middle, the whole water is in motion. But as the vessel is revolving, the motion is greatest at the outside, and is thus stable. There are no eddies, although the spiral rings are so close as nearly to touch each other. The vessel stops, and gradually stops the water, beginning at the outside. If this went on steadily, the spirals would be unwound and the streak restored; but as the velocity is now greater towards the centre, the motion is unstable for some distance from the outside, and eddies form, breaking up the spirals for a certain distance towards the middle, but leaving the middle revolving steadily. Besides indicating the effect of curvature, this experiment neatly illustrates the action of the earth's surface on the air moving over it, the variation of temperature having much the same effect on the stability of the moving fluid as the curvature of the vessel. The moving air is unstable for a few thousand feet above the earth's surface, and the motion consequently sinuous to this height. The mixing of the lower and upper strata produces the heavy cumulus clouds, but above this the influence of the temperature predominates; the motion is stable, and clouds, if they form, are stratus, like the inner spirals of the colour-bands.

REPORT ON ATMOSPHERIC SAND-DUST FROM UNALASKA [1]

THE specimen of sand which fell during a rain-storm, October 20, 1883, at Unalaska, Alaska, has been submitted to microscopical analysis, and found to be undoubtedly of volcanic origin. It is gray, and the grains are rather uniform in size, rarely attaining a diameter of 0·35 mm. Under a hand lens can be distinguished light-coloured crystals and fragments which are occasionally glassy in lustre, mixed with others of darker colours; both are more or less dusty in appearance from the presence of finer particles. For convenience of manipulation and preservation, as well as to render the optical tests more definite and decisive, the sand was mounted in Canada balsam upon glass slides, after the manner of thin sections of rocks for microscopical investigations. It is composed chiefly of either broken or complete crystals of feldspar, augite, hornblende, and magnetite, with numerous fragments of ground-mass and a few small particles of glass freighted with grains of iron oxide or other heavy minerals. The feldspar frequently occurs in well-preserved crystals. Cleavage plates are common, but irregular fragments predominate. A few thin cleavage lamellæ parallel to the base between crossed nicols show no bending due to polysynthetical twinning, and extinction takes place when the lines which indicate the clinopinacoidal cleavage are parallel to the principal section of either nicol. While it is evident that such thin plates are orthoclase, the prevailing feldspar is undoubtedly basic plagioclase, for chemical analysis shows the sand to contain only 52·48 per cent. SiO_2. The perfect crystals are usually about 0·15 × 0·13 mm. in size, and slightly tabular, parallel to the clinopinacoid. At times they present an almost hexagonal aspect, and generally contain inclusions so abundantly as to render the middle portion feebly translucent. Among the imprisoned particles may be recognised hornblende microlites, grains of iron oxide with crystallites of an indeterminable nature, and their arrangement frequently imparts a distinct zonal structure to the feldspar. The hornblende, which is not nearly as prominent a constituent of the sand as the feldspar, occurs chiefly in cleavage plates and irregular angular fragments. It has a brown to dark brown colour, with deep absorption and strong pleochroism, as in the andesite which it characterises. The size of the hornblende fragments varies within small limits, averaging 0·10 × 0·05 mm., and the extinction angle is about 9°. It occasionally contains numerous crystallites arranged parallel to the vertical ($\acute{c}$) axis. In the number of slides examined several brownish foliæ, apparently of biotite, were observed under such circumstances that their characterising optical properties could not be satisfactorily determined. Of the FeMg silicates augite is the most abundant. It is of a pale green colour, non-pleochroitic, and its angle of extinction as seen in the cleavage plates is about 46°. Like hornblende, it is found generally in irregular fragments. The prismatic fragments vary from 0·10 to 0·35 mm. in greatest length. The grains of magnetite, which may, in considerable quantities, be readily picked out of the sand with a magnet, are for the most part of irregular outline and small size. Instead of forming independent grains of themselves, they are generally found cleaving to fragments of the ground-mass, or included in the other minerals.

Besides the mineral ingredients already mentioned, the sand contains numerous irregular grains swarming with clear crystallites and microlites embedded in a grayish translucent to transparent, often amorphous, base. These composite fragments correspond to the ground-mass of the eruptive rocks to which the volcanic sand is allied. They vary in size up to a diameter of 0·26 mm., and are generally rendered heavier than they would otherwise be by small particles of magnetite or augite. The crystal fragments frequently have portions of the ground-mass attached to them, and present that ragged appearance which distinguishes volcanic sand from that which has been produced by other methods. Feldspar, augite, hornblende, magnetite, with fragments of the ground-mass, make up the bulk of the sand. Its composition is that of a hornblende-andesite very like those which occur at many points along the western coast. One is surprised to find a conspicuous deficiency in the most common and generally prevailing element of volcanic ashes. It is true that clear or sparingly microlitic glass particles are found in the sand from Unalaska, but they are rather exceptional and uncommon. This paucity in glass fragments may be readily comprehended by reflecting upon the origin and distribution of volcanic ashes.

