THURSDAY, MARCH 10, 1892.

THE SCIENCE MUSEUM AND THE TATE GALLERY.

THE men of science of this country owe a deep debt of gratitude to Mr. Goschen. As a result of his careful inquiry into the questions raised by the suggested use, for Mr. Tate's gallery, of land bought for scientific purposes, he has decided that the scientific claim must hold good. It is impossible to over-estimate the importance of this decision. Had it been otherwise, the possibility of establishing in London an institution which should be for Science what the National Gallery is for Art and the British Museum Library for Literature would have been wrecked for a generation.

One can easily imagine that it was not easy for a Chancellor of the Exchequer to come to such a conclusion—not easy, that is, to one who was prepared only to look at the surface of things.

On the one hand, there was the tempting offer of £80,000 from a well-known public benefactor, about which large sum so much has been said that very few have thought it worth while to consider either the value of the plot or what capital sum would represent the annual outlay necessary to keep up the gallery when once built; an outlay which, of course, would fall upon the nation.

On the other hand, the Lord President of the Council, who is responsible for the Science and Art Department (and, as many people think, however erroneously, for the proper setting out and consideration of any national question touching Science or Art), seemed to be willing that Mr. Tate should have his way. Nor was this all; the Report of the Committee appointed by the Treasury a few years ago is so vaguely drafted that it now appears that the view which we and others took in discussing its recommendations at the time was incorrect. The question referred to this Committee dealt with the space necessary for the housing of the science collections which had been brought together as a nucleus for the Science Museum, the establishment of which was recommended in 1874 by the Duke of Devonshire's Commission. The Committee's Report recommended that 90,000 square feet *should be provided.* We and others naturally took this to mean that this was in addition to the existing space. The modern gloss, however, is that this represented the whole space necessary, in the opinion of the Committee, for a complete Museum dealing with all the inorganic sciences (except geology and mineralogy) and their industrial applications! It may even be that this idea has been placed before Mr. Goschen. If so, all the greater credit to him for having seen through the fallacy of a view which it is absolutely impossible can ever have been in the heads of the scientific members of the Committee.

As we pointed out recently, it is better not to deal with opinions in such a matter as this, if facts are available; they exist. The space considered necessary not very many years ago for the sciences represented in the Natural History Museum was 150,000 square feet, nearly double that already mentioned. In the case of these sciences, moreover, "industrial applications" cannot be exhibited at all—except, by the way, in the case of geology, for which a special Museum exists in Jermyn Street.

One hundred and fifty thousand square feet being required, a plot of 500,000 square feet was provided; and it is quite certain that, at some not very distant time, the space not yet built on will be required. We cannot, therefore, call this generous appropriation unwise from the point of view of possible, or rather certain, future extensions; while all will agree that a national building of this class is all the better for standing a little away from noisy and dusty roads.

This, then, is the available fact with which we can deal, and we must again state whither it leads us; for in Mr. Goschen's letter to Mr. Tate, admirable though it is as a complete statement of the case, there is one phrase to which we must take exception. To show its force, we quote the whole sentence:—

"In conclusion, allow me to say that I can well understand that the difficulties in finding a suitable home for your collection, notwithstanding your munificent offer to build yourself, may not unnaturally have caused you some vexation. I think you will, however, admit that the Government have shown their desire to meet you in every possible way, and are willing to incur considerable outlay themselves in carrying out your plan. In the first instance, we not only offered the eastern and western galleries for housing British art, but adopted the plan of uniting them by a cross gallery, which seemed to remove many of the objections. When you came to the conclusion that the proportions given to the plan were not large enough or distinct enough to suit your views, and when you suggested the site at the corner of the Imperial Institute Road, I hoped that a solution had been found, and that this arrangement would meet with general acceptance. You are aware of the storm which followed, *and though, in my own judgment, the Government land at Kensington was of so large an area that, by some understanding between the representatives of science and those of art, satisfactory means could be provided for assigning sites for every purpose*, I was nevertheless so anxious that no obstacles should prevent the execution of your plans, that I consented to recommend the Government to incur a very considerable pecuniary liability if the Corporation of London should, on their part, offer the site on the Embankment on terms which were suggested to me as not impossible."

Now, the land at Kensington, of "so large an area," consists of something like 300,000 square feet, say three-fifths of the site occupied by the Natural History Museum: of this, Mr. Tate demanded roughly 100,000 square feet—thus leaving 200,000.

Of this, the new laboratories for physics, astronomical physics, and chemistry, if these are to be on the scale of similar institutions in a second-rate German town, will, including the necessary lighting spaces, &c., require 100,000 square feet. This leaves 100,000.

But this remainder, on which there is to be built a Science Museum, *is less than two-thirds of the exhibiting space of the Natural History Museum* as it stands at present, to say nothing of the total area devoted to it

It is clear, then, that Mr. Goschen has not had the facts placed before him by those upon whom he has relied for his information. While the official prompting has tended one way, the opinions of the President and Officers of the Royal Society and other men of science have clearly tended another; and Mr. Goschen's final attitude is, to a large extent, due to the weight which he has wisely and bravely attached to the latter.

"The proposal," he says, "has not met with the general acceptance which we anticipated for it. On the contrary, it is strenuously opposed by what appears to be the whole body of opinion representing scientific interests; and, although it might be possible to provide adequately for those interests and at the same time appropriate the site proposed to the British Art Gallery, I cannot say that the discussions in that sense with which we have for some time been occupied have so far had any effect in diminishing opposition from those quarters."

The opposition has, we may remark, not changed because the facts have not changed, and we do not think it would have been started if any *modus vivendi* had been possible.

And here we approach a side of the question which shows that as the world grows older, questions of science and art are not managed in this country any better than they used to be, and that some radical change is necessary in our manner of dealing with them. A correspondent of the *Pall Mall Gazette* ascribes this to *Tory government*. It is easy to see that the administrative system and not party government is to blame.

Mr. Goschen, in his letter, states that Mr. Tate himself suggested the site on the science ground, and it may be that some friends of science have said or thought hard things of Mr. Tate in consequence.

Mr. Tate replies:—

"I did not suggest the site at the corner of the Imperial Institute Road, and was only aware of it when it was pointed out to me as the plot offered by the Government as a desirable site for the Gallery of British Art, and with that site I expressed myself satisfied."

It must therefore be taken that it was the Government itself that offered the site. Did the Government offer first and consider afterwards? for Mr. Goschen now admits that it "would not be wise to assign this corner site to the Gallery of British Art." Another point can be best stated by again quoting from Mr. Goschen:—

"When it [the scheme] was first mooted, the intention was that works of British painters from the National and South Kensington Galleries should be transferred to the new gallery. It has since been ascertained that the trustees of the National Gallery are not disposed to fall in with this intention, and that the Science and Art Department is precluded by the terms of its various trusts from parting with many of its most important works."

The Science and Art Department is not more "precluded" now than it was when the land was offered to Mr. Tate. The preclusion dates from 1857, and it apparently was not known to those who, as it would now seem, without consulting the Science and Art Department, were ready both to hand over pictures and land.

We give these two instances as indications of the result of the present system of dealing administratively with such questions.

We have already stated that the scientific world is under great obligations to Mr. Goschen; but we must also point out that the President and Officers of the Royal Society, and the other men of science who memorialized Lord Salisbury and attended the deputation, have rendered a service to science worthy of the high position they hold.

There are men of science employed at South Kensington, it is true; but they, as we have said before, have no official voice in such matters as these.

Since it seems we may now hope that the land has been saved for scientific purposes, it is much to be desired that some representative of science in the House of Commons should move for a Committee on which the Treasury and the Office of Works, the Science and Art Department (though judging from recent events the last-named is too frequently ignored when questions directly connected with its duties are under consideration), together with the Royal Society and the Professors of the Royal College of Science, may be represented.

Mr. Goschen's answer on Monday to Dr. Farquharson's question as to what steps had been taken to provide for the building of the Science Museum, and for the extension of the Royal College of Science so urgently required, shows us clearly that it will be some time before the teaching at South Kensington will have passed through its present camping-out stage.

Mr. Goschen acknowledges that

"it has been impossible to take any steps towards beginning the erection of a Science Museum or the extension of the Royal College of Science until the question connected with the British Art Gallery had been settled. I myself had visions of a scheme, independently of building on the controversial corner, which I had thought might have given ample satisfaction both for the present and future to the scientific world, but the matter will now have to be reconsidered."

In answer to another question Mr. Goschen admitted that the scientific work at South Kensington is at present cramped, and stated that, in conjunction with the Commissioner of Works, he would endeavour to find some temporary buildings to meet the difficulty before the final scheme is adopted.

Let us hope that, some time before another generation has passed away, the "administration" which has led to the present *impasse* may be ameliorated, and that useful buildings on the site may prove to everybody the justice of the views held by the men of science in this matter.

THE CORRESPONDENCE OF CHRISTIAN HUYGENS.

Œuvres Complètes de Christiaan Huygens. Publiées par la Société Hollandaise des Sciences. Tome quatrième, Correspondance 1662-63. (La Haye: Martinus Nijhoff, 1891.)

THE fourth volume of the Huygens correspondence, covering the years 1662-63, is now before us. Although the interval, as regards fresh discoveries by the "Dutch Archimedes," was a comparatively barren one, the 249 letters referable to it (to say nothing of supplementary documents) afford materials for much instruction, and some entertainment. It is much to learn that the greatest astronomer of his time sought to keep in touch with Paris in respect to the cut and colour of his clothes; nor can we be indifferent as to the precise date of his beginning to wear a wig. On June 15, 1662, at the age of thirty-four, he communicated to his brother Constantine the distressing intelligence of his incipient baldness; a remedy for which, in the shape of the best *perruque* to be had in Paris, was provided in the following

October. A similar article of attire, despatched by him to the Hague for his elder brother's wear, figures in several letters, and engaged many anxious thoughts; but a little plot concocted by the *par nobile fratrum* for extracting the price—amounting to four and a half louis—from the liberality of their father, the Secretary, appears to have been baffled. They were, indeed, often made to feel—though not with any unreasonable harshness—that he who keeps the purse holds the reins; for the paternal authority exercised in their family was of no shadowy kind. The elder Constantine ordered his three sons—middle-aged, in Dante's sense, though they were—from realm to realm at his good pleasure, and was obeyed without hesitation. And notwithstanding that his demands from Paris for optical toys—pocket-telescopes, magic-lanterns, and the like—gave Christian considerable annoyance, he did not venture to refuse, or so much as remonstrate against the fulfilment of paltry, troublesome, and, to his sentiment, humiliating commissions. He, however, stooped instead to the scarcely laudable subterfuge of begging his brother Louis, then in Paris, to abstract one of the three lenses of the lantern, and so bring about at least a postponement of his father's appearance at the Louvre in the character of showman to scientific "marionettes," no longer claiming even the distinction of novelty.

Huygens spent the whole of 1662 in Holland, occupied mainly with experiments on the "weight and spring of the air." Pneumatic inquiries just then, largely through Boyle's example, raised very general curiosity; and pneumatic engines attracted much constructive ingenuity. The mode of creating *vacua* had been recently arrived at; phenomena of an unforeseen kind thence ensued, and led to continual surprises; their investigation involved that of the qualities and functions of the air; upon which the learned, accordingly, promptly and eagerly entered. Huygens among the number; yet with no result of the first order of importance. He fabricated an improved air-pump; and observed by its means some apparently anomalous effects, which occupied many of his thoughts, and gave rise to an extensive correspondence, both with French *savants*, and with Sir Robert Moray as the representative of the Royal Society of London. They did not, however, prove to possess all the significance which he was at first disposed to attach to them. Less than his customary success, also, about this time attended his efforts to give to pendulum-clocks the perfection needed for the solution of the problem of longitudes. His coadjutor was the ingenious Alexander Bruce, a few months later Earl of Kincardine, who, with unlucky result, took a pair of the carefully-adjusted timepieces on a trial voyage from the Hague to London in December 1662. The sea was rough; the ship a small one, but with large capacities for rolling and pitching; whereby a test more searching than tolerable was applied to the novel mechanism. One clock, thus "furiously shaken," lost the bob of its pendulum; the other stopped, and their custodian, having succumbed to sea-sickness, could do next to nothing to remedy the damage. Evidently, the purpose in view demanded some better invention, such as, indeed, Robert Hooke had already hit off, but, after his usual volatile fashion, had thrown, still incomplete, aside.

On arriving in Paris, April 3, 1663, the first care of our mathematician was to have himself bled, in order to get rid the sooner of a cold caught on the journey of six full days from Brussels; and the operation, singularly enough, produced the intended effect. His next desire was to place himself *au courant* of the state of practical optics in the French capital, and to compare his lenses with those ground and polished by Auzout and D'Espagnet. The handiwork of the latter excited his particular admiration; but the secret of his methods was carefully guarded, and Huygens records, with a perceptible shade of irritation, the vigilance of the Bordeaux alchemist over a case of lenses which might, for the care bestowed in keeping them tucked under his arm, have been a box-full of pistoles. He found, however, "Messieurs les Lunettiers" less advanced than he had expected in their grand schemes for telescopes 80 and 100 feet in length.

He set out with his father for London on June 7, and both were present three days later at a meeting of the Royal Society, where they were entertained with "occasional observations," and "promiscuous discourses," relating to petrifactions, the smutting of corn, the amelioration of flowers, and sundry other topics. Christian testified his usual courteous interest in the proceedings; but expressed, none the less, in one of his confidential letters to his brother Constantine, something of scorn for the miscellaneous doings at Gresham College. And he felt himself, he said, no whit the wiser for his election as a Fellow of the Society on June 17, 1663. English festivities, however, he admitted to be splendid. "This is the true land of good cheer," he wrote, after a succession of dinners given by the Earls of Manchester, Albemarle, and Devonshire, all of which were outdone by the brilliant hospitality at Roehampton of the Dowager Countess of Devonshire. A Court ball evoked no special comment; and perhaps Huygens's most genuine interest in London was in his visits to Sir Peter Lely's studio. Both he and Constantine dabbled about that period in pastels, and the recipe by which Lely's crayons were fabricated was an object of eager desire to them. It was freely imparted, and is here printed (p. 372).

Huygens quitted London on October 1, and spent the remainder of the year in Paris. And since his movements were regulated, not by the claims of science, but by family arrangements, his letters thence referred to no critical problems of that age. They are accordingly more "readable," in the general sense, than might have been expected from a geometer of his profundity; those addressed to his brothers, which form the majority in the present volume, being even playful and diverting. To them he showed himself without disguise. He sent them lively *causeries*, rather than formal epistles; social jottings, family intelligence, the first hints of his anticipated triumphs, his unvarnished opinions of his contemporaries: they alone were allowed to see that there was a keen edge to his wit. His erudite correspondents on occasions put him fairly out of patience; yet to Louis Huygens alone was it confided that he thought Chapelain intolerably tedious, and Petit uncommonly dull. Constantine, on the other hand, was the recipient of his impressions touching the harpsichord performance of William Brereton, a distinguished member of the Royal Society. Its effect upon a trained musician like Huygens can easily be gathered from the ominous facts that the player was self-taught, and executed fantasias chiefly remarkable for their disregard of every known rule of composition. Touches of family affection here and there relieve the intellectual pre-occupation lending its prevalent stamp to the Huygenian correspondence. One likes the great man better for his questions about the walking and talking achievements of his little niece, Gertruid Doublet, than for having solved the problem of the centre of oscillation, or discovered the isochronism of the cycloid. The maiden's modest proficiency was not carried to a high pitch. She died in 1665, at the age of four.

In the way of astronomy, Huygens did nothing of much moment during this interval. Admonished by Boulliaud of its visibility, he made his first observation of Mira Ceti at the Hague, on August 15, 1662, when it was nearly as bright as κ Ceti (fifth magnitude). The next account of the star is on September 15, three weeks at least after a maximum; and its declining state seemed to Boulliaud marked by the flaring and flashing of its light, as if in truth a semi-extinct conflagration revealed itself in his telescope. "C'est un spectacle," he adds, "à faire désespérer Aristote et ses disciples" ("Corr. de Huygens," t. iv. p. 231). Occasionally, too, Huygens pointed out the sustained conformity of the Saturnian appearances to his theory of them. The logic of fulfilled prediction had, indeed, by this time persuaded all but the few outstanders always averse to conviction by truth, that the hypothetical and the real systems were practically identical.

The two years embraced by the present section of this grand work were exceedingly peaceable ones. The gates of the Temple of Janus in the republic of letters remained fast shut as they slipped by. Scarcely a ripple of contention stirred. Everyone was in good humour, and carped at his rival's doings only *sotto voce*—a state of things peculiarly agreeable to our Batavian philosopher, who loved not to have his meditations broken in upon by the shrill outcries of wounded self-love. Could it but have continued! But that was not to be.

A. M. Clerke.

THE HORSE.

The Horse: A Study in Natural History. By William Henry Flower, C.B., F.R.S., &c. (London: Kegan Paul, 1891.)

If there be a fault in the admirable little volume which Prof. Flower has contributed to the "Modern Science" series, it is that the author too cautiously withholds his opinion on certain broad biological questions in which not only naturalists but the general reading public are just now specially interested. Early in the first chapter, for example, we read:—

"In many organs, but especially in the limbs and teeth, we find the strongest evidence of two opposing principles striving against each other for the mastery in fashioning their form and structure. We find *heredity*, or adherence to a general type derived from ancestors, opposed by special modifications of or derivations from that type, and the latter generally getting the victory, although in the numerous rudimentary structures that remain there is significant evidence of ancestral conditions long passed away. The various specializations, evidently in adaptation to purpose, will be thought by many to be the result of the survival, in the severe struggle for existence, of what is best fitted for the purpose to which it is to be applied. This may or may not be the explanation, but the interest of the study of such an animal as the horse will be increasd tenfold by the conviction that there is some true and probably discoverable causation for all its modifications of structure, however far we may yet be from the true solution of the methods by which they have been brought about."

Here natural selection is not so freely and fully accepted as many would wish. But the grounds of doubt are not indicated. On the other hand, use-inheritance fares worse. It is not so much as hinted at. It is well known that there are, especially in America, biologists of standing who contend that differentiations of structure are largely due to a Lamarckian factor in evolution; and they adduce specialization of tooth-structure and of limb-structure as evidence of the inherited effect of mechanical strains and stresses. Now, in the horse specialization in teeth and limbs has been carried far. The general public and not a few biologists would, we think, have been glad to learn the opinion of the Director of our National Museum as to the scientific value of such views in so far as they apply to the subject of his "study."

On another point of very general interest Prof. Flower does, however, express an opinion. It has been suggested that the horse has been separately evolved in America and in Europe through a parallel but not identical series of ancestral forms. The evidence for this hypothesis is generally regarded in this country as insufficient, and it is now held that the horse was probably evolved on the Western Continent. This is the view adopted, with his accustomed caution, by the author of this book.

"It is," he says, "by no means impossible that America may have been the cradle of all the existing *Equidæ*, as it seems to have been of such apparently typical Old World forms as rhinoceroses and camels, and that they spread westward by means of the former free communication between the two continents in the neighbourhood of Behring's Straits, and, having prevailed over the allied forms they found in possession, totally disappeared from the country of their birth until reintroduced by the agency of man. This supposition, based upon the great abundance and variety of the possible ancestral forms of the horse which have lately been discovered in America, may be at any time negatived by similar discoveries in the Old World, the absence of which at the present time cannot be taken as any evidence of their non-existence."

The discovery in the Old World of ancestral Perissodactyles, in numbers at all comparable to those which have been found in America, would no doubt throw a flood of light on difficult questions of evolution and distribution. If, as Madame Marie Pavlow has suggested, Sir Richard Owen's *Hyracotherium* is (perhaps) identical with Prof. Cope's *Phenacodus*, similar genera have existed on either side of the Atlantic since early Eocene times. In both continents these early forms presumably left descendants. Between the primitive *Phenacodus* and the existing horse there are many intermediate forms, some of which seem to be generically identical in America and in Eurasia. Have there, then, been many successive migrations from the West? Have there been counter-migrations from East to West? What have been the relations between the indigenous descendants of *Hyracotherium* and the successively immigrant descendants of *Phenacodus?* These and other questions may possibly receive some sort of tentative answer through the researches of the palæontologists of the future. Prof. Flower is no doubt wise in not attempting to theorize on the subject; but this is the kind of question on which, in our experience, the "intelligent layman," whom the editor of the "Modern Science" series has in view, most greedily seeks information. Details of structure, no matter how clearly and lucidly described, do not appeal to him. He says, in effect, to the distinguished man of science: "My dear sir, from *you* I can take the details on trust; of them give me only sufficient to illustrate your methods of research: what I really want is your opinion on those broad general problems in which every man of liberal culture, who follows the thought of his time, must take a keen interest."

