NATURE

A WEEKLY

ILLUSTRATED JOURNAL OF SCIENCE

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APRIL 1871 to OCTOBER 1871

" *To the solid ground*
Of Nature trusts the mind that builds for aye."—WORDSWORTH

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THURSDAY, MAY 4, 1871

THE SMALLER LECTURESHIPS AT THE LONDON MEDICAL SCHOOLS

I.—THE CONSERVATION OF FORCE

ABOUT sixty years ago the student who determined to enter the medical profession was usually bound as an apprentice to some respectable country practitioner, and spent several years in acquiring the rudiments of his profession, by bandaging bad legs, dressing simple wounds, bleeding freely everybody that presented himself and prescribing and dispensing for the poor. He then came to London, or attended one of the larger provincial towns provided with a hospital, and followed the practice of some celebrity, hearing an occasional lecture and much clinical discussion, and finally presented himself for examination before the Master and Court of Assistants of the College of Surgeons, and started in practice. Such training was solid and good; practice went before, and theory followed after; some thought, indeed, the cart went before the horse; yet the excellence of the plan was shown in the high scientific position and lucrative practice obtained by many a well-known name. As Shakespeare knew little Latin and less Greek, our student knew little anatomy and less physiology, but what he did know was substantial, and served him in good stead.

A few years after the time we are speaking of, systematic courses of lectures upon various subjects, as upon chemistry, botany, anatomy and physiology, medicine and surgery, began to be delivered at the larger schools, at the instigation of the Society of Apothecaries, who were constituted by the Act of 1815 the guardians of "general practice," two or even three subjects being given by the same lecturer; and attendance upon these soon came to be regarded as an important part of the student's education. So far all was well. The several subjects mentioned above were treated broadly by such men as Abernethy, Cooper, Babington, and others, generally speaking with direct reference to medicine or surgery; and the student underwent a training that possessed considerable value in relation to his future profession, whilst it furnished him with the rudiments of various sciences that he could pursue and extend in his leisure moments. A few years more passed away, and the advances made in every department of knowledge rendered it impossible for any man to undertake singly to lecture upon two different sciences, such as chemistry and botany, or even upon two such cognate subjects as anatomy and physiology. Each required its separate professor, who delivered from thirty to ninety lectures upon his special science, and attendance upon them was rigorously enforced both by the lecturer himself and by the examining bodies.

And now ensued a period that was undoubtedly opposed to all true intellectual training. The student, as soon as he entered the profession, saw little practice, but was everlastingly in attendance upon lectures. No mental effort was required, and, except in the case of first-rate lecturers, none, we are convinced, was ever exerted in acquiring and assimilating the information conveyed. Here and there a good lecturer, thoroughly master of his subject, chained his audience; but the substance of four out of five lectures either entered at one ear to pass out at the other, or was altogether refused admission to the brain by the locked portals of the slumbering student. The horses were indeed put before the cart, but the team was so strong that they often ran away with the cart before anything useful had been put into it. The requirements of the examining bodies in regard to these lectures rendered it imperative for every school, however small, to have as numerous a staff of lecturers as the largest. The senior officers of the medical staff consequently took the more important subjects of medicine and surgery, anatomy and physiology, whilst the younger ones divided amongst them chemistry and botany, materia medica, forensic medicine, and midwifery. In many instances these latter posts were filled by gentlemen who had received no special training, but who accepted them and often worked at them with praiseworthy energy, merely to secure the succession to the medical staff, upon obtaining which the minor lectureship was at once given up.

It is obvious that lectureships so obtained and so held must have been in many instances valueless alike to the lecturer himself and to the student who sat under him, yielding to the former a barren honour, and to the latter a signed schedule,—the advantage of the professor and not the advancement of the student being the point considered. During the last few years a reaction has been setting in against this perpetual lecturing, and the number required to be attended has been considerably reduced. The University of London deserves the credit of having been the first to break through this absurd system, by requiring attendance on only one or two courses, and this rather as evidence of the student being really engaged in the study of medicine than for any other purpose, leaving him free to acquire his information as best he can, but testing its extent and value by a searching examination.

No doubt many of the posts above alluded to are filled by men of great talent and ability, but their powers are crippled by the small means at their disposal, which prevents many illustrations or experiments from being exhibited which are almost essential for thorough teaching.

As a means of improving the system of education by supplying a better class of lectures on some subjects than those at present given, and at the same time obtaining better remuneration for the lecturers themselves, a scheme has recently been advanced by which it is proposed that certain medical schools in the metropolis should be amalgamated, a reduction in the number of lecturers being thus effected, whilst the pecuniary value of those that remain will undergo considerable augmentation. It is hoped that the value of these posts would then be sufficient to lead to their being accepted not by those who only use them as a stepping-stone for advancement, but by gentlemen who have devoted themselves exclusively to the study of the department of science on which they lecture.

At the present moment the lectureships in several of the smaller schools yield such small returns to their holders as would astonish many of their hearers. As a matter of fact we could mention an instance where the proceeds of an entire summer course of lectures has amounted on the average for the past three years to a sum not exceeding *6l.* Can this for a moment be regarded as in any way proportionate to the intellectual labour, the time, and the money expended in their preparation, illustration, and delivery? It might be considered to be a moderate recompense for one lecture, but as payment for a course it is simply monstrous. Is it surprising that the lectures are often given without animation, and listened to without interest?

By amalgamating several schools, however, such chairs might, it is hoped, be so far increased in value as not only to lead men of high ability, and distinguished for their knowledge in particular branches of science, to accept them, but to provide ample funds to admit of their copious illustration, and for the purchase of expensive apparatus — apparatus which the smaller schools now find it difficult or impossible to procure. It would not be difficult, we imagine, to find room for those who at present hold appointments as demonstrators, with lighter but not less important duties than they have hitherto performed. At all events it seems to us that the amalgamation scheme, if fairly carried out, would prove the most splendid example of the Conservation of Force with which we are acquainted, and on that ground alone should receive the cordial support of the medical teachers throughout the metropolis. In a future article we shall suggest what appears to us a desirable and practical scheme for medical education.

THE LITERATURE OF CHEMISTRY

THE appearance of the April number of the "Journal of the Chemical Society" marks the commencement of a new era in English Chemical Literature, containing, as it does, besides the papers which have been read before the Society, the first instalment of the promised "abstracts." The papers selected for this purpose by the accomplished editor are ninety-one in number, comprising every branch of Chemical Science, Technology included, and are classified under six various headings, as "Physical Chemistry," "Inorganic Chemistry," &c. The abstracts themselves, made by the gentlemen whose names appear on the wrapper of the journal, are naturally of different degrees of literary merit, but seem to be carefully and conscientiously done; all the points of essential importance in the original papers being retained. The reader will thus not only have a good general notion of the extent of the researches made by any particular author, but also be able to repeat any of the experiments, or prepare any of the substances from the directions given. These abstracts are therefore really what they profess to be, and not merely notices of a few lines in length, from which but little more information can be gleaned than from the title of the paper.

The Council of the Chemical Society is to be congratulated on the energetic way in which it has endeavoured to supply a great defect in our scientific literature, by affording us the means of obtaining a general view of the progress of Chemistry both here and on the Continent. Chemists have hitherto had to depend chiefly on Will's "Jahresbericht," which, although useful in its way, has the double disadvantage incident upon its method of arrangement, first, in not being published until long after the end of the year, and, secondly, of being rather a *résumé* of the chemical work done, than a condensed account of particular researches. There is no doubt that these abstracts, if furnished with a full and comprehensive index, both of the subject-matter and the names of the authors, will become a standard work of reference, not only here but on the Continent.

It is to be hoped that other Scientific Societies will be induced to follow the example of the Chemical Society, and, by publishing abstracts of all papers connected with their particular branch of science, give an impetus to its cultivation, and render a knowledge of its general progress easily attainable. The value of such abstracts is greater than might at first sight appear; for the study of Science, both for its own sake, and in its application to the Arts, is extending so rapidly that it requires a considerable expenditure of time to acquire a knowledge of the numerous researches and discoveries which are now being made in any particular science, and leaves but little for the study of the sciences allied to it. If, then, each of the learned societies were to publish abstracts similar to those of the Chemical Society, it would render it comparatively easy for the workers in any one department of science to acquire something more than a superficial knowledge of the discoveries made in the others.

GLAISHER'S TRAVELS IN THE AIR

Travels in the Air. By James Glaisher, Camille Flammarion, W. de Fonvielle, and Gaston Tissandier. Second and revised edition. With 125 illustrations. (London: R. Bentley, 1871.)

BOTH the scientific and the lover of adventure will find abundance to interest them in this handsome volume. The terrestrial fields of enterprise are getting exhausted. Mont Blanc has long since been used up. We are getting tired of Central Africa and the Steppes of Tartary. Even the invitation "Try Lapland" fails to stimulate the jaded nerves of the zealous explorer of "fresh fields and pastures new." In the realms of air, however, there is still plenty of new ground, if we may be allowed the Hibernicism. Mr. Glaisher and the illustrious French trio can claim this field as almost exclusively their own, though, doubtless, they will not long be left in undisturbed possession of it. After a brief history of the rise and progress of aërostatics in England, Mr. Glaisher here recounts to us the particulars of ten of his most remarkable ascents; and the Frenchmen then follow suit. The volume is got up in drawing-room style, as a veritable *livre de luxe;* we wish we could transfer to our pages some of the beautiful chromo-lithographs by which it is illustrated, in particular, the wonderful mirage and luminous aureole which serves as frontispiece, and the falling stars as observed from the balloon, at p. 262. We must, however, content ourselves with two or three of the scarcely less effective woodcuts.

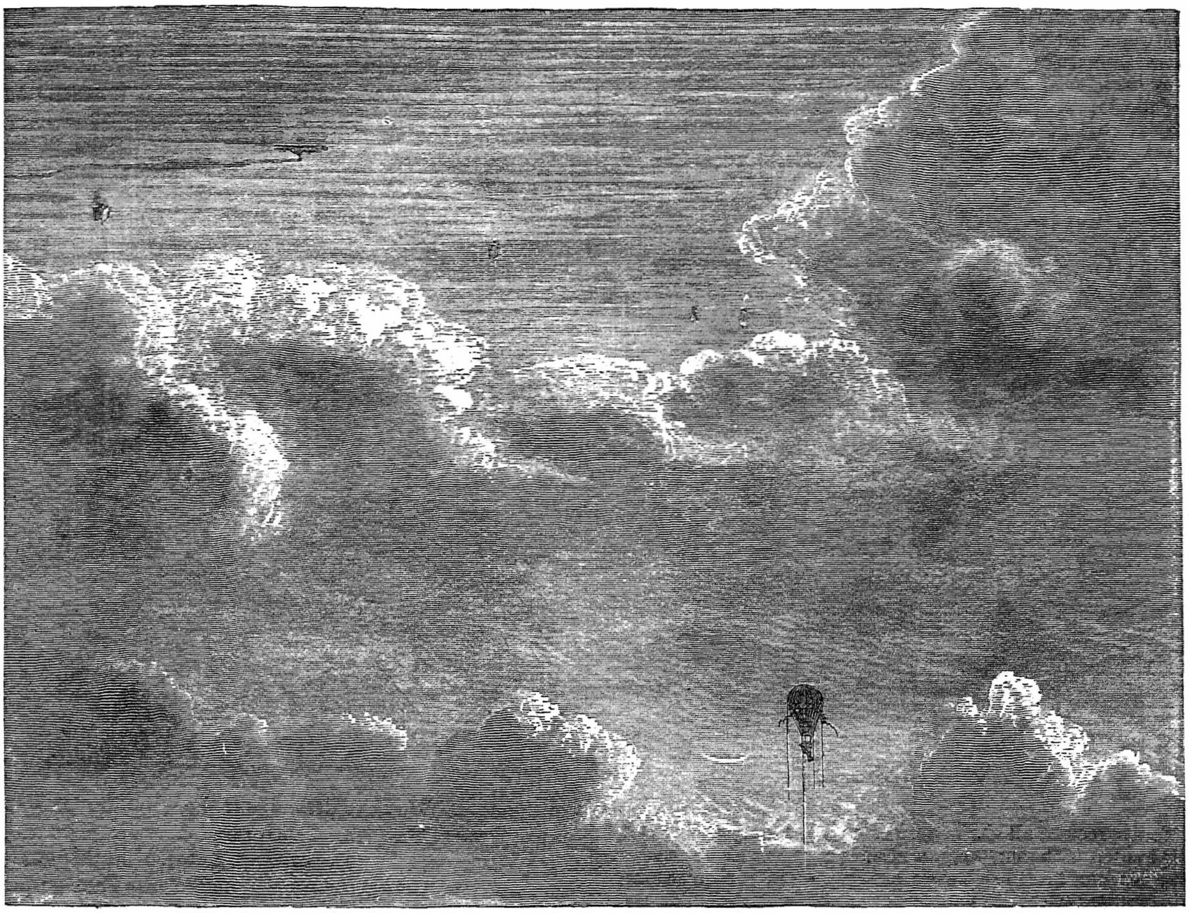

FIG. 1—MIRAGE IN THE SKY, AS SEEN FROM THE BALLOON

The scientific information contained in the volume is important, though rather as showing how little we know at present of even the fundamental principles of Meteorology, than as establishing any new laws. With regard to temperature, Mr. Glaisher remarks that the decrease as we ascend is far from constant, and we must entirely abandon the theory of a decline of 1° of temperature for every increase of 300 ft. of elevation. With reference to the colour of the sky, he states that, as viewed from above the clouds, it presents a deep blue colour, which deepens in intensity with increase of elevation regularly from the earth if the sky be free from clouds, or with the increase of elevation above the clouds if they be present, and on this subject he gives the following laws:—

"The azure colour of the sky, though resembling the blue of the first order when the sky is viewed from the earth's surface, becomes an exceedingly deep Prussian blue as we ascend, and, when viewed from the height of six or seven miles, is a deep blue of the second or third order. 2. The maximum polarising angle of the atmosphere, 45°, is the same as that of air, and not of water, which is 53°. 3. At the greatest height to which I have ascended, namely, at the height of five, six, and seven miles, where the blue is the brightest, the air is almost deprived of moisture. Hence it follows that the exceedingly deep Prussian blue cannot be produced by vesicles of water, but must be caused by reflection from the air, whose polarising angle is 45°. The faint blue which the sky exhibits at the earth's surface is therefore not the blue of the first order, but merely the blue of the second or third order rendered paler by the light reflected from the aqueous vapour in the lower regions of the atmosphere.

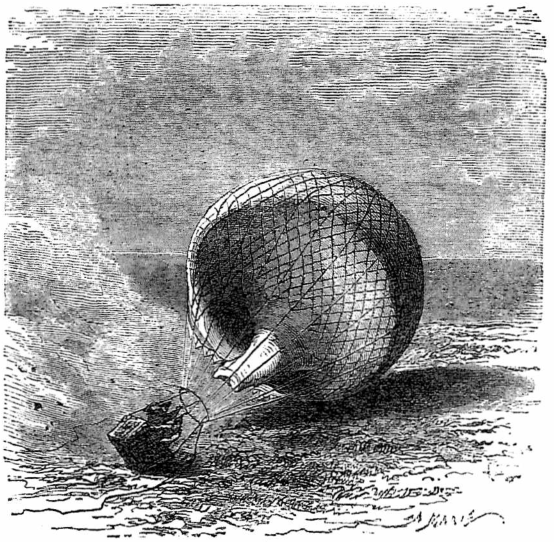

FIG. 2—DRAGGING

To appreciate all the beauty of cloud scenery when the air is loaded with moisture, an aërial voyage must be made on an autumn morning before sunrise, when the atmosphere is charged with the vapours of night."

Clouds were frequently met with to a height of 20,000ft. or nearly four miles, and heavy rain at almost as great an altitude; and on one occasion, while descending, rain fell on the balloon at a height of three miles, and then for the next 5,000ft. lower, it passed through a beautiful snowy scene; there were no flakes in the air, the snow was entirely composed of spiculæ of ice, of cross spiculæ at angles of 60°, and of an innumerable number of snow crystals, small in size, but of distinct and well-known forms easily recognisable as they fell and remained on the coat. The drawings show many a beautiful scene—sunrise from a balloon, moonlight effects, a lunar halo, the shadow of a balloon on the clouds, sometimes surrounded by an aureole, though, perhaps, none more remarkable than the mirage represented in our first illustration.

