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Plant Quarantines.

THE raw material of vegetable origin produced in the British Empire for consumption as food or use in industry is of infinite variety and immense value. Rubber in Malaya, tea in India and Ceylon, cocoa in the Gold Coast, jute, cotton, rice, and oil-seeds in India, wheat and fruit in Canada and Australia, all represent interests of primary importance. It is natural, therefore, to find close attention paid to safeguarding the health of the plant world throughout the Dominions and Colonies, and in recent times there has grown up a system of barriers directed against the free circulation of living plants that might serve to introduce plant pests and diseases.

It has been recognised for some time that insect, fungous, and bacterial parasites of plants are readily transported from one part of the world to another with the living host-plants on which they feed, but not so readily in any other way. Many of these organisms are delicate and short-lived, requiring food and more or less congenial conditions to enable them to survive long journeys. On that account many have remained, probably for centuries, restricted to their proper habitat —the localities in which they are "indigenous." Increased facility of communication, and the opening up of large areas to the cultivation of crops that are often exotic, have greatly increased the chances of dissemination and harmful activity of these pests. Country after country has had its lesson in the invasions of insect and cryptogamic parasites of crops, and in many cases these have been traced to introductions from overseas similar to those to which attention was directed in England by the import of wart disease of potatoes and American gooseberry mildew.

To prevent these events, or at least to reduce their frequency, a series of plant quarantines is now in force in practically all parts of the Empire. It is, in many countries, easier for an alien to land than for a living plant to be secured entry from overseas. Permits to import have to be obtained by the importer, certificates of health and freedom from danger have to accompany the consignment, and an army of inspectors is occupied in granting these certificates and in re-inspecting the plants on arrival at the ports of entry.

Such restrictions are undoubtedly hampering to the export trade in nursery stock, and even, at times, to bulk trade in agricultural produce. In 1914 an abortive attempt was made to secure international agreement in establishing a common basis for facilitating commerce in living plants, through the International Phytopathological Convention of Rome. A further attempt is to be discussed shortly under the ægis of the International Institute of Agriculture in Rome.

Advantage was accordingly taken by the Ministry of Agriculture in Whitehall of the presence of a body of Dominion and Colonial botanists and plant pathologists, who were attending the Empire mycological and botanical conferences earlier in the month, to call a conference on July 17 to consider the whole matter. This conference was attended by a number of the scientific and administrative officials responsible for the application of plant quarantine measures in England and overseas, by many botanists and mycologists, and by representatives of the trade. The opportunity was taken for a frank discussion of the various interests affected by these measures, and of the scientific bases for their application.

There is no possibility of the producing countries withdrawing altogether their restrictions of plant imports. Nevertheless, there is a strong body of opinion that total prohibition may easily be carried too far, and that prohibitions should be as few as possible and carefully scrutinised from time to time, especially so as to avoid rejection of consignments because of a small percentage of infection with some pest already widespread in the importing country. It is felt that in some cases prohibitions are inspired by distrust of the methods of disease control in the exporting country and of the efficiency of the inspecting service which certifies to the health of export consignments. Such distrust can only be remedied, on one hand, by the establishment of really efficient methods of control and inspection, and on the other, by a closer contact between the services of the different countries, such as is secured by conferences of this nature. Without mutual confidence in the plant health services, increased facilities for trade in living plants are unlikely. There is a feeling that matters are improving in this respect, and it is hoped that ultimately some amelioration of the regulations now in force may result.

The common bases for international agreement are somewhat scanty at present. Only three were formulated at the meeting, namely, (1) that every country should have the right to impose prohibition of imports with the view of restricting the risk of introducing diseases, (2) that no country had a right to ask another country to accept its exports before it had established effective plant disease control within its own borders, and (3) that no country was entitled to make a similar request unless it maintained an efficient inspection service and proper arrangements for giving health certificates. Indeed, in a general way the chief result of the conference is a recognition of the fact that a country must set its house in order before it can secure such confidence in the health of its consignments as will facilitate their admission into other countries.

Exploration in Central Asia.

Records of the Survey of India. Vol. 17: *Memoir on Maps of Chinese Turkistan and Kansu, from the Surveys made during Sir Aurel Stein's Explorations, 1900–1, 1906–8, 1913–15.* With Appendices by Major K. Mason and J. de Graaff Hunter. Pp. xv+208+30 plates (+48 maps+12 charts, separate). (Dehra Dun: Trigonometrical Survey Office, 1923.)

THIS memoir is a record of the geographical surveys carried out by Sir Aurel Stein during his explorations in Central Asia, and is accompanied by 47 maps of the mountainous and desert countries north of Tibet. Stein's journeys were primarily undertaken for archæological exploration, but he made use of his opportunities for geographical surveying. The geographical world owes a debt of gratitude to Stein for his surveys of these inhospitable regions; his maps will for many years to come be the main source of our geographical knowledge of this portion of Asia. The maps have been printed in colours by the Survey of India, and the memoir furnishes information as to their history; there is an appendix on Stein's triangulation written by Major Mason, the triangulator of the Hindu Kush, and there is another appendix on Stein's heights by Dr. Hunter, the mathematical adviser of the Survey.

The theatre of Stein's explorations has been the great mountain horse-shoe of Central Asia, known as the Tarim basin; the Tarim river collects the waters from the glaciers surrounding the basin, and carries them eastwards until they are choked and lost in the desert of sand. The plains of the Tarim horse-shoe have an easterly opening into the Gobi desert of China; on the south they are shut in by the snowy ranges of Tibet, on the west by the Kashgar range of the Pamirs, and on the north by the Tian-Shan mountains. Inside the basin the sand is increasing owing to the disintegration of the surrounding mountains and to the decrease of the surrounding glaciers.

Many parts of the earth have been discovered by geologists to have undergone a slow desiccation in the course of ages. But Stein's surveys have shown that the Tarim basin has suffered a rapid desiccation during the last 2000 years. The volume of water available for irrigation has decreased considerably within historic times; the relics recovered by Stein from the sand-buried sites of ancient towns have shown that the latter were abandoned about A.D. 400; a long line of ruined boundary towers has been proved by his investigations to date from 200 B.C.

It was in 1898 that Stein first approached the Trigonometrical Survey of India and asked for their

co-operation in his scheme for exploring the ancient sites buried under the sands of Tarim. The Superintendent of the Survey was then Colonel Gore, and when we now look back upon the brilliant successes that have attended Stein's three expeditions, we cannot but feel that this first meeting between the experienced frontier surveyor and the young ambitious archæologist has led to great results. At this meeting was founded the alliance between the Trigonometrical Survey and Stein, an alliance that has lasted without a break for a quarter of a century.

Stein has now carried out three expeditions. On his first expedition (1900–1901) he was accompanied by Surveyor Ram Singh, and it was on this expedition that he discovered the extensive ruins of Niya, which have been abandoned to the sands since A.D. 300. It was on this expedition that the peak of Kongur (25,146 feet) was definitely proved to be higher than the famous Mustagh Ata (24,388 feet), which had hitherto been believed to be the highest point of Asia north of the Himalaya-Karakoram mountains. In observing the clusters of peaks round Kongur, Surveyor Ram Singh made a mistake that is not uncommon in mountain surveys; he mistook the identification of different peaks as seen from different places, and from his observations the Trigonometrical Survey drew the conclusion that there were two Kongur peaks, both higher than 25,000 feet; this is now known to have been incorrect; there is but one true Kongur peak (height, 25,146 feet), and it is depicted in the second photograph of the Memoir. It may be recalled that Schlagintweit made the same mistake as Ram Singh, when he was observing Mount Everest sixty years ago, and that Schlagintweit's error of identification led to the name of Gaurisankar being wrongly applied to Mount Everest, a geographical blunder that has been unfortunately perpetuated in the new *Times* Atlas.

On Stein's second expedition (1906–1908) Rai Sahib Ram Singh again accompanied him, but his health gave way under the hardships of the work and he was relieved in 1907 by Surveyor Lal Singh. On this second expedition Stein's feet were severely injured by frost-bite, and he had to be carried back to Leh in Tibet, where the toes of his right foot were amputated. On the third expedition (1913–1915) Stein was again accompanied by Surveyor Lal Singh, who had displayed exceptional zeal and fitness for surveying under trying conditions.

The discoveries by Sir Aurel Stein of the relics of a vanished population who had had to struggle for generations against the encroachments of sand took geographers by surprise. This people, whose rivers had been choked and whose towns had been buried, were found by Stein to be of a higher civilisation than that prehistoric race which was similarly driven from its homes in Europe by the advancing glaciers of the ice-age. The entombment of the Tarim towns was not sudden like that of Herculaneum and Pompeii, but it was as complete. Stein's descriptions [1] of the ancient sites have gained for him so high a reputation as an archæological explorer that his contributions to geography are apt to be overlooked, and for this reason the publication of the new Memoir will be welcomed.

Mathematics of Relativity.

(1) *Introduction au calcul tensoriel et au calcul différentiel absolu.* Par Prof. G. Juvet. Pp. iv+101. (Paris: Albert Blanchard, 1922.) 12 francs.

(2) *From Determinant to Tensor.* By Dr. W. F. Sheppard. Pp. 127. (Oxford: Clarendon Press; London: Oxford University Press, 1923.) 8*s.* 6*d.* net.

(3) *Qüestions de Mecànica Clàssica i Relativista. Conferències donades el Gener de 1921.* Per Prof. T. Levi-Civita. (Publicacions de l'Institut de Ciències. Collecció de Cursos de Física i Matematica.) Pp. viii+151. (Barcelona: Institut d'Estudis Catalans, n.d.)

(4) *Les Axiomes de la mécanique (Examen critique): Note sur la propagation de la lumière.* Par Prof. Paul Painlévé. (Les Maîtres de la Pensée scientifique.) Pp. xvii+112. (Paris: Gauthier-Villars et Cie, 1922.) 3 francs.

(1) ONE of the most interesting features of Prof. Juvet's book on the calculus of tensors is the preface by Prof. Hadamard. In discussing the value of a book that deals with the pure mathematical theory of tensors, Prof. Hadamard has some hard things to say about the geometrical work of recent years. Henri Poincaré once said: "The physicist expects us to solve the problems that he sets us. But in setting us these problems he pays us in advance for the service we do him in solving them. The numbers and symbols of mathematics can form an infinite number of combinations. Of all this multitude how are we to choose those that are worthy of our attention? Should we be guided solely by caprice? . . . The study of physics prevents us from losing ourselves, or, more important still, prevents our moving constantly in a circle." Prof. Hadamard thinks that this danger of losing ourselves in a mist of symbolism or of moving continually in a circle of barren argument is, in fact, a characteristic of the innumerable researches of recent years, where "the classical ideas of Gauss, Ossian Bonnet, and Darboux reappear untiringly in all

[1] "Sand-buried Ruins of Khotan," 1904; "Ancient Khotan," 1907; "Ruins of Desert Cathay," 1912; "Serindia," 1921.

possible orders, somewhat like the performers in a circus, or like the pieces of red, green, and blue paper that our children are made to put together at school in accordance with the methods of Froebel." Prof. Hadamard concludes: "Whatever view we may hold of the value of the new hypotheses of Einstein's theory, they give geometry a new rôle, and open out for her a new lease of life . . . full of infinite fertility. . . ."

For this reason and others, Prof. Hadamard welcomes M. Juvet's book, which is indeed a very good account of the main features of the pure mathematical aspects of the geometry of relativity. The theory of vectors is developed into the theory of linear transformations of vectors, and so into the theory of tensors, followed by the theory of quadratic forms and the tensors of generalised space. The illustrations of the meaning of the quantities g in the case of two- and three-dimensional space are very helpful. There is also a good account of the theory of parallelism according to Levi-Civita and Ricci.