Prof. Flower divides his book into four chapters, of which the first deals with the horse's place in nature, and its ancestors and relations. The second chapter is devoted to the horse and its nearest existing relations. This contains a short account of the tapirs and the rhinoceroses, as well as the existing members of the horse tribe. The cuts with which it is illustrated are from photographs, and are admirable. The last two chapters (iii. and iv.) deal with the structure of the horse, chiefly as bearing upon its mode of life, its evolution, and its relation to other animal forms, the head and neck and the limbs being selected for detailed treatment.

Especially interesting are the paragraphs on the *ergot*, a roundish bare patch in the fetlock covered with rough thickened epidermis. It is suggested, and the suggestion is both valuable and interesting, that this represents

"the palmar or plantar pads of those animals which walk more or less on the palm and sole. Owing to the modified position of the horse's foot, standing only on the end of the last joint of the one toe, this part of the foot no longer comes to the ground, and yet the pad with its bare and thickened epidermic covering, greatly shrunken in dimensions and concealed among the long hair around, and now apparently useless in the economy of the animal, remains as an eloquent testimony to the unity of the horse's structure with that of other mammals, and its probable descent from a more generalized form, for the well-being of whose life this structure was necessary."

Of the other callous patches, the so-called "chestnuts," or "mallenders" and "sallenders," which occur on the inner aspect in the fore-limb just above the "knee," and in the hind-limb just below the "hock," Prof. Flower says that their signification and utility are complete puzzles.

There are one or two misprints or inelegancies which will probably be removed in a second edition. On p. 52 we read: "The upper molars have a very characteristic pattern, admirably adapted for bruising and crushing coarse vegetable substances, and which is clearly a modification of the pattern," &c. Another redundant *and* before *which* occurs in the very awkward sentence on the top of p. 136. A somewhat quaint misprint occurs on the top of p. 68, where the "various species of the American general called *Merychippus* and *Protohippus*" are spoken of. One can imagine how the printer's devil prided himself on his knowledge of American proclivities. They give the name "general" even to an ancient fossil equine!

C. LL. M.

OUR BOOK SHELF.

A System of Sight-Singing from the Established Musical Notation, based on the Principle of Tonic Relation. By Sedley Taylor, M.A. (London: Macmillan and Co., 1891.)

THIS book is divided into two parts: (I.) the tonic sol-fa notation, (II.) the staff notation. Part I. differs from the "official" tonic sol-fa system only in the method of writing music in the minor key. Mr. Taylor is an out-and-out tonicist, and therefore most strongly opposed to the so-called "Lah mode" of the official system. It must be allowed that Mr. Taylor's method has the merit of consistency. For practical purposes, however, it is not so certain that the "Lah mode" is a mistake. At any rate, the opinion of most tonic sol-faists appears to be in its favour, as being the best method, from a utilitarian point of view, of treating the minor mode.

Part II. is an application of the tonic system to the ordinary staff notation. Mr. Taylor suggests that the line or space on which the tonic falls should be clearly marked by a thick line, of varying colours for major and minor keys. As long as there is little or no modulation in the music, there can be no objection to this, but when modulation sets in, the appearance which the stave assumes when these lines are inserted, becomes most puzzling. Two examples taken at random from the book will suffice to show this. In Ex. 142 the Do-line changes 6 times in the space of 9 bars of 2-4 time. Ex. 147, in 4-4 time, has 5 changes in as many bars.

It appears to us that these constant guides are calculated only to worry instead of directing the singer; "the graphic up-and-down-ness of the pitch-notation of the staff" (to use Mr. Taylor's words) seems to us to point out the way just as well without as with their assistance.

The book is most clear, logical, and interesting throughout; and whether one agrees with the reforms proposed in it or not, one cannot help feeling that the author, in his endeavours to minimize the difficulties of vocal music, deserves the thanks of all musicians.

The Statesman's Year-book for the Year 1892. Edited by J. Scott Keltie. (London: Macmillan and Co., 1892.)

THE "Statesman's Year-book" is too well known, and too highly appreciated, to need the commendation of reviewers. It presents such great masses of important facts, and these are generally so accurate and so well arranged, that the work has become indispensable to all who desire to obtain the latest information on the various subjects with which it deals. The changes for the year 1892 are described as "heavy and extensive," and all of them, we need scarcely say, add to the usefulness of the volume. The date of issue was somewhat later than usual; but it was well worth while to postpone publication, as the delay enabled the editor to include, among other valuable statistics, the results of the censuses of the leading countries of the world. This year the volume has been enriched with four admirably executed maps. They relate respectively to the density of the population of the globe on the basis of new censuses and estimates, the distribution of the British Empire over the globe, the partition of Africa, and the international frontiers on the Pamirs. These maps are most welcome, and will be of great service to all who may have occasion to refer to them.

The Optical Lantern as an Aid in Teaching. By C. H. Bothamley. (London: Hazell, Watson, and Viney, Limited, 1892.)

THOSE who wish to acquire a general knowledge with regard to the manipulation of an optical lantern, without entering into the minor details, will find in this little book a most useful guide. The author has dealt with the subject rather curtly, but nevertheless in this space the reader will find descriptions of various lanterns for different methods of projection; hints on the most suitable positions in which screens should be placed to be best viewed by audiences; the best kinds of burners for the lamps, both oil and oxy-hydrogen, and the different adjustments for producing good results. Many other useful hints are given, accompanied by several woodcuts. W.

LETTERS TO THE EDITOR.

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

Heat-Engines and Saline Solutions.

MR. MACFARLANE GRAY (p. 414) appears to call in question my assertion that in a vapour-engine a saline solution may take the place of a simple liquid when it is desired to replace water by a substance of less volatility, and that the advantage which Carnot proved to attend a high temperature can thus be attained without encountering an unduly high pressure. He contends that "the saline mixture is not the working substance. Carnot's law refers to the working substance only, and not to anything left in the boiler."

Perhaps the simplest way of meeting this objection is to point out that Maxwell's exposition of Carnot's engine ("Theory of Heat," chapter viii.) applies *without the change of a single word*, whether the substance in the cylinder be water, mercury, or an aqueous solution of chloride of calcium. In each case there is a definite relation between pressure and temperature; and (so far as the substance is concerned), all that is necessary for the reversible operation of the engine is that the various parts of the working substance should be in equilibrium with one another throughout.

Let us compare the behaviour of water in Carnot's engine before and after the addition of chloride of calcium, supposing that the maximum and minimum pressures are the same in the two cases. The only effect of the addition is to raise both the superior and the inferior temperatures. The heat rejected at the inferior temperature may still be available for the convenient operation of an engine working with pure water. At the upper limit, *all* the heat is received at the highest point of temperature—a state of things strongly contrasted with that which obtains when vapour rising from pure water is afterwards superheated. RAYLEIGH.

Superheated Steam.

LORD RAYLEIGH touches on a most important question (February 18, p. 375), which merits the attention of all interested in the economy of prime movers. Few have troubled themselves with determinations of temperatures and pressures within a steam generator. Ebullition means work, and the performance of work involves cooling; hence the temperature of steam in the steam space of any boiler is lower by several degrees than the temperature of the steaming water. I have failed to find any record of this important truth, and shall be glad to know if my observations have been anticipated.

Prof. Cotterill, in his work on the steam-engine (p. 33), referring to the process of formation of steam under rising pressure in a closed vessel, says:—"The mixture of steam and water must be supposed so treated that the temperature is sensibly uniform. If the experiment were tried without proper precautions, the steam would probably be found to be of higher temperature than the water—that is, it would be superheated." So far as my observations go, this is impossible, and the steam is never superheated by compression in a closed vessel, in contact with water.

In a small experimental boiler the records of temperature indicated as follows:—

Temperatures in Model Boiler working up to 10 *pounds pressure*

Water temperature $1\frac{1}{4}$ inches below upper level.	Steam temperature. Thermometer in steam space.	Pressure, pounds per square inch.
° F.	° F.	
100	87	—
120	106	—
140	126	—
158	145	—
174	164	—
188	179	—
200	192	—
212	205	—
215	212	—
226	222	$5\frac{1}{2}$
236	233	$9\frac{1}{2}$
239	235	10
239	235	10
239	235	10

To avoid supersaturation of the steam it must be separated as promptly as possible from the water, which it projects, more or less, into the steam space. It is this which renders it so important in practice to secure the most active circulation. Provision for this, whereby the water falls, whilst the steam rises, can be made.

Uniformity of temperature of the boiler contents is of the utmost importance; and I was recently told by an able engineer, connected with the Midland Railway, that the unequal expansion of the boiler plates in locomotives on getting up steam was not only disastrous in its consequences, but *impossible* of prevention. Pursuing thermometric experiments, I found this not to be the case, and on a first trial of suitable apparatus, I obtained the following result:—

Model Locomotive Boiler, showing Hottest Water at the Bottom under 212° (*October* 24, 1891).

Upper level above fire...	60°	80°	90°	100°	110°	120°	130°	140°	150°
Temperature below furnace ...	60	65	70	76	82	90	96	107	114
Upper level above fire...	160	170	180	190	196	198	199	204	209
Temperature below furnace ...	122	134	156	176	200	204	206	208	209
Upper level above fire...	212	212	—	—	—	—	—	—	—
Temperature below furnace ...	210	212	—	—	—	—	—	—	—

Lord Rayleigh's suggestion to use liquids of higher boiling-point than water, such as saline solutions, to get hotter steam whereby to raise the upper limit of temperature in a steam-engine, is not feasible. Increased elasticity of steam or increased tension was long since shown by John Sharpe ("Annals of Philosophy," vol. i. p. 459, 1813) to be due to a corresponding increase in its density. He pointed out that at 212° the density of steam was 150 times greater than at 32°, and at 252° it was twice as great as at 212°. Increasing the density of the liquid does not help us, but liquids of lower boiling-point yield vapours of higher density than steam at equivalent temperatures. Anhydrous ammonia vapour exerts a pressure of 4 atmospheres at 32°, and its density is about 0·2, whereas at 120° F. the pressure is in round figures 285 pounds on the square inch, and its density 0·850.

Properties of Saturated Steam as compared with Saturated (*Anhydrous*) *Ammonia Vapour.*

Steam.			Anhydrous ammonia.		
Pounds per square inch above the atmosphere.	Temperature in ° F.	Weight of steam in pounds per cubic foot.	Pounds per square inch above the atmosphere.	Temperature in ° F.	Weight of vapour in pounds per cubic foot.
15	249°·8	·07344	14·744	0°	·1060
30	273·9	·10790	32	20	·1639
60	307·2	·17493	57·607	40	·2428
120	349·8	·30503	113	70	·4096
165	372·8	·40053	164·7	90	·5587

Regnault, Frost, Fairbairn, Tate, and others have shown that the rate of expansion of superheated steam is almost identical with that of air and other permanent gas, if calculated not too close to the temperature of maximum saturation. In passing steam through pipes heated by the hot gases from the furnace, the effect is not much, if any, better than using a trap to separate the water of condensation.

It is obvious that, for steam to pass from a boiler into a superheater, the latter can only be at the same pressure as the boiler, or somewhat lower, and the gasification in transit is not attended by increased density nor exalted tension; hence the failure of ordinary superheaters.

Practical engineers—makers of high-pressure engines for the trade—discovered long since that compression of steam at the end of each stroke, or steam cushioning, notwithstanding certain theoretical disadvantages, yielded an average efficiency greatly in excess of free discharge of steam from the cylinder. In this case superheating, of course, occurs, by compression, under circumstances insuring exalted tension; hence the economy. Hook's law, "Ut tensio sic vis," cannot be translated into "Ut calor sic vis." JOHN GAMGEE.

The Laboratory, 3 Church Street, Westminster, S.W., February 23.

Poincaré's "Thermodynamics."

I FEAR M. Poincaré has not read my review of his book with sufficient attention. Otherwise he could hardly have written the letter printed in your last number.

The chief objections I made, taken in the *reverse* order of their importance, were

1. The work is far too much a mere display of mathematical skill. It soars above such trifles as historical details, while overlooking in great measure the experimental bases of the theory; and it leaves absolutely unnoticed some of the most important branches of the subject.

[Thus, for instance, Sadi Carnot gets far less than his due, Rankine is not alluded to, and neither Thermodynamic Motivity nor the Dissipation of Energy is even mentioned!]

2. It gives an altogether imperfect notion of the true foundation for the reckoning of absolute temperature.

3. It completely ignores the real (*i.e.* the statistical) basis of the Second Law of Thermodynamics.

If these are what M. Poincaré alludes to as "reproches généraux, contre lesquels ma préface proteste suffisamment," I can only express genuine amazement that a Preface should be capable of having such powers, and envy the man who is able to write one.

As to smaller matters:—I did not attack M. Poincaré's printer, I virtually said he was excusable under the circumstances. And as to the quite subsidiary question which M. Poincaré seems to think I regard as the most important, I have only to say that I could scarcely be expected to know that the words "on n'a pu jusqu'ici *constater l'existence* des forces electromotrices, &c.," imply, as M. Poincaré now virtually interprets them, "One has not yet been able to *assign the origin of* the electromotive forces, &c." P. G. T.

4/3/92.

The Function of a University.

YET one more definition—it is no part of the business of a University to *teach*, says Prof. Fitzgerald in NATURE of February 25 (p. 392). We have now the following definitions of the function of a University:—

1. It should be a mere examining body, *e.g.* the London University.

2. It is a place for the cultivation of athletics, good breeding, and gentlemanly behaviour.

3. At the University there should be taught classics, mathematics, and pure science.

4. The Professors of the University should teach *useful* subjects like mechanical and electrical engineering, medicine, &c., as at Cambridge.

5. The true function of the University is the teaching of *useless* learning.

6. It is no part of the business of a University to *teach*.

Truly, a wide choice of definitions, and seeing that the teaching of applied science which has been developed "at schools, technical colleges, by patent-mongers and the trade," aided "by a lot of savages," has been recently appropriated by the Universities, I have no doubt, when these degraded mortals have similarly worked out a system of teaching applied literature, that a seventh definition of the function of a University will be added later on, viz.:—

7. At the University, modern languages and literature are studied in such a way as to be of the greatest value to the nation at large.

As Prof. Fitzgerald relegates the teaching of things useful to the class of pariahs mentioned above, perhaps he will tell us whether he raises the study of mechanical and electrical engineering to the lofty position of uselessness, or whether he utterly condemns the appeal that is now being widely made—made even to technical teachers—for aid in the establishment of engineering laboratories at a University which has recently thought that the best place to obtain an assistant was a London technical college.

He thinks that students, "if they are so ill prepared that they have not acquired the art of learning, should go to a College, . . ." and not to the University. I presume, then, that they ought to go, for example, to the Colleges of Trinity or St. John's, but not to Cambridge; or to the Colleges of Balliol or Christ's, but on no account to Oxford. Perhaps this somewhat conflicting advice is the result of Prof. Fitzgerald's studying literature "for its own sake," as contrasted with studying language for the sense it conveys. Examples were recently given in a leader in one of the daily papers illustrating that the public utterances of some of the most prominent advocates of the compulsory teaching of Greek conclusively proved that it was not to improve their English that they had studied the classics.

In the same lucid way Prof. Fitzgerald adds: "The Bible produced very little effect until it was read in translations; and the danger of a pagan revival, if ancient literature were studied without the obstruction of difficult languages, is the best reason for insisting on those languages in a Christian University." Surely a man of his wide intellectual power cannot mean that the general reading of the Bible, which became possible after it was translated into modern languages, is to be deplored. But neither, on the other hand, can he mean that the incalculable benefit, that has resulted from the translation of the Bible into the vulgar tongue is an argument for the suppression of free translation. On whichever horn of his own dilemma he decides to pose himself, I, at any rate, have no sympathy with the Roman Catholic dogma that good comes from making the knowledge of the truth difficult of attainment by the world at large.

He chides me with forgetting the debt electrical science owes to those who studied it while useless. Does the statement that one *Volt* sends one *Ampere*—that is, one *Coulomb* per second—through one *Ohm* look as if the practical electrical engineer had forgotten the labours of Volta, of Ampère, of Coulomb, and of Ohm? Indeed, is not Prof. Fitzgerald himself forgetting the deep debt of gratitude the theoretical study of electricity owes to its practical applications? The late Prof. Fleeming Jenkin, a Professor at a University bear in mind, wrote in 1873:—"In England at the present time it may almost be said that there are two sciences of electricity—one that is taught in ordinary text-books, and the other a sort of floating science known more or less perfectly to practical electricians. . . . A student might have mastered Delarive's large and valuable treatise, and yet feel as if in an unknown country and listening to an unknown tongue in the company of practical men. It is also not a little curious that the science known to the practical men was, so to speak, far more scientific than the science of the text-books."

While there are University Professors like Thomson, Hertz, and Fitzgerald, what matters it whether we call them the *teachers* or ourselves the *learners?* When the work they are now carrying on may be of incalculable service to the practical man in the future, of what avail is it to discuss whether it is to-day *useful* or *useless?* For the labours of such men I have too profound a respect and admiration to "sneer" at what I hold to be the true function of the University.

But equally worthy of respect do I think is the *teacher* in a *school* of engineering—that is, one who aims at presenting useful knowledge, and the methods for extending it, in such a form as to be most easily grasped by those who intend to devote their lives to engineering.

My friend Prof. Fitzgerald and I are at any rate wholly in accord on one important point urged in my recent inaugural address, viz. that it is the special function of the technical school to teach *useful* knowledge. W. E. AYRTON.

Sir R. Ball's "Cause of an Ice Age."

SOME books appear under such authoritative sanction that, apart altogether from their arguments and their facts, they naturally influence opinion. This must be said of a book recently reviewed in your pages (January 28, p. 289); namely, "The Cause of an Ice Age," by Sir Robert Ball, the first of a series on modern science, edited by Sir John Lubbock.

The position taken up in this work is so much at issue with the views of many prominent geologists, and its general tendency seems so retrograde, that I am a little surprised it has not been adversely criticized.

I do not propose in this letter to enter into the general question as to the astronomical causes of an Ice Age, or whether an Ice Age can be shown to be a consequence of a varying eccentricity, upon which Croll and others have spoken very emphatically. I would rather limit myself to the particular new factor which Sir R. Ball has added to the problem. He claims that he has shown, and I do not contest the matter in any way, that, "of the total amount of heat received from the sun on a hemisphere of the earth in the course of a year, 63 per cent. is received during the summer, and 37 per cent. is received during the winter." This law he claims as "the fundamental truth which is the cardinal feature of his book, . . . the one central feature by which it is to be judged." His chief object, he says, "is to emphasize the relation of these figures to the astronomical theory, which will be entirely misunderstood unless the facts signified by these numbers are borne in mind."

What I wish to point out is that, although I have read the book more than once, I cannot find how this law is in any way connected with the general conclusions of the book.

"The cause of an Ice Age" must surely be something which is not always present and always equally efficient, but which works differently at different times, which, if operating at one time to produce an Ice Age, must either lose its effectiveness or be otherwise modified so as to permit of the existence of a temperate climate at another time.