The United States Geological Survey party sent out last summer in my charge under the direction of Capt. Dutton for the reconnaissance of the southern portions of the Cascade Range, collected a lot of volcanic sand about a dozen miles north-east of Mount Shasta. It does not form a thick deposit, but is widespread over the basaltic slopes south of Sheep Rock, and like that collected at Unalaska consists chiefly of crystal fragments, of which feldspar is the most abundant. Hornblende, hypersthene, augite, and magnetite are less prominent. In addition to these and numerous fragments of microlitic ground-mass, there are many clear or sparingly crystallitic glass particles of a pumiceous character. The composition of the sand is that of a hypersthene-bearing hornblende-andesite like that which forms the well-preserved and prominent crater springing up from the north-western slope of Mount Shasta, about two miles from that summit. This crater is the counterpart of Shasta cone, when we consider the whole volcanic pile, and has been christened Shastina by Capt. Dutton to indicate the relation it bears to its majestic neighbour. In the volcanic sand which travelled about a dozen miles north-east from Shastina, grains may be found having a diameter of 0·5 mm., so that it is, on the whole, considerably coarser and less uniform than that which fell at Unalaska, October 20, 1883, but like the latter it is made up chiefly of fragments of crystalline matter.

On the other hand, volcanic dust which has been carried long distances is composed principally of glass particles, and there is a conspicuous paucity of crystals and fragments of dense microlitic ground-mass. That which emanated from a crater in Iceland and fell over Norway and Sweden March 29 and 30, 1875, more than 750 miles from its source, is composed almost exclusively of sharp-edged angular glass fragments with curved sides. These splinters, chips, and shards of glass show by their more or less curved outlines, as well as by their tubular or vesicular structure, that they differ from pumice only in being fragmental. In the formation of pumice the inflation and distension by inclosed steam and gases is carried so far as to produce a froth, but if the same process be continued until explosion takes place,

[1] By J. S. Diller, Assistant Geologist, United States Geological Survey.

volcanic dust will be the result. The same might be said of the Krakatoa dust which has been collected far from its source. That which fell August 27 at Batavia, about sixty miles from Krakatoa, according to Renard, consists chiefly of glass particles, with plagioclase, augite, rhombic pyroxene, and magnetite, giving the general composition found in some augite-andesites In Krakatoa dust and pumice obtained from various localities in the vicinity of the Java coast, I have always found glass the most abundant constituent. The rhombic pyroxene, hypersthene, predominates largely over augite, and as Mr. Iddings has already shown, the ejected material belongs to hypersthene-andesite very like the pumiceous variety of the same rock upon the south-western slope of Mount Shasta in the Cascade Range.

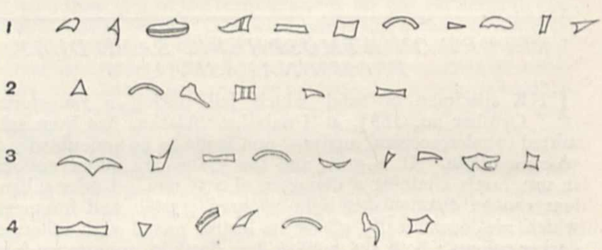
While it is evident that all kinds of ejected material, from the finest dust to the coarsest fragments, may be found upon their parent cone, yet it is true that all ashes which have been transported by the winds for distances greater than one hundred miles are composed chiefly of glass fragments distinguished by their pumiceous character. Volcanic glass may be considered an almost inevitable product of violent eruptions; and of all the important constituents of sand and dust formed in this way, it is the lightest. Furthermore, for a reason easily explained, it is blown to much finer dust-particles than any of the products of crystallisation. In a magma where crystallisation is taking place, the absorbed gases and uncombined water under enormous tension are gradually accumulated in that portion which is most liquid and least individualised. In this way the portion of the magma which upon solidification yields glass becomes stored with the energy that will cause its distension and perhaps blow it to atoms when the mass is relieved from the antagonising pressure. The individualised and unindividualised portions of the magma may be irregularly commingled, or they may arrange themselves, as is frequently the case in obsidians from Oregon, in more or less regular alternating bands. The streams of microlites must necessarily imprison less uncombined water or absorbed gases than the bands between them, so that when the pressure is relieved the latter will suffer the greatest amount of distension. If the tension of the confined water and gases is great enough, the amorphous portion of the magma may be blown to glassy dust, while the individualised portion, pulverised rather by external than internal forces, is not reduced to so high a degree of fineness. Volcanic dust is the extreme term of a series which begins in compact lava, and has for its middle members pumice in different stages of inflation. It appears to be a significant fact, at least as far as I have had an opportunity to observe, that effused pumice, *i.e.* pumice which occurs in places as froth upon a stream of obsidian into which it gradually passes, is highly microlitic. The glassy partitions which bound the more or less rounded vesicles are crowded with microlites and crystallites, while in ejected pumice where long, distended vesicles prevail, or in volcanic glass dust, the products of crystallisation are comparatively few or entirely wanting.

Prof. F. W. Clarke, chief chemist of the United States Geological Survey, has determined the amount of silica in the sand which fell at Unalaska, as well as that from the north-eastern slope of Mount Shasta. The former contains 52·48 SiO_2. As should be expected, it is more basic than hornblende-andesite, and indicates that the acid portion of the magma—the volcanic glass in the form of dust—was blown away from the sand. It is well known that the glassy base is in general the most acid portion of a rock, and any mechanical means by which the magma is separated into crystal sand and glass dust divides the rock into a basic and acidic portion. This division is in certain degrees indicated by the analysis of Renard and Iddings of material from the recent eruption of Krakatoa. The pumice contained only 62 per cent. of SiO_2, while the dust which fell at Batavia, according to Renard, contained 65per cent. of SiO_2. The few observations I have been able to gather indicate that even under favourable circumstances volcanic sand is not carried a hundred miles from its source, while dust from the same vent may be distributed over many hundreds of miles beyond the sand.