(2) Dr. Sheppard's aim is similar to that of M. Juvet, and he carries it out with equal success. His point of view is distinctly different, due to the fact that he is interested in algebra rather than in geometry. The book consists of two parts—the first dealing with Determinants, the second with Sets. Basing himself on the possibility that a reader who wishes to study tensor methods may be insufficiently acquainted with the necessary determinant theory, Dr. Sheppard devotes five chapters to the subject. One may reasonably suppose that a reader unacquainted with determinants will scarcely be fired with ambitious schemes like the study of tensor theory, and that, in the rare event of this happening, his eagerness is quite unlikely to survive the shock of the author's eminently and severely logical presentation of the theory. We may, however, express the belief that Dr. Sheppard's real aim is to instruct the reader who does "know" determinants, and to lead him on to the algebraic point of view as applied to tensors in the second half of the book: at any rate all readers will find the chapters on determinants a useful and interesting repetition of theory that most students know rather vaguely. There are also one or two deviations from usual notation to add zest to the repetition.

From the theory of reciprocal determinants Dr. Sheppard introduces sets, double sets, and sets of higher ranks, and thus paves the way for the second part of the book, where the sets of arithmetical quantities become sets of variable quantities and finally tensors. He adopts the Einstein contracted notation for summation, but develops a notation calculated to avoid all misconception, one feature being that Einstein's contracted notation is used only with Greek suffixes.

As already remarked, the book is algebraic, as opposed to Prof. Juvet's geometrical point of view. It is true that Dr. Sheppard gives a chapter on the theory of tensors as applied to relativity; but even here the aspect is analytical only, and it would be possible for a reader who did not know what the theory of relativity is about to read the book without suspecting that the subject is at bottom connected with geometrical concepts.

Mention must be made of Chapter xi., which deals with the use of tensor calculus in the theory of statistics, based upon recent papers by the author and by Prof. Eddington.

The book is one that all English readers of the mathematics of relativity should study attentively.

(3) and (4) The books by Prof. Levi-Civita and Prof. Painlévé are not primarily concerned with relativity as such. The former is a set of four lectures delivered by the distinguished Italian mathematician at Barcelona in January 1921, the subjects being the problem of three bodies, the propagation of waves in water canals, parallelism and curvature in generalised space, and geometrical optics as applied to Einstein's theory. The second book is a reprint of an essay by the famous French mathematician and statesman on the axioms of classical mechanics, first published in 1909, as well as an essay on the principles of mechanics and causality, published in 1905 in the Bulletin de la Société Française de Philosophie. An introduction and notes on relativity theory have been added to the present reprint.

If we associate these two books with the other books of this joint notice, it is because the chief interest of Prof. Levi-Civita's book must lie mainly in the masterly exposition of the theory of parallelism—one of the pioneering stages in the mathematics of generalised relativity, while in the case of Prof. Painlévé's book the reader can at once see that the republication of these two essays was dictated and motived by the relativity controversy.

The fundamental notion of the theory of parallelism is easily seen as follows. A developable surface consists of a number of generators. Suppose that the surface is developed into a plane: two generators which then become parallel are said to be parallel (in the generalised sense) when the surface is not developed, and the directions of any two elements of curve on the developable can be related in the same way. Now we can fit a developable surface to any curve drawn on any given surface, the developable touching the surface at all points of the curve: hence we can define parallelism between elements of curve on any surface. Developing the analytical conditions for such

parallelism and extending to any number of dimensions or variables, we are led to the general theory of geodesics, and to the equations that play so important a part in defining the motion of a particle in Einsteinian space.

Turning now to Prof. Painlévé's book, we have to preface the remark that his attitude towards relativity is one of caution, as shown both by the present publication and by other contributions on the subject elsewhere. "The theory of relativity is like very strong wine, that inebriates brains which are insufficiently accustomed to the rigorous discipline of science": for this reason the author advises particular attention to the fundamental axioms of the classical laws of mechanics, in order that he who wishes to study the modifications involved in relativity theory may at least know what is being changed! Incidentally, Prof. Painlévé mentions one or two common errors in the presentation of Einstein's theory. The first is in the suggestion that the Lorentz transformation applies when the relative velocity of two observers is uniform: the transformation is really laid down only for the case where each observer's motion is uniform relative to the "absolute" space of Newton, or to the system of fixed stars. Another error is the statement that, according to the theory of relativity, the laws of Nature are the same to all observers: of course, this is only true in the sense that certain fundamental differential equations are satisfied independently of the particular frame of reference, its type or its motion. It need scarcely be said that the errors here mentioned are almost inevitable consequences of the attempts made to put exact mathematical statements into vague and "intelligible" language.

Prof. Painlévé insists on the existence of *privileged* axes of reference in actual fact: but whereas in classical mechanics we speak of these axes as absolutely fixed, or as moving with uniform velocity relative to absolutely fixed space, in relativity mechanics these axes are at rest in, or move with uniform velocity relative to, the totality of bodies in the universe. Axes with origin at the centre of mass of the solar system, and in directions fixed relative to the *ensemble* of material bodies in the universe, Prof. Painlévé calls *Copernican* axes: axes moving uniformly relative to these are called *Galilean*, as is the custom in most modern writings on the mechanics of relativity.

The author, in fact, attributes a very important place in the evolution of the fundamental axioms of mechanics to the influence of Copernicus. Given forces acting on a given system of bodies will make the system assume a configuration which at any moment depends on these forces, on the time, and on the conditions at zero time—the *initial conditions*. Now what are these initial conditions? Prof. Painlévé attributes to Copernicus the germ of the principle of classical mechanics, namely, that the initial conditions comprise both *position* and *velocity* of each particle of the system.

Prof. Levi-Civita's book gives also a brief account of the optical properties of Einsteinian gravitational fields in a manner leading up to the discussion of the light bending in the sun's field. The other two lectures give excellent accounts of important modern topics. The lecture on the problem of three bodies is on the regularisation of the problem; *i.e.* putting the equations of motion in such a form that singularities due to the possible vanishing of the distance between two of the particles are made to disappear, so that the variables can be obtained, theoretically, as functions of the time for all values real and finite. Sundmann's fundamental investigations are explained, and the later work by the author and others, leading to the regularisation of the restricted problem of three bodies, and of the general problem in three dimensions. The lecture on waves is one of Prof. Levi-Civita's characteristic investigations in two-dimensional hydrodynamics, reducing the problem of the propagation of waves of permanent type to a functional equation, with Airy's formula for surface waves and other approximate results as special cases.

Prof. Levi-Civita's book will be of interest to all who wish to keep abreast of modern research in problems of applied mathematics. Prof. Painlévé's book should be read and re-read by all students and teachers of mechanics. S. BRODETSKY.

Theories of Colour Vision.

An Introduction to the Study of Colour Vision. By Sir John Herbert Parsons. (Cambridge Psychological Library.) Second edition. Pp. x + 323. (Cambridge: At the University Press, 1924.) 25*s.* net.

SINCE all knowledge comes to us primarily through the evidence of the senses, it is unavoidable that some of the greatest controversies which have occurred in the development of the sciences should have been centred around the *modus operandi* regulating the translation of the energy of a physical stimulus into the energy of thought. It is also not surprising that the fiercest and most prolonged of these battles, not yet concluded, should have originated in connexion with the sense of sight, whereby we come most widely and most directly into relation with our external surroundings. These struggles have resembled no merely local disputes. They are prolonged campaigns conducted on the common borderland of three great territories; and they cannot cease until "natural" delimitations are determined as the result of statesmanship rather than as the result of militant capacity.

In the case of the colour vision controversy, the stage now attained is, on the whole, that of statesmanship, which implies the recognition of essentiality. The chief essentiality was perceived early in the contest by some of the great leaders, but the compulsion behind their conclusions was not adequately perceived until their individual work had ceased. These great leaders, working on wide lines, sought to fix the physical law which dominates visual sensation and is true irrespective of the nature of the structural details which embody it. In such a case, time gradually, and almost imperceptibly, settles the matter.

The record of this process may be traced in Sir John Parsons's work. The dominating law referred to is that of trichromasy in colour mixture. The essentiality referred to is that of trichromasy in colour perception or sensation; but there is not yet universal recognition of the *pari passu* compulsion to trichromasy, *i.e.* a triple set of freedoms only, in the physiological and the psychological processes. Yet Fechner's law is universally recognised as, and is called, a psycho-physical law —the law which relates perception to, and expresses it in terms of, the physical stimuli with regard to the results of which triple freedom is proved. The point is not merely that freedoms cannot be added, while they may be removed, in any subsequent actions having that one-to-one correspondence to precedent actions which Fechner's law asserts to hold between sensation and stimulation under fixed conditions. It is rather that the triplicity is asserted with regard to the sensations themselves. There is no room left for an independent fourth fundamental sensation whether adopted on physiological or on psychological grounds, though it may, for some purposes of description, be convenient to adopt it and use it as if it were independent. A full description cannot then be attained until the connecting linkage is at least formally taken into account.

It is intensely satisfactory to find a physiologist of Sir J. H. Parsons's standing directly speaking (p. 313) of "the trichromatism of normal colour vision, which is a fact, and not a theory." He states quite frankly his recognition of difficulty in connexion with the trichromatic, or, as he calls it, the three components theory, on two points—peripheral vision and the so-called phenomena of induction. He says (p. 231) that "we must therefore accept the theory as explaining satisfactorily *either* the phenomena of after images *or* those of dichromatic vision, but not both." But this view results from a too circumscribed estimate of what the contents of the theory are. In this particular case he speaks of necessary modifications of the theory, while all that is necessary is its legitimate development to suit new facts. The possibilities of the theory are so great that the evidence of new facts is required to place limitations upon it, and that in the very matters of which he speaks. At the top of the same page he states a dilemma arising from the Helmholtzian view of the way in which stimulation by light of one colour increases sensitivity towards the complementary colour. But the trouble only arises because Abney's, or similar, fundamentals are used; and Helmholtz's work on differential sensitivity shows that these cannot be the absolute fundamentals. The dilemma is really non-existent.

Sir J. H. Parsons's volume has filled a great gap in our scientific literature, and will be indispensable as a text-book or book of reference even after the appearance of the American edition of Helmholtz's great work. The treatment which it contains of the observational and the theoretical parts of the subject is very complete, and the discussions of the various outstanding views are fair and full.

The new edition is gracefully dedicated to the memory of Abney and Watson, "worthy successors of Thomas Young and James Clerk-Maxwell in this field of science."

W. PEDDIE.

Chinese Pottery.

The Early Ceramic Wares of China. By A. L. Hetherington. Popular and abridged edition. Pp. 169+31 plates. (London: Ernest Benn, Ltd., 1924.) 12*s.* 6*d.* net.

THIS abridged edition of Mr. Hetherington's excellent volume on the early pottery and porcelain of the Chinese artist-craftsmen will be welcomed by all those students who were unable to purchase the large and profusely illustrated volume from which this has been condensed. The work of reduction and compression has been so skilfully carried out that there is little or no loss of matter that is absolutely relevant, and the work here presented will serve as an admirable introduction to a complete knowledge of the subject, and to the more important works to which all of us must turn for the completion of the story of Chinese ceramics, in all its fascinating and masterly developments.

The immediate purpose and scope of this little work cannot be better expressed than by an extract from the preface, where the author writes: "The chapter on technique has been omitted, and so have the chapters on miscellaneous factories and on marks and inscriptions; the present object being to confine attention to the principal features displayed by the wares without digressing into more difficult paths." As an example of the care which has been taken to render this abridged edition usefully complete, one may mention the list of "The Dynastic Epochs of China from the Mythical and

Legendary Periods, before 2205 B.C." (a date which corresponds roughly with that of the XVIth Egyptian dynasty), down to the Yüan dynasty which held sway in China from A.D. 1280 to 1368.