Sir Robert Ball admits without doubt that the factor he relies upon, instead of being a variable one, is constant. He says: "The datum in our system on which the distribution depends, is the obliquity of the ecliptic"; and he goes on to say that, "amid so much that is changeable in the planetary system, it is fortunate that the obliquity of the ecliptic may for our present purpose be regarded as practically constant" (*op. cit.*, 87). He then goes on to compare the conditions which follow a small and a large eccentricity, and says: "Notwithstanding the wide difference between such a movement and that previously considered" (*i.e.* between movement in a very oblate and one in a more prolate ellipse), "it still remains true that 63 per cent. of the sun's heat is received by each hemisphere in summer, leaving only 37 per cent. for the winter" (*ib.*, 92). He again tells us that the figures 63 and 37 are independent both of the eccentricity of the orbit and of the position of the line of equinoxes; and that while the varying eccentricity created a distinction between a possible winter of 199 days and a summer of 166 days in one hemisphere, and the reversal of these same proportions in the other, that in each case the figures 63 and 37 represent the proportional quantities of heat which that hemisphere receives in summer and winter respectively" (*ib.*, 99). Lastly, speaking of the same figures, he says "they derive their importance from their constancy; they would remain the same however the dimensions of the orbit be altered, however its eccentricity be altered, or in whatever direction the plane of the earth's equator may intersect the plane of the earth's revolution around the sun." "These numbers are both functions of but a single element, which is the obliquity of the ecliptic. As this fluctuates but little, at least within the periods that are required for recent Ice Ages, the numbers we have given are regarded as sensibly constant throughout every phase through which the earth's orbit has passed within Glacial times" (*ib.*, 121).

These statements are explicit enough, and they show that the factor upon which Sir R. Ball relies is a constant factor, and being constant under all circumstances it cannot be the cause of an Ice Age. Whatever potency it has is being exerted now as much as it would be then. If it were an efficient cause of an Ice Age, we ought to be passing through one now. This argument seems to me to be complete and conclusive, and, if so, I cannot see how Sir R. Ball has done anything at all to solve the problem; for, putting this factor aside, we are remitted back to the conditions present to Croll and others, which have been so completely shown to be inadequate to produce an Ice Age. As I am writing a big book in which I am attacking what I deem to be the extravagant and fantastic views of an influential school of geologists in regard to the so-called Ice Age, I naturally looked forward to Sir R. Ball's book with interest, and have read it with care, but I cannot see how it advances the solution of the problem, or how its position can be maintained.

HENRY H. HOWORTH.

House of Commons, February 13.

The University of London.

MR. THISELTON-DYER, in his recent discussion of the London University question (p. 392), makes one statement which seems to me open to criticism:—

The statement is that the Colleges of the English Universities have "intrusted the business of sampling their goods to those who had nothing to do with their manufacture." Of the internal mechanism of the University of Oxford I know nothing: but I do know that in Cambridge the tendency is, and has been for the last ten years, in the direction of the reconstruction of that "teacher-examiner system" which Mr. Thiselton-Dyer believes to have been given up. The higher teaching in Cambridge is falling more and more completely into the hands of three classes of men, namely:—

(1) Professors, appointed by the University, and imposed by the University upon the Colleges, so that in each College there is at least one person who is a member of the body simply by virtue of his University office. In this way at least one subject is represented in every College by a University officer.

(2) University Readers and Lecturers, who give systematic instruction to all members of the University, without distinction of College. As these men are on the one hand appointed by the University, and are on the other hand, as a rule, members of various Colleges, they establish a further bond of union between the Colleges and the University.

(3) College Lecturers, who are now in the habit of throwing open their lectures to members of Colleges other than their own, and who are frequently members of the University Boards of Studies.

In this way the higher teaching is being thrown more and more completely into the hands of men who are under the direct control of the University itself; and a study of the current Calendar shows that the task of examining students is intrusted largely to these very men. Of the examiners for the various Triposes (of whom there are about eighty), at least fifty-six belong to one of the three categories above mentioned. Those examiners who are non-resident, or who are not engaged in teaching, act as a rule in conjunction with colleagues who are actual teachers, so that there is no single Tripos in which a student is not fairly certain to be "sampled" (to use Mr. Thiselton-Dyer's phrase) by a man who has had a great deal to do with his "manufacture."

This is almost precisely the "teacher-examiner system" to which Mr. Thiselton-Dyer refers; and the steady growth of this system in Cambridge is a certain proof that it is not incompatible with the development of the highest type of University in England.

W. F. R. WELDON.

University College, London, February 27.

The Aneroid in Hypsometry.

FROM a review under this title in NATURE of the 11th ult. (p. 339) it appears that Mr. Whymper has done good service to those who use the aneroid in measuring heights, by pointing out a very serious source of error in this instrument. According to the reviewer:—"All who have had any experience in testing aneroids in the usual way, viz. by subjecting them to gradually reduced pressures under the air-pump, and comparing their readings with the concomitant indications of the manometer, are aware that the variations of the two instruments with falling and then with increasing pressures are by no means concordant; but it will be probably new to most that, when the aneroid is allowed to remain for some weeks under the reduced pressure, its indications continue falling, and to such an extent that its final error in certain cases is five or six times as great as when the exhaustion was first completed. On the other hand, aneroids that have been kept for some weeks at a low pressure when restored to the full pressure of the atmosphere take many weeks to regain their condition of equilibrium. The greater part of the recovery takes place in the first week, and a considerable part in the course of the first day."

Now I have little doubt that both the want of accordance in the readings of the instrument with decreasing and then with increasing pressure, and the "after-working" mentioned above, are mainly, if not entirely, due to the imperfect elasticity of the corrugated disk that forms the cover of the exhausted chamber. No metal is perfectly elastic except with very minute stresses, and, as a consequence, when a metal is made to go through a complete stress cycle, there is always more or less lagging of strain behind stress. Again, there is with all metals more or less of *time-lag*, so that any alteration of stress does not produce its full effect all at once. Provided the temperature be kept constant, and the metal be not in any way disturbed, the time-lag is of such a nature that for equal successive intervals of time the corresponding changes of strain form a descending geometrical progression. With some metals, such as tempered steel, and with moderate stresses, the effects of imperfect elasticity are not of any material consequence. With others, however, such as aluminium and zinc, and the alloys of the latter metal—namely, brass, *German-silver*, &c.—we meet with very appreciable deviations from the laws of perfect elasticity, even when the stresses used do not produce any permanent deformation. I understand that the corrugated cover is frequently made of an alloy something like German-silver, only softer. If this be so, I can well believe, from my experience of this alloy, that grave errors might arise, and probably have arisen, in the determinations of heights by the aneroid. If such a thing be feasible, I would suggest that the cover should be made of tempered steel.

HERBERT TOMLINSON.

King's College, Strand, February 19.

Sparrows and Crocuses.

THE time of year has arrived when we shall once more be hearing of the ravages of sparrows on crocus blooms, and the theories advanced in order to account for this propensity for destruction on the part of the sparrow in suburban gardens and elsewhere. One pet theory is that the sparrow has a fondness for *yellow*, and shows it by destroying crocuses of that colour. Most unfortunately for the holders of such an opinion, the sparrow does not confine its attentions to yellow crocuses only, but attacks also the purple, white, &c., as any grower of crocuses can prove. Undoubtedly the yellow suffer most, probably because they are the first to appear, and meet the birds' most pressing requirements. Moreover, the sparrows sometimes attack the flowers while still in the sheath, and before it is certain what colour they will be.

The object of the sparrow in destroying the flowers is simply to obtain *succulent food* at a time of year when such in the form of larvæ, &c., is scarce. I have repeatedly watched the operation from my study window at a distance of very few feet. The stalk of the flower is bitten off by the bird some little distance below the flower itself. The succulent stalk is then nibbled away until the flower falls to pieces. The reproductive parts, and especially the anthers are not attacked, as some writers have asserted; but in consequence of the structure of the flower, they, like the petals and sepals, often fall away owing to the close nibbling of the bird.

Primroses also suffer. Early primroses are usually the common *yellow* form, *ergo*, according to theory-makers, the same cause is at work. So it is, but not in the direction they would have us believe. Here, again, I have distinctly seen the birds eating the flower-stalk.

I had written you a letter to the same effect as this about the same time last year, but from some cause or other it was not forwarded. I take this opportunity of possibly anticipating other letters on the same subject, and of inducing theorists to carefully watch the *modus operandi* as I have done before rushing into print.

R. MCLACHLAN.

Lewisham, February 26.

A Possible Misunderstanding.

I HAVE seen a report that, in a recent number of the *Atti della Regia Academia delle Scienze di Torino*, Prof. Galileo Ferraris is credited with a statement which might mean that one of the formulæ which appear in a paper read by me before the Physical Society of London, in May 1888, was derived from a paper by him. If that be Signor Ferraris's meaning, he is entirely mistaken. My formulæ were obtained quite independently of Signor Ferraris or of anyone else.

THOMAS H. BLAKESLEY.

Royal Naval College, February 29.

HERMANN KOPP.

HERMANN FRANZ MORITZ KOPP, a distinguished German chemist, and one of that band of literary and scientific workers which, five-and-twenty years ago, made Heidelberg celebrated as a centre of intellectual activity, passed away from the scene of his labours on February 20, in the seventy-fifth year of his age. He had been in failing health for some time past, and although his recuperative power at times seemed wonderful, his friends were not wholly unprepared for his decease.

Born October 30, 1817, at Hanau, where his father, Johann Heinrich Kopp, practised as a physician, Hermann Kopp received his school training at the Gymnasium of his native town, and thence passed to the Universities of Heidelberg and Marburg with the object of studying the natural sciences, and more particularly chemistry. The special bent of his mind towards chemistry would seem to have been given by his father. The elder Kopp occasionally busied himself with experimental chemistry, and Leonhard's *Taschenbuch* and Gehlen's *Journal* contain papers by him on mineral analyses and on investigations relating to physiological chemical products.

In 1839, Hermann Kopp joined Liebig at Giessen, drawn thither by the extraordinary influence which has made the little laboratory on the banks of the Lahn for ever famous in the history of chemical science. For nearly a quarter of a century Kopp found in Giessen full scope for his scientific and literary activity. In 1841 he became a *privat-docent* in the University, two years later he was made an extraordinary professor, and in 1853 he became ordinary professor. In 1864 he was called to Heidelberg, where he remained until his death, occupying himself latterly with lectures on the history of chemistry, and on chemical crystallography.

At the very outset of his career as an investigator, Kopp seems to have devoted himself to that field of inquiry in which his chief distinction as an original worker was won, viz. physical chemistry. One of his earliest papers—"Ueber die Vorausbestimmung des specifischen Gewichts einiger Klassen chemischer Verbindungen," published in *Poggendorff's Annalen* in the year he went to Giessen—deals with the conception of *specific volume*, which he here introduces for the first time. During the ensuing five-and-twenty years, so far as laboratory work was concerned, he was almost entirely occupied in attempting to trace experimentally the connection between the physical properties of substances and their chemical nature. We owe to Kopp, in fact, all our broad fundamental generalizations concerning the connection between the molecular weights, relative densities, boiling-points, and specific heats of substances, and on the relations of crystalline form and chemical constitution to specific volume. For work of this kind Kopp was eminently well fitted. To remarkable manipulative dexterity and great ingenuity—much of which, as in the case of Wollaston, was spent in satisfying a certain fastidiousness for simplicity of apparatus and experimental method—was joined the most scrupulous sense of accuracy and illimitable patience. As proof of his accuracy, it may be stated that, although many observers have had occasion, from time to time, to review his work on the thermal expansion of liquids—and on a far more ambitious scale, and with more refined apparatus, than was possible half a century ago—his determinations have been practically unchallenged, and retain their place among the best ascertained constants of their kind.

Kopp's scientific papers dealing with his laboratory labours mainly appeared in *Poggendorff's Annalen der Physik und Chemie*, and latterly in *Liebig's Annalen der Chemie*. One or two of his contributions appeared in the *Philosophical Magazine*, and the Chemical Society published his elaborate memoir on the specific heats of compound substances, in which he sought to develop and extend Naumann's law. But, compared with those of his contemporaries, Liebig and Wöhler, his papers are comparatively few in number. This is largely accounted for by the very character of his investigations His communications were, for the most part, records of measurement, often troublesome and tedious in their nature, and followed by long and wearisome calculations; and in many cases the substances with which he experimented could only be prepared in a state of purity by long-continued operations. It is only those who have engaged in work of this kind that can properly appreciate the amount of labour thus involved. The nature of the relations which he strove to elucidate necessitated the determination of the particular physical constants of some scores of substances; indeed, to Kopp, their number was only limited by the extent of his knowledge of the existence of their isomerides and homologues. Much of this work was necessarily of a pioneer character. It stands, in fact, to our later knowledge much in the same way as does the work of Boyle, Mariotte, and Gay-Lussac to the fuller development of the gaseous laws which we have witnessed during the past few years. Kopp, indeed, was among the earliest to venture into a province of which he actually was the first to recognize the exceeding fruitfulness. Its soil, however, is not of that nature which, tickled with a hoe, laughs with a harvest; it is only with much tillage and patient toil—the conjoint work of physicists and chemists—that it can be made to yield its riches. It is, however, by such work that the supreme secret—the true nature of the form of force with which the chemist is mainly concerned, the real nature of chemical affinity—will be revealed.

Kopp is known to the literary world mainly by his great work on the "History of Chemistry" (Brunswick, 1843-47, 4 vols.). The amount of labour and research involved in the preparation of this work was simply stupendous. It is not many men of twenty-five who would have either the skill or the patience to attack the mass of literature which embalms the chemical lore of the ancient peoples of the East, or who would devote years to extracting what there is of science or philosophy from the jargon of the alchemists, or the mystical writings of the Rosicrucians. It is hardly to be wondered at that nearly every subsequent writer on the history of chemistry has been content to take his facts from Kopp: their works, so far as they relate to the early history of the science, are based, and, for the most part, avowedly so, on his researches. From time to time Kopp published supplementary volumes on the same subject. In 1869-75 appeared his "Beiträge zur Geschichte der Chemie" (Brunswick, three parts); in 1871-73 the "Entwicklung der Chemie in neuerer Zeit"; and, in 1886, "Die Alchemie in älterer und neuerer Zeit" (Heidelberg, 2 vols.). In 1849 appeared his "Einleitung in die Krystallographie" (Brunswick; 2nd ed., 1862); and in conjunction with his Giessen colleagues, Buff and Zamminer, he published his "Lehrbuch der physikal. und theoretischen Chemie" (Brunswick, 1857; 2nd ed., 1863), which constitutes a portion of the well-known Graham-Otto's "Lehrbuch der Chemie," one of the standard text-books in Germany and Austria.

In 1848, Kopp joined Liebig in the production of the *Jahresbericht über die Fortschritte der Chemie*, which he continued to edit, latterly with Heinrich Will, down to 1862. In 1851 he became the acting editor of the *Annalen der Chemie*, and although, with increasing years and failing health, he was obliged to relinquish the responsible management, he continued to the last to take a lively interest in the fortunes of the periodical.

Kopp's services to chemical science were recognized by our own Chemical Society as far back as 1849; and, with the exceptions of Bunsen, who is the *Doyen* of the Forty, and who celebrates his jubilee as a Foreign Member this year, and of Fresenius, who was elected in 1844, he was the oldest Foreign Member of the Society. He was made an honorary member of the German Chemical Society in 1869, and in 1888 he was elected a Foreign Member of the Royal Society.

Kopp was a good linguist and an omnivorous reader, not only of matters scientific, but also of history and contemporary politics. He was remarkably catholic in his tastes and wide in his sympathies. Indeed, no man could be further removed than he in this respect from the conventional idea of the German professor. He was a constant reader of NATURE, and hence was well informed of the march of events, scientific and educational, in this country. The writer of this notice, who counts it a great privilege to be able to number himself among his pupils, when visiting him in Heidelberg last spring was astonished to find how fully and accurately he had grasped the details and bearings of the projected scheme for the new University in London, as it was at that time understood. He was much interested, too, in the great experiment which the County Councils have undertaken in relation to secondary education, but of the result of that experiment in its present form he expressed himself as not very hopeful. His extraordinary range of information, his wonderfully retentive memory, his geniality, his keen sense of humour, his fund of anecdote, and exceptional conversational powers, made him one of the most delightful of companions. Even in the pages of the *Jahresbericht*, the evidences of Kopp's humour are to be found. In abstracting the well-known paper by Playfair and Joule on the Specific Volume of Hydrated Salts, he is constrained to remark:—

"Die Verfasser dieser Abhandlung sind anerkannte Forscher, aber das hebt die Unbegreiflichkeit nicht auf, dass in dem phosphorsauren Natron, welches wir vor uns sehen, es nur das Wasser sein soll, welches den Raum erfüllt, *neither acid nor base occupy space*. Wie durch Zauberei kommen die letztern erst bei dem Erhitzen räumlich zum Vorschein.—Säure und Basis nehmen hier keinen Raum ein, *weil* die Annahme, das Wasser sei hier mit dem spec. Volum des Eises vorhanden, gemacht worden ist, und nach ihr fur Säure und Basis Nichts übrig bleibt. Jene Katze wurde von ihrem Herrn vermisst, obgleich er sie unter Händen hielt, *weil* er die Annahme gemacht hatte, sie habe das Fleisch gefressen. An diese merkwürdige Begebenheit wird man sehr oft in den Naturwissenschaften erinnert. Ein Mann supponirte, seine Katze habe Fleisch gefressen; er wog sie, und da sie grade so viel wog als das abhanden gekommene Fleisch, sagte er verwundert: 'hier ist mein Fleisch; wo bleibt meine Katze?'"

As Mr. Oscar Wilde has just reminded us, we are far too serious nowadays; our *Jahresberichte, Berichte*, and Chemical Society Journals have grown to be fat, unwieldy tomes, and the printers' bills grow steadily year by year; otherwise some of us would not be greatly shocked to find our scientific reading occasionally lightened a little in this way. For it was the saying of an ancient sage that humour is the only test of gravity; and gravity, of humour.

By no one will Kopp's departure be more keenly felt than by Bunsen, his friend and colleague for more than a quarter of a century. The strollers along the Anlage will miss the quaint little figure on its way to the daily visit to the old veteran, who, rich in honour and in years, is now the last of that famous triumvirate—Bunsen, Kirchhoff, and Kopp—the memory of whose services the world will not willingly let die. T. E. THORPE.

NOTES.

THE annual *soirée* of the Royal Society is to be held on Wednesday, May 4. There will be a ladies' *conversazione* later in the season.

ON Monday Mr. Balfour announced that the draft charter of the Gresham University would be remitted for reconsideration; and promised to make a statement on the subject this evening. The proposal to refer the charter back to the Privy Council has caused much dissatisfaction. The only reasonable course is to refer it to a Committee, on which educationalists and teachers in all the faculties shall be strongly represented.

AT the ordinary meeting of the Royal Meteorological Society, to be held at 25 Great George Street, Westminster, on Wednesday, the 16th instant, at 7 p.m., the President, Dr. C. Theodore Williams, will deliver an address on "The Value of Meteorological Instruments in the selection of Health Resorts," which will be illustrated by a number of lantern slides. The meeting will be adjourned at 8.30 p.m., in order to afford the Fellows and their friends an opportunity of inspecting the Exhibition of instruments, charts, maps and photographs relating to climatology, and of such new instruments as have been invented or first constructed since the last Exhibition. The Exhibition will be open from Tuesday, the 15th instant, to Friday, the 18th.

STILL another new chemical laboratory in Germany. We hear that Prof. Emil Fischer, at Würzburg, is now to have a new laboratory at a cost of 600,000 marks. Prof. Victor Meyer's new laboratory at Heidelberg is to be ready on May 1.

WE regret to have to record the death of Sir John Coode, the eminent engineer. He died on March 2 at the age of seventy-six. He was President of the Institution of Civil Engineers in 1889 and 1890.

IN connection with the International Congresses of Zoology and Prehistoric Archæology, which will be held this summer at Moscow, an exhibition of acclimatization will be opened at the end of June. It will contain specimens of all plants acclimatized in Russia.

THE office of Superintendent-General of Education for Cape Colony, rendered vacant by the retirement of Sir Langham Dale, has now been filled, Dr. Thomas Muir, of the High School of Glasgow, to whom it was offered some time ago, having definitely accepted the appointment. The *Glasgow Herald* speaks of Dr. Muir's departure as "a distinct loss to education and science in Scotland." Some years ago the Royal Society of Edinburgh awarded to him the Keith Medal for his contributions to mathematics.

