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CONTENTS.

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National Health and Medical Research.[1]

THE elaborately detailed report of the Medical Research Council for the past year gives much food for thought, whether we receive it in the spirit of the tax-payer, anxious to be assured that his contribution to the national health is being worthily expended, or in the spirit of the watchman, eager only for a sign, but untroubled by detail. We all have in us something of the tax-payer and, let us hope, something more of the watchman, so let us see how these respective parts of us are catered for in the Council's report. Whether we are able to appreciate its contents or not, we, as tax-payers, have always demanded this sort of governmental report. Does it not concern the disbursement of 130,000*l.*, or something like a halfpenny per head of the population, on the pursuit of new knowledge that is to alleviate human suffering? Unthinking lay and even medical critics might regard it as a perilous investment. Were they holders of cinema shares, they would probably accept without question a similar disbursement to the parents of a Jackie Coogan.

If, then, we expect to find definite assurance that new knowledge leading directly and immediately to improvement in the health of the community has been acquired, we shall be disappointed. The average newspaper, keen only for sensation, would vote it dull. But a closer study of the report, including its admirable introductory chapter by the special Committee of the Privy Council, is calculated to bring to the more responsive of us the conviction that inability to appreciate springs from our own ignorance and shortsightedness. We gather, in fact, that the machine which registers advance in scientific medicine resembles a piece of complicated clockwork, the wheels of which represent movements in all the biological and physical sciences, not excluding mathematics. We note, for example, how the Hill katathermometer—an instrument of precision for measuring the cooling power of the atmosphere—may be made to afford a most valuable index of conditions affecting the efficiency of the worker in factory and workshop. We note also recent progress in our knowledge of the biological action of sunlight, and its remarkable influence on diseases such as rickets. A new field is here opened.

The discovery of insulin by the Toronto workers is alluded to at length. We gather that a method of preparing a potent product of consistent uniformity has not yet been achieved, but doubtless this difficulty will yield to further research. It is worth reflecting that this new knowledge might still be withheld from us, were it not for the elaboration in recent years of

[1] Report of the Medical Research Council for the year 1921–22. (Published by His Majesty's Stationery Office.) 3*s.* 6*d.* net.

quantitative tests for sugar in the blood. It is probable that many a preparation of pancreas has failed, in the past, to become established because its physiological activity could not be satisfactorily tested and recourse was limited to casual clinical trials. When one considers the plethora of commercial pancreatic preparations already on the market, which claim to contain the specific sugar-destroying principle, it is comforting to know that the Medical Research Council has taken the action it has, and that its own experts are actively engaged in studying methods that may yield preparations of uniform potency. In connexion with these difficulties, we note with some interest Dudley's work at the National Institute in refining pituitary extract. Apparently, the further the purification was carried, the less potent the substance became physiologically. This is not the first time that such stumbling-blocks have interfered with attempts to refine biologically potent principles contained in organ extracts or in culture fluids which have served for the growth of micro-organisms.

It would be superfluous to attempt to enumerate the many lines along which research is being pursued, either by expert workers at the National Institute or by the many outside specialists whose work the Medical Research Council encourages or finances; nor can we mention even the terms of reference of the numerous committees and sub-committees which have taken upon themselves the task of co-ordinating attack upon a multitude of problems in all fields of scientific medicine and hygiene. Membership of these committees is no sinecure, and it is notorious that much self-denying work is performed. Verily, the appreciative tax-payer can have no reason to grumble at the way in which his exiguous contribution to the community's health is expended.

Now what has the report to say to the watchman seeking for a sign? We believe the organisation of research under the ægis of a responsible body of scientific advisors is a valuable national asset. Will such organisation interfere with the individual freedom of the research worker? Is there a danger that the extension of the team-principle and the laying down by a higher authority of precise research programmes may stifle what originality the worker may possess? The answer is, we believe, that there are men who work best in a team and men who prefer to work alone, and that there is ample room for both types. There are periods both in war and in peace when stocktaking of knowledge is essential if we are again to make advance into the unknown. The present is one of those times of national stocktaking in medical science. The very fundamentals of many departments of medical science require revision. A doyen of the chemical world recently referred to certain developments and proposals in biological chemistry as being simply re-search, with the accent and insistence on the first syllable.

The statement is both true and false. Simple reconstruction must inevitably form an integral part of modern research. Possibly the biological sciences, on which advance in scientific medicine mainly hangs, contain a greater proportion of inexact, un-coordinated, and incomplete statement than the so-called exact physical sciences. Every advance in the latter reacts on biology, necessitating re-search in some form or other. Co-ordinated investigation by teams is necessary in peace as in war, and the fruit will duly appear. The scientific investigation of deficiency diseases—a war-time necessity—has developed into something like a science of its own. The organised investigations on anærobic bacteria—another war-time necessity—which was perhaps a very typical example of a re-search, has already borne abundant fruit in recent exact studies of such diseases as botulism and braxy.

What of the night? The morning cometh.

J. C. G. L.

The Fourier-Bessel Function.

(1) *A Treatise on Bessel Functions and their Applications to Physics.* By Prof. A. Gray and G. B. Mathews. Second edition prepared by A. Gray and Dr. T. M. MacRobert. Pp. xiv+327. (London: Macmillan and Co., Ltd., 1922.) 36*s.* net.

(2) *A Treatise on the Theory of Bessel Functions.* By Prof. G. N. Watson. Pp. viii+804. (Cambridge: At the University Press, 1922.) 70*s.* net.

THE function to which these volumes are devoted received its name from the astronomer Bessel, 1824, on introducing it for the coefficients in the expansion of radius vector, and true or eccentric anomaly in a Fourier series of sines and cosines of multiples of mean anomaly or time. Two years before, in 1822, Fourier had encountered the same function essentially in his analytical theory of heat, and his variable is the square of the variable of Bessel.

The function is, however, first met in a dynamical problem, of the oscillation of a vertical chain, investigated by Bernoulli, 1738, and here the Fourier form is the natural one to use. The oscillation is replaced by a steady motion of permanent shape in a chain hanging down, and revolving bodily, and this is easy to realise experimentally; the plane oscillation is then seen in the shadow on a vertical wall.

Take the condition of relative equilibrium of a length x above the lowest point, where it is assumed that the displacement is small enough for vertical distance x

and the length of the chain to be undistinguishable, so that the tension $T=\sigma x$, as at rest, σ the line density.

Putting $g=\omega^2 l$, where l is the height of the equivalent conical pendulum revolving at the same rate ω, the equation of relative equilibrium is

$$T\frac{dy}{dx}+\int\sigma\frac{y}{l}dx=0,\quad x\frac{d^2y}{dx^2}+\frac{dy}{dx}+\frac{y}{l}=0,$$

having a solution $y=b\mathrm{F}(x/l)$, where $\mathrm{F}(x)$ is Fourier's function, defined by the series

$$\mathrm{F}(x)=\Sigma\frac{(-x)^k}{(\Pi k)^2}.$$

The sort called *Furniture Chain* is suitable for experiment: the links are small hollow brass spheres, joined up by rivet links, and it is sold in various sizes.

A length of the large size of about 4 feet is suitable for whirling round by hand, and producing a curve in 1, 2, 3, 4, . . . waves, showing to the eye the position of the first roots of $\mathrm{F}(x)=0$.

Standing up on a chair or the table, a length of 8 or 12 feet of the smaller size may be set in rotation by the dynamobile toy. The chain springs at once into a series of waves, where the higher roots are seen and their spacing, prolongation of the figure at the end of Gray.

The chain can also be used to show off a real catenary curve, instead of the string recommended in Routh—much too kinky and destitute of flexibility to form a good catenary. And dropping the chain from a height is a good problem on a steady blow, equivalent of a series of impacts of the discrete links.

With a rotating chain of variable density, σx^n, the tension $T=\sigma x^{n+1}/(n+1)$, and the equation changes to

$$T\frac{dy}{dx}+\int\sigma x^n\frac{y}{l}dx=0,\quad x\frac{d^2y}{dx^2}+(n+1)\frac{dy}{dx}+(n+1)\frac{y}{l}=0,$$

the solution of which may be written

$$y=b\left(-\frac{d}{dx}\right)^n\mathrm{F}(n+1)\frac{x}{l},$$

and l is the length of the subtangent at the lowest point.

For if $u=\mathrm{F}(x)$ is the solution of the equation

$$x\frac{d^2u}{dx^2}+\frac{du}{dx}+u=0,$$

differentiating n times, with $y=(-d/dx)^n u=\mathrm{F}_n(x)$,

$$x\frac{d^2y}{dx^2}+(n+1)\frac{dy}{dx}+y=0,\quad y=\mathrm{F}_n(x)=\Sigma\frac{(-x)^k}{\Pi(n+k)\Pi k},$$

the Fourier function of the nth order.

Here n may be changed into $-n$, and the differentiation into an integration, making $\mathrm{F}_{-n}(x)=x^n\mathrm{F}_n(x)$.

Gray's function $\mathrm{I}_n(t)$ (p. 20), is the equivalent of $\mathrm{F}_n(-x)$.

But with the variable $z=2\sqrt{x}$ of the Bessel form, the equation changes to

$$z^2\frac{d^2y}{dz^2}+(2n+1)z\frac{dy}{dz}+z^2y=0,$$

and this, with $y=(\frac{1}{2}z)^{-n}u$, into

$$z^2\frac{d^2u}{dz^2}+z\frac{du}{dz}+(z^2-n^2)u=0,$$

defining $u=\mathrm{J}_n(z)=(\frac{1}{2}z)^n\mathrm{F}_n(\frac{1}{4}z^2)$, and the simplicity disappears of the derivation of $\mathrm{J}_n(z)$ from $\mathrm{J}_0(z)$ by successive differentiation or integration; factors intervene of powers of z.

The interlacing of the roots of F_n and F_{n+1} is evident from the differentiation; and there is an infinite series of positive roots, but none are negative.

This chain of variable density could be imitated by a flexible lattice blind, of appropriate curvilinear outline, hanging vertically, and rotating bodily.

Lecornu's problem of the oscillation of a large weight, raised or lowered by a chain of which the density may be neglected, is seen in operation in the erection of the tall buildings springing up around; it gives rise to similar expressions.

A Fourier function of fractional order arises in the question of the stability of a tall mast or tree, or of a chimney stalk when it begins to flinch on the foundation, and starts to curl over from the vertical; illustrated experimentally by a thin steel wire clamped in a vice.

With uniform cross-section, the equation is

$$ek^2\frac{d^2p}{dx^2}+xp=0,\quad \frac{1}{p}\frac{d^2p}{dx^2}+\frac{x}{ek^2}=0,$$

where $p=dy/dx$, k is the radius of gyration of the horizontal section across the plane of flexure, and e is Young's elastic length of the material, quotient of the modulus of elasticity divided by the density.

Every linear differential equation of the second order is reducible, by a change of independent and dependent variable, to the canonical form

$$\frac{1}{u}\frac{d^2u}{dx^2}+\mathrm{I}=0,$$

and when the differential invariant $\mathrm{I}=kx^n$, any power of x, the form to which Riccati's equation is reducible, the equation is reduced to Fourier's form by a mere change of the independent variable to

$$z=\frac{kx^{m+2}}{(m+2)^2},$$

and becomes Fourier's equation for

$$u=\mathrm{F}_n(z),\quad n=-\frac{1}{m+2}$$

(Watson, p. 88).

Here with the uniform column on the verge of drooping from the vertical, $m=1$, $p=b\mathrm{F}_{-\frac{1}{3}}(x^3/9ek^2)$.

The smallest root of $F_{-\frac{1}{3}}=0$ is about 0·88, say $\frac{8}{9}$ (Watson); this makes the critical height

$$x=2(ek^2)^{\frac{1}{3}}=(\tfrac{1}{2}ed^2)^{\frac{1}{3}}$$

for a circular rod of diameter d.

For steel, we may take $e=250$ million cm, one quarter of a quadrant Q of the Earth, $\sqrt[3]{\tfrac{1}{2}e}=500$.

With a steel wire held in the vice vertical, one millimetre in diameter, $d=0{\cdot}1$ cm, the critical height $x=500\,d^{\frac{2}{3}}=107{\cdot}7$ cm, a little over one metre. As the height is increased through this length, the vibration becomes sluggish more and more, and finally ceases, and the wire droops.

The drooping of a candle on a hot day will give an illustration; also a field of corn when it is ripe, where, to obtain a complete solution, the weight of the head would require the introduction of the Fourier function of the second kind, or a Bessel-Neumann-Weber function (Gray, p. 14; Watson, p. 308); so too for the addition of a weight at the end of the vibrating chain.

Here the flexural elasticity keeps the rod, mast, or cornstalk vertical; a flexible chain cannot be made to stand upright; the sign of x would be changed in the relation, and the Fourier function has no negative root.

But a quasi-rigidity can be imparted, as in the reported rope trick of the Indian juggler magician, if our chain carries a gyroscopic flywheel in rapid rotation inside each link, like a pile of spinning tops, and then, as shown in *Phil. Mag.*, Nov. 1919, p. 506, the differential equation of the former result changes to the form

$$(a-x)\frac{d^2y}{dx^2}-\frac{dy}{dx}+\frac{y}{l}=0,$$

with x measured downward from the free end at the top; the solution is

$$y=bF\left(\frac{a-x}{l}\right),$$

and the first value of $y=0$ is given by $(a-x)/l=1{\cdot}44$. Thus a length x of the gyroscopic chain can be made to stand upright, given by $x=a-1{\cdot}44\,l$.

The whip and whirl of a revolving shaft has become a question of practical importance in the swift-running machinery of a turbine, internal-combustion flying-machine motor, and gyro-compass.

Here it is obvious that the shaft will depart from the straight form when the revolutions are equal to the lateral vibrations of the shaft at rest, held between the same bearings, the disturbing and restoring force being the same in the two cases.

The more general form of the differential equation, required when the cross-section and density varies as some power of x, will be

$$\frac{d}{dx}\left(x^q\frac{dy}{dx}\right)+kx^my=0,$$

and hence a change to the independent variable

$$z=\frac{kx^{m-q+2}}{(m-q+2)^2}$$

will lead to Fourier's equation of order

$$n=\frac{q-1}{m-q+2}.$$

The general solution of Riccati's equation is thus expressed by the Fourier function; and the condition that Riccati should have a solution in finite terms requires n to be half an odd integer.

Beginning with $n=-\frac{1}{2}$,

$$F_{-\frac{1}{2}}(x)=\Sigma\frac{(-x)^k}{\Pi(k-\frac{1}{2})\Pi k},$$

$$F_{-\frac{1}{2}}(x)=\frac{1}{\sqrt{\pi}}\Sigma\frac{(-2\sqrt{x})^{2k}}{\Pi 2k}=\frac{\cos 2\sqrt{x}}{\sqrt{\pi}};$$

and a phase angle ϵ may be added to the variable $2\sqrt{x}$ to include both forms of the function.

Then the other Fourier functions of order half an odd integer are derived by an integration or differentiation with respect to x:

$$\sqrt{\pi}F_{\frac{1}{2}}(x)=-\frac{d}{dx}\sqrt{\pi}F_{-\frac{1}{2}}(x)=\frac{\sin 2\sqrt{x}}{\sqrt{x}},$$

$$\sqrt{\pi}F_{\frac{3}{2}}(x)=-\frac{\cos 2\sqrt{x}}{x}+\frac{\sin 2\sqrt{x}}{2x^{\frac{3}{2}}}=x^{-\frac{3}{2}}\sqrt{\pi}F_{-\frac{3}{2}}(x),$$

and so on.

The same simplicity of derivation is not so obvious in the table (Gray, p. 17) for $J_{n+\frac{1}{2}}(z)$, although the sines and cosines are replaced by sin, cos $(z+\epsilon)$.

Functions of this fractional order are of frequent occurrence in mathematical physics, as in the vibration of a sphere (Love's "Elasticity," Lamb's "Hydrodynamics") for the functions ψ_n and Ψ_n, solution of $(\nabla^2+m^2)\phi=0$, in the propagation of spherical waves or the conduction of heat; also for the function F_n of Bromwich and $\gamma\rho$ of Macdonald in electromagnetic waves; simplicity would be obtained if all these functions were referred to the Fourier form and classed there (*Phil. Mag.*, Nov. 1919, pp. 508, 526).

The Fourier function comes in useful for the discussion of a long flat tidal wave in an estuary or channel of vertical cross-section K, and surface breadth b, treated as slowly variable, on the assumption of K and b varying as x^q and x^m, simple powers of x.

The Fourier function is suitable, too, in the discussion of diffraction (Gray, Chapter XIV.), provided the area of a circular fringe is taken in the formula instead of the circumference or diameter.

The derivation, by differentiation and integration, of the Fourier function of different order marks it out as more appropriate than Bessel for the passage, in Lord Rayleigh's manner, of the tesseral harmonic $P_n{}^k(\mu)$ direct into a Fourier function $F_p(x=\frac{1}{4}m^2r^2)$ as the order

n is increased indefinitely (*Phil. Mag.*, Nov. 1919, p. 526).

In Gray's treatise the physical applications are kept in view throughout the book up to the end. The requirements are considered of the mixed mathematician. Not to start with general theory, but to give definite technical examples, to show how the problem may be reduced to the differential equation considered, he will consult the appropriate part of the book as the need arises, and will take for granted the discussion of details of pure analysis, on the validity of an expansion, definite integral expressions, asymptotic expansions, and all the niceties appealing to the pure mathematician of a logical metaphysical intellect.

These can be skipped by the physical student engrossed in a physical problem, and only anxious to dig out the facts and apply the formula to a concrete numerical application, for which the tables at the end of the book will give the requisite material.

The treatise of Watson has a different scope. A first short historical chapter cites name and date of the pioneers up to 1826 encountering the function in dynamical, astronomical, and heat problems, namely, Bernoulli, Euler, Fourier, Bessel.

After this introduction, all definite mention of the physical application is dismissed by Watson in the subsequent 800 pages, and the reader is not encouraged to lift his eye from the page and look up at any materialisation of the analysis, or to study a geometrical picture.

The book proceeds in what is now the conventional manner of a modern analytical treatise, stopping in a leisurely manner to emphasise and scrutinise every possible objection that may arise on the part of rigour. Those who like this work become uncommonly fond of it, and lose interest in a realisation of the ideas.

"Making possible the necessary degree of abstraction is one of the most important merits of mathematical logic."

The Bessel function has few attractive analytical qualities, and does not deserve elaborate treatment to the exclusion of more valuable interest, say of the elliptic function.

The students must be few to afford the time demanded for this subject, not to speak of the expense—for Watson's book, 70*s.*; and Gray's of 327 pages, at 36*s.*

We see the tax laid on knowledge by the price of all mathematical work; the expense of publication has risen far beyond anything contemplated in the old days of debate in the Mutual Improvement Society on the need of a free press and cheap diffusion of knowledge.

It is the fashion to-day to discard a redundant *i* in the name Bernoulli, as in the Bernoullianum Mathematical Museum in Basel, Basle, Bâle in Switzerland. But Maclaurin in his "Account of Newton's Philosophical Discoveries," 1750, spells the name Bernovilli, and here we see the etymological derivation and a reason for the restoration of the banished *i*.

G. GREENHILL.

A Yearbook of the Learned World.

Index Generalis: Annuaire général des Universités, Grandes Écoles, Académies, Archives, Bibliothèques, Instituts scientifiques, Jardins botaniques et zoologiques, Musées, Observatoires, Sociétés savantes. Published under the direction of Dr. R. de Montessus de Ballore. Pp. 2111. (Paris: Gauthier-Villars et Cie, 1923.) 35*s.*

WE welcome the appearance of the third (1922–23) issue of a work which, pending the issue of "Minerva" in its old form, is the only comprehensive directory of the learned world. Its scope is shown by the following analysis of its 2111 pages: (1) Directories of universities, colleges, and professional schools grouped by countries, 913 pages; (2) astronomical observatories, 86 pages; (3) libraries and archives, 325 pages; (4) museums and scientific institutes, 100 pages; (5) learned societies and academies, 194 pages; (6) list of *savants* who desire to exchange original dissertations with their fellow-workers, 7 pages; (7) index of names (more than 40,000), 428 pages; (8) other indexes and vocabularies, 53 pages. In part (1), in addition to the names of professors, lecturers, and other teachers and their subjects, are mentioned the principal administrative officers and, in many cases, the date of foundation, the total number of students, and the total annual expenditure; in part (2), publications, principal instruments, and programme of work; in part (3), days and hours of admission and annual holidays, date of foundation, special features, number of volumes, MSS., etc., annual budget, catalogues, rules for borrowers, name of librarian; in part (4), similar particulars with general description of exhibits or plant and mention of publications; in part (5), objects and aims, number of members, date of foundation, names of president and secretary, subscription, particulars of meetings, lists of fellows and of foreign members of some of the more important societies, and details of publications.