It is unfortunate that we do not possess more definite and detailed knowledge with reference to the source and distribution of the volcanic sand from Unalaska. Mr. Applegate, in his letter of transmittal dated October 22, says, "I forward by this mail a sample bottle of sand that fell during the storm of October 20, 1883. At 2.30 p.m. the air became suddenly darkened like night, and soon after a shower of mixed sand and water fell for about ten minutes, covering the ground with a thin layer. The windows were so covered that it was impossible to see through them. This sand is supposed to have come either from the Makushin or the new volcano adjacent to Bogeslov. The former is a distance of about nineteen miles to the south-west, but for years has only issued forth smoke or steam. The latter is a new one which made its appearance this summer, and burst out from the bottom of Behring Sea. It has been exceedingly active, and has already formed an island from 800 to 1200 feet high. Bogeslov is about sixty miles from here (Unalaska) in a west direction. The new volcano is about one-eighth of a mile north-west of it." Judging alone from the size of the grains of sand it seems probable that it may have been brought from Bogeslov. Its paucity in glass fragments as compared with the coarse sand from a dozen miles north-east of Shastina, indicates that it was carried a considerable distance from its source, so as to allow a pretty complete assorting of the material by the wind.

Grewingk, who has given us the most important contribution to the geology of Alaska, more especially of the Aleutian Islands, has prepared a geological map of Unalaska, and reports the volcanoes there as emitting basic lavas which, from his meagre description, appear to be similar to those poured out by volcanoes of the Cascade Range. It seems very probable that the volcanic sand ejected by Makushin must be of the same general composition as that which lately fell at Unalaska. Grewingk's work contains a description of the island of Bogeslov, but in it are contained no petrographic notes of importance. Of the rocks on the new volcanic island north-west of Bogeslov, for which the name Grewingk has been proposed, we have no information. If the sand under consideration really came from Grewingk, as seems most probable, we should expect the island to be made up of hornblende-andesite.

In connection with the all-absorbing topic, the peculiar sunset phenemena, much has been said of volcanic dust from Krakatoa. A surprisingly wide distribution has been assigned to it, and there is doubtless considerable scepticism concerning its identification. The forms of glass particles in volcanic dust are peculiar, and this, taken in connection with their isotropic character, renders them easily recognised under a polarising microscope. In the annexed figures Series No. 1 gives the outlines of glass fragments in Krakatoa dust. Series No. 2 is taken



from the volcanic dust which fell in Norway and Sweden, March 29 and 30, 1875. Series No. 3 represents the curious fragments found in an old quartz-porphyry tufa at Breakheart Hill, in Sangus, north of Boston. The forms of glass particles seen in the volcanic dust collected by Mr. Russell near the Truckee River are represented in Series No. 4. The fragments represented in Series No. 3 are now chiefly quartz, but were once particles of volcanic glass, and show that in the early geological history of Eastern Massachusetts there were volcanoes belching forth volcanic ashes like that of recent times, and flooding the country with acid lavas whose beautiful and regular fluidal banding has puzzled many observers and led them to suspect its sedimentary origin. It seems reasonable to suppose that the Grewingk crater must have yielded dust as well as sand, and that the former can, with a high degree of probability, be distinguished from the dust of Krakatoa. The glass dust from Grewingk, judging from that seen in the Unalaska sand, is less clouded than that from Java. In the Krakatoa dust it is hypersthene which is associated with the feldspar, augite, and magnetite, but in Grewingk dust we should expect to find hornblende.

A complete knowledge of the distribution of volcanic sand and dust has such an important bearing upon meteorological conditions, as well as upon volcanic phenomena, that it is hoped accurate and continuous observations may be made upon this subject at suitable meteorological stations. When we consider the dust in cities rising from the ground into the air during dry weather, as well as contributions, frequently glassy, made by various furnaces and factories, it is evident that observations for meteoric and volcanic dust should be made at elevated stations far removed from large cities. If a station were established upon Mount Shasta, California, as suggested by Mr. Gilbert Thompson, it would afford excellent opportunity for such observations. The station on Mount Washington is also favourably situated, and if regular observations were made at these stations and in Alaska for small as well as large quantities of such dust, and the sediments collected subjected to microscopical examination, the result would doubtless be of great interest.

Washington, D.C., March 25

THE POLAR CONFERENCE[1]

THE Fellows need hardly be reminded that it was at the suggestion of an Austrian, the late Carl Weyprecht, that this great international undertaking was set on foot, and accordingly Vienna was the most fitting city in which to welcome the several expeditions on their return to civilisation, and to discuss the best mode of utilising their labours.

The chiefs of nine expeditions were present at the meeting. The unrepresented stations were the two Russian ones, at Nova Zemlya and at the mouth of the Lena (at which latter station the observations will be continued until August 1884); that established by the Society of Science of Finland at Sodankylä, the German station in South Georgia, and the second American station at Lady Franklin Bay. As to the fate of the observers at the last-named locality there are unfortunately grave reasons for anxiety.

Most of the expeditions had brought home a collection of photographs, giving a vivid representation of their respective surroundings during their sojourn. Many of these possess ethnological interest, and one was humorous, as it showed the Dutch Arctic tin band, with instruments made out of preserved meat canisters.

I suppose my audience is aware that the Dutch Expedition was ice-bound and drifted about in the Kara Sea, ultimately saving itself in its boats. The ship was crushed in the autumn of 1882, but did not actually sink for six months, so that all the property was saved. Under such circumstances, however, it is no wonder that no magnetical observations were made.