AN important memorial will shortly be brought before the Board of the Faculty of Natural Science, Oxford, by the Council of the Association for the Improvement of Geometrical Teaching. It relates to what the Council regard as a serious defect in the Oxford Pass Examination papers in geometry. These generally consist entirely of propositions enunciated without any variation from the ordinary text of Euclid, and scarcely any attempt is made to discover whether a student's answers are other than the outcome of a mere effort of memory. The Council are of opinion that such papers have the effect of a direct incentive to unintelligent teaching, and respectfully ask for the introduction of simple exercises and of simple questions on the book-work set in order to promote the rational study of geometry.

THE relics of the explorers John and Sebastian Cabot, preserved at Bristol, are to be sent to the Chicago Exhibition. It is expected that they will attract much attention.

IN the electricity building at the Chicago Exhibition there will be no fewer than 40,000 panes of glass. This building will be especially conspicuous at night, as, owing to its extensive glass surface, the brilliancy of its electrical exhibit will be strikingly visible from the outside.

LAST Saturday Prof. Roberts-Austen delivered one of the series of lectures now being given at the South Kensington Museum for the purpose of extending the knowledge of the science and art collections and of making them more generally useful, taking as his subject art metal-work. He pointed out that, as a metallurgist, he could only claim authority to deal with the materials employed for art metal-work. Setting aside wrought iron, the most important of these were alloys, especially those of the copper-tin series (the bronzes), and those of the copper-zinc series (the brasses). When the elder Pliny wrote in the first half of the first century of our era, and described the nature of the early metallurgy, industrial art in bronze was really far advanced. The artist, however, had in point of skill left the metallurgist far behind. Referring to the presence of lead in bronze as giving to the metal a beautiful velvety *patina* by atmospheric exposure, Prof. Roberts-Austen said that there was little use in attempting to compose a bronze with a view to enable it to acquire a *patina* in the London atmosphere. He took as an instance one of our last erected monuments, the equestrian statue of Lord Napier of Magdala opposite the Guards' Memorial in Waterloo Place. A few weeks ago the *patina* had begun to form, and iridescent tints played over the features, while unsightly rain stains ran down his horse; now the layer was thickening, and a gray-brown tint deepening, but there was no velvety-brown oxide, or rich green and blue carbonate. The soldier, field-glass in hand, was sternly looking away from the Athenæum and the learned Societies, as if conscious that, in the present state of the London atmosphere, he was beyond the aid of science, for science had clearly stated that so long as bituminous coal was burnt in open fire-places London must be smoky, and man and horse would soon be covered with a black pall of soot and sulphide of copper, such as now enshrouded the unfortunate occupants of the adjoining pedestals.

THE Royal Society of New South Wales offers its medal and £25 for the best communication (provided it be of sufficient merit) containing the results of original research or observation upon each of the following subjects:—To be sent in not later than May 1, 1892: on the iron ore deposits of New South Wales; on the effect which settlement in Australia has produced upon indigenous vegetation, especially the depasturing of sheep and cattle; on the coals and coal measures of Australia. To be sent in not later than May 1, 1893: upon the weapons, utensils, and manufactures of the aborigines of Australia and Tasmania; on the effect of the Australian climate upon the physical development of the Australian-born population; on the injuries occasioned by insect pests upon introduced trees. To be sent in not later than May 1, 1894: on the timbers of New South Wales, with special reference to their fitness for use in construction, manufactures, and other similar purposes; on the raised sea-beaches and kitchen middens on the coast of New South Wales; on the aboriginal rock carvings and paintings in New South Wales. The competition is not confined to members of the Society, nor to residents in Australia, but is open to all without any restriction whatever, excepting that a prize will not be awarded to a member of the Council for the time being; neither will an award be made for a mere compilation, however meritorious in its way. The communication, to be successful, must be either wholly or in part the result of original observation or research on the part of the contributor. The successful papers will be published in the Society's annual volume. Fifty reprint copies will be furnished to the author free of expense.

A PRIZE is offered by Schnyder von Wartensee's Foundation, Zürich, for the solution of the following problems in the domain of physics. "As the numbers which represent the atomic heats of the elements still show very considerable divergences, the researches conducted by Prof. H. F. Weber on boron, silex, and carbon, regarding the dependence of the specific heats upon the temperature, are to be extended to several other elements, prepared as pure as possible, and also to combinations or alloys of them. Further, the densities and the thermic coefficients of expansion of the substances investigated are to be ascertained as carefully as possible." The following are the conditions: the treatises handed in by competitors may be in German, French, or English, and must be sent in by September 30, 1894. The examination of the treatises will be intrusted to a Committee consisting of the following gentlemen: Prof. Pernet, Zürich; Prof. A. Hantzsch, Zürich; Prof. E. Dorn, Halle-on-the-Saale; Prof. J. Wislicenus, Leipzig; Prof. E. Schär, Zürich, as member of the Committee offering the prizes. The Prize Committee is empowered to award a first prize of two thousand francs, and minor prizes at its discretion to the amount of one thousand francs. The work to which the first prize is awarded is to be the property of Schnyder von Wartensee's Foundation, and arrangements will be made with the author regarding its publication. Every treatise sent in must have a motto on the title-page, and be accompanied with a sealed envelope bearing the same motto outside and containing the author's name. The treatises are to be sent to the following address: "An das Praesidium des Conventes der Stadtbibliothek, Zürich (betreffend Preisaufgabe der Stiftung von Schnyder von Wartensee für das Jahr 1894)."

At the meeting, on February 17, of the Russian Geographical Society, the Constantine Medal was awarded to M. V. Pyevtsoff for his work of exploration in Central Asia, especially during the last Tibet expedition. The Count Lütke Medal was awarded to A. I. Vilkitsky for his measurements of pendulum oscillations in Russia. A newly established prize, consisting of the interest on a sum collected by public subscription after the death of Prjevalsky, was granted to G. E. Grum-Grzimailo for his researches in Central Asia in 1889–90, and large silver medals, also associated with Prjevalsky's name, were awarded to the companions of his expeditions, V. I. Soborovsky and P. K. Kozloff, to the geologist of the last Tibet expedition, K. I. Bogdanovitch, for his geological work in Central Asia, and to M. E. Grum-Grzimailo for the surveys he made in company with his brother in the Pamir. The great Gold Medal of the Society was awarded by the Section of Ethnography to A. N. Pypin, for his "History of Russian Ethnography," and by the Section of Statistics to A. A. Kaufmann for his researches on the economical conditions of the peasants and indigenes in the Ishim and Tura districts of West Siberia. Four small gold medals and seventeen silver ones were awarded for works of less importance.

At the same meeting the yearly report of the Society was read, and we learn from it that the Expedition which has been sent out for the exploration of the Chinese province Sy-chuang, and the territory on the slopes of the Tibet plateau, will soon start from Peking. The leader of the Expedition, the zoologist M. V. Berezovsky, is already in Peking, preparing to start on his journey. N. F. Katanoff is hard at work collecting ethnographical materials in Mongolia. K. P. Sternberg continued his pendulum observations in South Russia and Crimea; and A. E. Radd continued to investigate the magnetic anomalies about Byelgorod, in Kursk. L. I. Lutughin has made geological explorations and levellings on the watershed between the Volga and the Northern Dvina; while the Ministry of the Navy has continued this year the exploration of the Black Sea. In the department of ethnography, the report mentions the work of E. R. Romanoff in White Russia, and MM. G. E. Vereschaghin and Shilkoff among the Votyaks. The East Siberian branch of the Society has accomplished, as usual, a good deal of useful work. Prof. Korzynski has explored the Amur region, with especial reference to the advantages it offers for culture and colonization: V. A. Obrutcheff continued the exploration of the Olekma and Vitim highlands; MM. Yadrintseff, Klementz, and Levin took part in Prof. Radloff's expedition to the valley of the Orkhon in Mongolia; and Dr. Kiriloff continued his studies of Mongolian medicine. The Museum at Irkutsk has been enlarged, and further enriched by new collections. The publications of the Society included: the work of the Novaya Zemlya Polar Station; the ornithology of North-west Mongolia, by MM. Berezovsky and Bianchi; several volumes of Memoirs; and the Bulletin (*Izvestia*). The new monthly periodical, meteorological *Vyestnik*, and the "Living Antiquity" (*Jivaya Starina*) have been issued regularly during the past year.

We are glad to be able to report an advance in the Meteorological Service of Roumania. For some years the official publication of that country has been limited to the yearly volume containing the observations for Bucharest. From January 1 last, however, the Meteorological Institute has begun the issue of a monthly bulletin containing observations taken three times daily at Soulina, Bucharest, and Sinaia, 6 feet, 269 feet, and 2821 feet above the sea, respectively. The various weather phenomena are represented by the symbols adopted for international meteorological publications.

The Danish Meteorological Institute and the Deutsche Seewarte, conjointly, have recently issued daily synoptic weather charts, for the North Atlantic Ocean and adjacent continents, for the year ending November 1887, completing the series from September 1873, with the exception of the following dates: December 1876 to November 1880, being the period which elapsed from the death of Captain N. Hoffmeyer, who commenced the work, to its resumption by the two above-named institutions; and September 1882 to August 1883, being the period for which the Meteorological Office published its elaborate synchronous charts for the same area. For three years ending November 1886, the Deutsche Seewarte has published a separate text explanatory of the general conditions of weather for the area embraced by the charts, and showing the effect of the conditions upon the navigation of vessels, together with charts, selected for various periods of special interest, showing the position and movements of barometrical maxima and minima. The work furnishes the best possible materials for studying the connection between the weather of the Atlantic and that of our islands.

Observations of air-pressure during a total solar eclipse reveal an influence of the latter phenomenon on the former. In a recent number of the *Annalen der Hydrographie*, Herr Steen studies the eclipse of August 29, 1886, in this respect, using the records (at intervals of a quarter of an hour) of fourteen Norwegian ships between Panama and Madagascar, of which four were in the zone of totality, and at least four others quite close to it. Having first eliminated the daily period of air-pressure, he groups the observations of the ships, and forms means; and he finds both these and the individual records reveal two maxima of air-pressure, separated by a minimum. In the totality zone the first maximum is 35m., and the second 2h. 15m., after the middle of the eclipse; in the partial zone, the first is 25m. before, and the second 1h. 40m. after, the middle. This double wave, Herr Steen explains thus. During a solar eclipse, day is changed to night for a short time, and the transition is much like the ordinary change from day to night in the tropics, where the twilight is but short. There the curve of air-pressure has regularly a maximum about 10 p.m., some time after sunset, and a minimum about 4 a.m., shortly before sunrise; while a second maximum appears about 10 a.m. It is natural a total solar eclipse should act similarly. The displacement of the "epochs" of the air-pressure wave in the partial zone as compared with the zone of totality is more difficult to account for.

THE Smithsonian Institution has printed a capital study of the puma or American lion (*Felis concolor* of Linnæus), by Mr. F. W. True. The author notes that the puma possesses in a remarkable degree the power of adapting himself to varied surroundings. The animal endures severe cold during the winter in the Adirondack Mountains and other parts of the northern frontier of the United States, and tracks his prey in the snow. He is equally at home in the hot swamps and canebrakes along the river-courses of the Southern States. In South America he inhabits the treeless, grass-covered pampas as well as the forests. In the Rocky Mountains, as Mr. True is informed by Mr. William T. Hornaday, he ascends to the high altitudes in which the mountain sheep are found. Mr. Livingston Stone saw tracks of the puma on the summit of Mount Persephone in California, at an elevation of 3000 feet. Similarly, Darwin states that he saw the footprints of the puma on the Cordillera of Central Chili, at an elevation of at least 10,000 feet. According to Tschudi, the puma is found in Peru in the highest forests and even to the snow-line.

IN his Report on the Royal Botanic Gardens, Trinidad, for 1890, just issued, Mr. J. H. Hart, the Superintendent, says that, while on a journey to St. Vincent, in August 1890, he discovered a form of *Agave rigida*, Mill., previously unknown to West Indian floras. It produces a useful fibre, but appears to be too short in the leaf to rival the variety known as *Agave rigida*, var. *sisalana*, of Perrine. The same species has also since been found in Barbados, and identified with the above. "With nothing," says Mr. Hart, "is it more easy to make a mistake than the various species of *Agave*, and special care should be taken by growers for economical purposes to have their plant identified by competent persons, before expending large sums on cultivation. As an instance, I may mention that the *Coratoe* of Jamaica was for long years popularly supposed to be no other than the Tropical American *Agave americana*, until an examination was made into its characteristics by Mr. D. Morris when that gentleman was resident in Jamaica. The same thing occurred in Trinidad. The *Langue Bœuf* of the Bocas Islands was for many years supposed to be *Agave vivipara*, Linn., but a plant sent to Kew from these Gardens proves it to be the Mexican *Agave polyacantha*, Haw. A plant from St. Lucia, recently received, shows characteristic points differing from any of the above, though popularly supposed to be identical with our Bocas Island plant, and it may be found that several unknown *Agaves* exist in the West Indies that have been passed over by botanists from their similarity of growth to the commonly known forms of the larger islands and mainland."

AN excellent series of "Museum Hand-books" is being issued by the Manchester Museum, Owens College. A "General Guide to the Contents of the Museum" has been prepared by Mr. W. E. Hoyle, Keeper of the Museum, and Prof. Milnes Marshall has drawn up an "Outline Classification of the Animal Kingdom," and a "Descriptive Catalogue of the Embryological Models."

WE have received the tenth Annual Report of the U.S. Geological Survey to the Secretary of the Interior, 1888–89, by Mr. J. W. Powell, Director. It is divided into two parts, the first relating to geology, the second to irrigation.

MESSRS. GAUTHIER-VILLARS have published a work entitled "Leçons de Chimie," by Henri Gautier and Georges Charpy. It is intended mainly for the use of students of special mathematics.

WE learn from the *Journal of Botany* that the first part will shortly be issued by Messrs. Dulau and Co. of a new botanical publication, to be called *British Museum Phycological Memoirs*, edited by Mr. George Murray. It will be devoted exclusively to original algological papers, the records of research carried on in the Cryptogamic laboratory of the British Museum in Cromwell Road, and is intended to be issued at about half-yearly intervals. The first part will be illustrated by eight plates, and will contain, among other articles, the description of a new order of Marine Algæ.

DR. BAILLON'S "Dictionnaire de Botanique," the publication of which was commenced in 1869, is now completed.

A NEW acid, chromosulphuric, possessing the composition $H_2Cr_2(SO_4)_4$, is described by M. Recoura in the current number of the *Comptes rendus*. A short time ago the same chemist obtained a remarkable isomeric form of chromic sulphate $Cr_2(SO_4)_3$, which exhibited neither the reactions of a sulphate nor of a salt of chromium. For instance, its solution yielded no precipitate of barium sulphate with barium chloride. This isomeric form of chromic sulphate is found to combine directly with one equivalent of sulphuric acid or of a metallic sulphate to produce the new acid, or a salt of it. Thus, when a solution of zinc sulphate is mixed with a solution of the isomeric sulphate of chromium in equivalent molecular proportion, zinc chromosulphate is formed, $ZnCr_2(SO_4)_4$. The solution of this zinc salt so obtained gives none of the reactions of sulphuric acid, nor does it yield those of chromic acid, but it exhibits the usual reactions of zinc salts; hence it must be a zinc salt of a specific acid, chromosulphuric. When the solutions of the new acid and its salts are allowed to stand, they gradually decompose, and barium chloride commences to precipitate barium sulphate, hence they appear not to be very stable, but to decompose slowly into a mixture of ordinary chromic sulphate and sulphuric acid or the metallic sulphate. Boiling brings about the decomposition at once. The acid itself has been obtained in the solid state, combined with eleven molecules of water; it is a green powder, which is very hygroscopic, and rapidly deliquesces in moist air but is quite permanent in a dry atmosphere. Its solution possesses a brilliant green colour when freshly prepared, but, upon standing, changes to blue, and, after a few days, passes completely into a violet-coloured solution of ordinary chromic sulphate mixed with free sulphuric acid. The potassium salt has also been obtained in the solid state, combined with four molecules of water, as a green powder whose dilute solution yields no precipitate with barium chloride, but at once gives the usual potassium precipitates with platinic chloride and picric acid. This salt also appears to be formed when chrome alum is dehydrated first for some time at 90°, and finally at 110°. The sodium and ammonium salts have likewise been obtained, and are found to resemble the potassium salt closely in their nature and properties.

THE additions to the Zoological Society's Gardens during the past week include two Silver-backed Foxes (*Canis chama*), two Leopard Tortoises (*Testudo pardalis*) from South Africa, presented by Mr. C. Holmes; a Vulpine Phalanger (*Phalangista vulpina* ♂) from Australia, presented by Mr. W. J. C. P. Macey; a Ring-tailed Coati (*Nasua rufa*) from South America, presented by Miss M. Tew; a Fallow Deer (*Dama vulgaris* ♀), British, presented by Mrs. Edith Hilder; a Milky Eagle Owl (*Bubo lacteus*) from Mashonaland, South Africa, presented by Mr. E. A. Maund; four Herring Gulls (*Larus argentatus*), a Lesser Black-backed Gull (*Larus fuscus*), two Black-headed Gulls (*Larus ridibundus*), a Jackdaw (*Corvus monedula*), a Tawny Owl (*Syrnium aluco*), British, an Orange-cheeked Maxbill (*Estrelda melpoda*) from South Africa, two Hooded Finches (*Spermestes cucullata*) from West Africa, an Indian Silver-bill (*Munia malabarica*) from India, twelve Barbary Turtle Doves (*Turtur risorius*) from North Africa, presented by Mrs. Kate

Taylor; a Sharp-nosed Crocodile (*Crocodilus acutus*) from Havana, presented by Mr. Arthur Morris; a Chimpanzee (*Anthropopithecus troglodytes* ♂) from West Africa, a Bison (*Bison americanus* ♂) from North America, an Anaconda (*Eunectes murinus*) from South America, deposited; a Brazilian Tapir (*Tapirus americanus* ♀) from South America, four Hairy-rumped Agoutis (*Dasyprocta prymnolopha*) from Guiana, a Mexican Agouti (*Dasyprocta mexicana*) from Mexico, four Scarlet Ibises (*Eudocimus ruber*) from Para, a Blue and Black Tanager (*Tanagrella cyanomelæna*) from South-East Brazil, a Prince Albert's Curassow (*Crax alberti* ♀) from Columbia, purchased.

OUR ASTRONOMICAL COLUMN.

CORDOVA OBSERVATORY.—A publication of some importance has recently been issued from the Observatorio Nacional Argentino. It contains the observations made under the direction of Dr. Gould, in 1880, for the General Catalogue, arranged and published by Mr. J. M. Thome, the present Director of the Observatory. The mean places of 10,923 stars have been found from 33,837 separate and complete determinations, and this during one year of observation. In addition, 1613 observations of circumpolars, and 1738 of time-stars, have been made for determining instrumental corrections. It is therefore well remarked that "the dimensions of the volume almost entitle it to the rank of a General Catalogue, and the results for the month of December alone, when 5938 determinations of positions were made, would form a fair Annual Catalogue." In order to get through this immense amount of work, the meridian circle was manned with an observer, a microscope reader, who also pointed the telescope, and a recorder; and on four nights of eight hours each, in December, these three observers made, on the average, 1549 complete determinations. And the work has been done in such a thorough manner, in spite of the rapidity of execution, that one cannot but admire the dexterity of Messrs. Bachmann, Davis, and Stevens, who have assisted Mr. Thome. The right ascensions are referred to the "Standard Places of Fundamental Stars," second edition, published in 1866. The mean places of these stars for the beginning of each year, to 1880 inclusive, are published in the American Ephemeris tables, and their apparent places in successive volumes. The magnitudes recorded in the Catalogue are generally the results of estimation. Stars, however, which occur in the "Uranometria Argentina" have had their magnitudes taken from the data collected for that work. Catalogues of southern stars are hardly so plentiful as those containing places of stars north of the equator. This volume is therefore doubly welcome. It represents work carried out in spite of the vicissitudes to which an Observatory in the Argentine Republic must be subject, and the results obtained will be appreciated by all.

