THURSDAY, APRIL 26, 1894.

BIOLOGY AT THE ANTIPODES.

The "Macleay Memorial Volume." Published by the Linnean Society of New South Wales. (London: Dulau and Co., 1893.)

THE "Macleay Memorial Volume," dated September 1893, is a handsome work of 308 pp. quarto, with 42 plates and woodcuts. It contains a biography, by the editor, Mr. J. J. Fletcher, Secretary of the Linnean Society of New South Wales, with an accompanying portrait, and a series of thirteen representative memoirs, which deal chiefly with certain indigenous worms, molluscs, crustaceans, fishes, and mammals. Botany and vegetable palæontology are duly represented; and the claims of anthropology as a branch of biological science are rightly recognised, in the incorporation of an article by Mr. R. Etheridge, jun., on a series of exhibits forwarded by the Commissioners for New South Wales to the Chicago Exhibition of last year. The class Aves is, curiously, unrepresented; and we could have wished that Prof. Parker's revisionary monograph of the Dinornithidæ might have been reserved for its pages.

The project, which is commemorative of the work of the man who, as the scientific world knows well, has done more than all others for the furtherance of biology at the antipodes, emanated with Prof. Haswell, of the Sydney University, himself a contributor of two of the most important monographs, and it was carried into effect by a small committee, of which he and the editor were members.

William Macleay was born at Wick in 1820, and educated at the Edinburgh Academy. He emigrated in 1839; and, after spending fifteen years as a squatter, and thirty-five as a politician (serving under seven successive parliaments), he retired, to devote the rest of his life wholly to biology. As a politician he appears to have been neither a mere jobber nor an office-seeker, and he will be long remembered as the friend of the inland districts, and the foremost advocate of railway extension. The connection of his family with scientific progress in Australia is now historical; his own work in the same field dates from the year 1860. His entomological collection, originally associated with the foundation of the Entomological Society of New South Wales, became in time the nucleus of the Macleay Museum, which has now reached famous proportions. Having founded the Linnean Society of New South Wales, he proceeded to develop it, chiefly in association with the labours of a personally equipped and conducted expedition to the north-east coast of Australia and New Guinea, in the working out of the results of which he was materially assisted by others whose latent enthusiasm and abilities he aroused by his influence and example. The purchase and presentation of the Linnean Hall, to make good the loss by fire of its predecessor, the Garden Palace, set the seal to his life's labours, his total benefices being estimated at a value of £100,000. His work for the University has since his death entered upon a new phase, by his having bequeathed the sum of £12,000 for the endowment of a chair of bacteriology, and one of £35,000 for that of four research fellowships in natural science, open only to members of the Sydney University, on the condition that they reside in New South Wales and publish their work in its Linnean Society's volumes. The energy and enthusiasm of professional workers in biological science at the antipodes is now sufficiently evident, although perhaps insufficiently recognised at home; and that of more private inquirers, such as is associated with the names of Bracebridge Wilson, Chilton, G. M. Thomson, Maskell, and others, has been already productive of most interesting and important results. The "Linnean Macleay Fellowships," indeed worth the having, cannot fail to inspire investigations of a high order; and owing to the conditions of their tenure, they must ever remain peculiarly suggestive of a welding together of the highest aims of their founder, in a manner destined to keep his memory green. Zoology is especially favoured; and the great desideratum of the moment is the fuller cultivation of the botanical field, which is wide enough for an army of workers, and, in consideration of the localisation of the various climatic conditions under which the colony is placed, must abound in treasures perhaps undreamt of. The investigation of this on broad morphological lines is imperative.

The first monograph which the volume contains is by Prof. Spencer, "On the Blood-vessels of *Ceratodus*," and he incidentally records some observations upon the habits of that animal. His confirmation of Günther's discovery of its vena cava inferior, and that of its pulmonary artery, of its anterior abdominal venous system, of its circulus cephalicus, and of the origin of its hyoidean artery from the first *efferent* branchial, are all of intense interest and very welcome, especially in anticipation of Prof. Semon's work upon the development of the fish, now progressing. This is followed by a monograph upon the "Pliocene Mollusca of New Zealand," by Prof. F. W. Hutton. Prof. Haswell contributes a "Revisionary Monograph of the Temnocephaleæ," in extension of his well-known work upon the type genus; and it heightens the interest in these anomalous animals at all points. The discovery of a ciliated integument and of other features of a unique order for the Trematoda, leaves him still in doubt as to the affinities of these worms, and of an equally remarkable proboscis-bearing ally (*Actinodactylella*), leading the life of a scavenger on the burrowing crayfish, *Engæus fossa*, which he describes as new. Not the least generally interesting of Prof. Haswell's incidental discoveries are those of the behaviour of the Temnocephalan in relation to the surface film of water, of the presence of a series of ciliary flames within the substance of a single cell, and of the apparent passage of chromatic substance into the tail of the developing spermatozoon. Prof. Parker and Miss Rich contribute an elaborate monograph upon "The Myology of the New Zealand Sea-Crayfish (*Palinurus Edwardsii*)," and it is in the spirit suggestive of Dr. Johnson's famous remark that easy reading is precious hard writing. The discovery that Milne-Edwards' flexor abdominis is in part an extensor is apparently perfectly sound; and that of vestigial muscles in relation to the bases of the antennules and their sterna with which they are continuously calcified, is particularly welcome, as it opens up new possibilities of approaching difficulties now arising in certain quarters, as to the exact interpretation of parts of the arthropod body where similar fusion is effected. Messrs. Wilson and Martin contribute a couple of papers on "The Muzzle of Ornithorhynchus," and inform us that the beak of that animal is in life "no more horny than a dog's nose." They show that Turner's "fibrous membrane" is really a cartilaginous tract, and that the immense pre-nasal cartilage is the inter-trabecular one of Parker, highly specialised. Their observations on the "rod-like tactile organs," which Poulton first described and discussed in their exquisite bearings on the functions of end-organs of the Pacinian type, appear on the whole unsatisfactory, in consideration of their having worked upon fresh material. Their illustrations are crude, and they do not seem to have made the most of their preparations. Then follows a paper by Mr. C. Hedley, on the aberrant gasteropod *Parmacochlea*, and one by Prof. Ralph Tate on the "Geographical Relations of the Floras of Norfolk and Lord Howe Islands," in which he concludes that the latter are to be regarded as outliers of the New Zealand region. Baron von Mueller contributes two papers on systematic botany, and Mr. R. Etheridge, jun., one, already alluded to, upon "Some Implements and Weapons of the Alligator Tribe, Port Essington, North Australia." The series closes with a monograph of 51 pages, by Mr. W. A. Cobb, on "Nematodes, mostly Australian and Fijian," in which eighty-two species (half of which are new, and many of which are European) are worked out, in relation to a plan under which the unit of measurement equals the 1-100th part of the worm's length, and certain longitudinal and transverse measurements, taken at points which mark the disposition of leading organs and apertures, are ingeniously formulated for ready comparison.

Such is the scope of the volume, and we congratulate the committee upon it. So far as the editor is concerned, there is internal evidence of the great labour of his task, and that its execution has been to him a labour of love. When it is considered that during the compilation of a work so costly and unremunerative, the country lay under a sore financial depression, we earnestly hope that the meagre list of subscribers announced within its covers will be supplemented by a number sufficient for adequate repayment.

The illustrative plates are somewhat unequal in merit, those of the Photoline Printing Company being in particular not a little crude and muzzy. We note, however, with intense satisfaction, the work of a native lithographer, Wendel by name. Anything more satisfactory than his draughtsmanship it is difficult to conceive; and illustrations such as those numbering pl. xi., fig. 9, and pl. xiv., fig. 1, betoken, on his part, artistic feeling (*Geist*) of a high order, and, on that of the printer, manipulative skill worthy the highest encouragement. For the "discovery" of this artist Prof. Spencer has to be thanked; and it is not a little irritating to us at home that it should have remained for our antipodean *confrères* to first reach that standard of excellence in scientific illustration which, in association with the well-known names of certain continental lithographers, has been so long the admiration of the biological world.

The contents of the volume, when broadly estimated in correlation with the work which the Australasian biologists have during the last decade made public, amply testifies to a determination on their part to leave the study of histogenesis and the refinements of microscopy to us at home, in preference for the monographing of their indigenous fauna and flora, along those broader lines upon which the great problems to which they hold the keys must be solved. The resolution is as wise as it is noble on their part, and in adopting it they are unquestionably furthering the foremost desires of the generous and far-sighted man whose pioneer's work they have so successfully combined to memorialise.

G. B. H.

HARMONIC ANALYSIS.

An Elementary Treatise on Fourier's Series, and Spherical, Cylindrical, and Ellipsoidal Harmonics, with Applications to Problems in Mathematical Physics. By W. E. Byerly, Ph.D., Professor of Mathematics in Harvard University. (Boston, U.S.A.: Ginn and Co.)

THIS treatise contains, in an expanded form, the subject-matter of a course of lectures by Prof. Byerly, on the functions mentioned in the title. The properties of the functions are developed, to a large extent, by means of special examples of their application to obtain solutions of problems involving the differential equations of physics. The object of the treatise appears to be rather to give examples of the practical applications of the functions, than to develop in detail their analytical properties; many important theoretical points are accordingly passed over, the results of investigations being in many cases merely stated. In the introductory chapter the functions of Legendre and Bessel are introduced by means of some of the simpler differential equations of physics. As a matter of method, we think it might have been better to have referred all the functions to Laplace's equation in the first instance, leaving the cases of the equations of heat, vibrations, &c. for subsequent treatment; thus, for example, the circular and exponential functions, spherical harmonics, and Bessel's functions should make their first appearance in the *normal forms*,

$$e^{\pm\sqrt{m^2+n^2}z} \begin{matrix}\cos\\ \sin\end{matrix} mx \,.\, \begin{matrix}\cos\\ \sin\end{matrix} ny, \quad r^n \begin{matrix}\cos\\ \sin\end{matrix} m\phi \,.\, \mathrm{P}_n^m(\cos\theta),$$

$$e^{\pm kz} \begin{matrix}\cos\\ \sin\end{matrix} m\phi \,.\, \mathrm{J}_m(k\rho),$$

which satisfy the equation

$$\nabla^2 V = 0.$$

The least satisfactory part of the book appears to us to be the treatment of Fourier's series in chapters ii. and iii.; it is neither desirable nor possible in an elementary treatise to give a complete discussion of the various points which arise in such a subject as the expansion of arbitrarily given functions in series of circular functions, but it is eminently desirable that it should be distinctly pointed out whenever a result is obtained by a method which falls short of demonstration, and the nature of the assumptions made, should as far as possible be indicated. If this is not done, the student is misled into thinking that results have been demonstrated which have really only been suggested as possibly true. A case in which the criterion we have laid down is not satisfied, occurs on p. 35, where, after having shown that a finite series of sines can be found, the sum of which coincides with the values of a prescribed function at n points, the author states that since this result holds good however large n may be, the limiting form of the curve represented by the series absolutely coincides with the arbitrarily given curve between the limits of the variable. A precisely parallel argument would show that a similar result was true for a power series, which is well known not to be the case. No sufficient safeguard is given by the statement on the next page that the infinite series must be convergent, or by the limitation introduced on p. 38. The method by which Fourier's double integral is obtained on p. 53, is another example of a case in which the student will be apt to believe that the result has been proved. We think that it is very doubtful whether the simplification of Dirichlet's proof of the convergence of Fourier's series obtained by considering a particular case of the series, as in chapter iii., is sufficiently great to compensate for the loss of generality.

In chapter iv. a number of interesting and instructive special problems in heat and in vibrations are considered, a considerable number of exercises being left for the student to solve.

The treatment of spherical harmonics in chapters v. and vi. is satisfactory; a little more space might, however, have been with advantage devoted to the discussion of solid harmonics as developed by Thomson and Tait, and by Maxwell.

In chapter vii., in which Bessel's functions are considered, the infinities of the two Bessel's functions, both for real and imaginary arguments, should have been evaluated, as the selection of the proper forms for the solution of potential problems requires a knowledge of the values of the functions when the argument is infinite. Chapter viii. gives a good introduction to Lamé's functions, the toroidal functions being also briefly mentioned. The interesting historical summary, added by Dr. Bôcher, adds considerably to the value of the book.

In spite of some defects, the treatise is in many ways in advance of any other on the same subjects, in the English language, and should be consulted by all students of mathematical physics. E. W. H.

OUR BOOK SHELF.

Bird Life in Arctic Norway. By Robert Collett, Professor of Zoology in the University of Christiania. Translated by A. H. Cocks, M.A. (London: R. H. Porter, 1894.

THE snow-covered peaks of the Land of the Midnight Sun possess irresistible powers of attraction for most lovers of nature. And they who make periodical migrations to this Switzerland of North Europe, as well as casual tourists, cannot do better than provide themselves with a copy of the popular *brochure* now before us. In it the traits of the bird-life in the three natural zones of which Arctic Norway consists will be found interestingly treated. These three natural divisions are (1) the coast district and the belt of islands girding the coast up to North Cape; (2) the deep fjords of the Arctic Ocean and the adjacent river basins in East Finmarken; and (3) the interior plateaus of Finmarken, or Lapland proper. Each region is brightly described, and the peculiar characteristics of the bird-life in it are plainly set forth. The information imparted by the guide is accurate and well adapted for the general reader; and the ornithologist will also find in it much that is worth reading, especially as a list of the birds of Norway, arranged according to the rules of the British Ornithologists' Union, is given in an appendix. It would be an advantage if, in future editions of the book, the names of places referred to by means of capitals and dashes, thus, M——, T——, &c. were printed in full. To guess the locality from these designations is sometimes difficult, and the signs themselves are always tantalising.

A Text-Book of Euclid's Elements. (Books ii. and iii.) By H. S. Hall, M.A., and F. H. Stevens, M.A. (London: Macmillan and Co., 1894.)

IN this work the authors deal exclusively with the second and third books of Euclid. The propositions and their proofs are clearly stated and proved, and very little additional matter, with the exception of corresponding algebraical formulæ and exercises, is inserted between the propositions themselves. Later in the book, following a few words on the method of limits as applied to tangency, several of the well-known theorems on Book iii., with numerous examples, are given; thus one is brought into contact with problems on tangency, orthogonal circles, properties of the pedal triangle loci, maxima and minima, &c., concluding with a series of harder miscellaneous examples. A short appendix contains one or two propositions on the pole and polar, and radical axes. The book is thoroughly suited for work in schools and colleges, and is printed neatly with distinct figures. 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.*]

Panmixia.

IT is now twenty years ago that I published in these columns the doctrine of Panmixia, or Cessation of Selection, and since this doctrine was independently re-enunciated by Prof. Weismann I have repeatedly had occasion both to explain and to defend our common views upon the subject. For it is surprising how many of our foremost English evolutionists seem to have found a difficulty in understanding exactly what is meant by the doctrine. In view, therefore, of Prof. Weismann's forthcoming lecture at Oxford, it seems desirable that the present standing of the matter should be presented to the consideration of English biologists. An opportunity may thus be afforded him of answering the objections which they have raised against one of the fundamental doctrines of his entire system.

In NATURE of April 12 Mr. Wallace writes:—"He (Mr. Kidd) is under the mistaken impression that the theory (*i.e.* the state) of *panmixia* leads to continuous and unlimited degeneration. Many writers have pointed out that this is an error. The amount of degeneration thus produced would be limited to that of the average of those *born* during the preceding generations in place of the average of those that had *survived*. As Prof. Lloyd Morgan puts it, the survival-mean would fall back to the birth-mean."

This way of putting it, however, was originally due to Prof. Ray Lankester, whose views and terms relating to the subject were afterwards adopted provisionally by Prof. Lloyd Morgan. It may still be remembered by your biological readers that about four years ago Prof. Ray Lankester somewhat vigorously attacked my views on the Cessation of Selection as a cause of degeneration, and disputed their identity with those of Prof. Weismann on Panmixia. He urged that by Panmixia Weismann meant, not the merely passive *cessation* of selection, but an active *reversal* of it, through Economy of Nutrition, &c.

And he strenuously maintained that a merely passive cessation of selection could not be a cause of degeneration in any degree at all. After a prolonged discussion, however, he allowed that it must be a cause of degeneration to the extent of reducing the previous "survival-mean" to the "birth-mean," but no further. In adopting this view, Prof. Lloyd Morgan estimated that "the amount of degeneration thus produced" might be set down at 5 per cent. More recently still Mr. Herbert Spencer, in the *Contemporary Review*, took the same points of exception to my Cessation of Selection as Prof. Ray Lankester had originally taken—*i e.* that it was not the same doctrine as Weismann's Panmixia (the latter being in Mr. Spencer's understanding of it the active reversal of selection due to Economy of Nutrition, &c.), and that it could not be, in any circumstances or in any degree, a cause of degeneration.

Both these points, however, were soon settled, as far as the question of Weismann's opinion was concerned, by his replying to Mr. Spencer that the doctrine of Panmixia was identical with that of the Cessation of Selection, and also that in his opinion the principle was not merely *a* cause of degeneration, but, as a general rule, the *sole* cause. Moreover, he has repeatedly stated that in his opinion "the amount of degeneration thus produced" is unlimited, so that any organ which has fallen under the influence of Panmixia may, by such influence alone, be reduced to a "vestige," and finally abolished altogether. Thereupon Mr. Spencer, like his predecessors, put the question—What is there in the state of Panmixia that determines a numerical excess of *minus* over *plus* variations, such as must be supposed if the amount of degeneration due to Panmixia alone is to proceed further than the survival-mean falling to the birth-mean? Now this very pertinent question has never been answered by Prof. Weismann. He has simply taken it as self-evident, that when the maintaining influence of selection is withdrawn as regards any organ (owing to the latter having ceased to be useful) atrophy of that organ must ensue in successive generations, and this to an unlimited extent. Therefore I am unable to say what his views upon this important point may be. But in answering Mr. Spencer I gave what my own views have always been with regard to it. I hold that there are at least three very good reasons why, as soon as selection is withdrawn from an organ, the *minus* variations of that organ outnumber the *plus* variations, and therefore that it must dwindle in successive generations. These three reasons are as follows:—

(1) The survival-mean must descend to the birth-mean. This is now on all hands acknowledged. But it will only produce, at the outside, 5 per cent. of dwindling.

(2) Atavism is always at work in our domesticated varieties; and although there is no evidence to show (as is generally assumed) that but for artificial selection this would in time cause any domesticated variety to revert to its wild type, there is abundant evidence to show that the cessation of such selection is soon followed by deterioration of the artificial type—*i.e.* degeneration to a very much greater amount than can be explained by the cause above mentioned (1). And, notwithstanding that atavism in the case of specific characters is less pronounced than it is in that of domesticated varieties (owing presumably to their having been much longer inherited), still we know that even here its occurrence is neither rare nor insignificant. And it seems evident that in whatever degree it does occur in the case of any specific character, in that degree it must determine a preponderance of *minus* over *plus* variations—at any rate through 10 to 20 per cent. of degeneration. So long as the character is of use to its possessor, natural selection will suppress these atavistic (*minus*) variations. But when the character ceases to be of use, natural selection will be withdrawn as regards that character, and the resulting preponderance of *minus* variations due to atavism will lead to degeneration—more slowly, no doubt, than in the case of our domesticated productions, but still, and eventually, to some amount considerably more than that contemplated by the English naturalists who object to the doctrine of Panmixia (1). Hence, it appears to me, these naturalists must have overlooked the necessary presence of this factor under a state of Panmixia—at all events in the earlier stages of degeneration, or before atavism begins to cut both ways.