No one could wish for a more sprightly and entertaining guide than Mr. Hetherington through the mazes of the story he sets out to unravel. Wherever possible, the history is enlivened by some amusing story of the remote past or by some shrewd hint which may help to untie a knot of ancient historic fact; yet, always there is the underlying sensibility of the serious student. As an example of this admirable faculty we cannot do better than quote a passage where the author deals with the evidence we now possess that the potters of the T'ang dynasty (A.D. 618–907) knew how to manufacture true porcelain with felspathic glaze.

"The advance in technical knowledge denoted by the manufacture of true porcelain as an alternative to the use of pottery bodies only, and by the use of high-fired felspathic glazes in substitution for the low-fired lead-silicate glazes, could not have been made very rapidly with the scientific knowledge possessed in those days in China. The process must have been evolved gradually by experiments conducted by competent craftsmen, no doubt, but by men without full appreciation of the underlying scientific principles. One feels, therefore, that the Chinese must have known how to use the simpler types of glaze for a very considerable time before the early part of the T'ang dynasty. The general tendency of further research into Chinese ceramics is to antedate rather than to postdate various types of ware."

The reader will welcome the terse and definite exposition of the technical and artistic qualities and characteristics of the many types of pottery and porcelain that are passed in review; no less than the consideration and valuation of the different racial influences, Chinese and other, that brought about the final artistic results. The simplicity of means and directness of aim manifest in the earlier wares is duly and rightly appraised equally with the glorious yet subtle colour-qualities of the Chün *yao* bowls and bulb-pots of the Sung dynasty. In addition, the author gives an interesting summary of our present knowledge of the famous Ting *yao*, with its well-marked varieties of ivory-white or rice-white glaze. Of the purple and black Ting *yao*, once so coveted by Chinese connoisseurs, no specimens can be identified in modern collections in Europe or America, and we are principally dependent for our knowledge of them on the drawings and descriptions in the album of a Chinese collector who lived in our Tudor times.

Naturally, there is a clear, though necessarily summary, account of the renowned Céladon wares, which seem to have been more largely exported at the time of their manufacture than any other variety of porcelain. In addition, the history of the Tz'ŭ Chow wares—made at what must be the oldest pottery-centre in the world that is still in active operation, for it dates back to the Sui dynasty (A.D. 589–618)—has its puzzles for the collector of to-day, for, as is well said, "It is extremely difficult to determine which specimens are of Sung origin and which of Ming or even later date."

In the final chapter we have an account of the Chien wares, which have only been recognised as a distinct class in what we may call recent times. The fascinating glazes which are usually associated with these wares and are distinguished on account of their markings as "hare's fur" or "partridge markings," are usually applied so thickly that in the majority of examples they form a dark pool in the inside and thick running lines with a terminal blot on the outside of the vessel to which they are applied. These special glazes appear to have been most extensively used in the decoration of small bowls which ritual use long ago prescribed for the "tea ceremonial" or tea contests. The Chinese have always been inveterate gamblers, and in this particular "gamble" the idea was to pit the cup of this type owned by one connoisseur against that owned by another to decide which would retain moisture longest. As Mr. Hetherington says, "The game seems a curious one to Western minds, but, after all, roulette has no more claim as a sensible method of gambling." The tea ceremonial was introduced into Corea and Japan, and with it the bowls and other apparatus of the game. The Japanese have made many varieties of these bowls, some of which are difficult to distinguish from Chinese specimens; though any one who collects with an eye to beauty alone may be delighted to treasure a Japanese specimen for its æsthetic worth.

A word must be added in praise of the illustrations, for though there is only one coloured plate (an extremely beautiful one), the half-tone illustrations convey an excellent impression of the objects they represent, and will greatly aid the student in the identification of specimens.

WILLIAM BURTON.

Diseases of Wild Animals in Captivity.

Disease in Captive Wild Mammals and Birds: Incidence, Description, Comparison. By Dr. Herbert Fox. Pp. vii + 665 + 91 plates. (Philadelphia, London and Chicago: J. B. Lippincott Co., 1923.) 60*s.* net.

ALTHOUGH it is the custom in most zoological gardens to keep a record of all post-mortem examinations, this is the first time an attempt has been made to correlate the results and place them in a compact form before the medical and veterinary professions.

Dr. Fox has held the post of pathologist at the Philadelphia Gardens for the past twenty years, and during that time has had the opportunity of making post-mortem examinations on 1860 mammals and 3505 birds. In addition to this he has also studied the living animals, and has been able to apply his pathological findings to the diagnosis, treatment, and prophylaxis of disease in general. The result of his work has been of extreme practical value in the management of the Philadelphia Gardens; epidemics have been arrested by scientific disinfection, and certain diseases, such as spiropteriasis in parrots and tuberculosis in monkeys, have been entirely eliminated. In order to prevent the introduction of tuberculosis, every new arrival before being placed in the collection is subjected to the tuberculin test, and the variations of temperature during the ensuing forty-eight hours are recorded. In healthy animals there is no reaction; in tuberculous animals there is usually a definite rise in the first twelve hours. No animal showing a positive reaction is placed on exhibit.

Among other communicable diseases investigated, the "jaw disease" of kangaroos has been made the subject of special research. The causative organism of this disease was found to be one of the Mycobacteriaceæ, which was cultured successfully and a vaccine prepared. It was found to be new to science, and has been named *Nocardia macropodidarum*. From experiments upon laboratory animals with cultures of *N. macropodidarum*, it would appear that the disease is transmitted with difficulty. As it is always found associated with a small Gram-negative bacillus, it is possible that the bacillus is a necessary factor in the production of the disease.

The section on the incidence and significance of animal parasites, by Dr. F. D. Weidman, emphasises the value of zoological gardens in general as a field for research on this subject. Tables showing the pathogenicity and frequency in the various orders are given, and various methods of treatment and prophylaxis are suggested.

The tables giving the relation of diet to disease show that birds and mammals which live on a mixed diet of plant and animal tissue are less liable to disease of the alimentary tract than those which are entirely carnivorous or herbivorous. The percentage of thyroid disease and rickets was highest among the Carnivora.

Neoplasms, both benign and malignant, are treated at some length, and valuable tables are given, showing the type of growth, organ of origin, relation to sex, duration of captivity, metastases, and order of animal affected. Neoplasms were found to be commonest among the Rodentia, Marsupialia, and Carnivora, and rare among the Primates. The main organs affected were uterus, liver, thyroid, and mammary glands.

The book is well illustrated with photographs of microscopical and macroscopical specimens of pathological changes, in addition to numerous interesting and valuable statistical tables dealing with the incidence of disease.

In the foreword, Dr. C. B. Penrose, the president of the Philadelphia Zoological Society, makes some general remarks on some of the problems which arise in relation to the keeping of animals in captivity, and the various mental perversions which are common among them, some of which are akin to prison psychoses in man. Diseases of the central nervous system and special senses are dealt with in a special section, as are the diseases of all the other organs of the body.

There is no doubt that this work, which is essentially a pioneer effort, should be read by every comparative and human pathologist. By those who are concerned in the management of living animals in captivity, it will be found to be a mine of valuable information.

Our Bookshelf.

(1) *Physics*. Vol. I.: *Mechanics, Heat and Heat Engines*. By W. J. R. Calvert. (Science for All Series.) Pp. x+260. (London: John Murray, 1924.) 3*s*. 6*d*.

(2) *A Text-Book of Physics: including a Collection of Examples and Questions*. By Dr. W. Watson. Eighth edition, revised by Dr. Herbert Moss. Pp. xx+976. (London: Longmans, Green and Co., 1923.) 16*s*. net.

(3) *Thermodynamique: Énergétique: Théorie cinétique des gaz* (*Cours professé à la Sorbonne*). Par Prof. A. Leduc. Pp. iii+333. (Paris: Gaston Doin, 1924.) 25 francs.

ACCORDING to Dr. George Saintsbury, "A review . . . is a thing addressed to the general body of educated people, telling them whether it is or is not worth their while to make further acquaintance with such-and-such a document purporting to bear their address." Each of the three books included in the present notice has its own merits, but each is addressed to a special class of reader.

(1) The book by Mr. Calvert, who has been a science master at Harrow since 1909, forms the first volume on physics in the "Science for All" Series. It is intended for pupils up to the age of, say, sixteen, who are taking a course of science as part of their general education. For such students the book is a most admirable one, the interest, both from the scientific and the literary point of view, being skilfully sustained throughout. The ideas of work and energy form the main theme, applications being made to the subjects of hydrostatics, statics and dynamics, and heat. In a preface of unusual interest Mr. Calvert discusses the principles underlying the teaching of science in the earlier stages of a general education. Such teaching should give the pupil some idea of the aims of science

and the kind of problems with which it deals; a knowledge of some of the broad fundamental principles; and some insight into scientific method.

(2) Dr. Watson's "Text-Book of Physics," intended for more advanced students, is too well known to require more than the briefest notice. In the revised edition considerable additions have been made to bring the work into line with recent progress, especially in the subject of electricity.

(3) Prof. Leduc reproduces in this volume a course of about thirty advanced lectures on heat delivered at the Sorbonne. He remarks that amongst his hearers future physicists are in the minority; nevertheless, he rightly considers it desirable to consider his subject from the point of view of research, discussing the methods and results of recent investigations, including those he has himself undertaken. Stress is laid on the accuracy of the numerical results, and one of the valuable features of the work is the information (not always easily accessible to the student), which is supplied as to the quantitative values arrived at in the most recent determinations of thermal constants. The book is divided roughly into four parts. The first deals with general questions connected with thermometry, calorimetry, and equations of state. The second and third parts are devoted to the general principles and applications of thermodynamics respectively, whilst the very short fourth part deals with the kinetic theory of gases.

In a few cases the historical references are not complete or accurate. It is probably useless to protest against the constant use of "la loi de Mariotte," but if we cannot have Boyle's law, we would enter a plea for some mention of Joule's law as to the additive nature of the specific heat of compounds. Again, "l'expérience classique de Tyndall" (p. 204), in which a loaded wire cuts through a block of ice, is really due to Lord Kelvin's nephew, Dr. J. T. Bottomley, as is stated in "Heat a Mode of Motion," p. 150 (1887). In spite of some minor defects the book is an excellent one, and an English translation might well appeal to a large number of students. H. S. A.

An Elementary Treatise on Frequency Curves and their Application in the Analysis of Death Curves and Life Tables. By Arne Fisher. Translated from the Danish by E. A. Vigfusson. American edition. Pp. xvi+244. (New York: The Macmillan Co.; London: Macmillan and Co., Ltd., 1922.) 20*s.* net.

THIS book under notice is divided into two parts; the first gives an account of the Gram-Charlier curves and curve fitting taken, in places verbatim, from the author's "Theory of Probability" and the second part deals with a method of estimating rates of mortality from statistics of the numbers of deaths from various causes at each age. The object in finding a method which will enable the statistician to dispense with censuses, or exposed to risk, when estimating mortality is that in some cases only the deaths are known and in others the trouble and expense of obtaining a census, or exposed, are considerable. The author's method is to choose a system of frequency curves based on the hypothesis that the distribution of deaths according to age from certain groups of diseases can be made to conform to those assumed curves; proportional death rates are calculated for each age (or groups of ages) according to the grouped causes of death. From these figures, by a lengthy arithmetical process, the number dying in a stationary population is reached, and this leads to the rates of mortality. The method is interesting and in some cases it gives results which are in close agreement with those obtained by the usual methods, but, in other cases, the examples given seem to imply that there may be considerable errors in the result, although in these cases a modification of the groupings of deaths might lead to improvement. It would appear from *a priori* considerations that, in some circumstances, it must be impossible to obtain a satisfactory result from deaths alone (compare, for example, two experiences having rates of mortality such that the rates by one are equal to r times the rates of the other at all ages).

