THURSDAY, JUNE 12, 1890.

ELECTRIC VERSUS GAS LIGHTING.

L'Éclairage Électrique actuel dans Différents Pays. By Jules Couture. (Paris: J. Michelet, 1890.)

IN this, the second edition of this pamphlet, a comparison is made between the prices of lighting by electricity and gas at Milan, Rome, Paris, Tours, Manosque, Perpignan, Marseilles, and New York. In Milan, the electric energy is either charged for by a fixed rate per lamp per year, plus a payment for each hour during which the lamp is turned on (the fixed annual rate and the hourly payment depending on whether the lamps be of 10 or of 16 candles), or the payment may be made to depend entirely on the consumption. In the latter case, however, the hourly payment per lamp diminishes with the number of lamps employed in the building, the rate per hour varying from 6 centimes for a 10-candle lamp if there be not more than 40 lamps, to 3⅞ centimes per 10-candle lamp if the number exceed 151. The incandescent lamps at Milan appear to require 6 watts per candle, and are therefore evidently specimens of the old Edison lamp; at the present day, however, there are lamps that can be incandesced with 40 per cent. less power, and still have a long life. In comparing the price of lighting by electricity and gas, M. Couture assumes that one Bengel gas-burner consuming 105 litres of gas per hour gives 10 candles. This is equivalent to 5·9 cubic feet per hour for 16 candles. Now a good Argand burner with London gas will give 16 candles for a consumption of 5 cubic feet per hour, whereas a common burner will not give more than 5 or 8 candles. M. Couture's typical burner and the Milan gas must therefore be good, whereas, as already mentioned, the incandescent lamps employed in Milan must be of an old character. Nevertheless, since electric lighting is supplied at 9 centimes per hour for a 16-candle lamp, and at 5·6 centimes (or about one halfpenny) in buildings using many lamps, the Milan Gas Company thought it wise to drop their price from 36 to 25 centimes per cubic metre of gas in the regions of the town supplied with electricity. For the benefit of readers who may study the copious information contained in this French treatise, we may mention that the London price of 2*s.* 6*d.* per 1000 cubic feet of gas is equivalent to almost exactly one penny per cubic metre.

In Rome, the Anglo-Roman Gas Company have utilized alternate-current transformers to distribute electric energy throughout the town from an electric station with 2700 horse-power, constructed on their own grounds, and have thus avoided the erection of expensive central stations in the town itself. The price charged is 8 centimes per hour for a 16-candle glow-lamp, and this M. Couture regards as a very remunerative one. It represents about 2½ times the cost in Rome of lighting with improved 16-candle Wenham gas-burners. M. Couture speaks of the two dynamos employed there as being the largest in the world, but, as they are only of some 500 horse-power each, it is clear that the author has not heard of the dynamos at Deptford, one of which has been running for some time, and which produces 1500 horse-power. Indeed, M. Couture is wonderfully silent about the electric lighting of towns in England, and makes no reference whatever to the prices charged for electric energy at various places in this country, or to the regulation of these prices by the systematic action of the Board of Trade.

Various installations employing transformers are referred to, amongst others that at Tours, and it is mentioned that the new price charged there for electric energy is only about 30 per cent. more than for an equivalent amount of gas. The only reference to electric lighting in Great Britain is to the first use of transformers when the Metropolitan Railway stations at "Edgard Road" and "Olgate" were experimentally lighted in 1883; and of the large amount of electric lighting work that has been carried out on the Continent by English engineers nothing is said, if we except the statement that "Badkok" and Wilcox boilers are used at Marseilles and at other towns. The value of the book, which is considerable, would have been increased if some reference had been made to "Sir Siemens" and "Sir Crompton," since certain large towns abroad, not mentioned in this book, owe their electric lighting to the exertions of these firms.

Formerly, electrical companies maintained installations at a loss, for the sake of advertisement; while gas companies, to avoid losing the streets that were lighted, have continued the lighting for a return less than the cost price. The financial results of electric supply companies have often not been sufficiently prosperous to enable interest to be paid upon the capital invested, but the same may be said of many gas companies in the early days of their existence. At Dijon, a central electric station has been rendered commercially impossible by the Gas Company dropping their price from 45 to 25 centimetres per cubic metre when they heard that the erection of one was contemplated.

The Marseilles Gas Company was the first gas company to establish a central station for the purpose of ascertaining the conditions under which the new method of lighting could be advantageously used in conjunction with gas and oil. Since 1881, when the Marseilles Gas Company first took up electric lighting, they have gradually extended their operations, so that to-day the electric lighting of the town is considerable. At the rates charged, it is 20 per cent. dearer to obtain 10 candles for 1000 hours in the year by electricity than with a *good* gas-burner; but if the time of lighting be extended to 2000 hours, electric lighting is only 6 per cent. dearer than gas lighting, and in the case of a 10-candle lamp lighted for 3000 hours in the year, electricity and gas come out equal in price. Consequently, if the gas be burnt in common burners, or if governors be not employed to keep the pressure of the gas constant, lighting with gas will actually be dearer in Marseilles than by means of electric glow-lamps. However, as the author points out, it is very important to see that a 10-candle glow-lamp really gives an illumination of 10 candles, since it is by the lamp, and not by the light, that the charge is made.

Electricity is, of course, now being much used where gas was formerly employed, but an interesting example is given in this book of electricity being resorted to for the lighting of a town in which gas could not be adopted. Manosque, in the Basses Alps, was lighted, up to 1888, with oil, the municipality not being able to introduce gas, as nearly all the houses had cellars under the public street; but for the last two years the town has been lighted by means of electricity. The price charged is either at a fixed rate per month, independently of the number of hours the lamp is lighted, or the consumer can pay for the actual time the lamps are used at the rate of 5½ centimes per hour for a 16-candle lamp, 4 centimes for a 10-candle lamp, and 3½ centimes if the lamp be of 8 candles. It is interesting to notice that this charge of 5½ centimes per hour for a 16-candle lamp is almost exactly equivalent to 8*d.* per Board of Trade unit—the legalized rate for London.

At Perpignan, the prices per hour per lamp are the same as at Manosque, but if the lighting be charged at a fixed rate per month, the rate for a 10-candle lamp is either 3½ or 6 or 8 francs per month, depending on whether the lamp is put out every night at 10 o'clock or at midnight, or is left alight all night.

In Paris, gas costs 30 centimes per cubic metre, or, roughly, 7*s.* 6*d.* per 1000 cubic feet, while, for a 10-candle glow-lamp, 4·8 centimes per hour is charged; the user has also to pay an annual subscription of 4 francs, and he has to replace his lamp after 1000 hours at a cost of 4 francs. With these figures the author concludes that electric lighting with glow-lamps is 40 per cent. dearer than lighting with gas.

The largest single electric installations of *arc*-lamps is at Brooklyn, in America, where the Thomson-Houstin Company supply current for 1325. The following the author gives as the prices paid per hour for the current for one arc-lamp:—

Detroit	29 centimes.	
Paris	40 ,,	
Milan	44 ,,	if burning all night.
,, ...	50·2 ,,	,, only until midnight.
Marseilles ...	52·5 ,,	burning only until midnight.

To enable a comparison to be made, we have ascertained that the yearly price charged for the arc-lamps on the Parades of the English watering-places is equivalent to about 35 centimetres per arc-lamp per hour.

M. Jules Couture concludes his treatise in a very judicious manner as an old director of the Marseilles Gas Company:—"Little Jack Gas lives still, and will continue to live, I hope, for a long time yet. To prolong its existence, gas will not hesitate to inscribe on its banner, 'Gas-Electricity,' because its advocates are not at all adverse to progress."

The treatise forms a handy reference-book for those interested in the progress of electric lighting. It would have been well, however, if the author had given the price of *electric energy* in the various towns, instead of the price per ampere or the price for the current for a particular lamp. Constant reference is made to the supply of the light "*au moyen de compteurs*" in the various towns. Electrical engineers would have gladly welcomed some information as regards the character and the behaviour, satisfactory or otherwise, of the meters employed. We have already said that we think statistics of electric lighting in Great Britain might well have been added, seeing that it is now nearly two years ago since the Englishman's backwardness in taking up electric lighting began to disappear.

In justice to the consumers of gas, more stress should have been laid on the fact that ordinary gas-burners are very inefficient things. It might, for example, have been pointed out that, while as much as 6 candles per cubic foot of gas consumed per hour can be obtained with a Welsbach or with an albo-carbon burner, as little as ⅗ of a candle per cubic foot consumed per hour is the meagre efficiency of certain twopenny-halfpenny nondescript burners. And if such a nondescript burner be ungoverned, as it probably will be, since people who have not the sense to buy good gas-burners are not likely to buy governors for them, then, when the pressure of the gas rises in the mains, the burner will not give more than ⅙ a candle per cubic foot. So that a burner passing 5 cubic feet of London gas per hour may give any illumination from 3 to 30 candles, depending on the nature of the burner.

In dealing, therefore, with the vexed question of the relative cost of lighting with electricity and gas, we must remember that, apart from glow-lamps causing much less damage than gas to books and decorations of rooms, lighting with glow-lamps at 8*d.* per Board of Trade Unit costs no more than lighting with ungoverned common gas-burners using gas at 2*s.* 6*d.* per thousand cubic feet. On the other hand, lighting with glow-lamps costs about 3 times as much as lighting with governed Argand burners, and 4 or 5 times as much as using albo-carbon or Welsbach burners.

A TEXT-BOOK OF GEOLOGY.

The School Manual of Geology. By J. Beete Jukes, F.R.S. Fifth Edition. Edited by A. J. Jukes-Browne, B.A., F.G.S. (Edinburgh: A. and C. Black, 1890.)

THE title and success of this handy little book lead one to inquire how far and where geology is taught in schools. There is no doubt that the subject has for scholars, particularly in the country, the strongest fascination; and the fine museum of Marlborough is an example of how "natural history" studies may be kept alive in seats of youthful learning. But it would be interesting to know how many schools, excluding special evening-classes, can give such a work as this a place in their curriculum, and thus carry back the history of England, Rome, and Greece to the earliest dawn of life upon the globe. The preliminary training for the appreciation of geological features such as every lad can see around him need not be excessively severe; the mere appreciation is at first the great thing—the knowledge that there is something to be learnt in road-side quarries, in familiar hollows of the hills, beside which the "Dictionary of Antiquities" seems like a fashion-book of yesterday; while at the same time, perhaps, the kinship of the boy with his favourite classic hero becomes something more real and inspiriting in face of the enormous past beyond them both.

While the work before us is a concise and convenient text-book, we suspect that, from mere force of circumstances, it aims more at the individual student than at the school-boy and the class. Just as William Smith, at the beginning of the century, pleaded for geology as a study advantageous to land-owners, so the editor appeals in his preface to the practical good sense of parents. The claims of education in natural history as a means to individual and mutual happiness are perhaps too well known to need assertion; at any rate, it is not fashionable to put them forward.

For schools, one would like in this book a little more of the breath of the open country, such as appears in the few lines descriptive of the Cotteswolds; but the direct appeal to Nature in chapter ix. is very refreshing and characteristic of the author. Where, indeed, the work has been altered from the first edition of 1863, it is in matters of more recent discovery, its tone being fully preserved. Some little notes have gone, such as that on the difficulties of the Welsh "ll" on p. 216 of the original (p. 261 of the present edition is more serious); but the references to history and familiar authors remain, even to Wilkie Collins, while the introduction of derivations has been considerably and interestingly extended. Quaint effects in such matters cannot always be avoided, as in the following (p. 247), "Illænus (*squint-eye*) Davisii (*after Mr. Davis*)."

It is difficult in such a book to deal with rival theories; but the discussion of coral-islands, carried over seven pages, scarcely does justice to Darwin's position, and is certainly not complete—as in accounting for the atoll—in its statement of more recent views. Nor can we consider the treatment of the specific gravity of the earth (p. 8) as altogether beyond question, accepting as it does the continuous compressibility of crystalline bodies.

To come to small matters, the use of "potash" in different senses on pp. 46 and 48 may mislead the tyro; the spelling "tachylite" is adopted for "tachylyte"; and "Protospongia fenestella" for "fenestrata" occurs on both p. 238 and p. 239. On p. 329 we have, freshly inserted, the Pterodactyl from Owen's "Palæontology." This figure, arising from the difficulty of interpreting some of the earlier specimens, still appears in well-regulated text-books, but is sometimes accompanied with warning foot-notes; here it is aggravated by having its digits numbered, and the existence of a fifth, "answering to the little finger in our own hands," is distinctly stated in the text. But the other woodcuts are numerous and effective; and we have a few bold drawings of natural features as they actually appear, which always appeal strongly to the untrained observer. It is too much to ask for full-page sketches of our British scenery; but we look back in this matter somewhat regretfully on that earlier work of Jukes, the "Popular Physical Geology," illustrated by Du Noyer, and published with undoubted spirit by Reeve and Co. in 1853. G. C.

OUR BOOK SHELF.

Magnetism and Electricity. By W. Jerome Harrison, F.G.S., and Charles A. White. (London: Blackie and Son, 1890.)

WE note one or two features in this work which make it worthy of commendation; for example, the authors have avoided speaking of magnetic or electric fluids, and have endeavoured to bring out the fact that these forces are but "states or affections of matter," and their endeavour is much to be praised. It is also good to see an introductory chapter on "Matter and Force," and a special chapter on "Potential," about which elementary students, as a rule, know very little. Most of the diagrams, however, are of the stock kind, and with the exception of the above points the book possesses nothing to distinguish it from many other elementary manuals dealing with the same subject

Science applied to Work. By John A. Bower. (London: Cassell and Co., 1890.)

THERE is much that is praiseworthy in this little work; it is an easy introduction to mechanics, and free from all mathematical formulæ, is written in very clear language, and deals entirely with the mechanics of every-day life. The book has been designed especially for the artisan section of the National Home Reading Union, and will doubtless be a means of eradicating the rule-of-thumb work which is still characteristic of a large proportion of the artisan community. Many hints are given for making simple apparatus to demonstrate the principles laid down, the applications of these principles are well pointed out, and the work altogether meets the requirements of the class for whom it is intended.

LETTERS TO THE EDITOR.

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Testing for Colour-Blindness.

DR. OLIVER LODGE asks (May 29, p. 100) why those interested in testing for colour-vision do not employ Lord Rayleigh's arrangement, in which yellow is matched by certain proportions of red and green.

This suggests to me a difficulty I have felt for many years. I am partially colour-blind, and have the usual difficulty in seeing whether a fuchsia or a *Pyrus Japonica* is in flower or not. I have noticed that many persons speak of flowers such as *Lychnis flos-Jovis*, or *Epilobium angustifolium*, &c., as being red. I should unhesitatingly class them among blue or purple flowers. They give me no suggestion of red, but I observe that when thev are coloured in botanical works, such as Sowerby's "Botany," &c., they are painted of a decidedly reddish colour, and not as they appear in Nature. I used to attribute this to carelessness, but it is now evident to me that two colours which when placed side by side appear identical to normal vision do not appear at all identical to the colour-blind. Doubtless pigments could be found which would produce similar impressions on both orders of vision, but this is only a matter of chance. An investigation on these lines might give useful information.

On the question of flag signals, I would observe that though I can make nothing out of the ordinary dull greens, reds, and browns, and am ready to believe anything that is told me about them, my impressions of scarlet and orange are intensely distinct and vivid. Scarlet (and especially orange scarlet) is the most vivid and beautiful colour which I know, and utterly unlike any other; it becomes nearly black in very faint twilight. I could recognize a flag of scarlet or orange under any possible circumstances and at almost any distance. If danger flags had this colour they would perfectly suit the ordinary colour-blind, and could never be mistaken for green.

On the subject of night signals I cannot make a useful suggestion. Green lights are very distinct, but they appear to me as a poor blue with very little power in them. Red lights are distinct enough compared side by side with ordinary yellow ones, but seen alone under unfavourable circumstances there is nothing to catch the eye or the imagination, and they might easily be mistaken for yellow or ordinary lights.

London, June 9. LATIMER CLARK.

Coral Reefs—Snail Burrows.

IN regard to Dr. von Lendenfeld's letter (May 29, p. 100) it may suffice for me to say that I had not seen his reviews of Darwin's "Coral Reefs" in the periodicals which he names (for I find it impossible to keep level with the advancing flood of scientific literature), and that if his reply "considerably modifies the meaning" of what I wrote, I must leave it to others to settle whether this be in a favourable or an unfavourable sense.

Turning to another matter: in reference to an interesting paragraph on p. 110 concerning the excavation of rock by snails, a subject on which I once wrote (*Geol. Mag.*, 1869, 1870), may I ask whether any of the readers of NATURE are acquainted with instances of these burrows occurring in non-calcareous rocks? All which I have seen were in limestone, and, as I believe, always in a pure variety. Hence, in the case of snails, one would suspect that the excavation was mainly due to chemical action.

T. G. BONNEY.

Coral Reefs, Fossil and Recent.

I SUPPOSE it will be expected of me that I should answer the two objections raised by Captain Wharton (May 22, p. 81), viz. (1) that he knows of no steep submarine reef-slopes exceeding 4000 feet in height; and (2) that the lagoons could not be so shallow as they are if we assumed any extensive positive shifting of the coast-line.

From the statements in the literature on the subject, concerning point (1), I select the following three:—

Captain Fitzroy found at the Keeling no bottom 2200 yards from the breakers with a line 7200 feet long (Darwin, "Coral Reefs").

Bourne says in his account of Diego Garcia (Proc. Roy. Soc., vol. xliii.), that the Maldives, Laccadives, and the Chagos rise from a bank 1000 fathoms below the surface very abruptly.

Heilprin ("Bermudas") states that the Bermudas rise abruptly out of a depth of 12,000 to 13,000 feet.

Concerning point (2), I cannot see why the gentle inward slopes of atolls should not be in harmony with the subsidence theory. It must be borne in mind that the shifting of the coast-line is both slow and oscillating. Positive and negative shiftings alternate. The latter predominates on the whole. Dr. Murray says that in shallow water the accumulation of material exceeds the removal by solution. I have professed my accordance with this view in my previous letter. Particularly in an inclosed or partially inclosed lagoon, sheltered from ocean currents, this filling-up process will be a rapid one. We can easily conceive that it will balance the subsidence until the lagoon becomes so shallow as to impede the life of those organisms whose skeletons form the raising-up deposit. If there is any oscillatory negative shifting of coast-line, the dry rim will rise, and extend horizontally, and afford to the atmospheric agencies a larger surface wherefrom material can be washed into the lagoon.

On the whole, if there is anything difficult to explain, it is that the lagoons are as deep as they are. Deep lagoons are, however, not common, and are generally only met with in large and interrupted atolls. Perfectly dry central depressions (with deposits of gypsum and the like) are by no means infrequent in very small atolls. The general proportionality of the depth and the horizontal extent of the lagoons is perfectly in accordance with the subsidence theory. It supports no other theory better than this one.

R. VON LENDENFELD.

Photographs of Water Drops.