As regards the publications, these are to be carried out independently in each country, but on a uniform plan. The meteorological observations are to be given in metric and centigrade measures; the magnetical according to the C.G.S. system of units.

The hourly observations are to be published in detail. The barometer observations are not to be corrected for gravity, but the value of this correction is to be given in the tables.

As regards terrestrial magnetism, besides the publication of the term day observations a detailed reproduction of all the observations for certain days of disturbance is to be given. A list of these days will be prepared by Prof. Wild.

All the members of the Conference are requested to collect data for earth currents for their respective countries during the period of the circumpolar observations. The auroral observations are to be published on the scheme proposed by Weyprecht.

As to the magnetic disturbances and their elimination there was, as might be expected, a long debate, but no definite resolutions were adopted.

The publication of a number of observations was left optional, such as evaporation, solar radiation, the resolution of the wind to four components, the calculation of wind-roses according as the pressure was above or below 760 mm., &c.

It is hoped that the whole of the results will have appeared by the end of 1885.

The Conference was most graciously received by the Emperor at an audience. The members were also entertained at a magnificent banquet on April 23 by Count Wilczek, at whose sole expense the Austrian Expedition to Jan Mayen had been fitted out and maintained during its stay.

The detailed report of the proceedings of the Conference will be published in French and German, and will appear before long.

[1] Notes on the Proceedings of the International Polar Conference, held at Vienna, April 17-24, 1884. Read at the Royal Meteorological Society by Robert H. Scott, F.R.S., President.

GEOLOGY IN RUSSIA

ALTHOUGH a large amount of geological work has been done in Russia, especially during the last twenty years, the geological exploration of this wide region has not been carried on in the detailed and accurate manner required by modern geology. An important step towards the attainment of more precise knowledge on this subject was taken in 1882 by the formation of a special Geological Commission intrusted with the geological survey of Russia. A yearly subsidy of 30,000 roubles was granted for that purpose by the State, to which must be added various occasional subsidies for special aims, supplied either by Government or by provincial assemblies and private bodies. This Commission has now published two volumes of its *Bulletin* and one fasciculus of *Memoirs*.[1] From these we learn that the chief work undertaken has been the preparation of a geological map of Russia on the scale of 10 versts (6·7 miles) to an inch. Russia has been divided into ten regions: Baltic, Central, Dnieper, Western Frontier, Volga and Don, Caspian, Ural, Crimea and Caucasus, Northern, and Finland. The survey has been started in several regions at once, each region being subdivided into three parts: (1) those which are well explored, and the maps of which already exist and could be employed for geological purposes; (2) those in which various isolated explorations have been made; and (3) unexplored parts. The explorations will be prosecuted first of all in the second of these three areas. The system of colours for the map will be adopted which was recommended by the Congress of Bologna. The explanations, as also the chief names, will be printed in French, side by side with the Russian text.

The first volume of the *Memoirs* contains a work by M. Lahusen, on the Jurassic fauna of the Government of Ryazan, written in Russian, with a summary in German. It is a complete enumeration of the Jurassic fossils of the region, the deposits of which belong—the black clay, with *Cardioceras cordatum*, to the Lower Oxfordian; the oolitic gray clay, with iron and *Cardioceras lamberti*, to the Upper Callovian; the gray and brown clays, with *Perisphinctes mosquensis* and *mutatus*, to the Middle; and the brown iron sandstone, with sheets of black clay and characterised by *Cosmoceras gowerianum*, *Cardioceras chamusseti*, and *Stephanoceras elatinæ*, to the Lower Callovian. The new fossils of the *Aucella* sandstone will be described by M. Nikitin. Eleven quarto plates illustrating a great number of species, many of which are new, accompany the paper.

The *Bulletin* (*Izvestia*) contains, besides the minutes of meetings, a number of preliminary reports of the geologists of the Survey, and the description, by M. Nikitin, of the sheet 58 (*Yaroslavl*) of the geological map of Russia. These notices are full of valuable information regarding the details of the geological structure of Russia. Among papers of more general interest we may mention Prof. Fr. Schmidt's report upon his explorations on the Baltic Railway, which embodies the results of his prolonged researches in the same region (vol. ii. fasc. 5). It has long been known that Esthonia is built up of Silurian formations, from beneath which rises the Cambrian Ungulite sandstone characterised by *Obolus apollinis*. After the emergence of the Silurian deposits, the country remained for a vast period a barren land undergoing atmospheric denudation. During this long lapse of time the terrace of the Glint, which runs from Lake Ladoga to Baltisch Port, was formed. During the Glacial period the country was covered with an immense ice-sheet, which moved south-west in its western parts, due south in the middle, and south-east in its eastern parts. The bottom moraine of this ice-sheet spreads over the country, and consists of a mixture of far-transported boulders with debris of the local rocks. It is the equivalent of the British Till and of the Swedish *Krossstensgrus*. It sometimes gets the local name of *Richk*. It rises into elongated hills or "drums," which extend also throughout the Government of Novgorod, and must be distinguished from the Åsar. These last, in the opinion of Prof. Schmidt, who indorses the explanation of A. Törnebohm, are shore-walls of those mighty sub-glacial rivers, so well described by Nordenskjöld, which circulate on the surface of the ice-sheets, and, after having found an exit through the ice, run beneath it.