Humorous incidents occur here and there; as when the whole apparatus is taken by the French peasantry for "le diable" himself, or when the travellers approaching the earth are required by too zealous gensdarmes to show their passports! And the adventures are not without their serious attendant dangers. More than once the diminished pressure and the intense cold produced so great a numbness and tendency to sleep that it has required the greatest presence of mind for all control over the balloon not to be lost—and for ever. Life and limb were also not unfrequently endangered by the too sudden descents, sometimes to escape the imminent peril of an involuntary dip into the sea. Fig. 2 depicts the manner in which the "Swallow," having Tissandier and de Fonvielle on board as passengers, was dragged along the ground by a furious gale, and both those eminent aëronauts were considerably hurt and in danger of losing their lives.

There is not much contribution in the volume to the mechanics of aërostation, and that mostly from the French

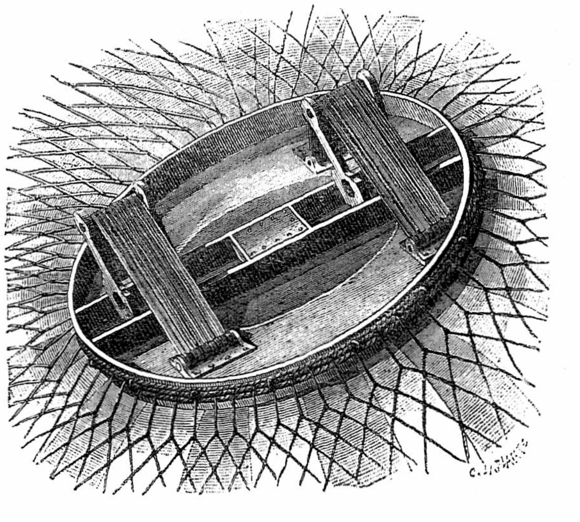

FIG. 3—THE VALVE OF THE "ENTREPRENANT" BALLOON

contributors. We have drawings of the weighing machine and pulleys of the great Captive balloon of Chelsea, and Fig. 3 represents the valve of the "Entreprenant" balloon from which M. de Fonvielle attempted to take photographs of an eclipse of the moon. The book is one which will doubtless find a large circle of readers, and will greatly increase the public interest in aërostatics.

OUR BOOK SHELF

A Text-Book of Elementary Chemistry, Theoretical and Inorganic. By George F. Barker, M.D. (New Haven. Conn.: C. C. Chatfield and Co., 1870, pp. 336.)

THIS little book is evidently the result of much labour on the part of the author, and cannot fail to be of much value to students of chemistry. In the preface a list of books is given of which the author has made free use; consequently the peculiarities of the systems of many chemists are to be found in the book; but though it cannot be said that any school has been followed, yet all are more or less represented. The prevailing ideas are that each element has a definite combining power or equivalence, and that the arrangement of atoms in compounds is of as much importance as their kind or number. This work is remarkable for the conciseness of its definitions; one of the first is on chemical and physical changes, in which it is said that "physical changes in matter are those which take place outside the molecule; they do not affect the molecule itself, and therefore do not alter the identity of the matter operated on. Chemical changes take place within the molecule, and hence cause a change in the matter itself." Some of the definitions would not, however, find general acceptance; thus, an acid molecule is said to be "one which consists of one or more negative atoms united by oxygen to hydrogen;"—a definition which excludes hydrochloric acid and its analogues. And a saline molecule is defined to be one containing a "positive atom or group of atoms, united by oxygen to a negative atom or group of atoms," which removes sodic chloride from the list of salts. The term base is confined to the hydrates of positive elements or groups of elements, and the hydrates of the metals calcium, zinc, and iron are sometimes called calcic base, zincic base, ferrous base, and ferric base. The nomenclature of the acids is systematised, but peculiar names are the result: an ortho-acid is one containing as many atoms of oxygen and hydrogen as is equal to the equivalence of the negative atom or group; and a meta-acid is derived from an ortho-acid by the subtraction of molecules of water, thus orthophosphoric acid would be $P(OH)_5$, metaphosphoric acid $(PO)'''(OH)_3$, and dimetaphosphoric acid $(PO_2)'(OH)$. These names and those of most other acids are liable to some misunderstanding, as the compounds they represent have long been known by other designations. The theoretical part of the book contains chapters on elemental molecules and atoms, compound molecules, volume relations of molecules, and stoichiometry. The part on inorganic chemistry is divided into eleven chapters, on hydrogen, the negative monads, dyads, triads, boron, negative tetrads, the iron group, positive tetrads, triads, dyads and monads, thus treating of the elements according to their electro-chemical characters, commencing with the most negative. Each chapter is divided into sections containing the history, occurrence, preparation, and properties of the elements, and is followed by a series of questions intended as exercises for the students, a method now much adopted, and found to be of great assistance to teachers. This book is another of the evidences of the rapid progress of pure science in America.

Czermak's Electric Double Lever. (*Der Electrische Doppelhebel, von J. N. Czermak.*) (Leipzig: Engelmann. 1871. London: Williams and Norgate.)

A DESCRIPTION of a most ingenious little contrivance for marking the exact moment in which a movement begins or changes its direction. The old arrangement, by which a lever, forming part of a circuit, comes, when set in motion, in contact with a fixed point connected with the other part of the same circuit, and so closes the circuit and makes a signal, is modified by Prof. Czermak as follows. The fixed contact point is replaced by a secondary lever, whose axis of revolution is the same as that of the primary lever. This secondary lever bears at one end a contact point. The primary lever touches in its swing this contact point, and so closes the circuit; it then pushes the secondary lever before it, but having reached the limit of its oscillation, leaves the secondary lever at rest in a position marking the farthest point of the excursion. A counter contact-point, however, on the other arm of the primary lever (where the lever is a double-arm one; with single arm levers, a special arrangement is introduced), as the primary lever is returning into position gives to the secondary lever a movement in the same direction. Thus the two levers are continually following each other, making and breaking contact. The instrument is in this way made capable of being used for signalling all manner of movements. It is impossible fully to explain its construction in a few lines, and we therefore refer the reader to the pamphlet itself, which, we should say, is published in celebration of the Jubilee of the great Leipzig Professor, Ernst Heinrich Weber. By the invention of his delightful "Rabbit Holder," Czermak has endeared himself to every physiologist, and we may well share his hope that this new double lever will be found no less useful. M. FOSTER

LETTERS TO THE EDITOR

[*The Editor does not hold himself responsible for opinions expressed by his Correspondents. No notice is taken of anonymous communications.*]

Pangenesis

IT appears from Mr. Darwin's letter to you in last week's NATURE,* that the views contradicted by my experiments, published in the recent number of the "Proceedings of the Royal Society," differ from those he entertained. Nevertheless, I think they are what his published account of Pangenesis (Animals, &c., under Domestication, ii. 374, 379) are most likely to convey to the mind of a reader. The ambiguity is due to an inappropriate use of three separate words in the only two sentences which imply (for there are none which tell us anything definite about) the *habitat* of the Pangenetic gemmules; the words are "circulate," "freely," and "diffused." The proper meaning of circulation is evident enough—it is a re-entering movement. Nothing can justly be said to circulate which does not return, after a while, to a former position. In a circulating library, books return and are re-issued. Coin is said to circulate, because it comes back into the same hands in the interchange of business. A story circulates, when a person hears it repeated over and over again in society. Blood has an undoubted claim to be called a circulating fluid, and when that phrase is used, blood is always meant. I understood Mr. Darwin to speak of blood when he used the phrases "circulating freely," and "the steady circulation of fluids," especially as the other words "freely" and "diffusion" encouraged the idea. But it now seems that by circulation he meant "dispersion," which is a totally different conception. Probably he used the word with some allusion to the fact of the dispersion having been carried on by eddying, not necessarily circulating, currents. Next, as to the word "freely." Mr. Darwin says in his letter that he supposes the gemmules to pass through the solid walls of the tissues and cells; this is incompatible with the phrase "circulate freely." Freely means "without retardation;" as we might say that small fish can swim freely through the larger meshes of a net; now, it is impossible to suppose gemmules to pass through solid tissue without *any* retardation. "Freely" would be strictly applicable to gemmules drifting along with the stream of the blood, and it was in that sense I interpreted it. Lastly, I find fault with the use of the word "diffused," which applies to movement in or with fluids, and is inappropriate to the action I have just described of solid boring its way through solid. If Mr. Darwin had given in his work an additional paragraph or two to a description of the whereabouts of the gemmules which, I must remark, is a cardinal point of his theory, my misapprehension of his meaning could hardly have occurred without more hesitancy than I experienced, but I certainly felt and endeavoured to express in my memoir some shade of doubt; as in the phrase, p. 404, "that the doctrine of Pangenesis, pure and simple, as I have interpreted it, is incorrect."

As I now understand Mr. Darwin's meaning, the first passage (ii. 374), which misled me, and which stands: " . . . minute granules . . . which circulate freely throughout the system" should be understood as "minute granules . . . which are dispersed thoroughly and are in continual movement throughout the system;" and the second passage (ii. 379), which now stands: "The gemmules in each organism must be thoroughly diffused; nor does this seem improbable, considering . . . the steady circulation of fluids throughout the body," should be understood as follows: "The gemmules in each organism must be dispersed all over it, in thorough intermixture; nor does this seem improbable, considering . . . the steady circulation of the blood, the continuous movement, and the ready diffusion of other fluids,

* NATURE, vol. iii. p 502.

and the fact that the contents of each pollen grain have to pass through the coats, both of the pollen tube and of the embryonic sack." (I extract these latter *addenda* from Mr. Darwin's letter.)

I do not much complain of having been sent on a false quest by ambiguous language, for I know how conscientious Mr. Darwin is in all he writes, how difficult it is to put thoughts into accurate speech, and, again, how words have conveyed false impressions on the simplest matters from the earliest times. Nay, even in that idyllic scene which Mr. Darwin has sketched of the first invention of language, awkward blunders must of necessity have often occurred. I refer to the passage in which he supposes some unusually wise, ape-like animal to have first thought of imitating the growl of a beast of prey so as to indicate to his fellow monkeys the nature of expected danger. For my part, I feel as if I had just been assisting at such a scene. As if, having heard my trusted leader utter a cry, not particularly well articulated, but to my ears more like that of a hyena than any other animal, and seeing none of my companions stir a step, I had, like a loyal member of the flock, dashed down a path of which I had happily caught sight, into the plain below, followed by the approving nods and kindly grunts of my wise and most-respected chief. And I now feel, after returning from my hard expedition, full of information that the suspected danger was a mistake, for there was no sign of a hyena anywhere in the neighbourhood. I am given to understand for the first time that my leader's cry had no reference to a hyena down in the plain, but to a leopard somewhere up in the trees; his throat had been a little out of order —that was all. Well, my labour has not been in vain; it is something to have established the fact that there are no hyenas in the plain, and I think I see my way to a good position for a look out for leopards among the branches of the trees. In the meantime, *Vive* Pangenesis. FRANCIS GALTON

The Hylobates Ape and Mankind

THE readers of Mr. Mivart's communication in NATURE for April 20, on the affinity of the Hylobates genus of ape to the human species, may be interested to learn that the fact was well known to the author of the Ramayana, the earliest Sanscrit epic, probably contemporaneous with the Iliad. In this poem the demigod Rama subdues the demon Ravana, and regains his ravished bride Sita by the assistance of a host of apes, which may be identified with *Hylobates Hoolook*. The human characteristics of these semi-apes, their gentleness, affection, good humour, sagacity, self-importance, impressionability, and proneness to melancholy, are portrayed with the most vivid strokes, and evidently from careful observation. See Miss Frederika Richardson's charming volume, "The Iliad of the East," a selection of legends drawn from the Ramayana. (Macmillan and Co., 1870.)

April 27 R. G.

Tables of Prime Numbers

WHEN a number is given, and it is required, without the aid of tables, to find its factors, there is not, I believe, any other method known except the simple but laborious one of dividing it by every odd number until one is found that measures it, and if the number should be prime, this can only be proved by showing that it is not divisible by any odd number less than its square root. Thus to prove that 696 6007 is prime, it would be necessary to divide it by every odd number less than 2639, and even if a table of primes less than 2639 were at hand, about 380 divisions would be requisite.

On the other hand, there are few tables which are more easily constructed than tables of divisors, and it is the extreme facility of a systematic tabulation compared to the labour of isolated determinations, which has led to the construction of such elaborate tables on the subject as have been produced.

The principal tables are Chernac's, which give the factors of numbers from unity to a million; Burckhardt's, which extend as far as three millions, and Dase's, which form a continuation of Burckhardt's, and extend to ten millions.

The mode of formation of these tables was extremely simple. By successive additions, the multiples of 3, 5, 7, 11, 13, 17 . . . were formed up to the limit to which the table was intended to extend; this gave all the numbers having these numbers for factors, and the primes were recognised from the fact of their not occurring as multiples of another prime less than themselves.

Practically the work was rendered even simpler by mechanical means; thus, forms were printed containing, say, a thousand squares, and in these were written consecutive thousands of odd numbers in order; one number in each square, room being left for its divisors, if any, in the square. A pair of compasses was then taken and opened a distance corresponding to the prime whose multiples were to be obtained; for example, in marking the multiples of seven, the compasses were opened the width of seven squares, and then "stepped" along the lines starting from 7, thereby marking the numbers 7, 21, 35 . . . and the number 7 was written in each of the squares in which a leg of the compasses fell. When the factor was large it was more convenient to form a separate table of its multiples, and enter it in the square corresponding to the latter. Many simplifications were introduced in the details of the construction; for instance, Burckhardt had a copper plate engraved with 77 ($=7\times 11$) squares one way and 80 the other; by this arrangement the multiples 7 and 11, which were of the most frequent occurrence (for all multiples of 2, 3, and 5 were rejected from the tables), occupied the same place on each sheet, and he was thus enabled to engrave the numbers 7 and 11 on the plate, so that these numbers were *printed* in all the squares containing the numbers they measured.

Dase, who originally applied himself to the construction of the tables at the suggestion of Gauss, left behind him in manuscript at the time of his death, in 1862, the seventh and part of the eighth million complete, besides a considerable portion of the ninth and tenth millions. The seventh, eighth, and ninth millions were completed by Dr. Rosenberg, and published by a committee at Hamburgh. In the preface to the ninth million (1865), which is the last I have seen, it is stated that the tenth million, which was nearly ready, was the last the committee intended to publish.

My object in writing this letter is not only to call attention to a most valuable series of tables, which seem to have scarcely excited so much interest as they deserve, but also to ask if any of your readers can inform me if the work is being continued, or if there is any chance of its continuation. It is not often that tables are so indispensable as in the present case, or that a want so pressing can be supplied with such comparative ease; and the cessation of the tables would be a real calamity. The tenth million has, I presume, been published.

At the British Association Meeting at Dundee in 1867, a list of 5,500 large prime numbers was communicated to Section A by Mr. Barrett Davis. A short discussion took place on the "reading" of the paper, in the course of which it was stated that Mr. Davis's table was unaccompanied by any explanation of how the numbers had been obtained, or on what grounds they were asserted to be prime; it was also asserted that Mr. Davis wished to keep his method secret.

Perhaps some reader of NATURE can say whether Mr. Davis's numbers have been printed. If they exceed Dase's limit, their publication (if they have not yet been published) is very desirable; and even supposing they are given in Dase's tables, it would be valuable to know how far the latter have been verified by them. The statement about Mr. Davis's method being secret was probably founded on some mistake, and no doubt Mr. Davis would not object to explain it. J. W. L. GLAISHER

Trinity College, Cambridge, April 29

Units of Force and Energy

THE best root for the name of a unit of force is δύναμις. There is, therefore, no ground for Mr. Muir's complaint (NATURE, vol. iii. p. 426), and I now venture to propose that the name *dyne* be given to that force which, acting on a gramme for a second, generates a velocity of a metre per second. A thousand dynes to make one *kilodyne*, and a million dynes one *megadyne*.

Borrowing a hint from Mr. Muir, I would point out that the kilodyne may also be defined as the force which, acting on a *kilogramme* for a second, generates the velocity of a *metre* per second, or, as the force which, acting on a *gramme* for a second, generates a velocity of a *kilometre* per second.

The *kinit*, or pound-foot-second unit of force, is about $138\frac{1}{4}$ dynes. Very roughly expressed in terrestrial gravitation measure, the kinit is the gravitating force of half an ounce, the dyne of about $1\frac{1}{2}$ grains, the kilodyne of about $\frac{1}{4}$ of a pound, and the megadyne of 2 cwt., the approximation being much closer in this last case than in the others, so that within one part in 400 we have 10 megadynes = the force of terrestrial gravity on a ton.