IN NATURE of May 22 (p. 95) there is an account given of the discussion following Mr. C. V. Boys's demonstration of his photographs of falling water drops at the meeting of the Physical Society. In the course of this discussion, Lord Rayleigh, who was naturally much interested in the subject, remarked that it had never occurred to him that it would be possible to get enough light from a single spark to photograph the drops as Mr. Boys had done. And Lord Rayleigh believed Mr. Boys's success was owing to the fact of his using no lenses, which would absorb the ultra-violet rays.

With reference to this, it might, perhaps, be interesting to mention that I succeeded very well, some years ago, in photographing water drops, falling through air, with single sparks, the light of the spark passing two glass lenses and the objective of a camera which gave magnified images. My photographs (copies of which appeared in the *Annalen der Physik und Chemie*, vol. xxx., 1887) show all the forms obtained so very beautifully by Mr. Boys. From photographs taken at different depths below the orifice of the tube I could measure the periodic time of the elliptical vibrations and of the vibrations according to the next higher spherical harmonic, and show that the ratio of these two periodic times agreed very closely with the formulæ given by Lord Rayleigh in the Proc. Roy. Soc., 1879. The amplitudes had no influence upon the periodic times.

Richmond, Surrey, June 6. P. LENARD.

THE CLIMATES OF PAST AGES.[1]

I.

IT happens sometimes in the history of science that a few striking facts lead to the building up of a far-reaching theory, which at first satisfies us, and with which, without being rigorously critical, we endeavour to bring the further results of experience into conformity. But contradictions and difficulties gradually manifest themselves, and go on accumulating, until at last we are convinced that we have built on an unsure foundation, and that the edifice that we have raised upon it must be utterly pulled down. Then follows a period of discussion and collection of further evidence, during which we abstain from any attempt to substitute new and more correct explanation for that which we have abandoned, until by assiduous labour we shall have prepared a broader and more stable basis for the superstructure.

In such a stage of transition, the old ground abandoned, the new not yet won, is our knowledge of the climatic conditions of our earth in bygone ages. In the far north a rich mass of fossilized plants and coal-beds had been found in the Carboniferous formation. Reef-building corals, such as to-day live only in tropical seas, were yielded by the Carboniferous limestone and the Silurian formation up to 80° of northern latitude; and many of the species were found to range, without any essential change of form, from arctic to temperate, nay in some cases even to equatorial regions. From a small number of data such as these it was hastily concluded that, under the influence of the internal heat of the earth, a warm uniform climate must have prevailed generally from the pole to the equator, while a sultry atmosphere, heavily charged with water vapour and carbonic acid, prevented the sun's rays from reaching the earth or in any case from exercising any considerable influence on it. As a consequence, the existence of climatic zones or of a distribution of the fauna and flora in such zones was denied. It was held that with the beginning of the Tertiary era a polar cooling first set in, and that it increased during its passage, until the present distribution of heat was brought about as the final result of this long-continued process.

The falsity of these assumptions is now pretty generally recognized, and the number of their adherents diminishes daily. It would lead us too far afield were we to follow out the hypothesis into all the details of its ofttimes fantastic errors, and to note their individual failure. It will be more to the purpose if, in the first place, we test the methods by which we arrive at conclusions on the temperature conditions of past ages, in order that we may thus gain a knowledge of what these really were and of the better-grounded attempts to explain them.

Among the more important data for judging of the climate of a past epoch, is the character of its plants and animals, on the assumption that these various organisms must have lived under nearly the same conditions of temperature as their nearest relatives now existing. This kind of reasoning has been very extensively applied, and within certain limits its validity cannot be gainsaid. If, for instance, in a comparatively recent deposit of the Pleistocene period in Central Europe, we find remains of the arctic willow, the dwarf birch, the white dryas, together with such mammals as the lemming, the musk-ox, the

[1] Translation of a Lecture delivered by the late Dr. M. Neumayr before the Society for the Dissemination of Natural Science, at Vienna, on January 2, 1889.

glutton, the arctic fox, and also certain snails which, at the present day, live in Lapland or the higher Alps, we may safely conclude that a severe climate formerly prevailed there. An example of the opposite kind is afforded us by the later Tertiaries, which belong, indeed, to a considerably earlier but still not very remote period. Here we find, in our own neighbourhood, a flora of plants with evergreen coriaceous leaves, such as now grow in the warmer parts of the Mediterranean area, and we are quite justified in concluding that a higher temperature was once here prevalent. But, although in many cases such conclusions are well founded, a universal extension of this kind of reasoning leads to deceptive results, and the whole method must be applied with the greatest caution.

In the first place, we must bear in mind that, even at the present day, some forms that are nearly related to each other live under very diverse conditions. Antelopes, for instance, are for the most part animals characteristic of warm regions, and yet a kind of antelope, the chamois, lives in a very severe climate in the high mountains of the temperate zone. The arctic fox lives in the far north beyond the polar limit of trees, the Fennec in the burning African desert, and yet the two are nearly related to each other. The elephant and rhinoceros are at the present time peculiar to hot countries, and yet we know from unmistakable evidence that species of both these genera prevailed in Europe and Northern Asia in the cold Pleistocene climate. We have similar instances among marine animals, and we may adduce a whole series of cases in which a group of forms is predominantly peculiar to a certain kind of climate, but have individual representatives living under totally different conditions. The molluscous genera *Voluta* and *Terebra*, for example, are among the most characteristic inhabitants of warm seas, but each of them has a representative in the icy waters of the Magellan's Straits. And among land plants we have the remarkable fact that many forms of the north temperate zone, when they have been transplanted or have escaped to far warmer regions, have extended in an extraordinary manner, and locally to such an extent that they have overpowered and displaced the indigenous flora, as has occurred with the most diverse species of European weeds when transported to foreign countries.

On the whole, we are inclined to infer that, with the exception of the Pleistocene fauna and flora, the animal and plant remains of past ages, in their generality, point to a warmer climate than that which we now experience; and in point of fact, several very striking items of evidence lead to that conclusion. The most important is the very great extension of reef-building corals in the older deposits, while their modern representatives are restricted to the warmer seas.

Many other instances of the same kind may be quoted, while in other cases similar conclusions have been somewhat uncritically based on insufficient evidence. Thus, some have inferred the prevalence of a high temperature from the abundance and occasional great size of the chambered-shelled Cephalopoda, solely because the last existing representative of this once widely distributed group, the well-known Nautilus, happens to live in a warm sea. This conclusion is quite unjustified, for it is obvious that the many thousands of extinct species must have lived under very varied conditions; and if we are to infer, from the great size of these creatures, that they lived in warm seas, we ignore the fact that the largest Cephalopoda of the present day, the cuttle-fishes, are most prevalent in the northern part of the temperate zone.

But even when we have excluded all such evidently erroneous cases, the number of those in which fossil forms do really present the characters of types highly characteristic of warm regions is very considerable. It is true, that the opposite case sometimes presents itself, though less frequently. Thus, in all the older formations, a group of Bryozoa, the Cyclostomata, is extensively distributed, but it is now especially preponderant in the circumpolar seas. The molluscous genus *Astarte*, so common and widely distributed in Mesozoic deposits, is at the present day entirely restricted to cold seas; and there also occurs the last representative of the once widely spread genus *Cyprina*. The Brachiopodous genus *Rhynchonella*, common in the Silurian formation, and especially abundant in the Jurassic and Cretaceous formations, is now a form of high northern latitudes, and the Squaloid genus *Selache*, now restricted to the seas of Greenland, occurs in Cretaceous deposits in much more southerly latitudes.

Such instances, and they are far from singular, teach us, unmistakably and assuredly, that animal and vegetable types are not unchangeable in respect of the external conditions of their existence, and especially of temperature, but that they are capable of accommodating themselves to changed circumstances. Whether, then, we infer that reef-building corals formerly lived in cooler waters, or that Cyclostomoid Bryozoa frequented warmer waters than at the present day, or finally that both have changed their habit of life, the conclusion is overwhelmingly forced upon us that organisms continually adapt themselves to changed temperatures, and in a far higher degree than has generally been supposed.

In connection with this, we may notice a very remarkable circumstance, viz. the great vitality, adaptability, and toughness of the organisms of the temperate and especially the north temperate zone, when transported to other parts of the globe. Just as European man carries on a successful struggle with the children of all other zones of the earth, so also do the animals and plants indigenous to Europe, and especially those of its central and northern parts. As already remarked, when they are transplanted to foreign countries, they extend rapidly, and often drive out the indigenous forms; English naturalists who have had most opportunities of observing these relations in their colonies, speak expressly of the great aggressiveness of North European organisms.

At the present time, when the dissemination of the most diverse forms is brought about in the highest degree by world-wide human intercourse, such displacements present themselves in a particularly striking manner, and yet similar processes must have gone on, more slowly indeed, but on a far greater scale, for many millions of years. At some given epoch, a certain assemblage of organic forms appears in moderately cold regions, from which colonists wander away southwards; these gradually adapt themselves to the new local conditions, and spread still further, until, at last, their further progress is stayed by some natural barrier. They become acclimatized under the new conditions and the higher temperature, and become enfeebled; but in the meantime new forms have been developed in their former home, which in their turn pursue the same course and suffer the same fate; and thus the southern types always display a certain relationship to the older forms of the northern region, without any change having supervened in the temperatures of their respective stations.

We now see with how great caution we must proceed, when we attempt to draw any inference as to the temperature of former ages from the relationship of species, stratigraphically remote, with those of the existing organic world. The danger of error is here very great, and it is the greater and more menacing, the older the deposit the climatic conditions of which are in question; obviously, the probability of a change having taken place in organic constitution with regard to temperature is the greater, the more remote the epoch with which we are dealing. While, therefore, we may deduce conclusions having some claim to probability, on the climatic conditions of Pleistocene and Tertiary times, even in the Mesozoic deposits such conclusions become doubtful, and quite untrustworthy when we are concerned with Palæozoic times. We must, indeed, admit that as the result of more searching criticism, and the increased knowledge of the facts which the labours of many years have now amassed for us, we are not in a position to answer that most important and fundamental question whether a continuous and universal cooling of terrestrial climate has or has not been progressing from the time of the earliest stratified deposits down to the present day.

The difficulties with which we have to contend in dealing with this problem may be illustrated by a very significant example. The fact has already been noticed that reef-building corals occur only in warm seas, in which, throughout the year, the surface-temperature never sinks below 20° C. If now we compare the geographical distribution of the reef-building corals of the older formations, we find in very early times, in Silurian and Carboniferous deposits, the remains of such corals beyond the Arctic circle; at a much later period in the Jurassic formation, we find that they reach only to North Germany and to Southern England; during the second half of the Cretaceous formation, they do not pass the northern limit of the Alps and the mountains of Southern France, and their northern limit in the first half of the Tertiary era is nearly the same. At the beginning of the second half of the Tertiary era, we find them but scantily represented on the northern boundary of the Alps, and abundant only in Southern Europe; and in the latest subdivisions of the Tertiaries, in Pliocene times, they have almost disappeared from Europe.

From these facts it might seem almost a manifest conclusion that there has been a continuous fall of temperature since Silurian times, in consequence of which reef-building corals have retrograded through some fifty degrees of latitude; nevertheless, on closer examination, we find that such an inference would be altogether premature. In the first place, the Palæozoic corals differ very essentially from those that now exist, and therefore their requirements in respect of warmth may have been totally different; further, we have no knowledge of any coral reefs in the far north in all the older formations; and between the Carboniferous and Jurassic formations which we have cited, there intervene the Permian and the Trias in which we know of no reef-building corals so far north; the most northerly representatives of the group in Permian times appear in North-Western India, those of Triassic times in the Alps. We are therefore absolutely ignorant whether these changes of distribution, supposing them to have depended on the temperature, are not to be ascribed to alterations in the distribution of temperature, while there may have been no continuous cooling. Lastly, it is by no means definitely ascertained that the position of the earth's axis has always been the same as at present; indeed, there are in the course of geological time certain definite epochs pointing to such a displacement of the poles, of which we have yet to gather the meaning. It may therefore be the case that those parts of the earth at which we find Silurian and Carboniferous corals in the neighbourhood of the pole, were much nearer the equator in those early times than they now are.

Similar difficulties present themselves in all our attempts to arrive at far-reaching conclusions by this method, and thus we are admonished how great caution must be exercised in the face of so many sources of error. Another method, by means of which it has been sought to attain some holding ground for determining the climatic characteristics of early times, is that, leaving out of consideration the conditions under which nearly related organic types exist at the present time, we should simply regard the extent of the geographic distribution of extinct organisms, and from their wide distribution conclude the existence of a uniform climate over very great areas, nay even over the entire globe. But in such an attempt the risk of over-estimating the facts is imminent, and especially is this true in the case of marine organisms; in a former state of our knowledge, we might well have believed that ancient forms of life had a wider distribution than such as now exist, since our knowledge of the tenants of the present seas related almost exclusively to those of shallow water and the coasts, many of which have a restricted range. But from the epoch-making deep-sea soundings of the last decennia, we have learned much of the inhabitants of the depths of the ocean, and have become aware that they possess much the same characters in all parts of the world; so that, in this respect, there is no essential difference between the present and former ages. As a fact, we have ascertained, from the distribution of organic life, that climatic zones existed in most of the early periods, and that this has not been done in some cases may be simply ascribed to the fact that they have not yet been rightly investigated.

Side by side with the diverse indications afforded us by the animal and vegetable worlds, regard must be had to the petrographic characters of the old deposits. We have rocks which have issued from the interior of the earth and have solidified from the fluid state, others have been deposited from water, and in the formation of others, again, ice has played an important part, and this mode of formation is generally recognizable by well-marked characters. For our present purpose, only such masses are important as have been transported by ice and thus brought to their present position, for these alone furnish us with conclusions as to temperature conditions; they inform us that, whenever they occur, the cold has been, at least at times, sufficiently great to freeze large masses of water.

The marks of ice action are well known. A moving glacier polishes and scores or scratches its rock floor, and carries with it fine silt, sand, great and small stones, and even mighty boulders, and deposits these materials in its moraine, without sifting them according to magnitude, as in the case of transport by water. Polished and grooved rock surfaces, scratched pebbles, and deposition without stratification in a confused mixture of silt, sand, coarse pebbles, and enormous blocks, are the indications of glacier deposits; in the identification of which, nevertheless, great caution is necessary. If a glacier reaches the sea or a great lake, under certain conditions, masses of ice may be floated away to great distances, carrying with them the enclosed stones and boulders, and often deposit them when thawed out of the iceberg, on the sea-bottom at great distances from their place of origin. Thus the deep-sea investigations of the *Challenger* show that, in high southern latitudes, in the deep sea and far from any coast, numerous stones lie scattered on the fine silt of the ocean-floor, and these can have reached their present position only by such means of transport. Such indications are, however, not quite undeceptive, since it sometimes happens that stones are transported in the roots of trees which are carried by rivers into the sea; but this kind of transport is operative only to a very small extent. When, however, we find in old formations water-formed deposits of fine clay or sand extending over great areas, in which numerous great stones and boulders are promiscuously intermingled, we may infer that they have been transported by floating ice, especially when the stones moreover are scored.

We have now learned what are the most important indications from which we may draw inferences as to the climatal conditions of past ages, and we have endeavoured to ascertain how far, and within what limits, such inferences are legitimate. Our next task will naturally be to apply the conclusions thus established to the phenomena which we meet with at different epochs of the past, and to form a conception of the climatic relations of those times, and of the conditions depending on them. It would, however, lead us too far afield were we to discuss each period in detail, and we must restrict ourselves to a hasty sketch of a few especially important formations that have been closely studied.

We pass over the oldest deposits, for the interpretation of which but few points of vantage present themselves, and we shall fix our attention on the upper half of the Carboniferous formation, the so-called Coal-measures. It has received this name because in many countries it contains those thick beds of fossil fuel which have become an indispensable factor of modern industries, and without which the actual status of our social and political condition could not have been attained. So great is the quantity of the fuel herein stored, that all that is furnished by other geological formations, taken together, falls far short of it. There is much difference of opinion as to the mode in which coal has been formed; but whatever disagreement there may be in matters of detail, this much is certain, that we have in coal the altered remains of a land-vegetation, which, partly at least, flourished in swamps. Of course the formation is not all or even chiefly coal; even where it is richest in coal, by far the greater part of the formation consists of shale, sandstone, and conglomerate, and the coal-beds are here and there interstratified, forming but a fraction of the total thickness. We may picture to ourselves the building up of the formation by supposing that a plain or depression was sometimes covered with water, sometimes dried up. When flooded, chiefly with fresh and but rarely with sea-water, beds of shale or sandstone were deposited; when dry, land or swamp plants sprang up, and their decayed remains furnished the material of coal. Then followed another period of inundation, and thick beds of shale, sandstone, and conglomerate were again deposited. . . . .

The vegetation that in its decay formed our beds of coal was of a peculiar character. As yet there existed no trees (with true foliage) and no flowering plants. A monotonous growth of plants with stiff leaves then clothed our continents. A great part in it was played by *Calamites*, great plants which no longer exist, and whose nearest relatives are the mares' tails so often met with in marshy ground; another important type was that of the *Lepidodendra*, large trees whose forked stems were covered with leaf scars arranged in a regular geometrical pattern, and the branches of which were clothed with short, stiff, grass-like leaves; and most important of all, the *Sigillarias*, the unbranching and twigless stems of which were marked with leaf scars in perpendicular rows and scale-like leaves. Both of these are long since extinct; and only the insignificant club-mosses of our present flora recall to us the varied gigantic forms of that distant age.

H. F. B.

(*To be continued.*)

LIGHTNING AND THE ELECTRIC SPARK.[1]

AT a date at least as remote as 600 years B.C. the Greek philosophers were acquainted with a curious little fact to which the modern science of electricity owes its name. They knew that a piece of amber (ἤλεκτρον) when rubbed against some suitable substance acquired a temporary attractive power, in virtue of which it became capable of lifting and holding light objects, such as dry leaves or pieces of straw. But another remarkable effect which often attends the friction of amber was for many centuries altogether overlooked. In A D. 1708 it was first noticed by Dr. Wall that a piece of strongly excited amber emitted sparks, which were accompanied by crackling sounds, and these he had the sagacity to compare to thunder and lightning.

It must be confessed that the recognition of any resemblance between the microscopic scintillations thus produced and the brilliant lightning flash imposed a somewhat severe strain upon even the scientific imagination, and a few years later Stephen Gray, in reference to the same comparison, expressed the hope that "there might be found out a way to collect a greater quantity of the electric fire" than was then possible. His hope was realized by the subsequent improvement of electrical apparatus, and especially by the invention of the Leyden jar; and the effects obtainable by the means now at our command amply justify the speculations of Wall and Gray. The essential identity of the artificial electric spark with the natural lightning flash was conclusively established by the experiments of Franklin, and in these days it has become a mere common-place, familiar to everyone.