The book has many defects; some of them are no doubt due, as is suggested by the author in his preface, to the original Danish MS. of the second part of the book having been translated by an Icelander and to the composition and proof reading having been done by a Copenhagen firm; but the explanation affords little comfort to the troubled reader. Possibly the international nature of its origin accounts for the fact that the book, which is dated 1922, has only recently reached us. Another point open to criticism is the omission of a clear explanation at the beginning of the second part of the theory and assumptions on which the author intends to base his construction of mortality tables, so that a reader has more difficulty than is necessary. We think that the author would have been well advised if he had set out some, at any rate, of the difficulties and criticisms that would naturally occur to his readers and how he would propose to answer them.

The idea and the method are interesting; but the evidence in favour is not conclusive and we are afraid that the remark in Prof. Raymond Pearl's introduction that "it may fairly be regarded as *fundamentally* the most significant advance in actuarial theory since Halley" is an unfortunate over-statement.

Smithsonian Institution. United States National Museum: Bulletin 82. A Monograph of the existing Crinoids. By Austin H. Clark. Vol. 1: The Comatulids. Part 2. Pp. xxv+795+57 plates. (Washington: Government Printing Office, 1921.)

RARELY can there have been produced a work so thoroughly deserving the title of Monograph as this vast production of Dr. Austin Hobart Clark's. The first part, of 387 pages, issued in 1915, dealt with some general principles and began the account of the anatomy; it is unfortunate that the pre-occupations of war prevented it from receiving adequate notice. This second part, continuing the description of the comatulids or feather-stars, completes the details of their anatomy, family by family and species by species. There follows a summary of the development, again with reference to every species in which any larval stage is known. An interesting chapter is that on the various habitats of the littoral crinoids. There follow notes on the habits of Antedon, and then a long, well-documented list of parasites and commensals. Next are brought together the scattered observations, experimental and other, made on the tropisms and relations to environment of numerous comatulids.

The chapter on the colour of crinoids includes the stalked and sessile forms as well as the unstalked. The part ends with a section on the economic value of the recent crinoids; this is confined to their sale as curios, for, we are told, they serve no useful purpose; they are not even eaten by any animal that serves as human food. In this respect it is probable that the recent crinoids have acquired a securer footing than some of their large-bodied ancestors.

These two large books, though they contain only "introductory matter" to the systematic descriptions, already furnish a corpus of nearly every observation ever made on these beautiful creatures, and reference is facilitated by full tables of contents and indexes. Although a great deal of the work is based on Dr. Clark's own observations, especially concerning the skeletal and muscular anatomy, it does not profess to give new facts or original theories. That in no way lessens its great value to the worker, who will also find his wants attended to by various keys and by comparative diagrams. He will be grateful to Dr. Clark and will marvel at the energy and perseverance that have brought him so far along a laborious road.

F. A. B.

The Subject Index to Periodicals, 1917–1919. Issued by the Library Association. L: List of Periodicals Indexed and Author Index. Pp. ix+103. (London: Grafton and Co., 1924.) 21*s.* net.

THE alphabetical index of names of authors of articles included in the various Subject Indexes to Periodicals issued by the Library Association for the period 1917–1919 has now been published. The index contains more than 20,000 names of authors, with the sections of the Index and the headings under which the titles of their papers are registered. It is estimated that, on an average, each author has published two papers, so that the total number of papers indexed for 1917–19 will be about 40,000. Those who possess the valuable Subject Indexes already published will be able through this author index to find a paper when they have forgotten its title although they remember the author's name. The abbreviations for 477 periodicals used in preparing the indexes for 1917–19 are also given.

The headquarters of the "Subject Index to Periodicals" were transferred to the National Library of Wales, Aberystwyth, in January 1921. The access to periodicals in this Library has been of great assistance to the editors in preparing the indexes. The editors record the voluntary help they have had from some forty-eight libraries in Great Britain and from a number of private contributors. While expressing its grateful thanks to all who have helped in the undertaking since its beginning in 1915, the Library Association makes a strong appeal for assistance to those librarians who have hitherto held aloof from active co-operation in the work.

It is obvious that the value of the Index depends upon its completeness; although up to the present time some 575 periodicals have been examined, some of the libraries that have not yet taken part in the work may very well have on their shelves other periodicals containing relevant matter. We would urge any such libraries to consider whether they cannot arrange to assist in the future.

Laboratory Experiments in Chemistry: to accompany Black and Conant's "Practical Chemistry." By N. Henry Black. Pp. x+167. (New York: The Macmillan Co.; London: Macmillan and Co., Ltd., 1923.) 5*s.* net.

THE author of this small work can be congratulated upon having written a really practical text-book which is much superior to most of those now used in Great Britain. Its chief feature is absolute clarity of presentation; no pupil should go wrong if he follows faithfully the directions given, and if he tries to answer the numerous questions interpolated throughout the text he will exercise his intelligence as well as his fingers and his capacity for obeying instructions. Those who prefer the strictly heuristic method of teaching will probably not regard with favour a book of this kind, but they would find it very useful if—as is usually the case—they are expected to cover a lot of ground with a large class in a limited time. Other valuable features are the optional work given after each experiment, and, near the end of the course, some elementary lessons in applied chemistry. The present writer has given some of these experiments to his pupils and can testify to their value, not only in imparting knowledge but also in stimulating interest. Some minor points of criticism will doubtless suggest themselves to every teacher, but these are negligible in comparison with the excellence of the work as a whole. Unconscious humour, too, is not often to be found in a school text-book, but if the reader will refer to the second sentence on page 1 of this book and then glance at the illustrations on the frontispiece opposite, he will learn that the homely test-tube, beaker, crucible, etc., are among the "less familiar" pieces of apparatus. We wonder what are the more familiar pieces of apparatus in American schools?

Principles of Electric Motors and Control. By Gordon Fox. Pp. xiv+499. (London: McGraw-Hill Publishing Co., Ltd., 1924.) 17*s.* 6*d.* net.

MOST books describing electric motors and controllers are written mainly from the point of view of the designer, that is, from the point of view of the manufacturer. The number of operating engineers, however, is much larger than the number of designers, and faulty application, as the author points out, can nullify good design. This book is intended for students and for those interested in the selection, application, purchase, and sale of electric motors and controllers. The discussions are simple and practical and will be easily understood by the engineer. Although many graphs are given, vector diagrams and higher mathematics have been rigorously excluded. The control diagrams all conform to standard American practice, but the practice in Great Britain is much the same. A very full bibliography is given.

The book will be found helpful both to the practical and theoretical electrical engineer. The latter will find in it diagrams which illustrate excellently practical applications of known theoretical principles with which he is familiar. For example, a clear diagram is given of the principal connexions for converting from one system of supply to another of different frequency at constant power.

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.*]

Chimæras Dire: Transplantation of Heads of Insects.

WITH some astonishment I notice my friend, Dr. W. T. Calman, agreeing with the German authors Hans Blunck and Walter Speyer in his letter to NATURE of July 5, p. 11, entitled "Chimæras Dire," which is written with much sarcastic humour, but little knowledge of the subject. The title itself is misleading. Walter Finkler has never claimed to have produced Chimæras in adult insects, a term signifying in biology "simultaneous development of parts compounded from tissues of different species (or races)"; he has merely studied the possibility of replantation of heads and described the results thereof. He has neither written that "The head of a herbivorous water-beetle persuaded a carnivorous body to be content with, and seemingly to digest, a vegetable diet," nor that "a Dytiscus strove to moderate the colourings of its wing-cases to suit the sober tastes of its new Hydrophilus brain." The only part of Finkler's work referring to nurture (*Archiv f. mikrosk. Anatomie u. Entwickl.mechanik*, xcix., 1923, p. 113) alludes to the passage of coloured algæ through the re-established connexion between the cut ends of the œsophagus in *homoplastic* experiments on the replantation of Hydrophilus-heads, while the assumption of a darker hue after heteroplastic replantation of a Hydrophilus-head to a Dytiscus-body refers to the yellow crossbars of the thorax in the swimming beetle (pp. 127-128), a result Finkler ascribes to the influence of eyesight, but that can perhaps be more readily explained on the assumption of tyrosinase diffusing from the head to the thorax.

Dr. Calman's sentence, "a male head led a female body into unwonted perversities," will, I am afraid, also produce a wrong impression of Finkler's observations. Finkler's xenoplastic experiments on the exchange of heads between a male and a female Hydrophilus were conducted to see if the reproductive glands have any influence on the sexual instinct as displayed by the head in the antennal play of the male (and the several reflexes of the legs inspired by the œsophageal ganglions of the intact imago). The result was that no such influence could be detected (p. 124). The male head kept its usual reaction towards the female, and the female head did not acquire this character when transplanted to a body of opposite sex, quite in agreement with the many experiments on other insects, where removal or even heterological exchange of the reproductive glands in larvæ always failed to display any change in the secondary sexual characters of the imago.

As to the knowledge of Drs. Blunck and Speyer, "already known by a long series of anatomical and biological researches on the very water-beetles that were among the chief of Finkler's *corpora vilia*," of the physiology of these insects, I have just stated an example of it: they have maintained that a Hydrophilus with Dytiscus-head could never live in water, because the former needs its feelers for respiration. Any one can easily convince himself of the fallacy of this belief, dating from an unlucky fabulation of Nitzsch (1811!) and repeated, it is true, in all treatises on the physiology of these beetles since his time. It is only necessary to amputate both antennæ of some Hydrophilus and keep the beetles as usual in water with some algæ. No inconvenience will befall them on account of this loss. I have a paper in the press on this subject for the *Zoologischen Anzeiger* which is to appear shortly, discussing the various criticisms of Finkler's experiments by several authors in Germany. I need not, therefore, go into further details now.

I should, however, like to add that Finkler has not "ignored requests to produce his chimæras, alive or dead, for investigation by others." His transplantations were produced alive at the meeting of the zoological section of the Zool. Bot. Society of Vienna on November 11, 1921, for general inspection, and some dead specimens were handed on to Dr. Boulenger (has not Dr. Calman had the opportunity of seeing these himself as an "exhibit at a Royal Society soirée"?); the total preparations of the beetles, of which Finkler's Plate IV. gives but a poor impression, are in our Museum and hundreds have seen them. Wit is appropriate "in the pages of *Punch*"—but in the pages of NATURE we should try to keep to strict truth.

As to Mr. J. T. Cunningham's recent note (NATURE, July 26, p. 124) on "Transplantation of Heads of Insects," I am puzzled if it is meant as a joke or is the author really used to making his experiments on *five* individuals? (By the way, I am sure he cannot have read Finkler's paper, or he would have known that Finkler has attempted the transplantation of the *head alone* in the meal-worms without success.)

HANS PRZIBRAM.

The Vivarium,
Vienna II. Prater.

Radial Velocities and the Curvature of Space-time.

THE question of the reduction of the Doppler effect from the earth to the sun, or conversely, raised by Prof. Eddington in NATURE for May 24, is completely settled in my letter of May 10, which was published in NATURE for June 7, p. 818.

In his letter, however, Prof. Eddington mentions another point, the possible occurrence of an "imaginary star constant v_0" in

$$D^2 = r^2/R^2 + v_0^2/c^2, \quad . \quad . \quad . \quad (1a)$$

which requires an explanation.