I have often felt the want of a name for an absolute unit of energy, or, what amounts to the same thing, an absolute unit of work. If the above names be adopted, they give us at once the foot-kinit as the unit of work based on the pound, foot, and second, the foot-pound (which varies with the value of g) being equal to g foot-kinits.

In like manner we have, for the metrical system, the *metre-dyne* and its derivatives.

But it would, I think, be advantageous to have short and independent names for these units. For, in the first place, we are thus saved from such cumbrous names as *metre-kilodyne* and *metre-megadyne*, which would be necessary in expressing large quantities of work; in the second place, energy of motion depends directly upon mass and velocity, and is only indirectly connected with the unit of force; and, in the third place, the characteristics of energy are such as specially entitle it to names suggestive of simplicity rather than of compositeness.

I propose, therefore, to call the foot-kinit, whether of work or energy, the *erg*. A thousand ergs to make one *kilerg*, which will be about 31 terrestrial foot-pounds, and a million ergs to make one *pollerg*, which is a little less than the work done by one horse-power in a minute.

The kinitic energy of m pounds, moving with a velocity of v feet per second, is $\frac{1}{2} mv^2$ when expressed in ergs.

The energy value of a Fahrenheit unit of heat is $772 \times 32{\cdot}194 = 24{,}854$ ergs.

In the metrical system, let the metre-dyne of work or energy be called the *pone* (from πόνος). A thousand pones to make one *kilopone*, which is the work done by a *kilodyne* working through a *metre*, or by a *dyne* working through a *kilometre*, and is about $\frac{1}{9{\cdot}81}$ of the variable unit of work in common use among French engineers, called the kilogrammetre. A million pones to make one *megapone*, which is about 723 terrestrial foot-pounds.

In employing the prefix *mega* to denote a million, I have followed the excellent example set by the B. A. Committee on Electrical Standards. As *megerg* would be intolerable, and *megalerg* sounds like a confusion of genders, I have substituted *pollerg*.

In constructing a new nomenclature, the metrical system is entitled to the best names which can be found, but the pound and foot cannot be ignored. J. D. EVERETT

Rushmere, Malone Road, Belfast

The Name "Britain"

IN his remarks on the derivation of the name "Britain," "A. R. H." says that tin "is found only in one of the Britannias." This is incorrect, for tin occurs in Brittany, and also in Gallicia. The fact of the three Britains mentioned by "A. R. H." being all tin-bearing districts seems to confirm the derivation given by Mr. Edmonds in NATURE for February 16.

C. L. N. F.

Piedimulera, Val d'Ossola, Piedmont, April 25

Derivation of the Word "Britannia"

IF Mr. Edmonds considers himself right in his derivation of "Britannia" and "tin," he will have to explain on the same basis the conformable names, and this he will find difficult to do.

The name B-ritannia corresponds with S-ardinia, D-ardania, and possibly with Mauritania, and these again with a number of river names of the root RDN (=RND, BRN, &c.), such as Rotanus, Rhodanus, Drinus, Eridanus, Artanus, Triton, Orethus, &c. B-radanus, P-rytanis, P-arthenias, V-artanus, are examples of B. K-artenus, I-ordanes, I-ardanes, I-ardenus. Then there are examples of Aternus, &c., Tanarus, &c., Mæander, &c., Orontes, &c. These must all be explained on one principle.

In the same way as Britannia is allied to river names, so are many of the ancient (classic) names of countries (except such as are volcanic) allied to river names of various roots, as RBD, &c., RKN, &c., SBN, &c.

These names are not explainable in Phœnician, because they were given long before the Phœnicians entered on the stage of history. They are Palæogeorgian, in a language to which Georgian, Lesghian, and other Caucasian languages are allied. These names were given by the Caucaso-Tibetans.

This is explained in my paper lately read before the Anthropological Institute and recorded in NATURE, and the name of Britannia is illustrated in papers sent in to the Society of Antiquaries and the Royal Irish Academy.

32, St. George's Square HYDE CLARKE

Aurora by Daylight

THAT the Aurora Borealis has been seen by daylight has never been doubted by me, although till now I have not been able to collect sufficient evidence to induce others to believe in the possibility of it. Your correspondent Mr. John Langton, in your last issue, gives two instances of the aurora having been seen during day time, which, I think, ought to dispel all further doubt. However, to satisfy the most sceptical of your readers, the following few cases have occurred to me:—

"A.D. 1122. . . . . This same year died Ralph, Archbishop of Canterbury; that was on the 13th of the kalends of November (October 20). After this were many shipmen at sea and on the water, and they said that they saw on the north-east along the earth a great and broad fire, and it increased speedily upwards in extent towards the sky, and the sky opened itself in four parts and fought there against it as if it would extinguish it: but nevertheless the fire extended up to heaven. They saw that fire in the dawn of the day, and it continued until it was quite light. This was on the 7th of the ides of December (December 7)."—*Anglo-Saxon Chronicle.*

It may seem bold to advance this as the record of an auroral appearance, but not to those who have studied this and other chronicles with their wearying vaguenesses. This passage gains clearness by the following lines from the "Prose Edda," concerning "The Twilight of the Gods and the Conflagration of the Universe," which I have elsewhere* supposed to be a description of the aurora borealis:—

"The fire-reek rageth
Around Time's nurse,
And *flickering flames*
With heaven itself playeth."

In the "Second Continuation of the History of Croyland," there is the following curious passage, under A.D. 1467:—"For one day . . . . horsemen and men in armour were seen rushing through the air; so much so, that St. George himself, conspicuous with the red cross, his usual ensign, and attended by a vast body of armed men, appeared visibly in great numbers. To show that we ought not to refuse our belief to what has been just mentioned, those persons to whom revelations of this nature were made were subjected to the most strict examination before the venerable Father Thomas, the Lord Archbishop of Canterbury."

I understand this occurrence to have taken place in the day between the rising and setting of the sun, because this passage is only part of a longer account of remarkable events which were said to have been observed in "one day." I do not put this instance forward as one of very great value,† as the Chronicle of Ingulf is undoubtedly spurious, as shown by Dr. Hickes and Sir Francis Palgrave, but the continuation, I think, can be safely said to date about the end of the 15th or the beginning of the 16th century, which, if correct, will place the phenomenon above referred to amongst the earliest notices of daylight Auroras in English History, and will come next to that mentioned in the *Anglo-Saxon Chronicle.* Of course I only speak here of my own acquaintance with the Chronicles, there may be other records, but I have not had the opportunity of searching through every monastic production.

Leaving this field of speculation, I come next to a more reliable record. I give the whole of the passage, as it is not very long:—"Aurora Borealis, seen in the Day-time at Canonmills." "The morning of Sunday, September 9, was rainy, with a light gale from the N.E. Before mid-day the wind began to veer to the west, and the clouds in the north-western horizon cleared away: the blue sky in that quarter assumed the form of a segment of a very large circle, with a well-defined line, the line above continuing dense, and covering the rest of the heavens. The centre of the azure arch gradually inclined to the north, and reached an elevation of 20°. In a short time, very thin fleecy clouds began to rise from the horizon within the blue arch; and through these very faint perpendicular streaks of a sort of milky light could be perceived shooting; the eye being thus guided, could likewise detect the same pale streaks passing over the intense azure arch, but they were extremely slight and evanescent. Between nine and ten in the evening of the same day, the aurora borealis was very brilliant, so that there is no reason to doubt that the azure

* Vide NATURE, vol. iii. p. 175.

† For a similar case to this see note to my letter on the aurora borealis in NATURE, vol. iii., p. 487.

arch in the morning, and the pale light seen shooting across it, were connected with the same phenomenon."*

I have just been informed by a friend whose veracity I would be the last to question, that he saw a very faint arch in the eastern sky on the afternoon of the 10th inst. (about 4.30 P.M.). There were no clouds near it, while the background was a beautiful azure. The colour of the arch was of a much fainter blue, or, as he calls it, "a whitish blue," and was almost a perfect semicircle. I have not the least doubt that it was a "daylight" aurora; it must be remembered that on the previous night there was a most magnificent aurora borealis.

In conclusion, after carefully examining the facts contained in the various communications to your journal, as well as those which I have collected, I cannot see any reason for doubting the possibility of the aurora borealis being seen by daylight. It will be interesting to know what those daylight phenomena are, if not auroras.

JOHN JEREMIAH

Red Lion Street

The Irish Fern in Cornwall

YOUR correspondent having, much to my regret, so exactly informed the "ruthless collectors" where they are to look for this fern, I fear that after the ensuing autumnal ravages not a single frond will be left to speak for itself. Permit me, therefore, to state that the fern unquestionably grows, or did grow, at the place indicated, and was, I believe, first recognised in 1866 by Mr. Robert Were Fox, F.R.S., who has a plant he thus obtained still growing in his fernery at Penjerrick near this town.

W. P. DYMOND

Falmouth, April 29

The Prevalence of West Winds

IN a letter with this heading in NATURE for February 16th, Mr. Murphy has very roundly objected to certain views which I have put forward regarding the predominance of westerly winds. In the paper read before the British Association, to the abstract of which he refers, and which was itself little more than a *résumé* of the propositions maintained at greater length in my "Physical Geography," reviewed by "A. B." in NATURE for March 16th, my object was not so much to show that westerly winds predominated in volume over easterly winds, as to show that all prevailing winds, not westerly, may be properly considered as deflected or secondary currents of air, and that more especially the trade winds may be so considered. I have supported this view by a detailed examination of the geographical circumstances, habitudes, and characteristics of the principal winds; but to have included every local exception—as "A. B." seems to consider I ought to have done—would have required more time than even the most industrious can spare, an amount of special topographical knowledge which is practically unattainable, and would have had no important bearing on the main question. I may go even further. I may say that, from a general point of view, isolated local registers have no value at all, unless the method of observing and the position of the vane are distinctly made known. It would be perfectly easy to name a dozen localities in Wales, in the Lake District, or in Scotland, where a vane would show a prevailing wind widely different from the W.S.W., which, however, we have no difficulty in accepting as the prevailing wind of the country; even at Liverpool the prevailing wind has been observed to be W.N.W., and at Valentia there is a marked difference between the wind in the northern and southern entrance. In Mr. Buchan's paper in the Transactions of the Royal Society of Edinburgh, December, 1869, I find that at Irkutsk the wind is almost always due north, or due south, would "A. B." imply that the Irkutsk observations afford any information as to the prevailing wind of Siberia?

In another paragraph, "A. B." considers that the preponderance of westerly winds cannot be very great. So far as the area over which westerly winds blow is concerned, I would partly agree with him; taking into account the constant interruptions to the west winds in the temperate zones, and on the other hand their frequent intrusion into latitudes considerably below 30°, more especially in the Pacific, and their prevalence during several months of the year over a large portion of the Indian Ocean, I am inclined to reckon the ratio of the area of westerly winds to the area of easterly winds as approximately 13 : 10. But such an estimate does not in any way include the velocity of the wind; and since the velocity of the west winds of temperate latitudes is, in the mean, about double that of the easterly winds of tropical, it would follow that the respective volumes of the winds bear to each other a much larger ratio, which, allowing freely for every reasonable reduction, cannot be less than 2 : 1. And this estimate still relates only to the lower strata of the atmosphere, through a height probably not exceeding 12,000 feet. Our knowledge of the winds above that height is very limited; but since, wherever observation extends, it points out to us a strong, frequently even a violent west wind, it seems to me that we have a fairly presumptive proof that the prevailing direction of the upper current is from the west. I base this belief entirely on the evidence which we have, defective as it is and as it almost necessarily must be; to explain the fact by a reference to a difference of barometric pressures, concerning which we have positively no evidence at all, is a task which I most willingly leave to my reviewer. But if, as I have maintained, we may fairly assume that the upper current has an almost invariable direction from the west, and that too with a comparatively high velocity, the ratio of the volumes of westerly and easterly winds is enormously increased, and if the upper part of the air, being quite half of the whole, is moving from the west with a mean velocity of 40 miles an hour, then, as we have already taken 20 miles, or the velocity of the trade winds, as the standard or unit of reference, we have the ratio of westerly to easterly winds as about 6 : 1.

The question which Mr. Murphy has suggested no doubt here arises: Must not this preponderance of westerly winds affect the rotation of the earth? I have throughout maintained the existence of this preponderance solely by geographical proof, and conceiving that the evidence is conclusive, whilst no meteorological theory points to any explanation of it, I am compelled to attribute it to the action of some force external to the earth; possibly, as I have endeavoured to show, to the attraction of the sun, moon, and other heavenly bodies; possibly also to some other force, magnetic or meteoric, of whose action we have as yet no knowledge or understanding: but supposing, as I do, that the force which produces this motion is external to the earth, it is impossible to avoid the conclusion that it does tend to increase the earth's velocity of rotation. On the other hand, there are forces, admitted by all naturalists, in constant action, which tend to decrease the velocity of rotation; and a certain amount of wonder that the decrease so caused is so small as observation proves it to be is implied, rather than expressed, in our most valuable works on Natural Philosophy. If it is impossible in the present state of our knowledge to show exactly what such decrease is and ought to be, it is certainly impossible to say that it is not to some extent counterbalanced by a contrary tendency towards an increase, such as I have shown probably exists. At any rate, I know of nothing connected with the rotation of the earth which in any way controverts or affirms the proposition which I have put forward, based on geographical evidence only.

I had written this before seeing Mr. Murphy's second letter on the subject in NATURE for March 30, but as he has in it merely repeated his former arguments, it is unnecessary to notice it more particularly.

J. K. LAUGHTON

Royal Naval College, Portsmouth

* Jameson's Journal, quoted in the "Arcana of Science and Art" for 1828.

SUBMARINE TELEGRAPHS

IT may possibly be within the memory of some persons that, about the year 1840, Sir C. Wheatstone first conceived the idea of transmitting messages under the sea, and practically carried out at that time the first submarine telegraph cable. Selecting Swansea Bay, South Wales, as the chosen spot for his experiment, the great inventor sat in an open boat, about three miles from the Mumbles Lighthouse, with the lighthouse keeper as his assistant. A conducting wire, insulated with hemp and a resinous compound, served as the electric communication between his open boat and the shore. It is from the successful results of this first crude experiment, and Wheatstone's investigations into the laws that regulate the transmission of electric currents through metallic conductors, published shortly afterwards in the Philosophical Transactions of the Royal Society of London, that our present system of the testing of submarine cables is based, and the vast system of inter-oceanic communication that connects the civilised world together, has been framed.

At the date of Wheatstone's first experiment, gutta-percha was undiscovered, and its insulating power unknown. By the employment of this gum, the electrical condition of the submarine cable, up to a certain standard, has been under ordinary circumstances rendered secure. Such being the case, and for the purpose of comparison hereafter, it is well to examine a little into the properties of this gum and that of india-rubber, another vegetable substance possessing insulating properties of the most remarkable kind, as applied to the construction of submarine cables. Gutta-percha, as is well known, is a vegetable gum, which becomes plastic and soft at a comparatively low temperature, about 100° F. Subjecting the gum to repeated cleansing processes to free it from impurities and extraneous vegetable matter, it is rendered tolerably dense and homogeneous, and in this state it is applied in successive layers or coats round the copper conducting wire as the insulating material, forming the "core" of the submarine cable, which is then termed "insulated," that is, capable to a certain extent of preventing the lateral escape of any electric current or charge which may be passed into the wire. A short investigation is now necessary to be made of some of the circumstances which take place when a wire thus insulated is submerged and subjected to the charge of an electric current. If the wire were absolutely insulated, that is, if gutta-percha were a perfect insulator offering an indefinite resistance to the passage of the current through its substance, any given quantity of electricity passed into the wire would remain there for a given time without loss, in the same way as when water is poured into a vessel, the level remains intact so long as there is no leakage. The amount of this leakage through the gutta-percha, or, in other words, its "conductive resistance," determines the insulating power of the cable. But this is not all that has to be considered; other circumstances affecting the value of the insulation come into play. The following analogous example will explain. When a leech is allowed to crawl through a glass tube, the head and body pass out first, while the tail—long and attenuated—is slowly withdrawn. So with the passing of an electric current through an insulated conductor, a portion of the current lags sluggishly behind, absorbed, as it were, into the substance of the insulating medium, and taking time to discharge itself in proportion to the amount of the sucking up, or "inductive capacity" of the insulator, for, in this respect, both gutta-percha and india-rubber may be regarded as a sponge, the current penetrating into the pores of the substance.