During the first part of the Post-Glacial period the Gulf of Finland, and probably all the northern part of the Baltic Sea, formed an immense lake which subsequently was connected with the ocean, and received its brackish-water fauna. The level of this lake was about 60 feet higher than the present level of the Baltic. The presence of Baltic shells at greater heights in the north (the author of this notice found them at 124 feet, on

[1] *Izvestia geologicheskago Komiteta*, vols. i. and ii. (fasc. 1 to 6), 1882 and 1883.—*Trudy geologicheskago Komiteta*, vol. i. fasc. 1; 4to. (St Petersburg, 1883.)

the northern coast of the Gulf of Finland, seven miles distant from the sea-shore) is explained by the increase of the rate of upheaval of the country towards the north. This old lake, like Lake Ladoga of our days, seems to have had but a poor fauna. Many smaller lakes which covered Esthonia, had a peculiar freshwater fauna. Gravel and sand, with *Ancylus fluviatilis*, like that found in Lake Baykal, and *Lymnæus ovatus*, as also *Neritina fluviatilis*, *Paludina impura*, *Unio*, and *Cyclas* are found at heights varying from 50 to 150 feet above the actual sea-level. On Œsel these deposits are widely spread, and descend to a level of 20 feet above the sea. At a still later period the lakes were filled with ooze, which constitutes now the so-called "marl of prairies" (*Wiesenmergel*) filled up with *Planorbis*, *Lymnæus*, &c., and containing also remains of man, together with bones of reindeer, as described by Prof. Grewingk.

In connection with this subject reference may be made to the conclusions arrived at as to the glacial formations by M. Nikitin, while making the geological survey within the limits of sheet 58 of the geological map of Russia, comprising Yaroslav and the eastern parts of Novgorod and Tver. The features of the Till, or Boulder-clay, which covers this region, are so much at variance with the theory of floating ice, which has been proposed to explain them, as well as with every other aqueous theory, and so much in conformity with the idea of a bottom moraine, that M. Nikitin has been compelled to admit the former extension of the northern ice-sheet of the Glacial period throughout the region of the Upper Volga (vol. ii. fasc. 3). The Boulder-clay of the Government of Poltava, sometimes 20 m. thick, consists of triturated, unstratified materials, partly derived from sources within the region itself, and partly brought from the north. It contains scratched boulders, and though undoubtedly of glacial origin, its precise mode of formation still remains in dispute, notwithstanding the careful attention given to the study of the question by M. Armashevsky (vol. ii. fasc. 6).

UNIVERSITY AND EDUCATIONAL INTELLIGENCE

CAMBRIDGE.—The Natural Sciences Tripos, Part I., commenced on May 17; Part II. will commence on May 29.

The examiners in the Mathematical Tripos of 1883–84 have reported that the work done in Part II. was on the whole disappointing, and inferior to that usually done in the old "five-days" examination. They suggest that this may be due to its taking place in the Easter Term, in which revision of subjects is usually much interrupted. In Part III. eleven candidates presented themselves, of whom seven were placed in the first division. The work was extremely good, the candidates having judiciously specialised their reading.

SCIENTIFIC SERIALS

Bulletin de l'Académie Royale de Belgique, February 2.—On the crepuscular phenomena of the months of November and December 1883, by F. Terby.—On the physiological action of aspidospermine (bark of *Aspidosperma quebracho*), by Dr. Closson.—Remarks on some Sanskrit verbal roots of the eighth class, by J. van den Gheyn.—Contributions to the biography of the portrait painter A. de Vries, and of the Flemish painter Theodore van Loon, by Auguste Castan.—Biographical notice of the Dutch painter Marin van Romerswael, by Henry Hymans.

March 1.—Note on the Pons-Brooks comet 1812, observed at Louvain during the winter of 1883-84, by F. Terby, and at Brussels by L. Niesten.—On an empirical relation between the coefficient of internal friction of liquids, and its variations under changes of temperature, by P. de Heen.—Preliminary communication on the anatomy of the Acarians, a group of Arachnidæ, by J. MacLeod.—On the changes of refrangibility in the electrical spectra of hydrogen and magnesium, by Ch. Fievez.

Journal of the Russian Chemical and Physical Society, vol. xvi. fasc. 1.—The dilatation of liquids, by D. Mendeléeff. —On the tension of vapour of solutions, by D. Konovaloff. The author has resorted in his measurements to a method much like that of Magnus, and gives the results of his measurements (illustrated by curves) for mixtures of water with alcohols and acids: formic, acetic, propionic, and butyric; they are followed by a discussion on the distillation of solutions, on mixtures, and on the solubility of liquids.—On an acoustic instrument for measuring the number of vibrations, by A. Izraileff.—New demonstrations of the conditions of minimum of deviation of a ray by the prism, by K. Kraevitch. In most treatises on physics this demonstration is made by means of methods more or less artificial, excepting the treatise of Jamin, who has resorted to differential calculus. However long, M. Kraevitch's demonstration is very simple, and is deduced very naturally out of the fundamental laws of refraction.—On the friction of well lubricated bodies, by N. Petroff.

SOCIETIES AND ACADEMIES

LONDON

Royal Society, May 8.—"On a Relation between the Coefficient of the Thomson Effect and certain other Physical Properties of Metals." By Shelford Bidwell, M.A., LL.B.

Having observed that the coefficient of the Thomson effect is generally positive in those metals which have a great specific resistance and specific heat, and negative in those which are distinguished by a great coefficient of expansion, the author endeavoured to find an empirical formula expressing the coefficient of the Thomson effect in terms of the specific resistance, specific heat, and coefficient of expansion. Though he was not altogether successful, he believes that the subjoined table points to a close relation between them.