The actual position is this. With some R-value, derived from previous material, a new object of estimated distance r may show an effect $|D|$ smaller than r/R. Then (1*a*) calls for a negative v_0^2 or an imaginary v_0. What is the meaning of such a value? Simply, that the orbit *does not pass* through O, the sun, but ends at some perihelion distance $r_0 = R\sigma_0$, where the motion is reversed. Such radial motions are possible in de Sitter's world. Even then the analytical form (1*a*) may be retained, provided we remember that v_0^2/c^2 is to be replaced by $-\sigma_0^2$. In fact, by the equation of motion (NATURE, March 8)

$$\frac{R}{c}\frac{d\sigma}{dt} = \pm \cos\sigma\sqrt{1 - \cos^2\sigma/k^2} = \pm\frac{v}{c},$$

or by the original meaning of the constant, $k = \cos^2\sigma c dt/ds$, we have

$$k = \cos^2\sigma/\sqrt{\cos^2\sigma - v^2/c^2} = \text{const.}$$

If the star passes through the sun, $v = v_0$ for $\sigma = 0$, and $k = (1 - v_0^2/c^2)^{-\frac{1}{2}}$, and the formula

$$D = k[1 \pm \sqrt{1 - \cos^2\sigma/k^2}] - 1 \quad . \quad . \quad (1)$$

reduces approximately to (1*a*). But if it does not

pass through the sun, we have $v=0$ for $r=r_0$, so that $k=\cos\sigma_0$, and (1) becomes, for small σ_0, σ,

$$D^2=\sigma^2-{\sigma_0}^2=\frac{1}{R^2}(r^2-{r_0}^2). \quad . \quad . \quad (1b)$$

If the object, no matter how distant, just passes through its "perihelion" or nearly so, we have a nil-effect or a small effect. Such cases may be rare (as *e.g.* that of N.G.C. 6626), but are possible and well provided for by the general formula (1). This removes every difficulty. At the same time we see that, in a correlation graph, the observed points r, $|D|$ need not lie all above a certain line, but may as well fall below it. They should only show a tendency of crowding along it, on either side, gathering pre-eminently, but not exclusively, in the first and the third quadrants (NATURE, June 7, p. 819, Fig. 1). Such a tendency is shown, by the points thus far available, markedly enough. These relations and formula (1*b*), a supplement to (1*a*), are discussed in my second *Phil. Mag.* paper now in the press. There also the desirable extension of the formula from radial to *any* inertial motions is given. If $r_0=R\sigma_0$ and $v_0=c\beta_0$ be the distance at and the velocity of passage through the perihelion, the result is, rigorously,

$$D=\frac{\cos^2\sigma/k}{1\mp\sqrt{1-\frac{\cos^2\sigma}{k^2}\left(1+\frac{p^2}{R^2\sin^2\sigma}\right)}}-1, \quad (2)$$

where

$$k=\cos^2\sigma_0/\sqrt{\cos^2\sigma_0-{\beta_0}^2}, \quad p=R\beta_0\sin\sigma_0/\sqrt{\cos^2\sigma_0-{\beta_0}^2},$$

and approximately, to all purposes,

$$D^2=\left(1-\frac{{r_0}^2}{r^2}\right)(\sigma^2+{\beta_0}^2), \quad . \quad . \quad (2a)$$

of which (1*a*), (1*b*) are but obvious special cases. The statistical formula, (2) (NATURE, June 7, p. 818), now becomes $R^2=\frac{2}{3}(\overline{r_1^2}-\overline{r_2^2}):(\overline{D_1^2}-\overline{D_2^2})$, and, when applied to all thirteen objects there tabulated, gives $R=7{\cdot}2\times10^{12}$ astr. units. Details are given in the last-mentioned paper. LUDWIK SILBERSTEIN.

Rochester, N.Y., July 5.

Growth-rings of Herring Scales.

WHILE engaged upon work on herring scales at the Ministry of Fisheries' Laboratory at Lowestoft in 1922 and 1923, I made several discoveries regarding the so-called "winter rings," and the comparative growth-rates of scale and fish. These discoveries appeared to me to be of sufficient importance to be brought forward for discussion at a meeting of the Herring Committee of the International Council held at Edinburgh in June 1923, at which I offered a theory of age-determination alternative to the Norwegian theory.

At a later meeting held at Christiania in June 1923, the Herring Committee rejected my theory and adopted the Norwegian theory as a working hypothesis. To this resolution I was a subscriber with some misgivings. In the light of further research, however, I am compelled to revert to my former position, and, while, in accordance with the resolution of the Herring Committee, the Norwegian theory is accepted by the Ministry of Fisheries as a working hypothesis, it has been thought desirable that I should be given an opportunity to state publicly the main facts on which my theory is based, since these have not yet been published. They are as follows:

(1) While in the case of young herrings the number of "winter rings" is the same on all normally developed scales, in the case of older fish there is considerable variation in their number. The greatest numbers appear on the large scales from the forepart of the body (position A), which are used by the Norwegians for age-estimation, while the smallest numbers of clear and easily-read rings appear on scales from near the edge of the dark dorsal pigment and below the posterior end of the dorsal fin (position B). Photos, Fig. 1 and Fig. 2, are of scales from an English fish of 27 cm. in length, landed at Lowestoft; Fig. 1 is from position A and Fig. 2 from position B.

(2) The proportionate growth-rates of scale and fish are similar on scales from regions A and B in the case of small herrings, but increasingly dissimilar as larger and larger fish are taken. Thus, in large fish of which the scales from position A are very ringy (usually known as "old" fish), either these ringy scales have grown disproportionately fast or the scales from position B disproportionately slowly in the later life of the fish. That the differences in

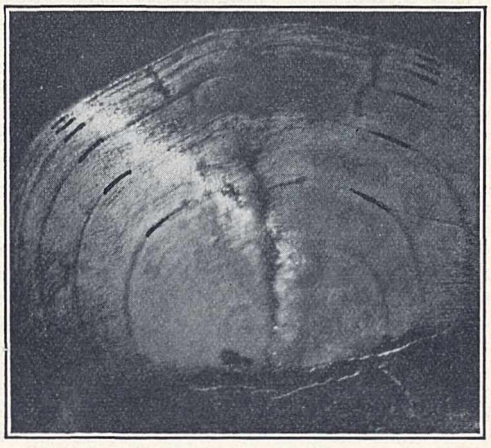

FIG. 1.—Showing six rings traceable all round the striated portion.

the "calculated growth" are significant is obvious from the following examples:

			Calculated Growth. Scale from Position (A).	(B).
(1) Shields fish .	37 cm.	1st year	10·5	12·6
		2nd ,,	20·3	23·6
		3rd ,,	27·2	30·4
(2) Norwegian .	34 cm.	1st ,,	8·0	9·8
		2nd ,,	15·1	16·9
		3rd ,,	22·6	25·5
(3) Norwegian .	34 cm.	1st ,,	6·7	8
		2nd ,,	12·1	14·1
		3rd ,,	21·3	23·8
(4) Norwegian .	34 cm.	1st ,,	6·4	8·8
		2nd ,,	11·0	13·6
		3rd ,,	13·8	17·1

This discrepancy in calculated growth is due to difference of growth-rate taking place mainly in the later part of the herring's life, as may be seen by assuming any length, say 15 cm., for the length of the fish (say No. 4) at the formation of the 3rd ring, and calculating the two first years' growths from the two scales, giving

	Scale A.	Scale B.
1st year . .	7·1	7·7
2nd ,, . .	12·0	12·0

This is very significant, considered in relation to the so-called "phenomenon of decrease of calculated growth-rate with age," which is ascribed by the Norwegians to the influence of migration, the largest fish of each year-class joining any shoal of larger fish first.

(3) The groupings of rings on the outer part of the scale of large herrings. In a large number of cases of ringy scales there is a tendency for the "winter rings" to get closer and closer as we go from the centre of the scale, until they become very crowded at a certain point; after which they widen out, again get closer and closer, and again become crowded. Fig. 3 exemplifies this phenomenon. If the rings are read in groups, instead of singly, an

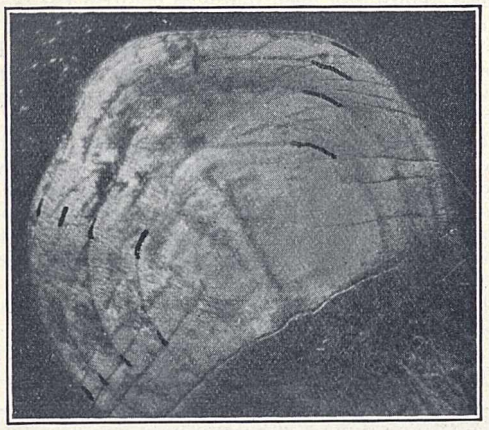

FIG. 2.—Showing only four rings traceable all round the striated portion.

estimate of age is arrived at, differing widely from that based on reading of single rings—in the present case 5 years instead of at least 14 years, the inner group under a high power being seen to consist of about 5 rings, and the outer of about 6 rings, and the three rings inside these two groups being read singly, as the sub-surface phenomena occurring inside these rings would not be considered as "annual rings" by any scale-readers.

(4) The existence of rings in the outer part of the

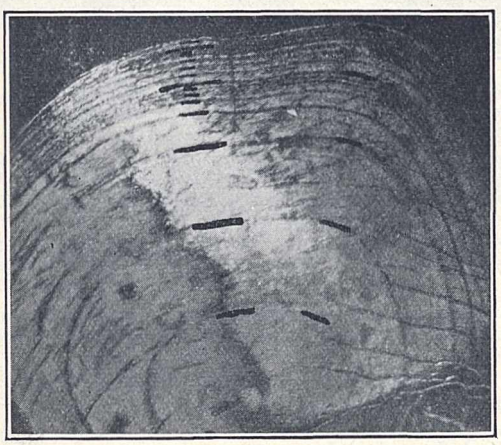

FIG. 3.—Showing three single rings and two groups of rings.

scale having stronger optical value than neighbouring rings, but similar optical value to the first 3 or 4 winter rings. These strong or "α" rings can often be traced out into the exposed part of the scale. If only these "α" rings are recognised as winter rings the age-estimate is of course lower than in the reverse case.

The above phenomena form the main basis of my disagreement with the Norwegian theory. To mention further evidence for my views or to describe my alternative theory would extend this beyond the bounds of a letter, but such evidence exists and will be laid before any workers interested in the matter. The scales from which the photos, here reproduced (Figs. 1-3), were taken, and many others, are also open to inspection.

H. J. BUCHANAN-WOLLASTON.
Ministry of Agriculture and Fisheries,
Fisheries Laboratory,
Lowestoft, July 17.

The Band Spectrum of Boron Monoxide.

IN two recent letters to NATURE (May 24 and 31) Mr. W. Jevons has questioned the adequacy of my evidence as to the oxide origin of a band spectrum which he had previously ascribed to boron nitride.[1] In his second letter he reports that these bands are absent from the spectrum of the discharge through a mixture of BCl_3 and O_2, although the ordinary boric oxide bands are present. This he considers convincing evidence against BO as the emitter of the bands in question. In view, however, of evidence outlined below, a full account of which will appear probably in the *Physical Review*, there seems little room for doubt that the bands are really due to BO and not to BN. The other oxide bands may then be ascribed, as in the past, and in accordance with their complex character, to B_2O_3.

When generated by the reaction of BCl_3 with active nitrogen, the intensity of the BO bands shows a maximum when perhaps 0·5 per cent. of oxygen is present. If the nitrogen is purified beyond this point, using phosphorus, its degree of activation, as gauged by the intensity of the α bands of the afterglow, is increased markedly, finally approaching asymptotically an upper limit. Unlike the BO bands, the SiN bands, obtained by using $SiCl_4$ instead of BCl_3, are stronger the less oxygen is present, and are practically extinguished by the amount of oxygen most favourable for BO. These facts appear to disprove Mr. Jevons's suggestion that the weakening of the BO bands in very pure nitrogen is due to a decrease in its activity when the oxygen is all removed. Probably, if this stage of purification was approached, phosphorus vapour replaced oxygen as a catalyst.