Without entering further into detail regarding the laws regulating the transmission of the current, it is sufficient to remember that the speed or power of transmitting a given number of messages in a given time over any cable depends materially upon the proportionate values of the "conductive resistance" and "inductive capacity" of the insulation. Thus there is at once established a measure by which the value of all known insulating materials may be determined and compared together, that is to say, if two cables of equal length and similar construction are taken—the one insulated with gutta-percha, and the other with india-rubber (Hooper's india-rubber)—the relative value and working speed of each can be accurately determined and compared. The successful employment of india-rubber as an insulating medium for submarine cables is of more recent date, and the estimation in which it is now held for that purpose is entirely due to the beautiful process employed in its manipulation by Mr. W. Hooper, of Mitcham. It is well known that india-rubber possesses a much higher insulating power than gutta-percha; as a gum it is also denser, more homogeneous, and infinitely more pliable and elastic than gutta-percha, while it is not affected in any considerable degree by variation of temperature—all qualities of the greatest importance as connected with submarine cable insulation.

Before entering upon a comparative statement of the insulation and speed of gutta-percha and Hooper's insulation, a short notice of the mode by which this insulating material is manipulated will be interesting, and will serve to give value to the practical data hereafter stated. The copper conductor, after being tinned, is coated with an insulation of pure india-rubber applied in the shape of a ribbon, lapped spirally round it. Next, two strips (one laid above and the other below) of india-rubber, chemically prepared to resist the action of sulphur, and called the "separator," are applied so as to completely surround the first rubber covering, as it were with a tube; a pair of grooved die-wheels giving the contour, and at the same time regulating accurately the guage of the core. Exterior strips are then similarly applied of a compound of rubber and a small percentage of sulphur. The whole is then lapped round with water-proof felt tape, and exposed for some hours in an oven to a heat of about 383° F. By this process the three successive coatings are welded into one solid, dense, homogeneous mass, having its distinctive features preserved as regards the individual character of the several layers. Thus the heat, in driving off the sulphur from the outside coating, has converted that envelope into an indestructible vulcanised rubber jacket. The second layer, or "separator," has intercepted the passing of the sulphur by reason of its chemical properties, while at the same time it has allowed an infinitesimal trace of the sulphur to combine with the internal coating of pure rubber round the conducting wire, sufficient to change its character into an indestructible and non-liquifying material, without its becoming in any way vulcanised. It is by this beautiful chemical affinity between the several layers, each performing its special part towards the production of one individual whole, that the "Hooper insulation" has succeeded in establishing the durability of the preparation, the comparative value of which, as compared with that of gutta-percha, will now be given.

First as regards temperature—it has been already stated that gutta-percha became plastic at about 100° F. At this temperature it loses also almost entirely its insulating properties; that is to say, if at a temperature of 32° F. the insulation of gutta-percha is taken as representing 100, at 75° it is reduced to 5·51, or little more than a twentieth part, while at the increased temperature of 100°, its insulating power has further decreased to 1·43, or about one seventieth part. Gutta-percha as an insulator is therefore unsuited for hot climates, or any exposed position where the temperature rises above 70°. Taking now Hooper's india-rubber insulation at 32° F. to be the same, 100, at 75° we find its insulation to be 24·50, or about one-fourth part, while at 100° it is 10·60, or about one-tenth part. Thus at the ordinary temperature of 75°, Hooper's core establishes its superior insulating properties under temperature in the proportion of four to one. The "inductive capacity" of Hooper's core, from its superior density, is only about two-thirds that of gutta-percha, while its insulation or resistance of the dielectric is fully twenty times greater than that of gutta-percha core, as exemplified in the tests given of some of the best known cables now at work.

The following is a list of some of the more important cables insulated with Hooper's core laid up to the present time:—

1. Cable crossing rivers in India, laid in 1865,	length	46 nauts.
2. Ceylon Cable, India, laid in 1866 . .	,,	35 ,,
3. India Cable	,,	40 ,,
4. Persian Gulf Cable	,,	500 ,,
5. Danish-English Cable	,,	363 ,,
6. Scotch-Norwegian Cable . . .	,,	247 ,,
7. Danish-Norwegian Cable. . . .	,,	73 ,,
8. Orkney and Shetland Islands Cable . .	,,	103 ,,

9. Pentlands Cable	. . . . .	length	11 nauts.
10. Scilly Islands Cable	. . . . .	,,	27 ,,
11. Swedish-Russian Cable	. . . . .	,,	103 ,,
12. Moen Bornholm Cable	. . . . .	,,	80 ,,
13. Hong-Kong-Shanghae Cable	. . . .	,,	1200 ,,
14. Shanghae-Possiette Cable	. . . .	,,	1100 ,,

These two latter cables have recently been completed, and the Shanghae-Possiette cable is now in course of submergence; the Hong-Kong-Shanghae cable was successfully laid last month. These lines give a total distance of over 3,978 nautical miles of submarine cable with Hooper's indiarubber insulation. The following observations as regards the electrical conditions of these cables as compared with well-known gutta-percha insulated cables is remarkable. The electrical tests of well-known cables with both the gutta-percha and the Hooper core are taken at the temperature of 75° Fahr., and in terms of British Association (B.A.) units, the standard measure now most generally adopted in England for comparison:

		Gutta-percha.	
England and Hanover Cable, laid	1866 .	239 million	B.A. units
Persian Gulf Cable . ,,	1864 .	190 ,,	,,
Atlantic Cable . . ,,	1865 .	349 ,,	,,
Atlantic Cable . . ,,	1866 .	312 ,,	,,
Placentia Bay Cable . ,,	1866 .	455 ,,	,,
Cuba and Florida Cable . ,,	1867 .	464 ,,	,,
		Hooper Core.	
Ceylon Cable (Hooper's Core) ,,	1865 .	7949 ,,	,,
India Cable . . . ,,	1865 .	8064 ,,	,,
India Cable . . . ,,	1866 .	8526 ,,	,,
Danish-English Cable . ,,	1868 .	8123 ,,	,,
Scotch-Norwegian Cable ,,	1869 .	7923 ,,	,,
Scilly Islands Cable . ,,	1870 .	7819 ,,	,,

With such results, it is not to be wondered at that the relative speed of two cables of similar length and construction, the one employing a gutta-percha core and the other a Hooper core, should be found greatly in favour of the latter, in the proportion of 130 to 100; that is to say, in any given time the Hooper core, from its superior insulating properties, will transmit thirty per cent. more words than a gutta-percha core, a most important circumstance when it is considered that the earnings or dividend upon each cable is dependent upon the work it can perform in a given period. As regards the apparatus employed for transmitting the currents through submarine conductors, the "Wheatstone" automatic recording system is the most successful. By this apparatus an average speed of over thirty words a minute is regularly maintained upon the Danish-English cable, a distance of 363 nautical miles, exclusive of a further land circuit of over 140 miles, making a total distance of about 500 miles. This speed must be compared with that of seventeen words per minute, the highest result recorded over the same circuit by the most improved Morse system. From the results of the "Wheatstone" apparatus working over this circuit since September 1868, it appears that to obtain maximum speed, the currents through a submarine cable require to be transmitted of equal duration, at equal intervals, in alternate directions, and the line discharged to earth between each successive reversal or current to neutralise the charge, all of which conditions are fulfilled in the "Wheatstone" Automatic Jacquard arrangement, which can only be compared to a loom weaving the currents into the line, the sequence of the currents representing the pattern on the cloth. This apparatus is now organised as the transmitting and recording register upon the vast system of submarine circuits belonging to the Great Northern Telegraph Company, and the extensions from Possiette Bay (Russian-Chinese frontier) to Nagasaki, Shanghae, and Hong-Kong. The subject of high speed transmission through insulated conductors, both by land and sea, is one which demands special attention, now that the telegraph is daily encroaching upon the postal service, a service in which both speed and accuracy are more than ever demanded by the public.

NATH. J. HOLMES

PFLÜGER'S NERVE ENDINGS IN GLANDS

In his "Archiv für die Gesammte Physiologie" (Bonn, 1871), E. Pflüger gives a short and summary answer to those many observers who have thrown doubt on the accuracy of his remarkable discoveries as to the continuity of nerves with the secreting cells of the salivary glands and liver. Pflüger's opponents in this matter have been Mayer, Hering, Krause, Henle, and Schweigger-Seidel. The objections which have been made are divided by him into three heads. 1st. It was said that the nerves he had seen were capillary vessels. 2nd. That they were threads of mucus. 3rd. They were disintegrated fat. These objections are successively shown to be groundless, and Pflüger stoutly maintains his original position. What is far more important in this short paper than these answers to objections is that the professor at length publishes an account of some of his methods as to which he has so long left every one in the dark. They are certain to be interesting to some of our readers. *Salivary glands.* A fresh submaxillary gland from the ox must be taken, and very fine sections made; these must be at once teased out in perosmic acid sp. gr. 1003, and covered with a thin glass in a shallow cell. A great many preparations should be made, and the best picked out. They will be sufficiently stained in 24 hours. As the water dries up it may be replaced by glycerine. *Liver.* A great number of very fine sections must be made from the fresh liver of a dog or pig. These sections must be placed 10 or 12 together in watch-glasses filled with Beale's carmine solution, and thus kept in a moist chamber 14 days. The sections must then be taken out, washed one by one in a drop of perosmic acid, sp. gr. 1003, transported to a fresh drop of the same on a slide, and carefully teased out, covered, and examined.

NOTES

ST. BARTHOLOMEW'S HOSPITAL has, we learn from the *British Medical Journal*, sustained a great loss in the resignation by Mr. Paget of his active duties as Surgeon to the Hospital. Mr. Paget will, of course, receive the appointment of Consulting Surgeon to the Institution which he has served long and faithfully, and on which he has conferred lustre.

THE following excursions have been arranged by the Geologists' Association to take place in May:—To Oxford on Friday, 12th May. On arriving at Oxford the New University Museum will be visited. Subsequently the party, accompanied by the President, Prof. Phillips, and Prof. Morris, will walk to Shotover Hill, where the Middle and Upper Oolites are well exposed. To Grays, Essex, on Saturday, 20th May. Exposures of the Mammaliferous beds of the Thames Valley, and afterwards sections of the Upper Chalk will be visited, under the guidance of Prof. Morris. A four days' excursion to Yeovil, Weymouth, and Portland is proposed for Whitsuntide. Particulars of arrangements will be duly announced.

THE Edinburgh Naturalists' Field Club, which has since its formation carried on active operation only from April to July inclusive, held its adjourned annual meeting and conversazione on Saturday, the 22nd April, when Mr. Robert Scot-Skirving, the president, delivered an introductory address, enlarging mainly on entomology as a fit summer field study. The business meeting was held in November last, when, in addition to the present president and committee, Prof. Liston was elected vice-president, and Mr. Andrew Taylor honorary secretary and treasurer.

THE following is the programme of the lectures on the Experimental and Natural Sciences in Trinity Term, in Trinity College, Dublin. Mineralogy, 11 A.M., on Mondays, Wednesdays, and Fridays. Demonstrations in Organic Chemistry, 12, Mondays, Wednesdays, and Fridays. Magnetism, 2 P.M., Mondays, Wednesdays, and Fridays. Comparative Anatomy, 11 A.M., Mondays, Wednesdays, and Fridays. Demonstrations in Botany, 11 A.M., Tuesdays, Thursdays, and Saturdays. Applied Geology, 1 P.M., Tuesdays, Thursdays, and Saturdays.

THE grace for allowing French and German as an alternative for Greek, was submitted to the Senate of the University of Cambridge on Thursday last, and rejected by a majority of three only. The subject will doubtless be reopened, and probably some slight modification of the original scheme will ultimately be accepted.

THE following gentlemen have been elected, by the Senate of the University of London, Examiners in Science and Medicine for the ensuing year :—Logic and Moral Philosophy : Prof. G. Croom Robertson and Rev. John Venn. Political Economy : Prof. W. Stanley Jevons and Prof. T. E. Cliff Leslie. Mathematics and Natural Philosophy : Prof. H. J. S. Smith, F.R.S., and Prof. Sylvester, F.R.S. Experimental Philosophy : Prof. W. G. Adams and Prof. G. Carey Foster, F.R.S. Chemistry : Henry Debus, F.R.S., and Prof. Odling, F.R.S. Botany and Vegetable Physiology : Dr. J. D. Hooker, F.R.S., and Dr. Thos. Thomson, F.R.S. Geology and Palæontology : Prof. Duncan, F.R.S., and Prof. Morris. Practice of Medicine : John S. Bristowe, M.D., and Prof. J. Russell Reynolds, M.D., F.R.S. Surgery : Prof. John Birkett and Prof. John Marshall, F.R.S. Anatomy : Prof. Geo. Viner Ellis and Prof. John Wood. Physiology, Comparative Anatomy, and Zoology : Prof. M. Foster, M.D., and H. Power. Obstetric Medicine : Rob. Barnes, M.D., and Prof. W. M. Graily Hewitt, M.D. Materia Medica and Pharmaceutical Chemistry : Thos. R. Fraser, M.D., and Prof. A. Baring Garrod, M.D., F.R.S. Forensic Medicine : E. Headlam Greenhow, M.D., F.R.S., and Thos. Stevenson, M.D.

MR. C. T. CLOUGH, of Rugby School, has been elected to an exhibition at St. John's College, Cambridge, of 50*l.* per annum, for proficiency in Natural Science. There were ten candidates.

SCIENCE appears to have penetrated even into the recesses of Christ's Hospital. Since October 1869, there has been a Chemistry class of about fifty boys, in connection with St. Bartholomew's Hospital. The work done is both practical and theoretical ; at the first, Dr. Matthiessen was the lecturer, and at his lamented death, Dr. H. E. Armstrong. Since Christmas the class has been under the care of Dr. W. T. Russell, F.C.S. For some weeks past, Prof. Tennant has been lecturing on Mineralogy, and next week commences on Geology. This class is very well attended. There has been established a permanent class for Natural Philosophy, under the care of Mr. James Noon, B.A. We believe also that those boys who are intended for the Navy are instructed in theoretical and practical Astronomy. There have been wishes expressed for a Museum, and numerous specimens are constantly brought to Prof. Tennant for information. It is much to be wished also that some sort of a Natural History Society might be established, notwithstanding the city-site of the Hospital.

WE continue to receive intelligence from the French Academy, and are in a position to give the full list of members who were present at the sitting on the 21st April, eighteen in number, viz., three astronomers, Yvon Villareau, Mathieu, and Langier ; one mathematiciau, Chasles ; one physicist, Jamin, three chemists, Chevreul, Payer, Peligot ; one mechanician, Ameral Paris ; and the others medical men or naturalists, Milne-Edwards, Blanchard, Robin, Trécul, Bienaymè, Duchartre, and Quatrefages. M. Egger, of the Academy of Inscriptions, sat with his colleagues, and M. Simon Newcomb, the American astronomer, sat at the place allotted to foreign learned men.

THE seventh part of the illustrated work on the butterflies of North America, by Mr. Wm. H. Edwards, has just been published, containing numerous well-engraved and coloured plates of butterflies.

THE Commune has its own balloons, twelve in number, but they are kept apart for the private use of members when the final exit shall take place. One was sent up into the air, as it was said in the political newspapers for carrying away the masonic proclamation, but it was a little one without aëronaut.

THE *Gardener's Chronicle* for last Saturday prints an interesting letter from Dr. Hooker, dated Tetuan, April 12. In the journey from Tangier to Tetuan, Dr. Hooker notices that the general features of the flora of the low grounds and moderate hills in that part of North Morocco coincide with those of South-western Spain. Whole tracts are covered with masses of broom, so that the hills precisely resemble those of Scotland or Jersey. The previous day a guard had been obtained in order to ascend Beni-Hosmar, which mountain had only been visited previously by one botanist, Mr. Webb, some forty years since. The party ascended to 3,500 feet, and obtained a superb view across the Mediterranean to the Spanish coast, and south to the snowy crest of Beni-Hassan. It is a splendid rugged mass of limestone peaks, separated by very steep narrow-floored valleys, the flanks of which are crested with rifted white precipices. The whole is clothed with stunted shrubs up to 3,000 feet. They found some rare, and some probably new plants, but at a height of 3,400 feet no signs of a sub-alpine flora. The party did not succeed in reaching the summit.