The editing of such an enormous mass of data is a formidable task and Prof. R. de Montessus de Ballore, the distinguished scholar who has had the courage to undertake it and the energy and perseverance to complete it, has thereby earned the gratitude of *savants* of all countries. The editor, who states that his object has been to achieve "the utmost clearness for reference," is to be congratulated on his judicious selection of type and on the ingenious device whereby he refers in the index of names not only to the page but to the particular section of the page in which the name sought is to be found.

The most generally useful part of the book, on the merits of which it will be judged, is part (1), and we have therefore examined some of the entries in this part, selected at random, in order to test its general accuracy. In such a work absolute accuracy is unattainable, but the editor, aiming at a high standard, "thought it better not to publish any information except such as has been directly communicated by administrative chief officials. . . . He has further had the proof of each entry corrected by its contributor." He has branded with an asterisk the rather numerous institutions which have failed to reply to his questionnaires in time and has reproduced the notices of them which appeared in the 1920–21 issue: thirty-one institutions which have not replied since 1919 have been excluded altogether. This procedure unfortunately has not prevented what we cannot but regard as an excessive percentage of error in the entries tested.

We venture to offer a suggestion regarding the entries in part (1) relating to institutions in the British Empire —about one-third of the total number. It is that the editor might use as the basis of such entries the Yearbook issued by the Universities Bureau of the British Empire. Had he done so he would not have omitted such important institutions as the Osmania University of Hyderabad, Deccan, the University of Rangoon, the University of Patna (except for casual references), and University College, Swansea, his entries would have been more rather than less up-to-date, he would have saved himself a great deal of labour and expense, and would have been saved from such "howlers" as *His Grace* Eamon de Valera (Chancellor of the N.U.I.) and showing (and indexing) Petro Drilling as the name of a teacher instead of showing it as a subject (petroleum well-boring).

There is, moreover, another and a very important side to the question. If our university administrative officials, after having supplied returns to their own Universities Bureau and to Government Departments, are to be plied with requests for the self-same information in different forms for international Indexes and the League of Nations (which now proposes itself to compile something of the kind), it will not be surprising if some of the answers are short or if the pages of the Index become even more abundantly starred than at present. If the universities of each country would combine to produce a national yearbook, these would make the best possible material for (if not constituent parts of) an Index Generalis. For the British Empire the work is already done. Italy has her "Annuario degli Istituti Scientifici"—not yet appearing annually, however. The American Council on Education is, in its recently formed Division of College and University Personnel, acquiring much of the requisite material for such a yearbook, and Switzerland and the Netherlands have similar inter-university organisations.

The Cactus Family.

The Cactaceae: Descriptions and Illustrations of Plants of the Cactus family. By N. L. Britton and J. N. Rose. Vol. 3, pp. vii + 255, with 24 plates. (Washington: Carnegie Institution, 1922.)

ALL who grow Cacti will be glad to learn that the third volume of this fine work has been issued. It will probably appeal to a larger number of Cactus fanciers than the two preceding volumes, because it treats chiefly of the smaller kinds, which are more generally cultivated than the columnar or climbing species. This volume is of the same high standard of excellence as the two others, and as an account was given in NATURE of July 7, 1921 (vol. 107, p. 580) of the general character, scope, and details of the work, it will be unnecessary to repeat them here.

The subtribes dealt with in this volume are the Echinocereanæ, consisting of 6 genera (3 of them new) and 115 species, the largest genera being Echinocereus, 60 species, and Echinopsis, 28 species. The Echinocactanæ consist of 28 genera (18 of them new) and 166 species, the largest genera being Ferocactus, 30 species, Malacocarpus, 29 species, Gymnocalycium, 23 species, and Echinofossulocactus, 22 species. The Cactanæ consist of the two genera Discocactus, 7 species, and Cactus (better known as Melocactus), 18 species. Altogether 36 genera (of which 17 are monotypic and 21 are new) and 306 species are described, and well illustrated by 250 figures in the text, and 24 plates, most of them coloured.

Most of the Echinocactanæ are known to cultivators as belonging to the genus Echinocactus, and they will perhaps find it difficult to understand why, in this volume, only 9 species are placed under that genus, and all the others relegated to other genera. The reason is that while the vegetative characters of a large number of species is similar in type, the structural details of their flowers differ, and these floral differences have, in this work, been utilised for generic distinction in a manner not practised before. All this is made manifest in the keys, which are concise and clear, so that with the aid of the very numerous illustrations few should find difficulty in referring an unnamed species of the group to its proper genus.

It is much to be deplored that such a cumbersome sentence-like name as "Echinofossulocactus" should have been brought into use, but unfortunately there seems no valid reason for its rejection, for although it has been overlooked, it was proposed and characterised 81 years ago. It would, however, be of benefit to horticulturists and botanists alike, if, at the next Botanical Congress, a law could be made to prohibit the formation of such atrocious names in future.

The charming coloured plates give a good idea of the beauty of the flowers of these prickly plants, and the views showing some of them as they grow wild will convey to the mind of the cultivator the appearance they should have when well cultivated. Of the plants figured, *Ferocactus rectispinus* is one of the most striking on account of the formidable aspect it presents by its stout straight spines about 4 inches long. Of all the flowers figured the most remarkable is that of *Denmosa rhodacantha* (better known as *Echinopsis rhodacantha*), which is curved in a sigmoid manner, and has the petals closed tightly around the exserted stamens and style, quite unlike that of any other genus.

The well-known spineless *Echinocactus Williamsii* is rightly removed from that genus and now forms a monotypic genus under the name of *Lophophora Williamsii*. This plant has remarkable narcotic properties and has long been used by certain tribes of North American Indians in some of their ceremonies. One peculiarity of this plant is that its stamens are irritable, and when touched at the basal part they rapidly close in around the style, dusting their pollen upon the insect or other thing that touched them; an evident means of securing cross-fertilisation. A very full index completes the volume. There remain to complete the work the subtribes to which the genera Mammillaria and Rhipsalis belong.

N. E. BROWN.

Our Bookshelf.

Kinematograph Studio Technique. (Technical Primers.) By L. C. Macbean. Pp. xii+111. (London: Sir Isaac Pitman and Sons, Ltd., 1922.) 2*s.* 6*d.* net.

ACCORDING to the subtitle of this little book, it is "a practical outline of the artistic and technical work in the production of film plays for producers, cameramen, artistes, and others engaged in or desirous of entering the kinematograph industry." There are chapters on production, the camera and its lenses, studio lighting and outdoor work, dark-room procedure, and so on. No previous knowledge of the subject is assumed, and many will be interested to learn of the artifices by which some of the more striking film scenes are produced, while they may also be surprised at the amount of painstaking labour and attention to detail which goes to the making of a successful film.

The Chemistry of Dental Materials. By Prof. C. S. Gibson. Pp. 176. (London: Benn Bros., Ltd., 1922.) 12*s.* 6*d.* net.

A CAREFULLY selected area in chemistry, largely metallurgy, is dealt with in this treatise, but what is done appears thorough. The treatment is not narrow and utilitarian, but as scientific as is possible. The second half of the book deals with miscellaneous materials used in dentistry, such as porcelain, cements, abrasive materials and antiseptics, and in this, of course, much information is given which cannot be found in the ordinary text-books of chemistry. The Brunner-Mond process for zinc, described on p. 100, is said to be now obsolete, and the same applies to the third form of tin (p. 105). Some mention of modern processes for lead extraction might have been given. Davy's name is incorrectly given on p. 146.

(1) *Installations électriques industrielles: Installation—Entretien—Contrôle.* Par R. Cabaud. (Bibliothèque Professionnelle.) Pp. 333. (Paris: J. B. Baillière et fils, 1922.) 10 francs net.
(2) *Alternating Current Electrical Engineering.* By P. Kemp. Second edition. Pp. xi+515. (London: Macmillan and Co., Ltd., 1922.) 17*s.* net.

(1) THE first part of M. Cabaud's book deals in a general way with electric installations for light and power. The numerical examples given will be helpful to the practical engineer. The maintenance of an installation is discussed in the second part, and in the third part methods of control are described. Various methods of penalising consumers who take their supply at a low-power factor are given.

(2) The principal changes in the new edition of Mr. Kemp's book are a new chapter on the protection of alternating current systems, and a number of alterations in the chapters on instruments.

The Radio Amateur's Hand Book. By A. F. Collins. Pp. xix+329+8 plates. (London, Calcutta, and Sydney: G. G. Harrap and Co., Ltd., 1922.) 7*s.* 6*d.* net.

A POPULAR description of radio communication which will be helpful to amateurs is given in this book. The author uses the proper technical terms, so any one who has read this book will be in a position to benefit by more advanced treatises on the subject. In the glossary, however, the attempt to define highly technical terms in the simplest language is of doubtful utility. Capacity is defined as "any object that will retain a charge of electricity." The book concludes with a long list of radio "don'ts," which will prove instructive to the beginner.

The Pupils' Class-book of Geography: the Americas. By Ed. J. S. Lay. Pp. 176. (London: Macmillan and Co., Ltd., 1922.) 1*s.* 3*d.*

IT is not easy to write an elementary text-book on geography which has any interest for the pupils who use it and at the same time is truly geographical, but Mr. Lay appears to have succeeded. His book is accurate, readable, and well illustrated by excellent black and white maps, and presents the essential features of the geography of the Americas.

Letters to the Editor.

[*The Editor does not hold himself responsible for opinions expressed by his correspondents. Neither can he undertake to return, nor to correspond with the writers of, rejected manuscripts intended for this or any other part of* NATURE. *No notice is taken of anonymous communications.*]

The Nature of the Liquid State.

IN his recent lecture to the Chemical Society on "The Significance of Crystal Structure," Sir William Bragg has described and discussed the extremely important results obtained in his laboratory by the X-ray analysis of various carbon compounds, notably those belonging to the aromatic series. The special feature brought to light by the investigations is that the ultimate unit of crystal structure or elementary parallelepiped is not the chemical molecule, but, generally speaking, is a complex formed by the union of two, three, or four molecules. Further, the symmetry of the crystal tends to increase with the number of molecules in the unit, and also with the symmetry of the molecule itself. In fact, there are simple quantitative rules, first stated by Shearer, connecting these quantities.

The question naturally arises whether when a crystal is melted and passes into the liquid state, the units in the latter condition are the same as in the crystal, or whether these break up further into the individual molecules. A method of investigating this very fundamental point is furnished by studies on the molecular scattering of light. If the units in the liquid state are the chemical molecules, that is, the same as in the condition of vapour, there should be a simple quantitative relation between the amount of *unpolarised light* (due to optical anisotropy) scattered by equal volumes of liquid and vapour and the densities in the two states of aggregation. This relation was indicated in my letter in NATURE of July 1, 1922, but the method of calculation there given has to be amended to make allowance for the fact that the electric polarisation within a fluid is, according to the Lorentz-Mosotti formula, greater than in free space. When this correction is made, it is found that the amount of *unpolarised* light actually scattered is considerably smaller than that indicated by the calculation. The conclusion thus appears to be forced upon us that the ultimate unit in the liquid state is not the same as in the state of vapour. On the other hand, if we adopt the view that the ultimate unit is the same in the liquid state as in the crystalline state, a way is opened for a satisfactory explanation of the observed result. For, according to Shearer's rule, the symmetry of the unit is always greater than that of the molecule, and hence the amount of unpolarised light scattered by it should be diminished, as is actually observed.

A further consideration which suggests that the ultimate unit in the liquid state is the same as in the crystalline solid is the existence of those remarkable substances, known as liquid crystals, studied by Lehmann and others. If a liquid be conceived of as a collection of elementary crystal parallelepipeds which are ordinarily prevented from thermal agitation from forming regular arrays, it is easier to understand how in favourable circumstances, such arrays come into existence temporarily and as quickly disappear. This conception appears to fit in very well with the mathematical framework of the kinetic theory of liquid crystals recently developed by Oseen (Stockholm Academy, Handlingar, 1921).

The same conception also appears to furnish a satisfactory explanation of the tendency shown by many liquids to refuse crystallisation and to pass into a highly viscous or glassy condition when supercooled. We have only to suppose that the units gradually join up, but in an irregular way, and form an optically heterogeneous structure. This conception of the constitution of vitreous solids is supported by the results of an extensive series of observations on the scattering of light in optical glasses and in supercooled organic liquids carried out under the writer's direction.

Finally, it may be remarked that the conception suggested does not, so far as the writer can see, appear to be inconsistent with any other known facts regarding the physical properties of liquids.

C. V. RAMAN.

210 Bowbazaar Street,
Calcutta, India,
February 22.

PROF. RAMAN'S very interesting explanation of his observations on the scattering of light by liquids is not affected if a slight change is made in his suggestion as to the appearance of the crystal unit in the liquid phase.

The crystal unit is a parallelepiped of minimum volume, the corners of which are occupied by molecules alike in all respects, including orientation. The definition allows the unit to be delimited in an indefinite number of ways. It is improbable that any one of these occurs as the only kind of unit in the liquid. For Prof. Raman's purpose it is sufficient, I think, to suppose that association, when it occurs, is ordered, the molecules joining up as if they were beginning to build a crystal. Let us suppose, for example, that the crystal belongs to the monoclinic prismatic class, in which there are four types of molecular arrangement. Any molecule of one type possesses with any molecule of the other three types, a plane, a digonal axis, or a centre of symmetry, respectively.

Groups of mutually arranged molecules may well be expected to form under suitable conditions, but it is not likely that the group will always consist of four, or be put together the same way. The group could always, however, be incorporated into a complete crystal: possibly some redressing of the boundary might be required.

An ordered association or incipient crystallisation has been suggested by Astbury (Proc. Roy. Soc., 102, p. 527) as the cause of the variability of the optical activity of tartaric acid with the strength of solution. The Debye-Scherrer photographs of colloidal gold show that each particle is essentially an association of gold atoms in crystalline array. It is possible that on the surface there is disorder which affects the further growth of the particle.

The point is that whenever association takes place, it tends to do so in the ordered fashion of the appropriate crystal.

W. H. BRAGG.

The Wegener Hypothesis and the Great Pyramid.

IN the discussions on the Wegener hypothesis I have not yet seen an allusion to the direct evidence given by Flinders Petrie ("Pyramids and Temples of Gizeh," second edition, 1885, pp. 11 and 41) of a change in azimuth at Gizeh amounting to four or five minutes since the erection of the Great Pyramid.

Petrie's account of the high accuracy used in the construction of the pyramid seems to render quite impossible an error of 4′ in the laying down of a meridian line 700 feet long, from which other baselines were set off during 30 or 40 years. As my brother, Lt.-Col. M. M. Bidder, pointed out to me, every annual class in the local school of engineers would, in its turn, verify the meridian line under the supervision of their instructors; yet the second pyramid has the same orientation ($5\frac{1}{2}'$ west of north) as the core-plane of the first pyramid.

There are five meridians deduced by Petrie (p. 41) from his measurements. Of these the lowest and highest values occur in the Great Pyramid, being $-3' 43'' \pm 6''$ for the casing sides and $-5' 49'' \pm 7''$ for the passage. The four of them representing the Great Pyramid core and passage, and the Second Pyramid casing and passage, are all covered by the value $-5' 33'' \pm 17''$. Petrie's conclusion (p. 11) is "that the original base was probably more accurate than 0·65 inch in length and 12″ in angle."

GEORGE P. BIDDER.

Cambridge, February 26.

THE undoubted trend of the pyramids at 4600 B.C. was about 5′ west of the present pole. Each of the data was probably set out afresh from polar observation, as that would be easier than transfer by measurement. The accuracy of work there to 12″ of angle is in keeping with the accuracy of later work, as of granite planes 20 square feet in area with only inch/160 error at 3300 B.C., or of weights in eighth century A.D. with variations all within grain/200. The cause of a change of axis of about 5″ per century might be due to ocean currents or to earth deformation.

W. M. F. PETRIE.

Science and Armaments.

DR. FRENCH'S reply (NATURE, February 10) to my letter in the issue of January 20 does not touch upon the essential idea which I desired to express. I did not raise the question of the dispensability or indispensability of armaments at the present moment: a question on which a great deal might be said, but one which, I think, is somewhat outside the province of NATURE. The very columns of this journal are, however, a witness to a very real international brotherhood between men of all lands who find a common interest in the study of natural science and in its ceaseless warfare for the knowledge and control of material things for the common good of humanity.

Taking the wider view, how can it be a *consolation* that, under the urge of apparent national expediency, men should be spending their time in devising new methods of warfare by the application of that knowledge and training which should be a blessing to mankind instead of a curse? The new weapon used against A by B is to-morrow directed by A against B. Moreover, these methods, the scientific cleverness and interest of which often provide a poor mask for their brutality, are directed, not against barbarism, but largely against those for whom we now profess friendship. Such a condition may be difficult to avoid, but the great danger is that we should treat it as natural and inevitable, and grow insensible to the shame of these things. Have we forgotten the folly of

"All valiant dust that builds on dust"?

In the time of Davy it seems clear that science was respected as a thing apart from war, and we are led to inquire the reason for the change. Has it not been the willingness of inventors to exploit their knowledge, and to allow themselves to be exploited by men who cared less than nothing for science and all that it really stands for? There was small patriotism in many transactions that might be recalled, for things were sold to the highest bidder.

My first letter was, in brief, a plea that we should treat our science as something rare and precious, belonging not to ourselves only but also to all nations. Whatever burdensome and unpleasant tasks it may fall to our national lot to perform, we shall not face them the less effectively because we keep some of our most cherished possessions free from the dust of conflict. Hence my comment on the proposed action at the Science Museum.

L. C. MARTIN.

Royal College of Science,
South Kensington, S.W.7.

Hafnium and Titanium.

REFERRING to Sir Edward Thorpe's interesting letter on this subject in NATURE of February 24, I would point out that the Cornish village of "Manaccan" is in the parish of Manaccan, which adjoins the parish of St. Keverne. There is an error also in the spelling. "Menaccan" should be M*a*naccan, and so with the stream at "Lenarth," it should be L*a*narth. Presumably, therefore, the Cornish mineral should have been called M*a*naccanite and not M*e*naccanite, and the "new element" from it should have been termed "manachin" and not "menachin."

WILSON L. FOX.

Falmouth, February 26.

The Cause of Anticyclones.

IN a letter to NATURE of December 23 (vol. 110, p. 845) Mr. W. H. Dines has raised certain questions connected with the cause of anticyclones. The chief observational facts to be explained are the features peculiar to *most* high pressures, namely, the warm troposphere, the high and cold stratosphere. But not all anticyclones are warm even from a height of 3 km. up to 8 km. Some are cold to considerable heights. The gradual rise of the coefficient of correlation between pressure and temperature at the same level as one proceeds from 0 to 4 km., and the comparative uniformity of the coefficient from 4 to 8 km., is in itself strong evidence that in our latitudes these first 4 km. are the theatre of changes of air more and more frequent as the surface is approached, and that in the regions above 4 km. the air is nearly always of one sort as regards its origin. Again, with regard to persistence, Hanslik pointed out that only the "warm" anticyclones are steady and slow moving; the "cold" ones move quickly. Further facts to be taken into account are, that the conception of an anticyclone as a region of great vertical stability and of fine bright weather appears to be correct as a rule only for the "warm" anticyclone. In the other type anything short of violent weather conditions may be experienced.

I have recently (Q. J. Roy. Met. Soc., January 1923) put forward some evidence in support of the view that the explanation of the temperature peculiarities of the high- and low-pressure systems of our latitudes is, to a large extent, contained in the Bjerknes theory of their origin. In particular, when a pocket is made in the polar front by the southward rush of a great patch of polar air and when the pocket is afterwards closed behind this patch by the equatorial current from the south-west, the result is the formation of an anticyclone with closed isobars. From an examination of a more or less continuous series of upper-air observations I endeavoured to show that in such cases the change in barometric pressure at a given spot in the British Isles was indeed brought about by the fact that a thickness $h + \delta h$ of polar air had replaced a thickness h of the equatorial current, and that the upper layers of the equatorial current appeared to have been raised unchanged through the height δh. Provided that the polar air was not more than 2 or 3 km. in depth, anticyclones formed in this way would be "warm" anticyclones, and would possess the features associated with such. But there are almost certainly cases where the encroaching polar air extends right up to the base of the stratosphere, and these appear to have all the characteristics of the cold, rapidly-moving anticyclone. This cold air, passing as it does into latitudes warmer than those where it acquired the main features of its existing temperature distribution, is heated from the bottom upwards, and becomes sufficiently unstable to provide within itself moderate rain and much cloud, but probably not persistent heavy rain. (It seems likely also that anticyclones do reach us in which there is either no polar surface air or only a negligible amount. Their formation was probably a much more gradual though similar process, and took place in more southerly latitudes.)