When the BO bands are at their strongest, the yellow of the α bands and the blue of the β bands of active nitrogen are roughly equal in intensity. Lord Rayleigh has shown[2] that the β (and γ) bands are due to the presence of oxygen, probably as NO. Prof. R. T. Birge has concluded[3] that the α bands are emitted by (metastable) excited N_2 molecules; also (private communication) that the β and γ bands are due to NO.[4] The formation of the emitters of the BO bands may then proceed somewhat as follows, denoting an electronically excited molecule by an accent ($'$):

(1) $BCl_3 + N_2' \rightarrow BN + NCl_3$. (2) $BN + NO' \rightarrow BO' + N_2$.

Or, the formation of BO′ may be more direct; in any case, some BN is probably also formed,[1] but apparently gives no spectrum.

In repeating Mr. Jevons's recent experiments, I have found the B_2O_3 bands best brought out with a very large excess of oxygen over BCl_3. Under these conditions the ratio of excited BO to excited B_2O_3 molecules present and emitting at any moment may well be negligibly small, in view of the chemically highly unsaturated character of BO. In active nitrogen,

[1] W. Jevons, Roy. Soc. Proc. A, 91, 120-34 (1915).
[2] Roy. Soc. Proc. A, 93, 254 (1917).
[3] *Phys. Rev.*, 23, 295 (1924).
[4] E. P. Lewis (*Astrophys. Journ.*, 20, 49, and 58 (1904)) has shown that the γ bands are, without much doubt, due to NO; and Birge finds that the β and γ bands have a common final state. Also, their simple structure indicates a diatomic emitter.

however, consisting of a small proportion of N_2' and NO′ molecules in a medium chiefly of unexcited and so inert nitrogen, and with no continuous exciting discharge, this ratio may well be reversed, especially in view of the probable mode of formation of BO.′

In some experiments with a carbon arc,[5] the anode of which contained BN, B_6C, or B_2O_3, I have found that in all three cases the BO (and the B_2O_3) bands appear, in moderate intensity, when an atmosphere of oxygen or air is used, but that they are completely absent in nitrogen. In the latter case BN is doubtless formed, but does not emit a spectrum. No doubt B_2O_3 is partly dissociated into BO at the high temperature of the arc. In the lower temperature of the flame only the B_2O_3 bands are known to occur.

The final piece of evidence is the very close agreement of the vibrational isotope effect with theory for BO, and its definite disagreement for BN. In view of the strength of the theory, this by itself makes BO very probable. If the bands were due to BN, the agreement of experiment with theory would become qualitative only; and if this were the case, the chance is very small that the deviation of the theory from quantitative correctness would be just such as to correspond to an exact but illusory quantitative agreement for BO. The following empirical equations represent within experimental error the positions of all the measurable BO band heads:[6]

$$B^{10}O:\ \nu_\alpha = \left\{\begin{matrix}23652{\cdot}2\ ;\ 23638{\cdot}9\ ;\\ 23526{\cdot}0\ ;\ 23512{\cdot}7\end{matrix}\right\} + 1285{\cdot}6n' - 11{\cdot}7n'^2 - 1926{\cdot}8n + 12{\cdot}21n^2$$

$$B^{11}O:\ \nu_\alpha = \left\{\begin{matrix}23661{\cdot}6\ ;\ 23648{\cdot}3\ ;\\ 23535{\cdot}4\ ;\ 23522{\cdot}1\end{matrix}\right\} + 1247{\cdot}9n' - 10{\cdot}6n'^2 - 1873{\cdot}2n + 11{\cdot}68n^2$$

Ratio: (*Difference* = −9·4) 1·0302 1·104 1·0286 1·045

$$B^{10}O:\ \nu_\beta = 42874{\cdot}6 - 0{\cdot}19nn' + 1304{\cdot}6n' - 10{\cdot}43n'^2 - 1927{\cdot}9n + 12{\cdot}66n^2$$

$$B^{11}O:\ \nu_\beta = 42880{\cdot}9 - 0{\cdot}17nn' + 1268{\cdot}8n' - 9{\cdot}98n'^2 - 1872{\cdot}9n + 11{\cdot}84n^2$$

Ratio: (*Difference* = −6·3) 1·0282 1·045 1·0294 1·069

For the coefficients of the linear terms, the theoretical ratio is 1·0292 for BO and 1·0276 for BN; for the quadratic terms, 1·0593 for BO and 1·0560 for BN. The mean of the four experimental values is 1·0291 ± 0·0004 for the former, 1·066 ± 0·010 for the latter.—The coefficients of n and n^2 indicate a common final state for the α and β systems.

A remarkable feature of the BO bands is the non-coincidence, for the bands having the vibrational quantum numbers n and n' both zero, of corresponding heads of the two isotopes. For the centres of these bands an approximate correction, based on measurements of band structure, increases the differences recorded above to −10·0 and −7·2 for the α and β systems respectively. According to the theory as now accepted, these corrected differences must represent electronic isotope effects, of much greater magnitude than have been found in line spectra. Since this is highly improbable, the following alternative explanation is decidedly to be preferred. If one assumes that the true values of the vibrational quantum numbers are not n and n', but each $\frac{1}{2}$ unit greater, the apparent isotope effect for the true vibrational zero point is reduced to −2·2 for the α and +2·4 for the β system. These differences are now small enough to have resulted from inaccuracies in the determination of equation coefficients. It is then probable that the minimum vibrational energy of BO (and doubtless of other) molecules is $\frac{1}{2}$ quantum. In the case of molecular rotational energy, the necessity of using half quanta is already well established. Analogous relations appear in line spectra; *e.g.* Heisenberg[7] has successfully used half-integral radial and azimuthal quantum numbers in explaining the structure and Zeeman effect of doublets and triplets.

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[5] Similar experiments by Jevons (*l.c.*) on a boron arc were inconclusive, although favouring the nitride origin of the BO bands.

[6] It can be shown that no appreciable error is introduced here in the isotope ratios by using data on heads. The nn' terms are due to the fact that the data are for heads.

[7] W. Heisenberg, *Zeit. für Physik*, 8, 273 (1922).

Effect of Length of Day on Flowering and Growth.

AN attempt has been made to confirm the work of Garner and Allard [1] done in America, under the conditions prevailing in Britain at the Welsh Plant Breeding Station, and to test particularly the behaviour of various strains of herbage plants under different lengths of day.

The plants, equal propagants, or pure line plants, were grown in pots or boxes placed on trucks which were run in and out of a three-sectioned hut so that they received 12, 9, and 6 hours' daylight. Control plants received the full natural daylight. Equal soil, water, and temperature conditions were provided so far as possible.

The results obtained fall into three divisions, namely:

I. EVER-BLOOMING TYPE.—Plants of *Poa Annua* flowered normally under all light periods.

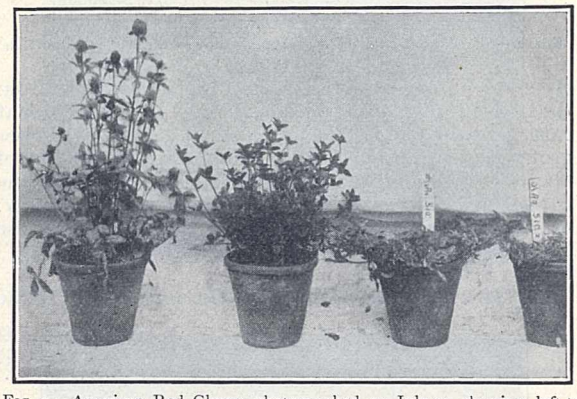

FIG. 1.—American Red Clover, photographed on July 29, showing, left to right, control (many heads ripening), 12-hour plant (with small flowers), 9-hour plant (almost prostrate, with a few small heads), and 6-hour plant (prostrate, in winter habit).

II. SHORT-DAY PLANTS—*Chrysanthemums* (var. Mrs. William Buckingham): Subjected to treatment on May 9. Short-day plants, flower buds July 26, open in early August. Controls, no buds August 12. *Phaseolus vulgaris* (Runner Bean, Sutton's "Best of All"): Treated plants were small and bushy, with thick nodes and swollen roots. Height of control plants 50 in., height of 6-hour plants 9 in. Treated plants flowered 4 days earlier than control plants.

III. LONG-DAY PLANTS—(1) *Broad Red Clover* (ex. Suffolk): Control plants started flowering May 21, attained flowering zenith June 6; 12-hour plants started flowering June 28, attained flowering zenith July 26; 9-hour plants started flowering July 6, attained flowering zenith July 31; 6-hour plants have remained entirely in the winter habit. (2) *Montgomery Variety*: Controls flowered freely from July 16, reaching their flowering zenith about July 26. The 12-, 9-, and 6-hour plants were quite prostrate and in the winter habit on August 10.

[1] "Effect of Relative Length of Day and Night and other Factors of the Environment on Growth and Reproduction in Plants," W. W. Garner and H. A. Allard (*Journ. Agric. Res.*, vol. xviii. No. 11, p. 553); "Further Studies in Photoperiodism, the Response of the Plant to Relative Length of Day and Night," W. W. Garner and H. A. Allard (*Journ. Agric. Res.*, vol. xxiii. No. 11, p. 71, 1923); "Photoperiodism in Relation to Hydrogen ion Concentration of Cell Sap and Carbohydrate Content of the Plant," W. W. Garner, C. Bacon, and H. A. Allard (*Journ. Agric. Res.*, vol. xxvii. No. 3, p. 119, 1924).

Cocksfoot.—Some of the Cocksfoot results can be summarised thus :

	First Panicle emerging.	Full Flowering (Pollen).	Ht. on 31/7.
"French Hay" strain :			
Control plants	19/5	5/6	34 in. ripe seed.
12-hour plants	6/6	16/6	15 in. ripening.
9-hour plants	Remained in winter habit, good leafy growth, no signs of panicles at all, 6/8/24.		5 in.
6-hour plants			
"Tussocks" type :			
Control plants	29/5	25/6	27 in. ripening.
12-hour plants	30/6	29/7	9 in. full flowering just over.
9-hour plants	Plants as yet in winter habit, 6/8/24.		
6-hour plants			

Briefly, the following have proved to be "long-day" plants :

Grasses.—Sweet Vernal, "Late" and "Early Broad Leaf" strains; Meadow Foxtail, "Late Pasture" strain, "Early Hay" strain; Cocksfoot

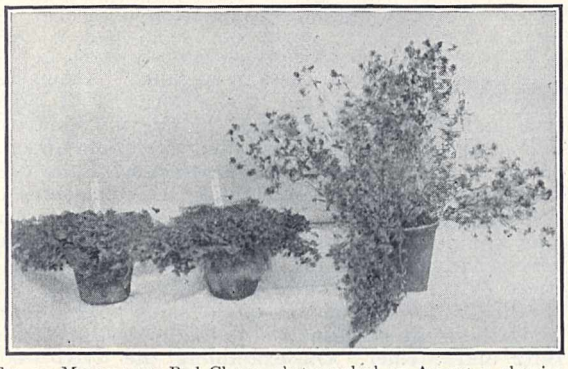

FIG. 2.—Montgomery Red Clover, photographed on August 2, showing, left to right, 9- and 12-hour plants quite prostrate in winter habit and control plant flowering.

strains, "French Hay," "Danish Open," "Late Indigenous," and "Tussocks"; Perennial Rye Grass, Early and late strains; Timothy, Early strains. *Red Clover.*—Broad Red, American Medium, and Montgomery. *Oats.*—Grey Winter, Record, Orion, Ceirch du Bach. *Radish.*—Scarlet Globe. *Foxglove.*

A more detailed account will appear shortly elsewhere. Thanks are due to Prof. R. G. Stapledon, who arranged for the necessary equipment and provided facilities for conducting the work, and to Mr. J. W. Watkins, Superintendent of the Welsh Plant Breeding Station Gardens, for careful attention to cultural detail.

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The Insect Fauna of an Indian Island.