There are generally said to be two kinds of lightning flash, which are known as forked lightning and sheet lightning, the former being dangerous and destructive, the latter harmless. To these is sometimes added a third class, called ball lightning. The lightning flash of artists which is familiar to us from innumerable pictures, and of which the venomous-looking zigzag now projected upon the screen (copied from an engraving) is a fair example, has no existence in nature. It is simply an artistic fiction or symbol, like the conventional representation of a galloping horse, which, in the severe language of Mr. Muybridge, resembles nothing to be found in the heavens above or in the earth beneath. The absurdities commonly perpetrated in depicting animals in motion have been fully exposed by Mr. Muybridge with the assistance of photography. So, too, it is photography that has given the *coup de grâce* to the traditional forked lightning. Within the last few years an immense number of photographs of lightning flashes have been made. The Meteorological Society has formed a collection of these, containing about 200 examples, which, by the kindness of Mr. Marriott, the Secretary of the Society, I have had an opportunity of examining carefully. Not a single instance of the artistic lightning flash is to be found among them. The great majority bear a close resemblance to the sparks of our electrical machines: a few are distinguished by peculiarities which, though at first sight a little difficult to account for, can generally be explained and even imitated artificially.

What may be called a typical lightning flash is a stream of light which follows a sinuous and wavering course, very like that of a river as shown upon a map. [Several photographs of this kind of flash were exhibited by means of the lantern.] The next slide is a photograph of a machine-spark, about $3\frac{1}{2}$ inches in length. The two kinds of discharge are so much alike in their general character that if it were not for the surroundings it would be hard to tell which was the lightning and which the artificial spark.

The variations upon the normal type of flash, which the Meteorological Society's photographs show, have been classified as ramified or branched lightning, beaded lightning, meandering or knotted lightning, ribbon lightning, and, lastly, dark lightning.

Branched lightning is again strikingly suggestive of a river in a map; not a simple stream, however, but one into which a number of tributaries flow. [Photographs were shown.] Sparks having branches of just the same character are easily produced by a large electrical machine. To obtain the effect well, the negative terminal should be made much larger than the positive, and the two should be separated so far that a spark will only just pass between them. According to Faraday, a ramified, or as he sometimes calls it a "brushy," spark occurs when the whole of the electricity has not been discharged, but only portions of it, more or less, according to circumstances. It is a "dilute" spark, generally passing to air or other badly conducting matter ("Exp. Res.," § 1448). When therefore a ramified flash occurs we may reason-

[1] Extracted from a lecture on "Electrical Phenomena in Nature," delivered by Mr. Shelford Bidwell, F.R.S., at the London Institution on February 10, 1890.

ably conclude that the discharge is partial and incomplete.

In beaded lightning there occur a number of bright spots, giving the flash the appearance of an irregular string of lustrous beads. This phenomenon is sometimes well shown in photographs of the machine spark, especially when the quantity of electricity passing is increased by using very large Leyden jars. Under these circumstances the path of the discharge is often found to contain at irregular intervals certain small and abrupt V-shaped indentations, and these, especially when seen "end-on," appear to be more luminous than other portions of the flash. Probably, therefore, in a beaded flash the quantity of electricity passing is more than ordinarily great.

Sometimes a lightning flash appears to take a very circuitous and roundabout path, perhaps forming a nearly closed loop, or even a complete knot. Such is what the Thunderstorm Committee of the Meteorological Society have called "meandering" lightning. This remarkable effect is no doubt the result of an optical illusion, and occurs when the general direction of the flash (or of part of it) is either towards or away from the observer.

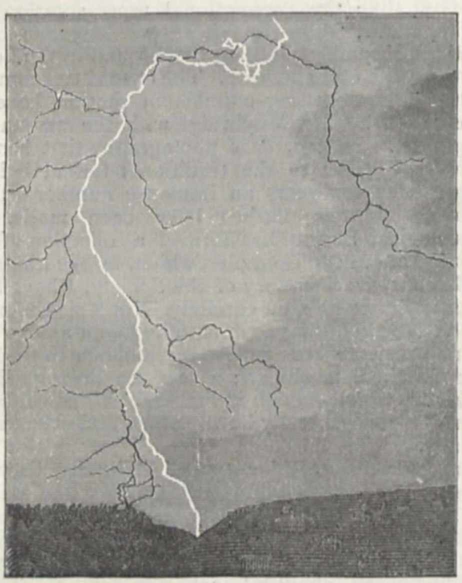

Fig. 1.

The different parts of the flash which seem to approach or to cross one another may in fact be miles apart. This explanation may be simply illustrated by means of the shadow of a properly bent wire. I have here a wire which is bent in such a form as to imitate a common type of flash or machine spark. When held transversely to the beam of the electric light its shadow is seen to represent fairly well the form of an ordinary sinuous flash; but if it is turned round so that its length is in the direction of the beam of light, the shadow presents an intricate appearance of loops and knots. Fig. 1 is from one of the most remarkable photographs of lightning flashes that I have seen. It was taken at Cambridge on June 6, 1889, by Mr. Rose, of Emmanuel College, and I am indebted for this copy to the kindness of Mr. W. N. Shaw, who described it at a recent meeting of the Physical Society. Among its many interesting features I will at present only direct your attention to the complicated knot which occurs in the upper part of the flash.

Many photographs of lightning have a curious flat and ribbon-like appearance. Such ribbons are sometimes broad and sometimes narrow. I have to thank Mr. Clayden for an excellent specimen of the broad kind, which was taken by himself last summer, and is reproduced in Fig. 2. The Thunderstorm Committee are of opinion that this peculiar structure may possibly not exist in nature at all, the effect being produced only in the photographic camera. It is noteworthy that, in nearly if not quite every case when broad ribbons have been obtained, the camera was held in the operator's hand, a fact which naturally suggests the idea that the widened image of the flash may be due to unsteadiness. It may be objected to this explanation that the duration of a lightning flash is so exceedingly brief as to preclude the possibility of any material movement during the time that its image is upon the sensitive plate. But such an objection is not unanswerable. It has often been observed that a lightning flash may be followed by one or more other flashes in rapid succession, all taking precisely the same path as the first. If then the camera were in motion a series of such flashes might impress themselves side by side upon the photographic plate, being so near together as to give the appearance of a single wide and flattened flash.[1] Moreover, though the true lightning flash is practically instantaneous it sometimes has a phosphorescent glow along its track, which lasts for at least a large fraction of a second. This phosphorescence would tend

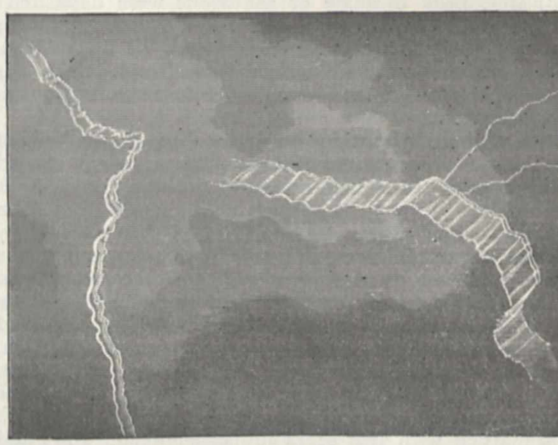

Fig. 2.

to connect the separate images into a uniform whole, and add to the ribbon-like appearance of the resulting picture. Dr. Hoffert has been kind enough to give me a copy of an exceptionally interesting photograph[2] which illustrates this explanation. The camera was held in the hand, and moved horizontally to and fro at the rate of about once in three-quarters of a second. The movement was continued until a flash was observed, when the lens was at once covered. The plate after development showed no less than two triple flashes and one double flash, eight in all, the whole of which, must have occurred, Dr. Hoffert thinks, within a little more than a second, forming a connected system of discharges which would appear to the eye as one. The several sets of flashes in the photograph are all joined together more or less perfectly by horizontal luminous streaks, which, though they may not impossibly represent a continuous brush-like discharge, are more probably due to phosphorescence of the oxygen of the air, oxygen, especially in the form of ozone, being a phosphorescent substance. If in taking Dr. Hoffert's photograph the camera had been moved

[1] It has been pointed out by Prof. S. P. Thompson that the path of the discharges might be shifted by the wind to a sufficient extent to produce the ribbon-like effect, even if the camera were perfectly steady.

[2] A good reproduction of this photograph is given in the *Phil. Mag.* (1889), and in the Proceedings of the Phys. Soc., vol. x. p. 176.

slowly instead of quickly, I think it is clear that the appearance of one or more ribbon-like flashes, like those in Fig. 2, would have been produced.

But the photograph of a flash may possibly assume a distinctly broadened form, perhaps more suggestive of a flattened wire than of a ribbon, when the camera is absolutely steady. In such cases it will generally (perhaps always) be seen that one edge of the image is sharp and clear, while the other is ill-defined and hazy. I have succeeded in imitating this effect very well in photographs of the machine spark: it is obtained when the light does not fall perpendicularly, or nearly so, upon the sensitive plate, and is no doubt due to successive reflections between the surfaces of the lens. [Exhibited.]

Lastly, we have to consider the so-called "dark flash." It occasionally happens that, on developing a photographic plate which has been exposed during a thunderstorm, the image of a lightning flash comes out black instead of white. Fig. 1 presents a striking instance of this phenomenon. Black ramifications are seen to proceed outwards on both sides of the main bright flash; there is also what appears to be an independent black flash which starts from the top of the picture and crosses the bright one near the knot. The origin of this strange appearance was for a long time a mystery. No one had ever seen a dark flash with the unassisted eye, and the question arose, whether the dark images in the photographs really represented a hitherto unobserved physical effect which occurred in the air itself, or whether, owing to some optical or chemical action taking place inside the camera or upon the sensitive plate, the impression of a luminous flash became converted into a dark one. There is no need to discuss the several ingenious hypotheses which were suggested in explanation of the anomaly; it is sufficient to say that the mystery was completely cleared up a few months ago by the experiments of Mr. Clayden. The fact, as demonstrated by him, is shortly this. If the lens of the camera be covered the moment after a flash has occurred, the developed image will always come out bright, feebly or strongly according to circumstances. If, however, the plate be exposed after a flash has acted upon it, either to the continued action of a feeble diffused light or to the powerful glare arising from one or more subsequent flashes, then on development the image of the original flash will probably come out black. The effect is therefore not a meteorological or physical one, but purely chemical. It can be obtained not only with a lightning flash, but also with a machine spark, or even with an ordinary flame. It is merely necessary that the plate should be exposed to the action of a certain amount of light after it has received the impression and before development.

Some photographs which I have made of machine sparks fully confirm this explanation of Mr. Clayden's. The room was illuminated by a single gas-jet, and the background was a white screen with a black post in the middle of it (see Fig. 3). Two series of sparks were passed between the ball terminals of an electrical machine and photographed. After the first series were taken, the lens was left uncovered for half a minute; then it was capped, the camera shifted slightly, and the second series taken; the lens was again left open for half a minute, and the plate afterwards removed from the camera and developed. It will be seen that while the second series of sparks come out bright in the natural way, the first series have been reversed and blackened by the action for one minute of the light reflected from the white screen upon the undeveloped image. Exposure to the diffused light for half a minute only was not in this case sufficient to cause reversal.

These experimental results make it almost certain that the flash in Fig. 1 was really a double one. The first flash was comparatively feeble, and possessed the lateral ramifications characteristic of an incomplete discharge. The second, which probably occurred immediately afterwards, was a powerful one without ramifications, and followed accurately the main path traced out by the other. The glare arising from this second discharge caused the photographic reversal of the ramifications belonging to the first.

Everyone must have noticed the proverbial quiver of a lightning flash. This peculiar effect is often due to the multiple discharge of which we have already spoken. Sometimes, however, I believe the phenomenon is a purely subjective one, depending upon a certain physiological reaction of the optic nerve. If we gaze at a bright flame which is suddenly uncovered and immediately extinguished, then after a very short interval of darkness a distinct but transient image of the flame will reappear; and it is even possible that after another brief interval a second after-image of the flame may be seen. It is, however, by no means easy to detect these appearances without considerable practice, because they belong to a class of impressions which we habitually train ourselves to disregard. But by means of a little device which I published a few years ago, the phenomenon may be easily demonstrated to almost anyone.

The beautiful effects produced by the rotation of a vacuum tube when illuminated by a series of discharges

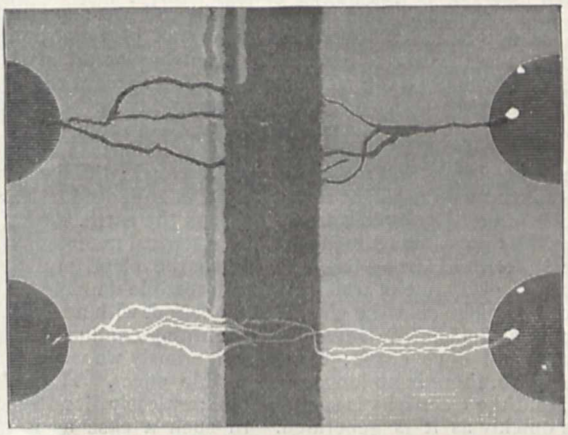

FIG. 3.

from an induction coil, are well known. The tube is generally attached to a horizontal axis, which is turned rapidly by means of a multiplying wheel; the images due to successive discharges, which, if the tube were at rest would be superposed, are thus caused to occupy different parts of the retina, and the result is the appearance of a gorgeous revolving star. But if the tube is caused to rotate very slowly, making about one turn in two or three seconds, there occurs a different and very curious phenomenon. The luminous images of the tube are almost superposed, forming a bunch which is slightly spread out at the ends. But about 40° behind the bunch, and separated from it by an interval of darkness, comes a ghost. This ghost is in shape and size an exact reproduction of the tube; it is very clearly defined, and is of a uniform bluish-grey tint. If the rotation is stopped, the ghost still moves slowly on, and after the lapse of about half a second disappears in coalescing with the luminous tube. The phenomenon of the ghost is clearly due to a succession of after-images, which are perceived a short time after the retina has been impressed by the flashes from the vacuum tube; and a similar physiological action, I think, explains—at least in some cases—the apparent reduplication of a flash of lightning.

Within the last year or two there has been a great deal of rather lively controversy concerning the protection of buildings from the destructive effects of lightning. The controversy originated in some lectures on lightning conductors, delivered by Prof. Oliver Lodge at the Society of Arts in 1888; it was continued at the Bath meeting of the British Association, and it culminated in a paper, also by Dr. Lodge, read last year at the Institution of Electrical Engineers, in which, after stating that "the old views on the subject of electrical conduction are hopelessly and absurdly and dangerously inadequate," the author expressed the opinion that it was "time that the prophets of the old superstition were slaughtered by the brook Kishon." In the animated discussion which followed, Dr. Lodge's views were ably opposed by Mr. Preece and others, and the question can hardly yet be considered as definitely settled. Time will not admit of an adequate review of the arguments which were employed on the two sides, but, considering its great practical importance, I think it will be of interest to give a very short statement of the matter in dispute, which I will illustrate by copies of Dr. Lodge's diagrams and apparatus.

Ever since the time of Franklin it has been customary to make use of long pointed metallic rods for the purpose of protecting important buildings from damage by lightning; and the "older electricians," as Dr. Lodge calls them, have always taught that, if the rod were well made, of sufficient size and height, and properly connected to earth, it afforded practically perfect security over a certain limited area. The function of the rod was supposed to be not so much to receive the shock of a lightning flash as to prevent a flash from occurring at all in the neighbourhood of the protected building: this it did by promoting the silent discharge of electricity between the cloud and the earth through the point of the rod.

The lower of these two tinfoil-covered boards represents the earth, and the upper one a cloud; the upright metal rod with a ball at the top of it is supposed to be a church, or other building, erected upon the earth. Charging the apparatus by means of the electrical machine, we get a series of strong flashes between the cloud and the church, every one of which might do terrible damage. If now we place near the church another rod, with a needle-point at its end, to serve as a lightning-conductor, the flashes at once cease: however vigorously we work the machine, there is no longer any visible effect. The fact is, that the electricity is silently and harmlessly discharged as quickly as it is generated. In such a case as is at present represented by the model, the efficacy of a lightning conductor would be complete. This is what Dr. Lodge calls the case of "steady strain," and is that indicated in his first diagram [exhibited], where the charged cloud above the church spire is supposed to have moved into its present threatening position from a distance. According to Dr. Lodge, this is the only kind of lightning discharge which was ever contemplated by the older electricians.

But suppose that a harmless uncharged cloud which might be hovering over the church were suddenly to receive an overflowing charge of electricity by a flash from another more distant cloud. There would then be no time for any gradual relief of the strain by a silent discharge through the lightning conductor, and either the conductor itself or the church would infallibly be struck by a flash from the overflowing cloud.

By altering the connections between the model and the electrical machine,[1] we can easily imitate this condition of things. The tinfoil-covered boards now remain absolutely uncharged until the moment when there is a spark between the terminals of the machine: then they are suddenly charged, and a flash instantly passes between the cloud and the church. Placing the needle-pointed lightning conductor beside the church, we now find that it is powerless to prevent the flashes: they go on just as rapidly as before, striking either the conductor or the church, or sometimes both at once. This case, which, I think, Dr. Lodge was undoubtedly the first to call attention to explicitly in connection with thunderstorms, is called by him the case of "impulsive rush." The occurrence of an "impulsive-rush" flash, then, cannot be warded off by a lightning conductor. The most that a conductor can do is to divert the main shock of the discharge from the building to itself. But even so the lightning may do considerable damage, for, as Dr. Lodge says, "it is hopeless to pretend to be able to make the lightning conductor so much the easiest path that all others are protected. All possible paths will share the discharge between them, and lots of apparently impossible ones." Moreover, not only is the lightning conductor itself, when struck, liable to spit off sparks laterally, however good its earth connection may be, but other metallic bodies in the neighbourhood may do the same, whether such bodies are insulated or not.

The moral appears to be this. In all cases of steady strain in which a charged cloud descending from the upper regions of the air, or approaching from a distance, might inflict serious injury upon an unprotected building, a well-designed and properly earth-connected lightning-rod is an absolute safeguard. In a case of "impulsive rush," the rod may often be of use in bearing the brunt of the discharge, though sometimes the lightning will take no notice whatever of it, striking the building and altogether neglecting the rod; and it is even possible that a high rod might attract a destructive discharge which otherwise would not have occurred at all. Although, therefore, a lightning-rod is in many cases, probably in a very large majority, of the greatest service, it cannot be depended upon as affording perfect immunity from risk; and the assumption which has universally been made by the "older electricians," that damage by lightning is in itself conclusive evidence of some imperfection in the conductor, is an unfounded one.

In conclusion, it may not be out of place to say a word or two on the subject of personal danger from lightning. The spectacle of a severe thunderstorm, magnificent as it is, is no doubt calculated to inspire a certain amount of alarm. But statistics show clearly enough that, at least in this country, its bark is worse than its bite. It appears, from a paper published last year by Inspector-General Lawson, that the number of deaths caused by lightning in England and Wales from 1852 to 1880, as recorded in the returns of the Registrar-General, were 546, or rather less than 19 per annum. The average population during that period may be taken as 22 millions; it follows, therefore, that the average annual death-rate from lightning was considerably below 1 per million of the population. The risk of a fatal lightning stroke in any individual case is therefore exceedingly small.

[1] The tinfoil-covered boards were connected with the outer coatings of the Leyden jars, their inner coatings being in connection with the terminals of the machine.