(3) As long as an organ or structure is under the influence of natural selection, any failures in the perfection of hereditary transmission will be weeded out. But as soon as natural selection ceases with regard to this organ or structure, all such imperfections will be allowed to survive, and, just as in the case of atavistic variations, will act as a dead weight on the side of degeneration. Be it observed, degeneration may occur either in regard to size (dwindling of bulk) or to structure (disorganisation of machinery); and it is in the latter case that the present cause of degeneration under a state of Panmixia is presumably of most importance. Thus, for example, we can understand why some of the blind crustacea in dark caves should have lost their eyes, while they have not yet lost their eye-stalks. The latter, although of larger bulk than the eyes can have been, are of much less complexity in regard to structure.

These, then, are my reasons for holding that there is no "error" attaching to Weismann's theory of Panmixia as a cause of degeneration, and, so far, no one has attempted to show that there is any error attaching to these reasons. It seems to me desirable that either Mr. Wallace or some of the English naturalists who think with him should now do so, if only for the sake of seeing what Prof. Weismann may have to say upon the whole subject a week or two hence. But I write in no spirit of controversy. I merely ask for information as to what is the "error" into which both he and I are said to have fallen.

There are certain other points of comparative detail connected with the theory of Panmixia as to which, owing to his reticence, I am uncertain whether Prof. Weismann is in agreement with me. But it seems unnecessary to go into them on the present occasion. For they refer to degeneration by Panmixia below 10 to 20 per cent. of dwindling, and the importance of the doctrine lies in the fact of its destroying the direct evidence of the inherited effects of disuse on which Darwin relied in the case of domesticated animals, where, as he showed, there is no Economy of Growth or Reversal of Selection, to account for the 10 to 20 per cent. which their disused organs have undergone. Hence, one can understand why the doctrine should be obnoxious to Lamarckians, but not why such should be the case with those who disbelieve in the transmission of acquired characters. Prof. Weismann may well ask these naturalists what cause, other than Panmixia, they have to suggest whereby to supplant Darwin's explanation of these particular cases of degeneration. GEORGE J. ROMANES.

Hyères, France, April 16.

The Late Mr. Pengelly, F.R.S., and the Age of the Bovey Lignite.

HAVING enjoyed the inestimable privilege of the acquaintance, and latterly of the friendship, of the late Mr. Pengelly, for nearly forty years, I ask permission to make a few remarks on Mr. Starkie Gardner's letter on the Bovey beds, which appears in your issue of the 12th inst. (NATURE, vol. xlix. p. 554).

From the year 1878 to 1885 Mr. Pengelly published an annual paper in the *Trans. Dev. Assoc.* entitled "Notes on Slips connected with Devonshire." It was a pillory of which the writer stood in wholesome dread, and which by the utmost care he succeeded in escaping. Had Mr. Gardner's letter appeared within the years named, its author would not have been so fortunate.

Mr. Gardner, in lightly attributing one slip to Mr. Pengelly, himself stumbles thrice.

Mr. Gardner, speaking of the Bovey beds, says (for the sake of clearness his remarks are quoted in italics):—

(1) "*They are, however, not lacustrine but fluviatile, consisting of current-bedded coarse grits alternating with lignitic muds.*" Now, according to Pengelly, the beds from the second to twenty-seventh were composed of sand, clay, and lignite; whereas all below the twenty-seventh consisted of clay and lignite only; of these latter beds there were forty-five. Among these occurred not even sand, to say nothing of coarse grits.

(2) "*Neither are they Miocene.*" This caution might lead some of your readers to infer that Mr. Pengelly considered that the beds referred to were Miocene. He, however, carefully avoided defining the horizon of the beds in his paper thereon, his title being, "On the Correlation of the Lignite Formation of Bovey Tracey, Devonshire, with the Hempstead beds of the Isle of Wight."

On this question of age Mr. Pengelly wrote:—"The question it will be seen is simply one of classification. It in no way affects the contemporaneity of the formations which have been spoken of, and which are, all Lower Miocene, *or, all Upper Eocene*; for they must certainly go together."

(3) "*In determining the age of the deposits, great stress was*

laid on the supposed identity of the Sequoia couttsiæ *of Bovey with that of the Hamstead beds."* (*Hempstead?*) Now in Mr. Pengelly's paper *Sequoia couttsiæ* occurs in the Hempstead list, but so far from special stress being laid on it, it is not referred to again. The correlation is shown not by the evidence of a single species, but by converging lines of argument all bearing on the same point.

"*The mistake having been made by such 'heroes of geology' as Heer and Pengelly, is extremely hard to eradicate.*" The mistake referred to is the recognition of *Sequoia couttsiæ* at Hempstead. If mistake it be, it is one for which Pengelly could not be held responsible, as it was eminently a case in which he could only rely on a specialist in botany. There is, however, no proof that Pengelly made any mistake in correlating the Hempstead and Bovey beds. What he did was this: suspecting the Hempstead beds to be on about the same horizon as Bovey, he commissioned Mr. Keeping, who made the excavations at Bovey, to collect fossils at Hempstead. The evidence of these fossils confirmed Mr. Pengelly in the belief that the Hempstead and Bovey beds were of the same age, but whether Eocene or Miocene, depended upon where the line of demarcation was to be drawn. This disputed point, about which English and French geologists had long been at issue, did not affect Pengelly's argument, as his object was to show the contemporaneity of Bovey and Hempstead, not to define the boundary between Eocene and Miocene.

Geologists will await with interest Mr. Starkie Gardner's proofs that the Bovey beds are not lacustrine.

Prof. Boyd Dawkins well describes Pengelly as one of the old heroes who laid the foundations of geological science. Pengelly's papers are models of scientific writing, with every fact tested, quotation verified, authority cited, and argument polished, to the utmost of the author's ability.

Two extempore interjections of Pengelly will suffice to reveal the cause of his strength, and his springs of action. On one occasion the present writer, seeking to turn a discussion which was getting wide of the mark, said: "That fact is unimportant." Pengelly instantly broke in with: "*No* fact is unimportant." On another occasion a member of the Devonshire Association, when on the platform replying on a paper, incautiously used the words "I think." Pengelly at once ejaculated, "We want to hear what Mr. X. *knows*, not what he *thinks*."

Taken seriously these pithy comments lie at the very root of all sound research, and of every paper worth printer's ink, which many are not. A. R. HUNT.

Torquay, April 14.

A Fine Aurora Australis.

ON February 25 one of the finest displays of auroral light seen in Australia for many years took place. It was seen first at Balranald at 8.30 p.m., and latest at Albury at 11.30 p.m., Albury, 190 miles east of Balranald, being the farthest east of reporting stations, and the last display being seen in the east.

At Adelaide Observatory, the farthest west, the latest time given is 10 p.m.; the range in longitude between these places is 8° 30′, the point farthest north is Wilcannia, latitude 31° 35′, and the farthest south in New South Wales was Deniliquin, 36° 10′; it is however, reported to have been seen in Melbourne also. In Sydney it was not visible, the night being very cloudy. At Deniliquin it was first seen at 9.30 p.m., presenting the form of an intense crimson arch from south to south-west, which lasted until nearly 11 p.m., when streamers of crimson and yellow were observed. The highest point reached was 30° above the horizon, and it was partly obscured by black clouds all the time. The postmaster at Balranald, who gives the best account of it, says: "An intensely brilliant aurora began here at 8.30 p.m.; it was by far the most extensive ever seen here. The display commenced at 8.30 p.m. with a dull red flush in the south, which disappeared at 9 p.m. At 9.50 the whole sky from a few degrees east of south to west-north-west, and almost up to the zenith, suddenly flashed into brilliant crimson. At intervals of a few minutes intensely bright steely shafts darted quite up to the zenith, and these changing gradually through phases of yellow to deepest red. At 10.40 p.m. the display trended more to eastward, and terminated with several very remarkable broad streaky and variegated flashes of dazzling brilliance, which shot up from east-south-east about 11.50 p.m."

March 17. H. C. RUSSELL.

Lepidosiren paradoxa.

PROF. HOWES says in NATURE, April 19, that the villi of the pelvic fins of this fish were "referred to" by me in NATURE of April 12. I think it is desirable to correct this inaccuracy. The villi in question were not "referred to" by me, but were *described and figured* by me on March 20 (published April 12). The description and figures were sent to NATURE a fortnight before the meeting of the Zoological Society at which Dr. Günther exhibited his specimens and mentioned the fact that Prof. Ehlers had "referred to" their existence in a recently published number of the *Göttingen Nachrichten*. I have not yet seen Prof. Ehler's remarks on the subject. My specimens were purchased from a well-known London dealer; and I know nothing of Dr. Bohl or the "signification of his intentions" as to specimens collected by him.

Prof. Howes is correct in his statement that six specimens of *Lepidosiren paradoxa* have been authoritatively recorded before the appearance of several in the market during the present year; but the arrival of these specimens tends to the conclusion that his statement in NATURE (vol. xxxviii.) to the effect that this species is "rapidly approaching extinction" is due to imagination, and does not correspond with the facts. E. RAY LANKESTER.

Oxford, April 23.

[The communication from Prof. Lankester was received on March 22. Proofs were sent to him on March 31 and April 2. The proofs were returned by him for press on April 6.—ED. NATURE.]

Are Birds on the Wing Killed by Lightning?

I CAN answer the question put in NATURE (of April 19) by "Skelfo," not only from several authentic records in my possession, but from personal observation. Many years ago I was standing on the steps of a woollen mill stair (outside) in the village of the Haugh, Ayrshire, in the company of others, some of whom are still alive, watching a terrific thunderstorm over the fields adjoining the river Ayr. What was then familiarly termed "forked lightning" was playing in the valley with great brilliancy. A lurcher puppy dog chased some ducks from behind an old gas-works building. One bird rose in the air, and with the characteristic cry of fright flew over the mill-race in the direction of a corn-field. When on the wing it was struck by lightning and killed "like a shot." I remember examining the dead bird, but do *not* remember if it really "smelt villanously of brimstone." I think not.

G. W. MURDOCHS.

Kendal, Westmorland, April 19.

P.S.—One of the reasons why so few birds are killed by lightning on the wing is because during a thunderstorm they are in shelter, and take to it before the storm comes on.

G. W. M.

A Remarkable Meteor.

YESTERDAY evening, Sunday, April 22, a very fine meteor was seen to traverse the sky, from near the zenith to near the horizon, in an easterly or south-easterly direction. It is reported to me as having appeared about 7.25 p.m., when twilight was strong, and before any stars had come out. It threw off sparks like a rocket, and was followed by a bright train. No noise was heard after the explosion.

Haslemere, Surrey, April 23. R. RUSSELL.

AFFORESTATION IN THE BRITISH ISLES.

THE question of extending the woods of the United Kingdom has recently been brought forward in the press, and questions have been asked in Parliament as to the willingness of Government to assist in furthering a scheme for stocking certain of our waste lands with trees. Now, afforestation may be required owing to those indirect advantages it affords to the climate and soil of a country, which have been described in detail by Dr. Schlich,[1] and again quite recently in NATURE, by Dr. Nisbet,[2] or merely to increase the national wealth in

[1] "Manual of Forestry," vol. i. p. 25-58.
[2] "Climatic and National Economic Influence of Forests," NATURE, January 25.

forest produce. In our case, forests are certainly not required merely to reduce the air and soil temperatures, or to increase the atmospheric humidity; they may afford useful shelter against the strong westerly gales, or cutting east winds, and in our more mountainous districts they may assist in preventing denudation of the soil, which on a large scale has proved so destructive to agriculture in the Rhone Valley and other regions, but is not very much to be feared in our islands.

The chief use of forests with us is, therefore, for our timber supply, and to render us more independent than at present of imports of this valuable and bulky material, the inland transport of which is so costly. Our mild moist climate is admirably adapted for producing oak, ash, beech, and other broad-leaved timber, as well as larch, silver fir, Scotch pine and spruce; and were the land stocked with trees whenever experience shows that it cannot be profitably used for agriculture, our wealth would be considerably increased, and so would be the demands for agricultural labour.

Exclusive of an import of £3,000,000 worth of teak, mahogany, and other tropical woods, which we cannot grow ourselves, we also import annually £12,000,000 worth of oak, ash, and coniferous timber, all of which we might grow at home. Dr. Schlich[1] has estimated that if 6,000,000 acres of our waste lands were planted, they would eventually yield sufficient timber to render these latter imports unnecessary. It is even probable that a smaller area would suffice, were the productiveness of our existing woodlands increased by better management.

This extension and improvement of our woodlands is the more urgent, as the forests of Canada, Scandinavia and Russia, from whence most of our timber imports come, are not sufficiently well managed to secure the production of a steady supply of timber for export. The markets for their timber are also extending in France, Italy, the Netherlands, the United States, South Africa, and other insufficiently wooded countries. The following table, comparing the ratio of the woodland area in 1892 of our own and other European countries, with their total area, places us at the bottom of the list:—

Name of country.	Area of forests per 1000 acres.	Remarks.
	Acres.	
Austria-Hungary	343	
Russia	342	Area of forests less by 102,000 acres since 1872.
Germany	257	
Sweden and Norway	250	
France	159	Countries importing more timber than they export.
Italy	145	
Belgium	143	
Holland	72	
Denmark	60	
British Isles	39	

If our present area of woodlands, 3,000,000 acres, were increased by 6,000,000 acres, as proposed by Dr. Schlich, we should still have only 117 acres of woodland per 1000 acres total area, and should stand between Belgium and Holland on the list.

These 6,000,000 acres would chiefly be taken from our unenclosed mountain and heather land, which, in the agricultural returns for 1892, is given as 12,117,000 acres for Great Britain, figures for Ireland apparently not being available. But as in 1880 there were 4½ million acres of waste land in Ireland, it is probably within the mark to estimate the total area of unenclosed mountain and heather land for the United Kingdom at 15 million acres.

1 "Manual of Forestry," vol. i. p. 65.

Much of this land is at present used for pasturing sheep, and leased in the Highlands of Scotland at from one to four shillings an acre, according to quality. Large areas of it are also let as deer forests, the rent being fixed at about £25 for each stag which may be shot; and as 2500 acres will support about 25 deer, five only of which are mature stags, the rent of average deer forests, exclusive of the buildings on them, cannot be more than one shilling an acre. It is the poorer lands at high altitudes, where sheep pasture does not pay, which are generally let as deer forests.

The cost of planting or sowing varies considerably according to circumstances, and is given in Brown's "Forester" (1882) as varying between £3 and £10 an acre, according to the nature of the fencing and draining required, which are the chief items. In calculating the returns from a plantation, the initial cost of planting must be reckoned at 2½ per cent. compound interest up to the date of felling, and this sum deducted from the proceeds of the felling. Any intermediate proceeds from thinnings will of course be added with interest allowed up to the date of the final felling.

Before a landowner would venture to plant his land on a large scale, he would have to answer the following questions:—

Is the land suitable for the successful growth of any particular forest species; and if so, what are these species, and how should they be grown? Will the sale of the timber be more profitable than the present rent of the land? As a rule, most of these rough pasture lands, except in their moister depressions, are only fit for conifers, and in many cases only for Scotch pine. A large part of the area also is at present stocked with game, and although forest growth may be compatible with pheasants, black game, capercailzie, or a moderate number of deer, it certainly cannot be expected to thrive where rabbits abound; so that the value of the land as a game-preserve will also intervene.

Experiments might certainly be made to plant up the extensive tracts in the Midlands and elsewhere, which are now encumbered with shale and slag from abandoned ironworks, and which may be bought for an old song. Ash and maple grow well on heaps of slag in the Ardennes, and these species, and probably some others, might certainly be planted on similar areas in our Black Country. It is true that the cultivation of trees will not prosper within a certain distance from factory chimneys belching out sulphurous and other noxious fumes, but means may be adopted to fix the sulphur within the factory, and to prevent the air from being contaminated; whilst much of the shale and slag is already sufficiently distant from the obnoxious chimneys.

As regards the increased demands which an extended area of woodlands would afford to labour, Dr. Schlich has calculated that if 6,000,000 acres of our waste lands were planted up at the rate of 300,000 acres a year, this would employ annually some 15,000 labourers, and that eventually, once the forests had been grown, about 100,000 labourers would find in them steady employment, besides the large number of hands required by the special forest industries which this large forest area would certainly call into existence.

Such an industry already exists in the chair-making business of Buckinghamshire. The forests on the Chiltern Hills supply thousands of people with beech-wood, 500,000 cubic feet of which are worked up annually into chairs in the town of High Wycombe and the surrounding villages. Some of these beech forests are getting thin and unproductive, owing to excessive felling and other bad management; but wherever a moderate amount of care is taken not to overcut the woods, as much as 20*s.* an acre per annum is obtained, without any expenses for planting, as the beech reproduces itself naturally. The poor dry soil above the chalk, on which the beech thrives, would, if the forest were rooted up and the soil limed at considerable expense, only yield a rental of 12*s.* an acre as farm-land. Evidently here we have a district where forestry is more productive than agriculture, and where planting might be extended; and the same may be said of the large area of heather land above the Bagshot Sands in Surrey, Berkshire, and Hampshire, which might all be stocked with conifers were sensible measures adopted to stop the progress of the annual heath fires.

When it is remembered that we import 70,000 tons of pit-props every year, chiefly from the cluster pine forests near Bordeaux, and that in the Belgian Ardennes, at a distance of 80 miles from the coal mines, 40-year old Scotch pine, used for pit-wood, can be sold standing for £55 per acre, exclusive of the value of thinnings, which would pay for the cost of producing and tending the forests, and this means an annual profit of 16*s.* an acre, including an allowance for compound interest at 3 per cent., there can be no reason why we should not grow our own pit-props on waste land unsuitable for agriculture.

Many farms on heavy land are at present either going out of cultivation or paying very badly, and as an example of the successful forest treatment of similar land on the London clay, the Princes Coverts, near Esher, in Surrey, may be cited.

Leopold of Saxe Coburg, the consort of our Princess Charlotte, and afterwards King of the Belgians, about seventy years ago united several small woodland areas, by planting up the land of two farms, in which they were situated, with hazel and ash coppice and oak standards. The present extent of the coverts is 868 acres, and their yield, after deducting all costs of management, amounts to at least 16*s.* an acre per annum, and probably more; but Messrs. Clutton, the agents of the Crown lands, in which these woods are at present included, might supply the correct figures. The coppice is felled every ten years, and yields supports for fruit and ornamental trees, bean- and pea-sticks, clothes-props, kindling fuel, &c., which are largely in demand for gardens, orchards, and laundries around London; while the oaks, which in seventy years attain a girth of about five feet, are readily sold standing at 1*s.* 6*d.* and 2*s.* a cubic foot, according to quality.

Whilst, however, the work of planting up our waste lands must necessarily be chiefly left to private agency, the State should bring the Crown forests into a high state of productiveness, and render them examples of good forest management. Forestry is eminently a practical business, and when a landowner wishes to plant, he should be able to see the ideal way of dealing with different localities on economic principles in our Crown forests. This at present is far from being the case. Very large sums of public money were spent in planting up the Crown forests in 1813–25, when there was a fear of our running short of timber for the Navy. It is true that our Navy now depends on teak and iron, rather than on oak and pine; but oak and pine are still valuable commodities, and the present condition of the Crown plantations, made about seventy-five years ago, is certainly not satisfactory, owing to the want of underwood, and the excessive nature of the thinnings to which they have been subjected. Over an extensive area in the New Forest the Scotch pine mosses have been allowed to outgrow the oaks they were intended to shelter temporarily. The fact is, a forester is wanted at the head of our Crown forests, who will see, among other things, that they are properly underplanted, and that all blanks are restocked; but in order to do this successfully, the rabbits, which now swarm in some of the woods, must be kept down. This was not the case twenty years ago; but their increase of late has been prodigious, and they not only eat every natural seedling which appears, but also threaten the existence of the older trees by barking them in the winter.

It should be noted that the Crown forests are managed by the State, and their proceeds go into the Treasury, but that the sporting rights in some of them are vested in the Crown. Surely the Royal sportsmen might be contented with a moderate number of rabbits, and with pheasants, which do no injury to the woods, and not require the enormous multiplication of rabbits, which no continental prince would suffer in his forests.