IT has been my good fortune to be associated with the late Dr. N. Annandale in the study of the fauna of a small island in the Chilka Lake, Orissa—the first work of its kind in India. This study has, I believe, a general interest, and I need scarcely apologise for presenting this brief analysis of the insect fauna of this island.

The physical features of Barkuda Island form the subject of a memoir by Annandale (1922), but it may be recapitulated here that the island is situated in the Chilka Lake on the east coast of India in lat. 19° 38′ N. long. 85° 12′ E., and lies in the extreme north-western corner of the Madras Presidency. In outline it forms a right-angled triangle, its longest side being about three-quarters of a mile long, and its shortest less than half as much : the total area equals about half a square mile. It is composed of stratified rocks covered in the interior with a thin layer of red soil, its geological nature, combined with a low average rainfall (as compared with that of the mainland), being responsible for the sclerophytic nature of its vegetation, a distinctive feature of which is the fig-jungles in which there is a dense undergrowth composed mainly of the shrub *Glycosmis pentaphylla.* The dominant tree in these ficetii is the Banyan (*Ficus bengalensis*), the decayed trunks of which are largely inhabited by termites. In inland areas where there is no ficetum, *Weihea ceylonica* is the dominant shrub, and the fig-trees are replaced by the Nim (*Barringtonia acutangula*) and *Craeteva religiosa.* The island is almost completely surrounded by a marginal zone of the trees of *Pongamia glabra.* Other common plants are the Euphorbias (*E. neriifolia* and *Opuntia* sp.), the Custard-apple (*Anona squamosa*), and the herbs *Crotolaria striata, Tephrosia purpurea,* and

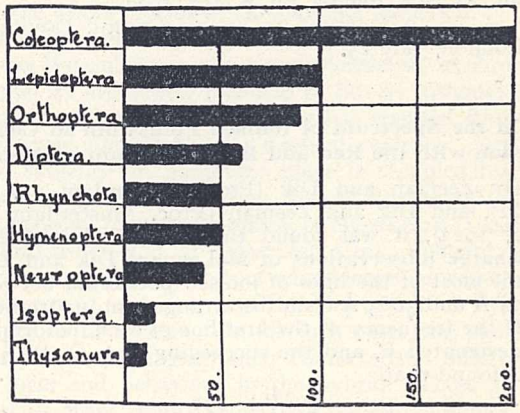

FIG. 1.

Jatropha gossypifolia. Barkuda is separated from the mainland of the western shore of the lake by a channel only a mile broad, and is thus not out of the range of insect immigrants, even those of comparatively feeble flight.

Dr. Annandale's main object in studying the fauna of the island was that it provided an easy means of ascertaining the faunal and floral constituents of a limited area in the tropics, of a somewhat commonplace nature, and the results provide an interesting comparison with the biological features of other areas in the East. It was found that the species of insects inhabiting the island exhibited no morphological peculiarities in response to an unfavourable environment, but were for the most part common and widely distributed species able to exist on the island by reason of their physiological "hardness," or because they could adapt themselves to feed on strange and not very delectable food-plants. It would seem that a rich flora tends to produce a large and varied number of insect forms with a comparative scarcity of individuals, while the insect fauna of such areas as Barkuda are poor in species but rich in individuals.

In the accompanying diagram (Fig. 1), I have attempted to indicate (relatively) the approximate number of forms of the various orders (used in the old sense, *e.g.* Neuroptera to include Odonata, etc.) found on the island. It must be remembered that the totals include regular visitors and stray immigrants to the island. Geographically it seems to be part of the frontier between the faunas of the central and southern districts of the Indian peninsula. *Per exemplum* Barkuda appears to represent the extreme north-eastern limit in India of the dis-

tribution of the Pierid butterfly *Colotis calais amatus*. The South Indian element is strongly noticeable in its insect fauna. In the diagram, the total for "Hymenoptera" includes only the Aculeates; three-quarters of the neuropteroid insects are dragon-flies.

In the space at my disposal it is not possible to consider any special characteristics within the various orders. I may mention, however, that much taxonomic and bionomic information has been accumulated (especially with reference to the termites), and the reader is referred to the various reports on the fauna of the island. A considerable number of new forms have also been described, including such interesting insects as the hemipterous termitophile *Termitaphis annandalei* Silvestri. At some future date a complete summary may be provided.

See Rec. Ind. Mus., xxii, pp. 313-421, 1921; xxiv, pp. 289-311, 1922; xxv, pp. 221-263, 1923; xxvi, pp. 165-191, 1924 (various authors). Also Annandale, Mem. As. Soc. Bengal, vii, p. 257, 1922.

CEDRIC DOVER.

London, July 25.

On the Spectrum of Ionised Potassium in Connexion with the Red and Blue Spectrum of Argon.

BY Zeeman and Dik (Proc. Amsterdam 25, 67, 1922), and Dik and Zeeman (Proc. Amsterdam 26, 500, 1923), it was found that in the electrodeless discharge (observations of McLennan, Dik and Zeeman) most of the lines of ionised potassium between 6594 Å and 3063 Å could be arranged in quadruplets.

If the frequency of the first line of each quadruplet is designated P, and the succeeding ones Q, R, S, it was found that

$$Q = P + 847$$
$$R = P + 1695$$
$$S = P + 2542.$$

For the red spectrum of argon, exhibited under the uncondensed discharge, and for λ below 4704 Å, Rydberg, in 1897, found a similar regularity. Paulson extended those results, and Meggers increased their accuracy. The frequency relations for the red argon spectrum are, with similar notations:

$$B = A + 846{\cdot}1$$
$$C = A + 1649{\cdot}3$$
$$D = A + 2256{\cdot}1$$

In both cases some of the "quadruplets" are incomplete. It is certainly remarkable that the number 847 occurs in both spectra.

We have extended the former investigation and have included an analysis of the "blue spectrum" of argon developed by the condensed discharge.

The following table contains the new results, together with those formerly given.

Argon, Red Spectrum (Rydberg).	Argon, Blue Spectrum.	Ionised Potassium.
A	p	P
$B = A + 846$	$q = p + 845$	$Q = P + 847$
$C = A + 1649{\cdot}3$	$r = p + 1695$	$R = P + 1695$
$D = A + 2256{\cdot}1$		$S = P + 2542$
	t	T
(411,57)	$u = t + 414$	$U = T + 413$

From this table it appears that the connexion between the spectra of ionised potassium and argon (blue) is closer than that between the spectra of ionised potassium and argon (red). We find the numbers 414, 845, 1695 characteristic for the blue spectrum of argon. The number 847 or thereabout occurs with red argon, blue argon, and ionised potassium; moreover, 1695 links blue argon to ionised potassium.

Then there is the number 414, which occurs, as we find, in numerous doublets of ionised potassium and argon (blue). It may be mentioned that Rydberg directed attention to the occurrence of the number 411·57 in the red spectrum of argon.

That there is a close numerical connexion between the three spectra considered seems proved, but the physical interpretation of the characteristic numbers is quite unknown.

Tables and calculations will be published elsewhere.

T. L. DE BRUIN.
P. ZEEMAN.

Amsterdam, August 15.

Anomalous Adsorption.

BILTZ and Steiner (*Kolloid-Zeitschrift*, 1910, 7, 113) have described several cases of so-called "anomalous adsorption," for example, the adsorption of Night Blue and Victoria Blue B. by cotton and charcoal. The adsorption isotherms rise to a maximum and fall off again with increasing concentration of the dyestuff. Hatschek in his "Physics and Chemistry of Colloids," 1922, p. 146, suggests that electrical factors may complicate adsorption "though these do not very readily account for the maximum." During a study of the dyeing of wool by Night Blue I have obtained adsorption curves of the same peaked form, using the same colorimetric method of estimation as Biltz and Steiner. On examining the dyed wool, however, it could not be said that the colour was any lighter in the case of the more concentrated solutions, and some defect was therefore sought in the method of experiment.

It had been noticed that the dyestuff solutions remaining after adsorption on the wool had a greenish-blue colour when viewed by transmitted light in the colorimeter, whereas the original Night Blue solutions were a pure blue; this gave the clue to the defect. Although Night Blue solutions appear to contain no free chlorine ions, the solutions remaining after adsorption were both acid and contained chlorine ions. Hydrochloric acid is probably produced during adsorption, and this has been shown to have a profound influence on the colour of Night Blue solutions. 1, 2, 3, and 4 c.c. of a very dilute hydrochloric acid solution were added to the same amounts of dyestuff solution and made up to the same volume with distilled water. These solutions were compared colorimetrically with a standard Night Blue solution of the same concentration but containing no acid. If we denote the concentration of the standard by unity, the *apparent* concentrations of the acid solutions in order were found to be 1·28, 1·50, 1·83, and 2·11. Furthermore, they showed the same greenish-blue colour noticed previously. In the adsorption of Night Blue by wool the amount of acid liberated will increase with the amount of dye adsorbed, but in consequence of this acid the apparent amount of dyestuff unabsorbed, estimated colorimetrically, will be increased. Since the amount of dye adsorbed is estimated by difference (original concentration known) the explanation of the peaked adsorption isotherms is self-evident, and "anomalous adsorption," as described by Biltz and Steiner, has probably no real existence. The determination of the true adsorption curve is in progress.

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Species and Chromosomes.[1]

By Prof. R. RUGGLES GATES.

IT is only since the beginning of the present century that the progress of biology has rendered possible the discussion of this topic. When the "Origin of Species" was written, chromosomes were unknown, and the study of nuclear division and the relation of chromosomes to the life cycle only began in the 'seventies and 'eighties of the last century. The names of Flemming, Strasburger, Boveri, and many others are connected with the early work on chromosomes, when alcoholic fixation and methods of sectioning first made possible their study. Flemming in 1882 first concluded that 24 chromosomes was probably a constant number in the nuclear divisions of the cells of the Salamander. In the following year van Beneden discovered, in Ascaris, that the egg and sperm contained half as many chromosomes as the somatic cells. From that time to this the process of chromosome reduction has been studied with increasing intensity. Its general relation to the life cycle is now known in nearly all the larger groups of plants and animals.

Until the end of the nineteenth century the study of cell structure developed quite independently of views regarding heredity and evolution, although it had often been suggested that the chromosomes formed the basis of heredity, and that they consisted of differentiated portions or elements. The rediscovery of Mendel's law in 1900 was the beginning of a remarkable convergence between two independent disciplines, the microscopic study of cells and chromosomes on one hand, and the observational and experimental study of heredity and evolution on the other. There is no more striking instance than this, of the convergence of two independent lines of investigation, in the whole history of biology.

It is equally significant that the advances in our knowledge of chromosomes have been alternately based upon studies of plants and animals, sometimes one and sometimes the other being the basis of a particular new line of advance. Whichever has taken the first step in a particular new line of departure, it has usually found confirmation from the other. Even sex chromosomes, which were first discovered in insects and were most intensively investigated in that group, are now known to occur not only in mammals, including man, but also in certain Liverworts and in certain dicœcious flowering plants. Nothing so strikingly proclaims the unity of the organic world as the profound similarity which has been shown to exist in the fundamental cellular processes of the two kingdoms.

Moore had discovered synapsis, or the contracted phase of the nuclei preceding the reduction divisions, in Elasmobranch fishes, in 1896. It was believed that a pairing of elements took place at this period of maturation. In 1901 Montgomery suggested that synapsis consisted in a conjugation of homologous maternal and paternal chromosomes before their separation in the reduction division. Guyer (1900), in a study of spermatogenesis in pure and hybrid pigeons, had already pointed out that the separation of the pairs of chromosomes would account for cases of reversion in hybrids. In short, the chromosome mechanism was recognised as furnishing a basis for what we now call Mendelian behaviour at the same time that Mendel's laws were made known. A similar suggestion was made by Cannon (1903) in a brief study of the reduction divisions in hybrid peas.