SPORTS.[1]

IT is highly desirable that we should attach a definite signification to this word. Among gardeners it may mean many things, whilst, among botanists, it is restricted to cases of bud-variation as distinguished from variation from seed. In this note we shall use the word in its botanical sense, as applying to a special illustration of that tendency to vary which is common to all living beings. We shall, however, gain a clearer idea of what true sports are by the elimination of certain things which are not sports, though often called so. In the first place they are not seedling variations. Out of a hundred seeds of Lawson's Cypress that are sown it is possible, I suppose,

[1] Reprinted from *Garden and Forest*. The article contains the substance of an unwr.tten address lately given to a society of gardeners.

to get ten more or less distinct varieties, besides others which are more or less indistinct. The great variability of this species is now well known, and the seedlings of *Abies subalpina*, Engelmann (*A. lasiocarpa* of Hooker), furnish another illustration of the same tendency. These seedlings may be the result of cross-fertilization between varieties, or they may be reversions to an earlier condition; at any rate, of whatever nature they are, they are not "sports" in the sense here intended.

Next, sports are not mere stages of growth. Most plants put on a different appearance at various periods or stages of their growth, and sometimes these changes are very remarkable. The Retinosporas of our gardens furnish us with excellent illustrations. *Retinospora* (or more strictly *Thuya*) *pisifera* exhibits during its growth very different appearances in its foliage. There is the squarrose form and the plumose form, the golden form, the silver form, the pendulous form, the thread-like form, the upright form, and perhaps others. All these, however, are not separate entities; they may all occur on the same bush. If cuttings or if grafts be taken from the sporting branches they may be reproduced almost indefinitely.

Barring the mere colour variation, these forms are but stages in the growth of the plant, occurring with more or less regularity and in greater or less degree of prominence in all the individuals of the species, as may be inferred from watching the growth of seedlings in a seed-bed.

Other illustrations of variations arising during growth are afforded by the differences often observable in the foliage on the flowering branches as contrasted with that on those branches which bear no flowers. The common Ivy furnishes an illustration. The short contracted shoots of the Laburnum, or the Apple, known as "fruit spurs," constitute other examples.

Another form of variation in flowers is that connected with difference of sex. A "pin-eyed" Primrose does not greatly differ in appearance from a "thrum-eyed" one, yet the difference between them is precisely of the same character as that between the variously formed flowers of some species of Catasetum and Mormodes. So utterly different are the male and female flowers of some of these species that they were at first placed by very competent botanists in different genera. It was only when the Protean plants produced all the forms of flowers on one and the same spike, that it was seen that, so far from belonging to different genera, they did not even belong to different species. It was left to Darwin to show what this paradoxical variation really means; and now, when we meet with a case of the kind, we say, "Ah! yes; only a sexual form," just as if we had known all about it from our earliest years, and very possibly, in our haste, mixing up, or, at least, not discriminating cases of a different nature. But this is not what we propose to discuss just now; we simply say that these cases, though often so designated, are not sports, at least in our acceptation of the term.

What, then, are sports? We have already characterized them as "bud-variations," but we must give some further indication of their peculiarities: First, as to the suddenness of their production. A tree or a shrub, all on a sudden and without any cause that is apparent to the eye, will put forth a bud, which, as it lengthens into a shoot, displays leaves of a different character from any that the plant has hitherto produced, which have no definite relation to any particular stage of growth; and which are quite different from any that under ordinary circumstances the plant in question has produced or is likely to produce in future. In short, the occurrence is sudden and unforeseen. Gardeners, of course, avail themselves of these variations. They remove them, bud them, graft them, strike them from cuttings, or, in some way or another, endeavour to perpetuate the variety, and thus have originated many of our cut-leaved Beeches, Maples, and Limes. Thus, too, may have originated some of our weeping trees and some of our pyramidal shrubs, though, for the most part, these have, as I believe, originated as seedling variations.

Not only do these variations occur suddenly, but they are very local in their manifestation. One particular shoot "sports," while all the rest remain in their normal condition. It is very different in the case of seedling varieties, where the whole system of branches and leaves is more or less affected.

Another and a most remarkable feature about these sports is, that they sometimes occur simultaneously in widely different localities; thus the same sport of a Chrysanthemum "turns up" about the same time, not only in different nurseries in this country, but also on the Continent. This may be because all the plants in question have originated from one and the same stock.

These, then, are the special characteristics of a true sport. Illustrations could be given by the hundred; but neither time nor space permit, nor, indeed, for our present purpose, is it requisite to do so. Whoever will investigate the cause of these sudden outbursts of local variation must, of course, sedulously examine each case for himself according to the measure of his ability and of his opportunity. The circumstances, the history, the progress, the anatomy of each particular sport must be investigated, both absolutely and in relation to similar outgrowths in other plants. Until this is done—and it has not been done yet—any explanation as to the cause of the phenomenon must be a matter of speculation. Still, we cannot help guessing, and though we may be wrong in our surmises, at least the process does good by setting us observing and thinking. Observing and thinking are processes valuable to all of us, but in a particular degree to those who practice the cultural arts. And so it happens—or, at least, we will hope so—that although the causes which have been assigned for these changes are various, some, perhaps, utterly wrong, others partially so, and all more or less inadequate to explain the whole of the phenomena, yet some advantage may accrue from the discussion. An indirect benefit is better than none at all, and anything which enforces us to take some measure of the extent of our own ignorance is likely to be beneficial. We should never be a bit the better if we simply acknowledged our ignorance, as, indeed, we needs must do in any case, but directly we attempt to find out in what particulars and in what degree we are ignorant, then there is some hope that some portion of our "nescience" may be dispelled. Under this impression we may allude to one or two of the assigned causes of sporting. External causes are those which the gardener most generally invokes. For him a sport is usually the consequence of some alteration in the nutrition of the plant. It gets too much or too little food, or the food is not of a suitable character—containing too much of one thing, too little of another, or the climate is charged with the results observed. It is very convenient to have the weather to blame; it may be too hot or too cold, too moist or too dry, too brilliant or too obscure; or the soil may be at fault, the drainage may be defective, the earth not sufficiently aërated, its temperature too high or too low. Combined action of some of these conditions is, of course, possible, intermittent action equally so, whilst we, in this country, are abundantly familiar, first with one thing in the way of the weather, and immediately afterward with another. It is, therefore, not surprising if some gardeners, without troubling themselves much to see how the explanation fits the facts, do attribute "sports" to such causes as we have mentioned. To our thinking, the objections to this kind of explanation are fatal. External circumstances are, no doubt, potent enough to effect very great changes indeed. We are daily witnesses of them; but they do not produce the kind of change which we know as "sports." On the contrary, sports occur sometimes when no alteration of external conditions is perceptible, and they do not occur when such alterations are very apparent. Or, again, they appear in one place under one set of circumstances, and at another place, simultaneously, under a different state of affairs; and although all the plants growing together have been exposed to the changed conditions of life, the sporting tendency shows itself in one particular plant only, and in one particular part of that plant, generally only in one bud. With all respect, then, for those who hold these views—and one at least of our most experienced and eminent plant-growers has lately publicly advocated them—we venture to think external causes, however adequate they may be in some cases, are inoperative in such cases as we are considering.

A better explanation is that offered by Darwin, by Naudin and others, according to which sports are due to a dissociation of mixed elements, a reversion to the character possessed by one or other of the ancestors of the plant, perhaps one or two, perhaps an indefinite number of generations ago. Let us recall for a moment what a very composite thing a plant is, even such a one as we call a simple plant. At first it is neutral and homogeneous, a mass of protoplasm, but the homogeneity of protoplasm is a thing of the past. We do not believe in it now. On the contrary, we believe in frameworks and interstitial fluid, in granules and fibres, in some parts that are alive, others that are dead; some that are stable and immutable, others that are mobile and changeable; in short, we have come to the conclusion that, physically and mechanically, as it was previously known to be chemically, protoplasm is very much "mixed."

Again, another of our old beliefs has been dissipated. Once we were taught that the cells of plants were closed bags without apertures, and that, while the fluid passed from cell to cell by osmosis, there were no visible pores, and no means of transmitting anything more solid than cell-sap. The passage of protoplasm from cell to cell was not then thought of as possible. But Mr. Walter Gardiner has changed all that. He and others who have followed in his steps have taught us how to see the pores in the cell-walls, how to see the passage of protoplasm through those pores from cell to cell, and how complacently to employ the phrase "continuity of protoplasm" in a manner that gives us, at present at least, great satisfaction. These modern discoveries of the composite nature of protoplasm, and of its passage, at certain times and under certain conditions, from cell to cell, seem to us to furnish a clue to the explanation of some of these cases of sporting, as they do also in the case of some of those curious cases in which the stock seems to influence the scion, or the scion the stock, in cases of grafting.

Again, in the life-history of a plant there are several stages. There is the neutral stage, when it is, at any rate, so far as sex is concerned, an epicene. Then there is the sperm stage, when our plant consists of a mass of neutral matter, a particular portion of which is developed into sperm-cells, or into what will ultimately produce them. At another time the neutral cells of one portion of the general plant-mass develop into germ or female cells, or it may happen that both sperm and germ cells may be developed at one and the same time, when the plant has, of course, a three-fold constitution.

All these modifications occur in the course of the life of each individual plant. But each individual plant is, necessarily, compounded of elements derived from its two parents, so that, for illustration sake, if we may consider the original stock to consist of three portions—neutral, male, and female, respectively—it is obvious that in the first generation there would be six component elements; in the second, twelve; in the third, twenty-four, and so on. Who can count the generations of plants? It is enough for our purpose if we succeed in showing clearly the composite nature of plants.

This being granted, it will not seem remarkable that occasionally a partial separation takes place, just as a scum may rise to the surface of some mixed fluid, or a sediment fall to the bottom of another. This illustration may, perhaps, serve to suggest the reason for the separation of mixed elements in plants; but that is too speculative a matter for us to enter upon here. It will be better for our present purpose to note one or two examples of dissociation of mixed characters wherein both the fact and its explanation are clear. One of the most interesting is that narrated by Mr. Noble, the originator of the white form of Jackman's Clematis. Noble's Clematis, as we may here shortly call it, is the result of a cross between Jackman's Clematis and *C. patens*. Soon after this Clematis was sent out, some dissatisfaction arose because, instead of producing flowers of good form and purity of colouring, more or less misshapen blooms of an unattractive appearance were formed. The matter was mysterious. The raiser was blamed by those who did not know that he is a highly competent man in his business, and one whose integrity is beyond question. The plant was condemned. Fortunately, however, the edict was not carried out in its entirety—some specimens were left. These were watched, and in due time afforded the explanation of the mystery. Jackman's Clematis flowers in the autumn on shoots formed during the spring and summer—on the new wood, as gardeners say, just as happens with a Rose. *Clematis patens* flowers in spring on shoots that were formed during the previous summer, on the "old wood," in gardening phrase. Now, when Noble's Clematis came to be scrutinized, it was found that it produced two kinds of flowers. Those which expand in spring are solitary, semi-double, never white, but bluish-gray, like those of *C. patens*. Those which unfold in autumn are produced in pairs and are single, like those of *C. Jackmanni*, but white. In the spring no flowers of the Jackman type are ever seen, and when the old wood is cut away, and only new wood thus suffered to produce flowers, no blooms of the *patens* character are seen, but only those of the Jackman type.

Another very interesting case of unmixing, or, if it be preferred, of partial mixture, is afforded by Neubert's Berberis. This is a hybrid between the evergreen pinnate-leaved Mahonia and the deciduous simple-leaved *Berberis vulgaris*, and it bears leaves some of which are intermediate in appearance, while others are like those of one or of the other of its parents.

The two illustrations above given are instances of the results of cross-fertilization, in which the whole process has, so to speak, taken place under our own eyes. But for how many centuries has the Chrysanthemum, we will say, been crossed and recrossed and crossed again? This process of crossing seems destined to come to an end, because the flowers, after a time, become sterile, owing to the fact that the stamens and pistils, one or both, are imperfectly or not at all developed. Seedling variations in such cases must become more and more rare as the process of sterilization becomes more and more marked. If new seedlings are desired, raisers will have to go back to less highly modified flowers—to flowers, that is, which are more nearly in their original condition. But although the production of varieties in the Chrysanthemum by fertilization is thus limited, the development of sports by bud-variation may, and probably will, still go on, to the delight of the grower and the interest of the student. It must, however, be said that at least in the case of the Chrysanthemum the change is sometimes very slight, depending solely on the presence of colouring matter in some cases and on its absence in others. The form of the flower and of the foliage in many of these Chrysanthemum sports is in no wise different from that of the parent plant. This is only an illustration of the fact that all degrees of combination or of dissociation, as the case may be, may be expected to occur.

Is there any commingling of the elements of stock and of scion in the case of grafts? Botanists and gardeners, almost without exception, have asserted that there is none. Place on a sheet of wet blotting-paper, which may represent the stock, a drier piece of the same substance, which may represent the graft, and there will be a passage of the fluid from the lower to the upper paper, but there will be no mixture of the constituents of the two.

We have always wondered, if there were no reciprocal influence of stock on scion, why grafting is practiced at all, because we cannot understand the acknowledged advantages of the practice except upon the supposition of some modification being exerted. Gardeners triumphantly, as they were quite justified in doing, pointed to the millions upon millions of cases where no such modifications are visible. Botanists pointed to the closed cells from whose cavities only the thinnest of liquids could exude and permeate through the walls of adjoining cells. This was before the days of "continuity of protoplasm," as above mentioned. Now that we know that not only water, but protoplasm itself, may, under certain circumstances, pass from cell to cell, the difficulties in the way of conceiving that any influence could be exerted on the scion by the stock, or *vice versâ*, are very materially lessened, if not entirely removed.

But before the time we speak of, there were some alleged facts which, provided the history given were true, could only be explained on the supposition of the commingling of elements by grafting and subsequent separation. In other words, the possibility of graft-hybridization must be assumed. Whether it has been proved is another matter.

One of the strongest cases in its favour that we know of is that of the famous Adams's Laburnum (*Cytisus Adami*). We cannot go into detail as to the history of this extraordinary tree. It must suffice to say, that it is stated to have originated from the implantation of a bud of the dwarf, shrubby, lilac-flowered *Cytisus purpureus* on to the common Laburnum. Be this as it may, we have in our gardens on this side of the Atlantic trees which every year astonish the beholder by producing, together with the foliage and flowers of the Laburnum, tufts of *Cytisus purpureus* and all sorts of intermediate conditions between the two. If the stock exerted no influence on the scion, the buds should be pure *Cytisus purpureus* and pure *C. Laburnum*, without any intermediate forms. It would lead me too far to give other illustrations of the production of shoots of an intermediate character between stock and scion. Many such are on record, and many have come under my own notice. It must suffice for me to show that whilst we may, with a very great amount of probability, attribute the existence of some sports to the "un-mixing" of elements blended by means of cross-fertilization, whether between species (hybrids) or between varieties (cross-breds), we may, likewise, but with a less degree of probability, attribute the existence of others to a similar dissociation in the case of grafted plants.

Obviously the latter cases must be much less numerous than the former, and are purely artificial productions, not likely to occur in Nature.

Other assigned causes appear to me to pertain rather to variation in general than to that limited, localized form of it which is here considered as bud-variation, and may be here passed with the mere mention.

MAXWELL T. MASTERS.

A NEW SCIENTIFIC SERIAL.[1]

THE imposing series of four octavo volumes before us is the embodiment of the first five years' work in the new Museum of the Austrian capital. Of the nature and plan of the building itself our readers have already been made aware; the collections housed within it are rich in types and specimens of priceless value, and its affairs are administered by a large and efficient staff of specialists, many of whom have attained a world-wide reputation. The directorship lies in the hands of Dr. Franz Ritter von Hauer.

Each of these volumes consists of four parts, and embraces one year's work. The parts are issued quarterly, their limitation in size being determined by the progress of work in hand. The first part of the first volume, issued early in the year 1886, is exclusively a "Jahresbericht" for the preceding year. It has already received notice in our pages (NATURE, vol. xxxiii. p. 424). While for the most part a report of work done, it contains information concerning the Museum itself, together with a list of names of the officers and staff, and of the various donors, correspondents, and persons who studied in the Museum during the year, as of those to whom material had been lent, together with references to published works in the production of which the resources of the Museum had been utilized. Of the remaining fifteen parts, each contains one or more special treatises, together with "notices" of a miscellaneous character, correspondence, personalia, and administrative detail, with acknowledgments of acquisitions. The four volumes make up a total of over 1900 pages of closely printed matter, with 80 plates and numerous woodcuts. The illustrations are, for the most part, highly satisfactory; we would, however, have preferred the substitution of ordinary lithographs for the photographs of Ophiurids described in vol. ii.; the latter are too indefinite and unsatisfactory. Excluding the notices and miscellanea, which monopolize collectively 22 per cent. (415 pp.) of the printed sheets, there remain 1532 pages of a more solid nature, which make up the bulk of the collective volumes. These bear, in all, 55 treatises; some of them, as our pages have already borne testimony (NATURE, vol. xxxv. p. 204), are lists of types and specimens in the Museum, others are elaborate monographs dealing with highly involved structural detail. The Museum is divided into five departments, each having its own working staff, and the published works bear the following ratio: zoology, 23; mineralogy with petrography, 13; geology with palæontology, 9; botany, 7; anthropology and ethnology, 3. As might be expected from this list, many new species of organic beings have been described. We find much to admire in some of the monographs; and especial attention is demanded by those devoted to the ethnology of the South Sea Islanders, by Dr. Otto Finsch, and to the artistic products of the Dyaks, by Prof. Alois Raimond Hein. These memoirs extend over the greater portion (240 pp.) of an average volume, and they are amply illustrated; the information contained in them is of inestimable value, the illustrations are of rare merit, and it would be difficult indeed to surpass the coloured representations of Papuan handiwork which adorn the pages of Dr. Finsch's important communication. These monographs are based upon the collections in the Vienna Museum, and upon perusal of them we know not upon which of their acquisitions most to congratulate our Austrian *confrères*—those of types of Nature's productions, or those of objects of human artifice. Moreover, the appearance of the memoirs cited, now that the South Sea Islanders are receiving renewed attention, is most timely; and their value is greatly increased by the fact that the peoples to whom they relate are becoming demoralized and demolished by the advance of "civilization."

The Museum whence these *Annalen* emanate was opened to the public in August 1889 by "His Apostolic Majesty the Emperor"; and an account of the ceremony, with its attendant honours, is to be found in vol. iv. The pages of the journal show the custodians of the institution to be fully alive to the value of their charge. The

1 "Annalen der k.k. Naturhistorischen Hofmuseums, Wien." Bd. I.-IV. 1886-89. (Wien, Alf. Hölder.)

journal itself not only serves them as a catalogue, but as a medium for publication of investigations into structure, such as the officers of our own National Museum are in the habit of contributing to the Proceedings of our Learned Societies and to other private journals. The authorities of the Austrian Museum might, at first sight, appear to be ahead of us in the possession of their recognized official *Annalen;* and there are those among us who would desire the founding of a similar official journal with its attendant restrictions for our own National Museum. We are very doubtful of the advisability of such a step, supposing the trustees were willing to undertake it. As matters stand, the excellent official catalogues which emanate from the building in Cromwell Road fulfil the public demands, and suffice for all purposes of nomenclature which it is a leading function of its authorities to control. The supplementary work, with the publication of which the members of its staff have so long honoured outside bodies, is voluntary. The progress of science in Britain is unique in the extraordinary degree to which it has been furthered by private enterprise; in contributing to the work of our Learned Societies and of those self-supporting institutions to which we have alluded, our Museum officials are encouraging an essentially national system, and fostering a love of science for its own sake. For these if for no other reasons, we would not desire the extension of the Austrian system to our own land.