It may be objected that by treating our Crown forests for economic forestry, as is the case with the Crown woodlands in other European countries, we should introduce uniformity, and spoil much of their picturesqueness. There are, however, 5000 acres in Epping Forest, 4000 in Windsor Park, and extensive tracts in the New Forest, which might be reserved for the lovers of the picturesque, and even then 100,000 acres might be found in the Crown forests which could be made into models o f good forest management, which are at present not to be found anywhere in Britain. W. R. Fisher.

NOTES.

It is stated that the Emperor of Austria has just made a graceful recognition of the important services which the Geological Survey of India has rendered to science, by the presentation of gold medals to the two senior members of the Survey, Dr. W. King and Mr. C. L. Griesbach. Surely for the Emperor of Austria we should read Empress of India.

The next annual meeting of the Museums Association is to be held in Dublin, beginning on the 26th of June, and lasting four days. Dr. Valentine Ball, C.B., F.R.S., is the President-elect, and a strong local committee has been formed, with Dr. R. F. Scharff and T. H. Longfield as honorary secretaries. There will be a reception of the members on Tuesday, June 26, at the Zoological Gardens, and on the following Thursday an excursion will be made to the Wicklow Mountains. Last year's meeting of the Association in London, under the presidency of Sir William H. Flower, resulted in the accretion of a considerable number of new members, and the Association has now become a strong and successful body.

The sixty-sixth annual meeting of German scientific and medical men will be held this year at Vienna, from 24th to 30th September. This function is still more all-embracing than the British Association, maintaining as it does the true brotherhood of natural and physical sciences with the branches of medicine. If all accounts be true which we hear of the section work at the recent Medical Congress in Rome, the best-meant efforts at organisation may sometimes fall short of their mark at a very large meeting. But no city knows better than Vienna how to entertain and, at the same time, to keep work going on smoothly. Active preparations have already been begun for the September meeting, and the programme of arrangements will be issued in the beginning of July.

A commission, nominated by the physical section of the Amsterdam Society for the Advancement of Physics and Medicine, and consisting of Profs. Gunning, van't Hoff, Polak, van Deventer, and Lobry de Bruyn, has made arrangements for the celebration of the centenary of the death of Lavoisier on May 8. Prof. Gunning will deliver a commemorative address, and Dr. van Deventer will describe the apparatus of the Dutch physicist van Marum, by means of which he has repeated the experiments of Lavoisier on combustion. The apparatus, constructed like Lavoisier's, but improved by van Marum, are contained in the museum of Teyler's Society at Harlem. Some of the works, portraits, and letters of the French investigator will also be exhibited at the coming celebration.

AT the end of last week a series of severe earthquake disturbances passed over Greece, causing great destruction of property and loss of life. A sharp shock was felt at Athens about seven o'clock on April 20. It appeared to pass from west to east, and lasted for about half a minute. The shock was also felt throughout the kingdom, though with less severity in the Peloponnesus than in Northern Greece, while Zante and the other Ionian Islands appear to have escaped injury. Thebes was almost completely wrecked by the first disturbance, and a second shock, which took place at six o'clock on Saturday morning, completed the destruction. Shocks were also felt at Athens on Saturday morning, but no very serious casualties have occurred there. The district that has felt the effects of the disturbance most severely is that lying between Thebes, Livadia, Atalanti, and Chalcis. According to the reports, the intensity of the shocks diminished in proportion to the distance from this centre. The villages round Atalanti have suffered terribly, Larymni, Proskina, Malesina, Martino, and Pelli being left in ruins. In the town of Chalcis, also, the earthquake has effected considerable damage. A violent shock was felt there at noon on Sunday, and caused great devastation. There is some uncertainty as to the number of persons killed by the effects of the earthquakes. The official estimate gives the number of lives lost as about 200, but other reports make it as many as 300. Tremors continue to be felt at Athens and other places, but no great shock has been reported since that which visited the districts of Chalcis and Atalanti on Sunday.

THE Royal Geographical Society has awarded its gold medals for the current session to Captain H. Bower, for his remarkable journey across Tibet from west to east, and to M. Elisée Reclus, on the completion of his great work on comparative geography, entitled "Nouvelle Geographie Universelle." The minor awards were given as follows:—The Murchison grant to Captain Joseph Wiggins, for his services in opening up the Kara Sea route to Siberia; the Back grant to Captain H. J. Snow, for his surveys of the Kurile Islands; the Gill Memorial to Mr. J. E. Ferguson, a native of Sierra Leone, for his elucidation of the geography of the Gold Coast interior; and the Cuthbert Peek grant to Dr. J. W. Gregory, in recognition of his journey to Lake Baringo and Mount Kenia. The Duke of York has consented to become Honorary President of the Society. Dr. H. Mohn (Norway), Mr. Frederic Jeppe (Transvaal Republic), and Mr. Justin Winsor (United States) were elected honorary corresponding members.

THE philosophical faculty of the University of Göttingen has offered two prizes—the first of 3400 marks, and the second of 680 marks—for the best investigations of the solubility of mixed crystals. At present this question is of especial interest, as according to van't Hoff's hypothesis a mixed crystal may be regarded as a solution in a solid solvent. By an application of the thermodynamical equations of Willard Gibbs, Roozeboom has also studied the conditions of equilibrium of mixed crystals when in contact with their saturated solutions. These considerations lead to a result which may be stated as follows:—If a substance A form a mixed crystal with another substance, when the mixed crystal is in contact with its saturated solution, the ratio of the concentration of A in the mixed crystal to its concentration in the saturated solution should be the same, no matter what the absolute value of the concentration may be, provided the molecular weight of A in the mixed crystal and in the saturated solution is the same. Measurements of the solubility of mixed crystals will therefore test the validity of the above theoretical views, and may lead to a method of estimating the molecular weights of substances in the solid state. Competitors must send in their results, written in German, Latin, French, or English, to the Dean of the Faculty by August 31, 1896. The awards are to be announced in March 1897.

THE international character of the Naples Zoological Station shows each year increasingly. Great Britain is at present represented by Mr. Riches for Cambridge, Dr. Günther and Mr. H. Vernon for Oxford, and Mr. Moore for the British Association. Germany maintains two tables, and keeps them both occupied. Among those present at Naples now are Prof. His of Leipzig, Prof. Ludwig of Bonn, Prof. Ewald of Strasburg, Dr. Klaatsch and Baron v. Uexküll of Heidelberg. Austria-Hungary's three tables are occupied by two physiologists of Vienna, Dr. Beer and Dr. Fuchs, and Prof. Klein, botanist, from Buda-Pest. The ten Italian tables are occupied all the year round. Russia has sent Dr. Golenkin, Prof. Ognew, and Miss Perejaslewzewa from Moscow. Switzerland, Holland, and Belgium maintain one table each, and Dr. Staehelin (Basel), Dr. Schmidt (Utrecht), and Prof. Heymans (Ghent) occupy them. It is said that Roumania will join the other nations this spring, taking a table and sending Prof. Sihleanu from Bucharest, and that negotiations are pending with Bulgaria. The contract with Spain will probably be renewed this year; indeed, nearly every State in Europe—France and the Scandinavian kingdoms excepted—is represented at Naples. A striking feature this year is the great number of Americans. Some years ago, no relations having then been established between the Zoological Station and the United States authorities, Major. Alex. H. Davis, of Syracuse, New York, instituted a table for his countrymen, but the demand becoming greater, a movement was set on foot among American naturalists asking the Smithsonian Institute to take a table, while at the same time Prof. Agassiz proposed the like to the authorities of Harvard College. The development of interest in the work is shown by the fact that not only are these tables continuously occupied by Americans, but that Major Davis has again stepped forward to take another to meet the urgent demand, and that Prof. Dohrn has consented to place provisionally one or two others at the disposal of American students who wished to work at the Naples Station this year. It is not improbable that, in the near future, California and Japan, representing respectively the eastern and western shores of the Pacific, may have their delegates working side by side in the famous "Stazione." It may then fairly claim to have girdled the world with the far-reaching influence of its aims and its methods. Of that imitation which is "the sincerest flattery" there has been no lack. Other and excellent stations have come into being; others still are projected, all doubtless, in varying degree, to serve for purposes of use; but as first exemplar, as foremost in equipment, as incomparably richest in its intimacy of association with the chief biologists of our time, and, above all, in its international comprehensiveness and representation, the Naples Station is now, and bids fair long to remain unchallenged, the universal clearing-house of the world's biological science.

THE death is announced of M. G. Salet, of the Paris Sorbonne.

M. GRIMAUX, Professor of Chemistry at the École Polytechnique, has been elected a member of the Paris Academy of Sciences, in the place of the late M. Frémy.

DR. W. A. TILDEN, F.R.S., Professor of Chemistry in the Mason College, Birmingham, has been appointed Dr. T. E. Thorpe's successor at the Royal College of Science.

MR. W. ESSON, F.R.S., has been appointed Deputy Savilian Professor of Geometry at Oxford, the continued illness of Prof. Sylvester having rendered him unable to perform the statutory duties of his office.

THREE research scholarships, each of the value of £250, and open only to British subjects, have been instituted by the Grocers' Company "as an encouragement to the making of exact researches into the causes and prevention of important diseases."

THE University College of Liverpool has a generous friend in Mr. George Holt, who has recently offered £10,000 to the Council for the endowment of a chair of pathology in the Medical School. The only endowed chair hitherto possessed by the school is that of physiology, which was also a gift from Mr. Holt.

THE *Chemist and Druggist* says that the herbarium of the late Isaac C. Martindale, of Philadelphia, comprising over 200,000 different plants and ferns gathered from every country in the world, and valued at ten thousand dollars, has been presented to the Philadelphia College of Pharmacy. The herbarium was bought from the heirs of the late proprietor by Mr. Howard B. French and Messrs. Smith, Kline, and French jointly, and given to the College by these gentlemen.

THE agricultural correspondent of the *Times* points out that the appointment of an official agrostologist to the Department of Agriculture at Washington is an event of exceptional interest, for it involves a recognition of the primary importance of the grasses in the rural economy of the nation. The duties of the United States agrostologist will include the identification of grasses and the investigation of forage plants, the preparation of monographs on grasses, and the conduct of various inquiries into grasses and forage plants. The gentleman who has been selected to fill the post is Prof. Frank L. Scribner. He has already filled the position of chief of the section of vegetable pathology in the Agricultural Department at Washington, and has recently been Director of the Tennessee Agricultural Experiment Station.

THE recent operations in Epping Forest have given rise to a large amount of correspondence in the daily papers, all the writers, with one or two exceptions, being opposed to the thinning of the timber and to the other improvements being effected by the Conservators. The Epping Forest Committee of the Corporation of London have so far met the public view of their proceedings as to promise that further operations shall be suspended till a select committee of experts have gone over the ground and reported upon the matter. Without prejudicing the decision of this committee, it may fairly be stated that the newspaper correspondents have given a most exaggerated account of the number of trees felled. In the meantime, the Essex Field Club has convened a meeting for Saturday, April 28, to examine the districts under discussion, and to give an opportunity for the ventilation of the whole question of the Forest management. The meeting will be conducted by the verderers, Sir T. Fowell Buxton and Mr. E. N. Buxton, Prof. Meldola, F.R.S., who as first president of the Club has in these columns expressed his views on the question (vol. xxvii. p. 447), and Prof. C. Stewart, the President of the Linnean Society. Mr. Angus D. Webster, a well-known expert in forest matters, who is now manager of woods to the Duke of Bedford, will be present at the meeting, and many other authorities are expected to take part in the proceedings.

THE Romanes lecture for 1894 will be delivered by Prof. Weismann, at the Sheldonian Theatre, Oxford, on Wednesday, May 2, at 2.15 p.m.

DR. JOHN HOPKINSON, F.R.S., will deliver the "James Forrest" lecture at the Institution of Civil Engineers, on Thursday, May 3, at 8 p.m., his subject being "The Relation of Mathematics to Engineering."

A COURSE of five lectures on "Geographical Distribution" will be delivered by Mr. F. E. Beddard, F.R.S., in the Lecture Room in the Zoological Society's Gardens, Regent's Park, on Saturdays at 4 p.m., commencing Saturday, May 19.

ON Thursday, May 3, Prof. Dewar will deliver the first of a course of lectures at the Royal Institution, on "The Solid and Liquid States of Matter"; on Saturday, May 5, Captain Abney delivers the first of the Tyndall Lectures on "Colour Vision," and on Tuesday, May 1, Prof. Judd begins a course of lectures on "Rubies."

DURING the present term, Prof. Clifton is lecturing at Oxford on the optical properties of crystals; Messrs. W. W. Fisher aud Watts on inorganic and organic chemistry respectively; Prof. A. H. Green on field geology and applied geology; Prof. Ray Lankester on the Mammalia; Prof. Burdon Sanderson on the special senses; and Prof. Vines continues his advanced course in botany. Dr. Tylor lectures on the races of mankind, as classified by language, civilisation, and history; and Mr. H. Balfour on the progress in the arts of mankind, particularly as illustrated by the Pitt-Rivers collection. Numerous supplementary lectures by demonstrators and others are announced in all the departments.

THE programme of the meeting of the Iron and Steel Institute, to be held at the Institution of Civil Engineers on May 2 and 3, has been issued. Mr. Windsor Richards will preside and deliver an address. Prof. J. O. Arnold will read a paper on the "Physical Influence of certain Elements upon Iron"; Mr. William Hawdon will describe a new departure in the construction of blast furnaces; and Mr. Jeremiah Head will point out the growing importance of Scandinavia as a source of iron ore supply. Mr. D. Selby-Bigge will discuss the uses of electricity in the way of replacing steam and other motors in the iron and steel industries. Mr. G. J. Snelus will explain a new French process—a Bessemer process on a small scale. A paper on the relations between the chemical constitution and ultimate strength of steel will be read by Mr. W. R. Webster; and Mr. J. E. Stead and Mr. H. K. Bamber will speak, the former on the microscopic examination of iron and steel, and the latter on the analysis of steel.

La Nature credits Mr. J. Lancaster, an American ornithologist, with the assertion that he has seen frigate-birds flying continuously for seven days. According to his observations, the birds do not get fatigued even after staying such a long time in the air; in fact, not only can the frigate-bird maintain itself in the air almost without moving its wings, but it can travel with a velocity of 160 kilometres per hour with very little exertion. Though the albatross has usually a greater breadth of wing than the frigate-bird, it can only sustain itself in the air four or five days.

THE Roman villa at Llantwit-Major has been described, and the remains figured, by General Pitt-Rivers. In the *Western Mail* of Monday last, Mr. John Storrie says that he has visited a Roman villa at Ely, near Cardiff, and found that the wall plaster is painted with exactly the same patterns as that of the villa at Llantwit. There is other evidence that both villas were erected by the same workmen. Mr. Storrie also found relics not only of the pre-historic village, but of palæolithic man, thus indicating that the district examined may have been a settlement of man continuously from the time of the palæolithic men of the river gravels, then the marsh dwellers, then the Romans, and that it was only deserted when the present village of Ely took its rise probably during the early Norman period.

THE fourth trip of H.M.S. *Jackal*, for physical observations in the northern part of the North Sea, takes place next week, completing the quarterly observations for one year undertaken by the Fishery Board for Scotland, in association with the researches simultaneously carried out by Prof. Krümmel of Kiel, and Prof. Pettersson of Stockholm. Mr. H. N. Dickson has had charge of the observations at sea, and will present a comprehensive report to the Fishery Board in the course of this year. While the trip of August 1893 was very successful, those of November 1893 and February 1894 were unfortunate as regards weather, the *Jackal* encountering the full force of the two most violent storms of the winter on these occasions, and being thus unable to complete the full programme of work.

In consequence of the break-down of the proposed expedition (under Dr. Stein) to Ellesmere Land, efforts are being made in this country and in Sweden to ensure that an adequate search is made by whalers, or by a special expedition, for the missing Swedish naturalists, Björling and Kalstennius, and the Newfoundlanders who were in their company. It will be remembered that the young Swedes set out from St. John's, in 1892, in a small schooner, the *Ripple*, the wreck of which was discovered last summer on the Carey Islands. The survivors intended to make for the Eskimo settlement on Ellesmere Land, where they hoped to be rescued. It is just possible that they may survive, and prompt action is needed to make up for the time lost in trusting to the intentions of the American expedition. Mr. Clements R. Markham has opened a subscription list at the Royal Geographical Society, 1, Savile Row, where a considerable sum has already been received.

The expedition of the German Cameroons Government, under Baron von Uechtritz, to delimit the Hinterland of the Cameroons has, according to a private letter of its scientific member, Dr. Passarge, published in Dr. Danckelman's *Mittheilungen*, had more than a political object. It proceeded up the Benue to Yola, and after being well received by the Sultan, left for the east, and reached Garua in the autumn of last year, where, in company with the French mission, the boundary line between French and German territory was settled, and access to Lake Chad from the south behind the Cameroons insured to the French Congo territory east of the Shari. Dr. Passarge has made the most complete geological survey of the Benue that has yet been attempted, and his observations throw much light on the geology of the Western Sudan generally.

The May number of the *Geographical Journal* announces two new expeditions into Africa of more than ordinary scientific interest. Dr. Donaldson Smith, an American traveller who has already had some experience in Somaliland, is to make another effort to force a way from the north coast of Somaliland to the Lake Rudolph region. The expedition will probably start in May. Mr. R. T. Coryndon, well known as a hunter and collector in South Africa, is on his way, *viâ* the Cape and Lakes Nyasa and Tanganyika, to the eastern edge of the great Congo forest, where he intends to make a permanent camp, from which natural history collecting may be carried on for a year or more. Both explorers are trained in the use of surveying instruments, and if all goes well, the results obtained cannot fail to be of the greatest interest and value.

A series of long, nearly parallel lakes, lying in Central New York State, has been investigated by Mr. Ralph S. Tarr (*Bull. Geol. Soc. Amer.* vol. v. pp. 339-356, 1894). Several of these lakes, known as Finger lakes, and notably lakes Cayuga and Seneca, are extremely long compared with their width. With the exception of one or two minute ones, they all drain northwards and eventually enter Lake Ontario through the Oswego or through the Genesee river. Mr. Tarr gives reasons for believing that "Lake Cayuga, and presumably other of the Finger lakes, is situated in a rock-basin with a maximum depth of approximately 435 feet. The nature of the proof is that the pre-glacial tributaries to this valley are found to be rock-enclosed, and that their lowest points are above the present lake surface." There appear to be various reasons why a rock-basin should be constructed with comparative ease in the region discussed. Mr. Tarr finds that the course of the pre-glacial Cayuga was northward, and probably tributary to a river which drained at least one of the great lakes, Ontario. And as the tributaries of Cayuga river seem to prove the rock-basin origin of Lake Cayuga, it is argued that the Cayuga river tributary to the Ontario stream indicates that Lake Ontario is also a rock-basin.

Kirchhoff's law connecting the absorptive and emissive powers of substances has been tested for glass by G. B. Rizzo, who has communicated his results to the *Accademia di Torino.* Kirchhoff's law states that any substance absorbs those rays which it is capable of emitting at the same temperature, and that the emissive and absorptive powers are, under similar conditions, numerically proportional. The glass tested had been coloured blue by means of oxide of cobalt. It was heated to a red heat in a Bunsen flame, and placed in front of the slit of a spectroscope in which a bolometer was substituted for the telescope. The absorptive power was measured by comparing the intensity of the continuous spectrum given out by an Auer lamp with that of the absorption spectrum due to the glass, and the emissive power was determined by noting the effect of the spectrum of the hot glass alone upon the bolometer. The results show that while the emissive power decreases nearly uniformly between the wave-lengths 685 and 580, the absorptive power shows decided maxima in the red, yellow, and green, which show no relation whatever to the emissive power. It must therefore be concluded that Kirchhoff's law does not hold good for this and similar cases.