ALGOL.—In a series of contributions to the knowledge of the variable stars, which has appeared in the *Astronomical Journal*, Dr. S. C. Chandler has discussed the periods, motions, and laws of variable stars. His last communication, contained in Nos. 255 and 256 of the *Journal*, deals with the inequalities in the period of β Persei; the theory which satisfactorily accounts for these and other phenomena being stated as follows:—"Algol, together with the close companion—whose revolution in 2d. 20·8h. produces by eclipse the observed fluctuations in light, according to the well-known hypothesis of Goodriche, confirmed by the elegant investigation of Vogel—is subject to still another orbital motion, of a quite different kind. Both have a common revolution about a third body, a large, distant, and dark companion or primary, in a period of about 130 years. The size of this orbit around the common centre of gravity is about equal to that of Uranus around the sun. The plane of the orbit is inclined about 20° to our line of vision. Algol transited the plane passing through the centre of gravity perpendicular to this line of vision in 1804 going outwards, and in 1869 coming inwards. Calling the first point the ascending node, the position-angle, reckoned in the ordinary way, is about 65°. The orbit is sensibly circular, or of very moderate eccentricity. The longest diameter of the projected ellipse, measured on the face of the sky, is about 2″·7. A necessary consequence of this theory is an irregularity of proper motion with an amplitude of something over a fifth of a time-second in right ascension, and nearly one and a half seconds in declination; the middle point being the centre of gravity of Algol, and the distant unknown companion, and the uniform proper motion of the latter being − 0·0010s. and + 0″·0120 annually, in the two co-ordinates respectively. The annual parallax of the star is about 0″·07. The mean period of light variation is 2d. 20h. 48m. 56·00s." It seems very probable, from Dr. Chandler's communication, that the inequalities in the periods of other variables of the Algol type will admit of a similar explanation.

THE SUN-SPOTS OF FEBRUARY.—Some facts with regard to the dimensions of the recent sun-spots appear in the March number of the *Observatory*. The group of spots apparently connected with the great magnetic disturbance of February 13-14, and the aurora which was visible at a large number of places on the latter date, was first seen on the east limb of the sun on February 5. It passed the central meridian six days later, and disappeared round the west limb on February 17. "The total spotted area measured on the photographs taken at Greenwich on February 13, when the group reached its maximum, was no less than 1/350 of the sun's visible hemisphere. At Greenwich the area of spots is measured in millionths of the sun's visible hemisphere, and this extensive group had an area of 2850 millionths, corresponding to 3360 millions of square miles. The centre of the group was then at 260° long., and in lat. − 23°. The group was a broad band extending over 22° of longitude in length and 10° of latitude in width, corresponding roughly to a greatest length of 150,000 miles and a width of 75,000 miles. The large central spot of the group was 15° in length in longitude and 8° in width in latitude. The spot-group is the largest ever photographed at Greenwich, and is the largest which has appeared on the sun since 1873."

A NEW COMET.—Prof. Lewis Swift, of the Warner Observatory, discovered a comet on March 6 in R.A. 18h. 59m., and N.P.D. 121° 20′. Unfortunately the comet is at present too far south to be seen in these latitudes.

PROF. KRUEGER (*Astronomische Nachrichten*, No. 3077) contributes an important paper on the determination of the perturbations set up in the motions of periodic comets as they approach the sun, owing to their proximity to the planets.

PHOSPHOROUS OXIDE.

IN addition to the well-known pentoxide formed when phosphorus is burnt in air or oxygen, a second oxide of phosphorus has long been surmised to exist. Very little, however, has hitherto been known concerning this second oxide. It is usually described in current chemical literature as a white amorphous powder of the composition P_2O_3, very voluminous, somewhat more volatile and more readily fusible than the pentoxide P_2O_5, and instantly dissolved with great rise of temperature by water, with formation of phosphorous acid. During the last three years an investigation has been carried out in the laboratory of the Royal College of Science by Prof. Thorpe and the writer, which has resulted in showing that phosphorous oxide is a substance possessing properties entirely different from these. Full details of this work have recently been laid before the Chemical Society, but a short account of the manner in which the pure oxide has been isolated in quantity, of its somewhat remarkable properties, and of a few of its more important reactions, may, perhaps, not be uninteresting to readers of NATURE.

Properties of Phosphorous Oxide.

Before describing the mode of preparing the oxide, it will be advisable to briefly indicate the external appearance and essential properties of the substance. Phosphorous oxide is not an amorphous powder, but, at temperatures not exceeding 22° C., a pure white crystalline solid, compact and heavy, soft and wax-like in character. Its most striking property is the ease with which it melts, the warmth of the hand which holds the vessel containing it being more than sufficient to convert it to the liquid state. Its melting point is 22°·5 C., hence upon a warm summer's day or when placed in a warm room it takes the form of a clear, colourless liquid, very mobile, but somewhat heavy. It is best preserved in sealed glass tubes, the air of which has been replaced before the introduction of the oxide by carbon dioxide or nitrogen in order to avoid the action of the oxygen contained in air, which rapidly converts phosphorous oxide to phosphoric oxide. When such a tube containing the liquid oxide is cooled by immersing it in cold water or allowing it to stand in a room of ordinary temperature (17°–

20° C.) the oxide rapidly resolidifies in a most beautiful manner, large crystals shooting out in all directions until the whole is one compact mass of interlacing crystals. When the liquid is heated in a distillation flask previously filled with one of the indifferent gases carbon dioxide or nitrogen, it soon commences to boil, and the vapour condenses in the condensing tube and the unchanged oxide runs down into the receiver placed to intercept it in the form of liquid, which eventually condenses to the solid again. Its boiling point is 173°·1 C.

The vapour of phosphorous oxide possesses a very characteristic odour, which appears to be the same as that so noticeable about a lucifer-match manufactory. Owing to its great volatility, both the solid and the liquid are constantly vapourizing, even at the ordinary temperature, and hence the odour is always strongly marked in their neighbourhood.

Phosphorous oxide may also be obtained by spontaneous evaporation *in vacuo* in beautiful large isolated crystals, probably belonging to the monoclinic system, which are quite colourless and transparent, and very highly refractive; crystals have frequently been obtained in this manner an inch in length and broad and thick in proportion, showing numerous prism and pyramid faces. Similar crystals are obtained when solutions of the oxide in carbon bisulphide, chloroform, ether or benzene, in which the substance readily dissolves, are evaporated out of contact with the air.

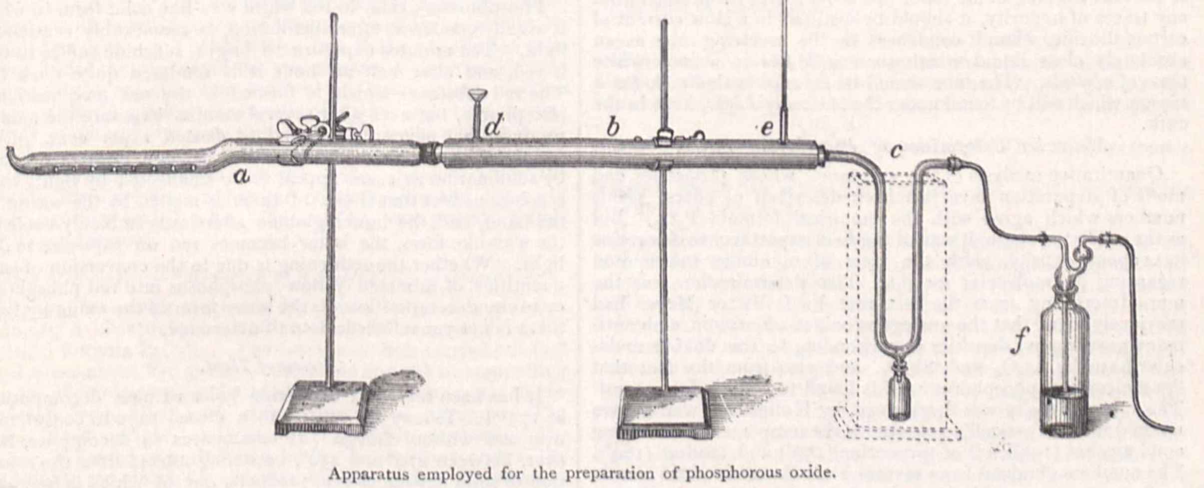
Instead of reacting with violence with water, as appears to have been generally supposed, phosphorous oxide is comparatively indifferent to that liquid, only dissolving with great slowness. If a few drops of the liquefied oxide are dropped into water of about the same temperature they at once fall to the bottom of the tube, and the two liquids do not mix. If the water is at the ordinary temperature the oxide solidifies as it falls to the bottom. A few grams of the oxide, either liquid or solid, require several hours for complete solution. The solution contains phosphorous acid. When phosphorous oxide is warmed with water to a temperature just below 100°, a violent reaction of an entirely different nature occurs; spontaneously inflammable phosphoretted hydrogen is evolved with a loud explosion, and red phosphorus and phosphoric acid are largely formed.

Preparation of Phosphorous Oxide.

It is quite a mistake to suppose that when phosphorus is burnt in a combustion-tube in a *slow* current of air the lower oxide, and not phosphorus pentoxide, is produced. Scarcely a trace of phosphorous oxide is obtained under these circumstances, the white amorphous powder deposited being pentoxide. It is only when the current is at all rapid that phosphorous oxide commences to be formed. Its advent is at once apparent, as it crystallizes all along the upper portion of the horizontal combustion-tube in beautiful feathery crystals, which at once melt if the finger is laid upon the exterior of the tube, while the pentoxide settles out along the bottom of the tube. After several less successful attempts to devise a method of producing these volatile crystals in larger quantity, and of separating them entirely from the pentoxide, a method has at length been found by which as much as twenty-eight grams of the pure oxide have been obtained in an experiment of five hours' duration.

Two sticks of phosphorus are cut into pieces about an inch and a half long, and placed in a glass tube bent into the shape shown at *a* in the figure, so as to retain the phosphorus when in the melted condition. The tube should be of 1½-inch bore, and should be made from *new* soft glass tubing, which is quite hard enough to stand the heat of burning phosphorus. The tube is drawn out somewhat, but quite open, at the end where the air is to be admitted, and at the other is narrowed slightly, so as to fit into the condenser *b*, a tight joint being obtained by means of a caoutchouc ring or a little bicycle cement. This condenser, *b*, is intended to retain the phosphorus pentoxide and any free phosphorus produced during the combustion, and is maintained at such a temperature that the phosphorous oxide passes uncondensed through it. It is therefore constructed of brass instead of glass, and is made double, that is, with an outer jacket also of brass, so that the space between the two brass tubes may be filled with water of the required temperature. This water may be run in by means of a funnel through a small vertical tube, *d*, a second such tube, *e*, serving for the introduction of a thermometer. The size of condenser found most convenient is 2 feet in length, and the inner brass tube has a bore of 25 millimetres. At the end of the condenser furthest from the phosphorus, a plug of glass wool about half an inch long is inserted, the fibres being arranged transversely as much as possible; such a plug forms an excellent means of filtering off any pentoxide which would otherwise escape into the phosphorous oxide condenser, especially after the first few minutes of the combustion, when its meshes become loosely filled with porous pentoxide. Directly into the end of the brass condenser fits tightly, by means of a cork annulus, the large glass U-tube condenser, *c*, in which the phosphorous oxide is condensed. The yield of oxide appears to depend somewhat upon the shape and dimensions of this condenser, that found most advantageous having the shape shown in the diagram, a height of 35 centimetres from the bottom of the bend, and an internal bore of 14 millimetres. A short vertical tube is fused on at the bend, and passes down into a bottle, into which the oxide may be melted at the end of each combustion. The whole condenser is surrounded by a tall wooden box, indicated by dotted lines in the figure, containing pounded ice. To the end of the condenser is attached a wash-bottle, *f*, containing sulphuric acid, which serves to prevent access of moisture to the oxide condensed in the U-tube, and also to measure the rate of the current of air drawn through the apparatus by the water pump.

In making a preparation, as soon as the phosphorus, dried by blotting-paper, has been introduced and the tube containing it attached to the brass condenser, which at first is quite cold, the phosphorus is warmed to the igniting point and the pump set working by turning on the water-tap to which it is firmly



Apparatus employed for the preparation of phosphorous oxide.

attached. After about ten or fifteen minutes, crystals begin to make their appearance in the U-tube; the oxide then rapidly collects in the form of a waxy mass. The best refrigerator for the U-tube is pounded ice; if salt is mixed with it, the oxide condenses so rapidly in the first cooled portion of the condenser as to form a bridge and stop the operation until it is melted down. When nearly half of the phosphorus is burnt, the brass condenser is warmed by pouring in water heated to about 70°–80° C., and the condenser is maintained at this temperature until about three-quarters of the phosphorus has been burnt, when the operation is stopped by slowly turning off the water working the pump.

When phosphorus is burnt under these conditions, three oxides are produced; more or less of the red suboxide P_4O is always deposited in the immediate neighbourhood of the burning phosphorus, a certain amount of pentoxide is formed and retained in the glass tube beyond the seat of combustion and in the brass condenser, and phosphorous oxide is produced in large quantity, and, being considerably more volatile, is carried forward to the cooled condenser, any which may be deposited in the brass condenser during the earlier stages of the combustion being carried along into the U-tube in the current of escaping nitrogen when the warm water is introduced into the brass condenser. Scarcely a trace of pentoxide escapes through the glass wool filtering plug, the product in the U-tube being almost pure phosphorous oxide. In the course of five hours three such charges of phosphorus may be burnt out and the total phosphorous oxide produced, which should amount to at least twenty grams, can be condensed in the same U tube, the product from each charge being melted down into the bottle so as to prevent choking of the tube. In order to free the product from any traces of impurity, it should be distilled in a slow current of carbon dioxide, when it condenses in the receiving tube as an absolutely clear liquid which soon solidifies to a snow-white mass of crystals. The tube should be at once sealed and, for a reason which will be found under the *Action of Light*, kept in the dark.

Molecular Composition of Phosphorous Oxide.

Quantitative analysis of the substance whose properties and mode of preparation have just been described of course yields numbers which agree with the empirical formula P_2O_3. But as the oxide is volatile it was of the first importance to determine its vapour density, with the view of obtaining information regarding its molecular weight. This determination was the more interesting from the fact that Prof. Victor Meyer had previously found that the analogous oxides of arsenic and antimony gave vapour densities corresponding to the double molecular formulæ As_4O_6 and Sb_4O_6, and also from the fact that the molecule of phosphorus itself is found to contain four atoms. The vapour density was determined by Hoffmann's well-known method in the Torricellian vacuum at the temperatures of boiling amyl alcohol (132°), oil of turpentine (159°) and aniline (184°). The numbers obtained from several such determinations are in perfect accordance with the molecular weight corresponding to the double formula P_4O_6. This result has been fully confirmed by a determination of the molecular weight by the totally different method of Raoult, which depends upon the degree of lowering of the freezing point of a solvent, in this case benzene, by the introduction of a small quantity of the substance undergoing investigation.

Hence phosphorous oxide must be symbolized by the formula P_4O_6 and not P_2O_3, phosphorus thus resembling its family relatives arsenic and antimony in the nature of its lower combination with oxygen.

Physical Properties of Phosphorous Oxide.

The specific gravity of the solid oxide at 21° C., compared with water at 4° is 2·135, and that of the liquid oxide at 24°·8 is 1·9358. Hence there is about nine per cent. of contraction upon the passage of the liquid into the solid state.

A somewhat interesting result has been obtained from the determination of the specific volume, that is, the number obtained by dividing the molecular weight by the density at the boiling point. The actual density, of course, cannot be experimentally determined at the temperature of ebullition, but by making a careful determination of the rate of expansion and knowing the density very precisely at some lower temperature the density at the boiling point can be calculated. The value thus found for the specific volume was 130·2. Now, phosphorus is known to possess two specific volumes; one in the state of combination (as determined from its halogen derivatives) and which is somewhere about 25·3, and another when in the free state, which is approximately 20·9. Oxygen, too, is usually supposed to have two values, one of 7·8 when it is linked to two different atoms, single linkage as it is termed, and another of 12·2 when doubly linked to one and the same atom of another element. If we subtract six times 7·8, that is deduct the specific volume due to six atoms of oxygen, from the specific volume 130·2 of phosphorous oxide, we arrive at the number 83·4 for four atoms of phosphorus, or 20·9 for that of one atom. If any of the oxygen atoms were doubly linked the number would be considerably less than 20·9, hence this number represents the greatest possible value of the phosphorus in phosphorous oxide.

It would appear, therefore, that the phosphorus in phosphorous oxide possesses the same specific volume as free phosphorus itself, a result of interest in view of the fact revealed by the determinations of molecular weight that there are four atoms of phosphorus in the molecule of the oxide just as there are in the molecule of free phosphorus itself.

The liquid oxide, considering that it contains such a highly refractive substance as phosphorus, possesses a remarkably low power of refracting light. Its refractive index at 27°·4 C. is only 1·5349 for the red line of lithium, and 1·5614 for the blue hydrogen line G. Not only is the refractive index of phosphorus (2·0677 for the red hydrogen line C) enormously reduced by its combination with oxygen, but the length of the spectrum is reduced to about one-fifth.

Action of Light.

Phosphorous oxide, in the white wax-like solid form in which it usually condenses after distillation, is remarkably sensitive to light. Ten minutes exposure to bright sunshine suffice to turn it red, and after half an hour it is rendered quite dark red. The red substance which is formed is the red modification of phosphorus, but even after several months' exposure the amount produced has never been found to exceed 1 per cent. of the weight of the oxide. The beautiful isolated crystals obtained by sublimation *in vacuo* appear to be unaffected by light, but it is a curious fact that if one of them is melted by the warmth of the hand, and the liquid globule afterwards suddenly cooled to the wax-like form, the latter becomes red on exposure to daylight. Whether the reddening is due to the conversion of small quantities of admixed yellow phosphorus into red phosphorus, or to the decomposition of the waxy form of the oxide by light, there is not yet sufficient data to determine.

Action of Heat.

It has been seen that the oxide boils without decomposition at 173°·1. It may be heated in a closed tube to considerably over 200° without change. It commences to decompose, however, between 210° and 250°, becoming turbid from the separation of solid decomposition products, one of which is free phosphorus, which becomes more and more deeply coloured until at 300° it is quite red. At about 400° the oxide is totally decomposed into solid products, consisting of both yellow and red phosphorus and phosphorus pentoxide. Occasionally, when only the lower half of the tube has been immersed in the heating bath, the formation of crystals has been observed in the cooler portion of the tube, which appear to be identical with some described in a previous communication to the Chemical Society which gave numbers on analysis agreeing with the formula P_2O_4, and which yielded a solution with water capable of reducing mercuric chloride to calomel. Hence the final decomposition by heat may be expressed by the equation

$$5P_4O_6 = 6P_2O_5 + 8P,$$

but under suitable circumstances the intermediate formation of the tetroxide may occur according to the equation

$$2P_4O_6 = 3P_2O_4 + 2P.$$

Action of Oxygen.

Phosphorous oxide takes up oxygen spontaneously at the ordinary temperature. It is probable, however, that the oxygen only reacts in the cold with the vapour. For if a small quantity of the oxide is placed at the bottom of a glass tube closed at one end and previously filled with oxygen, and the tube is sealed and left in the dark in an upright position, the oxide is gradually converted to a voluminous mass of pentoxide, which is deposited in a most beautiful manner in regular annuli all up the tube to the very top. When the oxide is placed in contact with oxygen in an apparatus in which the pressure can be rapidly diminished, the oxidation is seen to be accompanied by a phosphorescent glow, flickering up and down throughout the whole inclosed space, similar to that which occurs under the same circumstances with phosphorus itself. Moreover, this phenomenon is observed with the purest specimens distilled *in vacuo.* If the temperature is increased, the phosphorescence is brought about at pressures near the atmospheric, and if it is raised to 70° C., phosphorescence gives place to actual combustion, which, however, may be at once reduced to mere phosphorescence by diminishing the pressure. If the oxide is thrown into oxygen warmed to about 50°, it immediately burns to the pentoxide with a most brilliant flash of flame.

Action of Halogens.