Mr. Dines has referred to the difficulty of maintaining the polar air *in situ*. The patch of polar air with which we are dealing may be described as a roughly circular one of 1000 or more km. in diameter; in the case of a "warm" anticyclone we may limit its depth at the deepest part to 2 or 3 km.; in the case of a "cold" anticyclone the depth in the centre may include the whole thickness of the troposphere. It appears to be maintained *in situ, so far as it is maintained*, by the currents which produced it. But actually the motion of most "cold" anticyclones—*i.e.* those of the deep polar air—does strongly resemble that of the flat drop of mercury on the laboratory table.

This problem was dealt with hydrodynamically by Exner in 1918 (*Sitzungsber. Akad. Wiss.*, Wien IIa, 127, 1918, pp. 795-847). He assumed as the initial conditions the existence of a mass of cold dense air (at rest or in motion) covering a small portion of the earth's surface and surrounded on all sides and above by warmer, less dense air. Particular points made by him include—(1) that the rotation of the earth renders possible the maintenance (at a slight inclination to the horizon) of a definite fixed bounding surface between the cold and the warm air; (2) that if a long ridge of cold air divides into two ridges flowing apart like cold waves, then the square of the velocity of separation of these waves is proportional to the depth of the cold air and to the difference of density between the cold and the warm; (3) also that in such a case friction with the earth's surface results in a shallow cold film being left over the whole area traversed by the waves and in the consequent gradual reduction in the height of the waves.

There is another consideration which supports the view that an anticyclone is of complex structure, and that is the frequency with which the air above an "inversion" of temperature can be shown to be of different origin from that below. It has usually been said that the surface layers were being cooled by radiation, also that there was outflow of air in these layers, and that the upper air, descending and settling, was being warmed adiabatically. When, however, an attempt is made to apply numerical data, cases arise where the change of temperature at a given point in space appears to have taken place much more rapidly than can be provided for by the most favourable time scale of the assumed operating causes. But in particular it is difficult to see why these causes should lead rapidly to the formation of comparatively sharp discontinuities of temperature of the order of 10° F., and also how they can lead to other than a very unstable vertical distribution of temperature. It seems much simpler, being provided with air of about the appropriate temperatures to northward and southward respectively, to explain the formation of anticyclones and their temperature distribution by means of the horizontal motion and interaction of these "polar" and "equatorial" currents.

A. H. R. GOLDIE.

Wimbledon, S.W.19, March 8.

The Phantom Island of Mentone.

ON a fine dark night, looking towards the point of Mentone from the sea-front about the middle of the West Bay, the appearance is presented of a dark island rising out of the sea in the gap which separates the lights of Mentone from those of Bordighera, some ten miles distant. This "phantom island" appears to be about 200 feet high, and from its darkness one would imagine it to be thickly covered with vegetation, its sides rising steeply out of the water. It is directly opposite, and quite near the sea-front of Mentone, from which it is separated by a very narrow channel of water. It appears, in fact, to be quite close to Mentone.

The explanation of this curious optical illusion is comparatively simple. The lights of Mentone and those of Bordighera present the appearance of being ranged round a curved bay, and they throw their reflections on the water, but they are separated by the East Bay, which is not seen, and by a dark, unilluminated portion of the coast. The corresponding part of the sea is devoid of reflections, and the impression is produced of a dark obstacle breaking the continuity of the line of lights and of their reflections in the water. This effect has been seen by independent observers on several occasions.

G. H. BRYAN.

University College of North Wales,
March 6.

Ball Hardness and Scleroscope Hardness.

IN the ball hardness test Meyer found that $L = ad^n$. By combining this relation with Brinell's formula $H = L/A$, it can be shown that the hardness number when the ball is immersed up to its diameter is $\frac{2a}{\pi}D^{n-2}$. This value has been called the "ultimate hardness" (H_u), and is independent of the initial condition of the metal with regard to cold work.

Several attempts have been made to obtain a relation between standard Brinell and scleroscope numbers. The results have been more or less unsatisfactory. If, however, values of H_u be plotted against the scleroscope numbers of metals in the annealed condition, the points lie on a smooth curve which is independent of the ball diameter. The following results have been obtained by the writer using balls of 1 mm. and 10 mm. diameter:

Sample.	a.	n.	H_u.	Scleroscope No.	Ball diam.
Tin	5·53	2·185	5·4	3·5	10 mm.
Zinc	24	2·21	25	11	
Steel A	74	2·288	91	27	
,, W	185	2·292	231	51	
,, 4	262	2·292	327	64	
,, 3	342	2·293	428	73	
Armco	94	2·164	60	21	1 mm.
Steel 2N	112	2·185	71	23	
,, A	150	2·247	96	27	
,, S90	264	2·298	168	41	
Manganese Steel	453	2·303	288	50	

These results are plotted in the diagram below (Fig. 1).

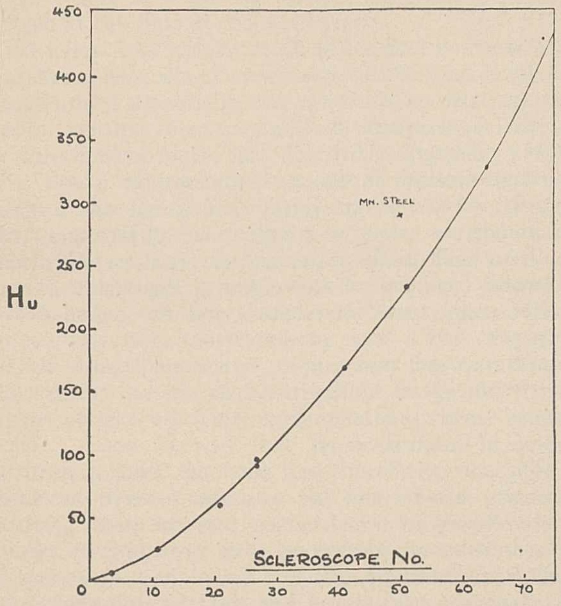

FIG. 1.

The relation between H_u and scleroscope number is quite good. The equation for the curve is:

$$H_u = 0{\cdot}79S^{1{\cdot}44}.$$

It is of interest that the ultimate hardness of manganese steel is higher than the scleroscope figure indicates.

If, as is believed, the value of H_u is independent of the ball diameter (D), then

$$kH_u = a_1 . D_1^{n_1-2} = a_2 . D_2^{n_2-2}.$$

k varies for different metals. Also, since with the 10 mm. ball

$$H_u = \frac{2a}{\pi} \times 10^{n-2},$$

then
$$0{\cdot}79S^{1{\cdot}44} = \frac{2a}{\pi} \times 10^{n-2},$$

$$S^{1{\cdot}44} = 0{\cdot}806a \times 10^{n-2}.$$

HUGH O'NEILL.

The Victoria University of Manchester.
March 5.

Metallic Crystals and Polarised Light.

DURING a research, not yet completed, on the optical properties of crystals, certain observations made in the case of metals appear to justify publication, from their importance in metallurgy.

If an etched metal specimen is examined under the microscope with the usual mode of illumination, but with plane-polarised light, and the reflected light is viewed through a " crossed " analyser, the different crystals in the field of view are sharply distinguished by differences of brightness. Rotation of the stage causes the brightest to grow dark and the darkest to light up, each crystal passing through four maxima and four minima in a complete revolution. The portions thus marked off often form parts of a crystal which appears of uniform structure under ordinary illumination; some structural difference which is indistinguishable, or with difficulty distinguishable without polarised light, produces marked differences with the crossed Nicol arrangement, which thus promises to be an effective new weapon in the metallurgist's armoury.

Curiously enough, these phenomena were observed quite independently by Miss Olwen Jones, who is engaged on the above-mentioned research in this laboratory, and by my colleague, Mr. C. Handford, of the Department of Metallurgy, who was working on a quite different problem. It was only on consulting him on the metallurgical aspects of the matter that I learned that he had noticed the effects a few days before. Her work suggests to Miss Jones that the cause may very possibly be a fine striated or laminated structure of the crystals, producing a sort of serration of their surfaces, the direction of the striation differing from crystal to crystal. When the vertical plane containing the serrations is parallel or perpendicular to the plane of polarisation in the incident beam the reflected light is plane-polarised, and is therefore extinguished by the analyser; when the angle between those planes is 45° or 135° the ellipticity, and therefore the brightness, is maximum.

Further investigations are being made both to test this theory and to develop the metallographic technique of the method. J. H. SHAXBY.

Viriamu Jones Physical Laboratory,
University College, Cardiff, March 12.

Easy Method of observing the Stark Effect.

IN the course of our investigations on the pole effect of the iron arc, we used a special device to keep the arc steady in the vertical position, and photographed the spectrum by means of a large quartz prism on a Littrow mounting. The lines originating in the electrode, extending from the visible part of the spectrum down to the ultra-violet, showed distinct separation, which was identical with the Stark effect observed with vacuum tubes. The separated lines show polarisations parallel and perpendicular to the field, which at the maximum amounts to about 20,000 volts per cm., and is confined to a very thin layer at the electrode, indicating a steep gradient. We found it convenient to work with a 500 volts arc, although the same phenomenon can be observed with a 100 volts arc. The effect is observed at the lower electrode, whether this be anode or cathode. Other metals can be used instead of iron.

The observation of the Stark effect is thus rendered extremely easy, as the only process involved is the production of a steady arc and the use of a spectroscope sufficiently powerful to resolve the lines into components. H. NAGAOKA.
Y. SUGIURA.

Institute of Physical and Chemical Research,
Hongo, Tokyo, February 13.

Volcanic Dust and Climatic Change.

ON page 20 of his very interesting book, " The Evolution of Climate," Mr. C. E. P. Brooks says that I have " attributed glaciation to the presence of great quantities of volcanic dust in the atmosphere." This is too generous. I only insist that volcanic dust is one of the factors that control climate, and that at times it may (not must) have been an important factor, especially when mountains were high and continents extensive.

W. J. HUMPHREYS.

U.S. Department of Agriculture,
Weather Bureau, Washington,
February 17.

The Character and Cause of Earthquakes.[1]

By R. D. OLDHAM, F.R.S.

THE character of earthquakes, that is, of the disturbance which can be felt and causes damage, has long been established as a form of elastic wave motion, originated by some sudden disturbance in the substance of the earth. In some cases, such as the Japanese earthquake of 1891 or the Californian of 1906, the earthquake was accompanied by visible fractures and displacements of the solid rock, and where these have been observed it has also been noticed that the violence of the disturbance reached its maximum close by, and became less as the distance from the fracture increased. From this it is evident that, in such cases at least, the earthquake originated from the jar caused by sudden rupture of the rocks, and the fault, or fracture, may be regarded as the cause of the disturbance to which the earthquake was due. In many other cases, where no actual faulting or fracture is visible at the surface, and especially in earthquakes of moderate intensity and extent, a study of the observations makes it very probable that the immediate cause of the disturbance was a fresh movement along an old fault, or the formation of a new one, and so may be found in many text-books the statement, put forward and elaborated, that faults are the cause of those earthquakes classed as tectonic. Thus it might seem that the cause of earthquakes had been explained, but this is only the beginning of the story, for we need to know what causes the fracture which gives rise to the earthquake.

In pursuing this object, reference may be made to an earthquake which occurred more than a hundred years ago, at a time when the observation of earthquakes was in its infancy, and when little information of present value could be expected, had it not been for certain peculiarities in the country affected, and in the effect of the earthquake. Just beyond the north-western angle of the Indian Peninsula lies one of the most extraordinary regions of the world, known as the Runn of Cutch; more than 200 miles in length, and some 30 in width, it is a level barren plain, so flat and so near the sea-level that when the waters of the sea are heaped up, by the south-west monsoon, and the streams from the surrounding country come down in floods, the greater part of the surface is covered with a sheet of water, varying from a few inches to five or six feet in depth.

The whole of this region, however, has not always been so barren as at present, for, up to the seventeen hundreds, a large river, fed by the waters of the Punjab, and by overflow from the Indus, flowed down through Eastern Sind, across the Runn to the Kori creek, and on the banks of this river were fertile and populated tracts; also on this river was situated a frontier fort of the Government of Cutch, where customs duties were collected. Then, in the eighteenth century, through changes in the river courses far inland, the supply of water in this river began to fail, and a series of bunds, or what we would now call barrages, was built to hold up the water and divert it for irrigation. Towards the end of the century, the whole of the water supply was intercepted, and the region below relapsed into a state of desolation; but the fort of Sindri was still maintained, with a small garrison and a few officials to collect the dues, and so things continued until June 16, 1819, when the classic earthquake of Cutch occurred.

The fort of Sindri was not only ruined, but the ground on which it lay was also lowered in level, water flowed in from the sea, and the small garrison of Sindri saved themselves from drowning by taking refuge in the main tower, whence they were rescued by boat the next day. Nor was this subsidence the only change noticed, for, about four miles to the north, where before had been only a dead level plain, the survivors observed a long low mound, stretching east and west with a height of about 20 feet, along the northern edge of the flooded area. This mound, so like an artificial embankment, was immediately named the "Allah Bund" or "God's Barrage," on the same principle which named the bunds or barrages higher up the stream after the names of their makers.

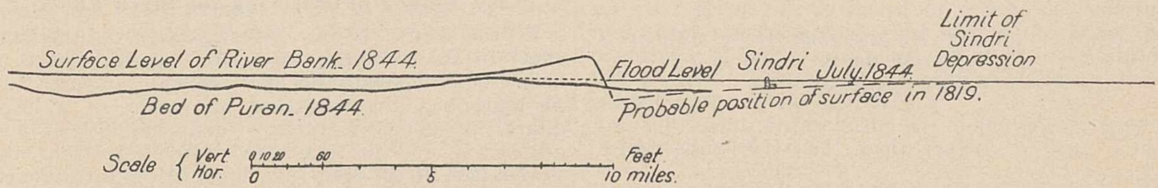

FIG. 1.—Section across the Allah Bund and Sindri depression of June 16, 1819.

Ten years later, the ruins of the fort were seen still standing out of a waste of waters, and twenty-five years later, in 1844, a careful survey was made and levels taken, and this survey revealed a remarkable condition of things (Fig. 1). From the north the surface of the delta sloped southwards, at about eight to ten inches in the mile, to within six miles from the crest of the Allah Bund, when a reverse slope was met, and the surface gradually rose to nearly 20 feet above the level of the continuation of the southerly slope, or the level at which it presumably stood before the earthquake. Thence there was a steep slope downwards, to the water of the Sindri lake. On the south the original reports mention a depth of twelve feet of water close to the shore, immediately after the earthquake, and, as the original surface level must have been a few feet above that of the sea, we have a depression of some fifteen feet, which gradually died out in a distance of some six miles to the southward. From these facts it is clear that there was no appreciable change of level at a distance of about six miles on either side

[1] Condensation of a course of two lectures delivered at the Royal Institution on January 30, February 6.

of the line of the Allah Bund, but that along that line the ground on the north was upraised by some twenty feet and on the south depressed by some fifteen at the time of the earthquake.

The next earthquake to be considered is one which has been investigated with great care and in great detail; it is the Californian earthquake of April 18, 1906. In this there was a visible fracture, following what is known as the San Andreas fault, along which the shock attained its maximum intensity. This fracture was crossed at various points by roads and fences, and after the earthquake it was noticed that, where these crossed the line of fracture, they were no longer continuous, but the ends were shifted laterally by distances which varied at different places, but frequently amounted to twenty feet. This was not all, for the displacement was of a very curious nature, revealed by surveys of the displaced fences, and by a repetition of the original trigonometrical survey of the region. These showed that for a distance of some miles back from the fault line the stations had been displaced, those nearest to the line by the greatest amount, which lessened as the distance increased and, at about five miles or so to the east, became very small. Moreover, it was found that the movement on the eastern side of the fault had been to the southwards, and on the western towards the north.

Here we have a result very like that in Cutch; in both cases there was a well-defined line along which permanent change of position of the ground took place, simultaneously, in opposite directions on either side of the line of separation, and in both cases the displacement decreased in amount with increasing distance, till it ceased to be measurable at a distance of about half-a-dozen miles. The only difference was that in California the displacements were horizontal, with little or no change of level, while in Cutch they were vertical, whether accompanied or not by horizontal shifting cannot be known.

Paradoxical though it may seem, this movement on opposite sides of the fracture in opposite directions is quite in accord with known physical principles. If any block of material is compressed or stretched in one way, while free to expand or contract in a transverse direction, or if it is twisted by two opposite sides being forced in opposite directions, a complicated system of strain is set up, and if the strain is more than the material will bear, disruption will take place, on opposite sides of which the material will move in opposite directions.

Models to illustrate this principle have been constructed by others and myself, and from these considerations there has arisen what is known as the elastic rebound theory of earthquake origin, and as generally expressed this takes the form of a very slow growth of strain and a sudden release by fracture. The former, however, is by no means necessary, and the same result, as regards displacements of the ground, would be attained if the strain was rapidly, even suddenly, produced. There are, in fact, reasons for supposing that the growth of strain is not slow but rapid, yet the fracture and elastic rebound theory might be accepted as sufficient, if earthquakes could always be attributed to a single fracture, or to a close-set group of fractures; but in the case of great earthquakes, and sometimes of minor earthquakes also, the interpretation is put out of court by a study of the distribution of the intensity of the disturbance.

In illustration I may take first the great Indian earthquake of June 12, 1897, in which the central region of greatest intensity covered an area of about 140 miles long by 40 miles broad, over which there was a complicated series of faults, fractures, and distortion, which was certainly widely different from the comparatively simple origin generally assumed for earthquakes. This seemed at the time sufficient to account for all the facts, though there were some recorded as difficult to explain, and later examination seems to have established the conclusion that the origin of the earthquake cannot be limited even to this extensive area. In this earthquake only two of the isoseists could be plotted in detail, those of eight degrees and of two, or the extreme limit at which the shock could be felt; both exhibit considerable irregularities of outline, the most conspicuous of which is a pronounced projection to the westwards, and on the continuation of this line is a detached area, where the shock was again felt, after a gap where it was not felt. Col. Harböe has suggested, from a study of the recorded times, that there was an extension of the origin along this line, and though his plotting of the origin cannot be accepted in detail, I am convinced that, in the main, his conclusions are correct, for they very materially help to explain some peculiarities of the recorded observations, which remained inexplicable on the older and more generally used interpretation.

From this it appears that in earthquakes covering a large area we are not dealing with a simple disturbance, starting from an origin of restricted dimensions and propagated outwards, but with one of complex origin; and that in the outer regions of the seismic area the disturbance may be compounded of wave motion propagated from a more or less distant origin, where the initial severity was great, and of that coming from a nearer origin, of a lesser degree of severity, so that, instead of a fracture of at most a few tens of miles in length, we have to deal with a cobweb-like system of fractures, or something analogous, which may run to hundreds of miles.

The general drift of the argument I wish to set forth is probably best illustrated by the California earthquake of 1906. In this the greatest degree of violence was found along the line of the San Andreas fault, but the plotting of the isoseists shows that there was not only an independent centre in the San Joaquin valley, some forty miles to the eastwards, but also several independent centres of great intensity at lesser distances from the San Andreas fault. Moreover, the displacements recorded by trigonometrical survey make it probable that other similar independent centres would be found to the west, if the waters of the ocean had not made observation impossible. The records, therefore, indicate a set of separate centres of disturbance, scattered over a region of about three hundred miles in length by very possibly one hundred miles in width, and these separate centres, though independent as regards the surface shock, were all evidently connected with some common cause. Had they been the result of breakage under a slowly growing strain it is difficult to understand how so complicated, scattered, and extensive a series of fractures could have originated simultaneously, but it is, to say the least, much less difficult to understand if the development of strain over the whole of the central area had been sudden, or at any rate rapid.

Then there is another point to be noticed, that in the central region the successive isoseists lie close together, while in the outer fringe they lie far apart; thus the distance separating the isoseists of ten and seven degrees, covering a range of three degrees of intensity, varies from 6 to 20 miles on either side of the San Andreas fault, while in the outer regions a similar range of three degrees covers from 120 to 250 miles. The close-set isoseists of the central region indicate a shallow origin, and such is proved by the San Andreas rifts, where the origin reached the surface of the ground; the widely set outer isoseists similarly indicate a deep-lying origin: and so we reach the conclusion that the earthquake origin was of a two-fold nature, the great violence in the central region being due to fractures and displacements close to, or at a comparatively shallow depth below, the surface, and that these fractures were the secondary result of a more deep-seated disturbance or bathyseism.

Having reached this conclusion there remain two questions of importance, what is the depth, and what is the nature of this bathyseism? As to the depth, the study of a remarkable, though only feeble, earthquake which affected northern Italy on August 7, 1895, has led me to conclude that the ultimate origin lay at 100 to 150 miles below the surface; but the best indications are to be had from the long-distance records of disturbances, which need not necessarily have been great earthquakes, in the ordinary sense of the words.