At a recent meeting of the *Accademia dei Lincei*, Prof. Riccò drew attention to the difference of time between the seismometer records of Zante and Catania during the first four months of last year, and communicated some important conclusions regarding the mode of propagation of earthquake shocks between the two places. The distance between the stations is 515 km. (320 miles), and the difference in time between the four earthquake shocks originating at Zante ranged from 4 min. 20 sec. to 7 min. 30 sec., and gave a mean velocity of 1439 m. per second. This velocity, curiously enough, nearly coincides with the velocity of sound in water. This means that the shock was not propagated along the bottom of the Ionian Sea—in which case it would have travelled with a speed of something between 2000 and 4000 m. per second—but was transmitted by the water to Sicily. The circumstance that no shock was propagated through the ground, Prof. Riccò attributes to the probability that the ground to the east of the Etna district is discontinuous and much broken up.

In a paper communicated to the R. Accademia delle Scienze dell'Istituto di Bologna, Prof. Augusto Righi gives a description of a very sensitive idiostatic electrometer which he has constructed. The essential part of the instrument consists of a thin aluminium disc about 9 c.m. in diameter, having a hole 1 c.m. in diameter at the centre, and also two sector-shaped windows. A light aluminium needle, of the usual shape employed in quadrant electrometers, is suspended above this disc by a bifilar suspension, and carries a thin platinum wire which dips into a vessel containing sulphuric acid. Two metal discs, pierced with central holes, are placed one above the needle, and the other below the disc with the windows. These two discs are generally placed in metallic connection with the conducting case which surrounds the instrument, and they form one plate of a condenser, the other consisting of the middle disc and the needle. If a difference of potential exists between these two systems of conductors, then the needle will be deflected, the deflection being approximately proportional to the square of the difference of potential. The sensitiveness of the instrument can be varied by altering the distance between the upper and lower discs and the middle one, or by placing the lower disc in metallic communication with the needle and middle disc, instead of having it connected with the upper disc. With a scale at a distance of five metres a deflection of one millimetre corresponds to 0·14 volts. On account of the deflection being proportional to the square of the difference of potential the sensitiveness increases with the deflection, so that when the instrument is employed in measuring a difference of potential of three volts, one millimetre of the scale corresponds to a change of potential of 0·0033 volts.

IN No. 7 of the pamphlets which the Physical Laboratory of the University of Leyden is issuing under the direction of Prof. Kamerlingh Onnes, there is an interesting paper by Dr. L. H. Siertsema on the magnetic rotatory dispersion of oxygen. In most substances the magnetic rotatory dispersion approximately, at any rate, follows the law that governs natural rotation, viz. that the rotation varies inversely as the square of the wave-length. In strongly magnetic bodies, such as solutions of iron salts, the dispersion is much greater; according to Becquerel the rotation being proportional to the fourth power of the wave-length. Oxygen seems to be an exception, for while Becquerel thought he obtained a small dispersion, more recently Kundt and Röntgen obtained no dispersion. The arrangement of the apparatus employed by the author resembles that used by Kundt and Röntgen. The gas under high pressure is enclosed with a polariser and analyser in a long tube, and the rotation is obtained by fixing one end of the tube and turning the other, so that torsion is given to the tube. The tube lies in a long magnetising coil containing 3600 turns, and through which a current of 70 amperes is passed. Some preliminary experiments, made with commercial oxygen at a pressure of about 100 atmospheres, have shown that, contrary to the result given by Becquerel, Verdet's constant for oxygen decreases regularly with increasing wave-lengths, and that for violet it is twice as large as for red.

AT a recent meeting of the Kaiserliche Akademie der Wissenschaften of Vienna, Prof. Klemencic read a paper on the magnetisation of iron and nickel wires by rapid electrical oscillations. From the amount of heat developed in a wire of a magnetic material traversed by electrical oscillations the author calculates, by means of the formula given by Lord Rayleigh and Stefen, the value of μ (the permeability). The heat developed in the wire under observation was determined by means of a thermoelectric couple, and was compared with the heat developed in a non-magnetic wire under similar circumstances. The following are some of the values obtained for μ:—Soft iron 118; steel wire, soft 106, hard 115; Bessemer steel, soft 77, hard 74; nickel 27. These values agree very well with those obtained by Lord Rayleigh and Bauer for very feeble magnetising forces. The results obtained by these observers show that for certain values of the magnetising force the permeability is constant, and that it afterwards rapidly increases. Now the results obtained by the author show that over the range he is employing μ has a constant value. This fact may be explained either by supposing that the magnetising forces employed are so small that we are dealing with that part of the curve where μ is constant, or that, although the magnetising forces are much greater than those to which the former supposition limits us, the magnetisation is unable to follow the rapid changes in the magnetising force, so that the magnetisation never reaches that part of the curve where μ is variable and has very much greater values. A rough estimation has shown that, at least on the surface of the wire and at the commencement of the oscillations, the magnetising force exceeds more than a hundredfold the maximum limit within which μ is constant. Thus in these experiments there must exist a time lag in the magnetisation which must not be confused with the hysteresis. It would also appear that Bauer and Lord Rayleigh's results which refer to longitudinal magnetisation, also apply to circular magnetisation.

THAT it is easy to find microbes in the soil capable of assimilating atmospheric nitrogen, if culture media devoid of all combined nitrogen are employed, was pointed out by M. Winogradsky last summer, and in a recent number of the *Comptes Rendus* an account is given of important progress made by him in this most interesting subject. By progressive cultivation of a mixture of microbes derived from soil, in a nutritive liquid from which all traces of combined nitrogen were carefully excluded, Winogradsky reduced the varieties present to three bacilli, of which one was finally separated out and discovered to be endowed with this function of assimilating atmospheric nitrogen. This organism is strictly anaërobic, and will not grow in either broth or gelatine. It ferments glucose, producing butyric, acetic, and carbonic acid, and hydrogen. The amount of atmospheric nitrogen assimilated is proportional to the quantity of glucose contained in the culture material, and which undergoes decomposition in the presence of this bacillus. Winogradsky concludes his paper by suggesting that this phenomenon of the fixation of atmospheric nitrogen may be due to the union within the living protoplasm of the microbial cell, of atmospheric nitrogen and nascent hydrogen, resulting in the synthesis of ammonia.

A CATALOGUE of second-hand books, including many rare and scarce volumes on scientific matters, has been issued by Messrs. E. George and Son, Booksellers, Whitechapel Road.

A REPORT upon the work of the City and Guilds of London Institute during 1893 has just been issued, and it affords satisfactory evidence of the advance of technical education, both in London and the provinces. A fact well worth recording is that the Salters' Company have recently offered to found, in connection with the Institute, a studentship or fellowship of the annual value of £150, to be awarded for the encouragement of higher research in chemistry in its relation to manufactures. A scheme of regulations for the award and tenure of this studentship is being drawn up, and the Council of the Institute hope that the action of the Company may result in increased cultivation of original research, and a consequent important advance in the application of chemistry to manufacturing industries. The report shows that the withdrawal of payment on the results of examinations in technology at centres outside the metropolis has had little or no effect in diminishing the number of candidates presenting themselves. It is pointed out that this is partly due to the pecuniary assistance which County Councils are now able to give for the furtherance of technical education, and partly to the recognised value of the certificates granted by the Institute in connection with these examinations.

WE have received a copy of Luke Howard's treatise "On the Modifications of the Clouds" (London, 1803), which has been issued by Dr. G. Hellmann as No. 3 of the reprints of important and rare works relating to meteorology and terrestrial magnetism. The first edition of this work is very scarce. The paper was first presented to the Askesian Society in the winter of 1802–3, and printed in vols. xvi. and xvii. of the *Philosophical Magazine*. It was the first successful attempt at cloud nomenclature, and up to the present time has formed the basis of all classifications. Many attempts of improving it have from time to time been made, but the problem of obtaining a more perfect nomenclature still remains, to a great extent, unsolved. When such an accomplished bibliographer as Dr. Hellmann undertakes the reproduction of a work, we may be sure that he will tell us all that can be known about it, and few persons can read his introductory remarks without learning something. Comparatively few copies appear to have been reprinted from the *Philosophical Magazine*, and Dr. Hellmann points out that the first part of the text was set up afresh, as some of the lines do not exactly agree ; also, that some small omissions were made in the separate copies of 1803 which have been added to this new edition. In 1832 a second edition was issued without plates; but in 1849 L. Howard appears to have drawn a new set of cloud pictures, and these, although not considered to be equal to the first, were included in the third edition, published in 1865. Many other details of great interest are given by Dr. Hellmann, to which we cannot now refer. We may mention that the plates only are actual *facsimiles*, while the type of the text is as nearly as possible like that of the original work.

The additions to the Zoological Society's Gardens during the past week include a Slow Loris (*Nycticebus tardigradus*) from Malacca, presented by Captain Spalding; two Sooty Mangabeys (*Cercocebus fuliginosus*, ♀ ♀), an African Civet Cat (*Viverra civetta*), two Royal Pythons (*Python regius*) from West Africa, presented by the Rev. Canon J. Taylor Smith ; two Crested Porcupines (*Hystrix cristata*) from South Africa, presented by Mr. Adrian Vander Byl ; a Water Vole (*Arvicola amphibius*) British, presented by Colonel L'Estrange ; a Buzzard *Buteo vulgaris*) British, presented by Colonel C. B. Rashleigh ; a Raven (*Corvus corax*) British, presented by Miss P. L. Graham ; two Pin-tailed Sand Grouse (*Pterocles alchata*, ♂ ♀) South European, a Black Gallinule (*Limnocorax niger*) from East Africa, two —— Moorhens (*Gallinula* sp. inc.) from Madagascar, presented by Mr. H. H. Sharland ; four Swainson's Francolins (*Francolinus swainsoni*), a Delalande's Lizard (*Nucras delalandii*), a Rough-keeled Snake (*Dasypeltis scabra*) from South Africa, presented by Mr. J. E. Matcham ; a Chimpanzee (*Anthropopithecus troglodytes*, ♂) from West Africa, a Lioness (*Felis leo*) from India, deposited ; a Chimpanzee (*Anthropopithecus troglodytes*, ♀) from West Africa, a White-backed Trumpeter (*Psophia leucoptera*), a Short-tailed Parrot (*Pachynus brachyurus*) from the Upper Amazons, a Blackish Sternothere (*Sternothærus subniger*) from Madagascar, purchased ; two Barbary Wild Sheep (*Ovis tragelaphus*, ♀ ♀) born in the Gardens.

OUR ASTRONOMICAL COLUMN.

Four New Variable Stars.—Prof. E. C. Pickering announces (*Astr. Nach.* 3225) that four new variable stars have been discovered by Mrs. Fleming from the presence of bright hydrogen lines in photographs of their spectra taken in connection with the Henry Draper Memorial. The first of these is a star in the constellation Sculptor, having the co-ordinates R.A. 0h. 10·4m. Decl. − 32° 36′. The range of variability of this star is from magnitude 6·5 or 6·6 to 10·0, and the period 366 days. The second star is Arg-Oeltz 16121, in Scorpius, its exact position being R.A. 16h. 50·3m. Decl. − 30° 26′. The range of variability is from 7·3 to 11·6 magnitude, and the period is 278 days. The star B.D. + 1°·3417, in the constellation Ophiuchus (R.A. 17h. 14·5m. Decl. + 1° 37′) is the third of the variables discovered, the range in this case being from magnitude 8·5 to 12·5, and the period 348·4 days. The fourth star is B.D. + 4°·4250, in the constellation Aquila (R.A. 19h. 46·5m. Decl. + 4° 13′). Its period is about a year, and at the last maximum on August 12, 1893, its photographic magnitude was 9·5. At a minimum it becomes fainter than the twelfth magnitude.

Speed of Perception of Stars.—When working at the Etna Observatory during a high wind, Prof. Riccò noticed how the pole star and its companion appeared to change their mutual distance at every vibration of the telescope. The phenomenon was not observed on the following night, which was calm, but could be reproduced by shaking the telescope. The pole star appeared in every case to move more rapidly than its companion. This observation has been communicated to the *Società degli Spettroscopisti Italiani*, and connected with Prof. Schaeberle's investigation of the difference of personal equation between bright and faint stars observed in transit. Schaeberle estimated the apparent retardation of faint stars at 0·02 sec. per magnitude. Prof. Riccò proposes to redetermine this by measurements of stellar distances by the micrometer as compared with the transit instrument. That the colour may have a determining influence is shown by the fact that when a spectrum is displaced rapidly at right angles to its length, the more refrangible portions appear to lag behind.

Elements and Ephemeris of Gale's Comet (*b* 1894).—The following elements and ephemeris are given in a supplement to *Astronomische Nachrichten*, No. 3225 :—

T = 1894 April 13·75 G.M.T.

$$\left.\begin{aligned} \omega &= 324^\circ\ 19' \\ \Omega &= 206\ \ 15 \\ i &= 87\ \ 15 \end{aligned}\right\}\ \text{Mean Eq. 1894·0.}$$

$$q = 0·9849$$

Ephemeris for Greenwich Midnight.

1894.		R.A.		P.D.
April 26	...	101 38	...	124 23
30	...	115 22	...	109 31

(R.A. and P.D. in ° ′.)

The comet is increasing in brightness, and on April 30 it will be 6·05 times brighter than at the time of discovery.

A Mistaken Cometary Discovery.—From a note by Prof. Krueger in *Astronomische Nachrichten*, No. 3224, it appears that the object seen by Mr. Holmes on April 9, and afterwards announced as a new comet, is really the nebula No. 6503 in the New General Catalogue.

THE INSTITUTION OF MECHANICAL ENGINEERS.

The meeting of the Institution of Mechanical Engineers was held last week in the theatre of the Institution of Civil Engineers, on Thursday and Friday evenings, April 19 and 20. The chair was taken by the President, Prof. Alexander B. W. Kennedy, F.R.S. Two papers were read at the meeting : the first, "On the Grafton High Speed Engine," by Mr. E. W. Anderson ; and the second, "On Fluid Pressure Reversing Gear," by Mr. David Joy. The President's address was, however, the chief feature of the meeting, and to this we shall mainly confine our report, more especially as it would be difficult to give an adequate description of the mechanical devices upon which the two papers were founded without somewhat elaborate illustrations.

After the usual formal proceedings, Prof. Kennedy read his address. It had been expected that in consequence of the leading part the President has recently taken in the development of electrical engineering that the address would deal largely with that subject, and in this respect the result proved to be in accordance with general expectation. The address pointed out that practical electrical problems divided themselves into three main sections, in which electrical energy is used, respectively : firstly, for lighting; secondly, for power; and thirdly, for physico-chemical processes. The third section, which relates to the deposition of metals, the reduction of chemical compounds, &c., was one in which the President had not had experience, but he had no doubt that there was a great future before it. In this section he also included the application of electricity to heating, and said it was to be hoped that there being so many competent workers engaged in the study of this subject, success would soon attend their efforts. The commercial problem of producing the heat sufficiently cheaply to allow of its general use was yet to be overcome. Remembering, however, that something like 95 per cent. of all the energy that goes to incandescent lamps appears only as heat and not as light, there would seem to be an ample opening here for another "thermal storage" process. The use of electrical energy for power, *i.e.* for transformation into mechanical energy, is, the President pointed out, a matter which lies obviously in the closest possible communication with mechanical engineering. He divided this branch of the subject into three sections, namely: (1) Transmission from a distance for whatever purpose; (2) transmission to a number of isolated points pretty near together, as the tools in a factory; (3) transmission for the purpose of traction on railways or tramways. Transmission comes in in every case, because we have as yet no electric prime mover analogous to a steam engine. With regard to transmission of power from a distance, the President said that Prof. Unwin had so fully and ably dealt with the matter recently, that it was unnecessary for him to go over the same ground again. The question of driving tools in a factory by electric motors instead of through counter shafting, is one which has recently come to the front. The carrying out of such work is obviously purely a matter of mechanical engineering. Prof. Kennedy had been at pains to collect information in regard to practical work bearing on this subject. In any given factory running on the ordinary system there is a large continuous waste of power due to the running of the whole shafting, no matter how many or how few machines are at work. The President gave the following figures as the approximate distribution of total work:—

	H.P.
Average useful work	100
Waste in belts and shafting	25
Waste in engine friction, the engine being supposed large enough to give 150 horse-power at tools as a maximum (at about 10 per cent. of maximum horse-power)	20
	145

On the other hand, if all machines in a similar case were driven by separate motors, each having an electrical efficiency of 88 per cent., and these motors worked from a dynamo having an efficiency of 92 per cent. (both of which are high figures for ordinary work at two-thirds of the output), the figures would stand as follows:—

	H.P.
Average useful work	100
Waste in motors and dynamo	24
Waste in leads (say 2 per cent.)	2
Waste in engine friction	20
	146

The two sets of figures it will be seen are practically the same, and the President pointed out that the electrical efficiencies which he had assumed were not likely to be exceeded. It is not, however, the really absolute saving so much as the proportionate saving which should be considered. It is little use to show an engineer that he can make even 20 per cent. saving in one item of expenditure, if that item only represents 3 or 4 per cent. of his costs, and if at the same time he has to expend a considerable amount of capital in making the change. One does not make important and expensive changes, especially changes whose results are by no means very certainly predicted to bring about an estimated saving of one-half of 1 per cent. to 1 per cent. in one's total expenditure. There are, however, other points to be considered, such as the practical convenience of getting rid of the huge mass of shafting gear and belting which fills up the upper half of many engineers' shops, and also that a properly arranged motor may give a much larger range of speed to each tool, than can be readily obtained in the ordinary way. On the other hand, the President pointed out that the cost of dynamo, leads, and motors is very greatly in excess of the cost of shafting in almost every case. It is hardly certain as yet, he said, how the costs of attendance, lubrication, renewals and repairs to the electrical plant, compare with the similar costs in the case of shafts and belting; probably, he said, on the whole they would be less.

The difficulty which besets the electrical engineer, of unequal demand for energy, was dwelt upon in the address. As is sufficiently well known, the demand for lighting energy varies enormously throughout the twenty-four hours, so that a plant which is giving 2500 horse-power for a couple of hours every day, will only be giving an average of 350 horse-power for the whole week, and not even half this for many hours every day and night. If it could be arranged that during the time of light load for lighting purposes, the plant could be used for powe purposes, then electrical energy might be sold at a low price This, however, is not possible, the electrical station must be prepared for any demand, and in case of fog, for instance, lights might be required when the factories were at work; the plant would therefore have to be designed to supply both demands. Electric transmission of power has, however, this advantage over belts and shafting, that when the machinery is not at work there are no losses in the motors; whereas, whilst shafts are being run and belts are at work there is loss through friction.

Prof. Kennedy, in referring to the driving of trains or tramcars by electric power, said that conditions were by no means so favourable as were sometimes supposed. The ordinary engine exerted about 80 per cent. of the gross indicated horse-power in pulling its load along the line. In an electric railway there was a somewhat lighter locomotive to be moved, but against this advantage, and the fact that a stationary engine can have a greater economy than a locomotive, was to be placed the fact that only about 35 per cent. of the indicated horse-power is available for useful work for pulling a train, the loss of course being the number of transformations through which the energy has to pass. In reference to this part of the question the following figures were given:—

	Per cent.
Mechanical efficiency of engine	85
Efficiency of belt driving, if employed	94
Efficiency of dynamos	90
Efficiency of line	85
Efficiency of motors...	85
Efficiency of gearing of motors	75
Total efficiency	39

From this would be deducted the power required for driving the locomotive, leaving 35 per cent. for pulling the train. In spite of this great drawback of loss of power, some conditions rendered electrical traction absolutely necessary. In the public streets there is the great mechanical difficulty of getting the current to the motors on the cars. In America overhead wires are used, and in country places, the President said, this is possibly the best solution of the problem; but in cities he considered it to be impossible, and that the introduction of electricity for car driving in this country will still wait for a practical underground system to be devised. In the meanwhile, electricity is being hard pressed by its rivals, cable and compressed gas, Prof. Kennedy thinking the latter far the more formidable. It has the advantage of being even more direct than a steam engine, and it can be applied to each individual car even more easily than an electric motor, and it enables the car to run freely on ordinary lines without their reconstruction and without any mains either above or below ground. It has had but a short trial, but what the President had seen of it made him sanguine as to its ultimate possibilities. Prof. Kennedy also referred to the Serpollet boiler and engine, which he wondered had not been introduced for tram work. The Serpollet machinery takes so little space that it might very possibly be put on the car itself, but he supposed some difficulty had been found in the application; at any rate, the proposal had not been made, so far as he knew. We may mention that a number of road carriages, propelled by the Serpollet boiler and engine, have been in use for some time past in Paris.