We cannot close this notice without commenting upon the growing desire to found journals in connection with departments of our native Universities and Colleges. From what we have said, we could hardly be expected to approve of this movement, especially as the interests of such journals are apt to centre in individual aggrandizement, and as the necessity for their continuity may lead to the publication of that which the literature of the sciences might well be spared. We have journals ample for our needs, provided sufficient care be exercised in the selection of their contents. Better far to improve and to extend these, than to tolerate that which in them may be least desirable, adding thereto a "literature" which can only ill compare with that of the last generation of British naturalists.

We note that the Viennese have as yet succeeded in effecting an interchange of publications with but few of our leading Societies, and that their *Annalen* are not yet to be found in a large number of our University and other leading libraries. With respect to this, comparison with foreign countries does not redound to our credit. We can strongly recommend the journal on its merits; and, if the standard of its early volumes be maintained, no working scientific library will be ere long complete without it.

G. B. H.

NOTES.

THE programme for the Leeds meeting of the British Association has been issued. The first general meeting will be held on Wednesday, September 3, at 8 p.m., when Prof. W. H. Flower will resign the chair, and Sir Frederick Abel, President-Elect, will assume the Presidency and deliver an address. On Thursday evening, September 4, at 8 p.m., there will be a *soirée;* on Friday evening, September 5, at 8.30 p.m., a discourse on "Mimicry," by Mr. E. B. Poulton, F.R.S.; on Monday evening, September 8, at 8.30 p.m., a discourse on "Quartz Fibres and their Applications," by Prof. C. Vernon Boys, F.R.S.; on Tuesday evening, September 9, at 8 p.m. a *soirée;* and on Wednesday, September 10, the concluding general meeting will be held at 2.30 p.m. The Vice-Presidents are the Duke of Devonshire, the Marquis of Ripon, the Earl Fitzwilliam, the Lord Bishop of Ripon, Sir Lyon Playfair, the Right Hon. W. L. Jackson, M.P., the Mayor of Leeds, Sir James Kitson, and Sir Andrew Fairbairn. The following are the Presidents of the various Sections:—A.—Mathematical and Physical Science, Mr. J. W. L. Glaisher, F.R.S. B.—Chemical Science, Prof. T. E. Thorpe, F.R.S. C.—Geology, Prof. A. H. Green, F.R.S. D.—Biology, Prof. A. Milnes Marshall, F.R.S. E.—Geography, Lieut.-Colonel Sir R. Lambert Playfair. F.—Economic Science and Statistics, Prof. Alfred Marshall. G.—Mechanical Science, Captain A. Noble, F.R.S. H.—Anthropology, Mr. John Evans, V.P.R.S. The local secretaries are Mr. J. Rawlinson Ford, Mr. Sydney Lupton, Prof. L. C. Miall, and Prof. A. Smithells, and the local treasurer, Mr. E. Beckett Faber.

THE annual meeting for the election of Fellows of the Royal Society was held at the Society's rooms in Burlington House, on June 5, when the following gentlemen were elected:—Sir Benjamin Baker, Robert Holford Macdowall Bosanquet, Samuel Hawkesley Burbury, Walter Gardiner, John Kerr, LL.D., Arthur Sheridan Lea, D.Sc., Major Percy Alexander MacMahon, R.A., Rev. Alfred Merle Norman, Prof. William Henry Perkin, Prof. Spencer Umfreville Pickering, Isaac Roberts, David Sharp, M.B., J. J. Harris Teall, Richard Thorne Thorne, M.B., Walter Frank Raphael Weldon.

LAST Saturday the Royal Observatory was inspected by the Board of Visitors. By invitation of Sir G. G. Stokes, the chairman, about 250 ladies and gentlemen interested in astronomy attended to see the instruments and methods employed in the Observatory.

IN the House of Commons, on Tuesday, Mr. A. Acland moved that the sum of £350,000, which the Government propose to use for the extinction of the licenses of public-houses, should be applied in England for the encouragement of agricultural, commercial, and technical instruction, and in Wales for like objects. This ingenious scheme did not commend itself to the Chancellor of the Exchequer. The Government, he said, "admired the enthusiasm of the hon. gentleman, but could not assent to his proposal."

IT is announced that the Committee of Council on Education have decided, with the sanction of the Treasury, to allocate a fixed sum every year, in the vote for the Science and Art Department, for grants in aid of technical instruction given under the Technical Instruction Act. The sum allocated for the financial year 1891-92 will be £5000. A grant in aid will not necessarily be equal to, and in no case will it exceed, the amount contributed by the local authority out of the rates. Each grant will be computed, as far as possible, on the basis of the amount of the rate spent on subjects of technical instruction other than those for which the Science and Art Department gives aid under the Science and Art Directory. The application from the local authority, which must be sent in before the end of April in each year, should therefore give a certified statement, with the necessary extracts from the accounts of the preceding year, showing how the rate raised has been expended, and especially how any portion may have been applied to instruction in subjects for which grants are not made under the Science and Art Directory.

IN the course of the discussion on Mr. Acland's proposal, Mr. Mundella commented severely on the fact that the sum to be allocated under the Technical Instruction Act for the financial year 1891-92 would be only £5000. There was not a canton in Switzerland, he declared, that would not be ashamed of such a paltry provision for technical education. Mr. Goschen replied that he had himself been struck by the smallness of the sum, "but it was the result of the comparatively small demand made by the local authorities. There was every disposition on the part of the Government to meet to the full the requirements under the Act."

THE Science and Art Department announces that it will make grants for the encouragement of instruction in drawing and of manual training in classes connected with elementary schools and in organized science schools. The instruction must be (*a*) in the use of the ordinary tools used in handicrafts in wood or iron; (*b*) given out of school hours in a properly fitted workshop; and (*c*) connected with the instruction in drawing—that is to say, the work must be from drawings to scale previously made by the students. The instruction may be given by one of the regular teachers of the school if he is sufficiently qualified; if not, he must be assisted by a skilled artisan. The work of the class will be examined by the local inspector of the Department, accompanied, if necessary, by an artisan expert, on the occasion of his visit to examine in drawing. If it appears that the school is properly provided with plant for instruction, and that the teaching is fairly good, a grant of 6*s.*, or, if excellent, of 7*s.*, will be made for every scholar instructed, provided (*a*) that he has passed the fourth standard; (*b*) that he has received manual instruction for at least two hours a week for twenty-two weeks during the school year; (*c*) that a special register of attendance is kept; and (*d*) that each scholar on whom payment is claimed is a scholar of the day school and has attended with reasonable regularity. The grant may be reduced or wholly withheld at the discretion of the Department, if it appears that the plant is insufficient or that the instruction is not good.

AUSTRALIAN educational legislators appear to be reconsidering the policy of the payment by results system, and in some instances, at least, to have come to the conclusion that it must be abolished. The Minister of Education in Victoria is said to have a measure drafted with the object of substituting fixed salaries for school teachers for the system of payment by results.

AT the annual general meeting of corporate members of the Institution of Civil Engineers, on June 3, it was pointed out in the Report that the meeting was held on the sixty-second anniversary of the incorporation of the Institution by Royal charter. At that time the number of members was 156, and the gross annual receipts were £447. At the close of the past financial year the number of members was 5872, and the gross receipts for the twelve months amounted to £22,478. This increase—thirty-seven-fold in numbers and fifty-fold in revenue—sufficiently indicated the position which the Institution had taken in connection with the profession it was designed to promote. At the same time the members were reminded that a large rate of increase was by no means desirable.

AT the beginning of May it was found at Howietoun that the supply of water from Loch Coulter had been interfered with on ten successive nights. On an examination being made each morning, a number of eels were discovered in the sluice, where the water is 10 feet deep. Thirty altogether were obtained, all of them proving to be females. One of these, 32 inches in length, and weighing about 2 pounds, was examined. The ovary, which was about 12 inches long *in situ*, and about 30 inches long when unravelled, was calculated to contain 10,077,000 eggs in various stages of development, some, 0·25 mm. in diameter, being nearly ripe. There is little doubt that these eels formed part of a band migrating to the sea (the smaller specimens escaping and the larger being caught); and judging from the condition of the ovary, it would appear that they were impelled by the instinct of reproduction.

THE Medical Section of the French Association for the Advancement of Science proposes to discuss thoroughly, at the approaching meeting at Limoges, the various questions relating to influenza.

THE visit of the Iron and Steel Institute to the United States in the autumn is likely to be in every way most successful. There will be three different sets of meetings—the meetings of the American Institute of Mining Engineers, which take place in New York on September 29 and 30; the meetings of the Iron and Steel Institute, which take place in the same city on October 1, 2, and 3; and the international meeting promoted jointly by those two Societies, which will take place about the middle of October at Pittsburg. The excursions which have been planned by the American Reception Committee, of which Mr. Andrew Carnegie is chairman, provide for about 3000 miles of free transportation through the United States. The principal excursions will take place to the iron ore and copper regions of Lake Superior, to Philadelphia, Harrisburg, and Chicago, where there are large iron and steel engineering works to be inspected, and to the new iron-making district of Alabama. About 300 members of the Iron and Steel Institute and 100 German ironmasters have intimated their intention of taking part in the meetings; and already many have booked passages in the Hamburg-American Company's steamer *Normannia*, leaving Southampton on September 12. The meetings and excursions will last altogether over a month, and will practically embrace every point of interest in the United States within a distance of 1500 miles of New York. Papers have been promised for the meetings by Sir Lowthian Bell, Sir Nathaniel Barnaby, Sir Henry Roscoe, and others. Among those who have intimated their intention of being present at the meetings are Sir James Kitson (President of the Institute), Lord Edward Cavendish, Sir John Alleyne, Sir James Bain, Mr. Hingley, M.P. (President of the Iron Trade Association), Mr. Theodore Fry, M.P., Sir J. J. Jenkins, Sir Thomas Story, Mr. Windsor Richards, Mr. Snelus, F.R.S., and Mr. Edward P. Martin.

IN the House of Commons, on Monday, Mr. Norris and Sir Henry Roscoe put questions to Mr. Chaplin with regard to the change made by him in "the muzzling order." Mr. Chaplin explained that the collar had been substituted for the muzzle only in those districts in which rabies had, it was believed, ceased to exist. The number of cases of rabies during last year was 340. The muzzling order had never at any time been extended to the whole kingdom, and there were no statistics to show what the effect of the order would be if it were made universal. From the progress made already, he anticipated that rabies might be effectually dealt with without any necessity for so stringent a measure.

IN January of the present year two samples of compressed or tablet tea were presented to the Museum of the Royal Gardens, Kew, by Colonel Alexander Moncrieff. In the new number of the *Kew Bulletin* the letter with which these samples were accompanied is printed; and much interesting information as to the making of compressed tea is brought together. Repeated attempts have been made to introduce compressed tea into this country, but never with complete success. "A few years ago," says the *Kew Bulletin*, "two companies were formed for working it, and at the present time there is a company in London which deals exclusively in this article, a sample of which is in the Kew Museums. It is claimed for this tea that it has many advantages over loose tea, the chief of which is that the leaves being submitted to heavy hydraulic pressure all the cells are broken, and the constituents of the leaf more easily extracted by the boiling water, thus effecting a considerable saving in the quantity required for use. Its great advantages over loose tea, however, would seem to be its more portable character, and in the case of long sea voyages, or for use in expeditions, the reduction of its bulk to one-third. The compression of tea into blocks further, it is said, constitutes a real and important improvement in the treatment of tea. These blocks weigh a quarter of a pound each, and are subdivided into ounces, half ounces, and quarter ounces; this insures exactitude in measuring, and saves the trouble, waste, and uncertainty of measuring by spoonfuls. It also insures uniformity in the strength of the infusion. By compression it is claimed that the aromatic properties of the leaf are retained for a much longer period, and that it is better preserved from damp and climatic changes."

Besides the paper on compressed tea, the *Kew Bulletin* for June contains a valuable catalogue of timber trees of the Straits Settlements. Among the late Dr. Maingay's botanical collections—which were acquired for Kew—was a herbarium of the woody plants of the Eastern Indian peninsula, a large proportion of which were new to science. These were accompanied with a series of careful note-books containing descriptions drawn up from fresh specimens, with the native names. The whole material has been worked up at Kew in the preparation by Sir Joseph Hooker of the "Flora of British India," and has proved, the *Bulletin* says, "of inestimable value." In the list now printed botanical identifications are given to the native names comprised in Dr. Maingay's catalogue. In the same number of the *Kew Bulletin* there is an interesting correspondence, in which attention is drawn to the growing of cotton in West Africa, and especially to an attempt which has lately been made to introduce and cultivate experimentally in that region the best forms of Egyptian cotton.

The *Manchester Guardian* says that many students of science in Lancashire will learn with satisfaction that the Council of the Manchester Literary and Philosophical Society have at last been able to make arrangements for the cataloguing of the Society's unique library. This includes, amongst much other rare and valuable material, the publications for a long series of years past of several hundred foreign Academies and learned Societies.

The "Association pour la Protection des Plantes" held an interesting exhibition at Montpellier during the recent centennial celebration. This Society, which is now seven years old, aims at the protection of Alpine plants, especially in Switzerland, where many species have been all but destroyed by the depredations of plant-dealers. Among its members are many well-known English men of science. It is doing good work in establishing Alpine botanical gardens, where rare species are preserved.

A botanical school-garden has recently been instituted in Breslau by the magistracy, for regular supply of plants to the schools of the place, and for enabling teachers to make observations on the spot with their pupils. The cost of the arrangement is about £300. Private schools share the advantages on payment of an annual subscription.

German papers announce the death of Dr. Anton Felix Schneider, Professor of Zoology and Director of the Zoological Museum at the University of Breslau.

The measurement of the Rhone glacier in a comprehensive and systematic way has been carried on since 1874 by the Swiss Alpine Club, and the abundant data obtained will shortly be published in separate form. It appears that the glacier was in recession till 1888, but since last year it has been advancing.

Two violent shocks of earthquake were felt at Sofia on June 7, at half-past 6 a.m. The seismic disturbance was accompanied by subterranean noises. Its direction was from south to north. No damage seems to have been done.

A large water-barometer is now in use in the Saint Jacques Tower, Paris. The glass tube—the longest that has yet been made—is 12 metres 69 centimetres long. The diameter is 2 centimetres. Special openings in the tower were required to allow it to be put in its place. It is connected with a registering apparatus, and it is proposed that a photographic apparatus shall be associated with it, in order that the thermometrical readings of the water in the barometer may also be obtained. The instrument is a very curious one, and may render many services in consequence of its considerable sensitiveness. During thunderstorms it is especially active.

Mr. R. H. Scott has contributed a note on thunderstorms to *Longman's Magazine* for June, showing various peculiarities in their behaviour in this country and abroad. These storms are generally divided into two groups: (1) heat thunderstorms (the summer type), and (2) cyclonic thunderstorms, which occur principally in autumn and winter. The frequency of the storms is much greater in low latitudes than in high, and their energy is materially moderated by the dampness of the climate, hence our own comparative immunity from them. Certain districts also appear more liable to storms than others; the damage by hail, which frequently accompanies electrical discharges, appears to be greater in Huntingdonshire and neighbouring counties than in other parts of England. From an extensive inquiry by the Berlin Statistical Office, published in 1866, it appears that houses with thatched roofs are struck by lightning much more frequently than slated houses, while houses in towns are less frequently affected than those in the country.

Föhn winds, it is now known, are due to the descent from a mountain region of locally heated air-currents, when minima are passing. The föhn phenomena of Greenland have been lately studied by Herren Paulsen and Hann (*Met. Zeitsch.*). Over the ice-covered interior in winter (they represent) lies a barometric maximum, and before minima approach from the west, the phenomenon of increase of temperature with height occurs, as in the Alps. The masses of air on the plateau, cooled by radiation, sink as local cold valley winds, by the fjords. But when an approaching depression from the west sets the air in more general motion, the milder air from higher portions of the anticyclone comes down into the fjords as a warm east wind—the föhn. The movement extends as the minimum comes nearer, and the warming effect is not confined to the föhn localities. On one side of the mountain precipitation occurs, causing diminished cooling of the rising air, and thereby a continuance of the föhn on the other side.

The new number of the Journal of the Bombay Natural History Society (vol. v. No. 1) contains a valuable paper, by Mr. G. W. Vidal, on the venomous snakes of North Kanara. It has been said that no case of the bite of the *Echis* having proved fatal is known. Mr. Vidal thinks that at the present day this statement can hardly need refutation. There is no doubt, he says, that the *Echis* is a far more potent factor in swelling the mortality of the Bombay Presidency than any other venomous species, and it seems to him important that this fact should be more generally known and recognized than it has been hitherto. In all those districts—such as Sind and Ratnagira—where the *Echis* is known to abound, the average mortality from snake-bite is markedly high, whereas the mortality is insignificant in districts where the *Echis* is either rare or absent.

At the meeting of the Linnean Society of New South Wales on April 30, Mr. R. Etheridge read a paper on the question, "Has man a geological history in Australia?" The general want of satisfactory evidence of man's existence in Australia during Post-Tertiary times was commented on, and the various opinions which have been given on the subject were passed in review. A portion of the human tooth found in the Wellington Breccia Cave by the late Mr. Gerard Krefft was described, and the question of its value as evidence, from what is known of its history, was discussed. After considering all the evidence at present forthcoming, the author arrived at the conclusion that the matter could hardly be summed up better than by the very reasonable and often correctly applied Scotch verdict of "not proven."

IN the annual address, delivered lately by Colonel J. Waterhouse, President of the Asiatic Society of Bengal, and now printed, he speaks highly of the work done by Indian museums and kindred institutions. He says they are exerting "a great educational influence" on "the teeming masses" of India. Native visitors are beginning "to take a really intelligent interest in the collections." Colonel Waterhouse urges that the work of local museums should be confined to the illustration of local products. If objects from other districts are admitted, the name of their place of origin should, he thinks, be distinctly marked upon them, and they should be kept apart from the local collections.