From these Dr. L. Pilgrim, in 1913, deduced the conclusion that the origin of the disturbance, in the case of the Californian earthquake, lay at a depth of about 100 miles, and, more recently, a similar method has been developed in this country by Prof. H. H. Turner, who has shown that the long-distance records indicate depths of origin ranging from fifty to three hundred miles below the surface of the earth. Now it seems fairly well established that earthquakes of quite shallow origin do not give rise to distant records, even when very violent in the place where they are felt, and it is probable that the disturbance recorded by these distant seismographs is not the superficial destructive earthquake, but the bathyseism.

Next comes the question of the nature of the bathyseism. That it must be in some way accompanied by a change in bulk of the material underlying the central area of the earthquake, seems clear, in some cases at least. Fracture such as is sufficient to explain most of the features of the surface shock seems out of the question, for the depths place it in the region of what it is nowadays the fashion to call the asthenosphere, that is, a part of the earth which is weak and plastic against stresses of long duration; but as regards change of bulk, recent researches have indicated one very likely mode in which it might be brought about. It is known that the foundation rocks of the outer crust are everywhere composed of an aggregate of crystalline minerals, the detailed study of which shows that the material must once have been in a condition analogous to that of fusion, from which it has solidified by cooling to its present condition. Further, it has been shown that the same original magma may crystallise out as quite different mineral aggregates, differing in density, and therefore in volume, by anything up to 20 per cent. The exact conditions which determine the passage from one form of chemical grouping to another are not known in detail, but it is probable that in each case there is some critical limit of temperature and pressure which determines it. If there were, in the interior of the earth, a mass of material near this critical limit, a small change of pressure or temperature might bring about a change of chemical combination, and with it a greater or lesser change of bulk, which, transmitted to the upper layers of the earth's crust, would give rise to displacements and distortion. Such changes might be unaccompanied by earthquakes, if they were slow and gradual, or, if rapid or sudden, might give rise to fractures in the surface rocks, of greater or lesser magnitude, and covering a larger or smaller area, according to the bulk of the deep-seated material undergoing a change of volume.

Without insisting on this as the nature of the bathyseism, and it is possible that other causes as yet unsuspected may also be at work, it is evident that we have an explanation which would suffice in the case of the larger, and of many of the smaller earthquakes. Yet there are some causes, perhaps no inconsiderable fraction of the total, in which the whole process leading up to the earthquake seems to lie quite close to the surface. To these, always small in extent, though sometimes of considerable severity, the consideration which I have outlined cannot at present be applied; in part they must be due to quite different causes, the consideration of which is not without interest, but this interest only arises after more extended and technical study than could be presented, even in outline.

Hydrogen Ion Concentration.

By Prof. A. V. Hill, F.R.S.

CERTAIN solutions are capable of conducting electricity, although their separate pure components are themselves incapable, or capable only to a slight degree, of so doing. This conductivity is attributed to the "ionisation" of the dissolved body, that is, to the splitting up of its molecule into two or more parts, some carrying a positive and others a negative charge, the resulting "ions" being capable of migration under an imposed electric field, and so giving to the solution the power of carrying a current. The electrically neutral molecule breaks up into (*a*) a negatively charged part, containing an excess of electrons which lend it its negative charge, and (*b*) a positive portion with a deficit of electrons, this deficit resulting in an equal positive charge. These positive and negative ions attract one another, as do all positive and negative charges, and are separable only if their mutual attraction be small enough to be overcome by the inter- and intra-molecular dynamic forces (not yet properly understood) tending to their separation.

The attraction between two charges is far greater if they be separated by some media than by others, to a degree inversely proportional to the so-called specific inductive capacity of the medium. Water has one of the highest specific inductive capacities of all known substances, so that in it the attraction between two ions is relatively small: hence in water the ions may separate more effectively than in other solutions, and watery solutions are found to show the phenomena of electrolytic dissociation to an exceptional degree. Now water is a solvent of unique importance, partly because of its common occurrence, partly because it dissolves so many other bodies, and especially because, without exception, all biological phenomena occur in media which are essentially solutions or suspensions in water. Hence the study of the electrolytic dissociation of bodies dissolved in water is of quite peculiar interest, especially in physiology.

Now water itself is capable of electrolytic dissociation, though only to a small degree. In pure water at 22° C., eighteen parts in ten thousand million, that is, one ten-millionth part of one gram molecule per litre, is broken up into hydrogen ($H^{\cdot}$) and hydroxyl (OH') ions, the $^{\cdot}$ denoting the positive and the $'$ the negative charge. Such a very small degree of dissociation is of little importance in pure water: its insignificance is presumably due to the smallness of what we have called—to cover our ignorance—the dynamic forces tending to separate H_2O into $H^{\cdot}$ and OH'. In solutions, however, especially in solutions of acids and alkalies (that is, of bodies capable, by their own dissociation, of yielding one of the ions of water, $H^{\cdot}$ or OH'), even this small dissociation of water into its ions may become of preponderant importance.

It is obvious that the ions of the solvent itself, if present in appreciable amount, might be expected to play a special rôle in the behaviour of a solution: there is, however, a very real interest in the study of the hydrogen ion, in view of modern theories of the electrical constitution of matter. Atoms are supposed to possess a positive nucleus, with a charge equal to some multiple of the elementary negative charge on an electron, with layers of electrons circulating round the nucleus in stable orbits. The simplest atom of all is hydrogen, with a positive nucleus of unit elementary charge and a single negative electron revolving round it: remove this negative electron from a dissolved hydrogen atom, and we are left with a singly charged positive nucleus—next to the electron the simplest of all known natural bodies. In mobility, in combining power, in general dynamic effectiveness, this dissolved elementary unit might be expected to be, and actually proves to be, an agent of quite peculiar importance.

Expressing concentrations, in gram molecules (or ions) per litre, by means of brackets, it is found that at 22° C. in pure water,

$$[H^{\cdot}][OH'] = 10^{-14}.$$

This is the law of chemical mass action, which, in such a dilute solution as water is of its own ions, is accurately obeyed. Now in pure water there is no other agent capable of carrying electricity, and since the water itself cannot carry an appreciable resultant charge the positive and negative charges must balance one another, and therefore

$$[H^{\cdot}] = [OH'] = 10^{-7}.$$

If, however, we dissolve in the water another substance supplying one of the ions of water, for example, hydrochloric acid (HCl), which we may regard as being almost totally dissociated into its ions $H^{\cdot}$ and Cl', to a concentration (say) of one gram molecule per litre, then the equation above is entirely upset: the hydrogen ion concentration $[H^{\cdot}]$, or $c.H$ as we shall often call it, has now become unity instead of 10^{-7}, so that the hydroxyl ion concentration $[OH']$ is now only 10^{-14}. Even this, expressed in actual molecules, is an astonishingly large number: there are about 6×10^{23} molecules in a gram molecule, so that even in normal hydrochloric acid there are six million hydroxyl ions per cubic centimetre. Clearly, even a strong solution of acid contains an appreciable number of hydroxyl ions.

If, conversely, we dissolve caustic soda to make a "normal" solution, instead of hydrochloric acid, then $[OH']$ becomes unity and $[H^{\cdot}]$ becomes 10^{-14}. We may make up different strengths of acids or alkalies in which the hydrogen and hydroxyl ion concentrations

Acid.	$[H^{\cdot}]$.	$[OH']$.	Alkali.	$[H^{\cdot}]$.	$[OH']$.
N	1	10^{-14}	N	10^{-14}	1
N/10	10^{-1}	10^{-13}	N/10	10^{-13}	10^{-1}
N/100	10^{-2}	10^{-12}	N/100	10^{-12}	10^{-2}
N/1000	10^{-3}	10^{-11}	N/1000	10^{-11}	10^{-3}
N/10000	10^{-4}	10^{-10}	N/10000	10^{-10}	10^{-4}

may be calculated as in the accompanying table. It is usual to consider only the hydrogen ion concentration: the hydroxyl ion concentration may always be calculated from it, by dividing the quantity k in the equation $[H^{\cdot}][OH'] = k$ by $[H^{\cdot}]$. At 22° C., $k = 10^{-14}$, but it varies slightly with temperature. Now $[H^{\cdot}]$, or $c.H$, may change enormously from one solution to another, say from 10^{-14} to 1, that is, one hundred million million times: hence it is impossible to represent the full possible range of variation of $c.H$ in a single diagram, and since it is often necessary in physical chemistry to show the relations of $c.H$ graphically, it has become customary to express the hydrogen ion concentration in terms of logarithms. The logarithm of 10^{-14} is -14, and of 1 is 0, so that log $c.H$ can be represented, over almost the entire possible range, by numbers lying between 0 and -14. To avoid, further, the use of negative numbers the negative sign is understood, and the symbol $p.H$ (or its variants P_H, P_h, etc.) is defined by the expression $p.H = -\log c.H$. In this way, at 22° C., if $p.H = 7$ the solution is neutral, if $p.H$ be less than 7 the solution is acid, if $p.H$ be greater than 7 the solution is alkaline; and a decrease of $p.H$ means an increase in hydrogen ion concentration.

This system of nomenclature has certain obvious advantages if used with discretion: not seldom, however, it lends itself to obscuring the fact that the real agent at work is the actual hydrogen ion concentration $c.H$; it is difficult enough even for the expert to picture a quantity in terms of its negative logarithm, and it leads to confusion and suspicion on the part of the inexpert and beginner. For most of the phenomena of biology, moreover, which occur within a narrow range of $c.H$, it is quite unnecessary: for example, in physiology, apart from a few cases of secretion, the important range of $c.H$ in the body is from 10^{-7} to 10^{-8}, and it is better when possible to deal with the hydrogen ion concentration in multiples (or decimals) of 10^{-7}, and to use the $p.H$ notation only when the total range considered is outside the limits of any reasonable diagram: occasions, in physiology, where this occurs will be comparatively rare.

The hydrogen ion concentration of a solution can be measured in a variety of ways: (*a*) by calculation from the laws of mass action, with a knowledge of the components of the solution and the proper constants; (*b*) by the use of a so-called hydrogen electrode: if a platinum wire, coated with platinum black and saturated with hydrogen gas, be dipped into a solution, it acts like a metallic electrode of pure hydrogen, and its electrode potential can be measured and made to give the *c*.H of the solution; (*c*) by the use of so-called "indicators," that is, dyes which change colour as the hydrogen ion concentration is altered, owing presumably to changes in their degree of electrolytic dissociation: the colour is used to measure the value of *c*.H. The study and measurement of the hydrogen ion concentration is becoming to-day almost a complete science in itself, and progress in physiology, and in some branches of colloid chemistry, still waits on further improvements in the accuracy and adaptability of its technique.

The importance of the hydrogen ion concentration in biology is bound up with the phenomena attending the dissociation of weak acids and of the so-called amphoteric electrolytes, and with the theory of "buffers." A weak acid, for example, carbonic acid H_2CO_3, is one which is only slightly dissociated into its ions: the reaction $H_2CO_3 \rightleftarrows H^{\cdot} + HCO'_3$ goes almost entirely $\leftarrow$: similarly with a weak base. The salt of a weak acid is a very effective regulator of the hydrogen ion concentration; it acts as a "buffer" to resist the effect of adding a strong acid. Let the salt of the weak acid be XY, dissociated into its ions $X^{\cdot}$ and Y'. Let us add to this a strong acid HZ, dissociated into $H^{\cdot}$ and Z': we might expect the *c*.H to be largely increased. In our solution now are all the ions $X^{\cdot}$, Y', $H^{\cdot}$, and Z'.: $H^{\cdot}$ and Y', however, cannot exist side by side in solution in appreciable amount, since (by hypothesis) the acid HY is a weak one, that is, the reaction $H^{\cdot} + Y' \rightleftarrows HY$ goes almost entirely $\rightarrow$. Hence the hydrogen ions are eliminated to form the undissociated weak acid HY, and we are left (i.) with the ions $X^{\cdot}$ and Z' of the salt XZ of the strong acid, and (ii.) with the undissociated weak acid HY.

The expected increases in *c*.H can, in this way, be reduced almost to an insignificant amount, and in physiology (where an exact constancy of *c*.H appears to be necessary for the maintenance of the normal physico-chemical structure and behaviour of the living cell) the presence of very effective "buffers" in every organ, tissue, and cell has been shown in recent years to be of ultimate importance. Phosphates, carbonates, and the salts of proteins, such as hæmoglobin, are the chemical agents by which this regulation is effected. In addition to these we have what we may call "living buffers," the cells of the respiratory centre and the kidney for example, which by their activity maintain, in an amazingly accurate manner, the constant *c*.H required in the "internal environment" of all the other cells of the body; that is, in the blood and tissue fluids which bathe them. In the body, the important buffers are those absorbing the effects of added acid, especially carbonic and lactic acids, which are produced with great rapidity and amount during muscular exercise. The salts of weak bases, however, are equally effective buffers, from the physico-chemical point of view, in their capacity of neutralising the effect of strong alkalies. Some bodies, moreover, the so-called "amphoteric electrolytes," of which amino acids and proteins are the most notable, are capable of functioning both as weak acids and as weak bases: hence their salts (for example, sodium "hæmoglobinate," or hæmoglobin chloride) may act, under suitable conditions, as buffers of either type.

The importance of the hydrogen ion concentration in physiology is almost certainly concerned—at least in part—with the electrical properties of the proteins which constitute the formed constituents of living cells. It may also be concerned with the processes of oxidation and reduction occurring in metabolism, but with these we will not deal further now. Proteins are complex compounds of amino acids, and each amino acid possesses the latent possibility of acting either as a weak base (in virtue of its $-NH_2$ group) or as a weak acid (by reason of its $-COOH$ group). Hence proteins are capable, at a suitable *c*.H, of forming salts at many and varied points in their enormous molecules. These salts are largely dissociated into their ions, so that the protein of the living cell may be regarded as a large electrified molecule, surrounded by a shell of attendant positive (or negative) ions.

The electrical phenomena accompanying any form of activity in a living tissue demonstrate the importance of this electrification of the fundamental chemical basis of protoplasm, and it is well known that the existence and properties of colloidal solutions are intimately dependent upon the electrical charges on the surfaces of the colloidal particles. Now the degree of dissociation of a weak acid HZ, into its ions $H^{\cdot}$ and Z', depends upon the hydrogen ion concentration: according to the laws of chemical mass action the ratio of the dissociated to the undissociated part is inversely proportional to *c*.H. Hence, if the protein be acting as a weak acid, the degree of electrification of the protein molecule will be decreased by an increase of *c*.H, and if the behaviour of a living cell depend upon the electrical characters of its protein constituents we should expect it to be largely modified by an appreciable change in *c*.H.

This actually occurs: the most violent and extensive physiological response is produced, both in single cells and in larger complex animals, by quite small changes in *c*.H, and all animals possess the power of reacting, in a sudden and vigorous manner, to any alteration in the *c*.H of the fluid immediately in contact with their cells, in such a sense that the change is diminished, or neutralised, and the physico-chemical characters of the protein molecules of their protoplasm are maintained in their normal state. We know, at present, very little about the molecular structure of living protoplasm: we cannot, however, be far wrong in supposing that the ionic and electrical phenomena displayed by the protein molecules which constitute it are among its most fundamental properties, and that these are modified, to a high degree, in accordance with purely physico-chemical laws, by the hydrogen ion concentration of the fluid in which it is suspended or dissolved.

Obituary.

DR. J. G. LEATHEM.

THE death of Dr. John Gaston Leathem on March 19, at the age of nearly fifty-two years, removes a scholar who was prominent in the world of Cambridge mathematics. Coming from Queen's College, Belfast, in 1891, he made his mark in the triposes of 1894 and 1895. He held the Isaac Newton studentship for astronomy and physical optics during the period 1896–99, soon gaining also a fellowship at St. John's College. His interests were then mainly in electrodynamic theory; and the work of his studentship produced a memoir (Phil. Trans., 1897, pp. 89-127) which ought to be classical, in which the theory of the magneto-optic rotation of light and the cognate reflection effect were finally systematised and co-ordinated, under the test of laborious comparisons with the numerical experimental data.

In due course Dr. Leathem became mathematical lecturer at St. John's College, and afterwards university lecturer: and for a series of years he exerted a wide influence on the teaching. For the mathematical tripos he was an examiner on as many as six occasions, two of them (1912, 1913) after he had been withdrawn from all teaching except an annual advanced course on electrodynamics. For he had become senior bursar of his college in 1908, and henceforth he threw himself into its external affairs and general administration with assiduity and practical success.

In 1905 Dr. Leathem took up the editorship, in conjunction with Prof. E. T. Whittaker, of a series of Mathematical Tracts projected by a Cambridge group of lecturers, which, in numerous volumes, has become under their care an important survey, almost an encyclopædia, of domains of recent higher mathematics. To this undertaking he contributed the earliest volume of the series, and one on optical systems. His own later special investigations, exhibiting the geometrical trend that is associated with the Irish school, thus including applications of conformal transformations to physical problems, were published mainly by the London Mathematical Society and the Royal Irish Academy. A note in Roy. Soc. Proc. established an unexpected mode of interaction between a magnet, supposed to consist of revolving electron-systems, and a varying electric field, too small, however, to permit of experimental scrutiny.

During the War Dr. Leathem felt bound to volunteer for work in the Research Department at Woolwich Arsenal, then in need of mathematical help, handing over as much of his bursarial work as was possible to senior colleagues. About two years ago he had to submit to a sudden and very drastic surgical operation: in time he recovered, and though never strong again, he resumed his activities with all the previous zeal and judgment. But the mischief could only be delayed, not removed: and his loss will now be deeply felt not only in his own college but also throughout the university.

J. L.

DR. E. A. MERCK.

THE death took place at Darmstadt on February 25 of Privy Councillor Dr. E. A. Merck, senior partner of the chemical works of E. Merck. Dr. Merck was born at Darmstadt on July 30, 1855; he studied pharmacology and chemistry, and took his degree in Freiburg i. B. under Ad. Claus. He then took over the Engel-apotheke, which had been in the possession of the family of Merck since 1668, and became one of the managers of the chemical works of E. Merck.

The works, which were then on only a modest scale, were greatly enlarged through the energy and initiative of Dr. Merck and his cousin, Louis Merck, who was his partner, and developed into one of the greatest manufactories of preparations for medical purposes. To the production of drugs was added that of alkaloids, the preparation of synthetic remedies (for example, "veronal"), and various sera. In response to the demand of chemists for pure reagents, the production of chemically pure preparations and solutions for volumetric analysis was taken in hand, and the firm's products became famous throughout the world. The connexion between the industry of chemical preparations on one hand and the pharmaceutical chemists and physicians on the other was steadily maintained by the literary publications: "Mercks Jahresbericht," "Mercks Index," and "Mercks Reagenzienverzeichnis."

Dr. Merck took an important part in all these developments. At the same time he worked continually for the improvement of the training of pharmaceutical chemists and the social position of the whole chemical profession. For six successive years he was president of the Verein Deutscher Chemiker, and he represented German chemistry at many international gatherings. His strong historical interest led him to give particular attention to the work of Liebig, and he was one of the founders of the Liebig Museum at Giessen.

WE regret to announce the following deaths:

Prof. A. S. Dogiel, professor of histology in the University of Petrograd, whose investigations on the histology of the peripheral nervous system are well known.

Prof. A. S. Flint, emeritus astronomer of the Washburn Observatory, University of Wisconsin, on February 22, aged sixty-nine.

Prof. W. S. Haines, professor of chemistry, materia medica, and toxicology at Rush Medical College, and professor of toxicology in the University of Chicago, on January 27, aged seventy-two.

Sir Joseph M'Grath, a vice-president of the Royal Dublin Society, and registrar of the National University of Ireland since 1908, on March 15, aged sixty-four.

Mr. W. Pearson, for nearly fifty-eight years prosector to the Museum of the Royal College of Surgeons of England, on March 15, aged eighty-two.

Sir Thomas Roddick, formerly professor of surgery, McGill University, and the first Colonial president of the British Medical Association, at its Montreal meeting in 1897, on February 20, aged seventy-six.

Sir William Thorburn, emeritus professor of clinical surgery in the University of Manchester, on March 18, aged sixty-one.

Prof. J. Trowbridge, emeritus professor of physics at Harvard University, on February 18, aged seventy-nine.

Mr. E. W. Vredenburg, of the Geological Survey of India, on March 12.

Prof. N. E. Wedensky, professor of physiology in the University of Petrograd.

Current Topics and Events.