The address next dwelt at some length on the question of security in running, in efficiency of regulation, and economy of work. In regard to the former the President pointed out the necessity of duplication of plant in order to provide against breakdown of engines or dynamos, and the difficulty of starting boilers with rapidity supposing a sudden call to be made for additional steam. In regard to security in connection with mains, he referred to Mr. Bailey's looped main system. In speaking upon the question of economy, Prof. Kennedy said that in an electric light station the cost of coal averages not far from four-tenths of the total of working expenses. He did not know of any one type of boiler which was better than all others under the conditions of an electric light station; in fact, he said there were five or six types equally good. One thing which tells very much against the economy of electric light stations is that fires must be kept alight and pressures maintained in boilers capable of giving eight or ten times the actual output; added to this is the extent to which in all stations fuel must be expended in getting boilers ready for the heavy load which comes on only once in twenty-four hours. Prof. Kennedy found that the total stand-by losses can be reduced in some cases to 8 per cent. of the total fuel; below this he had not yet succeeded in going, and he thought it was often considerably more than 10 per cent. He was of opinion that the greater waste of fuel occurred beyond the boilers, as it is more easy to get a good evaporation per pound of coal than a small consumption of water per indicated horse-power. Heavy causes of loss are by the condensation in steam pipes and by leakage. These are probably greater in electric light stations than in most other places, because security requires the use of a very elaborate system of steam pipes. Of steam traps Prof. Kennedy has not much that is favourable to say; he refers to them as the "apparatus which we call by courtesy steam traps," and says they require more looking after than the whole of the rest of the machinery put together. He thought also that sufficient attention is not paid to the proper covering of the pipes, including their flanges. He thought the use of super-heated steam might be found very largely to reduce this particular cause of waste. The cost of oil, water, and stores he puts down as averaging about one-fifth the cost of coal alone. Discussing the losses between the indicated horse-power developed and the records of the consumers' metres, the President said that the loss in the engine itself might be taken as about 10 per cent. of the full power of the engine, and remained very nearly constant at all powers so long as the speed was constant. The efficiency of the dynamo at full load might be as much as 95 per cent., so that the ratio of electrical indicated horse-power of a first-class steam-engine and dynamo might be 85 per cent. at full load, whilst at half load it would be about 76 per cent. This was assuming that the engine drove the dynamo direct, and he considered that direct driving with equal running engines was the proper method of proceeding. The losses between the dynamo terminals and the consumers' lamps in a low tension system are simply losses in the leads; in a high tension system they cover the losses in general, which are much smaller in the leads and in the transformers as well. Prof. Kennedy did not consider it desirable, however, to enter into a discussion on the respective merits of the two systems, but stated that as far as the figures to which he had access were concerned, he found that in the case of a low tension system where the maximum proportion of loss in the feeders is allowed to reach 20 per cent. or thereabouts, the actual average loss of energy throughout the whole year amounts to about 10 per cent. This was of course entirely due to ohmic resistance of the feeders themselves and of the network. He had no corresponding figures for the alternating current system, but he had reason to believe the total losses both in mains and transformers in the high tension system are not less than 25 per cent. the energy generated, but he thought it certain that this figure will be very considerably reduced in cases where banked transformers are employed with low tension distributing mains. In any case, however, he hardly thought that it could be expected that the total losses would ever be so low as with the low tension system.

In conclusion Prof. Kennedy referred to the ease and accuracy with which electrical measurements may be made with continuous currents, a fact which he thought had helped very much in the extremely rapid progress made during the last few years in matters electrical. In the case of the Westminster Electric Supply Corporation, the unaccounted for quantity as between the energy developed at the dynamo terminals and the readings of the metres of consumers has been reduced to 1·8 per cent. Unfortunately alternating current measurements are much more difficult and troublesome, and Prof. Kennedy thought that the fact had, to a certain extent, hindered their adoption. There were, however, he considered alternating current watt-metres practically free from error due to circuit induction and capable of giving results with quite sufficient accuracy under the actual conditions of station practice. He believed that very great improvements in the economy of alternating current working will date in every case from the time when the station commences to make accurate determinations of the true energy generated and the way in which it has been expended.

At the conclusion of the address a vote of thanks was proposed by Sir Frederick Bramwell, as the Senior Past President, and seconded by Dr. William Anderson, the Junior Past President. It was carried by acclamation, and responded to by Prof. Kennedy in a short speech.

The next business was the reading of a paper by Mr. Edward W. Anderson, of Erith, in which was described the Grafton high speed steam-engine. The design of this novel engine was illustrated by many large cartoons hung upon the wall of the theatre. As we have said, without the aid of illustrations we can only hope to give a general idea of the design of this engine. It consists, firstly, of a foundation casting, the engine being of the vertical type. Upon this casting is erected a second, forming a standard and also a cover for the whole mechanism, the engine being of the enclosed type and the crank shaft running in an oil bath, upon the system common with single-acting engines of this type. The upper casting has a cylinder formed in it by means of two loose liners, one placed in from each end till the liners nearly meet; the space thus left between them forms the admission port, and, as its width is the circumference of the cylinder bore, its length is only required to be very small in order to get a large area of opening. Communication with the steam pipe is effected through an external annular channel in the casting directly surrounding the space between the two liners or admission port. At a little distance from the steam port the upper liner has a circle of holes drilled through it, which holes open into a similar external annular channel connected with the exhaust branch. The liners are open at both their ends, forming a cylinder, without covers, in which two cast-iron pistons reciprocate. The lower of these is an ordinary trunk piston and has a connecting-rod attached working upon the centre throw of the crank shaft below. The upper piston serves both for a piston and for a valve. It is essentially a short cylinder having a strong diaphragm across the middle of its length, and just below the diaphragm a circle of holes is cut through the rim of the piston, and these holes communicate, therefore, with the space between the two pistons. The diaphragm in the upper piston has a hemispherical recess; this receives the steel ball attached to the crosshead. The latter spans the cylinder and acts on the two outer throws of the crank shaft by means of a return connecting rod attached to each end. The advantages claimed for this engine are:—That the waste spaces to be filled by steam are reduced to a minimum, as the steam is cut off close to the bore of the cylinder, and the long steam passages between the cylinder and the slide valve are done away with; the weight of the piston and that of the piston-valve, instead of being wholly unbalanced, act in the same line and for the most part in opposite directions so as nearly to balance each other, the result being that the unbalanced moment is small. The valve, instead of having a moving part that is idle as regards the transmission of power, performs the same function as an ordinary piston in rotating the crank shaft. The friction of the valve is also no greater than that of an ordinary piston valve of the same dimensions and stroke. The engine described was single-acting and non-compound, but the author said there was no reason why a combination of engines ranged side by side should not be made to work compound if desired. An experiment carried out on a 12-inch engine, working with an initial pressure of 100 lbs. per square inch at 603½ revolutions per minute, indicating a mean of 36·77 horse-power, gave a consumption of 28·2 lbs. of feed water per indicated horse-power per hour.

A discussion followed the reading of the paper. The general opinion appeared to be that the invention was one of great ingenuity, but no fresh points of importance were brought forward.

Mr. Joy, in his paper, dealt with the hydraulic reversing gear, which he described in his paper read before the recent meeting of the Institution of Naval Architects, and which we referred to in our report of that meeting in our issue of March 22.

The summer meeting will be held in Manchester during the first week in August.

WHAT ARE ZOOLOGICAL REGIONS?[1]

THE subject which I now propose to discuss, is the purport and use, and therefore the essential nature, of what are termed zoological regions. This seems necessary because, although such regions have been more or less generally adopted for more than thirty years, there has of late grown up a conception as to their nature and purport which seems to me to be altogether erroneous, and which, if generally adopted, is calcu-

[1] A paper read at the 500th meeting of the Cambridge Natural Science Club, March 12, by Dr. A. R. Wallace, F.R.S.

lated to lead to confusion, and to minimise, if not to destroy, whatever advantages may be derived from their use.

The time has therefore come when this question must be discussed and, if possible, settled, and, in the hope of leading to such a settlement, I propose to point out what seem to me to be the essential characteristics of such regions, considering them to be established for the purpose of facilitating the study of geographical distribution as one phase of the problem of evolution. In order to come at once to the question at issue, I will first summarise the statements or assumptions which seem to me to imply a misconception of the nature and uses of zoological regions. These fall under two heads:—

(1) It is asserted that the same regions will not answer to show the distribution of all groups of land animals. Some of the classes, or orders, or sometimes even the families, require us to establish different sets of regions—regions which may differ both as to their number and their limits—in order to represent and study the distribution of such groups.

(2) As a guide to what constitutes a region, it is laid down that areas which have few peculiarities in the higher groups—such as families, even though of continental extent, rich and varied in genera and species, and having a large number of peculiar types, are not of regional status. The criterion of a region is said to be the exclusive possession of peculiar groups of higher rank than genera; and this without any regard to proportionate area, or to the poverty and monotony of the fauna as a whole.

Now the first of these assumptions—that the same set of regions will not serve for the study of the distribution of all animals—raises the whole question of the nature and practical utility of zoological regions, and is a proposition which the chief purpose of this article is to disprove: it must therefore be considered in some detail.

In the first place, it implies that the students of any particular group—reptiles, beetles, butterflies, land shells, &c.—should each mark out the globe into regions exhibiting the chief features of the distribution of its families, genera, and species, and that any other division, arrived at by the study of other groups, will be of little or no use to them. But if this is true, it must be carried further; for not only do the various classes and orders of animals differ considerably in their distribution, but many of the tribes and families. To take the case of the mammalia, which, for distributional study, has always been treated as a whole, how different is the distribution of the Edentata from that of the Ungulata. In the former group South America is so rich that it is of more importance than all the rest of the globe, while in the latter it is so poor that even when joined with North America it would hardly equal either of the other continental regions in importance. But if we constructed a set of regions to correspond with the distribution of each of these orders, we should not bring out the facts more clearly than can be done by means of the regions most usually adopted for the whole class, while we should lose the advantage of easy comparison with each other, and with the remaining orders of the class, as well as with other classes of animals. But *comparative* distribution is the one essential feature of our study, without facilities for which the bare facts are uninstructive and of hardly any scientific value.

This point has been very clearly brought out in the case of birds, in a work specially devoted to the geographical distribution of one family—the plovers. These birds are, as a whole, cosmopolitan, so much so that Mr. Seebohm tells us "they have not even a remote connection" with the usually adopted zoological regions; and he adds: "These birds only recognise three regions—Arctic, Temperate, and Tropical." Again, after describing the distribution of the chief genera during the breeding season, he says: "The inevitable conclusion is that the Charadriadæ *do* pay considerable attention to the climatic or isothermal regions, but appear practically to ignore the Sclaterian regions."

These very positive statements would lead a reader to conclude that here, at all events, the regions established by Dr. Sclater for birds as a whole are of no use. Yet we find that in the great work above referred to—the "Geographical Distribution of the Charadriadæ"—Mr. Seebohm rarely uses these three climatal regions, but throughout the book gives the distribution of the species of each genus in terms of the six Sclaterian regions. And if we consider the habits of these birds, so many of which get their food on sea-shores and tidal estuaries, while all of them have great powers of flight, and many of them migrate along the coasts of all the continents, it is really surprising to find so many of the genera and species which are nevertheless strictly limited to certain of the Sclaterian regions. Owing, no doubt, to the peculiarities of habit just referred to, about half the genera are cosmopolitan, being found in all the six regions during some part of the year; but, even of these, certain groups of species are often confined to one or two regions.

When we turn to the non-cosmopolitan genera, however, we find some very instructive facts, which well serve to illustrate my main contention as to the sufficiency of one set of regions. The following table gives the distribution of these genera, taken from Mr. Seebohm's volume:—

Ædicnemus (Stone Curlews)	All regions except the Nearctic.
Lobivanellus (Wattled Lapwings)	All regions except the Nearctic and Neotropical.
Vanellus (Lapwings)	All regions except the Nearctic and Australian.
Cursorius (Coursers)	Palæarctic, Oriental, and Ethiopian regions.
Glareola (Pratincoles)	All regions except the Nearctic and Neotropical.
Ibidorhynchus (Ibis-billed Oyster-catcher)	Palæarctic only.
Phalaropus (Phalaropes) ...	Palæarctic and Nearctic, migrating or straggling into most of the other regions.
Limosa (Godwits)	All regions except the Ethiopian.
Ereunetes (Snipe-billed Sandpipers)	Palæarctic and Nearctic.
Phegornis (Short-winged Sandpipers)	Australian and Neotropical
Rhynchæa (Painted Snipes)...	The four Tropical regions.

Now we have here to notice two points:

(1) That in most of these genera not only are they absent from one or more of the Sclaterian regions and present in others, but in the regions where they do occur they are usually widely dispersed, thus showing that their range is defined and limited by the very same barriers which so well mark out the general range of land birds.

(2) We also find that the use of the old-established and widely accepted six regions of Dr. Sclater, enables us very clearly and concisely to describe or to tabulate the comparative distribution of the genera and species of this great family of wading birds, which have been thought to be such erratic wanderers that the author of a work devoted to them declares that—"the zoological regions of Sclater have nothing whatever to do" with them.

Now this case of the plovers is perhaps as strong as any that can be brought to prove that different groups require different sets of regions; and it at once brings us to the question at issue, which is, whether anything would be gained by establishing a set of Charadriine regions. The climatic regions—which Mr. Seebohm suggests as more natural in this case—would not bring out such facts as the absence of Ædicnemus from the Nearctic and of Limosa from the Ethiopian regions; the limitation of Glareola to the eastern hemisphere, and of Phegornis to the Australian and Neotropical regions, unless the Sclaterian regions were also used as sub-regions—thus introducing complication in place of simplicity, and gaining, so far as I can see, no advantage whatever.

But further, if the plovers are to have their own regions and sub-regions, there are probably 50 or 100 of the orders and families of the animal kingdom which would equally require to be so treated; and as in all these cases the new regions must have separate names, it is quite clear that by far the larger part of them would remain for ever unknown, except to their inventors.

A little consideration will, I think, convince us that this plan, of practically unlimited distinct sets of regions, would be a positive hindrance to any intelligent study of the distribution of animals, a study which derives its chief interest and importance from its relation to the theory of organic evolution, and which must therefore include the *comparative distribution* of the various classes, orders, and minor groups. But how will it be possible to make the necessary comparison if the distribution of the groups to be compared is given in terms of as many distinct sets of regions all differing in their names and in their boundaries? It would be like comparing the structures of different animals as described in the works of a number of anatomists each of whom had a different classification and a different set of technical terms, so that before a single comparison could be made the terms used in one description would have to be translated into the terms used in the other. In the study of geographical distribution, should this system prevail, the student would find it necessary to adopt some one set of regions for his own use, and then endeavour to translate the facts given by each specialist into terms of that set before he could obtain any clear conception or accurate knowledge of their comparative distribution.

An idea seems to be prevalent among biologists that there is some *law* of distribution, that may differ for different groups, and that may require different regions to exhibit it or to conform to it. This, however, is a mere supposition; but, if it is a correct one, we shall certainly not be likely to discover the "law" by recording the facts of distribution in such a way as to render a *comparative* study of them as difficult as possible. Laws of distribution can only be arrived at by comparative study of the different groups of animals, and for this study we require a common system of regions and a common nomenclature.

It appears to me, however, that the "law," or at all events the general principles on which the diversities of distribution among land animals depend, is already fairly well understood. What we require is to be able to work out the details in the different groups, and thus explain certain difficulties or anomalies. To detect anomalies it is essential to compare the distribution of the different groups by means of a common system of regions. If we construct regions to fit each group, the student of each separate group will be apt to forget that it presents any anomalies which require explanation

Before leaving this part of the subject it may be well to give a short account of the reasons which led to the original establishment of the six Sclaterian regions for the purpose of facilitating the study of the geographical distribution of animals; in order to show that they are not arbitrary divisions, but are founded on a large body of observations. It is evident, in the first place, that many of the ordinary divisions of the geographer serve well to define the areas characterised by special groups of animals or plants. The South European, the Malayan, the Brazilian, or the South African faunas and floras, are constantly referred to, because those districts are really characterised by distinct assemblages of animals and plants, and this undoubtedly depends partly on their possessing peculiarities of climate resulting in peculiarities of vegetation—as forest, prairie, desert, or woodland; partly in their being limited by more or less effective barriers, climatic or geographical; and partly on their past geological history and on the more recent changes of physical geography they have undergone. But such areas as these are too small and too numerous to enable us to express the broader features of the distribution of animals, and the larger or primary geographical divisions—which were those used by the older naturalists—are often unsuitable and misleading, because they are *not* coincident in their boundaries with those more permanent natural barriers which have mainly determined the zoological specialities of different parts of the globe. Yet some of the divisions of the geographer are such well-defined and ancient areas that they *do* nearly coincide with characteristic assemblages of animals; and thus the geographical units, Europe, Asia, Africa, North America, South America, and Australia, can be easily modified into six zoological regions, which do represent with considerable accuracy the broad features of animal distribution. These modifications may be briefly enumerated in order to show how the limits of the regions have been arrived at.

Beginning with Europe, we see at once that it is zoologically homogeneous, since a large proportion of the species and all the larger genera range over the whole of it. But the same genera, in the case of the higher animals, at all events, prevail in North Africa, mingled only with a few desert types, and we therefore, for zoological purposes, add this area to Europe. It is interesting to note that we have a clear explanation of this identity, in the proofs that quite recently — that is, during the Pleistocene period—Europe and North Africa were connected both at Gibraltar, and from Sicily and Malta to Tripoli, as indicated both by submarine banks which still unite them, and by the fossil hippopotami and elephants of the Maltese, Sicilian, and Gibraltan caverns. But further, if we go eastward from Europe into Siberia and Central Asia, we find the same genera and many of the same species of mammals and birds ranging all the way to the shores of the Pacific. To such an extent is this the case that about fifty-six species of British passerine birds range to Central and North-East Asia, while no less than fifty-three species (or representative subspecies) of land-birds are common to Great Britain and Japan. Europe and North Asia are therefore parts of one zoological region, the reason being that there is not, nor has been in recent geological times, any effective barrier between them, while in climate they are sufficiently alike.

Here, then, we have roughly marked out our first great zoological region—the Palæarctic, or northern old-world region. Southward its limits are undefined, and where there are no well-marked barriers, such as the Himalayas or the desert, there will always be a greater or less width of border-land between two conterminous regions.

Now this Palæarctic region is, fortunately, the only one that differs very largely from the ordinary geographical quarters or divisions of the globe. For when we go to Africa we find that, leaving out the northern portion, which we have seen to be essentially European, the remainder constitutes a very distinct and compact area zoologically—the land of giraffes, zebras, hippopotami, baboons, and antelopes—which has been termed the Ethiopian region. Then we have southern or tropical Asia, together with the larger Malay Islands, which we know must recently have formed a part of it, constituting the Indian or Oriental region, and corresponding almost exactly with tropical Asia. Then we come to Australia, which forms the nucleus of another well-marked region, including with it, however, most of the Pacific Islands, with New Guinea and the Moluccas. Turning now to the western hemisphere, we have South America and North America, which, with slight modifications, form two well-defined regions—the Neotropical, including all South America with the tropical portion of North America and the West Indian Islands; the Nearctic, comprising the remainder of North America.