I. Metals	II. Coefficient of Thomson effect.	III. $H \times R - E^2$	IV. Last column divided by 2400
Ni	5·12	12320	5·13
Fe	4·87	9918	4·13
Pd	3·59	7086	2·95
Pt (soft)	1·10	2309	0·96
Pt (hard)	0·75	—	—
Mg	0·95	1384	0·58
Pb	0	− 604	−0·25
Al	−0·39	1942	0·81
Sn	−0·55	− 868	−0·36
Cu	−0·95	−1137	−0·47
Au	−1·02	−1172	−0·49
Ag	−1·50	−2246	−0·94
Zn	−2·40	−2355	−0·98
Cd	−4·29	−4958	−2·07

The first column contains the names of the metals, except alloys, given in Tait's thermo-electric diagram (*Trans. R.S.E.*, vol. xxvii. p. 125). The second column gives the coefficients of the Thomson effect: these are taken from Everett's table ("Units and Physical Constants," p. 151), which is based upon Tait's diagram.

H, R, and E being numbers proportional to the specific heats, specific resistances, and coefficients of expansion of the various metals, $H \times R - E^2$ gives the numbers in the third column of the table. $H =$ specific heat $\times 10^3$, $R =$ specific resistance $\times 10^3$, $E =$ coefficient of expansion $\times 10^8 \div 34$. The multipliers 10^3 and 10^8 were used merely for the convenience of getting rid of decimals; the divisor, 34, was so chosen that while the ratio of the first number to the last in Column III. should be as nearly as possible equal to the ratio of the first number to the last in Column II., the number corresponding to lead in Column III. should at the same time be as near zero as possible. Both conditions could not be exactly fulfilled at once. The authorities for the specific heats, specific resistances, and coefficients of expansion are given in the paper.

Column IV. gives the numbers in Column III. divided by 2400, to facilitate comparison with Column I.

It will be seen that with one exception the order of magnitude of the numbers in Column IV. is exactly the same as the order of those in Column II. The rate of decrease is not, however, the same, the numbers diminishing too rapidly in the upper half of Column IV., and too slowly in the lower half.[1]

[1] With regard to aluminium it is suggested that Matthiessen's determination of the specific resistance, 0·029, is possibly too high. Moreover the author found experimentally that the Thomson coefficient of the specimen of aluminium which he used was slightly + instead of −, as given in Column II.; it is also shown as + in the diagram at p. 178 of Jenkin's "Electricity." If its specific resistance were as high as 0·026, it would come between magnesium and lead in Column IV.

Geological Society, April 23.—Prof. T. G. Bonney, F.R.S., president, in the chair.—The following communications were read:—On the geology of the country traversed by the Canada Pacific Railway, from Lake Superior to the Rocky Mountains, by Principal J. W. Dawson, C.M.G., F.R.S. This paper recorded observations made by the author with reference to the geology of the North-West Territories of Canada, in an excursion in the summer of 1883, along the line of the Canada Pacific Railway as far as Calgary, at the eastern base of the Rocky Mountains. After referring to the labours of the Canadian Geological Survey, and more especially of Dr. G. M. Dawson, in this region, the author proceeded to notice the Laurentian, Huronian, and other pre-Silurian rocks of the west of Lake Superior and the country between that lake and the Red River. Good exposures of many of these rocks have been made in the railway-cuttings, and important gold-veins have been opened up. The Laurentian rocks present a remarkable uniformity of structure over all the vast territory extending from Labrador to the Winnipeg River, and where they reappear in the mountains of British Columbia. They are also similar to those of South America and of Europe; and there was on the table a collection of Laurentian rocks from Assouan, in Upper Egypt, made by the author in the past winter, which showed the reappearance of the same mineral characters there. In Egypt there is also an overlying crystalline series, corresponding in some respects with the Huronian. The Huronian rocks west of Lake Superior are, however, more crystalline than those of Lake Huron, and may be of greater age. The Palæozoic rocks are exposed in places on the western side of the old crystalline rocks near the Red River, and show a remarkable union and intermixture of Lower and Upper Silurian forms, or rather, perhaps, a transition from the one fauna to the other in a very limited thickness of beds. The collections of Mr. Panton, of Winnipeg, were referred to in this connection. The Cretaceous and Eocene beds of the plains were then noticed, and certain sections showing the coal-bearing series described; and comparisons were instituted between the Cretaceous and Eocene succession in Canada and that in the United States and elsewhere. The Pleistocene drift deposits constitute a conspicuous feature on the western prairies. Along the railway, Laurentian, Huronian, and Palæozoic boulders from the east may be seen all the way to the Rocky Mountains, near which they become mixed with stones from these mountains themselves. The vast amount of this drift from the east and north-east, and the great distance to which it has been carried, as well as the elevation above the sea, are very striking. The great belt of drift known as the Missouri Coteau is one of the most remarkable features of the region. It was described in some detail where crossed by the railway, and it was shown that it must represent the margin of an ice-laden sea, and not a land-moraine, and that its study has furnished a key to the explanation of the drift deposits of the plains, and of the so-called "Terminal Moraine," which has been traced by the geologists of the United States from the Coteau round the basin of the Great Lakes to the Atlantic.—On the Dyas (Permian) and Trias of Central Europe and the true divisional line of these two formations, by the Rev. A. Irving, B.Sc.