THE Conjoint Board of Scientific Societies was dissolved by a resolution passed at a meeting of the Board held at the Royal Society on March 22. The Royal Society took the initiative in the formation of the Board in 1916; and when a few months ago the council decided that the society no longer desired to remain in this federation, whether under the original constitution, or the new one proposed, there was little hope for the continued vitality of a body so sharply truncated. The chief scientific and technical societies—about sixty in all—in the British Isles were represented on the Board, and the special committees appointed from time to time have produced a number of notable reports. Among such committees may be mentioned those on the water power of the British Empire, glue and other adhesives, national instruction in technical optics, timber for aeroplane construction, and the application of science to agriculture. A couple of years ago the Board appointed a committee to arrange for the publication of a world-list of scientific serials, with indications of libraries in the chief centres of Great Britain where such periodicals could be consulted. It is gratifying to know that the interests of the Board in the list, towards the publication of which the Carnegie United Kingdom Trust made a grant of 1000*l.*, have been vested in three trustees, so that notwithstanding the dissolution of the Board the issue of the list is assured. For this provision thanks are due largely to Dr. P. Chalmers Mitchell. In its early years the Board owed much to Sir Joseph Thomson, who, as president of the Royal Society, was president also of it. Sir Arthur Schuster and Sir Herbert Jackson were associated with the Board throughout its existence, and did invaluable work for it, while the devoted service rendered by the Secretary, Prof. W. W. Watts, created a sense of indebtedness which can never be adequately expressed. It is impossible not to regret that a federation of such early promise should have had so short a life.

SIR FREDERICK MOTT, pathologist to the mental hospitals of the London County Council for twenty-seven years, and director of the Council's pathological laboratory, is retiring from the service at the end of this month. By his own researches and by stimulating and encouraging the spirit of investigation in others, he has brilliantly discharged the difficult task of establishing the tradition that it is the business of the authority having control over asylums for the insane, not only to see to the security and comfort of the inmates, but also to secure that progressive work on the nature and causes of mental diseases shall be directed towards their prevention and cure. His demonstration that general paralysis of the insane is in fact a late manifestation of syphilis in the nervous system is perhaps the most conspicuous piece of his personal work among patients and in the laboratory, and it has entirely altered our conception of the disease. The *Archives of Neurology* and other journals show the quantity of good work which came from the laboratory at Claybury—the more remarkable when we remember that Sir Frederick was also a busy general physician attached to Charing Cross Hospital. Two of the plans in which he was much interested have now matured in the moving of the central laboratory to a more accessible site in London, and in the establishment of the Maudsley Hospital at Denmark Hill for the study of the early stages of mental derangement. The solid foundation which he has laid should do much to secure success for the new arrangements.

AMONG the important centenaries of scientific interest this year is that of the birth of Sir William Siemens, who was born in Lenthe, Hanover, on April 4, 1823, and died in this country on November 19, 1883. Siemens took up his residence in England in 1844, and from 1859 was a naturalised Englishman. It would be difficult to measure the value of his services to our industries, for he was one of the foremost electrical engineers of his day, while as a metallurgist his name is connected with the introduction of the regenerative furnace and the manufacture of open-hearth steel. His scientific knowledge was no less noteworthy than his inventive ingenuity, while above all he was a man of affairs. The first president of the Society of Telegraph Engineers, he also served as president of the Mechanical Engineers and of the Iron and Steel Institute. It was in his address to the latter body that he threw out the pregnant suggestion of utilising some of the power of the Niagara Falls and transmitting it long distances by electric conductors. In much of his work he was associated with his brothers Werner, Carl, and Friedrich. In the issue of NATURE for November 29, 1883, Lord Kelvin gave an account of Siemens's scientific career and work as a contribution to our series of Scientific Worthies.

ON April 7 occurs the centenary of the death of the French physicist Jacques Alexandré Cesar Charles, the pioneer of scientific ballooning. Born in 1746, Charles began life as a clerk in the Ministry of Finance. He devoted his leisure to scientific pursuits and he became known as a lecturer and experimenter. In 1783, a few months after the brothers Montgolfier had made their first experiments with the hot-air balloon, Charles conceived the idea of filling a balloon with hydrogen. His first important demonstration was made in December 1, 1783, when Charles and his companion, Francis Robert, rose from the gardens of the Tuileries to a height of 9000 feet. Charles made his hydrogen by the action of iron on sulphuric acid. To him is due the invention of the valve, the car, the use of ballast, and the employment of rubber for rendering the silken envelope gas-tight. He was also the first to use the barometer in a balloon. Very great interest was excited by the work of Montgolfier and Charles, and Lavoisier was instructed by the Paris Academy of Sciences to draw up a report as to the value of the discovery. Charles was admitted to the Academy in 1785, received a pension from Louis XVI., and, after the Revolution, occupied a post at the Conservatoire des Arts et Métiers. He is buried in the Père-Lachaise cemetery.

THANKS to the generosity of the Spanish Government the Science Museum, South Kensington, now possesses a model of the flagship of Columbus, the *Santa Maria*, in which, accompanied by the *Pinta* and *Nina*, he made his famous voyage of discovery in 1492. The model is a copy of one in the Naval Museum, Madrid, and has been made under the supervision of the director, Capt. Don Antonio de la Reyna y Pidal. From time to time many inquiries have been made regarding the details of the *Santa Maria*, and for the Chicago Exhibition of 1893 a replica was constructed and sailed across the Atlantic by a Spanish crew under Capt. Concas, the course followed being that travelled by Columbus. The *Pinta* and *Nina* were small vessels of about 40 or 50 tons, but the *Santa Maria* had a displacement of 233 tons. She was 95 feet long over all, carried a complement of 52 men, and mounted eight guns for firing stone shot. Another of the existing models of the *Santa Maria* is that made by Capt. Terry, who searched Southern Europe for information; this model is illustrated in Chatterton's well-known "Sailing Ships and their Story."

MR. STANLEY BALDWIN, Chancellor of the Exchequer, announced in the House of Commons on March 22 that he had decided to withdraw the proposal to charge fees for admission to the British Museum, Bloomsbury, and the Natural History Museum. The announcement followed a statement by Major Boyd-Carpenter, Parliamentary Secretary to the Ministry of Labour, that the cost of equipping the British Museum and the Natural History Museum with turnstiles for the collection of admission fees had been estimated at £500, and that possibly one extra attendant would be required.

A CONVENTIONAL distinction is often drawn between science and art, but in their finest developments they have much in common. In an address before the Circle of Scientific, Technical, and Trade Journalists on March 20, Prof. Beresford Pite defined the artist as one who found his pleasure in his work—a definition that surely applies equally well to the researcher in pure science. He also pointed out that the full development of architecture requires the stimulus of contact with other countries. The Elizabethan period was one of poverty in architectural effort, though literature flourished, a condition attributed to the isolation of this country from the Continent, owing to religious differences. This again applies to science, for the crippling effect of lack of intercourse with men of science in other countries is well recognised. Perhaps a third point of similarity might be found in his claim that the architect, like the man of science, does much work without prospect of reward. He is not paid for what he "rubs out," neither is the experimenter proportionately rewarded for the many fruitless experiments that usually precede a genuine discovery. In the course of the discussion the Press, the influence of which in directing public attention to the claims of science has already been invited at previous meetings, was given an opportunity of hearing a masterly lecture on the ideals of architecture.

THE annual meeting of the National Institute of Industrial Psychology was held on March 20 at the rooms of the Royal Society. Mr. H. J. Welch, chairman of the Institute, presided. Lord Balfour was the principal speaker, and he pointed out how mistaken is the idea that science has nothing to do with practical life. As a nation we are too apt to think that science exists for men of science, and that it can have no interest for practical men. He wished to bring together men of science, capitalists, leaders of labour—all the forces of society—in order to further the work of uniting science and practice. By the application of physiology and psychology Lord Balfour expressed the hope that the labours of the wage-earners may be made easier and smoother, so that work, instead of being a kind of torture, may become a pleasure. He quoted Francis Bacon to the effect that the object of science is the relief of man's estate. The next speaker, Sir Charles Sherrington, president of the Royal Society, described the changes which have taken place during his lifetime in the position of psychology. The early pioneers in experimental psychology occupied themselves with problems which seemed quite remote from any practical application; now, many of these early researches are recognised as of far-reaching practical importance. Sir Charles made a special plea for adequate support for, and sympathy with, that part of the work of the Institute which is known as vocational selection. Most boys have no chance whatever of getting into an occupation that suits them best; unguided, they drift into any trade. Both Sir Lynden Macassey and Mr. A. Pugh showed from different points of view that there is more waste in industry owing to indifferent management than to indifferent workmanship. Industrial managers are more equipped, as a rule, for controlling machines than for controlling men. Dr. C. Myers, director of the Institute, gave some details of the actual work of the Institute.

THE Central Mining-Rand Mines premium of 25*l.* has been awarded by the South African Institution of Engineers to Mr. W. J. Horne, organiser of technical education, Transvaal, for his paper on "Technical Education for Trades," read at Johannesburg.

AT the ordinary scientific meeting of the Chemical Society held on March 1, Prof. Bohuslav Brauner, Prof. Ernst Cohen, Prof. Gilbert N. Lewis, Prof. Charles Moureu, Prof. Amé Pictet, and Prof. Theodor Svedberg were elected honorary fellows.

THE King and Queen have consented to lay the foundation-stones of the new buildings for medical research at University College Hospital, London. These buildings, it will be remembered, have been made possible by a munificent gift of 1,250,000*l.* from the Rockefeller Foundation, announced some three years ago. It is probable that the ceremony will take place towards the end of May.

THE annual general meeting of the Society of Chemical Industry will be held at Cambridge on June 21–23. Dr. E. F. Armstrong will deliver his presidential address on the first day of the meeting. On June 22, the Society's medal will be presented to Dr. C. C. Carpenter, and later in the same day Dr. F. W. Aston will deliver an address on "Isotopes." During the early part of the same week, it will be remembered, the International Union of Pure and Applied Chemistry is also meeting at Cambridge.

AT the annual general meeting of the Chemical Society, held on March 22, Sir James Walker, the retiring president, delivered his presidential address entitled "Symbols and Formulæ." The following elections were afterwards declared: Prof. W. P. Wynne as president; Prof. J. F. Thorpe as treasurer; new vice-presidents, Dr. J. T. Hewitt, Prof. G. T. Morgan, Sir William J. Pope, Prof. J. M. Thomson, and Sir James Walker; new members of council, Dr. E. F. Armstrong, Prof. W. N. Haworth, Dr. C. K. Ingold, Dr. H. McCombie, Dr. G. W. Monier-Williams, and Dr. J. Reilly.

IN Great Britain the period of Summer Time will begin this year at 2 A.M., G.M.T., on Sunday, April 22, and will continue until 2 A.M., G.M.T., on Sunday, September 16. In Belgium, Summer Time begins after midnight on March 31. The Paris correspondent of the *Times* states that, in order to meet the opposition to Summer Time from representatives of agriculture in the Chamber of Deputies, the French Government has decided to substitute for it the time of Strasbourg, which is about thirty-five minutes in advance of Greenwich time.

WITH reference to the letter published in NATURE of February 17, p. 222, describing a remarkable mirage observed at Cape Wrath on December 5, 1922, a letter has been received from Mr. Albert Tarn of Thornton Heath, who describes a somewhat similar occurrence at Oban in August 1885. Mr. Tarn states that he was sleeping in a bedroom at the back of a house adjoining the Waverley Hotel, so that the room faced inland. During the course of the night he awoke, and on looking out of the window saw what appeared to be a view of Oban Bay with the moon shining on the water. The date is not given, and no observations are available to decide whether the circumstances resembled those at Cape Wrath.

THE report of the National Museum of Wales for 1921–22 announces the completion of the western section of the new building and of the western portion of the entrance-hall. A fumigating chamber has been installed to rid specimens of insects and other pests. Among the many interesting accessions we note a beaker of early Bronze Age type from Glamorganshire, which contained the remains of a child's skull showing symptoms of rickets, the earliest recorded instance of this disease in Great Britain or perhaps in the world. Several thousand specimens of fossil plants most carefully collected from the successive beds in the Coal Measures of Gilfach Coch and Clydach Vale by Mr. David Davies, and the basis of his recent paper before the Geological Society, have been presented by him and will be preserved in cabinets given for the purpose by local bodies interested in the coal industry.

THE Australian National Research Council has commenced the publication at Sydney of a quarterly journal under the editorship of Dr. A. B. Walkom, which is to give short abstracts of papers written by Australian scientific workers—even when they appear in periodicals not published in Australia. The price of the journal is 4*s*. per annum. The first four numbers of the journal have already appeared, and extend to 32 pages. The abstracts are arranged in sections according to the branches of science represented on the Research Council, and the 245 which constitute the first year's total are distributed among the sections as follows: agriculture 70, botany 31, chemistry 14, engineering 1, geography 1, geology 18, mathematics 1, mining and metallurgy 0, pathology 13, physics 1, physiology 4, veterinary science 3, zoology 88. Cross references are given so that an abstract of interest in a section other than that in which it appears can readily be found. The distribution of the abstracts among the sections is interesting as evidence of the extent to which science is being brought to bear on the special problems which a developing colony presents to its Government.

MR. J. REID MOIR is publishing through Mr. W. E. Harrison, the Ancient House, Ipswich, under the title of "The Great Flint Implements of Cromer, Norfolk," an account of his discoveries in 1921 of a large and remarkable series of flint implements and flakes, to which attention has already been directed in the columns of NATURE. The forthcoming volume will contain a number of illustrations by E. T. Lingwood.

WE have received from Messrs. Watson and Sons Parker Street, Kingsway, Bulletin 50.S., containing descriptions of some new X-ray accessories. A new mercury interrupter with a rotary rectifier designed for continuous work under heavy loads is illustrated, also an automatic time-switch for exposures ranging from one-sixteenth of a second to thirty seconds. The extensive use of X-rays for therapeutic purposes has led to great improvements in the design of suitable stands which serve the double purpose of holding the X-ray tube and allowing it to be manipulated at any angle. The new stand illustrated here has some good constructional features, and the tube itself is almost completely enclosed by protective material which has an absorption equivalent of 3 mm. of lead. This protective shield is provided with an arrangement which permits of forced air cooling during the working of the tube.

THE 1922 Year-Book of the Franklin Institute, Philadelphia, contains some interesting facts from the history of the Institute. It was organised in 1824 for "the discovery of physical and natural laws and their application to increase the well-being and comfort of mankind," and duly installed in its own house two years later. It is noteworthy that in 1831 a joint committee of the Institute and the American Philosophical Society began systematic meteorological observations in aid of agricultural and other interests, and eight years later the Pennsylvania legislature made a grant of 4000 dollars for the purchase of instruments at the discretion of the Institute; this is stated to be the earliest instance on record of the appropriation, in any country, of public funds for the collection of facts relating to the weather. The Institute awards medals, of which the best known is the Franklin medal, for distinguished work in advancing physical science or its applications; it was founded in 1914, and among its recipients have been Sir James Dewar and Sir J. J. Thomson. Other awards made are: the Elliott Cresson medal, for research and invention; the Howard N. Potts medal, for distinguished work in science or the arts and for papers presented to the Institute; the Edward Longstreth medal, for meritorious work in science or the arts; and the Boyden premium of 1000 dollars, to any resident of N. America who shall determine by experiment whether all rays of light and other physical rays are or are not transmitted with the same velocity; an award was made in 1907 for a solution dealing with the visible and ultra-violet parts of the spectrum.

Our Astronomical Column.

METEORS IN APRIL.—Meteors are seldom abundant in April, but there are a number of interesting showers visible, including the Lyrids, which are connected with the first comet of 1861. This display usually attains a maximum on April 21, and the conditions will be rather favourable this year, as the moon will be visible only as a crescent in the evening sky. The Lyrids exhibit a radiant which moves eastwards about 1 degree per day, and we require more evidence on this point. The shower, however, is of very short duration in its active stage, and meteors belonging to it are rarely seen two or three days before or after the date of maximum.

In April there are a large number of feeble showers which it is desirable to investigate further. These include positions near α Persei, β Ursæ Majoris, α Cygni, α Cephei, etc. In Hercules, Corona, Boötes, and Ophiuchus there are a few well-pronounced displays which apparently recur annually.

THE ECLIPSE OF SEPTEMBER 1922 IN QUEENSLAND.—Mr. J. C. Russell, of Brisbane, sends some notes on his observations of this eclipse made at Stanthorpe, a favourite summer resort, nearly 3000 feet above sea-level. The N.S.W. Branch of the B.A.A. were also stationed here. There was an extensive view over the plain to the west, and the moon's shadow was seen approaching, a little in front of the horizon line, and therefore about 10 miles distant, looking like a local rain squall. Shadow bands were observed at the same time. The central dark bands were 12 or 15 inches apart, about 4 inches wide, fringed with an equal width of half-tone on each side, and a bright strip between them. They passed at the rate of 10 per second. Their least distance from his eye was 8 feet. They were followed to a distance of 30 or 50 feet, where they appeared fainter but 3 or 5 times wider than when nearest. He ascribes them to compressional waves in the air caused by the cooling effect of the shadow cone, which was passing at a rate exceeding that of sound. Mr. Russell also makes the plausible suggestion that the shapes of the bands as seen are largely modified by the phenomenon of persistence of vision. He thinks the apparent enlargement at a distance was a (partly mental) effect due to this cause.

During totality the shadow covered most of the sky, but near the horizon to north and south there was a red glow, due to distant regions of the atmosphere beyond the shadow. (This effect was also seen in Norway in 1896.) The shadow was 120 miles wide, and the observer 9 miles north of the centre.

The corona was seen with direct vision to a distance of ¾ diameter from the limb, being very bright: with averted vision two faint extensions were seen, one to N.W., the other in the upper part, each 5 minutes wide and reaching to 1½ diameters from the limb; they gave the corona the appearance of a windvane, a simile used on former occasions. Mr. Russell's description of the corona mentions three immense "spearheads" of white light, one to the zenith, the other two on the lower side, the left-hand one being the larger; these formed "as it were a great forked beard." A ruby spot, doubtless a prominence, was seen on the low left hand.

A few stars were seen during totality, but they were not specified. An account in B.A.A. Journ. (Jan.) by Dr. A. F. Turner states that six were seen, of which Venus, Mercury, Jupiter, and Spica were identified; two that were seen far to the south may have been α and β Centauri.

PROBLEMS OF THE NEBULÆ.—The Rev. H. Macpherson contributes an article on the nebulæ to *Discovery* (March). The numerous and rapid changes of view that have taken place with regard to them illustrate the difficulty of knowing where to place them in schemes of stellar cosmogony. The "island universe" theory of the spirals was received back into general favour ten years ago, but Mr. van Maanen's detection of perceptible rotatory movements in several of them, in combination with the spectroscopic determination of radial velocities, enables hypothetical parallaxes to be estimated. These correspond to distances of a few thousand light years, so that they appear to be within the limits of our own universe. Dr. Jeans regards the luminous knots on the rims of these spirals as giant stars in process of formation at the rate of one every few centuries.

There is another difficulty not felt at the time when stellar types O, B, A were supposed to be the earliest in the spectral sequence, which the "Giant and Dwarf" theory renders puzzling: this is the frequent association of these types with planetary nebulæ in the case of O, and with bright diffused nebulæ in the cases of B, A (Orion and the Pleiades). It would seem that these nebulæ can scarcely be regarded as the parents of the stars that they surround, since, if such were the case, they would be much more in evidence round giant stars of type M. The conclusion appears to be that the natural condition of nebulosity is dark, but that it may become bright either by simple reflection, as appears to be the case with the nebulæ in the Pleiades, or by selective excitation, which causes some of its gases to glow. Prof. Russell compares this to the excitation that occurs in a comet when near perihelion.

Research Items.

Archæological Exploration at Zimbabwe.—A noteworthy contribution to the discussion of the origin and date of the Zimbabwe ruins appears in the recently issued vol. xx. of the Proceedings of the Rhodesian Scientific Association in the form of a communication from Mr. H. R. Douslin, lately Director of Public Works, on "Recent Explorations at Zimbabwe." Mr. Douslin has excavated the ruins on two occasions. In 1909 the trench made by Dr. Randall-MacIver in 1905 was carried down to solid rock by a pit under the wall of the Temple. The base of the foundations was reached at about 2 ft. and the rock at about 10 ft. below surface level. Only broken pottery, of a type common to all the ruins and similar to that made by natives to-day, was found. In 1915 excavations were carried out inside the wall of the Acropolis, which it is assumed was built before the Temple, and a large part of the red-earth filling was removed. The original entrance was discovered—a passage many feet below what is considered to be the original foundation of the wall on the western side. It ended against a dead wall of the internal red-earth filling. This filling, on which many of the internal walls are built, would therefore appear to be of more recent origin than the main outer wall. Solid rock was reached at about ten feet below present surface level, where the old dwellings were found. Their workmanship is superior to that of present-day natives and of a character unknown to them. The finds included two finely ornamented copper bands, an iron shackle, assegais, fragments of a soapstone bowl, and the usual Kaffir beads and pottery. No gold was found, and the author points out that the gold ornaments, etc., for which the greatest antiquity has been claimed, were found on or near the surface ten feet above the original occupation level.