Now, I do not think that any one has denied that these are truly natural divisions of the earth from a broad zoological point of view. The controversy respecting them has turned wholly on whether they are of equal rank. This point, however, will be referred to later on. We are now dealing with the question of the need of other modes of dividing the earth's surface in order to exhibit and to study the distribution of certain groups of animals. I have already urged that to do so would defeat the very object aimed at, and render the study of geographical distribution very much more difficult. I have shown how readily the Sclaterian regions enable us to describe or tabulate the distribution even of a group which has been said to "pay no attention to them whatever"; and I have now just pointed out that these six regions are, admittedly, natural, which can only be because during the more recent geological periods they have formed single more or less continuous areas, while separated either by geographical, climatal, or biological barriers from the adjacent areas.

Now the only real interest of the study of geographical distribution lies in its giving us a clue to the causes which have brought about the very divergent and often conflicting distribution of the various species, genera and higher groups, and by thus being able to explain most of the anomalies of distribution. These causes we can trace, in many cases, either to geographical or climatal changes in the past, which temporarily removed the barriers that now exist or interposed others that are now absent; or, on the other hand, to the recent extinction of groups in certain regions where they formerly abounded; or, again, to the very different powers of dispersal possessed by different organisms, which enable some groups to spread easily where others are stopped by an insurmountable barrier. Now it is usually this last phenomenon, of varying powers of dispersal, that has led the students of certain groups to urge that the old-established regions do not serve their purpose. But when a group can more or less easily traverse the barrier between two regions, however permanent that barrier may be, the fact enables us to explain the exceptional distribution of that group, but it does not render the established regions less natural, or require a fresh set of regions, which would certainly not be natural in any broad sense, to explain them.

Again, it will usually, perhaps always, be found that even in the groups appealed to as requiring a new set of regions, a portion of the species, and even of the genera, are limited to the older regions. I have already shown that this is the case with the almost cosmopolitan plovers, and it also occurs in another instance where it has been very strongly urged that the Sclaterian regions will not apply. I allude to the distribution of insects in the Oriental and Australian portions of the Malay Archipelago. Here, in the case of birds and mammals, there is a most abrupt and striking change on passing from Borneo and Java to the Moluccas and New Guinea; but in insects this is not conspicuously the case, and it has been said that the whole Archipelago, from Sumatra to New Guinea, and even to the Solomon Islands, is characterised by one uniform insect-fauna. This, however, is by no means a correct statement. There are undoubtedly many genera common to the whole Archipelago, as might be expected from the great similarity of climate and the uniformly forest-clad nature of the islands, together with the power of crossing narrow seas possessed by all winged insects. Yet, both among butterflies and beetles, especially the latter, there are a considerable number of genera confined respectively to the Indo-Malayan and Austro-Malayan divisions of the Archipelago, giving to the fauna of each a characteristic facies.

Now if we adopt for insects, as has been proposed, a single Malayan region including the whole of the Archipelago, we should be apt to lose sight of the two distinct elements it contains, the one due to an ancestral diversity corresponding to that which still exists in all the higher animals, the other dependent on a comparatively recent process of intermigration between the two portions of what are fundamentally distinct insect faunas; while it is not clear what corresponding advantage would be obtained by the student of geographical distribution.

From the point of view I have now endeavoured to set forth, we may, I think, draw the conclusion that the six Sclaterian regions are natural zoological divisions, because they are separated by barriers of considerable antiquity and permanence, which have led to their being characterised each by well-marked assemblages of the higher animals. Further, when groups of organisms which from their exceptional powers of dispersal, or from any other cause, have been able to extend themselves beyond these barriers, that is no reason whatever for establishing new regions—which would *not* be marked out by equally important barriers—since the divergencies in the distribution of the various classes or orders, as exhibited by means of a common series of regions, is one of those interesting problems of distribution which can only be solved by comparative study. Not only, therefore, is one set of regions all that is required to exhibit the distribution of the various terrestrial organisms; but, for all purposes of comparative study it is immeasurably superior to the establishment of numerous sets of special regions, constructed so as to accord with the distribution of special animal groups.

We now come to the second objection—the supposed inequality of the six Sclaterian regions. Some of them are said to be really only sub-regions, while others are said to be so diverse as to be rendered more equal if divided into two regions.

This question of equality is decided almost exclusively by one characteristic, and one that seems to me to be not the most important for the purpose we have in view. This character is the possession of peculiar groups of the rank of family or order, taking no account either of the richness and variety of life-development, or of the geographical extent of the area in question. From this point of view Australia is sometimes said to be equal to all the rest of the world, both on account of its rich development of the marsupial order, but especially because in the duck-bill and spiny ant-eater it possesses a distinct sub-class of mammals. From another point of view, however, Australia, Africa, and South America are united in one primary region, because they alone possess one of the sub-classes of birds—the Ratitæ.

New Zealand and Madagascar have each been proposed as regions, the first on account of its Apteryx and moas, with its isolated lizard-like Hatteria; the second for its peculiar families of Lemurs and Insectivora, and equally peculiar families and genera of birds. In contrast with these, we have the proposal to unite the rich and extensive Palæarctic and Nearctic regions to form one region only, because they do not possess a sufficient number of peculiar families and genera of mammals and birds, although the new region thus constituted is perhaps twenty times as rich as New Zealand in varied forms of life.

Those who adopt these views appear to me to attach a very exaggerated importance to the possession by a limited area of some remnant of an otherwise extinct group, which has been preserved owing to its long-continued isolation in a district where it has been secure from the competition of higher forms—almost always, therefore, in an island. Such survivals are exceedingly interesting; but I cannot see what they have to do with the division of the whole land-area of the globe into zoological regions, whose sole purport and use is to facilitate the study of the geographical distribution of all land animals.

The conception of zoological regions expressed in the views I am now combating seems to me to be altogether erroneous, and to lead to results which are neither useful nor instructive, and far less natural than that which takes account of a variety of characters as the best guides to an approximate equality. I urge, therefore, that zoological regions, to be at once natural and useful in the highest degree, must be founded on a combination of essential features, as follows:—

(1) They should be founded upon, and approximate to, the great primary geographical divisions of the earth, which there is reason to believe have been permanent during considerable geological periods.

(2) They should be rich and varied in *all* the main types of animal life.

(3) They should possess great individuality; whether exhibited by the *possession* of numerous peculiar species, genera, or families, or by the entire *absence* of genera or families which are abundant and widespread in some of the adjacent regions.

Tested by these conditions the six Sclaterian regions seem all that can be desired—subject of course to modification in details. If we make some allowance for the inevitable poverty of the temperate as compared with the tropical regions—due both to present and to past conditions of climate—they present a greater amount of equality than might be expected. The Neotropical region is somewhat the richest—very much the richest in birds and insects—and this may be traced to its possessing so enormous an area of tropical forest-clad land, together with the greatest of the mountain ranges situated wholly within the tropics—the Andes, and two other isolated mountain groups of great extent and antiquity in Brazil and Guiana; while the Nearctic is the poorest—due perhaps to its rather limited area, its large extent of arid lands, but more especially to its extreme climate, a severe winter prevailing to considerably south of the parallel of 40° N. Latitude.

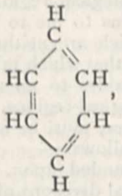
The subdivisions of the primary regions is far less important; and with the same facts before them, naturalists arrive at different conclusions. I would suggest, therefore, that for the present, at all events, no definite named subdivisions should be attempted, but that the continental portion of each region be subdivided by the use of the terms north, south, east, west, and central, with their combinations where required. By the use of these terms the range of a genus or species within the regions may be defined with sufficient accuracy, and in a manner at once intelligible to every student.

The conclusions to which this discussion has led us may now be briefly summarised as follows: Zoological regions are those primary divisions of the earth's surface of approximately continental extent, which are characterised by distinct assemblages of animal types. Though strictly natural, in the sense already pointed out, they have no absolute character as equal independent existences, since they may have been different in past ages, but are more or less conventional, being established solely for the purpose of facilitating the study of the existing geographical distribution of animals in its bearing on the theory of evolution. There is thus, in my opinion, no question of who is *right* and who is *wrong* in the naming and grouping of these regions, or of determining what are the *true* primary regions. All proposed regions are, from some points of view, natural, but the whole question of their grouping and nomenclature is one of convenience and of utility in relation to the object aimed at.

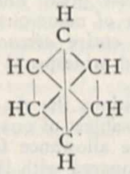
It is because I think that the future progress of a branch of biological study in which I take great interest will depend on our arriving at some uniformity of view as to this question of zoological regions, that I have devoted so much space to its discussion.

FURTHER LIGHT UPON THE NATURE OF THE BENZENE NUCLEUS.

AN important memoir, containing an admirable compendium of the data now accumulated bearing upon the much-discussed question of the nature of the fundamental hydrocarbon of the aromatic compounds, together with the results of new spectrometric observations of great value, is contributed to the current issue of the *Journal für praktische Chemie*, by Prof. J. W. Brühl, of Heidelberg. The main question now at issue is whether benzene is best represented by the well-known structural formula of Kekulé,



in which the carbon atoms are linked together by alternate double and single linkages, or by a formula in which there are no double linkages, and each carbon atom is attached to three others, the three extra linkages being diagonal,



a view which has latterly received some support at the hands of Prof. von Baeyer. A full discussion of the valuable experimental work of the latter chemist is given, together with the thermochemical work of Thomsen, Dieffenbach, Horstmann and Stohmann.

Prof. Brühl has recently determined the specific gravities and optical constants of the three compounds benzene dihydride C_6H_8, benzene tetrahydride C_6H_{10}, and benzene hexahydride C_6H_{12}, the two former of which were prepared some time ago by Prof. von Baeyer, together with those of hexylene. There have now been fully investigated as regards the spectrometric constants eight compounds which are so closely related as to enable most important deductions to be derived from their comparison. These compounds are: benzene itself C_6H_6, benzene dihydride C_6H_8, benzene tetrahydride C_6H_{10}, benzene hexahydride C_6H_{12}, hexane C_6H_{14}, hexylene C_6H_{12}, diallyl C_6H_{10}, and dipropargyl C_6H_6. The second, third, and fourth are the graduated products of the addition of hydrogen to benzene, two atoms at a time; the fifth, hexane, is the open chain six carbon paraffin, hexylene the six carbon olefine with one double linkage, diallyl the six carbon fatty compound containing two double linkages, and dipropargyl the six carbon compound containing two acetylene triple linkages.

Upon comparing the specific gravities at 20° of these eight compounds it is observed that the density steadily decreases from benzene to benzene hexahydride; there is then a sudden large fall upon the disruption of the ring and formation of the open chain compound hexane. The density then slightly increases through hexylene and diallyl, and again a sudden break of continuity, a large rise, occurs upon the passage to the acetylene derivative dipropargyl. Still more striking are the changes exhibited by the molecular volumes. There is an exceptionally large rise of twenty-three units between benzene hexahydride and hexane, and a similar large decrease between diallyl and dipropargyl. Passing to the molecular refraction, it is observed that upon the graduated addition of hydrogen to benzene, this constant becomes gradually larger as far as the hexahydride, then there is a great leap upon the breaking of the ring and production of hexane. Similarly as the hydrogen is again removed step by step a continuous decrease occurs until diallyl is reached, when upon removal of $2H_2$ and formation of dipropargyl, the two ethylene groups being changed into acetylene radicles, the molecular refraction falls precipitately.

The whole of these physical properties thus exhibit a break of continuity on passing from benzene hexahydride to hexane, that is upon the opening of the ring into a straight chain, and also when the ethylene derivatives are converted into derivatives of acetylene. Moreover, if the isomers among these eight compounds are compared, benzene with dipropargyl, benzene tetrahydride with diallyl, and benzene hexahydride with hexylene, it is found that the physical constants differ very materially. From these considerations Prof. Brühl concludes that the Kekulé structural formula is most in accordance with the facts.

In addition to the above new observations, the spectrometric constants of the ethyl ester of phthalic acid have been determined. Prof. von Baeyer considered that he had proved that phthalic acid cannot be constituted according to Kekulé's conception of the aromatic nucleus, but that a nucleus with three diagonal single linkages must be present. Upon comparing, however, the observed molecular refraction and dispersion of the ethyl ester with the values for these constants calculated upon the assumptions of the two hypotheses, they are found to correspond closely with those demanded by the Kekulé structural formula, and are very far removed from those calculated upon the basis of three diagonal linkages.

Prof. Brühl considers it to be well founded that in benzene tetrahydride and in hexylene there is one ethylenic double linkage, and that in benzene dihydride and in diallyl there are two such linkages. Now the continuity in the entire physical properties as hydrogen is removed step by step from hexane to diallyl on the one hand, and from benzene hexahydride to benzene itself upon the other, points conclusively to a continuity in the nature of the alteration of the constitution in both series. Benzene must therefore, according to Prof. Brühl, likewise contain ethylenic double linkages, three in number, if benzene dihydride contains two such linkages and the tetrahydride one. The view that three effective diagonal linkages, or, as has recently been surmised by certain chemists, three central potential linkages, can bring about in benzene the same physical action as three ethylenic bonds, appears to Prof. Brühl to be out of the question. He shows, moreover, that the values for the whole of the eight substances agree most remarkably with the numbers calculated upon the basis of the Kekulé formula, and further, that the thermodynamical data all point to the same conclusion.

The relation of the atoms to one another in the benzene nucleus is not, however, ideally expressed by Kekulé's structural formula. This can only be achieved by a spacial representation. The happiest conception of the spacial configuration of benzene, according to Prof. Brühl, is that of Sachse. This model is constructed by taking a cardboard octahedron, removing two parallel sides, and upon each of the six remaining ones placing a regular tetrahedron. The six tetrahedra represent the six carbon atoms, and the hydrogen atoms are supposed to be attached at the six apices. The six carbon atoms then lie in two parallel planes, as do likewise the six hydrogen atoms. The properties of such an arrangement would be such as accord with the observed facts. The gradual addition of hydrogen would cause a regular and continuous movement of the tetrahedra, corresponding with the observed continuity in physical properties. The best representation of this model in one plane is the structural formula of Kekulé.

A. E. TUTTON.

THE FACE OF THE EARTH.[1]

AT the present time we all acknowledge the value of the accepted classification of the relief-forms of the earth's surface in continents and islands, mountain chains, plateaus, plains, &c.; into ocean-basins, seas, lakes, and the like. But few of us ask ourselves the very natural questions, "What is the fundamental unit among all these morphological individuals, great and small? Is there any surface unit existent among them which, like the species of the biologist, once identified, will not only be found to group its individuals rank over rank into the genera, the families, the orders, and the kingdoms of the surface world; but the study of whose life-history and necessary interactions with its fellow-species will eventually afford us some clue to the relationships and the natural classification of the whole?"

This aspect of the subject perhaps excepted, there is probably no theory possible upon the matter of the grouping of the forms of the earth's surface which has not, either as a whole or in part,

[1] A aper read by Prof. Chas. Lapworth, F.R.S., at the Royal Geographical Society, on April 23.

been already suggested by one investigator or another. In the speculative parts of the subject, the names of Werner, Hutton, De Beaumont, Humboldt, Guyot, Lyell, and Peschel stand conspicuous amongst past investigators; and, among those of the present day, Le Conte, Dana, Crosby, Dutton, and Gilbert in America; Heim, Suess, Penck, and Reyer in Germany; Réclus, De Lapparent, and Bertrand in France; and the Geikies, Wallace, Murray, Fisher, Reade, and Mill in Britain.

Turning first to the general disposition of the recognisable parts of the terraqueous surface of the globe, the author passed in review a few of the fundamental facts and conclusions worked out by students of the subject, and showed that it had long since been acknowledged that between all the grander forms of the earth's surface there existed a curious correspondence of shape and of size, combined with a mysterious contrast of geographical arrangements or disposition. Next it was discovered that among the minor elements of surface form, the study of geographical homologies showed us that all the recognisable forms of a higher order discernible upon the earth's surface are made up of a kind of rhythmic repetition of forms of a lower order possessing in miniature the characteristics of the major forms. These conclusions had been practically arrived at by the students of the relief of the globe previous to the recent discoveries of the *Challenger* and other exploring expeditions, but the result of these deep-sea researches were so strange and so unexpected as almost to dwarf, for the time, these earlier ideas into insignificance.

Deep-sea researches showed that former ideas of the similarity of size and form between the surfaces of the land and water areas as such must be relinquished. For the mean height of the land was found to be only one-sixth of the mean depth of the ocean; and the entire volume of the solid lands above the level of the sea was discovered to be only one-fourteenth of the volume of the ocean waters below that level. Further, what was far more startling and far more important, it was found that the shore-lines of the visible continents by no means mark the true edges of the great ocean-basins; the dry lands were ascertained to be merely the undrowned portions of one universal continental plateau, the surface of which sinks at first very gently from the shore-line through a shallow water area many miles across, and then plunges rapidly downwards in a sudden slope to the true or abyssal floor of the ocean. This spreads out as a broad undulating plain some twelve thousand feet and more below the sea-level, and descends even still deeper locally in magnificent lake-like hollows to depths of from twenty thousand to thirty thousand feet. These results gave us for the first time a map of the forms of a region of the earth's surface at least twice as large as that of the whole of the dry lands united together. Nothing so important, from a geographical point of view, has been accomplished since the days of Columbus. It is the discovery of a new world. But in this new world it is plain that if the deductions of the earlier students of the earth's surface are of any value whatever, they must prove to be equally natural and inevitable.

Leaving the discussion of these deep-sea discoveries for a while, the author next summarised the fundamental conclusions arrived at by the geologist. The geologist has discovered that in all dry lands of the earth which he has hitherto investigated in detail, the local surface of the country is composed of the outcropping edges of solid rock-sheets known as the "geological formations." These formations show distinctly, by their composition and by the relics of marine life which they contain, that they were originally laid down as layers of gravel, sand, and mud upon the floor of the sea. In other words, the surface of every geological formation must have constituted, at the date when it was deposited, an integral portion of the submarine relief of the earth's surface of its time. But while it is clear that these formations were laid down below the sea-level and in an approximately horizontal position, they are now found, wherever we can examine them upon the dry lands, usually far above that sea-level; and, instead of being horizontal, the surface of each formation is now found to be typically warped into great undulations like the surface of a folded cloth, or that of a rolling sea.

The undulations or wave-like forms of the surfaces of the geological formations are of all degrees of importance, the smaller waves riding on the backs of the larger ones, like ripples on the backs of the sea-waves. But in spite of the extreme complexity of this arrangement, it is comparatively easy of study, for we find the whole to be made up of endless repetitions of one and the same fundamental unit—namely, an undulation or wave-like form; and the study of the characteristics and life-history of one of these typical undulations gives us, within certain limits, the key to those of all the rest.

Each simple geological undulation consists of two parts, an arch-like rise and a trough-like fall, and these two reciprocal elements are most naturally and conveniently united by the geologist under the single title of the "crust-wave" or "geological fold."

This curious wave-like disposition of the surface of any geological formation is apparent, whether we follow that surface, say, from east to west, or whether we follow it from north to south. So that the present surface of a formation is most simply pictured if we regard it as having been bent up into two sets of undulations, the one set crossing the other at right angles.

With this geological result as a guide, the author returned to the investigation of the main features of the earth's surface. It was pointed out that any straight line drawn completely round the globe from west to east over the earth's surface, either along the equator, the tropics, or along any of the neighbouring parallels, shows a more or less regularly alternating elevation and depression of that surface, of the same general type as the undulations of a geological section. Along these parallels we have three successive elevations, the Americas, Eurafrica, and Asia-Australia; and three intermediate depressions, the ocean-basins of the Atlantic, the Indian Ocean, and the Pacific. That is to say, the broad forms of these surface undulations naturally suggest the theory that the exterior parts of the earth-crust are bent into three primary meridional waves ranging practically from pole to pole, each wave consisting of a single rise and a single fall. Again, if the crest of any one of the three meridional continental ridges is followed in a transverse direction, *i.e.* from north to south, it is found that the surface of the crest itself rises and falls in its turn in three successive undulations. For example, in the case of the ridge of the Americas, it is crossed by the three transverse ridges of North America, South America, and the Antarctic continent; and the three transverse depressions of the Arctic Ocean, the Carribbean, and the depression south of Cape Horn.