THE principal object of interest at the *soirée* of the Linnean Society on the 26th ult., was again Mr. Wilson Saunders's collection of mimetic plants, which was even more remarkable than last year. The following is a list of the pairs exhibited :

Olea europœa	Oleaceæ
Swammerdamia antennata	Compositæ
Anemone coronaria	Ranunculaceæ
Pelargonium triste	Geraniaceæ
Osmanthus heterophyllus	Oleaceæ
Ilex aquifolium *var*	Aquifoliaceæ
Gnaphalium orientale	Compositæ
Lavendula lanata	Labiatæ
Iris pulchella	Iridaceæ
Dicrypta iridoides	Orchidaceæ
Pothos argyrea	Araceæ
Peperomia arifolia	Piperaceæ
Adonis autumnalis	Rannnculaceæ
Pyrethrum inodorum	Compositæ
Heterotropa asaroides	Aristolochiaceæ
Cyclamen persicum *var*	Primulaceæ
Oxalis Plumieri	Oxalidaceæ
Crotalaria laburnifolia	Leguminosæ
Gentiana lutea	Gentianaceæ
Veratrum viride	Melanthaceæ
Gymnostachyum Verschaffeltii	Acanthaceæ
Echites rubro-venosa	Apocynaceæ
Grevillea *sp.*	Proteaceæ
Acacia *sp.*	Leguminosæ
Rosa *sp.*	Rosaceæ
Xanthoxylon *sp*	Xanthoxylaceæ
Euphorbia mammillaria	Euphorbiaceæ
Apteranthes Gaponiana	Asclepiadaceæ
Dancus Carota	Umbelliferæ
Pelargonium rutæfolium	Geraniaceæ

A SERIES of scientific lectures, in connection with the School of Science and Art, has been for some time in contemplation at Taunton. It has recently commenced with a course of botanical lectures, by the Rev. W. Tuckwell, headmaster of the College School, which attract a large and diligent audience, consisting both of artisans and amateurs.

AT the annual dinner of the Institution of Civil Engineers held on April 22, Prof. Huxley, in responding to the toast of the learned societies in this country, gave the company some very sound advice as to the duty of the body of civil engineers in enforcing upon the public mind the truth that there can be no technical education of any value or soundness which is not based on a thorough preliminary training in abstract or theoretical practical science.

MR. JOHN GIBBS, of the Essex and Chelmsford Museum, publishes, at the price of a shilling, "A First Catechism of Botany," which has received the sanction of the Committee of Selection for the International Exhibition. Although the catechismal form always seems to us a needlessly cumbrous and circumlocutory one, for those who think otherwise a large amount of useful elementary information will be found in this little publication.

WE learn from Trübner's *American and Oriental Literary Record* that the American Ethnological Society was permanently reorganised under the name of "The Anthropological Institute of New York," on the 9th of March, and the following officers were elected:—E. Geo. Squier, president; J. C. Nott and Geo. Gibbs, vice-presidents; J. G. Shea, J. K. Merrill, E. H. Davis, C. C. Jones, jun., and W. H. Thomson, executive committee; A. J. Cotteral, treasurer; Charles Raw, foreign corresponding secretary; H. T. Drowne, domestic corresponding secretary; H. R. Stiles, recording secretary; and Geo. H. Moore, custodian. The objects of the institute are declared to be:—1. The study of man in all his varieties, and under all his aspects and relations. 2. Its special object the study of the history, conditions, and relations of the aboriginal inhabitants of America, and the phenomena resulting from the contact of the various races and families of men on this continent, before and since the discovery. 3. The physical characteristics, religious conceptions, and systems of men; their mythology and traditions; their social, civil, and political organisations and institutions; their language, literature, arts, and monuments; their mode of life and their customs are specifically within the objects of the Institute. 4. The collection of manuscripts, books, and relics illustrating these several subjects; the stimulation and encouragement of inquiry and research, particularly in unexplored American fields; and by means of such publications as may be deemed proper, to utilise the results of its investigations and efforts for the benefit of science and of mankind. 5. It recognises the widest range of discussion, and a complete tolerance of individual opinions on all subjects within the scope of the Institute's objects. The Institute proposes to publish a series of Memoirs, and a Journal.

THE attention of astronomers throughout the world is directed toward the approaching transit of Venus, to occur on the 18th of December, 1874, and it is hoped, we learn from *Harper's Weekly*, that the United States Congress, with the same liberality that induced it to make an appropriation for the observation of the solar eclipse of December last, and for the polar exploration under Captain Hall, will also, at the proper time, advance the funds necessary for the research in this case. Professor Hall, of the Washington Observatory, in a late communication to the *Journal of Science*, expresses the hope that a concert of action will be settled upon by American astronomers, in order that they may not be behind their European *confrères* in the attempt to secure satisfactory results. A committee has been appointed by the National Academy of Sciences to take into consideration a general plan of operations, and it is expected that a report will be made on the subject at the approaching meeting in Washington city.

THE annual report of Professor Cooke, State Geologist of New Jersey, for 1870, has just been published; and although less in bulk than some of its predecessors, it contains some important information in regard to fertilisers used in the State, the marshes and tracts of land subject to protracted freshets, the soils, the iron and zinc ores, and other miscellaneous topics. The subject of drainage has attracted Professor Cooke's especial attention, on account of the vast tracts of land in the eastern portion of the State now either regularly overflowed at certain periods of the tide, or liable to freshets or inundations. In order more properly to qualify himself for this inquiry, Professor Cooke paid an extended visit to the drained lands of Holland and England, the results of which he presents in his report.

M. LONGET, the celebrated physiologist, member of the French Institute and of the French Academy of Medicine, died at the age of sixty-eight, at Bordeaux, a few days since. M. Longet is the author of works on the nervous system, which explain many of his own discoveries. His death was sudden, and was referred by his friends to the horror with which he was stricken when hearing the sad news from Paris.

IN the forthcoming number of the *American Journal of Science* will be found an article, by Professor Marsh, upon some new serpents of the Tertiary deposits of Wyoming. It will be remembered that in a previous notice of Professor Marsh's discoveries in the Rocky Mountains, we called attention to the difference observed by him between the contents of the Tertiary beds in the vicinity of Fort Bridger and those of the Mauvaises Terres of the Upper Missouri, the former being especially characterised, as compared with the latter, by the presence of reptiles in great variety. Among these are many terrestrial species, including several kinds of land lizards; and among the forms generally serpents appear to be quite predominant. Of the latter, Professor Marsh has already determined the existence of five new species, belonging to three new genera; and others will probably be yet brought to light.

AT the present day, when the columns of our newspapers teem with advertisements of various preparations for promoting the growth or changing the colour of the hair, the following account of the results of the use of a preparation of boxwood for that purpose may be of interest. Boxwood, according to the old herbalists, was used from a remote period to render the hair auburn; and we are told by Phillips that a young woman in Lower Silesia, whose hair had fallen off after a severe attack of dysentery, was advised to wash her head with a decoction of boxwood, in order to induce it to grow again. This she did; and "hair of a chestnut colour grew on her head, as she was told it would do; but, having used no precaution to secure her face and neck from the lotion, they became covered with red hair to such a degree that she seemed but little different from an ape or a monkey!"

MR. JAMES BOYD, of Panama, published some time ago in the *Panama Star and Herald*, under the head of "The Migration of Butterflies across the Isthmus," an account of the phenomenon of the migration in one direction of the *Urania Leilus*. This being republished in England has led to some correspondence with Mr. Boyd, particularly from a naturalist resident at Liverpool. This gentleman states that in January 1845, he observed the same habit of the Urania in the Island of Caripi, one of those near Para, in the Brazils. From an early hour in the morning until nearly dark these insects passed along the shore in amazing numbers, but most numerously in the evening. It was very seldom that one was seen in the opposite direction. The main course was from west to east. He also saw it at Pernambuco, at Rio Janeiro, and in the Southern States of America, but nowhere so abundant as on the Amazons. The Urania is scarcely a butterfly; but between the day and night butterflies, something between a skipper and a hawk moth. By Latreille they were called Hespero-Sphyngidæ. The larvæ and pupæ are supposed not to have been adequately examined. The Liverpool naturalist could not identify them, and as yet they have not been able to find them at Panama. In Central America the Urania is found as far north as Guatemala. Mr. Darwin observed a butterfly of similar habits, the *Papilio feronia*, which frequents orange groves.

THE ROYAL SOCIETY'S LIST FOR 1871

THE following fifteen have been selected by the Council of the Royal Society out of the fifty candidates, and recommended to the Fellows for election:—*William Henry Besant*, M.A., Mathematical Lecturer at St. John's College; Senior Wrangler and First Smith's Prizeman in 1850, Moderator in 1856, Examiner in the University of London from 1860 to 1865; author of Treatises on "Hydromechanics and the Theory of Sound," 2nd ed. 1867; "Elementary Hydrostatics," 2nd ed. 1867; "Geometrical Conic Sections," 1869; "Roulettes and Glissettes," 1870. *William Budd*, M.D. (Edin.), physician, author of various medical papers, especially relating to contagious diseases. *George W. Callender*, F.R.C.S., lecturer on Anatomy at St. Bartholomew's Hospital School, and Assistant Surgeon to Bartholomew's Hospital; author of Anatomical papers. *William Carruthers*, F.L.S., F.G.S., keeper of the Botanical Department, British Museum; author of "Fossil Cycadean Stems from the Secondary Rocks of Britain;" "On the Structure and Affinities of Sigillaria and Allied Genera;" "The Cryptogamic Forests of the Coal Period;" "On the Structure of the Stems of the Arborescent Lycopodiaceæ of the Coal-measures;" "Revision of the British Graptolites," &c. *Robert Etheridge*, F.R.S.E., F.G.S., Palæontologist to H.M. Geological Survey of Great Britain; Demonstrator on Palæontology, Royal School of Mines; author of numerous geological papers. *Frederick Guthrie*, B.A., F.R.S.E., F.C.S., Professor of Physics in the Royal School of Mines; author of various papers on Chemistry and Physics. *Captain John Herschel*, R.E., of the Great Trigonometrical Survey of India. *Captain Alexander Moncrieff*, Militia Artillery, C.E., inventor of the Moncrieff gun-carriage, and author of the Moncrieff system of defence. *Richard Quain*, M.D. (Lond.), Fellow and late Censor of the Royal College of Physicians; author of a paper "On Fatty Degeneration of the Heart," which has exerted a marked influence on certain branches of Pathological Science; and of numerous communications published in the Transactions of the Pathological Society, of which Society he was President (1869-70). *Carl Schorlemmer*, Senior Assistant in Owens College Laboratory, Manchester; author of a series of papers on the Constitution of the Paraffins, chiefly published in the Proceedings of the Society since 1862. *Edward Thomas*, Treas. R.A.S., author of numerous papers on Indian Coins and Gems. *Edward Burnet Tylor*, author of "Researches into the Early History of Mankind;" "Primitive Culture;" and various memoirs on Savages and their Customs. *Cromwell Fleetwood Varley*, Civil and Telegraphic Engineer, M.I.C.E.; Consulting Electrician to the Electric and International Telegraph Company, the Atlantic Telegraph Company, la Société du Cable Transatlantique Français; author of many inventions in connection with the Electric Telegraph. *Viscount Walden*, President of the Zoological Society of London; author of various papers on Ornithology. *John Wood*, F.R.C.S., Examiner in Anatomy at the University of London; author of a number of anatomical papers published in the Phil. Trans.

ON COLOUR VISION *

ALL vision is colour vision, for it is only by observing differences of colour that we distinguish the forms of objects. I include differences of brightness or shade among differences of colour.

It was in the Royal Institution, about the beginning of this century, that Thomas Young made the first distinct announcement of that doctrine of the vision of colours which I propose to illustrate. We may state it thus:—We are capable of feeling three different colour-sensations. Light of different kinds excites these sensations in different proportions, and it is by the different combinations of these three primary sensations that all the varieties of visible colour are produced. In this statement there is one word on which we must fix our attention. That word is, Sensation. It seems almost a truism to say that colour is a sensation; and yet Young, by honestly recognising this elementary truth, established the first consistent theory of colour. So far as I know, Thomas Young was the first who, starting from the well-known fact that there are three primary colours, sought for the explanation of this fact, not in the nature of light, but in the constitution of man. Even of those who have written on colour since the time of Young, some have supposed that they ought to study the properties of pigments, and others that they ought to analyse the rays of light. They have sought for a knowledge of colour by examining something in external nature —something out of ourselves.

Now, if the sensation which we call colour has any laws, it must be something in our own nature which determines the form of these laws; and I need not tell you that the only evidence we can obtain respecting ourselves is derived from consciousness.

The science of colour must therefore be regarded as essentially a mental science. It differs from the greater part of what is called mental science in the large use which it makes of the physical sciences, and in particular of optics and anatomy. But it gives evidence that it is a mental science by the numerous illustrations which it furnishes of various operations of the mind.

In this place we always feel on firmer ground when we are dealing with physical science. I shall therefore begin by showing how we apply the discoveries of Newton to the manipulation of light, so as to give you an opportunity of feeling for yourselves the different sensations of colour.

Before the time of Newton, white light was supposed to be of all known things the purest. When light appears coloured, it was supposed to have become contaminated by coming into contact with gross bodies. We may still think white light the emblem of purity, though Newton has taught us that its purity does not consist in simplicity.

We now form the prismatic spectrum on the screen. These are the simple colours of which white light is always made up. We can distinguish a great many hues in passing from the one end to the other; but it is when we employ powerful spectroscopes, or avail ourselves of the labours of those who have mapped out the spectrum, that we become aware of the immense multitude of different kinds of light, every one of which has been the object of special study. Every increase of the power of our instruments increases in the same proportion the number of lines visible in the spectrum.

All light, as Newton proved, is composed of these rays taken in different proportions. Objects which we call coloured when illuminated by white light, make a selection of these rays, and our eyes receive from them only a part of the light which falls on them. But if they receive only the pure rays of a single colour of the spectrum, they can appear only of that colour. If I place a disc containing alternate quadrants of red and green paper in the red rays, it appears all red, but the red quadrants brightest. If I place it in the green rays both papers appear green, but the red paper is now the darkest. This, then, is the optical explanation of the colours of bodies when illuminated with white light They separate the white light into its component parts, absorbing some and scattering others.

Here are two transparent solutions. One appears yellow, it contains bichromate of potash; the other appears blue, it contains sulphate of copper. If I transmit the light of the electric lamp through the two solutions at once, the spot on the screen appears green. By means of the spectrum we shall be able to explain this. The yellow solution cuts off the blue end of the spectrum, leaving only the red, orange, yellow, and green. The blue solution cuts off the red end, leaving only the green, blue, and violet. The only light which can get through both is the

* Lecture delivered before the Royal Institution, March 24th.

green light, as you see. In the same way most blue and yellow paints, when mixed, appear green. The light which falls on the mixture is so beaten about between the yellow particles and the blue, that the only light which survives is the green. But yellow and blue light when mixed do not make green, as you will see if we allow them to fall on the same part of the screen together.

It is a striking illustration of our mental processes that many persons have not only gone on believing, on the evidence of the mixture of pigments, that blue and yellow make green, but that they have even persuaded themselves that they could detect the separate sensations of blueness and of yellowness in the sensation of green.

We have availed ourselves hitherto of the analysis of light by coloured substances. We must now return, still under the guidance of Newton, to the prismatic spectrum. Newton not only

> Untwisted all the shining robe of day,

but showed how to put it together again. We have here a pure spectrum, but instead of catching it on a screen, we allow it to pass through a lens large enough to receive all the coloured rays. These rays proceed, according to well-known principles in optics, to form an image of the prism on a screen placed at the proper distance. This image is formed by rays of all colours, and you see the result is white. But if I stop any of the coloured rays, the image is no longer white, but coloured; and if I only let through rays of one colour, the image of the prism appears of that colour.

I have here an arrangement of slits by which I can select one, two, or three portions of the light of the spectrum, and allow them to form an image of the prism while all the rest are stopped. This gives me a perfect command of the colours of the spectrum, and I can produce on the screen every possible shade of colour by adjusting the breadth and the position of the slits through which the light passes. I can also, by interposing a lens in the passage of the light, show you a magnified image of the slits, by which you will see the different kinds of light which compose the mixture.

The colours are at present red, green, and blue, and the mixture of the three colours is, as you see, nearly white. Let us try the effect of mixing two of these colours. Red and blue form a fine purple or crimson, green and blue form a sea-green or sky-blue, red and green form a yellow.