Social Significance of U.S. Army Intelligence Tests.—Prof. P. E. Davidson discusses in the *Scientific Monthly* (February 1923) some of the generalisations which have been drawn from the now well-known American Army intelligence tests. These tests, originally applied in order to differentiate men for army posts, disclosed the unwelcome fact that large numbers of the population ranked very low in innate intelligence. Some writers have concluded from this that the traditional democratic ideal must be renounced, as only a gifted few are capable of ruling. The writer of the article believes, however, that three assumptions have to be made if such conclusions are sound: (i.) that the army draft was truly representative of the American population in general; (ii.) that the tests were really tests of native ability and not of educational advantages; (iii.) that the native intellect in question is so general as to condition social success of any significant kind. He gives reasons for disputing each of these assumptions, and shows that large numbers of the more intelligent members of the community were unrepresented, that the tests made heavy demands on language knowledge, and that many factors other than native ability help to determine a man's social position. While agreeing that the gifted minority should have every possible advantage, he disputes the belief that these alone should be trained, while large numbers are to be denied training because of an arbitrarily imputed stupidity. The article gives a salutary and timely check to the ardent enthusiasts who would impute to tests more than they can legitimately bear. It is frequently the social applications of scientific research that are unscientific.

Efficiency in Fine Linen Weaving.—A report on fine linen weaving has been prepared by Mr. H. C. Weston on behalf of the Industrial Fatigue Research Board (Report No. 20, "A Study of Efficiency in Fine Linen Weaving," Textile Series No. 5, H.M.S.O., 1922, 1*s*. 6*d*. net). The investigation was undertaken for the purpose of enabling a comparison to be made between the conditions of work and efficiency in linen-weaving sheds and in cotton-weaving sheds, the latter having previously been investigated. The output from each of forty looms was recorded, hourly readings of the wet- and dry-bulb temperatures were taken, and the amount of time noted during which artificial light was used. A detailed description of the nature of the weaving process is given and the general conditions of the sheds. Tables showing the hourly, diurnal, daily and weekly variations of efficiency and temperature are appended. The writer concludes that there is evidence to show that the economic limit of temperature for fine linen weaving is reached when the wet-bulb temperature exceeds 73° F. Up to this limit increase of temperature results in increase of productive efficiency, but beyond it efficiency falls owing to the discomfort and fatigue of the workers. He also shows that the use of artificial light reduces efficiency approximately by 11 per cent. of its normal daylight value. A similar result was reported in a previous investigation made by the Industrial Fatigue Research Board into silk-weaving. These results are not unworthy of consideration in discussions of daylight saving.

The Distribution of Megalithic Monuments in England and Wales.—In the Proceedings of the Manchester Literary and Philosophical Society (vol. lxv. No. 13) Mr. W. J. Perry supplies some further arguments in support of his theory that megalithic monuments were the work of a race of miners engaged in the search for precious metals and other valuables. This he holds to be established in the cases of Cornwall, Devonshire, Wales, Derbyshire, Northumberland, and Cumberland. The difficulty remains regarding those in Dorset, Wilts, and Oxford, including Stonehenge and Avebury. The explanation is that this latter series is situated on the Upper Chalk flint-bearing formation. "Flint implements," he remarks, "are found in all parts of the country, even in places far away from the source of the material. Sir John Evans mentions particularly Devon and Cornwall as regions where there is an abundance of flint implements and flakes, and these counties have no flint-bearing formations, though in some places there are some on the surfaces. These would not be nearly so good for the purpose as those from the chalk regions of Wilts and Dorset. We have thus the remarkable fact that flint implements are found all over the country, and that the builders of megaliths, including long barrows, have chosen out those very portions of the chalk country which produce flints."

Distribution of Organisms in Culture Media.—As a rule the accuracy of biometrical determinations must be ascertained empirically from a statistical study of the observations; in certain cases, as has been shown in the theory of hæmocytometer counts, the law of variation may be calculated, and the accuracy known with precision, provided the technique of the counting process is effectively perfect. A study of the extensive bacterial count data accumulated at Rothamsted by Cutler and Thornton, using Thornton's agar medium, indicated that the same law of variation, the Poisson series, was obeyed by the number of colonies counted on parallel plates. Statistical tests were devised which proved that, save for a small proportion of definite exceptions, the necessary perfection of technique was effectively realised (R. A. Fisher, H. G. Thornton, W. A. Mackenzie, *Annals of Applied Biology*, vol. ix. p. 325, 1923). In studying the exceptional cases it appeared that these fall into two classes, (1) an abnormally high variation which, when investigated experimentally, has been traced to certain bottom-spreading organisms isolated from soil from Leeds and from Rothamsted, and (2) an abnormally low variation ascribable to defective procedure in the preparation of the medium. Application of the same tests to other extensive series of bacterial counts showed that a similar approach to theoretical accuracy, though rare, had been obtained by Breed and Stocking in counts of *B. coli* in milk. It should be emphasised that all cases of departure from the theoretical law of distribution, which have been investigated, are associated with large systematic errors in the means; for this reason simple tests are presented by which such deviations from the theoretical accuracy of the method can be detected.

PRIMULAS OF CENTRAL ASIA.—Mr. F. Kingdon Ward, who was referred to in NATURE of February 17, p. 231, as returning to England after extensive travels in Central Asia, has been contributing some account of his previous (seventh) expedition in Asia in the *Gardeners' Chronicle* since May 1922. These articles not only describe very vividly the first discoveries of many new plants, to be of interest afterwards to the British growers of novelties, but also frequently raise interesting general questions from the point of view of a keen observer of plants; as, for example, the discussion in the issue of February 10 (p. 80), as to the association of meal—a granular waxy deposit developed on the cuticle—and fragrance in the Primulas, and the observation that the Primulas found growing on boggy habitats are generally without meal.

THE CUTICLE OF COTTON.—A paper by R. G. Fargher and M. E. Probert, in the Journal of the Textile Institute, vol. 14, pp. T49-T65, February 1923, seems to represent a notable advance in our knowledge of the chemical composition of the plant cuticle. Material extracted from American cotton by benzol, heating with superheated steam, was available from some very large scale experiments. This method opens up the possibility of hydrolysis during extraction, but the large bulk of material made available by the scale of operations has provided very precise information as to certain constituents of the cotton wax, although doubt may remain as to the exact form in which they are present in the cuticle. A new alcohol, gossypyl alcohol, $C_{30}H_{62}O$, is identified and described, montanyl alcohol, $C_{28}H_{58}O$, present in smaller amount, is also described for the first time; small amounts of ceryl and carnaübyl alcohol were also found, and a mixture of phytosterols; little if any glycerol was present. Palmitic, stearic, and oleic acids were found in the free state, the sodium salts of montanic, cerotic, palmitic, and stearic acid were identified, as well as the salt of an acid, $C_{34}H_{68}O_2$, oleic acid and a lower isomeride of oleic acid were present as esters, but the proportion of unsaturated acids, either free or combined, was small. While this work, on one hand, will throw much light on the problem of scouring cotton, on the other, it gives much needed information as to the chemical constituents of the plant cuticle.

THE ISOETACEÆ.—Norma E. Pfeiffer has published a most valuable systematic study of this family in the Annals of the Missouri Botanical Garden (vol. 9, No. 2, April 1922). After a brief account of the morphology and ecology of the genus, which is incomplete as a bibliographical account of European work upon Isoetes, the species are grouped into sections, and keys are provided for the identification of species within the sections. Breaking away from former systematic studies, where habitat characters have largely been used for the establishment of main subdivisions, the present sections are based upon the megaspore surface, whether tuberculate, spiny, crested, or reticulate. Within the sections great use is made of the lobing of the corms and the amount of development of the velum; megaspore characters are again frequently used, and eight plates are provided with photographic illustration of megaspores of different species. The family is a remarkable one to the student of plant distribution. Of the 64 species described, most are very restricted in range, the only exceptions being *Isoetes Braunii*, Dur., in North America, and *I. lacustris* and *I. echinospora* in Europe. Some of the Mediterranean forms appear to the author to show close affinities, as though originating from a common stock; but, on the whole, present knowledge of the species and their distribution is too puzzling, and probably too incomplete, to encourage premature speculation as to centres of distribution and evolutionary tendencies. It is interesting to find one submerged species—*I. echinospora*—always without stomata while *I. Braunii* always possesses some.

PHYSIOGRAPHY OF PORTO RICO.—A detailed study of the physical geography of the West Indian island of Porto Rico by Mr. A. K. Lobeck is published by the New York Academy of Sciences (vol. i. pt. 4). It is the last section of a complete survey of the island undertaken by the Academy. The present part, which includes a large-scale map, is the outcome of field work in 1916–17. The physiographical history of Porto Rico appears to have begun with a complex mass of igneous rocks which were eventually reduced to a peneplain, except for two well-defined monadnock groups, now known as the Luquillo mountains and the Cordillera Central. No direct evidence on the horst nature of this ancient land mass was available. Uplift of the peneplain led to a new cycle of erosion, but only along the northern side of the island was a second peneplain produced. On the south the island was worn down less effectively, probably because of inadequate rainfall. Partial submergence then allowed the formation of coastal plains on both north and south sides which, after uplift, were considerably dissected. Mr. Lobeck traces these events and discusses also recent changes now in progress, illustrating his lucid paper by photographs and block diagrams. Some notes are added on the islands of Desecheo, Mona, Vieques, Culebra, and Muertos.

PLIOCENE VERTEBRATES FROM THE TERTIARIES OF ARIZONA.—On the initiative of the United States Geological Survey and with the co-operation of the United States National Museum, Mr. J. W. Gidley went early in 1921 to collect fossil vertebrates in the San Pedro Valley, Arizona, with the view of establishing the age of the deposits there, which until then had been termed Pleistocene. A preliminary report has now been issued as Professional Paper 131-E of the United States Geological Survey. Unfortunately the material collected represents for the most part new species which cannot therefore be correlated with known faunas of other localities where the age of the beds has been established. With two or three species of true horse (Equus) are associated the remains of Hipparion, Pliohippus, some Proboscidia, Camelidæ, Cervidæ (including Merycodus), Carnivora, numerous Rodentia, and Glyptotherium, as well as reptilian and bird remains. The author, therefore, refers these beds to the Pliocene, and points out that the presence of a true llama, a glyptodont, and a rodent belonging to a genus now living only in South America, bears out the theory of the derivation of the South American fauna by migration from North America, and that such migration may have taken place about this epoch. Detailed descriptions, with figures, of the Rodentia and Leporidæ, all of which represent new species and total some twenty in number, form the major portion of the paper. The reptiles and birds are to be dealt with later by other writers.

THE HIMALAYAN MOUNTAIN SYSTEM IN SOUTH-EAST ASIA.—One of the objects of Prof. J. W. Gregory's recent journey to Yunnan was to study the geographical relationships of the Alps of Chinese Tibet. A sketch of his conclusions appears in the *Geographical Journal* for March. He contends that the structure of western Yunnan is best explained on the view that the line of Himalayan folding is not wholly bent in Assam into the Burmese arc which follows the Arakan mountains, the Andamans, and the Nicobars into Sumatra, Flores, and Timor. Two routes have been suggested as the eastern prolongation of the Himalayas, the Great Khingan mountains, and the Tsinling mountains. The former view is untenable owing to the essential difference in structure; the latter is a doubtful thesis since there are indications that the Taliang Shan of southern Szechwan, which would appear to be a link in this chain, are east and west folds of Hercynian age. The evidence is more in favour of the Himalayan line being continued in the Nan Shan mountains, which separate the Yangtze Kiang from the Si River, although information as to their geological structure is still meagre. According to Prof. Gregory's interpretation, the Burmese-Malay arcs of folding form a loop on this eastern prolongation of the Himalayan axis comparable with the Persian loop in western Asia and the Apennine loop in Europe. The eastern end of the Malay arc is generally represented as a reversed bend round the Banda Sea. Prof. Gregory agrees with Suess that this is not so, and holds that the Malay arc continues into the mountains of south-eastern New Guinea. On the north of the Banda Sea these folds are also obvious and are continued in the northern mountain axis of New Guinea. But the eastern end of this line of folding is now cut across by the Pacific, into which it must at one time have extended. The paper also contains important evidence on the river system of Chinese Tibet.

PERIODICITY OF EARTHQUAKES.—Messrs. D. Mukiyama and M. Mukai, in a paper too brief to be quite clear (*Japanese Journ. of Astr. and Geoph.* vol. 1, 1922, pp. 49-54), indicate a general similarity in the deviation of the atmospheric pressure-gradient at the time of an earthquake from the mean pressure-gradient in each of four selected districts in Japan. The question of the influence of rainfall on earthquake-frequency is considered, as regards the Philippines, by the Rev. M. Saderra Masó (Bull. of the Weather Bureau for February 1921). He shows that in the western districts of both Luzon and Mindanao earthquakes are most frequent during the rainy season, but in the eastern districts of both islands during the dry season. Thus, though rainfall may have some influence, it cannot be the main determining factor in the frequency of earthquakes. The late Mr. Marshall Hall, in his study of the earthquakes of Jamaica from 1688 to 1919, suggested the existence of nearly forty earthquake-periods varying in length from about 10 to about 30 days in the different epicentres, especially one of about 21 days in the epicentre of the earthquake of 1907. These periods have been examined by Prof. Turner (Mon. Not. R.A.S., Geoph. Sup., vol. 1, 1923, pp. 31-50), who arrives at the interesting results that they are multiples of 21·00 minutes, and that the intervals between the means of these periods are also multiples of the same unit, or 0·0145843 day.

STRUCTURE OF BENZENE.—In the February number of the Journal of the American Chemical Society, Dr. M. L. Huggins discusses the structure of graphite, benzene, and other organic compounds from the point of view of X-ray measurements by Hull and by Debye and Scherrer. He concludes that graphite consists of layers of close-packed benzene complexes of the type proposed, from the point of view of organic chemistry, by Körner in 1874. This is built up of six tetrahedra, three on each side of a plane, with edges adjacent, and with the vertices alternately above and below the plane. On the assumption that similar close-packed layers are present in benzene and many of its derivatives, the dimensions of the benzene hexagon are computed from crystallographic data. The half length of this is 2·47 Å., the half-width 2·14 Å., and its area 15·84 Å.^{2}. The corresponding figures from Debye and Scherrer are 2·52 Å., 2·18 Å., and 16·47 Å.^{2} The probable error in each case is about 1 per cent.

SPACE GROUPS AND CRYSTAL STRUCTURE.—With the development of such methods of studying the arrangement of the atoms in crystals as are furnished by the use of X-rays, the geometrical theory of space groups has become of the utmost importance. Until recently the work published upon this theory has been primarily directed towards the preparation of a statement of all the different kinds of symmetry which are crystallographically possible. Such a statement, when complete, must give all the possible ways of arranging points in space which, by their arrangement, express crystallographic symmetry. In his "Krystallsysteme und Krystallstructur" (Leipzig, 1891) Schoenflies gave an analytical expression for the results of this theory in its most general form, but, before it is applicable to the study of the structures of crystals, modifications of this original representation are necessary. First, there must be selected such a portion of the grouping that, in its calculated effects upon X-rays, it can be taken as typical of the entire arrangement. Secondly, the X-ray experiments which have already been carried out show that the number of particles (atoms) contained in the unit cell is commonly smaller than the number of most generally placed equivalent points of the space group having the symmetry of the crystal. The special arrangements of the equivalent points (upon axes, planes, and other elements of symmetry), whereby the number of most generally placed equivalent positions is reduced, are thus of great importance, and it becomes essential to be able to state all of them in any particular case. In his "Geometrische Krystallographie des Discontinuums" (Leipzig, 1919), Niggli has given the simpler of these special cases. The complete set of them, enumerated by R. W. G. Wyckoff, is now presented in "The Analytical Expression of the Results of the Theory of Space-Groups," in Publication 318 of the Carnegie Institution of Washington, 1922; price 3.25 dollars.

The Dyestuffs Industry in Relation to Research and Higher Education.[1]

By Dr. HERBERT LEVINSTEIN.

WITHIN one generation we have seen the small mechanics' institute in a provincial city develop into an institution of university standing, constituting a technological faculty giving degrees, with some of its professors sitting on the university senate. In one way or another London, Birmingham, Bristol, all the large cities, show the same change. It means that within this period an enormous change has taken place in the character and requirements of our industries, and consequently in the demand for highly trained young men. The industrial world has changed. The present characteristic of industry is the tendency towards large units, using as one of their weapons an intelligence department (a research department), equipped with every resource of science. This is in itself nearly as far removed from the Victorian system of industry as that was from its predecessor, and it is causing nearly as great a social change as the industrial revolution that followed on the introduction of machinery.

The scientific educational establishments in this country are fundamental to the whole structure. By the vitality and originality, by the number and the quality of our teachers, the world can judge of the capacity of Great Britain in the long-neglected scientific industries, of which dyestuffs and fine chemicals are pre-eminent.

The dyestuffs industry is what is loosely termed a key industry. Mr. Runciman, speaking in the House of Commons on November 27, 1914, said: "The combined capital of such operations of textile and other industries which require aniline dyes comes to no less than 200,000,000*l*., and about 1,000,000 of our employees are either directly or indirectly interested in the adequate supplies of dyestuffs for their main industries." There were few people who questioned at that time the urgency and importance of producing within our own shores the commodities required to support so many staple industries. We were at war with Germany, on whom we had been dependent in peace time for 80 per cent. of our requirements, and at that moment it was necessary, both from an economic and military point of view, to replace at once those vanished supplies from home sources.

What happened after the War? In 1913 the dyestuffs industry in England supplied about 10 per cent. of the British consumption, which amounted in round figures to rather more than 20,000 tons. The factories were comparatively small, and the number of chemists proportionately few. By Armistice Day the two principal companies, already loosely united, employed some 7000 persons, nearly 300 of whom were academically trained chemists—an unheard-of number in this country. During the two years following the Armistice more than 25,000 tons of dyestuffs manufactured by this British company alone went into consumption in Great Britain.

The extraordinary prosperity in the textile trades at that period had its aftermath in the slump. In 1919, however, the employment provided by these trades, and the money brought into this country as payment for exports, were factors without which this country would not have readily recovered from the paralysis of war. The total value of the exports of printed and cotton dyed piece goods alone during 1919–20 amounted to 270 million pounds sterling. In October 1920 the British Dyestuffs Corporation alone employed some 8000 people, with a yearly wage roll of 1,600,000*l*. This company used 4000 tons of coal per week, 1000 tons of pyrites, and corresponding quantities of heavy chemicals and raw materials. These figures may be considered large in this country, where we are not so familiar with very large plants, but they are small compared with the aggregate of the German I.G.

Suddenly in October 1920 the slump fell upon the country. The position was made much worse by four factors. German production revived, considerable quantities of German dyes were imported as reparations, the Sankey judgment temporarily removed all protection from the home producer, and the rapid external depreciation of the mark temporarily made it difficult to compete with Germany in neutral markets. Stocks fell in value, large sums of money were lost, and the production of British companies fell almost to pre-war figures.

The dyestuff and fine chemical industries in this country, are by no means assured of a prosperous, development. If the factories are allowed to decay, the staffs to be gradually diminished, the capital invested rendered unremunerative, our position will become less strong. At the moment, should the occasion arise, the factories and organisations created during the war years are a source of strength.

The developments of higher scientific education in this country, on which our scientific industry is based, tend to strengthen the national life in a way which may not be immediately obvious but yet quietly and unobtrusively may be of fundamental importance to the State. There is another reason of great importance in favour of a flourishing and progressive dye industry. The dye industry is a key industry to invention. Its importance as a factor in producing new inventions is well summarised by Mr. J. A. Choate, the author of an official American publication issued by the Alien Property Custodian of the United States Chemical Section:

"The Technical skill and equipment provided by a successful Dye Industry, furnishes the means, and almost the sole means, to which every nation must look for advances in the application of chemical science to practical undertakings. No other industry offers a livelihood to any such large numbers of highly trained scientific chemists nor any such incentive to continuous and extended research."

Any firm wishing to become a serious factor in the world's markets for fine chemicals and dyes must employ a number of research chemists. Existing products tend towards obsolescence, competition from other makers tends to lower their price, and new demands constantly arise and are satisfied or created by new products for which high prices can be obtained owing to their novelty and, at first, the absence of competition. In the long run that nation will predominate in this industry which brings out the best and the largest number of new products.

These research organisations are expensive. Why then did the Germans start in this race for new products? They found this kind of research to be extremely profitable to their shareholders. Consequently, it was developed, and they were able to bring out annually quite a number of new products which, pushed by enterprising salesmen in all markets, home and foreign, gradually became established branches of manufacture in Germany.