Thus (precisely as in the case of the surface of a geological formation) the surface of the earth-crust at the present day is most simply regarded as the surface of a continuous sheet which has been warped up by two sets of undulations crossing each other at right angles. But in the case of the earth-surface, the one set ranges parallel with the equator, and the other ranges from pole to pole.

By means of a figure giving the natural disposition of the resultant forms and nodal lines characteristic of the surface of an elastic film warped by two orthogonal and simultaneous sets of undulations, the author showed how the phenomena apparent upon this cross undulated film suggested at a glance, (1) the forms and disposition of the terrestrial continents; (2) the triangular shapes of their extremities; (3) the diagonal treads of their shores; and (4) the courses of the archipelagic lines.

Carrying the method a stage farther, and breaking up each of the major waves symmetrically in a corresponding manner, the author showed how the subordinate forms so obtained now suggested the typical vertical contour of continents, namely a plain bounded by two marginal ridges and that of an ocean-floor, a submerged plain warped up centrally by a submarine elevation. The same correspondence was shown to hold good even in the broadest grouping of the forms, the collective land, and water areas.

After indicating that we have here the hint that the fundamental unit of form of the earth's surface is the *wave* or *fold*, and that the surface-contours of the globe are primarily the resultants of the two sets of undulations into which the outer parts of the earth-crust are warped up, the author pointed out that these results up to this point were reliable only as generalities, but appear at first sight valueless when we descend to particulars, and he next endeavoured to explain how the known minor variations and anomalies might be perhaps accounted for.

Returning to the subject of the geological fold, he showed how the various forms of the geological fold, and even many of the phenomena of its life-history, could be imitated by the lateral compression of flexible sheets of material; and how as the pressure increases the original symmetrical undulation becomes progressively deformed. The fold divides itself ultimately more or less definitely into three parts; the "arch-limb," the "trough-limb," and a central limb of contrary motion, which is known as the "middle limb" or "septum." In the different regions studied by the geologist, the mode in which this middle limb or septum yields varies greatly according as the material which is being folded behaves as if it were elastic, flexible, or rigid; the strata in the septum or middle limb being sometimes sheared, sometimes bent, but in the majority of cases becomes twisted and broken, while the parts of the fold move most easily and rapidly in proportion as the septum approaches the perpendicular.

Illustrating the behaviour of this middle limb or septum by the corresponding behaviour of its representative in tidal waves, wind waves, and waves of the sea, &c., and in flexible and brittle sheets of material, the author pointed out that in all these cases the wave or fold, however much deformed, always consisted in essence of the two reciprocal halves of the arch and the trough; but as it became more compressed, the deformation became more and more concentrated within the middle or septal portion of the fold.

These results not only constitute the key of the geological position, but give us a clue to several of the more remarkable secondary phenomena of the earth's surface, and at the same time afford us a means of grouping together and reducing to fairly natural order many of its supposed anomalies.

From this fresh point of view we now regard the undulations of the earth's surface not only as wave-forms, and consequently each made up of two reciprocal and balanced elements, the one positive and the other negative, but we also look upon them as folds of various degrees of development, all undergoing a progressive deformation.

The recognisable amount of this deformation in any surface fold affords us a rough index of that especial stage in its life-history which the fold has attained; and such a fold should present the phenomena characteristic of a typical geological fold at that special stage of its development.

The counterbalance or dissymmetry of the positive and negative parts of the narrower and more continuous earth-folds is well illustrated in the case of the great western marginal ridge of the Americas. The crest of the Rocky Mountain-Andes plateau is the longest, straightest, and most continuous ridge on the face of the globe; and it is bordered throughout, as it should be, by its natural reciprocal—the Eastern Pacific depression or trough, which is correspondingly long, deep, straight, and continuous; and the two together constitute a single crust-fold.

Where, on the other hand, the component crests of the great compound earth-ridges are short, irregular, and confused, the reciprocal compound depressions are correspondingly short and irregular; as, for example, the compound arch of the Alpine ranges, when compared with its compound reciprocal, the Mediterranean troughs.

The same balance of parts of the two component halves of every crust-wave is discernible even in those subordinate examples where, as in the cases of the archipelagoes, the entire wave is almost wholly carried under water in the trough of a larger oceanic wave, for the collective island-arch immediately overlooks its reciprocal—a deep groove in the ocean-floor. Again, where, as in the cases of the Alps and the Himalayas, the subordinate wave is lifted on the back of a grander continental arch completely out of water, its necessary reciprocal or depression, which at first glance appears to be presumably absent, is found by the geologist to be tucked in in the form of a buried valley, for miles below the great mountain ridge, which has been forced forward, beyond, and above it.

The same rule holds good even when the collective dry-land areas are regarded as constituting a single arch. Where the marginal septal zone of this continental arch dies down insensibly towards the North Pole, we have the shallow reciprocal basin of the Arctic Ocean; but upon the opposite edge of the arch, where the septal slope rises up steeply and boldly, as along the outer and higher and shattered rim of the continents facing the Pacific and Indian Oceans, the grandly elevated but broken crest, the continental wave looks out immediately, as theoretically it should do, over its negative reciprocal the most greatly depressed and broken parts of the ocean-floor.

In the case of the geological fold, the study of its life-history shows that the region of yielding and fracture is of necessity the middle region or septum, and that the folding movement takes place most swiftly and easily as this septal portion increases in steepness.

These natural phenomena of the fold we also find paralleled in the case of the earth-waves, whether major or minor. The septal areas and lines dividing the two component halves of the great earth-surface folds mark out distinctly the areas and lines of maximum present volcanicity and earthquake movement on the face of the globe. In proportion as the septal slopes are well marked, long, steep, and continuous, or *vice versa*, so the intensity of crust-movement and vulcanicity seem to vary from region to region.

The septal area of the seaward edge of the great Rocky-Mountain-Andes fold is not only the septum of the longest and most continuous crust-fold of the present day, but it actually constitutes the longest and most continuous line of present volcanic and earthquake action. The steep outward septal edge of the collective continental mass of the globe, sweeping from Behring Strait to the East Indies, thence to the Cape of Good Hope and Cape Horn back to Behring Strait, shows from end to end its littoral or submarine volcanoes; while the almost insensible septal edge of the collective continental arch facing the shallow Arctic depressions, shows not a single volcano along the gentle septal declivity for the whole of its extent. In obedience to the same law, surface land marking the steeper edges of all (or, in other words, their septal slopes) of the great mountain plateaus of the Old World, where they face their reciprocals (the deeper plains in front of them), from the Bay of Bengal through the Himalayas, Hindoo Koosh to the Alps and the Mediterranean shores, constitutes the most active and typical zone of continental earthquakes. This rule of septal yielding and movement not only obtains when the great earth-surface waves are regarded in *section*, but also when they are figured in *plan*.

The great compound trough or basin of the Pacific shows all along its septal edge dividing it from its reciprocal or complement, namely, the higher parts of the earth's surface which bound it, an almost complete ring of active volcanoes; and when a projection is made of the entire earth's superficies, having the North Pole as its centre, it is found that this long volcanic band of the Pacific practically divides that surface in two. It is the primary septal band of the earth's superficies, ranging twice from pole to pole.

It was next shown that the minor local surface wrinkles of the earth-crust are not only folds in section, and domes and basins when seen in plan, but that they comport themselves as folds even when regarded laterally or horizontally; the line marking the axes of their crests creeping or flowing horizontally outwards and forwards towards the reciprocal deeps in front. In this way the festoon islands which margin the Pacific, and also the outwardly curving shores of the continents, find an additional explanation.

Finally, it was pointed out that if the theory of the fundamental character and domination of the fold or wave in the forms of the earth's surface be well founded, it must necessarily include the most conspicuous features of the earth's surface-relief regarded as a whole. The existence of this paramount feature was first made known to us by the recent deep-sea researches, which made it evident that the vertical relief of the earth-surface regarded collectively consisted of two members—namely, the so-called Continental Plateau (of which our present lands are merely the unsubmerged portions), and the so-called Abyssal Region, 12,000 feet and more in depth; these two contrasted elements being united normally by a rapid transitional slope, which lies buried from sight, at a depth of from 1000 to 2000 fathoms below the sea-level.

This remarkable phenomenon the author now interpreted as perfectly natural, and indeed inevitable upon the theory of the crust-fold. The Continental Plateau is merely the collective arch (or dome) of the entire relief of the globe, and the Abyssal Region is the collective trough (or basin), while the intermediate slope is merely the natural septal slope common to the two. But, of course, if this view is correct, it follows of necessity, from the characteristics of a fold (1) that the line marking the position of the axial horizontal plane separating the great earth-arch from the great earth-trough must be about midway down this septal slope; (2) the entire area of the surface of the dome must be equal to that of the basin; (3) the collective volume of the dome must be equal to that of the basin; and (4) that wherever the septal slope is fairly straight it must coincide in direction with the nodal lines of the earth's surface.

It was pointed out by the author that it had already been satisfactorily demonstrated by the results of the calculations and researches of Mr. Murray, Dr. H. R. Mill, and others, that all these necessary correlations actually existed, although hitherto some of them had been looked upon as mere curious and inexplicable coincidences.

But if the fold or wave rules in the arrangement of the forms of the earth-surface of the present day, it must of necessity rule also in corresponding planetary surfaces, both in space and time; and the author gave it as his opinion that it afforded an equally natural and plausible explanation of cycles, systems, and transgressions of the geological formations, and of the surface (for example) of the planet Mars.

The final conclusion which the author drew from a consideration of the known facts and phenomena was, that the wave or fold appeared to be the natural unit of classification of all the grander forms of the earth-surface. The recognisable surface undulations of the present earth-surface are, broadly speaking, the surfaces of corresponding waves or warpings of the outer parts of the earth-crust, in part obliterated by erosion, &c., and in part masked by deposition. In the crust-wave, its divisions, modifications, combinations, and intersections, we seem to find the key to the dissymmetries, the harmonies, the contrasts, and even the supposed anomalies of the surface features of the globe. Upon the surface of the earth, the crust-deformation expressible in terms of this unit seems to be the paramount factor. Denudation, deposition, earthquake movement, volcanicity, and even the surface forms and distributions of the main land and water areas, appear to be all subordinated to this ruling element. As the minor undulations stand related to the major undulations as subordinates, it is probable that not the slightest local change can be brought about without disturbing to that extent the balance of parts, and so leading to a readjustment of the equilibrium of the whole. The fold theory, however, affords us merely a natural and convenient means of classification of surface form, and in the meantime does not concern itself with the mode of origin of these forms. It is a theory, not of causes, but of the most natural grouping of effects.

SCIENTIFIC SERIALS.

American Journal of Science, April.—Further studies of the drainage features of the Upper Ohio basin, by T. C. Chamberlin and Frank Leverett. The general view adopted is that of Carll, according to whom the present drainage system of the Upper Ohio basin has been formed by the union of several pre-glacial systems that formerly flowed into what is now the Lake Erie basin. These were blocked up by the ice of the earlier glacial period, which invaded their lower courses and forced them to flow over low divides and unite to form a common south-westward flowing system nearly parallel to the border of the ice. The evidence for reversals and displacements of river beds is given in detail, and four hypotheses are presented to account for them. They all greatly emphasise the importance of the first glacial epoch, and indicate that, while the last glacial invasion was very much more pronounced in its apparent effects, it was, after all, much the smaller factor in the glacial period.—An apparatus to show, simultaneously to several hearers, the blending of the sensations of interrupted tones, by Alfred M. Mayer. A short brass tube is cemented in a hole in the bottom of a glass flask. When the tube is closed the flask resounds powerfully to a tuning-fork of suitable pitch vibrating near its mouth. When the tube is open the resonance is very feeble. The opening and closing is effected by a perforated disc rotating in contact with the brass tube. At a certain velocity the interrupted sounds blend into the sound of the tuning-fork, the velocity giving an indication of the amount of residual sensation.—The appendages of the pygidium of *Triarthrus*, by Charles E. Beecher. Further studies of the Yale Museum specimens have enabled the author to make out the main characteristics of the appendages of the caudal shield. At the pygidium, the endopodites preserve the slender, jointed, distal portion found at the thorax, but the proximal part is composed of segments which are considerably expanded transversely, thus making a paddle-like organ, the anterior edge of which is straight, while the posterior one is serrated by the projecting points of the expanded segments. These points bear small bundles of setæ. The specimens from which these details are gathered are very perfectly preserved. The author proposes next to describe the structure of the under side of the head, and then to review the present enlarged knowledge of *Triarthrus*, with its bearings upon the position and affinities of the Trilobites generally.

Bulletin de l'Académie Royale de Belgique, No. 2.—The sense and the period of the Eulerian movement, by F. Folie. The sense of the Eulerian movement of the pole of inertia round the instantaneous pole is direct; that of the movement of the instantaneous pole at the surface of the earth is retrograde. The period of the latter is 321 days; for an integral number of years, a direct and somewhat slower motion may be substituted for this, giving the commonly accepted period of 423 days. But the shorter period is free from the geometrical objections attached to the latter.—The influence of pressure upon specific heat, taken below and above the critical temperature, by P. de Heen. The law governing this influence is analogous to that determining the relation between pressure and compressibility. Little variable at first, the specific heat rises with increasing pressure up to a certain limit, and then diminishes.—On the phenomenon of beats in luminous vibrations, by Dr. J. Verschaffelt. Prof. Righi showed in 1878 that if two rays are brought to interference whose periods are only slightly different, fringes are obtained which move with such velocity that a number equal to the difference of frequency passes each point of the screen in one second. Righi realised this practically by means of a rotating Nicoll prism and Fresnel's mirror. The principle applied by Dr. Verschaffelt is that of Doppler, according to which a motion of the source with respect to the ether changes the wave-length of the light emitted. The retardation was produced by a moving wedge of quartz cut parallel to its axis, and placed at 45° between the crossed Nicolls of a polarising microscope.—On absorption by the bile ducts, by Célestin Tobias. Ligature of the thoracic canal suppresses absorption of acids and biliary pigments, as pointed out by Harley. But it does not affect that of sodium ferrocyanide, of strychnine, or of atropine at the surface of the bile ducts. Sodium iodide is not absorbed at all. Whether the absorption is lymphatic or sanguine depends upon the nature of the substance.

SOCIETIES AND ACADEMIES.

LONDON.

Physical Society, April 13.—Prof. A. W. Rücker, F.R.S., President, in the chair.—The President invited discussion on Prof. Henrici's paper on calculating machines, and said a description of Mr. Sharp's harmonic analyser, giving direct readings of the amplitude and epoch of the various constituent simple harmonic terms, had been sent in. This machine requires no adjustments to be made before using. The amplitude is given by the length of a line joining the initial and final positions of the point of contact of a roller with a rotating disc, whilst the epoch is determined by the angle which this line makes with the plane of the roller in its initial position.—Prof. Perry congratulated Prof. Henrici on the success attained with his analysers. Referring to planimeters, he said the average error made in working out indicator diagrams with Hine and Robertson's instrument was only about one-third that made with Amsler's. After pointing out the great importance of Fourier's series to practical men, and especially to electrical engineers, he said that in studying reciprocating motions, such as those of pistons, valve gears, &c., it was most useful to resolve the motion into its fundamental harmonic motions and its overtones. In this way remarkable differences could be seen between various motions which have the same fundamental, and which are usually considered equivalent. In the *Electrician* of February 5, 1892, he had published the numerical work for a given periodic curve developed in Fourier's series, and he now exhibited a graphical solution done by one of his students, who was probably the first to carry out the late Prof. Clifford's idea of wrapping the curve round a cylinder and projecting it on different planes. Prof. Henrici had, he said, based the construction of his first analyser on Clifford's method, but used the Henrici principle (viz. $\int y \sin\theta \, d\theta = \int \cos\theta \, dy$, when integrated over a complete period) to explain the later machines. As a matter of fact the first machine in which the coefficients were determined by an Amsler planimeter carried by a reciprocating tangent plane, was a beautiful example of the Henrici principle, and he, Prof. Perry, saw far greater possibilities before it. The defects in the first instrument were mechanical ones, and could be got over by increasing the amplitude of the harmonic motion. Not only was the machine useful for Fourier expansions, but by giving suitable motions to the tangent plane developments of arbitrary functions in spherical harmonics, Bessel's functions, Lamé's functions, and other normal forms could be determined. He had designed a machine which, on Prof. Henrici's principle, develops arbitrary functions in Bessel's, and hoped to have shown it in working order at the meeting; the Easter holidays had prevented its being finished in time. In this machine the motion is given to the table by a cam and roller, the cam being shaped so that the displacement of the table is $x \times J(x)$ when the shaft turns through an angle proportional to x. The revolving cylinder is driven by variable gearing from the cam shaft. By using cams of other shapes, developments in many normal forms may be obtained; the machine is therefore of general analytical use. An example of development in Bessel's worked out arithmetically by two of his students, Messrs. Hunt and Fennel, was given, and the process of performing the integration by the machine described. Prof. Boys, speaking of arithmometers, said Prof. Selling's machine had several inconveniences. In the first place, it occupied a large space, and the projecting racks were apt to upset things put behind the machine. Secondly, the result of any operation was indicated by continuous motion, and therefore cannot be read off instantly with certainty. On the other hand the "Brunsviga" machine was very compact and convenient, the only serious defect being that one cannot carry on figures obtained as the result of one operation to work with again, as was possible in the well-known Colmar machine. As another improvement he suggested that the two sets of numbers on the wheels showing the result of any operation, should be coloured differently, so that it would be easy to see whether multiplication or division had been performed. The labour of operating with large digits could then be considerably reduced with certainty. For example, in multiplying by 2998, instead of 28 (2+9+9+8) turns of the handle, 5 would be sufficient, viz. 3 in the forward direction and 2 backward, thus giving $300\bar{2}$. In his opinion logarithum tables were not nearly so convenient for ordinary calculations as this machine.—Mr A. P. Trotter described how, by the use of templates cut to suitable shapes, one could obtain true curves from those given by recording voltmeters and similar apparatus. Mr. Yule said he had recently seen the newest analyser made by Coradi for Prof Weber, and was present when it was tested by the latter on a simple harmonic curve. It gave excellent results, the errors not amounting to 1 part in 2000. Speaking of the "hatchet" planimeter, he thought the first one was exhibited by Mr. Goodman at the Institution of Civil Engineers. Mr. A. Sharp, he said, remarked that since last meeting he had designed an inversion of the mechanism in his harmonic analyser, which made it much more practical. Prof. Henrici, in reply, said the uses of his first machine, suggested by Prof. Perry, might lead to great developments in this subject. Lord Kelvin had shown that with the sphere and roller integrator products of two functions such as $f(x)\ F(x)\ dx$ could be got. Referring to Prof. Boys' criticism on the Selling arithmometer, he did not consider the difficulty in reading off the result at all serious. Mr. Trotter's method of solving problems by templates might be very useful. Speaking of the "hatchet" planimeter, he said he believed it was first brought out in Denmark. Mr. F. W. Hill, of the City of London School, had sent him a solution of its action. Mr. Sharp, he said, had made a very considerable improvement in his machine, and the elements of this integrator may be useful for other purposes.—Mr. P. L. Gray read a paper on the minimum temperature of visibility, describing experiments made to find the lowest temperature at which bright or blackened platinum becomes visible in the dark The instrument used was a Wilson and Gray's modification of Joly's meldometer, in which a thin strip of platinum, about 10 c.m. long and 1 c.m. wide, is heated by an electric current. The expansion of the strip is indicated by an optical method, and used for estimating the temperature of the strip. To calibrate the arrangement, small particles of substances having known melting points were placed on the strip, and observed through a microscope, the position of the spot of light showing the expansion being noted when the substance melted. The general conclusions arrived at are:—(1) That the minimum temperature of visibility is the same for a bright polished surface as for one covered with lampblack, although the intensity of radiation in the two cases may be different. (2) That the visible limit at the red end of the spectrum varies greatly for a normal eye according to its state of preparation. Exposure to bright light diminishes the sensitiveness of the eye, and darkness increases it. (3) That for the less sensitive condition, the minimum temperature of visibility for the surface of a solid is about 470° C., but this may be much reduced by even a few minutes in a dark room. (4) That at night a surface at 410° C. is visible, and that by resting the eyes in complete darkness this may be reduced to 370° nearly. (5) That different people's eyes differ somewhat in their "minimum temperature of visibility," but probably not to any great extent if tested under the same conditions as to preparation, &c. To most observers the strip at these low temperatures had no appearance of red, but looked like a whitish mist. Inserting a plate of glass or a layer of water in the line of vision had no effect on the temperature of visibility. Mr. Blakesley inquired if the author had tried condensing the light from the strip? As to colourlessness, he observed that the parts of the retina active in oblique vision were less sensitive to colour than the central portions. Dr. Burton remarked that in the experiments, the presence of light and not colour was being observed. When illumination was faint, as in twilight or moonlight, it was very difficult to distinguish colours. In the solar spectrum one did not see any whitish termination at the red end. Mr. Elder said Captain Abney had shown that all colours appear grey when of small intensity. The President thought the question as to whether visibility depends on wave-length or on energy was an important one. Probably a minimum amount of energy was essential. At such low temperature the emission curves of the different wave-lengths may not have become sufficiently separated to be distinguished. Mr. Gray, in reply, said Prof. Langley had shown that a minimum, but very small, amount of energy was necessary to vision in all parts of the spectrum.—Dr. Burton's paper on the mechanism of electrical conduction was postponed.