THE U.S. Department of Agriculture has issued an elaborate Report on the English sparrow (*Passer domesticus*) in North America. The Report has been prepared, under the direction of Dr. C. Hart Merriam, ornithologist to the Department, by Mr. Walter B. Barrows, assistant ornithologist. Dr. Merriam claims that it is "the most systematic, comprehensive, and important treatise ever published upon the economic relations of any bird." The new immigrant into the United States is accused of an enormous number of offences; and no one who studies the evidence brought together in this Report will be disposed to say that his evil deeds have been exaggerated. The climatic and other conditions of America have suited the sparrow to perfection, and he has exercised freely all his powers of doing mischief. The evidence set forth relates to the importation, spread, increase, and checks on the increase of the bird; the injury done by him to birds, blossoms, and foliage; the injury to fruits, garden-seeds, and vegetables; the injury to grain; and the relations of the sparrow to other birds, and to insects. All sorts of suggestions for the destruction or abatement of the nuisance are carefully considered. There is also interesting evidence as to the sparrow in Europe and Australia.

A PAPER upon the atomic weight of magnesium and the properties of the pure metal obtained by distillation *in vacuo* is communicated to the current number of the *American Chemical Journal* by Messrs. Burton and Vorce, of Cleveland, U.S. When an attempt is made to distil magnesium in an ordinary hard potash glass tube it is found that the vapour of the metal attacks the glass in a remarkable manner, a black voluminous substance being formed which evolves a spontaneously inflammable gas on treatment with an acid. This black substance is, in fact, magnesium silicide, Mg_2Si, and the explosive gas silicon tetrahydride, SiH_4. When the silicide is brought in contact with dilute acid there remains, after the liberation of silicon hydride and conversion of the magnesium into a salt of the acid employed, a quantity of a yellow substance which possesses the properties of the lower oxide of silicon described by Mabery. Hence it is not possible to use tubes entirely of glass for the distillation of magnesium. But by lining the interior of the heated portion of the tube with an inner tube of thin sheet-iron, magnesium not alloying with iron, the distillation can be conducted with perfect safety. The magnesium was packed in the iron tube in the form of small pieces of ribbon, and the iron tube then placed in an outer glass tube closed at one end and about twice the length of the iron tube. The other end was afterwards drawn out and connected with a Sprengel pump, and the tube exhausted. The apparatus was then laid in a combustion furnace and the tube heated, the closed end near which the iron tube and its magnesium contents had been placed being heated much more strongly than the end nearest the pump. When the iron tube became heated to bright redness the magnesium commenced to volatilize and sublime into the relatively cooler portion, forming at first a black mirror of silicide upon the glass, which protected it from further corrosion. After continuing the heating for about an hour in the case of the distillation of about ten grams of metal, the gas was shut off, and the whole allowed to cool very slowly so as to prevent fracture of the glass, the vacuum being maintained as perfect as possible until quite cold. The distilled magnesium was similarly redistilled three times, the product of the fourth distillation alone, in which no traces of impurities could be detected by analysis, being employed in the atomic weight determinations. The magnesium was generally deposited in the form of a thin crystalline bar of pure white metal which readily separated from the coating of silicide, but in certain of the distillations beautiful isolated crystals of considerable size were formed. Weighed portions of the metal thus purified were converted to the nitrate by means of purified nitric acid diluted with water also specially purified and recently redistilled in a platinum apparatus. The nitrate was then ignited to oxide, first over a sand-bath, and finally to constant weight at the highest temperature of a muffle furnace. From the relation between the weights of metal taken and oxide produced in ten experiments, the mean value of the atomic weight of magnesium if $O = 16$ was found to be 24·287; if $O = 15·95$, $Mg = 24·211$. The highest value found when $O = 16$ was 24·304, and the lowest 24·271. The crystals of magnesium obtained during the distillation were very perfect hexagonal prisms showing no planes but those of the primary prism ∞P, primary pyramid P, and basal plane oP. From measurements of the angles the axial ratio $a : c = 1 : 1·6202$, which agrees tolerably well with the ratio given by Des Cloizeaux from the measurement of crystals obtained by Dumas in 1880. Magnesium is therefore isomorphous with zinc and beryllium, which latter metal it very closely resembles in its angular measurements and the ratio of its axes. In case of Zn, $a : c = 1 : 1·3564$, and for beryllium, $a : c = 1 : 1·5802$.

THE additions to the Zoological Society's Gardens during the past week include two Oak Dormice (*Myoxus dryas*), Central European, presented by Lieut.-Colonel G. M. Cardew; a Vulpine Phalanger (*Phalangista vulpina* ♂) from Australia, presented by Mrs. Waterson; a Silver-backed Fox (*Canis chama* ♂) from South Africa, presented by Captain H. D. Travers, R.M.S. *Tartar*; a Great Kangaroo (*Macropus giganteus* ♀) from Australia, presented by Mr. Henry Irving, F.Z.S.; a Ring-necked Parrakeet (*Palæornis torquatus* ♂) from India, presented by Mr. Arthur O. Cooke; a West African Love Bird (*Agapornis pullaria*) from West Africa, presented by Mrs. Fell; a Chinese Bulbul (*Pycnonotus sinensis*) from China, presented by Lieut.-General Sir H. B. Lumsden, K.C.S.I., F.Z.S.; three Common Peafowl (*Pavo cristatus* ♂ ♀ et juv.) from India, presented by Mrs. Francis Leighton; a Common Kestrel (*Tinnunculus alaudarius*), British, presented by Mr. C. Ashdown, F.Z.S.; a Loggerhead Turtle (*Thalassochelys caouana*) from the Atlantic Ocean, presented by Miss Beatrice Fort; a Grey Monitor (*Varanus griseus*) from the Sahara Desert, presented by Dr. John Murray; a Hawk-headed Parrot (*Deroptyus accipitrinus*) from Brazil, deposited; a Vociferous Sea Eagle (*Haliaëtus vocifer*) from West Africa, a Red-crowned Pigeon (*Erythrænas pulcherrima*) from the Seychelles, purchased; a Japanese Deer (*Cervus sika* ♂), two Bennett's Wallabys (*Halmaturus bennetti* ♂ ♂), a Vulpine Phalanger (*Phalangista vulpina* ♂), a Peacock Pheasant (*Polyplectron chinquis*), a Swinhoe's Pheasant (*Euplocamus swinhoii*), four Spanish Blue Magpies (*Cyanopolius cooki*), bred in the Gardens.

OUR ASTRONOMICAL COLUMN.

OBJECTS FOR THE SPECTROSCOPE.

Sidereal Time at Greenwich at 10 p.m. on June 12 = 15h. 24m. 22s.

Name.	Mag.	Colour.	R.A. 1890.	Decl. 1890.
			h. m. s.	° ′
(1) G.C. 4087	—	White.	15 12 57	+56 43
(2) G.C. 4234	—	Bluish.	16 39 51	+24 0
(3) *x* Serpentis	4	Reddish-yellow.	15 43 48	+18 29
(4) δ Boötis	3	Yellow.	15 11 6	+33 44
(5) α Coronæ	2	Bluish-white.	15 30 0	+27 5
(6) W Cygni	Var.	Reddish.	21 31 53	+44 53

Remarks.

(1) This is a long white nebula in Draco which was described by Sir John Herschel as "a superb ray nebula." The G.C. description is: "Considerably bright; very large; very much extended in the direction 155°; at first very gradually, then pretty suddenly brighter in the middle, where there is a nucleus." In Herschel's 20-foot reflector it was seen to be 7½′ long. The spectrum of the nebula has not been recorded.

(2) This is one of the planetary nebulæ, and according to Dr. Huggins its spectrum shows the three bright lines usually seen in nebulæ. He also noted that F was the faintest line, and that there was a faint continuous spectrum. The spectrum was re-observed by Vogel in 1872, and he observed two additional lines near wave-lengths 518 and 554. It is important that these lines should be confirmed, and comparisons made with the flutings of carbon and manganese at 517 and 558 respectively. The existence of these lines will further tend to prove the connection between comets and nebulæ, for two bands in these positions have frequently been observed in cometary spectra. It is not improbable that a third cometary band, near λ 468, may also appear in the nebula, as a line near that position (λ 470) has been recorded by Dr. Copeland and Mr. Taylor in other nebulæ. Unfortunately, a rather large aperture is required for this observation; with a 10-inch refractor I have not been able to more than glimpse the additional lines seen by Vogel. The G.C. description of the nebula is: "A planetary nebula; very bright; very small; round; disk and border." It is not advisable to employ a cylindrical lens in searching for faint lines, even though the nebula is a small one.

(3) Vogel describes this star as a fine one of Group II., but Dunér states that the bands are narrow, 4 and 5 being little more than lines. He also notes that the spectrum approaches Class II.*a* (Group III.). It is therefore probable that the spectrum is an intermediate one, and will show some of the lines characteristic of Group III. Any differences in these lines, either in positions or relative intensities, from those seen in stars like the sun, should be noted, as they will form valuable criteria for the subdivision of the Class II.*a* stars of Vogel into two groups—one of increasing temperatures (Group III.), and the other decreasing (Group V.).

(4 and 5) The first of these has a spectrum of the solar type, and the second one of Group IV. (Gothard). The usual observations are required in each case.

(6) The range of this variable is very small—5·8–6·2 at maximum to 6·7–7·3 at minimum—and it will be interesting to observe if any changes in spectrum take place at maximum similar to those which occur in stars of greater range with the same type of spectrum. The general spectrum is a "very fine" one of Group II., but so far no variations with change of magnitude have been noted. The period is given by Gore as 120–138 days, and there will be a maximum about June 21.

The Spectrum of Comet Brooks (*a* 1890).—I made further observations of this comet on June 6 and 7, and found that it had become considerably brighter since my last observation (Nature, vol. xlii. p. 112). The tail was also slightly extended. The principal spectroscopic change noted was a diminution in the brightness of the continuous spectrum relatively to the carbon flutings, making the latter more distinct. There was no change in the positions of the bands, and as the comet has now passed perihelion, it is not likely that it will go through any of the higher-temperature stages. As its distance from the sun increases, it should be observed for the cooler stages. The first decided change, according to Mr. Lockyer's investigations, should be the replacing of the present "hot carbon" spectrum for that of "cool carbon," the criterion for which is a fluting near λ 483. This, again, should be replaced by a spectrum consisting mainly of a line in the position of the chief nebula line (λ 500).

In connection with the observations of the comet, I have also made observations of the spectrum of the nebula G.C. 4058 (see notes for June 5). I found that the spectrum of the nebula was irregularly continuous, with a very decided maximum of brightness coincident with the carbon fluting near λ 517. There were also other brightnesses, the positions of which are not yet determined. The whole spectrum is strikingly similar to that of the comet, and as the two objects are not far removed from each other, this is a good opportunity for observers to satisfy themselves that comets and nebulæ are intimately connected.

A. Fowler.

The Planet Uranus.—M. Perrotin, of Nice Observatory, has made some observations of dusky bands on Uranus, similar to those that are seen on Jupiter (*Vierteljahrsschrift des Astronomische Gesellschaft*). The following are some values found for the position-angle:—

1889	31 May	13°
	"	35
	1 June	20
	7 "	30

The mean value is 24°·5, or about 10° from the plane of the orbit of the satellites, from which it would appear that the plane of the Uranian equator differs little from the trend of the satellites. M. Perrotin also found that the direction of the bands, according to repeated measures, coincided with the longest diameter. The bands do not appear always to have the same aspect, but vary in number and in size in different parts of the surface. This unequal distribution will, it is hoped, afford a means of accurately determining the time of rotation. The oblateness deduced from the measures is said to be not less than $\frac{1}{20}$.

Mr. Tebbutt's Observatory.—We have received the Report of this Observatory for the year 1889. A considerable amount of extra-meridian work has been done during the year, observations having been made of some minor planets, phenomena of Jupiter's satellites, and occultations of stars by the moon. Barnard's comet (*a* 1889) and Davidson's comet (*d* 1889) were observed on eight occasions, and Brooks's comet (*e* 1889) on two occasions. The comparison observations that were made have been reduced, and sent to *Astronomische Nachrichten*. Brorsen's periodical comet was carefully searched for, with the help of Dr. Lamp's ephemeris, on December 21 and 25, 1889, and again on January 18, 20, and 22, but without success. Comparisons have been made, both of η Argûs and R Carinæ, with the neighbouring stars, and it is noted that the former star has not sensibly varied in its lustre since the announcement of its sudden increase of magnitude between April 1887 and May 1888. A satisfactory determination of a maximum of the latter star was made in June 1889, and its period determined as 312 days.

New Asteroid.—A minor planet of the 13th magnitude was discovered by M. Charlois at Nice on May 20. This brings the number up to (293).

CORAL REEFS AND OTHER CARBONATE OF LIME FORMATIONS IN MODERN SEAS.[1]

THE vast organic accumulations known as coral reefs are, undoubtedly, among the most striking phenomena of tropical oceanic waters. The picturesque beauty of coral atolls and barrier reefs, with their shallow placid lagoons, and their wonderful submarine zoological and botanical gardens, fixed at once the attention of the early voyagers into the seas of equatorial regions of the ocean. Questions connected with the peculiar form, the structure, the origin, and the distribution of these great natural productions have, from the very outset, puzzled and interested all those who delight in the study of natural things. In this communication we propose to point out and discuss some of the more general phenomena of oceanic deposits, with special reference to the functions of corals and other lime-secreting organisms, and the accumulation of their dead shells and skeletons on the floor of the great oceans.

Coral reefs are developed in greatest perfection in those ocean waters where the temperature is highest and the annual range is least. It may be said that reefs are never met with where the temperature of the surface water, at any time of the year, sinks below 70° F., and where the annual range of temperature is greater than 12° F. Bermuda, which is the coral island the farthest removed from the equator (lat. 32° N.), and one or two other outlying reefs, may be, in a sense, exceptions to this

[1] Paper read on December 2, 1889, before the Royal Society of Edinburgh, by John Murray, LL.D., Ph.D., and Robert Irvine, F.C.S.

statement, for in these exceptional cases the temperature of the ocean water appears occasionally to fall to 66° or 64° F., and there is a wider annual range than 12° F. This condition of high temperature with small range in the temperature of the water is only to be met with in the middle and western portions of the Atlantic and Pacific Oceans and the central parts of the Indian Ocean; consequently, coral reefs flourish along the eastern shores of the continents, where the coasts are bathed by currents of pure oceanic water coming directly from the open sea; while, on the other hand, they are absent along the western shores of the continents, where the water is colder and the annual range is very much greater—for instance, off the western coasts of America and Africa. The *Challenger* observations have also shown that the layers of warm surface waters are much thicker towards the western parts of the great oceans; consequently, reef-forming organisms flourish at a greater depth along the eastern shores of the continents than in positions further to the eastward in the open ocean, where the warm layer of water—over 70° F.—is much thinner. Throughout the temperate and polar regions there are no coral reefs. This is all the more remarkable, seeing that organisms belonging to the same orders, families, and even genera as those which build up coral reefs flourish throughout colder, and even in polar, seas. In these colder seas the representatives of the reef-builders either do not secrete carbonate of lime in their body-walls, or, if they do so, the shells or skeletons are much less massive than in tropical waters. An attentive examination of the animals procured by the dredge and trawl from all depths shows that in descending into deeper water in equatorial regions the amount of carbonate of lime secreted by the animals living on the sea bottom becomes less with increasing depth, and all the calcareous structures of the organisms become less massive with the descent into the deeper and colder water of the abysmal regions. This remark does not, of course, apply to the shells and skeletons of surface organisms which have fallen to the bottom from the surface waters.

Still another illustration of the same fact is furnished by the study of the pelagic organisms collected in the surface and subsurface waters by means of the tow-nets. In the warmest tropical waters there are numerous species of Pteropoda, Heteropoda, Gasteropoda, Foraminifera, and Coccospheres and Rhabdospheres (calcareous Algæ), which lead a purely pelagic existence, and secrete carbonate of lime shells. Mr. Murray estimates from his tow-net experiments that at least 15 tons of carbonate of lime exists in this form at any moment of time in a mass of tropical oceanic water 1 square mile in extent by 100 fathoms in depth.[1] The number of species and individuals of these lime-secreting organisms decreases and the shells become less massive with a wider removal from the equator and an approach to the colder water of the poles, till we find in the surface waters of the polar regions only one or two thin-shelled Pteropods, and one, or at most two, dwarfed species of pelagic Foraminifera. It would appear then that organisms, as a whole or individually, are able to, and actually do, secrete more lime in regions where there is a uniformly high temperature of the ocean water than in those regions where there are great seasonal fluctuations of temperature, or where there is a uniformly low temperature of the water, as in the polar regions and in the deep sea. In temperate seas more carbonate of lime is secreted in the warm summer months than during winter months. Indeed, a high temperature of the sea water is more favourable to abundant secretion of carbonate of lime than high salinity.

An examination of the deep-sea deposits collected by the *Challenger* and other expeditions in all oceans shows that, after the death of the pelagic organisms above referred to, their calcareous shells are rained down on the ocean's bed, and there make up the larger part of the deposits known as Pteropod and Globigerina oozes, as well as a very considerable part of nearly all other marine deposits. If we take the samples of deep-sea deposits collected by the *Challenger* as a guide, then the average percentage of carbonate of lime in the whole of the deposits covering the floor of the ocean is 36·83, and of this carbonate of lime, it is estimated that fully 90 per cent. is derived from the remains of pelagic organisms that have fallen from the surface waters, the remainder of the carbonate of lime having been secreted by organisms that live on or attached to the bottom. If coral muds and sands, together with Pteropod and Globigerina oozes, be considered, then it is estimated that these contain an average percentage of 76·44 of carbonate of lime, and cover about 51,859,400 square miles of the sea bottom. We have little knowledge as to the thickness of these deposits; still such as we have goes to show that in these organic calcareous oozes and muds, we have a vast formation greatly exceeding in bulk and extent the coral reefs of tropical seas; they are most widely distributed in equatorial regions, but some patches of Globigerina ooze are to be found even within the Arctic circle in the course of the Gulf Stream. The following table shows the estimated area of the various kinds of deposits, with the average depth, and average percentage of carbonate of lime in each:—

Table showing the Estimated Area, Mean Depth, and Mean Percentage of $CaCO_3$ *of the different Deposits.*

Deposits.		Area, square miles.	Mean depth in fathoms.	Mean per cent. of $CaCO_3$.
Oceanic Oozes and Clay.	Red clay.	50,289,600	2727	6·70
	Radiolarian ooze.	2,790,400	2894	4·01
	Diatom ooze.	10,420,600	1477	22·96
	Globigerina ooze.	47,752,500	1996	64·53
	Pteropod ooze.	887,100	1118	79·26
Terrigenous Deposits.	Coral sands and muds.	3,219,800	710	86·41
	Other terrigenous deposits, blue muds, &c.	27,899,300	1016	19·20

One of the most remarkable facts discovered by the *Challenger* Expedition is that, although the dead shells of these pelagic organisms are rained down on the sea bottom, and in shallower depths accumulate so as to form calcareous deposits of immense extent, still, in other contiguous but deeper areas, these shells do not accumulate on the bottom, being wholly removed either while falling through the water, or shortly after reaching the ocean's floor. The pelagic organisms are as abundant in the surface waters over the one area as over the other, the only apparent difference in the conditions being one of depth. In the shallowest deposits of the open sea, shells, representative of nearly all the lime-secreting surface organisms, are to be found in the deposits. With increasing depth the more delicate ones disappear from the bottom, till, in 1800 or 2000 fathoms, it is rare to find more than traces of Heteropod, Pteropod, or the more delicate pelagic Foraminifera shells in the deposits, while these same delicate shells occasionally make up fully one-half of the carbonate of lime that is present in depths of 700 or 1000 fathoms. Again, in the still greater depths of 3000 and 4000 fathoms and deeper, the Foraminifera, Coccoliths, and Rhabdoliths are either wholly removed, or are represented only by the broken fragments of the thickest and most compact shells, like *Pulvinulina menardii*, *Sphæroidina dehiscens*, or *Globigerina conglobata*. This gradual decrease in the quantity of carbonate of lime in the deposits with increasing depth is well illustrated in the following table, showing the percentage of lime in the samples of deep-sea deposits collected by the *Challenger* towards the central parts of the ocean basins, away from the immediate influence of the *débris* from continental land or volcanic islands.