Research for new products costing no more than the old, but for which the public will pay a higher price, is intimately wrapped up with the question of patents. Without the prospect of a monopoly for a term of years, and the lure of high profits, this kind of

[1] From a paper read before the Association of Technical Institutions on March 3.

work would not be undertaken on a comprehensive scale. Unfortunately, the monopolies granted in our country in the past for this kind of work were granted to German industries, and not to our own, and large profits were made out of British patents by the German dyestuff works. A similar research system, if sufficiently supported on the commercial and technological side and directed with sufficient knowledge of the requirements of the industry, and with some imagination, can be made to pay in England just as in Germany, where this combination existed. It is important to remember that firms employing this modern commercial weapon were large, for the amount of money that can be spent on research is a function of the turnover.

It is further true that to build laboratories, to engage for them a number of chemists, are not alone sufficient for our success.

If the stream of chemical invention can be induced to flow in this country in the future not less sluggishly than in Germany, we shall gradually build up new industries as the Germans built up theirs.

In this country we rely too much on our staple industries and look too little for new inventions to find food and employment for our people. In the Report of the Department of Scientific and Industrial Research, 1921–22:

". . . It is well recognised that for four-fifths of their food and for a great part of the necessary raw and semi-manufactured materials for industry the people of these islands are dependent on supplies from overseas. These supplies can only be obtained if this country is able to carry on its exporting industries in future with greater efficiency than the rest of the world."

The Department spent in this year more than half a million pounds with this purpose in view, and provision is made for expenditure on a similar scale for the current year. Under its auspices no less than 24 Industrial Research Associations have been formed, of which 22 are licensed by the Department, and received more than 86,000*l*. in grants during the year in question. Broadly speaking, the work of the Department and of the Research Associations with which it collaborates is to ensure the best utilisation of our natural resources and of the raw materials which we buy from abroad for our staple industries, with the view of increasing the efficiency of those industries and enlarging the demand for their products in customer countries.

This work does not replace that of private firms, but is complementary to and ought to stimulate it. There is a radical difference between industrial research carried out by a company and that by a Research Association, or by a Department of State. Patents taken out by chemists who receive part of their emoluments from the Department, belong apparently to the Government. Patents which may be taken out by a Research Association would presumably be available for all subscribers and could not easily become a profitable monopoly for any one member. For this reason it appears likely that in the future, as in the past, the dyestuffs industries and the allied fine chemical industries will be the main source from which chemical discoveries will be transferred from the laboratory to the factory.

Running through all this is one common factor which must be realised if the expectations of the State are to be satisfied. The industry must be big. There must be large factories containing plant capable of producing great quantities of organic chemicals, staffed by an adequate number of experienced and well-trained chemists. Moreover, the factories must be growing. It is an industry which cannot succeed if it be static. It must be ever increasing its plant and the number of its chemists and ever spreading its tentacles wider and deeper into the markets of the world.

It follows that if the industry is successful there will be a continual flow of students from the universities and technical schools to the industry. Two distinct classes of chemical students are required: (*a*) for factory and research, and (*b*) for the dyehouse and technical sales. It is customary in aniline dyestuff factories to recruit the chemists for plant supervision from their own research department. The young chemist engaged on leaving the university is first placed in the research department for at least a year before a permanent engagement is made. The training required of a dyestuff works chemist is usually identical, whether he intends to devote himself afterwards purely to research, or, as in the majority of cases, to become actually employed in the factory. It is of the first importance that chemists should have a good general secondary education. After taking his degree the student should cary out, under direction, original work for one or, preferably, two years. What branch of organic chemistry he studies is comparatively immaterial. A special knowledge of dyestuffs chemistry is not very important.

Undoubtedly a knowledge of chemical engineering is useful, but subjects added, however useful, will be at the expense of chemistry. The recent formation of the Institution of Chemical Engineers is welcome. Good chemical engineers are invaluable in any chemical industry, but, above all, good organic chemists are wanted in the dyestuff industry.

There is also a considerable demand for another type of chemist. All aniline dye works have a dyehouse which fulfils a treble function—the control of the production, the valuation of new specimens sent in from the research department, and the supply to the sales organisation of technical information and assistance in the application of dyestuffs. The technical salesman is a person of great importance in the industry. He should preferably take a pure or technological science degree, followed by a course in dyeing, printing, paper-making, etc., at a technical college. There is a constant demand for such men in a flourishing dyestuffs industry, the more so as the experience obtained in the experimental dyehouse is so varied, that such men are afterwards sought for as managers or as assistant managers in print-works, dyehouses, paper-works, and the like.

The foundation stones of our scientific industries were laid by those responsible for the creation of our great technical institutions and University Colleges. If that is so, we should expect to see during the years which have elapsed since 1914 a corresponding development in the chemical schools of this country. The progress in the study, teaching, and research in pure chemistry has been at least as striking as the progress of those sections of chemical industry such as fine chemicals and dyestuffs in which we were not particularly strong before the War. Twenty or thirty years ago the German organic schools were as pre-eminent in research and in teaching as the German dyestuff and fine chemical industry. To-day one may fairly say that there are several organic chemical schools in this country equal to that of any organic chemical school in Germany. Brilliant original work is being done here. Students are attracted to schools where good research is being done, and so round each head is formed a coterie of young men deriving inspiration from their chief, to strengthen the ranks of industry. Probably there has never been such a concentration of chemical talent as that which gathered round A. von Baeyer in Munich thirty or forty years ago, but something of the kind is happening in Great Britain to-day, and not in one centre alone.

Thirty years ago, institutions comparable, for example, with the Federal Polytechnic at Zurich or the Technical High School of Charlottenburg did not exist in Great Britain. The scale on whch they were designed, their large staffs of distinguished teachers, the number of full-time students, students who had remarkably good secondary school training and had passed a rigorous entrance examination, astonished all English visitors. The English organic chemist with industrial experience was equally astonished at, for example, the Leverkusen or the Badische factories. These factories differed from the corresponding English factories in scale, in the size of the buildings, their staffs, their financial results, just as the British schools differed from the corresponding German institutions.

The number of students taking a degree in pure science at 17 English and Welsh Universities in 1913–1914 was 1867. In 1921–22 the number was 4575, *i.e.* about two and a half times the 1913–14 number. At the University of Cambridge the figures were as follows:

	1913–14.	1921–22.
Number of chemical students working	498	804
Research workers	10 (about)	29
Staff, including professors . .	25	43

The growth of the dyestuffs industry within this period is well known, and there has been a similar growth in the fine chemical industry. In 1913 some 100 fine chemicals were made in England, whereas 4000 are now being made; for every ton of fine chemicals made here in 1913 exactly $2\frac{1}{2}$ tons are made to-day. This ratio is identical with that of the increase in science students taking a degree course.

Is it possible that this parallel growth in our teaching institutions and newer industries is accidental? The figures are symptomatic, but they indicate that the strength of our higher teaching bodies is a measure of our strength in the industries depending on invention.

It may be said that there has been in Germany, too, and no doubt in other countries, a great increase in the number of students at their High Schools. In part this is one of the social changes brought about by the new industrial revolution.

The increase in the number of chemical students is partly due to the publicity given in 1914 to the renascent dyestuffs industry, and to the support given by public opinion and by the Press for the first time in our history to those engaged in these industries. These industries open out to a young man who has a love of research the opportunity of earning a livelihood in a most interesting way, with the added possibility, if his inventions prove commercially successful, of earning considerable profits. Before the War it was difficult to live by research.

It is probable that the grants made by the Department of Scientific and Industrial Research have tended to increase the number of chemists undertaking training, "for the underlying object of the Scheme of Grants is the output of an increased number of trained scientific investigators." At the same time, the Department has done much to increase the possibility of finding employment for chemists. The Department, including its headquarters staff, boards and committees, Fuel Research Station and the Research Associations, already employs 78 chemists, none of whom were employed in 1913, at salaries ranging from about 250*l.* to 2000*l.*, the majority between 350*l.* and 700*l.* In other Government Departments, too, there has been a great increase in the number of chemists employed. In 1913–14 the staff of the Government Chemist consisted of 48, with a salary range of 120*l.* rising to 1500*l.* The majority of the posts ranged from 120*l.* to 500*l.* In 1921–22 there were 75 posts, ranging in salary from 300*l.* to 700*l.* At the War Office in 1913–14 there were 22 posts and 2 teaching posts at the Ordnance College. The salary range was about 150*l.* to 550*l.* In 1921–22 there were 93 posts, with salaries ranging from 300*l.* up to 1200*l.*, but with the majority falling within a range of 300*l.* to 700*l.* At the Admiralty in 1913–14 there was one inspector of cordite, in addition to the teaching staff at the Royal Naval College at Greenwich and the schools at Dartmouth and Osborne. In 1921–22, in addition to these teaching staffs, there were 20 posts with salaries of from about 150*l.* to 600*l.* The total number of chemists who can to-day find employment in the service of the above Government Department is thus 193 more than in 1913.

In the 1921 report of the Department it is stated that of the 132 students receiving grants 24 found employment under the State or under State-aided research institutions, 22 went into the teaching profession, and none went into industry, no doubt owing to the slump in trade.

If our fine chemical industries begin to increase their staffs regularly, as in prosperous years they will, the situation will be improved, but it is to the general trade of the country and not to the specifically chemical industries that we must look to give employment to all those who have taken a chemical degree.

Large Telescopes and their Work.

SIR FRANK DYSON'S presidential address to the Optical Society on February 8 on the subject of "Large Telescopes" dealt with the progressive advance of astronomy so far as it was brought about by the increased optical powers of telescopes. The Copernican system was established before the discovery of the telescope, but Galileo's telescope removed many difficulties and commanded its acceptance. The great telescopes of Herschel revealed the vast extent and variety of the stellar system. At the beginning of the nineteenth century, excellent achromatic telescopes of 6 inches were made by Fraunhofer and Merz, and in 1824 an object glass of 9·6 inches was made for Struve at Dorpat with which he carried out his great work on double stars.

When the Russian National Observatory at Polkovo was founded a 15-inch glass was obtained from the Munich firm, and this was the largest refractor in the middle of the nineteenth century. The large telescopes of this time were the reflectors of Lord Rosse and Lassell, and with them the heat from the moon was measured and new satellites of Uranus and Neptune discovered. A new development in reflecting telescopes came with the process of silvering on glass, and gradually these superseded speculum. In England in the early 'eighties photography of nebulæ began with Common's photograph of the Orion nebula, and was pursued by Isaac Roberts. The manufacture and mounting of reflectors was brought to a high degree of perfection by Ritchey at the Yerkes Observatory, but it was with the Crossley reflector, made by Calver and presented to the Lick Observatory by Sir Edward Crossley, and remounted by Keeler, that most systematic work was done.

Meanwhile, larger refractors were being made. In 1868 one of 26 inches aperture was made by Cooke for H. S. Newall of Newcastle. This was soon followed by large telescopes in America by Alvan Clark, by Grubb in England, and the brothers Henry in France. In 1892 a 36-inch glass was made for the Lick Observatory by Alvan Clark, and a 40-inch for the Yerkes Observatory in 1897. These large telescopes led to the discovery of new satellites, the accurate determination of the sizes of planets and satellites, but their main work—used visually—was the discovery and measurement of large numbers of double stars, leading to a very satisfactory knowledge of the masses of stars. Used with the spectroscope, they gave the velocities of stars to and from the earth, and enabled the velocity of the sun among the stars to be determined as 19 kilometres per second. This result, in combination with measurements of angular motions of stars, served to give the mean distances of stars. Large photographic refractors have made possible the measurement of the actual distances of thousands of stars, leading to a much more complete view of the stellar system.

The discoveries made by the large 60-inch and 100-inch reflectors of Mt. Wilson and the 72-inch of British Columbia were also detailed, culminating with the measurement of the size of the disc of Betelgeuse and of several other stars by the interferometer as applied by Michelson.

Irish Sea Plankton.[1]

SIR WILLIAM HERDMAN, in an interesting paper recently issued, gives a summary of plankton researches in a single area extending over a period of fifteen years, and compares the results in each year in such a way that certain general facts are at once apparent.

The object of the investigations was twofold: "(1) To study the distribution of the plankton as a whole, and of its various constituents during the year; and (2) to arrive at some estimate of the representative value of the samples collected in the plankton nets."

The results show very clearly that the distribution of life in the sea is not uniform, but that the organisms appear in patches. Although this applies to a certain extent to all the plankton, it is especially the case with the copepods, which are frequently present in large swarms in one place, while possibly only a short distance away few or none occur. This naturally affects the distribution of other organisms feeding on the copepods, especially fishes, and is of fundamental importance. The diatoms were found to be more evenly distributed both vertically and horizontally during their maximum in the spring than at any other time. Comparing the records for the fifteen years (1907–21), there is always this spring maximum of phytoplankton (chiefly diatoms), which may range from March to June and reach to hundreds of millions in one haul, a dinoflagellate maximum, in much smaller numbers, coming on about a month later; and later still, a copepod maximum ranges from June to October. In late summer or autumn each group may have a second smaller maximum in the same order.

That the bulk of the plankton consists of a small number of genera, chiefly diatoms and copepods (and only a few species of copepods), is well established, and these few form the chief food of most of the marine animals. So far as fishes are concerned, copepods are by far the most important food of the young stages, and also of the plankton-eating adults; but as most copepods are predominantly diatom feeders the presence of diatoms is quite as important to the fish as to the copepod. With regard to the phytoplankton, however, Sir William Herdman apparently regards it as the direct food of many larval fishes, at any rate of the plaice in its infancy, which he has seen with its stomach full of diatoms.

The diatom maximum occurs usually just before the time when most of the fish larvæ begin to be abundant, and the copepods follow. These plankton investigations are thus of great importance relative to the food of fishes.

Dr. Johan Hjort suggests that large mortality among the fish larvæ may occur because of the lack of suitable food at the time when they begin to feed. In the present plankton investigations, together with data gathered from experiments in the plaice hatching at the Port Erin Biological Station, it is shown that diatoms are abundant usually a short time before the very young plaice are set free; but in four out of thirteen years the diatoms were late, and in these years it is possible that the young fishes may not have found enough to eat. "The evidence so far seems to show that larvæ set free as late as March 20 are fairly sure of finding suitable food: but if they are hatched as early as February they run some chance of being starved."

While discussing fully the phytoplankton in relation to fish larvæ very little is said of the zooplankton other than copepods, and one would infer from the conclusions that it is only the diatoms which are of importance as young fish food in the spring. It is, however, probable that in spite of the fact that more diatoms than anything else are present, yet the zooplankton is really of more direct value as food for the larval and post-larval fishes: for example, cirripede nauplii and mollusc larvæ besides copepods, the latter, although not at their height in the spring, yet occurring in large numbers.

Sunlight is shown to play a very important part in the growth of the plankton. In the daytime, however, the largest hauls are usually not at the surface but at about five or ten fathoms, the depth varying with the meteorological conditions. It is regarded as probable that the spring phytoplankton maximum is due chiefly to the great increase of sunlight aided by the winter increase of carbon dioxide and other food matters. The rapid disappearance of the diatoms after the spring maximum is accompanied by a greater alkalinity of the water, and it is suggested that it may be due to the injurious effect of their own metabolism. May not the explanation lie partly in the fact that the diatoms are eaten by an enormous number of pelagic animals coming on just after the diatom maximum?

As to the representative value of the samples collected in the plankton nets, it is shown that variation in the composition of similar hauls is great. These differences show clearly that the life in the sea is not spread evenly either horizontally or vertically, but everywhere occurs irregularly. Simultaneous hauls of similar nets were usually different in quality even if alike in quantity, and the same applied to successive vertical hauls in which the amount of organisms was much the same in each haul but different in kind.

In plankton investigations in which tow-nets are used, however carefully the experiments may be carried out, there is necessarily a great deal of inaccuracy, which is freely admitted and discussed. None of the numerical results can be absolutely exact, but when, by examining and recording these, certain phenomena are seen to repeat themselves year after year, we can at least feel sure that by making these careful quantitative experiments in connexion with numbers of hauls all carried out in an exactly similar way, we are approaching the solution of the general problems relative to the distribution of life in the sea.

M. V. L.

[1] "Spolia Runiana. V. Some Results of Plankton Investigations in the Irish Sea," by Sir William Herdman. Extracted from the Linnean Society's Journal—Botany, vol. xlvi., July 1922.

University and Educational Intelligence.

BRISTOL.—Dr. L. J. Russell, lecturer in philosophy at the University of Glasgow, has been appointed to the chair of philosophy which will be vacated by Prof. C. D. Broad at the end of the current session.

CAMBRIDGE.—The Duke of Devonshire has been elected High Steward of the University in succession to the late Earl of Plymouth. So far back as the fourteenth century a Cavendish held high office in the University, and the name of Henry Cavendish is perpetuated in the Cavendish chair of experimental physic.

Mr. G. S. Adair, scholar of King's College, Mr. P. M. S. Blackett, Bye-fellow of Magdalene College, and Mr. B. Ord, organ scholar of Corpus Christi College, have been elected fellows of King's College.

LEEDS.—The Council has agreed with the University of Basle to a scheme of mutual recognition of certain courses and examinations in the case of students proceeding from either of these Universities to the other.

LONDON.—Prof. A. V. Hill has been appointed as from August 1 next to the Jodrell chair of physiology tenable at University College. Prof. Hill was educated at Trinity College, Cambridge. He was Third Wrangler, and obtained a first class in physiology in the second part of the Natural Sciences Tripos. He was fellow of Trinity College from 1910 to 1916, and in the latter year was elected fellow of King's College. During the War he was director of the anti-aircraft experimental section of the Munitions Inventions Department and a member of the Inventions Committee. Since 1919 he has been professor of physiology in the Victoria University of Manchester. He is the author of a number of papers in the Proceedings of the Royal Society and the *Journal of Physiology*.

Mr. W. J. Perry has been appointed as from August 1 next to the University readership in cultural anthropology tenable at University College. He was educated at Selwyn College, Cambridge, and studied ethnology under the late Dr. Rivers. Since 1919 he has been reader in comparative religion in the Victoria University of Manchester, and has also delivered courses on ethnology in the department of psychology of that University. He is the author of "The Megalithic Culture of Indonesia," "The Children of the Sun," and "The Origin of Magic and Religion," and of numerous papers on ethnological and anthropological subjects.

Dr. B. Malinowski has been appointed as from August 1 next to the University readership in social anthropology tenable at the London School of Economics. From 1914 to 1918 he was engaged in anthropological field-work in Eastern New Guinea. He is the author of "The Family among the Australian Aborigines" and "Argonauts of the Western Pacific," and of a number of articles on anthropological and allied subjects.

The following doctorates have been conferred:—*D.Sc. in Agricultural Chemistry*: Mr. N. M. Comber, an external student, for a thesis entitled "The Flocculation of Soil Particles considered in relation to the Action of Lime and the Constitution of the Soil," and other papers. *D.Sc. in Physics*: Mr. E. T. Paris, an external student, for a thesis entitled "On Doubly-Resonated Hot-Wire Microphones," and other papers.

The Senate has resolved to hold a reception for the sixth triennial congress of the Société Internationale de Chirurgie, which will be held in London in July next.

MANCHESTER.—The chairman of the council, Sir Frank Forbes Adam, has received from the Viscount Morley of Blackburn a letter asking leave, on account of the growing weight of years, to withdraw from the office of Chancellor of the University, the resignation to take effect from April 30. The council passed a resolution expressing regret at losing the Chancellor, and deep appreciation of the honour which he has conferred on the University during his tenure of office.

The council passed the following resolution: "The council have heard with deep regret of the death of Sir William Thorburn, professor-emeritus of the University. They desire to record their sense of his great services as an administrator, a teacher, and an investigator, his eminence as a surgeon, and the whole-hearted devotion with which he sacrificed himself in the service of his country. His sterling integrity inspired respect in all his colleagues and students. The council desire to convey to his relatives their profound sympathy with them in their loss."

The following appointments have been made:—Mr. F. Fairbrother, to be lecturer in chemistry; Dr. D. S. Sutherland, to be clinical lecturer in infectious diseases; and Dr. R. Marsden, to be hon. clinical lecturer in tuberculosis.

MR. W. H. ALLEN, past-vice-president of the Institution of Mechanical Engineers, has presented to the Institution the sum of 1000*l*., and has desired the council to select a suitable student or graduate to receive this grant, in three annual instalments, at Trinity College, Cambridge. Applicants should preferably be between 20 and 25 years of age, and must be able to satisfy the council that they possess such educational qualifications as will ensure that they would derive the maximum possible benefit from an honours course in engineering (Mechanical Science Tripos) at Cambridge. Preference will be given to an applicant who has had some practical workshop training. Applicants must be prepared to go into residence at Cambridge in October 1923. Applications should be made on a form to be obtained from the secretary of the Institution, and must be returned not later than May 1.