Here again we have a fact not universally known. No painter, wishing to produce a fine yellow, mixes his red with his green. The result would be a very dirty drab colour. He is furnished by nature with brilliant yellow pigments, and he takes advantage of these. When he mixes red and green paint, the red light scattered by the red paint is robbed of nearly all its brightness by getting among particles of green, and the green light fares no better, for it is sure to fall in with particles of red paint. But when the pencil with which we paint is composed of the rays of light, the effect of two coats of colour is very different. The red and the green form a yellow of great splendour, which may be shown to be as intense as the purest yellow of the spectrum.

I have now arranged the slits to transmit the yellow of the spectrum. You see it is similar in colour to the yellow formed by mixing red and green. It differs from the mixture, however, in being strictly homogeneous in a physical point of view. The prism, as you see, does not divide it into two portions as it did the mixture. Let us now combine this yellow with the blue of the spectrum. The result is certainly not green; we may make it pink if our yellow is of a warm hue, but if we choose a greenish yellow we can produce a good white.

You have now seen the most remarkable of the combinations of colours—the others differ from them in degree, not in kind. I must now ask you to think no more of the physical arrangements by which you were enabled to see these colours, and to concentrate your attention upon the colours you saw, that is to say, on certain sensations of which you were conscious. We are here surrounded by difficulties of a kind which we do not meet with in purely physical inquiries. We can all feel these sensations, but none of us can describe them. They are not only private property, but they are incommunicable. We have names for the external objects which excite our sensations, but not for the sensations themselves.

When we look at a broad field of uniform colour, whether it is really simple or compound, we find that the sensation of colour appears to our consciousness as one and indivisible. We cannot directly recognise the elementary sensations of which it is composed, as we can distinguish the component notes of a musical chord. A colour, therefore, must be regarded as a single thing, the quality of which is capable of variation.

To bring a quality within the grasp of exact science, we must conceive it as depending on the values of one or more variable quantities, and the first step in our scientific progress is to determine the number of these variables which are necessary and sufficient to determine the quality of a colour. We do not require any elaborate experiments to prove that the quality of colour can vary in three and only in three independent ways.

One way of expressing this is by saying, with the painters, that colour may vary in hue, tint, and shade.

The finest example of a series of colours varying in hue, is the spectrum itself. A difference in hue may be illustrated by the difference between adjoining colours in the spectrum. The series of hues in the spectrum is not complete; for, in order to get purple hues, we must blend the red and the blue.

Tint may be defined as the degree of purity of a colour. Thus, bright yellow, buff, and cream-colour, form a series of colours of nearly the same hue, but varying in tint. The tints corresponding to any given hue form a series, beginning with the most pronounced colour, and ending with a perfectly neutral tint.

Shade may be defined as the greater or less defect of illumination. If we begin with any tint of any hue, we can form a gradation from that colour to black, and this gradation is a series of shades of that colour. Thus we may say that brown is a dark shade of orange.

The quality of a colour may vary in three different and independent ways. We cannot conceive of any others. In fact, if we adjust one colour to another, so as to agree in hue, in tint, and in shade, the two colours are absolutely indistinguishable. There are therefore three, and only three, ways in which a colour can vary.

I have purposely avoided introducing at this stage of our inquiry anything which may be called a scientific experiment, in order to show that we may determine the number of quantities upon which the variation of colour depends by means of our ordinary experience alone.

Here is a point in this room: if I wish to specify its position, I may do so by giving the measurements of three distances—namely, the height above the floor, the distance from the wall behind me, and the distance from the wall at my left hand.

This is only one of many ways of stating the position of a point, but it is one of the most convenient. Now, colour also depends on three things. If we call these the intensities of the three primary colour sensations, and if we are able in any way to measure these three intensities, we may consider the colour as specified by these three measurements. Hence the specification of a colour agrees with the specification of a point in the room in depending on three measurements.

Let us go a step farther, and suppose the colour sensations measured on some scale of intensity, and a point found for which the three distances, or co-ordinates, contain the same number of feet as the sensations contain degrees of intensity. Then we may say, by a useful geometrical convention, that the colour is represented to our mathematical imagination by the point so found in the room; and if there are several colours, represented by several points, the chromatic relations of the colours will be represented by the geometrical relations of the points. This method of expressing the relations of colours is a great help to the imagination. You will find these relations of colours stated in an exceedingly clear manner in Mr. Benson's "Manual of Colour," one of the very few books on colour in which the statements are founded on legitimate experiments.

There is a still more convenient method of representing the relations of colours, by means of Young's triangle of colours. It is impossible to represent on a plane piece of paper every conceivable colour, to do this requires space of three dimensions. If, however, we consider only colours of the same shade, that is, colours in which the sum of the intensities of the three sensations is the same, then the variations in tint and in hue of all such colours may be represented by points on a plane. For this purpose we must draw a plane cutting off equal lengths from the three lines representing the primary sensations. The part of this plane within the space in which we have been distributing our colours will be an equilateral triangle. The three primary colours will be at the three angles, white or gray will be in the middle, the tint or degree of purity of any colour will be expressed by its distance from the middle point, and its hue will depend on the angular position of the line which joins it with the middle point.

Thus the ideas of tint and hue can be expressed geometrically on Young's triangle. · To understand what is meant by shade, we have only to suppose the illumination of the whole triangle increased or diminished, so that by means of this adjustment of illumination Young's triangle may be made to exhibit every variety of colour. If we now take any two colours in the triangle and mix them in any proportions, we shall find the resultant colour in the line joining the component colours at the point corresponding to their centre of gravity.

I have said nothing about the nature of the three primary sensations, or what particular colours they most resemble. In order to lay down on paper the relations between actual colours, it is not necessary to know what the primary colours are. We may take any three colours, provisionally, as the angles of a triangle, and determine the position of any other observed colour with respect to these, so as to form a kind of chart of colours.

Of all colours which we see, those excited by the different rays of the prismatic spectrum have the greatest scientific importance. All light consists either of some one kind of these rays, or of some combination of them. The colours of all natural bodies are compounded of the colours of the spectrum. If, therefore, we can form a chromatic chart of the spectrum, expressing the relations between the colours of its different portions, then the colours of all natural bodies will be found within a certain boundary on the chart defined by the positions of the colours of the spectrum.

But the chart of the spectrum will also help us to the knowledge of the nature of the three primary sensations. Since every sensation is essentially a positive thing, every compound colour-sensation must be within the triangle of which the primary colours are the angles. In particular, the chart of the spectrum must be entirely within Young's triangle of colours, so that if any colour in the spectrum is identical with one of the colour-sensations, the chart of the spectrum must be in the form of a line having a sharp angle at the point corresponding to this colour.

I have already shown you how we can make a mixture of any three of the colours of the spectrum, and vary the colour of the mixture by altering the intensity of any of the three components. If we place a compound colour side by side with any other colour, we can alter the compound colour till it appears exactly similar to the other. This can be done with the greatest exactness when the resultant colour is nearly white. I have therefore constructed an instrument which I may call a colour-box, for the purpose of making matches between two colours. It can only be used by one observer at a time, and it requires daylight, so I have not brought it with me to-night. It is nothing but the realisation of the construction of one of Newton's propositions in his "Lectiones Opticæ," where he shows how to take a beam of light, to separate it into its components, to deal with these components as we please by means of slits, and afterwards to unite them into a beam again. The observer looks into the box through a small slit. He sees a round field of light, consisting of two semicircles divided by a vertical diameter. The semicircle on the left consists of light which has been enfeebled by two reflexions at the surface of glass. That on the right is a mixture of colours of the spectrum, the positions and intensities of which are regulated by a system of slits.

The observer forms a judgment respecting the colours of the two semicircles. Suppose he finds the one on the right hand redder than the other, he says so, and the operator, by means of screws outside the box, alters the breadth of one of the slits, so as to make the mixture less red; and so on, till the right semicircle is made exactly of the same appearance as the left, and the line of separation becomes almost invisible.

When the operator and the observer have worked together for some time they get to understand each other, and the colours are adjusted much more rapidly than at first.

When the match is pronounced perfect, the positions of the slits, as indicated by a scale, are registered, and the breadth of each slit is carefully measured by means of a gauge. The registered result of an observation is called a "colour equation." It asserts that a mixture of three colours is, in the opinion of the observer (whose name is given), identical with a neutral tint, which we shall call Standard White. Each colour is specified by the position of the slit on the scale, which indicates its position in the spectrum, and by the breadth of the slit, which is a measure of its intensity.

In order to make a survey of the spectrum we select three points for purposes of comparison, and we call these the three Standard Colours. The standard colours are selected on the same principles as those which guide the engineer in selecting stations for a survey. They must be conspicuous and invariable, and not in the same straight line.

In the chart of the spectrum you may see the relations of the various colours of the spectrum to the three standard colours, and to each other. It is manifest that the standard green which I have chosen cannot be one of the true primary colours, for the other colours do not all lie within the triangle formed by joining them. But the chart of the spectrum may be described as consisting of two straight lines meeting in a point. This point corresponds to a green about a fifth of the distance from *b* towards F. This green has a wave-length of about 510 millionths of a millimetre by Ditscheiner's measure. This green is either the true primary green, or at least it is the nearest approach to it which we can ever see. Proceeding from this green towards the red end of the spectrum, we find the different colours lying almost exactly in a straight line. This indicates that any colour is chromatically equivalent to a mixture of any two colours on opposite sides of it and in the same straight line. The extreme red is considerably beyond the standard red, but it is in the same straight line, and therefore we might, if we had no other evidence, assume the extreme red as the true primary red. We shall see, however, that the true primary red is not exactly represented in colour by any part of the spectrum. It lies somewhat beyond the extreme red but in the same straight line.

On the blue side of primary green the colour equations are seldom so accurate. The colours, however, lie in a line which is nearly straight. I have not been able to detect any measurable chromatic difference between the extreme indigo and the violet. The colours of this end of the spectrum are represented by a number of points very close to each other. We may suppose that the primary blue is a sensation differing little from that excited by the parts of the spectrum near G.

Now, the first thing which occurs to most people about this result is that the division of the spectrum is by no means a fair one. Between the red and the green we have a series of colours apparently very different from either, and having such marked characteristics that two of them, orange and yellow, have received separate names. The colours between the green and the blue, on the other hand, have an obvious resemblance to one or both of the extreme colours, and no distinct names for these colours have ever become popularly recognised.

I do not profess to reconcile this discrepancy between ordinary and scientific experience. It only shows that it is impossible, by a mere act of introspection, to make a true analysis of our sensations. Consciousness is our only authority; but consciousness must be methodically examined in order to obtain any trustworthy results.

I have here, through the kindness of Professor Huxley, a picture of the structure upon which the light falls at the back of the eye. There is a minute structure of bodies like rods and cones or pegs, and it is conceivable that the mode in which we become aware of the shapes of things is by a consciousness which differs according to the particular rods on the ends of which the light falls, just as the pattern on the web formed by a Jacquard loom depends on the mode in which the perforated cards act on the system of movable rods in that machine. In the eye we have on the one hand light falling on this wonderful structure, and on the other hand we have the sensation of sight. We cannot compare these two things; they belong to opposite categories. The whole of Metaphysics lies like a great gulf between them. It is possible that discoveries in physiology may be made by tracing the course of the nervous disturbance

Up the fine fibres to the sentient brain;

but this would make us no wiser than we are about those colour-sensations which we can only know by feeling them ourselves. Still, though it is impossible to become acquainted with a sensation by the anatomical study of the organ with which it is connected, we may make use of the sensation as a means of investigating the anatomical structure.

A remarkable instance of this is the deduction of Helmholtz's theory of the structure of the retina from that of Young with respect to the sensation of colour. Young asserts that there are three elementary sensations of colour; Helmholtz asserts that there are three systems of nerves in the retina, each of which has for its function, when acted on by light or any other disturbing agent, to excite in us one of these three sensations.

No anatomist has hitherto been able to distinguish these three systems of nerves by microscopic observation. But it is admitted in physiology that the only way in which the sensation excited by a particular nerve can vary is by degrees of intensity. The intensity of the sensation may vary from the faintest impression up to an insupportable pain; but whatever be the exciting cause, the sensation will be the same when it reaches the same intensity. If this doctrine of the function of a nerve be admitted, it is legitimate to reason from the fact that colour may vary in three different ways, to the inference that these three modes of variation arise from the independent action of three different nerves or sets of nerves.

Some very remarkable observations on the sensation of colour have been made by M. Sigmund Exner in Prof. Helmholtz's physiological laboratory at Heidelberg. While looking at an intense light of a brilliant colour, he exposed his eye to rapid alternations of light and darkness by waving his fingers before his eyes. Under these circumstances a peculiar minute structure made its appearance in the field of view, which many of us may have casually observed. M. Exner states that the character of this structure is different according to the colour of the light employed. When red light is used a veined structure is seen; when the light is green, the field appears covered with minute black dots, and when the light is blue, spots are seen, of a larger size than the dots in the green, and of a lighter colour.

Whether these appearances present themselves to all eyes, and whether they have for their physical cause any difference in the arrangement of the nerves of the three systems in Helmholtz's theory I cannot say, but I am sure that if these systems of nerves have a real existence, no method is more likely to demonstrate their existence than that which M. Exner has followed.

Colour Blindness

The most valuable evidence which we possess with respect to colour vision is furnished to us by the colour-blind. A considerable number of persons in every large community are unable to distinguish between certain pairs of colours which to ordinary people appear in glaring contrast. Dr. Dalton, the founder of the atomic theory of chemistry, has given us an acccount of his own case.

The true nature of this peculiarity of vision was first pointed out by Sir John Herschel in a letter written to Dalton in 1832, but not known to the world till the publication of "Dalton's Life" by Dr. Henry. The defect consists in the absence of one of the three primary sensations of colour. Colour-blind vision depends on the variable intensities of two sensations instead of three. The best description of colour-blind vision is that given by Prof. Pole in his account of his own case in the "Phil. Trans.," 1859.

In all cases which have been examined with sufficient care, the absent sensation appears to resemble that which we call red. The point P on the chart of the spectrum represents the relation of the absent sensation to the colours of the spectrum, deduced from observations with the colour box furnished by Prof. Pole.

If it were possible to exhibit the colour corresponding to this point on the chart, it would be invisible, absolutely black, to Prof. Pole. As it does not lie within the range of the colours of the spectrum we cannot exhibit it; and, in fact, colour-blind people can perceive the extreme end of the spectrum which we call red, though it appears to them much darker than to us, and does not excite in them the sensation which we call red. In the diagram of the intensities of the three sensations excited by different parts of the spectrum, the upper figure, marked P, is deduced from the observations of Prof. Pole; while the lower one, marked K, is founded on observations by a very accurate observer of the normal type.

The only difference between the two diagrams is that in the upper one the red curve is absent. The forms of the other two curves are nearly the same for both observers. We have great reason therefore to conclude that the colour sensations which Prof. Pole sees are what we call green and blue. This is the result of my calculations; but Prof. Pole agrees with every other colour-blind person whom I know in denying that green is one of his sensations. The colour-blind are always making mistakes about green things and confounding them with red. The colours they have no doubts about are certainly blue and yellow, and they persist in saying that yellow, and not green, is the colour which they are able to see.

To explain this discrepancy we must remember that colour-blind persons learn the names of colours by the same method as ourselves. They are told that the sky is blue, that grass is green, that gold is yellow, and that soldiers' coats are red. They observe difference in the colours of these objects, and they often suppose that they see the same colours as we do, only not so well. But if we look at the diagram we shall see that the brightest example of their second sensation in the spectrum is not in the green, but in the part which we call yellow, and which we teach them to call yellow. The figure of the spectrum below Prof. Pole's curves is intended to represent to ordinary eyes what a colour-blind person would see in the spectrum. I hardly dare to draw your attention to it, for if you were to think that any painted picture would enable you to see with other people's vision I should certainly have lectured in vain.

On the Yellow Spot

Experiments on colour indicate very considerable differences between the vision of different persons, all of whom are of the ordinary type. A colour, for instance, which one person on comparing it with white will pronounce pinkish, another person will pronounce greenish. This difference, however, does not arise from any diversity in the nature of the colour sensations in different persons. It is exactly of the same kind as would be observed if one of the persons wore yellow spectacles. In fact, most of us have near the middle of the retina a yellow spot through which the rays must pass before they reach the sensitive organ: this spot appears yellow because it absorbs the rays near the line F, which are of a greenish-blue colour. Some of us have this spot strongly developed. My own observations of the spectrum near the line F are of very little value on this account. I am indebted to Professor Stokes for the knowledge of a method by which any one may see whether he has this yellow spot. It consists in looking at a white object through a solution of chloride of chromium, or at a screen on which light which has passed through this solution is thrown. This light is a mixture of red light with the light which is so strongly absorbed by the yellow spot. When it falls on the ordinary surface of the retina it is of a neutral tint, but when it falls on the yellow spot only the red light reaches the optic nerve, and we see a red spot floating like a rosy cloud over the illuminated field.