When phosphorous oxide is thrown into a vessel containing chlorine gas, it instantly takes fire and burns with a pale green flame. If chlorine is led over the oxide at the ordinary temperature, violent combustion also occurs; but if the vessel containing the oxide is cooled by ice, the reaction occurs in a more moderate manner. The product is a clear liquid which is found to be a mixture of phosphorus oxychloride, $POCl_3$, which may be distilled off, and metaphosphoryl chloride, PO_2Cl, which remains as a viscous residue after the distillation of the phosphorus oxychloride. The reaction occurs in complete accordance with the equation

$$P_4O_6 + 4Cl_2 = 2POCl_3 + 2PO_2Cl.$$

Bromine also acts with considerable violence upon the oxide, generally with incandescence. Analogous products are eventually obtained as in the case of chlorine; but if the experiment is so arranged that the vapours of the two substances only are allowed to react at the ordinary temperature, an intermediate reaction occurs with deposition of annuli of large and very perfect crystals of phosphorus pentabromide, PBr_5, phosphorus pentoxide being also formed at the surface of the phosphorous oxide.

Iodine only slowly reacts with the oxide, and best when the two substances are dissolved in carbon bisulphide and the solution heated in a sealed tube. On cooling, orange-red crystals of P_2I_4 separate out.

Action of Sulphur—Formation of a Sulphoxide of Phosphorus.

Sulphur reacts with the oxide in a most interesting manner, producing a beautifully crystalline addition compound of the empirical formula $P_2O_3S_2$. The reaction is best carried out in a sealed tube, about five grams of the oxide and the corresponding quantity of sulphur being placed together in the tube, which has previously been filled with carbon dioxide or nitrogen. The tube is fixed upright, and its lower portion, containing the mixture, is heated in a glycerine bath. No reaction occurs, the two liquids remaining in separate layers, until a temperature in the neighbourhood of 160° is attained, when sudden and very violent combination takes place, the tube being usually shattered into fragments if more than 5 grams of the oxide are employed. The sulphoxide produced is a pale yellow solid substance which melts at about 102°, and boils without decomposition at 295°. When heated *in vacuo* it sublimes largely in the form of tetragonal prisms of considerable size, quite colourless and transparent; a certain amount frequently condenses in a vitreous form, which eventually devitrifies into feathery aggregates of the tetragonal prisms. Occasionally long needles, elongated tetragonal prisms, are formed. A very slight residue usually remains of sulphur, to which the yellowish colour of the crude product is probably due. The sulphoxide is soluble in carbon bisulphide, and the solution deposits it again in tetragonal prisms on evaporation.

As phosphorus sulphoxide is undecomposed even at 400° C., it has been found possible to determine its vapour density by Victor Meyer's method in an atmosphere of nitrogen. The numbers obtained agree with the double formula $P_4O_6S_4$. Hence phosphorus sulphoxide is a direct sulphur addition product of phosphorous oxide.

It is deliquescent, and is decomposed by water with liberation of sulphuretted hydrogen and formation of phosphoric acid.

Other Reactions of Phosphorous Oxide.

Ammonia gas, when led over melted phosphorous oxide, causes immediate ignition of the mass. When the oxide is dissolved in ether, however, the action is more manageable, and a new white solid compound is formed. This compound is the diamide of phosphorous acid, $P\begin{cases}NH_2\\NH_2\\OH\end{cases}$. It is an amorphous powder which dissolves instantly in water with production of flame. Dilute hydrochloric acid liberates pure non-spontaneously inflammable phosphoretted hydrogen from it, owing to the decomposition, at the high temperature brought about by the reaction, of the phosphorous acid first produced.

Hydrochloric Acid gas converts the oxide into phosphorus trichloride and phosphorous acid, the former being readily decanted from the latter at the close of the experiment.

$$P_4O_6 + 6HCl = 2PCl_3 + 2H_3PO_3.$$

Concentrated *sulphuric acid* deflagrates violently with phosphorous oxide with production of flame, formation of phosphoric acid, and liberation of sulphur dioxide.

Caustic alkalies, when tolerably concentrated, at once decompose the oxide with production of a flame of burning phosphoretted hydrogen, red phosphorus being deposited, and a phosphate formed.

Sulphur chloride and *phosphorus pentachloride* respectively react with great energy with the oxide, the resulting liquid products being immediately raised to the boiling-point. When the reactions are performed in vessels cooled by ice, the products may be collected and examined. Sulphur chloride yields a mixture of oxychloride and sulphochloride of phosphorus,

$$P_4O_6 + 6S_2Cl_2 = 2POCl_3 + 2PSCl_3 + 2SO_2 + 8S.$$

Phosphorus pentachloride produces a mixture of oxychloride and trichloride of phosphorus,

$$P_4O_6 + 6PCl_5 = 6POCl_3 + 4PCl_3.$$

Ethyl alcohol instantly sets fire to phosphorous oxide. The reaction may readily be moderated, however, by cooling the vessel by ice, and under these circumstances a new liquid, diethyl phosphorous acid $P\begin{cases}OC_2H_5\\OC_2H_5\\OH\end{cases}$, is produced. This liquid possesses a strong garlic-like odour, boils at 184°–185°, and has a specific gravity of 1·0749 at 15°·5.

An account of the properties of phosphorous oxide would not be complete without a reference to its physiological action. Most people are aware that persons engaged in lucifer-match making occasionally suffer terribly from disease of the lower jaw, and it is found that this is due to the direct action of the fumes upon the bone. It would appear that this deplorable action is directly traceable to the vapour of the volatile phosphorous oxide now described, for this oxide is found to be largely formed when phosphorus oxidizes without igniting; and if any benefit in the way of increased precautions against such action should follow from the further knowledge now gained concerning this substance, none will rejoice more heartily than those who have attempted to place its chemical history upon a surer foundation.

A. E. TUTTON.

UNIVERSITY AND EDUCATIONAL INTELLIGENCE.

OXFORD.—Mr. George B. Grundy, B.A., Brasenose College, has been elected to a Geographical Studentship (see November 19, 1891, p. 70). This student, after preliminary study at Oxford, or at some other place appointed by the electors, will be expected to reside at least three months in the region he is investigating, and to forward the results of his work to the Royal Geographical Society.

A meeting of the Ashmolean Society was held in the Museum on Monday, March 7, Mr. E. B. Poulton, F.R.S., in the chair. The Rev. F. J. Smith, Trinity College, Mellard Lecturer, was prevented by illness from giving his paper on some of the uses of photography in scientific research. Mr. Veley, University College, read a paper on some chemical transformations of nitric and nitrous acids.

MR. F. E. WEISS, Assistant Professor of Botany at University College, London, has been appointed Professor of Botany at Owens College, Manchester.

Mr. Wyndham R. Dunstan, the Director of the Research Laboratory connected with the Pharmaceutical Society, has been elected Lecturer on Chemistry at St. Thomas's Hospital Medical School, in succession to the late Dr. Bernays.

SCIENTIFIC SERIALS.

American Journal of Science, February.—On the use of a free pendulum as a time standard, by T. C. Mendenhall. The accuracy with which we measure hours, minutes, and seconds is dependent upon our ability to subdivide the sidereal day by mechanical arrangements, *e.g.* chronometers and clocks. The author believes that a free pendulum, vibrating under constant conditions, furnishes a much more trustworthy standard for short intervals of time than any clock or chronometer. To determine the period of such a pendulum, a small mirror is placed in a vertical plane on the pendulum head, and another is placed parallel to it, but rigidly attached to the support upon which the pendulum swings. At a distance of about a metre, an apparatus is arranged which illuminates a slit at intervals of a second. Each of the two mirrors reflects images of the illuminated slit to an observing telescope, and the arrangement is such that when the pendulum is at rest, or at its lowest point, the two images just overlap. Suppose this overlapping to be observed at any instant, then, if the chronometer which makes the current for the illumination of the slit, and the pendulum, have the same period, or if they differ by half a period, the same appearance would be observed continually. But if the two differ by an extremely small amount, the image from one of the mirrors will be a little above or below the image of the other when the slit is illuminated, and the distance separating them will go on increasing until the pendulum has gained or lost one oscillation. Such a pendulum and accessories can be used to compare one chronometer with another or with a clock. And the great advantage it possesses is that in an hour or less a daily rate can be determined, correct to about three-hundredths of a second.—On the Bear River formation, a series of strata hitherto known as the Bear River Laramie, by Dr. Charles H. White.—The stratigraphic position of the Bear River formation, by T. W. Stanton. The object of these two articles is to show that the strata which have hitherto been known as Bear River Laramie are not only not referable to the Laramie formation, but that they occupy a lower position, being overlain by marine Cretaceous strata the equivalents of which are known to underlie the true Laramie.—The iron ores of the Marquette district of Michigan, by C. R. Van Hise.—An illustration of the flexibility of limestone, by Arthur Winslow.—The separation of iron, manganese, and calcium, by the acetate and bromine methods, by R. B. Riggs.—The Central Massachusetts moraine, by Ralph S. Tarr.—Proofs that the Holyoke and Deerfield Trap sheets are contemporaneous flows, and not later intrusions, by Ben. K. Emerson.

THE *Quarterly Journal of Microscopical Science*, vol. xxxiii., Part 1 (December 1891), contains:—Dr. Marcus M. Hartog, Some problems of reproduction: a comparative study of gametogeny and protoplasmic senescence and rejuvenescence (pp. 1–80). This important paper cannot be summarized within the space at our disposal; the table of contents runs to two pages, and the theses which state concisely the results of the inquiry are twenty in number, extending over three pages.—Herbert E. Durham, On wandering cells in Echinoderms, &c., more especially with regard to excretory functions (plate i.). Following up his researches on the emigration of amœboid corpuscles in starfish, the author of this paper inquires as to the subsequent fate of the pigment-containing corpuscles in other animals, selecting *Dytiscus marginalis* for this purpose. In the irregular Echinids the process of removal of products from the body by means of amœboid cells was seen to be more definitely associated with pigment; these wandered out at any point of the free surface of the body, in the neighbourhood of the circumoral rosette feet, and in the feet themselves, or into the tubes of the madreporite. In the consideration of this subject the great importance of these two processes—the reaction to minute foreign bodies, and the use of the wandering cells in getting rid of effete material from the system—are insisted upon, and numerous weighty and important facts are detailed. In notes on Echinoderm histology the dorsal organ is minutely described, and its functions are detailed.—Sidney F. Harmer, On the nature of the excretory processes in marine Polyzoa (plates ii. and iii.). A series of interesting investigations, made at the Zoological Station at Naples, go to confirm the view that the marine Ectoprocta are not provided with definite nephridia; and appear to show that the excretory processes are carried on principally by the "brown bodies," the funicular (connective) tissue, and the free mesoderm cells contained in the meshes of the latter.—J. T. Cunningham, Spermatogenesis in *Myxine glutinosa* (plate iv.). These investigations as to the development of the spermatozoa in this hermaphrodite fish were carried on at Alverstrommen, some twenty miles to the north of Bergin. The author confirms in great measure his previous work, but he failed to find fertilized ova.—Dr. W. Blaxland Benham, Notes on some aquatic Oligochæta (plates v. to vii.). We have notes on the anatomy and histology of *Heterochæta costata*, Claperède; a note on *Spirosperma ferox*, Eisen; on a species of Psammoryctes; note on the chetæ of *Tubifex rivulorum*; on *Stylodrilus vejdovskyi*, n. sp., found just below Goring-on-Thames; note on *Nais elinguis*; on the supposed constancy of *n* in a given species of Naid, *n* being the position of the zone of budding, the numbers following signifying the number of segments in front of the zone.—Charles Slater, on the differentiation of leprosy and tubercle bacilli. As any staining agent which will colour the leprosy bacillus will also stain the tubercle bacillus, the methods proposed to stain the one leaving the other unstained are untrustworthy, and the apparent differences in respect to rapidity of staining and resistance to decolorization are due to difference in numbers of bacilli present.—Charles Stewart, On a specimen of the true teeth of Ornithorhynchus (plate viii.).

Part 2, January 1892, contains:—Arthur E. Shipley, On *Onchnesoma steenstrupii* (plate ix.), describes the minute anatomy of this the smallest Sipunculid known, one of three species, all of which have been described from the north-west coast of Norway. The head is much simplified; the lip surrounding the mouth bears no tentacles, but is produced dorsally into a blunt ciliated process; there are neither tentacles, hooks, collar, pigmented skin, or eyes; there is no vascular system, no spindle muscle, and no giant cells are found in the brain, which latter is not bilobed. The retractor muscle is single, arising from the posterior end of the body; the nephridium is also single. Nothing is known as to its development.—Edward A. Minchin, Note on a sieve-like membrane across the oscula of a species of Leucosolenia, with some observations on the histology of the Sponge (plates x. and xi.). In a species of Leucosolenia, probably *L. coriacea*, found at Plymouth, a thin perforated membrane was found stretching across the oscular openings. This membrane occurs a little below the actual margin of the opening, varies in size with the oscula, but is imperforate in the very smallest openings; it is composed of two layers of cells in apposition; these are separated by a thin layer of jelly. The author suggests an analogy between this membrane and the well-known sieves in some of the Hexactinellid Sponges, and severely criticizes Von Lendenfeld's homologies concerning oscular sieve plates. Some new points about the ectoderm and endoderm are alluded to.—Ernest W. MacBride, The development of the oviduct in the frog (plates xii. and xiii.). The author states the principal new points as follows: (1) the oviduct arises opposite the first and not the third nephrostome of the pronephros; (2) the whole of the duct and not merely its posterior half, as Hoffman supposed, arises apparently by proliferation from a strip of modified peritoneum, entirely independent of the Wolffian duct; (3) the lumen appears quite close to the peritoneum and in patches.—Margaret Robinson, On the nauplius eye persisting in some Decapods (plate xiv.). The nauplius eye has been described as persisting in Schizopods, and has been referred to by Dr. Paul Mayer as occurring in Palæmonætes, but the author describes and figures it as found by her in several species of Decapoda, *Pandalus annulicornis*, *Virbius varians*. As regards the shape of the pigment cells, the position of their nuclei, and the arrangement of the nerve end cells in three groups, these eyes exactly resemble the median eye of Branchipus as described by Claus.—Dr. W. Blaxland Benham, Notes on two Acanthodriloid Earthworms from New Zealand (plates xv. and xvi.), describes *Plagiochæta punctata*, n. gen. et. sp.; this new genus has apparently affinities with Perichæta and with Acanthodrilus. Also describes *Neodrilus monocystis*, Beddard.—Asajiro Oka and Arthur Willey, On a new genus of Synascidians from Japan (plates xvii. and xviii.). This remarkable Compound Ascidian was found in some quantities at Moroiso, a place on a small bay to the north of Misaki, some fifty miles south of Tokio. It belongs to the Didemnidæ, and has been called *Sarcodidemnoides misakiense*. The colour is a brilliant red, and the surface of the colony is smooth and glistening; at the tips of the round knob-like lobes, which are a very characteristic feature of the genus, are seen the small but extinct excurrent orifices, the lips of the pores being slightly raised above the level of the surrounding surface.

SOCIETIES AND ACADEMIES.

LONDON.

Royal Society, February 11.—"Contributions to the Physiology and Pathology of the Mammalian Heart." By Prof. Roy, M.D., F.R.S., and J. G. Adami, M.A., M.B.

The authors have spent several years in attempting to give to the study of the intact mammalian heart the accuracy which has been attained in the study of the heart of cold-blooded animals. They described two instruments which had been found by them to be of especial value: one which they term the *cardiometer* (a form of cardiac plethysmograph or oncograph); the other, the *myocardiograph*, by means of which records were obtained of the contraction and expansion of the muscle between two points upon the surface of either ventricle, or of ventricle and auricle simultaneously. They pointed out the ease wherewith cardiac tracings may be misinterpreted if certain elements of the mechanics of the heart be not constantly kept in mind. Thus, if, when the chambers of the heart become expanded, there is a lessening of the extent to which at each systole the muscle fibres contract, this does not mean that the contractile force is weakened: for with increase in the contents of the cavities of the heart there is increased strain (or weight) thrown upon the walls, and a comparatively slight diminution in the circumference of the expanded ventricle suffices to expel the same amount of blood, whose expulsion, when the ventricle is but little expanded, is accompanied by great diminution in circumference. Thus, in considering the action of the vagus upon the heart, it was shown that stimulation of this nerve does *not* cause loss of ventricular force of contraction. Moderate stimulation induces weakening or paralysis of the auricles, accompanied by ventricular dilatation. This dilatation is due to the increased venous and intraventricular pressure accompanying the slowed rate of beat. And though, as shown by the myocardiograph, there is now lessened systolic contraction of the ventricular wall, and also lessened output in a given time, each individual contraction leads to the expulsion of an increased quantity of blood. The only direct action of the vagus upon the ventricles, according to the authors, is a diminution of the excitability of the ventricular muscle. Upon continued fairly strong vagus excitation the auricular rhythm is weakened or inhibited, and does not suffice to set up the normal "sinus," or post-auricular rhythm of the ventricles; so for a time the ventricles usually cease to beat; but soon the independent idio-ventricular rhythm manifests itself, the same that is to be seen when, after the methods of Wooldridge or Tigerstedt, the mammalian auricles and ventricles are cut off from one another; or, again, shows itself after muscarin poisoning. Experiments of the authors and early observations of Einbrodt were mentioned proving this contention. With a certain degree of vagus excitation, irregularity of the ventricles results in consequence of the sinus and idio-ventricular rhythms interfering with one another. In the dog this is the common form of irregularity; probably this is also true for man.

The authors conclude that the term *nervi augmentores* is better and more comprehensive than that of *nervi accelerantes cordis*. Excitation of these nerves in the dog leads more often to augmentation in the force than in the frequence of contraction: the two effects do not by any means go hand-in-hand.

Vagus excitation relieves the heart of work, and therefore of waste, to as great an extent as is compatible with a continuance of the circulation; the vagus may therefore be looked upon as primarily the protective nerve of the heart, and secondarily it was shown to act in the interests of the central nervous system; while the presence in the sciatic and other mixed nerves of fibres which cause reflex vagus excitation would seem to indicate that the nerve may be used by other parts of the body to diminish the output of the heart, and so to reduce the activity of the circulation as a whole. The idio-ventricular mechanism must be looked upon as a means whereby arrest of the circulation—and death—is prevented when the vagus action exceeds a certain limit.

The augmentor nerves, on the other hand, increase the work and tissue waste of the heart, this organ being sacrificed for the needs of the economy until the vagus is called into play by cardiac reflex. The output is increased, and the ventricles are enabled to pump out their contents against heightened arterial blood pressure.

Other considerations dealt with by the authors were: the mode of interaction of the vagi and augmentores, and factors other than nervous affecting the force of the heart's contractions; for example, the blood pressure in the coronary arteries; changes in the volume and in the constitution of the blood, asphyxia, fatigue, and organic disease; the part played by the nerves in all these cases being especially taken into consideration.

February 25.—"The Electric Organ of the Skate: Observations on the Structure, Relations, Progressive Development, and Growth of the Electric Organ of the Skate." By J. C. Ewart, M.D., Regius Professor of Natural History, University of Edinburgh. Communicated by Prof. J. Burdon Sanderson, F.R.S.

After referring to the observations of Stark, the discoverer of the skate's electric organ, and to the work of Robin, Leydig, Babuchin, and others, the author describes the arrangement of the muscles in the tail of Selachians with a view to determining which muscles in the skate are transformed into the electric organs.

By comparing the caudal muscles of *Scyllium*, *Lamna*, *Myliobatis*, and *Raia*, it is made out that, while the middle row of muscular cones remains unaltered in the sharks and rays, it is transformed into a more or less perfect electric organ in the skates the various members of the genus *Raia*. It is pointed out that, while the middle row of muscular cones is transformed in *Raia* into electric cones, the two adjacent rows of cones, as in the rays and certain sharks, diminish in size, and in some cases disappear about the middle of the tail.

In considering the structure of the organ, it is stated that, when the various modifications are taken into consideration, it may be described as consisting of a series of electric cones made up of more or less completely metamorphosed muscular fibres. Twenty-eight distinct cones were counted in the organ of *R. batis*. The first, which in a half-grown fish measured 5 cm. in length, was all but completely invested by the last unaltered muscular cone. From the first to the tenth the cones slightly increased in length; but from the eleventh they diminished in length, the twenty-sixth measuring only 0·75 cm. Beyond the twenty-eighth there were from six to eight incomplete cones.