THE Ministry of Agriculture and Fisheries announces that a number of scholarships under the scheme approved last year for establishing scholarships and maintenance grants for the sons and daughters of agricultural workmen and others are offered for award for the session commencing in October next. The scholarships are provided out of the special fund for agricultural development voted by Parliament under the Corn Production Acts (Repeal) Act, 1921. They are of three kinds: Class I. scholarships, tenable for three years at Oxford, Cambridge, or other Universities, enabling students to attend degree courses in agriculture; Class II. scholarships, tenable for two years, at certain university departments of agriculture and agricultural colleges; and Class III. scholarships, tenable for one year at farm institutes and similar institutions. Candidates for Class I. and Class II. scholarships must be at least 17 years of age on June 30, 1923, and must satisfy the selection committee that they have reached a sufficiently high standard of education to derive educational benefit from the courses of instruction. For Class III. scholarships candidates will be required to furnish evidence of their acquaintance with practical agriculture, and they must be at least 16 years of age on June 30, 1923. Applications should be lodged with the Secretary, Ministry of Agriculture and Fisheries, 10 Whitehall Place, London, S.W.1, not later than May 14.

Societies and Academies.

LONDON.

Royal Society, March 22.—L. T. **Hogben** and F. R. **Winton**: The pigmentary effector system. III.—Colour response in the hypophysectomised frog. After complete removal of the pituitary gland, the melanophores remain permanently contracted, even when the frogs are exposed to conditions which are optimum for darkening of the skin; they can be made to expand by pituitary extract, but the animals regain pallor under conditions which invariably produce darkening in the normal or partially hypophysectomised (anterior lobe alone) frog. The minimum dose of pituitary extract for melanophore expansion was compared in normal and pituitaryless frogs. The experiments provide evidence that: (1) the rhythm of colour change in normal life is correlated with fluctuating amounts of pituitary secretion, and (2) direct nervous influences do not play a significant rôle in co-ordinating pigmentary responses in Amphibia.—H. R. **Hewer**: Studies on amphibian colour change. The presence of "frayed" ends to processes and isolated granules and irregular edges to the concentrated mass of granules precludes any theories postulating amœboid movement of cell processes. This is supported by (1) irregular movements of the granules; (2) slight massing of granules towards tips of processes in dispersed phase; and (3) stained sections of skin. Adult *Rana temporaria* respond, similarly to other Amphibia, to factors of normal environment. Dryness and light background cause concentration; moisture and dark background dispersion. Low temperature causes dispersion and medium temperature concentration. Higher temperatures appear to have an intermediate effect. Neither nitrogen nor hydrogen produced any effect during three hours; carbon dioxide did not affect colour before proving toxic; oxygen produced concentration in melanophores; chlorine changes melanin granules to a red colour.—J. **Walton**: On Rhexoxylon, Bancroft: a Triassic genus of plants exhibiting a liane-type of vascular organisation. The genus Rhexoxylon was instituted in 1913 for a fossil stem from South Africa. The evidence given by certain structural details was in favour of attributing it to the Palæozoic group of polystelic arborescent plants, the Medulloseæ. The study of additional specimens from South Africa shows that the organisation of the vascular system resembles very closely that of certain modern South American Lianes, especially in the anomalous methods of secondary thickening of the axis. Histologically, the secondary wood of Rhexoxylon resembles that of the group Dadoxyla, characteristic of the southern botanical province during the latter part of the Palæozoic era. Possibly Rhexoxylon, as a specialised ecological type, bore much the same relation to the gymnospermic Dadoxylon stock as the modern Liane bears to the angiospermic group at the present day, and the occurrence of an anomalous type of vascular system in the modern Liane is an example of a repetition, in a distinct phylum, of a specialised organisation evolved in Palæozoic times. The fossil stem *Antarcticoxylon priestleyi* Seward, from South Victoria Land, Antarctica, has some of these peculiarities, and its occurrence in the Beacon Sandstone Series of Antarctica points to a probably close relationship between portions of this series and the Stormberg Series of South Africa, from which came the majority of specimens of Rhexoxylon.—G. **Hewett**: The Dusuns of British North Borneo. The Dusuns themselves claim descent from the Chinese who settled in North Borneo. The general political conditions in Asia during the thirteenth century led to the invasion of North Borneo by Kublai Khan. The Bruni tribute was transferred from Majapahit to China, and the Chinese acquired the throne of Bruni. The Bruni government based its claim to the whole territory of North Borneo on the marriage of Sultan Akhmed to the Chinese daughter of Ong Shin Ping, who was in all probability the occupant of the Bruni throne at the time. The Chinese occupation and development probably lasted some four hundred years.—M. **Tribe**: The development of the hepatic venous system and the postcaval vein in the Marsupialia. The development of the hepatic veins is subject to variation. Two venous rings of vitelline origin are transformed into a spiral vessel encircling the gut. In most genera the left allantoic vein becomes the more important and in some genera it anastomoses with the spiral vessel. The mesenteric vein is probably derived, in part, from the caudal venous ring. The postcaval is derived from three sources. The postrenal section takes origin from the paired supracardinal plexus, the renal section from the subcardinal veins, the hepatic and prehepatic sections from the vitelline veins. The azygos and lumbar veins, and the suprarenal sinusoids, are derived from the supracardinal plexus. The left suprarenal vein is the persistent left subcardinal vein.—J. **Gray**: The mechanism of ciliary movement. III.—The effect of temperature. Between 0° and 33° C. the speed of the cilia on the gills of Mytilus increases with a rise in temperature, although the amplitude remains normal. Between 34° and 40° C. there is a marked falling off in the amplitude of the beat, followed by a reduction in speed. At 40° C. the cilia come to rest in the relaxed position. At 45° C. the cilia occupy the contracted position. The temperature coefficient of movement between 0° and 32·5° C. varies from 3·1-1·92. High temperatures have a destructive effect on individual cells of the epithelium. In well aerated tissue the oxygen consumption is directly proportional to the speed of the beat between 0°-30° C. At about 30° C. the initial oxygen consumption is not maintained, due to the disintegrative effect of the temperature on the epithelium. The effect of temperature on the activity of cilia is closely parallel to its effect on cardiac muscle.—E. **Ponder**: The inhibitory effect of blood serum on hæmolysis. The hæmolytic action of saponin is inhibited by the proteins of serum, and also, to a lesser extent, by the cholesterol. The action of the bile salts is inhibited by the proteins, and by the lecithin of the serum. The inhibitory power is fairly constant in man and animals, is altered by drying the serum, and is affected by bacterial action. A quantitative study of the inhibition produced by serum shows inhibition is probably due to the formation of a loose compound between the proteins of the serum and the hæmolytic agent. The inhibitory effect of hæmoglobin on hæmolysis produced by saponin and bile salts is considered. Probably the reaction which takes place between saponin or bile salts and red cells is a chemical one of the first order.

Royal Anthropological Institute, March 13.—Mr. H. J. E. Peake in the chair.—Miss M. Edith **Durham**: "Bird Men" and kindred customs in the Balkans. On the western side of the Balkan peninsula a considerable part of the population still identifies itself with birds. Thus the Albanians call themselves Shkypetars, and derive the word from Shkyp, an eagle, and regard the killing of an eagle as unlucky. In Montenegro also there is a strong bird tradition. Here it is the "soko," the falcon. Officers address their men as "my falcons," and Montenegrins hail each other as falcons. In the traditional ballads of the people the falcon appears as the messenger. Between the popular hero, Marko Kralyevitch, and the falcons there exists a very great friendship. In other ballads the hero actually refuses to kill a falcon on the ground that it is kin to him, and in yet another the Tsar's daughter is with child by a "bird man," who is a falcon by day and who dies when his wings are taken from him, killed by the jealous Vilas who, in their turn, fly about in the guise of swans. The falcon and the swans dwell on the mountains where the sun rises, and magic lights herald their coming and going. The tale is obviously the remains of some ancient beliefs about the sun and the birds and recalls the quaint bronze bird chariots of the sun, found at Glasinatz in Bosnia. Ballads also describe warriors of the Middle Ages dressing themselves up with eagle's tails and wings, and a print from a book on Turkey by Nicholas de Nicolay (1568) shows such a warrior. Plume-wearing is extinct, but in the Eagle dance of the Montenegrin he leaps high off the ground, flaps his arms, and yells.

PARIS.

Academy of Sciences, February 26.—M. Albin Haller in the chair.—The president announced the death of E. Ariès, corresponding member for the section of mechanics.—André **Blondel**: The calculation of the forced oscillations of an electrogenic group (or of an analogous apparatus) turning with a constant mean velocity, but submitted to periodic variations of the motor couple at the same time as an elastic resisting force variable with the angle of deviation.—M. Louis Gentil was elected a member of the section of geography and navigation in succession to the late M. L. Favé.—Boris **Delaunay**: The geometrical interpretation of the generalisation of the algorithm of continued fractions given by Voronoï.—Maurice **Lecat**: Expression of the most general determinants of a matrix as a function of the sections.—C. E. **Traynard**: Surfaces of the fourth degree with fifteen double points and singular Abelian functions.—René **Lagrange**: Varieties with zero total torsion in Euclidian space.—Stanislas **Millot**: A criterion of the probable value of certain experiments.—J. **Grialou**: The rotational, but permanent, movement of liquids possessing viscosity, when the trajectories are plane and vertical.—C. **Flammarion**: The increase of brightness of the star β Ceti. A sudden increase in the brightness of this star was notified on February 13 by Mr. Abbott from Athens. This has been confirmed by observations at Juvisy by the author.—Emile **Belot**: The collective and discontinuous evolution of stars and nebulæ.—M. **Holweck**: The optical properties of X-rays of great wave-length. Experimental evidence has been obtained of the diffraction of X-rays of a minimum wave-length $\lambda = 47$ Å (effective wave-length $\lambda = 60$ Å approx.). Evidence of the reflection of X-rays by a polished bronze surface is also given.—G. **Laville**: The propagation of electromagnetic waves, maintained along two parallel wires. The theories of Kirchhoff and Lord Kelvin appear to explain the phenomena of propagation as exactly as the more complicated theories of Sommerfeld and M. Mie.—V. **Ylöstalo**: The measurement of high-frequency coefficients of self-induction.—H. **Copaux** and Ch. **Philips**: The heat of oxidation of glucinum. A correction of an earlier result; the new figure is 131·3 calories in place of 151·5 calories.—Paul **Riou**: The velocity of absorption of carbon dioxide by ammoniacal solutions. Curves are given showing the influence of additions of ammonium chloride, sodium bicarbonate, and sodium chloride to the solution, and of changes of temperature.—L. J. **Simon**: The action of methyl sulphate and of potassium methyl sulphate on monobasic organic acids in the absence of water. The interaction of anhydrous organic acids with these substances in certain cases may be used with advantage for the preparation of methyl esters.—A. **Roche** and V. **Thomas**: Researches on picryl sulphide. Study of the binary mixture: tolite-picryl sulphide. This explosive was extracted from German bombs: it is very stable and stands a compression of 500 kilograms per square centimetre without losing its property of detonating.—Raymond **Delaby**: The preparation of some ethers and glycidic derivatives of alkyl glycerols.—Y. **Milon**: The fauna and age of the carboniferous limestone of Saint-Segal (Finistère).—Jean **Piveteau**: The morphology of the scapular arc of the Permian reptiles of Madagascar.—Methodi **Popoff**: The respiratory system of plants. According to the generally accepted view the respiration of plants is confined to the leaves. This view leads to difficulties, and it is suggested that plants have a respiratory system presenting analogies, from the physiological point of view, with the respiratory system of animals.—Marcel **Mirande**: The proteolipoid nature of the sterinoplasts of the white lily. By the application of various microchemical tests the central body of the sterinoplasts has been proved to be of a lipoid nature, covered with a thin external layer of proteid material.—P. **Delauney**: New researches relating to the presence of loroglossin in native orchids. Loroglossin has been isolated, up to the present, from 17 species of native orchids belonging to five different genera.—Paul **Becquerel**: Observations on the necrobiosis of plant protoplasm with the aid of a new reagent. The reagent consists of methylene blue (2 parts), Bismarck brown (1 part), and neutral red (1 part) in aqueous solution ($\frac{1}{10,000}$). The death of the cell is accompanied by definite colour changes in the parts stained by this reagent.—G. L. **Funke**: Biological researches on plants with creeping stems.—Marc **Fouassier**: The influence of copper on the lactic fermentation. The minute traces of copper dissolved by milk in contact with that metal have a distinctly retarding influence on the growth of the lactic organism.—A. **Desgrez** and J. **Meunier**: The mineral elements of the blood.—L. **Cuénot**, R. **Lienhart**, and M. **Mutel**: Experiments showing the non-heredity of an acquired character.—Ed. **Lesné** and M. **Vaglianos**: The utilisation by the organism of the C vitamins introduced through the parents. From experiments on rabbits the authors conclude that it does not matter whether the C vitamins are introduced by ingestion or by injection, the beneficial effect is the same in either case.—A. **Pézard**, Knud **Sand**, and F. **Caridroit**: The experimental production of bipartite gynandromorphism in birds.

March 5.—M. Albin Haller in the chair.—G. **Urbain** and A. **Dauvillier**: The coexistence of celtium (element 72) and the yttria earths. The view of Coster and Hevesy regarding the improbability of element 72 being associated with the rare trivalent earths is said to be negatived not only by the work of the authors but also by the discovery of this element by Goldschmidt and Thomassen in malakon and in alvite.—Charles **Moureu** and Charles **Dufraisse**: Auto-oxidation: attempt to explain the mechanism of anti-oxygenisers.—André **Blondel**: Elementary calculations of the couples damping alternators with a forced regime in the theory of two reactions, when the resistances of the armature are neglected.—C. de la Vallée **Poussin**: Quasi-analytical functions with real variables.—Ph. **Glangeaud**: The earthquake of October 12, 1922, in the Creuse and the Limousin, and some earthquakes in the north-west of the Central Massif. A map of the district over which the shocks were felt is given, showing also the lines of the faults in the geological strata. These earthquakes in the Central Massif are due to slipping along the old lines of the faults.—M. Gabriel Bertrand was elected a member of the section of chemistry in the place of the late H. Georges Lemoine.—Georges **Darmois**: The local integration of the equations of Einstein.—F. **Defourneaux**: A category of polynomials analogous with electrospherical polynomials.—N. **Abramesco**: The auto-generation of curves.—Henri **Milloux**: The growth of integral functions of finite order and their exceptional values in the angles.—Kyrille **Popoff**: The pendulum of variable length.—J. **Haag**: The interior problem of Schwarzschild, in the case of a heterogeneous sphere.—B. **Salomon**: The gryoscopic analogies of synchronous and asynchronous electrical machines and the transposition into mechanics of certain diagrams of electrotechnics.—MM. **Huguenard, Magnan**, and A. **Planiol**: An apparatus giving the instantaneous direction of the wind. This is a modified compensated hot-wire anemometer. By using this and the compensated hot-wire instrument for measuring wind velocity, both the instantaneous direction and velocity of the wind can be recorded on the same chart. Examples of such records are reproduced, and their bearing on problems of flight without motors indicated.—Jean **Chazy**: A correction derived from the theory of relativity to the Newtonian time of revolution of the planets.—J. Ph. **Lagrula**: Test of the rapidity realisable in equatorial measurements of small planets with a telescope provided with a photo-visual comparator and some additional accessories.—J. **Guillaume**: Observations of the sun made at the Lyons Observatory during the fourth quarter of 1922. The results of the observations taken on 61 days during this quarter are summarised in three tables showing the number of spots, their distribution in latitude, and the distribution of the faculæ in latitude.—Henri **Béghin** and Paul **Monfraix**: A new gyrostatic compass. This instrument, composed of a system of three gyrostats, has been specially designed to neutralise the deviations produced by the motion of the ship.—F. W. **Klingstedt**: The ultra-violet absorption spectra of the cresols.—A. **Dauvillier**: The high frequency spectrum of celtium. Reply to a criticism by D. Coster and G. Hevesy.—André **Charriou**: The removal of acids from solution by precipitates of alumina. A study of the removal of chromic acid by aluminium hydroxide, and of the means of purifying the precipitate by washing with suitable reagents.—R. **Locquin** and Sung **Wouseng**: The preparation of various pinacones by the action of alkyl magnesium compounds on some α-hydroxy-methyl ketones. Details of a generally applicable method for preparing bitertiary α-glycols of the type $RR'C(OH)—C(OH)R''(CH_3)$.—Pauline **Ramart**: A molecular transposition in the pseudo-butyl-diphenylcarbinol series. A study of the compounds produced by the action of acetic anhydride and acetyl chloride upon the alcohol $(C_6H_5)_2 . C(OH) . C(CH_3)_3$.—Emile **André**: The separation of methyl oleate and methyl linoleate by fractional distillation. The separation is difficult, owing to the tendency of the linoleate to form polymers.—A. **Mailhe**: The decomposition of the aryl formamides. A new method of preparation of substituted ureas. The vapours of formanilide passed over finely divided nickel at 400°-410° C. give some aniline and diphenylurea. The formotoluides behave similarly.—Henri **Longchambon**: The study of the spectrum of the triboluminescence of some substances. Crystals of tartaric acid when broken give a band spectrum of nitrogen similar to that obtained from sugar. Crystals of cadmium sulphate, uranium nitrate, and fluor spar also show nitrogen bands. The light from the uranium salt, which has a colour differing from the other, shows the four green fluorescence bands of uranium nitrate.—E. **Schnæbelé**: The granites of the Champ du Feu (Vosges).—Léon **Bertrand** and Antonin **Lanquine**: The co-ordination and origin of the Pyrenees-Provençal structural units in the south-west of the Maritime Alps.—Pierre **Bonnet**: The tectonic relations of the gneiss and coal measures in the northern Morvan.—Henry **Joly**: The constitution of the Jurassic at Torrelapaja and Bordejo (Celtiberic chain, provinces of Saragossa and Soria, Spain).—E. **Bénévent**: The mistral on the coast of Nice. The freedom of Nice from the mistral is not due to its sheltered position, but to its situation with respect to the trajectories of the barometric minima.—Joseph **Lévine**: Triatomic hydrogen and meteorological depressions.—J. **Beauverie**: Influence of the rainfall during the "critical period" of wheat on the yield. Provided the rainfall during the "critical period" is below a certain amount, the yield of wheat is roughly proportional to the rainfall.—A. A. **Mendes-Corrêa**: The proportions of the limbs in Portuguese. The Portuguese, from the point of view of the proportions of their limbs, are of a clearly European type.—Henri **Piéron**: The propagation of luminous stimulation of the retina to the cerebral outer layers.—Marc **Romieu**: The histological study of the testicle of *Orthagoriscus mola*.—R. **Hovasse** and G. **Teissier**: Peridinians and Zooxanthelles.—C. **Levaditi** and S. **Nicolau**: The filtration of neurotropic ultravirus through collodion membranes. The virus of rabies, encephalitis, herpes, and neurovaccine can be filtered under pressure through collodion membranes. The filtrates vary in toxic power; not only from one membrane to another, but also according to the nature of the virus.

Official Publications Received.

Report of the Commissioner of Education for the Year ended June 30, 1922. Pp. iii+32. (Washington: Government Printing Office.)

Report of the Marlborough College Natural History Society (founded April 9th, 1864) for the Year ending Christmas, 1922. (No. 71.) Pp. 72+3 plates. (Marlborough.)

Forest Bulletin No. 51: An Investigation of certain Factors concerning the Resin-tapping Industry in *Pinus longifolia*. By H. G. Champion. Pp. 20. (Calcutta: Government Printing Office.) 8 annas.

Carnegie Institution of Washington. Annual Report of the Director of the Department of Terrestrial Magnetism. (Extracted from Year Book No. 21 for the Year 1922.) Pp. 266-309. (Washington.)

Diary of Societies.

WEDNESDAY, APRIL 4.

SOCIETY OF PUBLIC ANALYSTS AND OTHER ANALYTICAL CHEMISTS (at Chemical Society), at 8.—Dr. S. White: Physiological Standardisation.—B. S. Evans: An Investigation into the Chemistry of the Reinsch Test for Arsenic and Antimony, and its Extension to Bismuth.—Dr. G. W. Monier-Williams: The Estimation of Boric Acid in "Liquid Eggs" and other Foodstuffs.

ENTOMOLOGICAL SOCIETY OF LONDON, at 8.

FRIDAY, APRIL 6.

ROYAL SOCIETY OF ARTS (Indian Section), at 4.—G. R. Clarke: Postal and Telegraph Work in India.

PHILOLOGICAL SOCIETY (at University College), at 5.30.—Prof. W. A. Craigie: Dictionary Prospects.

INSTITUTE OF MARINE ENGINEERS, INC., at 6.—Annual Meeting.

SATURDAY, APRIL 7.

GILBERT WHITE FELLOWSHIP (Annual General Meeting) (at 6 Queen Square, W.C.1), at 2.—Sir David Prain: Presidential Address.