Zoological Society, May 6.—Prof. W. H. Flower, F.R.S., president, in the chair.—Prof. Bell exhibited some specimens of *Estheria melitensis* sent from Malta by Capt. Becher, R.A., and stated that, in answer to his inquiries, that gentleman had confirmed the fact of the males appearing to equal in number the females, as had been stated by previous observers of the members of the genus.—Mr. G. A. Boulenger read a paper on the reptiles and Batrachians of the Solomon Islands, principally based upon two collections forwarded to the British Museum from that locality by Mr. H. B. Guppy, R.N. — Lieut.-Col. Godwin-Austen, F.R.S., exhibited an old Indian drawing representing a tiger-hunt; and called attention to the colour of one of the elephants engaged, which was of a creamy white.—Prof. Flower, F.R.S., described the state of dentition of a young Capybara (*Hydrochœrus capybara*) born in the Society's Gardens, which had died when eight days old. All the teeth of the permanent series were present and in use.—Prof. F. Jeffrey Bell read a paper on *Amphicyclus*, a new genus of Dendroclinotous Holothurians, and on its bearing on the classification of the suborder.—A communication was read from Mr. Edgar A. Smith, containing a report on the land and freshwater Mollusca which had been collected during the voyage of H.M.S. *Challenger* from December 1872 to May 1876. The collection contained examples of 152 species, some of which were of interest and several new to science.—A communication was read from Count Berlepsch and M. Taczanowski, containing an account of a second collection of birds made in Western Ecuador by Messrs. Stolzmann and Siemiradzki. There were stated to be examples of 177 species in this collection, which had been made at various localities on the western slope of the Cordilleras above Guayaquil. The following species were described as new:—*Henicorhina hilaris, Chlorospingus ochraceus*, and *Sphenophila pauper*. A new genus, *Pœcilotriccus*, was proposed for *Todirostrum ruficeps* of Kaup.—A paper by Messrs. Godman and Salvin was read, which contained a list of the Rhopalocera obtained by Mr. G. French Angas during a recent visit to the Island of Dominica. The number of species in this collection was twenty-seven, among them being a species of Nymphalinæ apparently new; this the authors proposed to describe as *Cymatogramma dominicana*.—Mr. Herbert Druce read a paper describing the Heterocera collected by Mr. Angas on the same island.

Victoria Institute, May 6.—Vice-Chancellor Dawson, C.M.G., of McGill University, Montreal, read a paper on prehistoric man in Egypt and Syria, and described the investigations which he had carried on during the winter in Egypt and Syria. Dr. Dawson illustrated his paper by diagrams and specimens, among which were several of the bones of animals, in the classification of which Prof. Boyd Dawkins, F.R.S., had taken part; in dealing with his subject Dr. Dawson remarked that great interest attaches to any remains which, in countries historically so old, may indicate the residence of man before the dawn of history. In Egypt, nodules of flint are very abundant in the Eocene limestones, and, where these have been wasted away, remain on the surface. In many places there is good evidence that the flint thus to be found everywhere has been used for the manufacture of flakes, knives, and other implements. These, as is well known, were used for many purposes by the ancient Egyptians, and in modern times gun-flints and strike-lights still continue to be made. The debris of worked flints found on the surface is thus of little value as an indication of any any flint-folk preceding the old Egyptians. It would be otherwise if flint implements could be found in the older gravels of the country. Some of these are of Pleistocene age, and belong to a period of partial submergence of the Nile Valley. Flint implements had been alleged to be found in these gravels, but there seemed to be no good evidence to prove that they are other than the chips broken by mechanical violence in the removal of the gravel by torrential action. In the Lebanon, numerous caverns exist. These were divided into two classes, with reference to their origin, some being water-caves or tunnels of subterranean rivers, others sea-caves, excavated by the waves when the country was at a lower level than at present. Both kinds have been occupied by man, and some of them undoubtedly at a time anterior to the Phœnician occupation of the country, and even at a time when the animal inhabitants and geographical features of the region were different from those of the present day. They were thus of various ages, ranging from the post-Glacial or Antediluvian period to the time of the Phœnician occupation. In illustration of this, the caverns at the Pass of Nahr-el-Kelb and at Ant Elias were described in some detail, and also, in connection with these, the occurrence of flint implements on the surface of modern sandstones at the Cape or Ras near Beyrout. These last were probably of much less antiquity than those of the more ancient caverns.

SYDNEY

Linnean Society of New South Wales, March 26.—C. S. Wilkinson, F.G.S., F.L.S., president, in the chair.—The following papers were read:—On plants which have become naturalised in New South Wales, by the Rev. W. Woolls, Ph.D., F.L.S. In this paper the author not only deals with the various importations, whether intentional or otherwise, of new and often injurious weeds, but also with the general and deliberate destruction of the native flora, especially in timber. He also points out that many of our most valuable trees, as for instance the Myall (*Acacia pendula*), are dying out in consequence of the want of any kind of protection for the young plants. They are produced in abundance, but eaten down as fast as they grow. The paper contains a complete account of all the exotic *Mono-* and *Di-cotyledons* known in the colony.—The Australian *Hydromedusæ*, part i., by R. von Lendenfeld, Ph.D. It is proposed in this paper to describe a series of new species of *Hydromedusæ* of our shores. A new classification of the *Hydromedusæ* is proposed. The present paper forms a