Very few persons are unable to detect the yellow spot in this way. The observer K, whose colour equations have been used in preparing the chart of the spectrum, is one of the very few who do not see everything as if through yellow spectacles. As for myself, the position of white light in the chart of the spectrum is on the yellow side of true white even when I use the outer parts of the retina; but as soon as I look direct at it, it becomes much yellower, as is shown by the point W C. It is a curious fact that we do not see this yellow spot on every occasion, and that we do not think white objects yellow. But if we wear spectacles of any colour for some time, or if we live in a room lighted by windows all of one colour, we soon come to recognise white paper as white. This shows that it is only when some alteration takes place in our sensations that we are conscious of their quality.

There are several interesting facts about the colour sensation which I can only mention briefly. One is that the extreme parts of the retina are nearly insensible to red. If you hold a red flower and a blue flower in your hand as far back as you can see your hand, you will lose sight of the red flower, while you still see the blue one. Another is, that when the light is diminished red objects become darkened more in proportion than blue ones. The third is, that a kind of colour blindness in which blue is the absent sensation can be produced artificially by taking doses of santonine. This kind of colour blindness is described by Dr. Edmund Rose, of Berlin. It is only temporary, and does not appear to be followed by any more serious consequences than headaches. I must ask your pardon for not having undergone a course of this medicine, even for the sake of becoming able to give you information at first hand about colour-blindness.

J. Clerk Maxwell

SCIENTIFIC SERIALS

The *Quarterly Journal of Science* for April commences with a very interesting account, by Dr. Hofmann, of the early days of the Royal College of Chemistry, under the title of "A Page of Scientific History." After tracing the influence of Liebig's school at Giessen on the progress of chemical science in this country, and the choice of himself, at the recommendation of Liebig, as the professor at the laboratory which it was determined to establish in London, Dr. Hofmann proceeds to a narrative of the difficulties experienced by the new school in the deficiency of the money received from the fees of students to meet the necessary expenses as well as the debt incurred by the outlay for building. At this stage the college narrowly escaped the entire abandonment of its primary object, the advancement of science by means of practical instruction and original researches, to sink into a mere commercial undertaking for conducting analyses. To the influence of Sir James Clark, one of the earliest friends of the College, was mainly due the ultimate success of the efforts of the Council to induce the Government to adopt the College as the chemical department of the Museum of Practical Geology; since which period its career of usefulness has been unchecked.—Dr. A. E. Sansom follows with an article on "The Theory of Atmospheric Germs," in which he records the investigations on this subject which have been conducted to the present time, especially those of Hallier and Bastian; and sums up adversely to the theory of abiogenesis.—Mr. Mungo Ponton, in his short paper on Molecules, Ultimates, Atoms, and Waves, suggests the use of the term "molecule" to denote the particles of chemical compounds; "ultimate," those of chemical elements; and "atom," the assumed constituents of those ultimates, themselves incapable of further analysis.—Prof. Piazzi Smyth occupies no less than thirty-eight pages with the conclusion of his article on "The Great Pyramid of Egypt from a modern scientific Point of View."—Sir William Fairbairn has some very practical remarks on Steam Boiler Legislation, in which he details the failure of voluntary associations for the purpose of diminishing the loss of life and property occasioned by the use of defective boilers, and advocates the enforced legal testing of boilers by competent authorities, maintaining that it is clearly the duty of the Government to interfere on behalf of those whose lives are jeopardised, and to enact that no boiler shall be worked unless periodically examined and certified.—The last article is an account of the Eclipse of last December, by Mr. R. A. Proctor. Notices of books and a record of the progress of science in the departments of light, heat, electricity, meteorology, mineralogy, mining, metallurgy, engineering, geology and palæontology, and botany, fill up a very good number.

THE numbers of the *American Naturalist* for March and April contain some good articles. The Polarity of the Compass Plant (*Silphium laciniatum*) is a subject which has recently attracted attention, and Mr. W. F. Whitney's short article under this title sums up what is at present known about its causes.—Mr. J. A. Allen's paper in a previous number on "The Flora of the Prairies" is followed by one on "The Fauna of the Prairies."—Dr. G. H. Perkins describes some interesting relics of the Indians of Vermont, illustrated with woodcuts.—Mr. F. W. Vogel has an article on the Principles of Bee Breeding.—Mr. E. L. Greene gives an account of the Spring Flowers of Colorado.—Mr. W. Wood has a valuable article on the Game Falcons of New England; and Dr. A. S. Packard, jun., one on Bristle-tails and Spring-tails, the Lepismas and Poduras, illustrated by plates, and containing a very full account of this interesting family. In both numbers are also reviews of recent works on natural history, and many interesting paragraphs of intelligence under the heads of botany, zoology, geology, anthropology, and microscopy, original or compiled, from American and foreign sources.

SOCIETIES AND ACADEMIES

LONDON

Royal Society, April 27.—"On the Increase of Electrical Resistance in Conductors with rise of Temperature, and its application to the Measure of Ordinary and Furnace Temperatures; also on a simple Method of measuring Electrical Resistances." By C. W. Siemens, F.R.S., D.C.L.

The first part of this paper treats of the question of the ratio of increase of resistance in metallic conductors with increase of temperature.

The investigations of Arndtson, Dr. Werner Siemens, and Dr. Matthiessen are limited to the range of temperatures between the freezing and boiling-points of water, and do not comprise platinum, which is the most valuable method for constructing pyrometric instruments.

Several series of observations are given on different metals, including platinum, copper, and iron, ranging from the freezing-oint to 350° Cent.; another set of experiments being also given, extending the observations to 1000° Cent. These results are planned on a diagram, showing a ratio of increase which does not agree either with the former assumption of a uniform progression, or with Dr. Matthiessen's formula, except between the narrow limits of his actual observations, but which conforms itself to a parabolic ratio, modified by two other coefficients, representing linear expansion and an ultimate minimum resistance.

In assuming a dynamical law, according to which the electrical resistance of a conductor increases according to the velocity with which the atoms are moved by heat, a parabolic ratio of increase of resistance with increase of temperature follows; and in adding to this the coefficients just mentioned, the resistance r for any temperature is expressed by the general formula,

$$r = \alpha T^{\frac{1}{2}} + \beta T + \gamma,$$

which is found to agree very closely both with the experimental data at low temperatures supplied by Dr. Matthiessen, and with the author's experimental results, ranging up to 1000° Cent. He admits, however, that further researches will be necessary to prove the applicability of the law of increase expressed by this formula to conductors generally.

In the second part of this paper it is shown that, in taking advantage of the circumstance that the electrical resistance of a metallic conductor increases with an increase of temperature, an instrument may be devised for measuring with great accuracy the temperature at distant or inaccessible places, including the interior of furnaces, where metallurgical or other smelting operations are carried on.

In measuring temperatures not exceeding 100° Cent., the instrument is so arranged that two similar coils are connected by a light cable containing three insulated wires. One of these coils, "the thermometer-coil," being carefully protected against moisture, may be lowered into the sea, or buried in the ground, or fixed at any elevated or inaccessible place whose temperature has to be recorded from time to time; while the other, or "comparison-coil," is plunged into a test-bath, whose temperature is raised or lowered by the addition of hot or cold water, or of refrigerated solutions, until an electrical balance is established between the resistances of the two coils, as indicated by a galvanoscope, or by a differential voltameter, described in the second paper, which balance implies an identity of temperature at the two coils. The temperature of the test-solution is thereupon measured by means of a delicate mercury thermometer, which at the same time tells the temperature at the distant place.

By another arrangement the comparison-coil is dispensed with, and the resistance of the thermometer-coil, which is a known quantity at zero temperature, is measured by a differential voltameter, which forms the subject of the second paper; and the temperature corresponding to the indications of the instrument is found in a table, prepared for this purpose, in order to save all calculation.

In measuring furnace temperatures the platinum-wire constituting the pyrometer is wound upon a small cylinder of porcelain contained in a closed tube of iron or platinum, which is exposed to the heat to be measured. If the heat does not exceed a full red heat, or, say, 1000° Cent., the protected wire may be left permanently in the stove or furnace, whose temperature has to be recorded from time to time; but in measuring temperatures exceeding 1000° Cent., the tube is only exposed during a measured interval of, say, three minutes, to the heat, which time suffices for the thin protecting casing and the wire immediately exposed to its heated sides, to acquire within a determinable limit the temperature to be measured, but is not sufficient to soften the porcelain cylinder upon which the wire is wound. In this way temperatures exceeding the welding-point of iron, and approaching the melting-point of platinum, can be measured by the same instrument by which slight variations at ordinary temperatures are told. A thermometric scale is thus obtained embracing without a break the entire range.

The leading wires between the thermometric coil and the measuring instrument, which may be under certain circumstances several miles in length, would exercise a considerable disturbing influence if this were not eliminated by means of the third leading wire before mentioned, which is common to both branches of the measuring instrument.

Another source of error in the electrical pyrometer would arise through the porcelain cylinder npon which the wire is wound becoming conductive at very elevated temperatures; but it is shown that the error arising through this source is not of serious import.

The third part of the paper is descriptive of an instrument for measuring electrical resistance without the aid of a magnetic needle or of resistance scales. It consists of two voltameter tubes fixed upon graduated scales, which are so connected that the current of a battery is divided between them, with one branch including a known and permanent resistance, and the unknown resistance to be measured. The resistance and polarisation being equal, and the battery being common to both circuits, these unstable elements are eliminated by balancing them from the circulation, and an expression is found for the unknown resistance X in the known resistances *C* and γ of the voltameter, including the connecting wires and the volumes V and V′ of gases evolved in an arbitrary space of time within the tubes, viz. :—

$$X = \frac{V}{V'}(C + \gamma) - \gamma \quad . \quad . \quad . \quad . \quad . \quad (1)$$

Changes of atmospheric pressure affect both sides equally, and do not therefore influence the results; but a reading of the atmospheric pressure is obtained at both sides by lowering the little supply reservoir with dilute acid to the level indicated in the corresponding tube. The upper ends of the voltameter tubes are closed by small weighted levers provided with cushions of india-rubber; but after each observation these levers are raised, and the supply reservoirs moved so as to cause the escape of the gases until the liquid within the tubes is again brought up to the zero line of the scale, when the instrument is ready for another observation. A series of measurements are given of resistances varying from 1 to 10,000 units, showing that the results agree within one per cent. with the independent measurements obtained of the same resistances by the Wheatstone method.

The advantages claimed for the proposed instrument are, that it is not influenced by magnetic disturbances, or the ship's motion if used at sea; that it can be used by persons not familiar with electrical testing; and that it is extremely simple and easily procured.

Royal Institution of Great Britain, Annual Meeting, Monday, May 1.—Sir Henry Holland, Bart., F.R.S., president, in the chair. The Annual Report of the Committee of Visitors for the year 1870 was read and adopted. Eighty-one new members were elected in 1870. Sixty-three lectures and nineteen evening discourses were delivered during the year 1870. The books and pamphlets presented in 1870 amounted to 118 volumes, making, with those purchased by the managers, a total of 307 volumes added to the library in the year, exclusive of periodicals. Thanks were voted to the president, treasurer, and secretary, to the committees of managers and visitors, and to the professors, for their services to the Institution during the past year. The following gentlemen were unanimously elected as officers for the ensuing year: President—Sir Henry Holland, Bart., F.R.S. Treasurer—Mr. William Spottiswoode, F.R.S. Secretary—Dr. Henry Bence Jones, F.R.S. Managers—Mr. John J. Rigsby, F.R.S., Mr. George Berkley, Mr. William Bowman, F.R.S., Mr. George Busk, F.R.S., Mr. Warren De la Rue, F.R.S., Capt. Douglas Galton, C.B., F.R.S., Mr. John Hall Gladstone, F.R.S., Mr. William Robert Grove, F.R.S., the Lord Lindsay, Mr. George Macilwain, the Duke of Northumberland, William Pole, F.R.S., Sir W. Frederick Pollock, Bart., Mr. Robert P. Roupell, Col. Philip James Yorke, F.R.S.

Geological Society, April 5.—Prof. Morris, vice-president, in the chair. The following communications were read :—1. "On a new Chimæroid Fish from the Lias of Lyme Regis," by Sir Philip Grey Egerton, Bart., M.P., F.RS. The fish for which the author proposed the name of *Ischyodus orthorhinus*, was represented by a specimen showing the anterior structures imbedded in a slab of Lias. It exhibited the characteristic dental apparatus of the Chimæroids, surrounded with shagreen, a very large prelabial appendage six inches long, and terminating in a hook abruptly turned downwards, and a process which the author regarded as representing the well-known rostral appendage of the male Chimæroid, but in this case attaining a length of 5½ inches, and covered more or less thickly with tubercles, bearing recurved central spines somewhat toothlike in their aspect. This appendage is attached to the head by a rounded condyle, received into a hollow in the frontal cartilage. The dorsal spine, which measured 6 inches in length, was articulated by a rounded surface to a strong cartilaginous plate projecting upwards from the notochordal axis, and was thus rendered capable of a considerable amount of motion in a vertical plane. This structure also occurred in *Callorhynchus* and *Chimæra*. Dr. Günther commented on the interest of this discovery, as in no other sharks is the same articulation of the dorsal spine as that described in the paper to be found. He inquired whether the granulated plate supposed to be dorsal might not be a part of the armature of the lateral line, as in sturgeons. He thought that the Chimæroids would eventually prove to be intermediate between the ganoid and shark types, and that all belonged to one subclass. Mr. Gwyn Jeffreys inquired what other remains were found with these fishes such as might represent the food, molluscan or otherwise, on which they lived. Sir P. Egerton replied that there was no deficiency of pabulum for any kind of fish in the sea represented by the Lias of Lyme Regis. He also made some remarks on another somewhat similar specimen in his own museum. The plate referred to by Dr. Günther, he stated, was symmetrical, and not like the lateral plates on the sturgeon, which are unsymmetrical. He therefore thought it dorsal.—2. "On the Tertiary Volcanic Rocks of the British Islands," by Archibald Geikie, F.R.S. In this communication the author gave the first of a series of papers which he proposes to lay before the society upon the volcanic rocks of Britain of later date than the chalk. In a general introduction to the whole subject, he pointed out the area occupied by the rocks, showing that they are chiefly developed along the broad tract which extends from the south of Antrim, between the chain of the Outer Hebrides and the mainland of Scotland, up into the Faroe Islands, and even to Iceland. The nomenclature of the rocks was discussed, and the following arrangement was proposed :—

	Felspathic series					Pyroxenic, or Augitic.					
	Syenite	Felstone and Quartz porphyry.	Trachyte and Trachyte-porphyry.	Pitchstone.	Porphyrite.	Dolerite	Basalt.	Trachylite	Diallage-rock ? altered dolerite.	Felspathic tuffs.	Pyroxenic tuffs and agglomerate.
I. INTERBEDDED OR CONTEMPORANEOUS.											
A. *Crystalline.*											
Sheets or beds	...	...	?	*	*	*	*	...	*		
B. *Fragmental.*											
Beds or layers	...	...	...	...	..	...	...	..	...	?	*
II. INTRUSIVE OR SUBSEQUENT.											
A. *Crystalline.*											
α. Amorphous masses	*	*	?	...	...	?					
β. Sheets	...	...	...	...	...	*	*				
γ. Dykes and veins	*	*	?	*	...	*	*	*			
δ. Necks	...	?	...	...	...	...	?				
B. *Fragmental*											
Necks	...	...	...	...	...	...	...	...	...	...	*