The organic oozes, including the red clays and the coral deposits, make up a total of 231 samples, and are arranged as follows, showing the percentage of carbonate of lime in relation to depth:—

14	cases under 500	fathoms,	m. p.c.	86·04.
7	,, from 500 to 1000	,,	,,	66·86.
24	,, ,, 1000 to 1500	,,	,,	70·87.
42	,, ,, 1500 to 2000	,,	,,	69·55.
68	,, ,, 2000 to 2500	,,	,,	46·73.
65	,, ,, 2500 to 3000	,,	,,	17·36.
8	,, ,, 3000 to 3500	,,	,,	0·88.
2	,, ,, 3500 to 4000	,,	,,	0·00.
1	,, over 4000	,,	,,	trace.

The fourteen samples under 500 fathoms are chiefly coral muds and sands, and the seven samples from 500 to 1000 fathoms contain a considerable quantity of mineral particles from continents or volcanic islands. In all the depths greater than 1000 fathoms

[1] Murray, "Structure and Origin of Coral Reefs," Proc. Roy. Soc. Edin., 1880, p. 508.

the carbonate of lime is mostly derived from the shells of pelagic organisms that have fallen from the surface waters, and it will be noticed that these wholly disappear from the greater depths. These figures are derived from a study of the *Challenger* deposits alone, but they are confirmed, as to the general result, by an examination of the deposits collected by the U.S.SS. *Tuscarora* and *Blake*, by H.M.SS. *Egeria* and *Investigator*, the ships of the Telegraph Construction and Silvertown Companies, and other ships. One other peculiarity as to the distribution of carbonate of lime organisms on the ocean's floor may be noted. Where these calcareous shells are most abundant on the surface, as in the tropics, the remains of the dead shells are as a rule found at greater depths on the bottom than in temperate or polar regions, where they are relatively much less abundant in the surface waters.

In his paper on the origin of coral reefs, published many years ago, Mr. Murray pointed out that sea-water, rushing in and out of the lagoon twice in the twenty-four hours, would take up and carry away large quantities of the carbonate of lime which, in the form of coral sand and mud, covers the bottom of these shallow basins. Just as the surface shells are dissolved by falling through the layers of ocean water, so in this case the dead coral fragments are dissolved by the sea-water that continually passes over them; in this way, chiefly, he accounted for the formation of lagoons in atolls and barrier reefs.

During the past few years a large number of experiments have been carried on at the Scottish Marine Station for Scientific Research, with the view of throwing some additional light on the oceanic phenomena referred to in the preceding paragraphs, in so far as these relate to the secretion and solution of carbonate of lime under varying conditions. Those dealing with the secretion of carbonate of lime by organisms will be considered in the first place, and afterwards those treating of the solution of the dead carbonate of lime shells and skeletons will be discussed.

A brief account of some of the experiments will show the nature of the investigations, and indicate the results which have been obtained in so far as they bear on the subject with which we are dealing.

Experiment 1. A number of laying hens were shut up in a wooden building, all ordinary sources of lime being withheld. In a few days the eggs, in place of a calcareous shell, had only a membranous covering. Thereafter sulphate, phosphate, nitrate, and silicate of lime were successively added to their otherwise limeless food, and from all these salts they were enabled to form normal shells for their eggs consisting of carbonate of lime.

From the investigations of Irvine and Woodhead it is believed that the lime salts in passing through the blood assume the form of phosphate, which is carried to the point of secretion, where it is decomposed and deposited as carbonate. When magnesium and strontium salts were added to the hens' food the eggs became membranous and shelless.

Ex. 2. Artificial sea-water was prepared, from which carbonate of lime was rigidly excluded. In this water crabs after ecdysis produced the usual exo-skeleton of carbonate of lime from the lime salts, other than carbonate, present in the water.

Ex. 3. The artificial sea-water of Ex. 2, which was perfectly neutral before the introduction of living crabs, in the course of a short time became distinctly alkaline in character. This was found to be due to the decomposition of their effete nitrogenous products, and the formation of carbonate of ammonia, and ultimately of carbonate of lime.

Ex. 4 and 5. Sea-water was mixed with urine and kept at a temperature ranging from 60° to 80° F. After a time the whole of the lime present in the sea-water was thrown down as carbonate and phosphate.

Ex. 6. A number of small crabs were placed in two litres of ordinary sea-water, and were fed with mussel flesh. This water was not renewed, the effete matters from the crabs passing into it. After a few days the crabs died; the water being then in a putrid condition was set aside at a temperature of from 70° to 80° F., when it was found that practically the whole calcium in the sea-water had been thrown down as carbonate of lime.

Ex. 7. We obtained absolutely fresh "liquor" from a number of living oysters, and examined it before decomposition had begun. It appeared to be a mixture of lymph with unchanged sea-water. The specific gravity was 1·023, indicating a considerable admixture of fresh or river water. This liquor contained 0·1889 grammes per litre of total lime in excess of that present in sea-water of the same specific gravity, and its alkalinity was equal to 0·2581 grammes per litre in excess of sea-water of the same specific gravity.

Thus we had in this liquid an accumulation of total lime (in excess of that present in sea-water) amounting to 0·1889 grammes per litre, the greater part of which was in the form of carbonate in solution, presumably in an amorphous or hydrated condition. Apparently this is due to the direct secretion of carbonate of ammonia by the cells of the living animals, which, reacting on the sulphate of lime in the sea-water, is capable of throwing out nine-tenths of the soluble calcium salts present, in the insoluble condition of carbonate. The oyster liquor was found to contain saline ammoniacal salts in enormous excess over that which is present in ordinary sea-water.

Ex. 8. A similar experiment was made with the liquor taken from living mussels. The results coincided with those obtained in Ex. 7.

Theoretically urea plus two molecules of water will give carbonate of ammonia. If, therefore, this substance be a stage in the formation of urea, it is not unnatural to suppose that in shell-forming animals the shell-formation may take place at this stage without the formation of urea at all. In these experiments the usual method for the estimation of saline and albuminoid ammonia could not be followed, and we made use of the following simple adaptation by which we obtained concordant results.

Absolutely pure potash was added to a measured and carefully filtered portion of the sea-water under examination, and the precipitate formed removed by filtration. The clear filtrate was then Nesslerized in the usual manner. We had thus an accurate means of determining between the actual ammoniacal salts and the albuminoid matter, both of which are, as a rule, present in sea-water according to the amount it carries of living and dead organisms. To satisfy ourselves that the addition of pure potash to a fluid containing albuminoids alone does not give rise (immediately) to the production of saline ammonia, we treated pure albumen taken from a newly laid egg in this manner, as also urea, without obtaining any trace of ammoniacal reaction.

These experiments show the alteration in the constitution of the lime salts in sea-water, both by the decomposition of effete matters thrown into the sea by animals, as also by the secretion of carbonate of ammonia by the cell action of the animals.

Sea-water collected among the coral atolls of the Louisiade Archipelago, received from Captain Wharton, F.R.S., Hydrographer to the Admiralty, contained per million parts—

Saline ammonia	0·48
Albuminoid ammonia	0·18
	0·66

whilst water collected by the *Challenger* in the North Atlantic (lat. 30° 20′ N. long. 36° 6′ W.) contained—

Saline ammonia	0·26
Albuminoid ammonia	0·16
	0·42

and water from the German Ocean near land contained—

Saline ammonia	0·13
Albuminoid ammonia	0·13
	0·26

This is exactly what we were led to expect from the experiments enumerated—the greatest amount of saline ammonia being present where the greatest animal life activity existed, as in the waters from the coral sea; and least in the German Ocean winter water where it was at its minimum.

Thus the whole of the lime salts in sea-water may, under these circumstances, be changed into carbonate, and in this way may be presented to the coral and shell builders in the form suitable for their requirements.

The temperature of the water is of great importance in this reaction. In cold water, of which the great bulk of the ocean consists, the decomposition of nitrogenous organic matter is retarded, whereas in tropical surface waters it proceeds with great rapidity. Thus coral-reef builders and pelagic organisms may not only benefit by the decomposition arising from their own effete matter, but also from the undecomposed nitrogenous matter carried to equatorial regions from the cold water of the deep sea, or from polar regions.

The quantity of carbonate of lime normally present in sea-water is exceedingly small; and the opinion hitherto held seems to have been that lime-secreting organisms must pump enormous quantities of sea-water through their bodies in order to be able to separate out a sufficient quantity to form their shells and skeletons.

Bischoff, in his "Chemical and Physical Geology," vol. i. p. 180, estimates that oysters in this way have to deal with an amount of sea-water equal to from 30,000 to 75,000 times the weight of their shells. It seems more probable that the reactions indicated by our experiments render the whole lime salts in sea-water available for coral polyps to build up their structures. In polyps, which unlike the higher animals have no true circulatory system, and where the animal is immersed in sea-water, it is hardly possible to account for the enormous secretion of carbonate of lime in the manner indicated by Bischoff; but if the conclusion we have arrived at be correct, and such animals, in place of secreting urea, secrete carbonate of ammonia, then we have a perfectly reasonable explanation of the phenomenon of coral formation.

As a laboratory experiment, when carbonate of ammonia is added to sea-water, the greater proportion of the calcium in solution is after a time thrown down as carbonate of lime; whilst the magnesium salts remain in solution. So that if the reaction above indicated be that which takes place in sea-water, then to this circumstance may be due the fact that carbonate of magnesia is almost wholly absent from coral reefs and deep sea calcareous formations.

That the amount of nitrogenous organic matter in a state of suspension and solution must be enormous will appear evident when it is remembered that the floor of the ocean, almost throughout its whole extent, is covered with living animals; that the surface of the sea and shallow waters off the coasts are crowded with plants and animals down to a depth of several hundred fathoms. (The *Challenger* experiments have shown that some species of animals flourish in the intermediate depths of ocean water from the surface to the bottom.) The waste products arising from the functional activity of these organisms, and the nitrogenous products arising from the decomposition of their dead bodies, must work continual changes on the internal constitution of sea-water salts, varying according to their amount, the temperature, the sunlight, and other conditions. It has been shown that ammoniacal salts are to be found everywhere in the ocean, but much more abundantly in warm tropical waters than in colder seas—a result no doubt due to the rapid decomposition of the nitrogenous organic matter present at a high temperature, and its retardation in colder water. The ammonia of the air, and all nitrogenous substances carried from the land to the sea, must also effect changes in the internal constitution of sea-water. Indeed, the peculiar pelagic fauna and flora met with in all regions of the ocean, where it is affected by river and coast waters, are as different in relation with the internal constitution of the sea-water salts as with the lower salinity which prevails in these circumstances.

It is well known that organic substances in the presence of alkaline and earthy sulphates become oxidized at the expense of the oxygen of these salts, with the production of carbonic and hydrosulphuric acids, the latter on oxidizing producing sulphuric acid. The greater part of the organic carbon, which it has been pointed out is of enormous amount, must apparently be thus oxidized, producing an equivalent amount of carbonic and sulphuric acids. The effects of this reaction are likely to be more marked in the deeper parts of the ocean, where the motion of the sea-water must be extremely slow, and where consequently the effete products accumulate; in this way the larger amount of lime and carbonic acid and the less amount of oxygen in solution in such waters is to be accounted for. Not only so, but the very existence of such a relatively large quantity of sulphate of lime in sea-water goes far to prove that this reaction must continually take place, seeing that sulphuric acid cannot exist in a free state in the presence of carbonate of lime. Thus it is probable that the quantity of sulphate of lime in solution in the ocean is only limited by the amount of organic decomposition which takes place in its waters. On the other hand, if marine organisms procure the whole of their carbonate of lime from the sulphate of lime by the reaction of ammoniacal salts, then the amount of lime that may be secreted from ocean waters is likewise limited by the amount of organic matter undergoing this oxidation process in the ocean.

Gmelin, in his "Chemistry," vol. ii. p. 191, refers to this decomposition as follows:—

"In hot climates, as on the west coast of Africa, where the water of rivers charged with organic matter mixes with sea-water, hydrosulphuric acid, sometimes to the extent of 6 cubic inches to the gallon, is found in sea-water, even at a distance of 27 miles from the mouth of the rivers."

This is also confirmed from samples of water which we have received, taken from the roadstead of Monte Video by the telegraph ship *Seine*.

If now we turn our attention to the solution of dead carbonate of lime in shells and coral skeletons by the action of sea-water, it will be found that the rate of this solution varies greatly according to the conditions in which these remains are exposed to the solvent power of the water. A large number of experiments have been conducted with the view of determining the solubility of carbonate of lime under its different conditions. It may be pointed out that the normal amount of carbonate of lime dissolved in sea-water is very small, strikingly so (0·1200 grammes per litre) when compared with the vast amount of this substance continually being secreted from the sea by organisms. Sea-water can, however, take up 0·6490 grammes per litre of carbonate of lime in an amorphous (or hydrated) condition, forming a clear supersaturated solution, but after a time not only the excess so added is thrown down, but also sometimes a portion of that normally present in the water itself. It would thus appear that it is unable permanently to retain in solution more of this substance than is usually found present in sea-water. This peculiarity of sea-water, after taking up a large amount of amorphous carbonate of lime, and throwing it out in a crystalline form, accounts for the filling up of the interstices of massive corals with crystalline carbonate in coral islands and other calcareous formations, so that all trace may ultimately be lost of their original organic structure. These experiments show a great diversity as to the amount of carbonate of lime which will pass into solution in sea-water from various calcareous structures in a given time. As a rule, the more definitely crystalline the substance is, the less it is soluble. Calcspar is less soluble than massive varieties of coral, and these again less than the more porous varieties. We have already indicated that amorphous or hydrated carbonate of lime is (in that condition) much more soluble than any other form of the substance. The rate of solution is also much greater when the water is constantly renewed, than when the same water remains in contact with carbonate of lime. The water quickly becomes saturated and unable to exert further solvent action. In this connection we found that different samples of sea-water from different localities possessed very different solvent powers. Especially was this the case between summer and winter waters, the former having distinct solvent action on coral skeletons, whilst with the latter there was hardly any. The lower specific gravity of winter waters may be regarded as to some extent reducing their solvent power, but this is more probably to be attributed to the absence of free carbonic acid—that is, carbonic acid in excess of what is required to saturate the free base in the sea-water as normal carbonate. To test this point, carbonic acid was added to one of these winter waters (which had no solvent action on coral), the quantity added not being sufficient to destroy its alkaline character. It was found that in these circumstances an appreciable amount had been dissolved.

This appears to indicate that there is more carbonic acid in summer than in winter waters in our latitudes, due probably to the increased activity of animal life. Mr. Buchanan's observations on board the *Challenger* show that the carbonic acid present in sea-water, over and above that necessary to form normal carbonate of lime, was subject to great variations. It appears that this is a much more effective agent in the removal of carbonate of lime shells, &c., than the solvent power of sea-water itself (although artificial sea-water quite free from carbonic acid dissolves carbonate of lime). Buchanan's observations have also shown that carbonic acid as a rule is more abundant in bottom than in surface waters; and Reid's experiments show that carbonated sea-waters under high pressure take up more carbonate of lime than that at a normal atmospheric pressure. The fact that carbonic acid is more abundant in deep waters is evidently connected with the respiration, and also the decay, of the animals which live and die on the ocean floor; and also with the decay of those which fall from the surface. The water filling the deeper hollows has also in its passage to the equator passed over thousands of square miles of this floor covered with living animals, and as this water has a very slow motion, and is but slowly renewed, we would expect an accumulation of carbonic acid and deficiency of oxygen in these abysmal depths. When, therefore, carbonate of lime secreting animals die at the surface of the water and their bodies fall to the bottom, the shell is exposed to solution from the action of the sea-water through which it passes, and it may be to that of carbonic acid produced by the decomposition of its own organic matter. If the shell be thin, as in the case of Heteropods and Pteropods, it may be wholly removed before reaching the bottom, but the thicker shelled varieties tend to accumulate even in depths of 2000 fathoms, where they are soon covered up by other shells; and being surrounded by sea-water already saturated with carbonate of lime, are preserved from solution, and form vast beds of calcareous ooze. It is found that the amount of carbonate of lime present in such ooze is greater or less according to the depth of water through which the shells pass from the surface to the bottom, and also to the slow renewal of the water in contact with these great lime deposits. In the red clay area the carbonate of lime is almost entirely absent. The deeper waters which cover such areas are more active in the removal of carbonate of lime, not only because of the larger amount of carbonic acid they contain, but doubtless to the deoxidation of alkaline sulphates by organic matter, which, we have already pointed out, gives rise to sulphuric acid, &c. At the same time account must be taken of the great pressure at such abysmal depths, and the fact that the substance of the shells being less compressible than sea-water, they would fall more slowly, and hence would be longer exposed to the action of the deeper layer of water than those near the surface.

What calcareous remains do reach the ocean floor at such abysmal depths represent the hardest and crystalline varieties of carbonate of lime which resist the solvent action of sea-water to the greatest extent.

In this way we appear to have a perfectly rational explanation of the partial disappearance of carbonate of lime shells from the shallower depths, and their total disappearance from all the greater depths of the ocean. It is to be observed that all those shells in which a considerable quantity of organic tissue is associated with the carbonate of lime disappear in solution more rapidly than the shells of the Foraminifera, which contain little organic matter. (During the whole of the *Challenger* cruise only two bones of fishes, other than the otoliths and the teeth, were dredged from the deposits, and all traces of the cetacean bones were removed, except the dense ear-bones and dense Ziphioid beaks.) The remains of crustacean animals were almost wholly absent from deep-sea deposits, with the exception of Ostracode shells and the hard tips of some claws of crabs.

Turning now to the lagoons and lagoon channels of coral islands, it is believed that large quantities of carbonate of lime are in the same way being dissolved from these shallow basins as well as from the deposits of the deep sea, but under somewhat different circumstances. In the case of a shell falling to the bottom of the sea, it is continually brought in contact with new layers of water, which has the same effect as if a continuous stream of water were passing over the shell. In the case of the lagoons this last is what takes place. The water which flows in and out of the lagoons twice in twenty-four hours passes over great beds of growing coral, and from all the observations we have is largely charged with carbonic acid, owing probably to the large number of living animals on the outer reef over which the water passes on its way to the lagoon. This water passes continually over the dead coral and sand of the lagoon, and takes up and removes large quantities of carbonate of lime in solution (as well as suspension), for in these lagoons the spaces covered by dead coral *débris* always greatly exceed the patches of growing coral. Owing to the fact that the water of the lagoon is continually in motion, and constantly renewed, the layer in contact with the bottom of coral sand can never become saturated or unable to take up more lime, as is apparently the case in the layers of water in contact with the Globigerina ooze and other calcareous deep-water deposits.