Prodromus of a system of the *Hydroid Zoophytes* and *Craspedote Medusæ*, which will be used and marked out in detail in subsequent papers. The order of the *Hydromedusæ* is here divided into five sub-orders and twenty-one families.—The *Scyphomedusæ* of the Southern Sea, part ii., by R. von Lendenfeld, Ph.D. This paper is a continuation of the paper read at the last meeting of the Society, and contains a description of all the species of the third order of the *Scyphomedusæ*, the *Cubomedusæ*, which have been described from the South Sea.—On some fossil plants from Dubbo, New South Wales, by the Rev. J. Milne Curran, F.G.S. This paper, which was illustrated by specimens in an extraordinary state of preservation, and mounted for the microscope, is a very careful essay towards the determination of the (so-called) Hawkesbury beds at Dubbo, and names or describes as belonging to that formation the following forms, viz. :—*Sphenopteris crebra*, *S. glossophylla*, *Neuropteris australis*, *Thinfeldia odontopteroides*, *T. media*, *Alethopteris Currani*, *A. concinna*, *Merianopteris major*, and a Conifer, *Walchia milneana*. Of new species Mr. Curran names *Odontopteris macrophylla*, *Alethopteris* (*Pecopteris*) *australis*, *Hymenophyllipes dubia*, *Podozamites*, sp., and one Conifer set down doubtfully as *Walchia piniformis*.

BERLIN

Physiological Society, April 18.—Prof. Zuntz, with the help of a diagram, described and explained an apparatus for determining the gaseous inhalation and exhalation in the case of animals affected with curare. Essentially it consisted of two glass bells set by means of an electric motor into regular up-and-down rhythmical movements, alternately sinking into a larger vessel filled with mercury, and rising out of it. Each bell had two connecting-tubes, one communicating with the animal under examination, the other with other parts of the apparatus. One bell was connected with a graduated reservoir containing the air that was to be inhaled, while the second communicated with a bell, likewise graduated and filled with mercury, intended to receive the exhaled air. By means of inserted mercurial valves the path of air was so arranged that in the rising of the bells the first came into communication only with the reservoir, and filled itself with the contents of the same, while the second bell had communication solely with the trachea of the animal, and drew in the air of the lungs. In the sinking of the bells, on the other hand, the first communicated with the trachea, and forced the air that was to be breathed into the lungs, while the second communicated with the reservoir, and emptied into it the air previously exhaled from the lungs. This apparatus kept up the most regular artificial respiration in animals paralysed by curare for any length of time, even for many hours, and enabled, on the one hand, gases that might be exactly measured, and of any composition that might be desired, to be employed for the purpose of respiration; on the other, the products that were exhaled to be collected for measurement and chemical analysis. A whole series of other arrangements connected with this respiratory apparatus, provided automatically for supplying the reservoir with exactly the appointed kind of air and in uniformly identical mixture, as also for producing and conducting to the reservoir, automatically, the requisite quantities of oxygen for determinate experiments.—Dr. Kempner, with the apparatus above described, had, in the laboratory of Prof. Zuntz, instituted measuring experiments on the influence of the proportion of oxygen in the air that was to be inhaled on the consumption of oxygen and the exhalation of carbonic acid from the lungs. It was a universally accepted doctrine that the proportion of oxygen in the air to be inhaled might vary within very wide limits, from between 100 and 15 per cent., without essentially affecting the respiration, and that only when the oxygen sank to 5 per cent. or less did phenomena of suffocation appear. This view, which was based principally on the experiments of Regnault and Reiset, was not, in Dr. Kempner's opinion, sufficiently justified by the experiments referred to. In consequence he some years ago carried out experiments on himself by inhaling, for the space of ten minutes on each occasion, by means of forced inspiration, air of different proportions of oxygen, and then analysing the exhaled air. From these experiments he found that respiration and the consumption of oxygen were not influenced by a higher than the normal proportion of oxygen in the air that was breathed. With a reduction, however, of the oxygen in the air to be inhaled below the normal proportion, the consumption of oxygen became likewise reduced. It might be supposed that this result, which was at variance with the general view on the subject, was due to the abnormal conditions of respiration and the forced inspiration. It was necessary, therefore, that this result should be confirmed by experiments on animals. Such, accordingly, were soon afterwards carried out by Dr. Kempner, and yielded a result similar to that arrived at in the experiments on men. Seeing, however, that the movements of the animal might have affected the result, Dr. Kempner determined on repeating the examination with animals that had been subjected to curare. The experiments were carried out on animals with the respiratory apparatus of Prof. Zuntz. After fasting for twenty-four hours, the animals were kept, throughout the time that the experiments lasted, in exactly the same temperature—which was a warm one—and they made thirty artificial respirations per minute. The result yielded by these last experiments was that with a higher than the normal proportion of oxygen in the air breathed the consumption of oxygen was not different from that in the case of normal air. When, however, the proportion of oxygen sank to 18 per cent., the consumption of oxygen became diminished, and decreased still further in proportion as the oxygen of the air was further lessened. Similarly the amount of carbonic acid exhaled was affected by the reduced proportion of oxygen in the inspired air. Carbonic acid also decreased with the decrease of oxygen, though not in the same degree as did the consumption of oxygen, a circumstance which pointed to the fact that in the exhaled carbonic acid was contained a certain portion of this gas formed by processes of dissociation independently of the oxygen of the inhaled air. An explanation of this fact, of such high importance physiologically, that a reduced proportion of oxygen in the air inhaled was attended by a reduced consumption of oxygen, was next given by the speaker, and in conclusion he indicated a series of practical useful applications which might be made of the fact.

CONTENTS

PAGE