Mathematical Society, April 12.—A. B. Kempe, F.R.S., President, in the chair.—The following communications were made:—On regular difference terms, by the President. (Prof. Greenhill, F.R.S., Vice-President, *pro tem.*, in the chair.) In the expression of the invariants of a binary quantic Q_n in terms of the roots, we employ functions such as

$$\Sigma(T),$$

where T is a product of differences of the roots into which each root enters the same number of times, and the summation extends to all expressions derivable from T by transpositions of the roots. If the number of roots be n, and each root enters v times into T, then T is a *regular difference term* of the system of roots considered, and is said to be of degree n and order v. For a given degree n the simplest regular difference terms are of order 1 or 2, according as n is even or odd, and are called *elemental terms* of the system of roots. The object of the paper is to show that every regular difference term of a given system of roots is a rational integral function of the elemental terms of that system. One result of this theorem is that every invariant of the binary quantic Q_n, which is a rational integral function of the roots of Q_n, is expressible as a rational integral function of such of those invariants as are of the form

$$\Sigma(E_1^{\lambda} E_2^{\mu} E_3^{\nu}\ ..)$$

where E_1, E_2, E_3, ... are elemental terms of the n roots of Q_n.—Theorems concerning spheres, by S. Roberts, F.R.S.—Second memoir on the expansion of certain infinite products, by Prof. L. J. Rogers.—A property of the circum-circle, ii., by Mr. R. Tucker.—A proof of Wilson's theorem, by Mr. J. Perott.—On the sextic resolvent of a sextic equation, by Prof. W. Burnside, F.R.S. The group of an irreducible equation of the fifth degree, after adjunction of the square root of the discriminant, is either the icosahedral group, the dihedral group for $n = 5$, or the cyclical group for $n = 5$; the two latter being sub-groups of the former. In the two latter cases the equation is solvable by radicals, and in the former not. For a given equation with numerical coefficients the two latter cases may be distinguished from the former by constructing the sextic resolvent and determining whether or no this has a rational root. This sextic resolvent has been calculated by Cayley ("Collected Papers," vol. iii. 2) for the general quintic. When the quintic is taken in its standard form, $x^5 + ux + v = 0$, the calculation is enormously simplified (see C. Runge, *Acta Math.* vol. vii.). For a given irreducible sextic there is a greater range of possibilities After adjoining the square root of the discriminant, the group of the equation may be either the alternating group of 6 variables, a transitive group of 6 variables which is isomorphous with the icosahedral group, or a group of order less than 60, which is necessarily solvable. In the first case the solution of the given equation cannot be made to depend on an equation of lower degree than the 6th; in the second case the roots of the equation are rationally expressible in terms of the roots of an equation of the 5th degree; and in the last case the equation can be solved by radicals. For a given equation with numerical coefficients the cases are distinguished by forming the resolvents of the 6th and 10th degrees and determining whether either of these have a rational root. If the resolvent of the 10th degree has a rational root the equation can be solved by radicals, and if that of the 6th degree has a rational root the solution depends on a quintic. It is this latter resolvent which is calculated in the present paper, on the supposition that the sextic is reduced to the standard form

$$x^6 + ux^2 + vx + w = 0,$$

which is always possible by solving a cubic equation. Representing the roots of the equation by 0, 1, 2, 3, 4, 5, a transitive icosahedral group is generated (see Serret, "Cours d'Alg. Sup." vol. ii.) by the two even permutations

$$(12345) \text{ and } (01)(25).$$

There is no function of the roots of the 2nd degree that is invariable for this group, but it is easily verified that

$$012 + 023 + 034 + 045 + 051 + 124 + 235 + 341 + 452 + 513$$

is such a function; and therefore that this function takes 6 values for all even permutations of the 6 roots. If

$$y^6 + p_1y^5 + p_2y^4 + p_3y^3 + p_4y^2 + p_5y + p_6 = 0$$

is the equation whose roots are these 6 values, p_1 &c., must be rational in u, v, w, and $\sqrt{\Delta}$, where Δ is the discriminant of the sextic. By comparing the degrees of these functions it is seen that

$$p_1 = 0,\ p_2 = m_1w,\ p_3 = m_2uv,\ p_4 = m_3u^3 + m_4w^2$$
$$p_5 = m_5v^3 + m_6uvw + m_7\sqrt{\Delta},\ p_6 = m_8u^2v^2 + m_9w^3 + m_{10}u^3w,$$

where the m's are numbers; and it is further easily shown that

$$m_2 = m_5 = m_6 = 0.$$

Finally, by choosing suitable special cases, the values of the other m's are completely determined. The final result is that this sextic resolvent has the form

$$y^6 + 30wy^4 + (165w^2 - 4u^3)y^2 + 25u^2v^2 - 80w^3 + 64u^3w = y\sqrt{\Delta}.$$

It is obvious that the twelve values that the function

$$012 + 023 + \ldots\ldots\ldots\ldots\ldots + 513$$

takes for *all* permutations of the roots are, for the standard sextic equal and opposite in pairs, so that y^2 is a 6-valued function for the symmetric group. If then the above equation be squared, while z is written for y^2 and its value in terms of u, v, w substituted for Δ,

$$(z^3 + 30wz^2 + (165w^2 - 4u^3)z + 25u^2v^2 - 80w^3 + 64u^3w)^2 - \Delta z = 0$$

is the resolvent, a rational root of which will indicate that the solution of the sextic depends on that of a quintic.—Mr. Perigal exhibited some diagrams illustrating circle-squaring by dissection.

Entomological Society, April 11.—Henry John Elwes, President, in the chair.—The Hon. Walter Rothschild exhibited male and female specimens of *Ornithoptera paradisea*, Stdgr., from Finisterre Mountains, New Guinea; *O. trojana*, Stdgr., from Palawan; *O. andromache*, Stdgr., from Kina Balu, Borneo; *Œnetus mirabilis*, Rothsch., from Cedar Bay, Queensland, and a few other splendid species from the Upper Amazons. The President, Mr. J. J. Walker, R.N., Mr. Osbert Salvin, F.R.S., Lord Walsingham, F.R.S., Colonel Lang, R.E., Mr. Champion, and Mr. Hampson made remarks on the geographical distribution of some of the species and the elevation at which they were taken.—Mr. H. Goss exhibited, for Mr. G. A. J. Rothney, several specimens of a species of Hemiptera (*Serinetha augur*, Fab.), and of a species of Lepidoptera (*Phauda flammans*, Walk.), the latter of which closely resembled and mimicked the former. He said that Mr. Rothney had found both species abundantly on the roots and trunks of trees in Mysore, in November last, in company with ants (several species of *Camponotus* and *Cremastogaster*). The Hemiptera appeared to be distasteful to the ants, as they were never molested by them, and he thought that the species of Lepidoptera was undoubtedly protected from attack by its close imitation of the Hemipteron. Mr. Goss said he was indebted to Mr. C. J. Gahan for determining the species. A discussion followed on the mimicking species, in which the President, Mr. Waterhouse, Mr. J. J. Walker, Colonel Swinhoe, and Mr. Hampson took part.—Mr. J. W. Tutt exhibited a typical specimen of *Lycæna corydon*, captured in July 1893; a hybrid male (*L. corydon* and *L. adonis*), taken *in copulâ* with a typical female *L. adonis*, May 20, 1893; a typical male *L. adonis*, May 20, 1893; a female *L. adonis*, the pigment failing in one hind wing; a pale var. of *L. corydon*, probably to be referred to var. *apennina* of Zeller, usually taken in Italian mountains, or var. *albicans*, H. S., taken in Andalusia. Mr. Tutt remarked that, of the first, Staudinger (Cat. p. 12) says "pallidior," of the latter "albicans." He also remarked that the hybrid retains the external features of the species *corydon*, but has taken on to a great extent the coloration of *L. adonis*. It was captured *in copulâ* with a female *L. adonis*, at a time when *L. adonis* was very abundant, and some weeks before *L. corydon* occurred.—The question having been raised by the President as to the number of meetings of the Society which it was desirable to hold during the year, and the most convenient dates for such meetings, a long discussion on the subject ensued, in which Mr. Waterhouse, Mr. Salvin, the Hon. Walter Rothschild, the Rev. T. Wood, Mr. S. Stevens, the Rev. Seymour St. John, and others took part.

Royal Meteorological Society, April 18.—Mr. Richard Inwards, the President, delivered an address on some phenomena of the upper air. He said that there are three principal ways in which the higher atmosphere may be studied: (1) by living in it on some of the great mountain chains which pierce many miles into the air in various parts of the globe; (2) by ascending into it by means of balloons; and (3) by the study of the upper currents as shown to our sight by the movements of the clouds. After describing the effects of rarified air on animal life and natural phenomena, Mr. Inwards proceeded to give an account of various balloon ascents which had been undertaken with the object of making meteorological observations. In 1850 Messrs. Barral and Bixio, when they had ascended to 20,000 feet, found the temperature had sunk to 15° F.; but this was in a cloud, and on emerging from this 3000 feet higher, the temperature fell as low as − 38°, or 70° below freezing point. In 1862, Mr. Glaisher and Mr. Coxwell made their famous ascent when they reached an altitude of about seven miles from the earth. A short time ago a balloon without an aeronaut, but having a set of self-recording instruments attached, was sent up in France, and from the records obtained it is shown that a height of about ten miles was attained, and that the temperature fell to − 104° F. Clouds are simply a form of water made visible by the cooling of the air which previously held the water in the form of invisible vapour. Every cloud may be regarded as the top of an invisible warm column or current thrusting its way into a colder body of air. After referring to the various classifications and nomenclatures of clouds, of which that proposed by Luke Howard in 1803 is still in general use, Mr. Inwards said that whatever system of naming and classifying clouds be adopted, it should depend on the heights of the various clouds in the air, and he gave a few rough rules by which the comparative altitudes of the clouds may be judged when there is no time or opportunity to make exact measurements. Among the indications by which a cloud's height in the air may be gathered are its form and outline, its shade or shadow, its apparent size and movement, its perspective effect, and the length of time it remains directly illuminated after sunset. By the last method some clouds have been estimated to have been at least ten miles above the surface of the earth. The cloud velocities at high altitudes have been carefully noted at the Blue Hill Observatory, Mass., U.S., and show, practically, that at about five miles' height, the movement is three times as fast in summer, and six times in winter, as compared with the currents on the earth's surface. After showing a number of lantern slides illustrating the various types and forms of clouds, the aurora borealis, rainbows, &c., Mr. Inwards concluded his address by urging the desirability of establishing a good cloud observatory somewhere in the British Isles. At the close of the meeting, the Fellows and their friends inspected the exhibition of instruments, photographs, and drawings relating to the representation and measurement of clouds, which had been arranged in the rooms of the Institution of Civil Engineers. A lantern display of slides, showing cloud effects and other meteorological phenomena, was also given.

Paris.

Academy of Sciences, April 16.—M. Lœwy in the chair.—On mountain observatories in connection with cyclones, by M. Faye. A polemical paper discussing the evidence afforded as to the causes of cyclones by the institution of meteorological observatories at high altitudes. The author contends that the convection theory is completely overthrown. He observes that the theory of the constitution of the sun should benefit from the work possible at these observatories.—M. Grimaux is elected a member of the chemistry section in place of M. Frémy.—Report concerning a demonstration of Fermat's theorem on the impossibility of the equation $x^n + y^n = z^n$, submitted by M. G. Korneck. The demonstration depends on a lemma which is inexact, and hence is not valid.—On the photography of the chromosphere of the sun, by M. H. Deslandres.—On an application of the theory of continuous groups to the theory of functions, by M. Paul Painlevé.—On the generalisation of algebraical continued fractions, by M. Padé.—On the determination of the number of prime numbers inferior to a given quantity, by M. H. von Koch.—On the structure of diffraction waves from the same source, by M. G. Meslin.—Achromatism and chromatism of interference fringes, by M. J. Macé de Lépinay.—On the magnetic properties of iron at different temperatures, by M. P. Curie. The intensity of magnetisation slowly decreases, then more rapidly lessens, with rise in temperature, the rate of loss attaining its maximum for soft iron between 740° and 750°. There is no definite point for the *temperature of transformation of iron*. At temperatures above 750°, the intensity of magnetisation continues to decrease at a continually lessening rate in general; from 950° to 1280°, the coefficient of magnetisation is almost constant. Between 755° and 1365°, the coefficient is independent of the intensity of the field.—On an electrochemical method of observation of alternating currents, by M. P. Janet. By means of paper soaked in potassium ferrocyanide and ammonium nitrate, and wrapped on a revolving metallic drum, a metallic style registers the periodic variations of the E.M F.—The general problem of transformers in a closed magnetic circuit, by M. Désiré Korda.—On the allotropic transformation of iron, by M. Georges Charpy.—Evolution of organised beings. On certain cases of duplication of Galton's curves due to parasitism and on dimorphism of parasitical origin, by M. Alfred Giard.—On the poison organs of the Hymenopteræ, by M. Bordas.—The ejection of blood as a means of defence among some of the Coleopteræ, by M. L. Cuénot. The author has particularly studied the following species:—*Timarcha tenebricosa* and *coriaria* Fabr., *Adimonia tanaceti* Fabr., *Coccinella septempunctata* and *bipunctata* L., *Meloe proscarabeus* L., and *majalis* L., and *autumnalis* Oliv.—On the muscular buds (*bourgeons musculaires*) of the paired fins of *Cyclopterus lumpus*, by M. Frédéric Guitel.—On the parasitism of a species of Botrytis, by M. Louis Mangin. The conditions under which copper or zinc salts may be used to combat with this parasite are indicated.—Anatomical modifications of plants of the same species in the Mediterranean region and in the region of the neighbourhood of Paris, by M. W. Russell. Plants in the Mediterranean climate differ from those of the Parisian region by (1) the cellules of the epidermis are larger, and have more regular contours and thicker walls; (2) the bark has assimilating tissue supported on parenchyma without chlorophyll (transformed into protective tissue); (3) the diameter of the vessels is greater; (4) the thickness of the leaves is augmented owing to the great development of the palisade tissue.—On the structure of certain varieties of rust; their analogy with the sedimentary ferruginous minerals of Lorraine, by M. Bleicher. The combination of ferric hydroxide and silica in presence of soft water underground may be so rapid as to form rusts comparable in appearance and structure with iron minerals of geological age.—On the fruits of palms found in the Cenomanian near Sainte-Menehould, by M. P. Fliche.—Researches on a mode of striation of rocks independent of glaciation, by M. Stanislas Meunier.—Researches on rigor mortis, by M. J. Tissot.—The mechanism of hyperglycæmia determined by diabetic *piqûre* and by anæsthetics. Experimental facts serving to establish the theory of sugar diabetes and of the regulation of the glucose-forming function in the normal state, by M. Kaufmann.

BOOKS, PAMPHLETS, and SERIALS RECEIVED.

Books.—The New Technical Educator, Vol. 3 (Cassell).—Elementary Meteorology: Prof. W. M. Davis (Boston, Ginn).—The Microcosm and the Macrocosm; B. Waller (K. Paul).—Law and Theory in Chemistry: D. Carnegie (Longmans).—Rainfall in the East Indian Archipelago, 1892 (Batavia).—Observations made at the Magnetical and Meteorological Observatory at Batavia, Vol. xv. 1892 (Batavia).—Practical Paper-making: G. Clapperton (Lockwood).—Müller-Pouillet's Lehrbuch der Physik und Meteorologie, new edition, Erster, Zweiter (Erste Abthg. Erste Liefg.) und Dritter Bands (Braunschweig, Viewig).—Histories of American Schools for the Deaf: edited by Dr. E. A. Fay, 3 Vols. (Washington).—Recenti Progressi nelle Applicazioni dell' Elettricità: Prof. R. Ferrini, Parte II. (Milano, Hoepli).—La Trazione Elettrica: G. Martinez (Milano, Hoepli).—Trasmissione Elettrica: G. Sartori (Milano, Hoepli).—A Guide to Palmistry: Mrs. E. Easter-Henderson (Gay and Bird).

Pamphlets.—The Egg-Blower's Companion: W. M. Roberts (J. Heywood).—The Eight Hours' Day in British Engineering Industries: J. S. Jeans (Ballantyne).—The Constitutional Beginnings of North Carolina: J. S. Bassett (Baltimore).—Geological Club of Philadelphia, Charter, &c. (Philadelphia).

Serials.—Journal of the Institution of Electrical Engineers, No. 110, Vol. xxiii. (Spon).—Tufts College Studies, No. 1 (Tufts College, Mass.).—Palestine Exploration Fund Quarterly Statement, April (Watt).—Journal of Anatomy and Physiology, April (Griffin).—Quarterly Review, April (Murray).—Notes from the Leyden Museum, October, January, and April (Leyden, Brill).—L'Anthropologie, Tome v. No. 2 (Paris, Masson).—Proceedings of the American Academy of Arts and Sciences, new series, Vol. xx. (Boston, Wilson).—Royal Natural History, Vol. 1, Part 6 (Warne).—Morphologisches Jahrbuch, 21 Band, 2 Heft (Leipzig, Engelmann).—Journal of the Royal Microscopical Society, April (Williams and Norgate).—Bulletin of the Geological Club of Philadelphia, Vol. 1, No. 2 (Philadelphia).—Bulletino della Società Geografica Italiana, serie 3, Vol. 7, fasc. i.-ii. (Roma).—Mittheilungen der Deutschen Gesellschaft für Natur-und Völkerkunde Ostatiens in Tokio, Band vi. Seite 103-148 (Tokio).—Ergebnisse der Meteorologischen Beobachtungen, Jahrg. iv. (Bremen).—Mathematical Gazette, No. 1 (Macmillan).—Sitzungsberichte der K. Akademie der Wissenschaften Math.-Naturw. Classe.—Anatomie und Physiologie, 1893, January, February, March bis July.—Chemie, 1893, January, February, March, April, May bis July.—Mineralogie, &c., 1893, January bis March, April, May, June, July.—Mathematik, &c., 1893, January, February, March, April, May, June, July (Wien).

CONTENTS.