From the foregoing discussion and observations it is evident that a very large quantity of carbonate of lime is in a continual state of flux in the ocean; now existing in the form of shells and corals, but after the death of the animals passing slowly into solution, to go again through the same cycle.

On the whole, however, the quantity of carbonate of lime that is secreted by animals must exceed what is re-dissolved by the action of sea-water, and at the present time there is a vast accumulation of carbonate of lime going on in the ocean. It has been the same in the past, for with a few insignificant exceptions all the carbonate of lime in the geological series of rocks has been secreted from sea-water, and owes its origin to organisms in the same way as the carbon of the carboniferous formations; the extent of these deposits appears to have increased from the earliest down to the present geological period.

At the present time most of the carbonate of lime carried to the ocean by rivers has been directly derived from calcareous stratified rocks formed by organic agency in the sea in earlier geological ages, but the calcium in these formations was in the first instance derived from the decomposition of the lime-bearing silicates of the earth's original crust, and this decomposition, which is still going on in the sea and on the land surfaces, is a continuous additional source of carbonate of lime.

In considering the analyses showing the average composition of sea salts, one is struck with the relatively small quantity of those very substances which are extracted so largely from sea-water by plants and animals, viz. carbonate of lime and silica. Siliceous deposits are of vast extent, yet silica occurs merely in traces in sea-water; carbonate of lime deposits are of vastly greater magnitude, yet carbonate of lime makes up only $\frac{1}{700}$th part of the saline constituents of sea-water, and only $\frac{1}{83000}$th part of the whole bulk of sea-water. Sulphate of lime is ten times more abundant than the carbonate in sea-water; on the other hand, the river water that is poured into the ocean contains about ten times as much carbonate as it does of sulphate of lime.[1]

The total amount of calcium in a cubic mile of sea-water is estimated from analyses to be 1,941,000 tons, and the total amount of calcium in the whole ocean is calculated at 628,340,000,000,000 tons. The total amount of calcium in a cubic mile of river water is estimated at 141,917 tons, and the total amount of this element carried into the ocean from all the rivers of the globe annually is estimated at 925,866,500 tons. At this rate it would take 680,000 years for the river drainage from the land to carry down an amount of calcium equal to that at present existing in solution in the whole ocean. Again, taking the *Challenger* deposits as a guide, the amount of calcium in these deposits, if they be 22 feet thick, is equal to the total amount of calcium in solution in the whole ocean at the present time. It follows from this that if the salinity of the ocean has remained the same as at present during the whole of this period, then it has taken about 680,000 years for the deposits of the above thickness, or containing calcium in amount equal to that at present in solution in the ocean, to have accumulated on the floor of the ocean. From the data here furnished a number of other interesting speculations might be indulged in, relating to the amount of carbonic acid that has been abstracted from the atmosphere and fixed in carbonate of lime deposits; the total amount of disintegration of lime-bearing siliceous rocks measured in terms of the calcium at present existing in solution in water and fixed in calcareous deposits; the relative proportions of substances secreted from the ocean as compared with other materials derived from the direct disintegration of the land-forming deep-sea deposits; and the apparent accumulation of carbonate of lime formations towards the equatorial regions of the globe. These various matters will, however, be discussed in another place.

UNIVERSITY AND EDUCATIONAL INTELLIGENCE.

CAMBRIDGE.—The event of the week has been the achievement of Miss Philippa Garrett Fawcett, of Newnham College, who, in Part I. of the Mathematical Tripos, is declared to be "above the Senior Wrangler," Mr. Bennett, of St. John's.

Mr. Sedley Taylor, the delegate from Cambridge to the Sexcentenary Festival of the Montpellier University, in a letter to the Vice-Chancellor on the subject of his mission, writes:—"We had the great satisfaction of seeing Prof. von Helmholtz, Delegate of the University of Berlin, publicly received with much cordiality, and of learning that, on account of his optical researches, which have given such a beneficent impulse to modern ophthalmology, he was subsequently made the object of a special ovation by the Medical Faculty for which the University of Montpellier has long been famous."

Dr. Butler, Master of Trinity College, was on June 2 again elected to the office of Vice-Chancellor for the ensuing academical year.

The John Lucas Walker Research Studentship in Pathology is vacant by the resignation of Dr. William Hunter, of St. John's College, recently elected to a Research Scholarship in

[1] Murray, "Total Rainfall of the Globe," *Scot. Geogr. Mag.*, 1887.

Sanitary Science by the Grocers' Company. The election will take place about August 26. Candidates are requested to apply to Prof. Roy, 2 Wollaston Road, Cambridge, for information. The Studentship is of the annual value of £200, or of such larger sum, not exceeding £300, as the managers shall from time to time determine; and is tenable for three years. The Student is required to devote himself during the tenure of the Studentship to original pathological research. Dr. Hunter's tenure has been marked by his elaborate and valuable researches on pernicious anæmia.

The Professor of Mineralogy (Prof. Lewis) proposes to give a course of elementary lectures on crystallography in the long vacation, beginning on Tuesday, July 8, at 9 a.m. There will also be a practical course on crystallography given by the Demonstrator, beginning on the same day. Fees for lectures £1 1*s.*; for demonstrations £2 2*s.*

The Special Board for Biology and Geology have nominated Miss L. Ackroyd (Newnham College) to occupy the University table at the Laboratory of the Marine Biological Association for one month during the year 1890.

The Mechanical Workshops Enquiry Syndicate were on Thursday, June 5, empowered by a large majority of the Senate to inquire into the conditions and expense of establishing a definite school of engineering in the University.

The number of persons matriculated during the current academical year was on May 29 brought up to 1027, the largest number on record.

At a meeting of the Council of the Cambridge Philosophical Society on Monday, June 2, it was decided, in accordance with the Reports of the adjudicators, Sir W. Thomson, Lord Rayleigh, and Prof. G. H. Darwin, to award the Hopkins Prize for the period 1883-85 to W. M. Hicks, F.R.S., for his memoir upon the "Theory of Vortex Rings" (Phil. Trans., 1885) and for his earlier memoirs upon related subjects; also to award the Hopkins Prize for the period 1886-88 to Horace Lamb, F.R.S., for his paper on "Ellipsoidal Current-Sheets" (Phil. Trans., 1887) and for his numerous other papers on mathematical physics.

Prof. J. J. Thomson announces that a course of demonstrations in practical physics, suitable for students who intend taking the Natural Sciences Tripos after passing Part I. of the Mathematical Tripos, will be given during the Long Vacation in the Cavendish Laboratory on Mondays, Wednesdays, and Fridays, at 10 a.m., commencing July 9. Students wishing to attend the course are requested to send in their names to Prof. Thomson before the end of the term.

The Observatory Syndicate publish in the *Reporter* (June 10, 1890) their record of proceedings for May 27, 1889, to May 26, 1890. The astronomical work of observation and reduction has been steadily carrried out, and the report is not marked by any eventful feature.

Dr. D. MacAlister and Prof. Roy have been appointed to represent the University at the Tenth International Medical Congress at Berlin.

The General Board of Studies, with a view to recruiting the finances of the University, especially in the scientific departments, propose to raise the examination and other fees payable by students. As a commencement they propose that the aggregate fees to be paid for the six M.B. examinations be raised from eight guineas to twelve.

SOCIETIES AND ACADEMIES.

LONDON.

Royal Society, June 5.—"Account of Recent Pendulum Operations for determining the Relative Force of Gravity at the Kew and Greenwich Observatories." By General Walker, C.B., F.R.S., LL.D.

It is well known that a series of pendulum observations was carried on in India, during the years 1865 to 1873, with two invariable pendulums, the property of the Royal Society. The Observatory of the Royal Society at Kew was chosen as the base station of the operations, and the pendulums were swung there before being sent out to India, and again on their return from India. With a view to connecting the observations with those which had already been taken with other pendulums in other parts of the world, it was intended, on the return of the pendulums from India, to swing them at the Royal Observatory at Greenwich, which was a well-established pendulum station, observed at by General Sir Edward Sabine, the Russian Admiral Lütke, and others. But when the time arrived for making the observations at the Greenwich Observatory, such extensive preparations were being made there for the equipment of expeditions for the observation of the approaching transit of Venus that no room was available for the pendulum operations. It was, therefore, decided to make the connection with Kew by swinging at Kew Kater's convertible pendulum, for determining the absolute length of the seconds' pendulum, which had been swung 40 years previously at Greenwich by General Sabine. This being done, the length of the seconds' pendulum at Kew was found to be 0·0027 of an inch greater than the length which had been previously determined at Greenwich, and consequently that the daily vibration number was three vibrations greater at Kew than at Greenwich. The difference, however, was far too large to be admissible, as the Observatories are nearly in the same latitude, and differ very slightly in height.

In 1881, Colonel Herschel, R.E., was deputed by the Secretary of State for India to take pendulum observations at the two Observatories, and at the old pendulum station in London, and also at some stations in America, with a view to improving and strengthening the connection between the observations in India and those in other parts of the world. On completing his work in America, he handed over the three pendulums which he had employed to officers of the United States Coast and Geodetic Survey, by whom they were taken round the world, and swung at Auckland, Sydney, Singapore, Tokio, San Francisco, and finally at Colonel Herschel's terminal station at Washington.

But when the observations came to be finally reduced, it was found that the difference between Colonel Herschel's results at Kew and Greenwich, as shown independently by the three pendulums, had an extreme range of about seven vibrations in the daily vibration number. The cause of these differences was mysterious and inexplicable, and there was no alternative but to swing the pendulums a second time at the two Observatories.

The revisionary work was undertaken by the Observatory staff at each place, in such intervals of leisure as they could obtain from their regular operations. The final results, by the three pendulums, make the vibration number at Kew in excess of that at Greenwich by 1·56, 1·50, and 0·59, giving an average excess of 1·22.

The correction to this quantity for the excess of height of the Greenwich over the Kew Observatory is − 0·58. Thus, the revisionary operations, reduced to the mean sea-level, make the excess of Kew over Greenwich = 0·64 of a vibration, which may be accepted as very fairly probable.

Royal Microscopical Society, May 21.—Mr. James Glaisher, F.R.S., Vice-President, in the chair.—Mr. Mayall referred to the donation, by the Messrs. Trainini Bros., opticians of Brescia, of an early form of achromatic microscope objective, constructed by the late Bernardini Marzoli, Curator of the Physical Laboratory of the Lyceum of Brescia. The objective was a cemented combination, and was described and figured in the "Commentari della Accademia di Scienze" of Brescia in 1808. This and other works and documents in proof of its authenticity were exhibited.—Mr. Mayall exhibited on behalf of Mr. P. Vallance an eye-piece similar to that shown at the previous meeting by Mr. Goodwin. It was one of two constructed by Mr. Murrell nearly forty years ago, and was provided with a screw which enabled the compound eye lens to be adjusted with reference to the field lens through a space of nearly ½ inch.—Mr. E. M. Nelson read a paper on micrometers, in the course of which he described a new micrometer made for him by Messrs. Powell and Lealand. The subject was illustrated by a drawing upon the board, and the micrometer attached to a microscope and lamp was handed round.—Mr. Thomas Comber's paper on a simple form of heliostat, and its application to photomicrography, was read. Apart from the question of the extreme simplicity of the heliostat, which was mainly due to limiting the reflection of the mirror to the polar direction and deflecting the pencil in the horizontal direction in the axis of the microscope, by means of a fixed mirror placed at half the angle of the latitude above the heliostat mirror, Mr. Comber had rendered important service to photomicrography by showing how the heliostat might be placed close to the microscope so that the error due to slight inaccuracy of the adjustment of the heliostat might escape the optical leverage which took place when the reflected beam was made to travel through a considerable space.

PARIS.

Academy of Sciences, June 2.—M. Hermite in the chair.—On the application of a double plane mirror to the precise measurement of stellar distances, by MM. Lœwy and Puiseux. In previous communications the authors have developed the theory of the optical system formed by a double plane mirror cut out of a single block of glass in the form of a prism, and placed in front of the object-glass of an equatorial. The properties of the apparatus are now demonstrated, and a practical method of observation deduced.—On the reduction of sulphates of the alkalies by hydrogen and by carbon, by M. Berthelot.—The author discusses in detail the mechanism of the reactions taking place in these reductions, with especial reference to the conditions obtaining during the process of manufacturing sodium carbonate. The equation $K_2SO_4 + 4H_2 = K_2S + 4H_2O$ expresses approximately the final state of the system, but does not at all represent the course of the reaction, which is probably as follows:—

$$(1)\ K_2SO_4 + 4H_2 = KHS + KOH + 3H_2O;$$

the KHS then decomposes.

$$(2)\ 2KHS = K_2S + H_2S,$$

and the H_2S reacts with the KOH.

$$(3)\ KOH + H_2S = KHS + H_2O.$$

Equations (1) and (3) represent exothermic reactions, (2) is the expression of an endothermic dissociation which takes place at the temperature of reduction. In addition to the above an exothermic reaction takes place between the alkaline sulphide and water vapour, thus—

$$(4)\ K_2S + H_2O = KHS + KHO.$$

The reduction by hydrogen takes place at a comparatively low temperature. With respect to the action of carbon upon the alkaline sulphates, it is shown that solid carbon even at a very bright temperature fails to react with the sulphate, but that carbonic oxide at a bright red heat reduces the salt according to the equation—

$$(5)\ K_2SO_4 + 4CO = K_2S + 4CO_2,$$

the reaction being markedly exothermic.—Note by M. Blanchard accompanying the presentation of a work on the "Actions of the Products secreted by Pathogenous Microbes."—On the fossil Hippopotami of Algeria, by M. A. Pomel. The genus Hippopotamus has been represented in Algeria at different times during the Quaternary period, and the author describes the order in which the types succeeded each other. Of four species, two are said to be certainly special, and probably also a third, whilst the last is almost unknown.—Observations of Brooks's comet (*a* 1890) made with the Brunner equatorial at Toulouse Observatory, by M. E. Cosserat. Observations of the position of the comet, extending from April 28 to May 14, are given.—On the curve representing diffraction phenomena, by M. Ernest Cesaro.—On the characteristic equation of nitrogen, by M. Ch. Antoine. Some experiments by M. Amagat on the compression of nitrogen between 39·5 and 421·1 atmospheres are used to calculate the value of $\frac{pv}{D(\beta + t)}$, where p is the pressure, and v the volume of a gas. Taking $D = 2{\cdot}830 + 0{\cdot}00191p^{1{\cdot}1}$, which, however, can only be taken as a first approximation, the mean value found is 3·10.—On the ballistic electrometer, by M. Gouy.—The month of May 1890 at the Observatory of the Parc de Saint-Maur; the cold of June 1, by M. E. Renou. The month of May was remarkable for low mean pressure, viz. 753 mm. at an altitude of 49·38 m. The mean temperature was 14°·0, or 0°·7 above the average of other years. On June 1 the minimum thermometer 2 metres above the ground registered 2°·7, and the ground thermometer registered 3°·3 below zero at sunset.—On the determination of the molecular weight at the critical point, by M. Philippe A. Guye. M being the molecular weight of any body, k the critical coefficient (the relation of the absolute critical temperature to the critical pressure), and R the specific refractive power, given by the formula of Lorentz and Lorenz, we have $M = 1{\cdot}8\frac{k}{R}$. The author shows the agreement of the results obtained by calculation with those experimentally determined, and claims that his method should rank with the vapour-density and cryoscopic methods of determining molecular weights.—On the chloro-salts of iridium, and the atomic weight of this element, by M. A. Joly. The double chlorides of iridium and potassium and iridium and ammonium are described, and from the results of their analyses the atomic weight of Ir is found to be 192·75 (H = 1); Seubert's value is Ir = 192·744.—On the oxides of manganese obtained in the wet way; second part—manganous acid, by M. A. Gorgeu.—On some new double iodides of bismuth and potassium, by M. Ch. Astre. There are now five of these double iodides known—namely, $(BiI_3)_2$, KI; $(BiI_3)_2$, 2KI, $2H_2O$; $(BiI_3)_2$, 3KI, $2H_2O$; $(BiI_3)_2$, 4KI; and $(BiI_3)_2$, 6KI; of which the three latter are new, and form the subject of the present paper.—On soda-alum, by M. E. Augé. The properties of this body are incorrectly described in text-books. The author contrasts the observed properties with the properties attributed to the compound by most authors.—The *bouquet* of fermented drinks, by M. Georges Jacquemin.—New researches on the origin of omphalocephalic monsters, and on the primitive duality of the heart in the embryos of Vertebrata, by M. Dareste.—On the arrangement of the collections of molluscs at the Natural History Museum, by M. Edmond Perrier.—On the development of blastodermic layers in *Géphyriea tubicola* (*Phoronis Sabatieri*, nov. sp.), by M. Louis Roule.—On the androgynous castration of the *Muscari comosum*, Mill., by the *Ustilago Vaillantii*, Tul., and some remarkable phenomena accompanying the parasitic castration of the *Euphorbia*, by M. Ant. Magnin.—On the æleolithic syenite of Montreal, and on the endomorphous and exomorphous contact modifications of this rock, by M. A. Lacroix.—Action of soluble substances produced by microbes on inflammation, by MM. Charrin and Gamaleia.

BOOKS, PAMPHLETS, and SERIALS RECEIVED.

Characteristics of Volcanoes: J. D. Dana (S. Low).—A Contribution to the Natural History of Scarlatina: Dr. D. A Gresswell (Oxford, Clarendon Press).—A Manual of Pharmaceutical Testing: B. S. Proctor (Office of the *Chemist and Druggist*).—Aluminium, 2nd edition: J. W. Richards (S. Low).—Die Gesetze und Elemente des Wissenschaftlichen Denkens, Erster Band: Dr. G. Heymans (Leiden, van Doesburgh).—British Cage Birds, Part 2: R. L. Wallace (Gill).—The Canary Book, Part 2: R. L. Wallace (Gill).—Elementary Algebra, 2nd edition: C. Smith (Macmillan).—Induction and Deduction: C. C. W. Nadens (Bickers).—The Philosophy of Clothing: W. M. Williams (Laurie).—Madagascar; or, Robert Drury's Journal: edited by Captain Oliver (Unwin).—Blackie's Modern Cyclopedia, vol. 6 (Blackie).—Fifty Years of Science, 4th edition: Sir J. Lubbock (Macmillan).—Sanity and Insanity: C. Mercier (Scott).—Nature and Woodcraft: J. Watson (Smith and Innes).—Den Norske Nordhavs-Expedition 1876-78, xix. Zoologi—Actinida: D. C. Danielssen (Christiania, Grondahl).—Observations of the New England Meteorological Society in the year 1888 (Cambridge, Mass., Wheeler).—Meteorological Observations made at the Summit of Pike's Peak, Colorado, January 1874 to June 1888 (Cambridge, Mass., Wheeler).

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