In transverse sections the anterior third of the organ was seen to present an oval or rounded form, while the middle and posterior thirds were less regular, owing to the organ coming into contact with the vertebral column, and being grooved by the dorsal and ventral muscles.

The cones are described as consisting of numerous loculi or chambers, each having an electric disk suspended by nerve fibres from its anterior wall, and occupied in front and behind the disk with gelatinous tissue.

It is estimated that each organ in *R. batis* is made up of about 10,000 electric elements, *i.e.* about 20,000 in the two organs. *Torpedo marmorata* has about 500,000, and *T. gigantea* about 1,000,000, elements in the two batteries, all considerably larger than those of the skate.

The layers of the electric disks, the electric, striated, and alveolar, are described in detail; and the various views as to the termination of the nerve fibrils in the disk are referred to.

In the chapter on the progressive growth of the organ a table is given to show that in *R. batis* the organ, after a time, grows at a greater rate than the tail in which it is lodged: *e.g.* in fish 60 cm. in length the tail measures about 28 cm., and the electric organ 22·5 cm.; well-formed disks having an area of 0·8 to 1 sq. mm. In fish 225 cm. in length the tail measures 85 cm., the organ 70 cm., and the disks have an area of about 2·08 sq. mm. In fish from 25·5 to 30·5 cm. in length the organ is from 12·78 to 14·0 cm., and weighs 0·5 to 0·6 gram; in fish from 83·5 to 91·25 cm. the organ is from 30·50 to 34·25 cm., and weighs from 6·0 to 8·0 grams; in fish 157 cm., the organ measures 48·25 cm., and weighs 25·00 grams; while in 225 cm. fish the organ, which measured 70·00 cm., weighed 156·00 grams. These facts, especially the great size and weight of the organ in large skate (about 7 feet in length), do not seem to point to the skate's organ being in process of degeneration; more especially as the increase in size is not accompanied by any histological changes of a retrogressive nature, the largest organ examined being apparently as perfect as that of *Torpedo* and *Gymnotus*.

In discussing the organ from a physiological point of view, reference is made to the investigations of Sanderson and Gotch, and it is pointed out that, when the electric plate is taken as the unit, the value per square millimetre of the single plate of the skate is in all probability equal to, if not greater than, that of the torpedo.

The structure of organs of the skate and torpedo are compared at length, and it is shown that in the case of the torpedo all the non-essential structures are absent; while the all-essential part, the electric layer or plate, closely resembles the corresponding layer or plate in the skate; the electric layer of *R. circularis* being especially like that of the torpedo.

In considering the modifications of the electric organ in the skate genus, it is shown that in all the British species, with the exception of *R. radiata*, *R. circularis*, and *R. fullonica*, the elements are in the form of disks. In the three exceptions the elements are more or less cup-shaped. In *R. radiata*, as described in a former paper, they are in the form of thick-walled shallow cups. The electric plate, apparently a greatly enlarged motor plate, lines the cup, which throughout resembles an ordinary striated muscle. In *R. circularis*, a more specialized member of the group, the electric elements are larger and better developed. The cups are deep and well moulded, and the electric layer is even more complex than in *R. batis*; at least, it more closely resembles the electric layer of the torpedo. Further, the cups are invested by a thick nucleated cortex, from which a number of delicate short processes project—the first appearance of the long prongs found in *R. batis*. In *R. fullonica* the electric elements stand nearly midway between the only partially transformed muscular fibres of *R. radiata* and the complex disks of *R. batis*. The cups in *R. fullonica* are less deep than in *R. circularis*; and while the electric and striated layers appear to be all but identical in the two species, the cortex is decidedly more like that of *R. batis*. The short simple processes of *R. circularis* are represented in *R. fullonica* by processes, often complex, which, by projecting freely from the outer surface of the cup, give it an irregular villous appearance, and at once suggest the processes or prongs which are so characteristic of the alveolar layer of *R. batis*.

After giving a summary of his observations on the electric organ of the skate, the author concludes by pointing out that it is not yet possible to indicate by what method the electric organs of fishes have been produced.

"On the Organization of the Fossil Plants of the Coal-Measures. Part XIX." By W. C. Williamson, LL.D., F.R.S., Professor of Botany in the Owens College, Manchester.

Physical Society, February 12.—Annual General Meeting.—Prof. W. E. Ayrton, F.R.S., President, in the chair.—The Report of the Council was read by the President, as were also the obituary notices of Prof. W. Weber, late Honorary Member, Mr. W. G. Gregory, and Prof. James Couch Adams. A list of additions to the library accompanied the Report. Dr. E. Atkinson read the Treasurer's statement, showing a gain of about £240. On the motion of the President, the Reports of the Council and of the Treasurer were unanimously adopted. Prof. Van der Waals was elected an Honorary Member of the Society. Prof. Reinold proposed a cordial vote of thanks to the Lords of the Committee of Council on Education for the use of the rooms and apparatus in the Royal College of Science. This was seconded by Prof. S. P. Thompson, and carried unanimously. A similar vote was accorded to the auditors, Dr. Fison and Mr. H. M. Elder, on the motion of Mr. W. Baily, seconded by Dr. C. V. Burton. The following gentlemen were declared duly elected to form the new Council:—President: Prof. G. F. Fitzgerald, F.R.S. Vice-Presidents: Prof. A. W. Rücker, F.R.S., Walter Baily, Prof. O. J. Lodge, F.R.S., Prof. S. P. Thompson, F.R.S. Secretaries: Prof. J. Perry, F.R.S., and T. H. Blakesley. Treasurer: Dr. E. Atkinson. Demonstrator: C. Vernon Boys, F.R.S. Other Members of Council: Shelford Bidwell, F.R.S., Dr. W. E. Sumpner, Major-General E. R. Festing, R.E., F.R.S., J. Swinburne, Prof. J. V. Jones, Rev. F. J. Smith, Prof. W. Stroud, L. Fletcher, F.R.S., G. M. Whipple, James Wimshurst. A vote of thanks to the officers of the Society was proposed by Mr. Swinburne, seconded by Mr. A. P. Trotter, and carried unanimously. The Chairman then invited suggestions towards improving the working of the Society. In response, Prof. S. P. Thompson said that as the Society had been established fifteen or sixteen years, and had amply justified its existence, the time had now arrived for giving fuller recognition to the privileges of members. He thought they had earned the right to be called "Fellows," and that this ought to be signified by some distinctive title. Mr. J. Swinburne suggested that before papers were brought before the meetings they should be read by a Member of Council. If suitable, they should then be printed, and proofs sent to members who applied for them. Mathematical papers could then be taken as read; and the discussions would be more interesting and to the point. It would also be an advantage if communications on kindred subjects could be taken the same day, and discussed together. Papers on purely technical subjects should go to the technical societies. Prof. Ayrton, in reply to Mr. Swinburne, said the members had the matter of papers in their own hands, for, as pointed out in the Report of the Council, if they would only send in the papers early enough, the Secretaries would be glad to group them in the way suggested. Referring to Prof. Thompson's remarks, he said he had often thought it would be an advantage to have another class of members in the shape of "Students," who should hold meetings amongst themselves. Mr. A. P. Trotter said the Society was unique in many respects, and thought it was not desirable to have different grades of membership. Dr. C. V. Burton agreed with Mr. Trotter, and said that even if Prof. Thompson's suggestion was adopted, means should be provided that persons could be admitted into the Society without claiming any distinction therefrom. Prof. S. P. Thompson, referring to the communications brought before the Society, said it was not necessary that all should possess great novelty. Descriptions of new arrangements of apparatus, of diagrams, and exhibits of modern instruments were of great interest to members. The Chairman pointed out that at the early meetings of the Society exhibitions of instruments were frequent, and said the Council would be glad if instrument makers would send apparatus to be shown at any of the meetings.——The meeting was resolved into an ordinary science meeting, and Messrs. W. R. Bower and E. Edsen were elected members.—Prof. S. P. Thompson, F.R.S., communicated a note on supplementary colours, and showed experiments on the subject. As white light can be divided into pairs of "complementary colours," so any coloured light, not monochromatic, can be split up into pairs of tints; these, the author, for want of a better name, has called "supplementary colours." For producing such colours two methods were used. In the first one, a spectrum of the coloured light was formed by a direct-vision spectroscope and recombined on a screen. By interposing a narrow prism between the spectroscope and screen, a portion of the spectrum was separated from the rest, and various pairs of supplementary colours thereby obtained. In the other method, polarized light, a quartz plate, and a double image prism were used to form two patches of complementary colours. On interposing a coloured medium the patches became supplementary, and varied in tint as the prism was rotated. The chief peculiarity of supplementary colours was the great variety of tints that could be obtained from a single medium, permanganate of potash in dilute solutions being particularly rich in this respect. The author had also noticed that the eye was not very sensitive to orange-coloured rays. When experimenting by the second method, he had observed that with any composite light one of the supplementary patches could be got of a grayish hue, and the other nearly a pure spectrum tint. He thus unexpectedly verified Abney's law that any colour could be produced by diluting some spectrum tint with white light. Captain Abney said it was very interesting to see the gray colour and the supplementary colours shown by the author. General Festing and himself had experimented on colour phenomena by methods quite different from those used by Prof. Thompson, for they had matched colours by adding white light to pure spectrum tints until a match was produced. Greater purity of colour could be obtained in this way.—A paper on modes of representing electromotive forces and currents in diagrams, by Prof. S. P. Thompson, F.R.S., was postponed.

Chemical Society, February 18.—Prof. W. A. Tilden, F.R.S., Vice-President, in the chair.—The following papers were read:—A search for a cellulose-dissolving (cytohydrolytic) enzyme in the digestive tract of certain grain-feeding animals, by H. T. Brown. The author and G. H. Morris have recently shown that during germination of grass-seeds the cell-membrane of the endosperm is broken down and destroyed by a specific cellulose-dissolving enzyme, or cytohydrolyst; such disintegration of the cell-wall being a necessary operation, as otherwise the cell-contents would not readily come under the influence of the very indiffusible starch and proteid-dissolving enzymes secreted by a certain layer of cells in the embryo. As it was found by the author that the analogous starch-hydrolyzing enzymes of animal saliva and of the pancreatic secretion experiences the same difficulty in traversing the thin cell-membrane, it appeared almost certain that grain-feeding animals must possess some provision in their economy for removing, during digestion, the walls of the starch-cells of the interior of the grain, in order that the cell-contents may be accessible to the digestive enzymes of the alimentary canal. This is, however, found to be not the case. The cell-wall is completely dissolved before the grain food enters the small intestine, but the enzyme effecting the dissolution is not secreted by any part of the animal economy, but is pre existent in the grain before ingestion. The comparative abundance of the cytohydrolyst in the various grain foods given to stock is, as will be at once seen, of great importance, bearing as it does on the relative speed of digestion. Thus, oats contain a particularly large proportion of the cytohydrolyst; this fact throws considerable light on the cause of the high estimation in which oats are held as a food-stuff.—On the influence of oxygen and concentration on fermentation, by A. J. Brown. The author describes experiments on the reproductive power of yeast, from which it appears that all fermentable nutritive solutions encourage the increase in number of yeast-cells to some fixed point, beyond which they will not reproduce themselves. It is also shown that if a greater number of cells be introduced into a fermentable solution than the liquid could originally develop, no increase in the number of the cells takes place. As under conditions like these fermentation still proceeds vigorously, a number of disturbing factors which complicate the results obtained under ordinary conditions may be eliminated by using non-multiplying yeast-cells. By experimenting with a fixed number of cells, it is found that the presence of oxygen exercises an accelerating influence on the speed of fermentation by means of yeast. This fact seems irreconcilable with Pasteur's theory of fermentation. The author also finds that the speed of fermentation of sugar is not dependent on the concentration of the solution, but that, in solutions containing between 5 and 20 per cent. of dextrose, approximately the same weight of sugar is fermented in equal times. When the amount of dextrose in the solution reaches 30 per cent., fermentation proceeds much more slowly.—Limettin, by W. A. Tilden. Limettin, $C_{11}H_{10}O_4$, is a crystalline substance deposited from the essential oil of the lime. It forms very pale yellow, thin prisms which melt at 147°·5. Dilute solutions exhibit a beautiful violet fluorescence. It yields a dibromo-derivative, $C_{11}H_8Br_2O_4$, a trichloro-compound, $C_{11}H_7Cl_3O_4$, and a dibromochloro-derivative, $C_{11}H_7Br_2ClO_4$. Nitric acid converts it into a nitro-derivative, $C_{11}H_9(NO_2)O_4$. On fusion with potash it yields phloroglucinol and acetic acid. It seems to have the constitution $C_6H_3(OCH_3)_2 . C_3HO_2$.—The acid action of drawing-papers, by C. Beadle. Prof. Hartley has recently shown that drawing papers possess an acid reaction, and considers the acidity to be due to sulphuric acid left in the fibre after the processes of souring and washing in the manufacture of the paper. Drawing-papers are sized with gelatin and alum, and it is to this latter substance that the author attributes the acid reaction. The aqueous extract from one of these papers was found to react acid towards litmus solution, but basic towards methyl orange. The apparent acidity of the extract is hence due to the presence of a basic sulphate of alumina.

Geological Society, February 10.—Sir Archibald Geikie, F.R.S., President, in the chair.—The following communications were read:—The raised beaches, and "head" or rubble drift of the South of England: their relation to the valley drifts and to the Glacial period; and on a late Post-Glacial submergence, Part I., by Joseph Prestwich, F.R.S. The author remarks that, besides the subaërial, fluviatile, and marine drifts of the south of England, there is another drift which is yet unplaced. This he considers to be connected with the "head" overlying the raised beaches. Of these he describes the distribution, characters, and relations along the south coast. The "head" overlies the beaches, and frequently overlaps them. In the beaches large boulders are found, and marine shells, of which lists for the various localities are given. The "head" frequently shows rough stratification of finer and coarser materials. It contains *mammalian bones, land-shells* only, and occasionally flint implements. On the coasts of Devon and Cornwall it is separated from the raised beaches by old sand-dunes. In South Wales the beach occurs below the mammaliferous cave-deposits, whilst material corresponding to the "head" seals up the cave-mouths. The ossiferous breccias of the caves are therefore intermediate in age between the beaches and the "head." The origin of the boulders is discussed, and it is inferred that they have been brought, not from the French coast, nor from a submerged land, but from a north-easterly source by floating ice through the Straits of Dover. The Mollusca of the raised beaches, of which a list of 64 is given, are closely related to forms living in the neighbouring seas. These raised beaches are not of the age of the higher valley-gravels; but the evidence (especially that yielded by the Somme Valley deposits) points rather to their connection with the lower valley-gravels, and therefore, with the exception of the caves, they represent the latest phase of the Glacial period. After the reading of the paper, the President thought the Fellows were to be congratulated that the father of the Society should still continue to furnish them with such papers as that to which they had listened—so full of careful observation, ranging over so wide an area, and raising so many questions of the greatest interest. They would regret that the author was prevented by illness from being present that evening, but he hoped that he would be able to attend when the second part of the paper was read, and when the full discussion of this wide subject could be entered upon. Dr. Evans concurred in the advisability of postponing the discussion of the paper until the second part had been read.—The *Olenellus* zone in the North-West Highlands, by B. N. Peach and J. Horne. (Communicated by permission of the Director-General of the Geological Survey.) In the stratigraphical portion of this paper brief descriptions are given of certain sections in the Dundonnell Forest, from eight to ten miles north-north-east of Loch Maree, which have yielded fragments of *Olenellus*. The organisms are embedded in dark blue shales occurring near the top of the "fucoid beds" and towards the base of the "serpulite grit," forming part of the belt of fossiliferous strata stretching continuously from Loch Eriboll to Strome Ferry—a distance of ninety miles. In the Dundonnell Forest the basal quartzites rest with a marked unconformability on the Torridon Sandstone. There is an unbroken sequence in certain sections from the base of the quartzites either to the "serpulite grit" or to the lowest bands of the Durness limestone. At these horizons the strata are truncated by a powerful thrust, which, at Loch Nid, brings forward a slice of Archæan rocks with the Torridon sandstone and basal quartzite. The strata from the base of the quartzites to the base of the Durness limestone, exposed in the Dundonnell Forest, are compared with their prolongations to the north and south of that region, from which it appears that there is a remarkable persistence of the various subzones identified in Assynt and at Loch Eriboll. But between Little Loch Broom and Loch Kishorn dark blue shales near the top of the "fucoid beds" have been observed at various localities, evidently occupying the same horizon as the *Olenellus* shales in the Dundonnell Forest. The serpulites (*Salterella*) associated with the trilobites in the "serpulite grit" occur in the basal bands of the overlying limestone; they were found during last season in the brown dolomitic shales accompanying the *Olenellus* shales in the "fucoid beds," and they were formerly detected in the third subzone of the "pipe-rock" in Sutherland. Their appearance on these horizons leads us to cherish the hope that portions of *Olenellus* may yet be met with in certain shales in the quartzites, and probably in the lowest group of limestone. The evidence now adduced proves (1) that the "fucoid beds" and "serpulite grit" are of Lower Cambrian age, the underlying quartzites forming the sandy base of the system; (2) that the Torridon Sandstone, which is everywhere separated from the overlying quartzites by a marked unconformability, is pre-Cambrian. The *Olenellus* which has been discovered is described as a new species (*O. Lapworthi*) closely allied to *O. Thompsoni*, Hall, from which it differs chiefly in the arrangement of the glabella-furrows, and in the presence of a rudimentary mesial spine at the posterior margin of the carapace. Remains of other species referrable to *Olenellus* are described, but these are too fragmentary for exact determination. All are characterized by a reticulate ornamentation similar to that described by Walcott in *O.* (*Mesonacis*) *asaphoides*, Emmons. The remains consist chiefly of portions of carapaces. The reading of this paper was followed by a discussion, in which Dr. Hicks, Dr. Woodward, the President, Prof. Lapworth, and Mr. Peach took part.

February 24.—W. H. Hudleston, F.R.S., President, in the chair.—The following communications were read:—The raised beaches, and "head," or rubble-drift, of the South of England: their relation to the valley-drifts and to the Glacial period; and on a late post-Glacial submergence, Part II., by Joseph Prestwich, F.R.S. The ossiferous deposits of the Caves of Gower are shown to be contemporaneous with the raised sand-dunes between the beaches and the "head," and reasons are given for supposing that the elevation of land which preceded their formation need not necessarily have been greater than 120 feet. The mammalian fauna of these caves is the last fauna of the Glacial or post-Glacial period, and the "head" or rubble-drift marks the closing chapter of Glacial times. Evidence is given for considering that the "rubble-drift" has a wide inland range, and that to it are to be referred the "head" of De la Beche, the subaërial detritus of Godwin-Austen, the angular flint drift of Murchison, and in part the "trail" of Fisher and the "warp" of Trimmer, as well as other deposits described by the author. The accumulation is widespread over the south of England, and occurs in the Thames Valley, on the Cotteswold Hills, and on the flanks of the Malverns. The stream-tin detritus of Cornwall and the ossiferous breccia filling fissures (which must be distinguished from the ossiferous deposits of the true caves) are held to be representatives of the "rubble-drift," which is of a variable character. The author discusses the views of previous writers on the origin of the accumulations which he classes together as "rubble-drift," and points out objections to the various views. He considers that they were formed on upheaval after a period of submergence which took place slowly and tolerably uniformly; and that the absence of marine remains and sedimentation shows the submergence to have been short. This submergence cannot have been less than 1000 feet below present sea-level, and was shortly brought to a termination by a series of intermittent uplifts, of which the "head" affords a measure, sufficiently rapid to produce currents radiating from the higher parts of the country, causing the spread of the surface-detritus from various local centres of higher ground. The remains of the land animals killed during the submergence were swept with this *débris* into the hollows and fissures on the surface, and finally over the old cliffs to the sea- and valley-levels. Simultaneously with this elevation occurred a marked change of climate, and the temperature approached that of the present day. The formation of the "head" was followed in immediate succession by the accumulation of recent alluvial deposits; so that the Glacial times came, geologically speaking, to within a measurable distance of our own times, the transition being short and almost abrupt. In this paper only the area in which the evidence is most complete is described. The author has, however, corroborative evidence of submergence on the other side of the Channel.—The Pleistocene deposits of the Sussex coast, and their equivalents in other districts, by Clement Reid. (Communicated by permission of the Director-General of the Geological Survey.) The gales of last autumn and early winter exposed sections such as had not before been visible in the Selsey Peninsula. Numerous large erratic blocks were discovered, sunk in pits in the Bracklesham Beds. These erratics included characteristic rocks from the Isle of Wight. The gravel with erratics is older, not newer as is commonly stated, than the Selsey "mud-deposit" with southern Mollusca. Numerous re-deposited erratics are found in the mud-deposit, which is divisible into two stages—a lower, purely marine, and an upper, or *Scrobicularia*-mud, with acorns and estuarine shells. At West Wittering a fluviatile deposit, with erratics at its base and stony loam above, is apparently closely allied to the mud-deposit of Selsey; it yields numerous plants, land and fresh-water Mollusca, and mammalian bones, of which lists are given. The strata between the brick-earth (= Coombe Rock) and the gravel with large erratics yield southern plants and animals, and seem to have been laid down during a mild or interglacial episode. A similar succession is found in the Thames Valley and in various parts of our eastern counties. After the reading of these papers there was a discussion, in which the President, Dr. Evans, Mr. Ussher, Mr. J. Allen Brown, Prof. Hughes, Dr. Hicks, and others took part.