The age of the rocks was shown to be included in the Tertiary period by the position of the volcanic masses above the chalk, and by their including beds containing Miocene plants. As an illustrative district, the author described the volcanic geology of the island of Eigg, one of the Inner Hebrides, and brought out the following points :—1. The volcanic rocks of this island rest unconformably upon strata of Oolitic age. 2. They consist almost wholly of a succession of nearly horizontal interbedded sheets of dolerite and basalt, forming an isolated fragment of the great volcanic plateau which stretches in broken masses from Antrim through the Inner Hebrides. 3. These interbedded sheets are traversed by veins and dykes of similar materials, the dykes having the characteristic north-westerly trend, with which they pass across the southern half of Scotland and the north of England. Veins of pitchstone and felstone, and intrusive masses of quartziferous porphyry, like some of those which in Skye traverse or overlie the lias, likewise intersect the bedded dolerites and basalts of Eigg. 4. At least, two widely separated epochs of volcanic activity are represented by the volcanic rocks of Eigg. The older is marked by the bedded dolerites and by the basalt veins and dykes which, though strictly speaking younger than the bedded sheets which they intersect, yet probably belong to the same continuous period of volcanic action. The later manifestations of this action are shown by the pitchstone of the Scùr. Before that rock was erupted the older doleritic lavas had long ceased to flow in this district. Their successive beds, widely and deeply eroded by atmospheric waste, were here hollowed into a valley traversed by a river, which carried southward the drainage of the wooded northern hills. Into this valley, slowly scooped out of the older volcanic series the pitchstone and porphyry *coulées* of the Scùr flowed. Vast, therefore, as the period must be which is chronicled in the huge piles of volcanic beds forming our dolerite plateaux, we must add to it the time needed for the excavation of parts of those plateaux into river-valleys, and the concluding period of volcanic activity during which the rocks of the Scùr of Eigg were poured out. 5. Lastly, from the geology of this interesting island we learn, what can be nowhere in Britain more eloquently impressed upon us, that, geologically recent as that portion of the Tertiary periods may be during which the volcanic rocks of Eigg were produced, it is yet separated from our own day by an interval sufficient for the removal of mountains, the obliteration of valleys, and the excavation of new valleys and glens where the hills then stood. The amount of denudation which has taken place in the Western Islands since Miocene times will be hardly credible to those who have not adequately realised the potency and activity of the powers of geological waste. Subterranean movements may be called in to account for narrow gorges, or deep glens, or profound sea-lochs; but no subterranean movement will ever explain the history of the Scùr of Eigg, which will remain as striking a memorial of denudation as it is a landmark amid the scenery of our wild western shores. Prof. Haughton inquired whether Mr. Geikie's attention had been called to the Morne Mountains in Ireland, which seemed to present some analagous phenomena to those described in the paper. In the Morne district were dykes of dolerite, pitchstone, and other volcanic rocks of the same constitution as those of Antrim. He believed that a chemical examination of these rocks in different districts would prove their common origin. The evidence in Antrim was conclusive as to their Tertiary age in Ireland, and he was glad to find that the view of their belonging to a different age in Eigg was erroneous. Prof. Ramsay had hitherto believed in the Oolitic age of these trap-rocks in Eigg, but accepted the author's views. The interbedding of volcanic beds among the Lower Silurian beds in Wales was somewhat analogous. He was glad to find the history of these igneous rocks treated of in so geological a manner, instead of their being regarded from too purely a lithological and mineralogical point of view. The great antiquity of these Middle Tertiary Beds had, he thought, been most admirably brought forward in the paper, as well as the enormous amount of denudation; and he would recommend it to the notice of those who had not a due appreciation of geological time. Mr. Forbes hoped that the geologist would remember that his father was a mineralogist. It was refreshing to find a paper of this kind brought before the Society, as it was to be regretted that the details of mineralogy were so little studied in this country when compared with the Continent; and this he attributed to the backward state of petrology (admitted by Mr. Geikie) in this country. He quite agreed in the view of the Tertiary age of these rocks. With regard to the terminology employed by the author, he objected to the use of the word dolerite, as distinct from basalt; basalt properly comprised, not only dolerite, the coarse-grained variety, and anamezite, the finely-grained variety, and the true basalt, but also trachylite, which was frequently confounded with pitchstone. All four names merely referred to structure, and not to composition. Mr. Geikie, in reply, stated that he had not examined the Morne Mountains. He had not in any way wished to disparage mineralogy, but, on the contrary, had attempted to classify the different rocks according to their petrological character. He used the term dolerite in the same sense as the German mineralogists, both as the generic name for the whole series, and also for the coarser variety of basalt. 3. "On the formation of 'Cirques,' and their bearing upon theories attributing the excavation of Alpine Valleys mainly to the action of Glaciers," by the Rev. T. G. Bonney, M.A., F.G.S. The paper described a number of these remarkable recesses, which, though not restricted to the limestone districts of the Alps, are best exhibited in them. The author gave reasons why he could not suppose them to have been formed either as craters of upheaval, or by the action of the sea, or by glacial erosion. With regard to the last he showed that, even if glaciers had been the principal agents in excavating valleys, there were some cirques which could not have been excavated by them; and then went on to argue from the fact that glaciers had occupied cirques, and from the relation between them and the valleys, that they could not be attributed to different agents. He also showed that commonly the upper part of the valley, where the erosive action is perhaps least, is very much the steepest, and urged other objections to the great excavatory powers often attributed to glaciers. He then described one or two cirques in detail, and showed that they were worked out by the joint action of many small streams, and of the usual meteoric agents working upon strata whose configuration was favourable to the formation of cliffs. Mr. Whitaker suggested an analogy between the cirques and the combes in our own limestone countries. Mr. Geikie regarded the cirques as analogous with the combes of Wales and the corries of Scotland. They were not, however, confined to limestone districts, but occurred also in gneiss and granite rocks. He thought that the shape was much influenced by the bedding and jointing of the rocks, as there was an evident connection between these and the shape of the combes. He could not, however, see his way to account for the vertical cliffs surrounding the cirques. The Rev. T. G. Bonney, in reply, observed that though cirques were not confined to limestones, the finest instances occurred in such rocks. When cirques occurred in crystalline rocks, the talus was usually much larger than in limestone.—The following specimens were exhibited: Specimens of Fossil Fish-remains from the Lias of Lyme Regis; exhibited by Sir P. de Malpas Grey Egerton, in illustration of his paper.

Royal Society of Literature, April 26.—Mr. Hyde Clarke read a paper on the "Classic Names of Rivers," more particularly in Greece, Asia Minor, and Italy. After referring to the discoveries in the stone period by Mr. Finlay and others, and to the megalithic and cyclopean structures, he proceeded to consider what evidence was afforded by topographical nomenclature of the populations which preceded the Hellenic. He showed that the river-names in the classic regions conformed with each other, and that this was not attributable, as supposed, to Hellenic colonisation. These names also conform to those of India, and of the ancient world generally; but the explanation was not to be found in Aryan etymologies, but that it was to be sought in earlier forms. These are represented in the languages of the Caucasus, of which the Georgian, Suan, Latian, and Lesghian afford examples now. With these the Thracian and the languages of Asia Minor corresponded. The local facts gave colouring to the legends of the occupation and invasion of Attica by the Amazons, and of the existence in Europe of a Thracian population allied to that of Asia. The eastern connection of the Etruscan and Italian populations, too, was to be accounted for as with the Caucasus, and not with America. He referred likewise to the influence of the river-names on classic mythology, and particularly on the nomenclature of Tartarus.

Linnean Society, April 20.—Notes on Mr. Murray's paper on the Geographical Relations of the chief Coleopterous Faunæ, by Dr. Roland Trimen. The author considered that the argument of a continuity of land at a previous epoch is too often resorted to to explain the occurrence of the same species of insects in widely remote countries. He entered in considerable detail into the chief features of the distribution of the genera and species of Coleoptera, especially at the Cape; laying much stress on the difficulty which introduced species find in establishing themselves in soil already well stocked.

Society of Biblical Archæology, April 4.—Dr. S. Birch, F.S.A., president, in the chair.—Mr. Henry Theodore Bagster, Mr. Richard Bosanquet, Mr. A. W. Franks, M.A., V.P.S.A., &c., and Mr. Burnett Tabrum were duly elected members of the society. The Secretary read a paper communicated by Mr. Henry Fox Talbot, F.R.S., &c., "On an Eclipse mentioned on an Assyrian Tablet." The tablet in question is preserved in the British Museum, and is marked 154 and 122*b*. The translation runs thus: "To the King of the World—My Lord, Thy servant, Kukuru, sends this:—May Assur, the Sun, and Marduk be propitious to my Lord the King in his journey from his kingdom to the land of Egypt! I inform his Majesty that in the month of Su there was an Eclipse. Five portions of the full orb were obscured. Let the King be of tranquil mind, since the eclipse of the month of Su portends good fortune to the King." The translator proceeded to identify this eclipse thus recorded with one which took place in the seventh warlike expedition of Assurbanissal against Tiumman, King of Elam. The next meeting was then announced to take place on Tuesday, 2nd proximo, to which date the meeting was then adjourned.

DUBLIN

Royal Irish Academy, April 10.—Rev. T. H. Jellett, president, in the chair. Prof. Hennessy, F.R.S., read a paper On the Floatation of Sand by the incoming tide at the Mouth of a Tidal River. During the course of a tour along our western coast, in the summer of 1868, the following incident came under my notice; and, although I made a note of the facts at the time, I have never hitherto made them the subject of a scientific communication: On July 26, when approaching the strand at the river below the village of Newport, County Mayo, I noticed what appeared to be extensive streaks of scum floating on the surface of the water. As it was my intention to bathe, I was somewhat dissatisfied with the appearance of the water, until I stood on the edge of the strand, and I then perceived that what was apparently scum, seen from a distance, consisted of innumerable particles of sand, flat flakes of broken shells, and the other small *débris* which formed the surface of the gently-sloping shore of the river. The sand varied from the smallest size visible to the eye up to little pebbles, nearly as broad and a little thicker than a fourpenny piece. Hundreds of such little pebbles were afloat around me, and it is probable that the flakes of floating matter seen farther off contained also a considerable proportion. The air during the whole morning was perfectly calm, and the sky cloudless, so that, although it was only half-past nine, the sun had been shining brightly for some hours on the exposed beach. The upper surface of each of the little pebbles was perfectly dry, and the groups which they formed were slightly depressed in curved hollows of the liquid. The tide was rapidly rising, and, owing to the narrowness of the channel at the point where I made my observations, the sheets of floating sand were swiftly drifting farther up the river into brackish and fresh water. On closely watching the rising tide at the edge of the strand, I noticed that the particles of sand, shells, and small flat pebbles, which had become perfectly dry and sensibly warm under the rays of the sun, were gently uplifted by the calm, steadily-rising water, and then floated as readily as chips or straws. I collected a few specimens of these little objects, but I regret that they have been since mislaid. This phenomenon, it is scarcely necessary to say, is due to molecular action, such as accompanies the familiar experiment of floating needles on the surface of a basin of water. Although the specific gravity of the floating objects exceeds that of the fluid on which they rest, the principle of Archimedes still holds good, because the displacement of liquid produced by the body is considerably greater than the volume of the body itself. In the case of a floating needle, the repulsion of the liquid from the polished surface of the metal presents a groove, whose magnitude is obviously many times greater than the needle; but in the case of the floating pebbles this was not so manifest. The attraction of the molecules of water for one another produces, as is well established, a tension at the surface of the liquid, which, although extremely feeble, and generally noticed only in connection with capillary phenomena, yet interposes some resistance to the intrusion of foreign substances. I have floated small flat pebbles, similar in size and appearance to the largest of those observed floating on Newport river, for more than six days, while fragments of shells, and thin pieces of slate as broad as a sixpenny-piece, have continued to float much longer. These little bodies occasionally sank from the gradual absorption of water, but much more frequently from some accidental motion of the vessel containing the liquid. It is manifest that the floatation of sand in a tidal estuary, as in the instance I have seen, can occur only under favourable conditions. The shores must be very gently inclined, the air perfectly calm, and the weather dry and warm. Under these circumstances thin cakes or sheets of sand may not only be uplifted by the water, but if the tide flows rapidly they may continue to float sufficiently long to allow many of them to be drifted far from their original place up to the higher limit of the brackish water. In this way fragments of marine shells and exuviæ might become mingled with those belonging to fresh water. The conditions favourable for sand floatation must exist during calm weather in a very high degree of perfection on the sandy shores of tidal rivers in tropical and subtropical districts of the earth. As this phenomenon can take place only with the rising tide, and never with the falling tide, the result must generally be favourable to the transport of sand and marine *débris* in the direction of the flow of flood tide; and this may sometimes hold good along a coast as well as on the shores of a tidal estuary. Geologists, as far as I am aware, have not hitherto noticed this phenomenon in connection with the formation of stratified deposits by the agency of tides and rivers, although they have paid great attention to the influence of the molecular resistance of water to the sinking of very minute solid substances, with the view of examining the wide surface over which matter held in suspension ..er may be spread when ultimately deposited over the sea bottom.—Prof. W. King read a paper, by himself and Prof. Rowney, "On the Mineral Origin of the so-called *Eozoon Canadense*." It was resolved to purchase the Bell and Bell-Shrine of St. Patrick, from Dr. C. Todd, for the sum of 500*l*.

BOOKS RECEIVED

ENGLISH.—Travels in the Air: J. Glaisher, 2nd edition (R. Bentley).—The Natural History of Plants: H Baillon, vol. 1, translated by N. Hartog (L. Reeve and Co.).—Primitive Culture, 2 vols.: E. B. Tylor (J. Murray).—On Aphaxia, or Loss of Speech: Dr. F. Bateman (Churchill).

FOREIGN.—(Through Williams and Norgate)—Archiv für Anthropologie, vol. iv.—Zeitschrift der oesterreichischen Gesellschaft für Meteorologie, vol. v.—Compendium der chirurgischen Pathologie u. Therapie: Dr. C. Heitzmann.

DIARY

THURSDAY, MAY 4.

ROYAL SOCIETY, at 8.30.—On the Structure and Affinities of the Gwynia Annulata (Dunc.), with Remarks upon the Persistence of Palæozoic Types of Madreporaria: Prof. Duncan, F.R.S.—On Molybdates and Vanadates of Lead, and on a new Mineral from Leadhills: Dr. A. Schrauf.

SOCIETY OF ANTIQUARIES, at 8.30.—Roman Villa at Beddington: J. Addy.—Antiquities from Cyprus: J. B. Sandwith.

LINNEAN SOCIETY, at 8—The phenomena of Protective Mimicry, and its bearing on the Theory of Natural Selection as illustrated by the Lepidoptera of the British Islands: Raphael Meldola, F.C.S.—On the Ascalaphidæ: R. McLachlan.

CHEMICAL SOCIETY, at 8.—On the Productive Powers of Soils in relation to the Loss of Plant Food by Drainage: Dr. Voelcker, F.R.S.

ROYAL INSTITUTION, at 3.—On Sound: Prof. Tyndall.

LONDON INSTITUTION, at 7.30.—On Economic Botany: Prof. Bentley.

FRIDAY, MAY 5.

GEOLOGISTS' ASSOCIATION, at 8.—On the Fauna of the Carboniferous Epoch: H. Woodward, F.G.S.

ROYAL INSTITUTION, at 9.—On Russian Folk-Lore: W. R. S. Ralston.

SATURDAY, MAY 6.

ROYAL SCHOOL OF MINES, at 8.—Geology: Dr. Cobbold.

ROYAL INSTITUTION, at 3.—On the Instruments Used in Modern Astronomy: J. N. Lockyer, F.R.S.

MONDAY, MAY 8.

ROYAL GEOGRAPHICAL SOCIETY, at 8.30.

ROYAL INSTITUTION, at 2.—General Monthly Meeting.

LONDON INSTITUTION, at 4.—On Astronomy: R. A. Proctor, F.R.A.S. (Educational Course.)

TUESDAY, MAY 9.

PHOTOGRAPHIC SOCIETY, at 8.

ROYAL INSTITUTION, at 3.—On Force and Energy: Charles Brooke, F.R.S.

WEDNESDAY, MAY 10.

SOCIETY OF ARTS, at 8.—On the Application of Steam to Canals: Geo. Edward Harding, C.E.

GEOLOGICAL SOCIETY, at 8.—On the Ancient Rocks of the St. David's Promontory, South Wales, and their Fossil Contents: Prof. R. Harkness, F.R.S., and Henry Hicks.—On the Age of the Nubian Sandstone: Ralph Tate, F.G.S.—On the Discovery of the Glutton (*Gulo luscus*) in Britain: W. Boyd Dawkins, F.R.S.

THURSDAY, MAY 11.

ROYAL SOCIETY, at 8.30.

SOCIETY OF ANTIQUARIES, at 8.30.

MATHEMATICAL SOCIETY, at 8.—On the Singularities of the Envelope of a non-Unicursal Series of Curves: Prof. Henrici.

ROYAL INSTITUTION, at 3.—On Sound: Prof. Tyndall.

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