Linnean Society, February 18.—Prof. Stewart, President, in the chair.—The President exhibited specimens of *Cystocœlia immaculata*, an orthopterous insect from Namaqualand, in which the female is far more conspicuously coloured than the male (which is unusual), and the stridulating apparatus of the male differs in certain important details from that of other species. A discussion followed on stridulation in insects and the various modes of producing it, in which Messrs. C. Breeze, E. M. Holmes, and B. Daydon Jackson took part.—The President also exhibited some specimens of a Crustacean, *Ocypoda ceratophthalma*, and communicated some interesting information thereon.—A paper by Prof. Groom was then read, on bud-protection in Dicotyledons, and, in his unavoidable absence, the author's views were expounded by Mr. B. Daydon Jackson.—Mr. W. T. Thiselton-Dyer, C.M.G., F.R.S., communicated a paper by Herr F. Stephani, entitled "A Revision of Colenso's New Zealand *Hepaticæ*."

Entomological Society, February 24.—Mr. Frederick DuCane Godman, F.R.S., President, in the chair. The President referred to the loss the Society had recently sustained by the death of Mr. Henry Walter Bates, F.R.S., who had twice been its President; and he also read a copy of the resolution of sympathy and condolence with Mrs. Bates and her family, in their bereavement, which had been passed by the Council at their meeting that evening.—Mr. Frederick C. Adams exhibited a monstrous specimen of *Telephorus rusticus*, taken in the New Forest, in which the left mesothoracic leg consisted of three distinct femora, tibiæ, and tarsi, apparently originating from a single coxa. He also exhibited specimens of *Ledra aurita*.—Mr. G. A. James Rothney sent for exhibition a series of specimens of two species of Indian ants (*Myrmicaria subcarinata*, Sm., and *Aphænogaster* (*Messor*) *barbarus*, L., var. *punctatus*, Forel) which had recently been determined for him by Dr. Forel. He also communicated notes on the subject, in which it was stated that *Myrmicaria subcarinata*, Sm., was not uncommon in Bengal, and formed its nest by excavating the earth round trees, and throwing it up in mounds of fine grains. The author also stated that both sexes of this species swarmed early in the "rains," from about July 7 to July 10. Of the second species—*Aphænogaster barbarus* var. *punctatus*, Forel—Mr. Rothney observed that it, like the bee, *Apis dorsata*, seemed to have a great partiality for the gardens and buildings of the old Mogul Emperors in the North-West Provinces and in the Punjab, the bee disfiguring the arches and roofs with its huge nests, and the ant frequenting the gardens and steps.—The Hon. Walter Rothschild communicated a paper entitled "On a Little-known Species of *Papilio* from the Island of Lifu, Loyalty Group." The paper was illustrated by a beautifully coloured drawing of the male, variety of the male, female, and under side of the species.

EDINBURGH.

Royal Society, February 15.—Sir W. Turner, Vice-President, in the chair.—The Astronomer-Royal for Scotland read a paper on the new star in the constellation Auriga discovered recently by the Rev. Dr. T. Anderson, of Edinburgh. Dr. Anderson believes that he first saw the new star on January 24, but he did not recognize it as new until a few days later, when it struck him that its right ascension did not agree with that of 26 Aurigæ, for which he had mistaken it. When the Astronomer-Royal first examined the spectrum in the beginning of this month, its general appearance was that presented by new stars soon after their first outburst. Since then the spectrum has gradually become more continuous. Only one of the characteristic nebular lines (F) was present. Two other lines nearly coincide with characteristic nebular lines; but one has too great, the other too small, refrangibility, so that the displacement cannot be due to motion of the star, even if it had not been (as it is) too great a displacement to admit of probable explanation in this way. The brightness of the star increased gradually after its first observation, then decreased more rapidly, and finally became nearly steady. The brightness of new stars usually increases rapidly at first, and finally diminishes gradually to zero. The general phenomena presented in the present case resemble those of a variable star, such as R Andromedæ or R Cygni, rather than those of a new star which rapidly burns out.—Sir W. Turner read a paper on the lesser rorqual (*Balænoptera rostrata*) in the Scottish seas. After giving a brief account of the occurrence of this whale in Scottish seas, Sir W. Turner proceeded to discuss the specimen which was captured near Granton, in the Firth of Forth, in 1888. The lesser rorqual is characterized externally by a dorsal fin, by a large white patch on the front aspect of each flipper, and by great apparent distension anteriorly on the ventral aspect, the distension being prolonged to the extreme anterior end. The whalebone is also characteristic, the extremities of the plates being broken up into thin fibres. The author points out a distinction between whales belonging to the dolphin class and other whales, in respect of the stomach. In the former the first compartment of the stomach does not fulfil a digestive function; in the latter all the compartments have a digestive function. The number of compartments varies from four in the porpoise to fourteen in Sowerby's whale. The stomach of the lessser rorqual has five compartments, the first of which has not a digestive function, so that in this respect it resembles the dolphin's. The third compartment is very small, its existence being indicated externally only by a faintly marked line on the surface of what seems to be the third, but is really the fourth. The size of the openings connecting the various compartments diminishes rapidly from the anterior to the posterior end.—Prof. Tait read a paper on the relation between kinetic energy and temperature in liquids. He showed how, by considering (in the usual pressure-volume diagram) a Carnot's cycle formed by the horizontal part of an isothermal below the critical temperature, the lines of constant volume passing through the extremities of that part, and the portion of the critical isothermal intercepted between these lines, we can calculate the difference between the average specific heats of the liquid and the vapour at constant volume throughout the given range of temperature in terms of known quantities, the vapour, of course, starting from the condition of saturation at the lower temperature. In this cycle the substance is—except when in the state corresponding to the horizontal part of the lower isothermal—either entirely liquid or entirely vapour. In the case of carbonic acid, it appears that the average specific heat at constant volume throughout a given range is greater in the liquid condition than in the state of vapour. In the liquid state (judging from Amagat's results) the average at constant volume seems to be about equal to the specific heat of the vapour at constant pressure. He gave also a number of thermal details about CO_2, mainly based on Amagat's experiments. These included the latent heat of the vapour which (taking the volume of 1 pound of CO_2 at 0° C. and 1 atmosphere as 8 cubic feet) was shown to fall from 53 units at 0° C. to 17·8 at 30° C.

DUBLIN.

Royal Society, February 17.—The Right Hon. the Earl of Rosse, F.R.S., President, in the chair.—Note on the basal conglomerate of Howth, by Prof. W. J. Sollas, F.R.S. The author discussed the characters of these lowest-lying deposits of the Hill of Howth, and stated that he could find no evidence for the volcanic origin attributed to them by Sir A. Geikie: they had been formed in more than one way; a considerable part arose from the dislocation, fracture, and crushing of the Cambrian slates and quartzites *in situ*, the broken fragments being subsequently rounded by intratelluric flow; but some appeared to be true conglomerates, which had been powerfully affected by crust movements. This is only what one might expect when one considered that from the higher beds of Bray there was an increased development of arenaceous material downwards into the lower beds of Howth: the approximation to a shore indicated by the frequency of sandy shoals, leads at length to an actual beach, indicated by the basal conglomerates.—The variolite of Annalong, Co. Down, by Prof. Grenville A. J. Cole. This rock occurs as a dyke north of Annalong, exposed above low water for about 80 feet, and 4 feet wide. The mass consisted, at the time of its consolidation, of spherulitic tachylyte throughout, being a very remarkable development of basic glass, and probably the crest of an olivine-basalt dyke. The extreme edges still retain their glassy character. In the interior of the devitrified mass the spherulites are 1 cm. in diameter. This is the second recorded occurrence of variolite in the British Isles: a specimen, correctly named, and collected by the Irish Ordnance Survey some fifty years ago, led to the author's search for the rock on the coast of the Co. Down.—Mr. J. Joly read a paper entitled "On a Speculation as to a pre-Material Condition of the Universe."

OXFORD.

University Junior Scientific Club, February 17.—Mr. J. A. Gardner, of Magdalen College, President, in the chair.—Mr. F. R. L. Wilson, Keble College, exhibited some Telugu Palmyra-leaf manuscripts from the north-east of the Madras Presidency.—Mr. H. H. G. Knapp, Non-Coll., read a paper on muscular fatigue. A discussion followed, in which various members took part.—A paper was read by Mr. R. E. Hughes, Jesus College, on the nature of solution. A lengthy discussion followed this paper.

CAMBRIDGE.

Philosophical Society, February 8.—Prof. Darwin, President, in the chair.—The following communications were made:—On long rotating circular cylinders, by C. Chree, Fellow of King's College. A solution is found for a long cylinder of isotropic elastic material, with its cross-section bounded by a circle or by two concentric circles, rotating with uniform velocity about its axis. The solution is not exact, save when Poisson's ratio is zero, but is approximate in the same way as Saint-Venant's solution for beams. Formulæ are given on which are based tables showing the shortening of the cylinder and the increase in its radius or radii under rotation. Formulæ are also found for the limiting safe speeds according to the stress-difference and greatest strain theories, and these are compared with the formulæ arrived at by Prof. Greenhill on his theory of instability. The results appear to be of considerable practical importance.—On the theory of contact and thermo-electricity, by J. Parker, St. John's College. The phenomena are deduced by analytical thermodynamics solely from expressions for the energy and entropy functions of the system. These are of the most general type, in that they include all kinds of terms that are formally possible, the coefficients of these terms being the measures of physical properties of the system which may or may not have an actual existence. Thus there will occur terms which indicate, after Helmholtz, affinity between electricity and different kinds of matter. The results are just sufficiently wide to include the known facts of thermo-electricity. Considerations of a cognate kind have been treated by Lorentz, Duhem, and Planck.

February 22.—Prof. Darwin, President, in the chair.—The following communications were made:—Preliminary notes of some observations on the anatomy and habits of *Alcyonium*, by S. J. Hickson. Between the cœlentera of *Alcyonium* there is a dense, transparent gelatinous mesoglœa. This is penetrated (1) by endodermal cords connected with the endoderm of the cœlentera, and (2) a plexus of very fine nerve (?) fibrils connected with a number of very small uni-, bi-, or tripolar ganglion cells. The endodermal cords are not hollow canals, as they are usually described, and all attempts to inject them failed. At the periphery these endodermal cords come into contact with ectodermal invagination at places between the old polypes, and give rise to the buds. When the young buds have nearly developed all the characters of the older polypes, canals are formed which communicate with the cœlentera. The plexus of fine nerve fibrils can only be made out in fresh specimens stained with osmic acid. It could not be traced in the peripheral parts of the colony in consequence of the great quantity of the calcareous spicules in this region. Some experiments were made to determine whether in these animals the expansions and contractions of the polypes occur rhythmically. During the first two or three days after *Alcyonium* is placed in the tank it contracts completely with tolerable regularity twice in every twenty-four hours. After that time it either remains expanded or contracts irregularly. Of six *Alcyoniums* that were placed in a tank with an artificial tide that rose and fell every twelve hours, only three unfortunately survived for more than a fortnight, and these contracted with tolerable regularity once in twenty-four hours. These experiments seem to prove that *Alcyonium* contracts normally twice in every twenty-four hours, and that the rhythm of these contractions continues for some time after it is removed from the action of the tides, and that a new rhythm may be induced by subjecting them to the action of an artificial tide of a different period.—On the action of lymph in producing intravascular clotting, by Dr. L. E. Shore. The sudden injection into the vascular system of a rabbit of a small quantity (4 c.c. to 15 c.c.) of lymph drawn from the thoracic duct of a dog causes death with more or less complete intravascular clotting. The lymph loses this property after it has itself clotted. The injection of even large quantities of lymph-serum produces no such effect. Proteid bodies in the apparently normal lymph to which the power is due have been isolated.—On the fever produced by injection of *Vibrio Metschnikovi*, by E. H. Hankin and A. A. Kanthack.—On the method of fertilization in *Ixora*, by J. C. Willis. The flowers are massed together and thus rendered conspicuous. Honey is secreted by a nectary upon the disk, and protected by the length (3–4 cm.) and narrowness of the tube. The mechanism resembles that of *Campanula*. The anthers dehisce in the bud, covering the style, whose stigmas are closed up with pollen. The stamens bend away when the flower opens, nnd the style presents the pollen to insects. Later the stigmas separate, but never bend back so far as to effect autogamy. In *I. Westii* autogamy occurs in the bud, but the flower appears to be self-sterile.

Paris.

Academy of Sciences, February 29.—M. d'Abbadie in the chair.—On a differential equation relating to the calculation of perturbations, by M. F. Tisserand.—On the storm of June 8, 1891, in the Department of Lot-et-Garonne, by M. Faye. The account given in this paper of the circular movements of winds and descending currents supports M. Faye's theory of cyclones.—On the order of appearance of the vessels in the flowers of *Taraxacum dens leonis*, by M. A. Trécul.—Researches on monohalogen and monocyanogen derivatives of ethyl aceto-acetate, by MM. A. Haller and A. Held.—Influence of the intra-renal tension on the functions of the liver, by M. Félix Guyon.—On the fundamentals of geometry, by M. Sophus Lie.—Remarks on the subject of the last communication by M. Gouy, on the superficial tension of liquid metals, by M. H. Pellat.—On some diffraction experiments, by M. Hurmuzescu.—On the polarization of the atmosphere by the light of the moon, by M. N. Piltschikoff. A series of observations made by means of a polarimeter shows that the proportion of polarized light in the sky at night diminishes in a continuous manner from the time of full moon, when a maximum is attained, to new moon, when it reaches zero; it afterwards increases from new moon to full moon.—On the temperatures of certain industrial furnaces, by M. H. le Chatelier. Measurements of certain high temperatures by the method recently communicated to the Academy have led to results not in accord with previous estimations. — Stereochemistry and the laws of rotatory power, by M. Ph. A. Guye. A reply to the notes on this subject by M. Colson.—A series of new compounds: chromosulphuric acid and the metallic chromosulphates, by M. A. Recoura. (See Notes.)—Researches on the application of the measurement of rotatory power to the determination of the combinations formed by aqueous solutions of perseite with the acid molybdates of sodium and ammonium, by M. D. Gernez.—Action of soda and potassium cyanide on chlorodiamylamine, by M. A. Berg.—Metaphenyltoluene, by M. G. Perrier.—On the presence of mannite and sorbite in the fruits of the laurel cherry, by MM. Camille Vincent and Delachanal. The authors find these two alcohols present in equal proportions in the fruits of the laurel cherry.—The heats of formation of potassium carballylates, by M. G. Massol. The quantities of heat disengaged by the successive combination of three molecules of potash with one molecule of carballylic acid decrease progressively. The mean heat of combination is superior to that of the monobasic acids. These results are the same as those obtained for simple organic bibasic acids.—Note on the density of textiles, by M. de Chardonnet.—The detection of oil of resin in turpentine, by M. Zune.—Comparative nitrification of humus and unaltered organic matter, and the influence of the proportion of nitrogen in the humus upon the nitrification, by M. B. Pichard.—On the medical utilization of alternating currents of high potential, by MM. G. Gautier and J. Larat. The authors have reduced an electromotive force of 2000 volts, by means of transformers, to a voltage suitable for medical purposes, and have experimented on several patients to determine the influence of alternating currents on nutrition.—On the composition of hæmocyanin, by M. A. B. Griffiths. The results of analyses are represented by the formula $C_{867}H_{1363}N_{223}CuS_4O_{258}$.—Ptomaïnes in some infectious disorders, by M. A. B. Griffiths.—The *Molle*, a disease of the *Champignons de Couche*, by MM. Costantin and Dufour.—Spring and autumn woods, by M. Emile Mer.—On fecundation in cases of polyembryony, by M. G. Chauveaud.—On the action of the *nucleole* on the turgescence of the cell, by M. Ch. Decagny.—On the regimen of subterranean waters in the Upper Sahara of the province of Algiers, between Laghouat and El Golea, by M. Georges Rolland.

Berlin.

Physical Society, February 12.—Prof. Kundt, President, in the chair.—Dr. Kalischer showed how, without using Kirchoff's law, the distribution of currents in a system of linear conductors may be calculated in a very simple manner by employing the once much-used but recently neglected principle of the superposition of currents.—Dr. E. Budde gave an exact definition of "temperature" on the basis of mathematical deductions and of physical considerations.

Physiological Society, February 19.—Prof. Munk, President, in the chair.—Dr. Katzenstein has satisfied himself, on the basis of careful anatomical and physiological investigation, that the crico-thyroid muscle is innervated by the inferior laryngeal nerve, a conclusion also arrived at by Prof. Zuntz.

Physical Society, February 26.—Prof. Kundt, President, in the chair.—Prof. Neesen gave an account of measurements of latent heats of evaporation which he had determined by means of a condensation-calorimeter. In these experiments a small quantity of the fluid under investigation was allowed to evaporate *in vacuo* for one or two minutes while resting on the surface of mercury in such a way as not to be in contact with the walls of the containing vessel. Pure water gave a latent heat of evaporation which corresponded closely with that obtained by Regnault. Dilute solution of sodium chloride (one molecule of the salt per litre of water) gave a result which was nearly the same as for water, but slightly greater. As the percentage of salt in solution was increased (up to four molecules per litre) the latent heat of evaporation rapidly diminished. A series of alcohols have similarly been examined, but the values for these not yet accurately determined. It was found that in general the latent heat of evaporation is greater during rapid than during slow evaporation. The condensation of the vapours on the walls of the vacuous space was recorded by the movement of the calorimeter scale.—Dr. Thiesen spoke on the properties of perfect dioptric systems, as based upon certain mathematical deductions, and on the construction of systems with any given properties.

BOOKS RECEIVED.

Our Trees: J. Robinson (Salem, Horton).—An Advanced Class-book of Modern Geography: W. Hughes and J. F. Williams (Philip).—The New University for London: Prof. K. Pearson (Unwin).—Marriage and Disease: Dr. S. A. K. Strahan (Kegan Paul).—A Study of Influenza, and the Laws of England concerning Infectious Diseases: Dr. R. Sisley (Longmans).—The Naturalist in La Plata: W. H. Hudson (Chapman and Hall).—The Elements of Plane Trigonometry: R. Levett and C. Davison (Macmillan).—The Grammar of Science: Prof. K. Pearson (Scott).—Homilies of Science: Dr. P. Carus (Arnold).—Chemical Calculations: R. L. Whiteley (Longmans).—Thoughts and Reflexions of the late David Tertius Gabriel (Unwin).—Text-book of Psychology: W. James (Macmillan).—Mathematical Recreations and Problems: W. W. R. Ball (Macmillan).—Palæontographical Society, vol. xlv. (London).—Things Japanese, 2nd edition: B. H. Chamberlain (Kegan Paul).—Bulletin of the U.S. Geological Survey, Nos. 62, 65, 67 to 81 (Washington).—Universal Atlas, Part 12 (Cassell).—The Ilford Manual of Photography; C. H. Bothamley (Ilford).

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