Sutton in 1903 produced definite evidence of the pairing of homologous chromosomes of different sizes and shapes in the grasshopper Brachystola. In 1905 Strasburger showed the same arrangement of homologous chromosome pairs in plants, and in the same year Farmer and Moore suggested the term "meiosis" for the whole process of chromosome reduction.

For the original recognition of the individuality, or to use Wilson's term, the genetic continuity of chromosomes, we are largely indebted to Boveri, although the general acceptance of this view has resulted from an enormous amount of later detailed evidence. Among this evidence an important place is occupied by the work on hybrids, including that of Rosenberg (1904) on a species hybrid of Drosera, of Moenkhaus (1904) on hybrid fishes, and of Doncaster, Gray, Tennant, and others on generic hybrids of echinoderms, as well as the more recent experiments of Federley on species hybrids of the moth Pygæra. In all such cases the parental chromosomes maintain their characteristic differences of form and behaviour in the hybrid. These and a host of other results show that the chromosomes are not only self-perpetuating entities, through longitudinal division, but that they are also self-determining as regards their form, and we may now add as regards the finer elements of their structure.

In the last fifteen years particularly, the alliance between cytology and genetics in the experimental study of heredity and variation has become increasingly intimate. Beginning with the recognition of chromosome segregation in meiosis as the basis of Mendel's law of heredity, this was soon followed by the discovery (1906) of definite relations between chromosome numbers and mutations in Œnothera. Since 1910 Morgan and his colleagues have built up a combined system of genetical and cytological results in Drosophila which is unequalled in any other organism. Their theory of linkage and crossing-over has brought the phenomena of meiosis, chromosome structure, and heredity into still closer relationship. More recently Blakeslee and Belling have discovered chromosome relationships in Datura which parallel many of those formerly obtained with Œnothera, and in a striking series of experiments have extended those results in various directions.

In recent years, a number of predictions of peculiar cytological conditions have been made on the basis of genetic experiments, and afterwards confirmed by observation of the cells. An example is the work of Bridges with strains of Drosophila having an extra chromosome. This condition arises, as was first shown in Œnothera, through failure of one pair of chromosomes to enter separate nuclei in reduction, a process which is now known as non-disjunction.

The following may now be regarded as generally

[1] Opening paper of a joint discussion of Sections D (Zoology) and K (Botany) at the Toronto meeting of the British Association on August 12.

accepted facts concerning the chromosomes. They are bodies of relatively fixed size, shape, and point of attachment to the spindle fibres. Homologous pairs usually separate in meiosis and thus furnish the basis for simple Mendelian behaviour. Their number is generally fixed for each species so far as the germ-lineage is concerned. The relations of genetical crossing-over to chromatin behaviour are complicated and need not concern us here. Aberrant chromosome numbers arise in various ways and produce forms with different external characters. Such forms have been specially investigated in Œnothera, Drosophila, and Datura. The most striking changes found are tetraploidy ($4n$ chromosomes), triploidy ($3n$), and non-disjunction leading to forms with an extra chromosome ($2n+1$, $4n+1$, etc.). These conditions occur in all three genera, except that tetraploid forms have not been observed in Drosophila. The condition found in Œnothera particularly furnished the first experimental basis for a comparison of the chromosome numbers in various wild and cultivated species of plants.

When we examine the chromosomes of related species of plants and animals, differences in number or in size and shape of the chromosomes are often found. How have these differences originated? The answer to this question has already given us the beginnings of a chromosome phylogeny, which can now be soundly based on analogy with experimental results. The case of *Œnothera gigas* furnished the first experimental clue to the origin of tetraploidy. Many wild tetraploid species of plants are now known, and they must have arisen in some such way as *Œ. gigas* appeared, *i.e.* as mutations. The tetraploid and higher polyploid species are turning out to be surprisingly common in plant genera, though apparently much less frequent in animals.

Before considering further the phenomena of polyploidy, let us attempt to classify the various types of change which are indicated to have taken place in the phylogeny of chromosomes by the comparison of related species or genera. We may mention:

1. Polyploidy, or the development of higher multiples of chromosome numbers.

2. Transverse segmentation or fragmentation of all the chromosomes, or of particular pairs. A phenomenon of this nature seems to have occurred on a large scale in the phylogeny of the Liliaceæ, where in such genera as Yucca, Albuca, and Eucomis, a number of pairs of short chromosomes take the place of certain long pairs in other genera. In the tetraploid *Primula Kewensis*, a transverse segmentation of all the chromosomes is shown by measurements (Farmer and Digby) to have taken place. In certain species of Hyacinthus and Carex the sum of the lengths of a medium and a short chromosome is equal to the length of a long one, indicating that transverse segmentation of a long one may have taken place.

3. The end-to-end fusion of certain chromosomes. This is particularly clear, both from genetical and cytological evidence in certain species of Drosophila, and appears to have happened in various other cases. The basal number of chromosomes in the Muscidæ appears to be 6 pairs. In different species of Drosophila the n number may be 6, 5, or 4. In *D. melanogaster* and *D. Willistoni*, which have 4 pairs, two of these are long and broadly V-shaped, with a median constriction, and each of these has evidently been formed by the permanent end-to-end attachment of two chromosomes. That *different* chromosome pairs have undergone this union in these two species is shown by the different genetic relationships of their characters in breeding experiments; and that the tendency towards end-to-end union still continues is indicated by the recent discovery of a strain of *D. melanogaster* in which the two X-chromosomes in the females have similarly become attached to each other and behave as a single body.

4. The gradual diminution in the size of certain chromosomes until they disappear. That this evolutionary process has occurred in the Y-chromosome of various insects, is indicated by its range of size in different species, from as large or even larger than its mate the X-chromosome in some species, to a tiny body on the verge of extinction in others. Wilson showed, for example, in the Hemipteran genus Nezara that the Y-chromosome is nearly as large as the X in *N. hilaris*, but very small in *N. viridula*.

In the Copepod genus Cyclops a gradual diminution in the number of chromosomes, from 22 in *C. strenuus* to 6 in *C. gracilis*, is accompanied by reduction in the fifth pair of swimming feet. In another section of the genus a parallel process has apparently occurred, with corresponding gradual diminution of the chromosomes from 14 to 10 and a small pair. Here phylogenetic change has apparently been accompanied by the continuous diminution in size of certain chromosomes until they disappear. Whether such a process should be looked upon as an orthophyletic change arising in the germplasm is not at present clear, but the subject is evidently worthy of further investigation.

5. Irregular divisions or non-disjunction may lead to forms with additional pairs of chromosomes. If this condition becomes balanced it would be perpetuated in a new species. This may have happened in various species.

6. The recent genetic evidence from Drosophila and the behaviour of the chromatin in such forms as *Œnothera lata*, indicate that not only may chromatin fragments enter a nucleus and afterwards divide, but also that portions from one chromosome may become attached to another and thus alter the genetic relationships of the factors concerned. This process is one which must also be considered as important in the evolution of species.

7. In the genus Carex, Heilborn (1924) has shown that the haploid numbers in forty-four species run from 9 almost continuously to 42 and 56, but without multiple numbers. With increase in numbers there is a general decrease in size of the chromosomes, and the same is true of certain other genera, such as Lactuca. This is regarded as due to a limitation in the capacity of the cell for producing chromatin. Heilborn suggests that one of the most important methods of chromosome increase in Carex has been by mutations of the *Œnothera lata* type followed by a division of the extra chromosome.

8. Certain species and even genera with new chromosome content have probably arisen through crossing. There is some evidence, both cytological and morphological, that cultivated maize may have arisen from a

cross between the Mexican Euchlæna and some species of grass belonging to the Andropogoneæ. A much clearer case is the one recently described by J. Clausen. He finds that *Viola tricolor* and *V. arvensis* have respectively 13 and 17 chromosomes as haploid numbers. In a cross the F_1 plants have 30 chromosomes, but in certain of the pollen mother cells 47 were found, *i.e.* 13+17+17, a condition of semi-tetraploidy. Two later generations of plants were grown from these hybrids, the chromosome number continuing 43-46. When the chromosome number is a very unbalanced one in a hybrid, as in crosses between diploid and tetraploid forms, irregularities of meiosis usually occur with loss of chromosomes until the diploid condition is reached in the later generations of offspring. In this Viola hybrid, with less disparity in numbers and a doubling in one parental set of chromosomes, the hybrid may later settle down to uniformity, in which case it might be regarded as a new species with higher chromosome number arising from crossing. Probably various species with increased chromosome numbers have been produced in this way, as Winge has suggested.

It is thus becoming clear that chromosome changes have arisen in a variety of ways, including transverse segmentation or fragmentation, end-to-end union of certain pairs, gradual diminution and disappearance of certain chromosomes, non-disjunction, rearrangement of portions of chromosomes, crossing of species having different numbers, and polyploidy. In some of these cases, of course, a certain amount of nuclear and cytoplasmic readjustment may be involved, but we have no present knowledge of how this takes place. In the simplest cases of tetraploidy all the external changes appear to follow directly from the doubling of the chromosomes.

All of these processes of chromosome change have had their place in the evolution of the germplasm, but certain of them appear to have been characteristic of particular genera or families. Our knowledge of polyploidy is at present much more extensive than any of these other processes, and it is on an experimental basis.

From the work of the last fifteen years, it has become clear that polyploidy has played an important part in the evolution of many plant genera and families, and that it is of particularly common occurrence among the varieties of cultivated plants. If tetraploidy can be brought about, as seems likely, by a lowering of temperature when the fertilised egg is beginning to divide, then one may perhaps understand its prevalence in plants and its relative infrequency in animals where temperatures are more controlled. But that it can be produced in other ways is shown by its experimental production in mosses by wounding (Marchals), in Solanum by grafting (Winkler), and semi-tetraploidy at least by crossing.

The cases of polyploidy in plants that have now been investigated are far too numerous to be discussed here, but reference may be made to a few of them. The genus Rubus, in which Longley (1924) has recently found *2n*, *3n*, *4n*, *5n*, *6n*, and *8n* species, has 7 as basal number. The basal number of chromosomes in Rosa is also 7. In the genera Prunus and Potentilla the fundamental number is 8, and several species of Potentilla are known to be tetraploid. In Cratægus, where $n=16$, Longley (1924) has found *2n*, *3n*, and *4n* species. If 16 is the fundamental number in this genus, then the genus must have originated in connexion with a tetraploid mutation. In some species of Alchemilla $2n=64$ and they are therefore octoploid in comparison with the fundamental number. It is evident that further chromosome studies in such families as the Rosaceæ will throw light on the origin and relationships of genera. The fact that such notoriously polymorphic genera as Rosa, Rubus, and Cratægus are all found to show polyploidy in a high degree is a discovery too fresh for its significance to be fully realised.

Similarly in the evolution of various other genera and families, higher and higher polyploid numbers have been reached. Thus in the genera Chrysanthemum, Rumex, and Rosa, species are found which are *2n*, *4n*, *6n*, and *8n* in their chromosome constitution. Some of these genera also have *3n*, *5n* and even *10n* species. Many of these species are apogamous, and where the chromosome number is an unbalanced one as in *3n* and *5n* species, it can only be maintained by apogamous or vegetative reproduction. Thus these unbalanced species must always have been apogamous from their origin.

The conditions in the wheats, where $n=7$, may be briefly mentioned. Einkorn wheat (*Triticum monococcum*) is diploid, the species of hard wheat are tetraploid, and the Vulgare wheats (soft), which comprise our highest yielding modern sorts, are hexaploid. When members of different groups are intercrossed they produce sterile hybrids. All three groups go back to prehistoric times. The tetraploid wheats presumably arose, like *Œnothera gigas*, through a sudden doubling in the number of chromosomes. The most probable hypothesis of the origin of the *6n* condition is that it came from a *3n* hybrid between diploid and tetraploid species, one such hybrid having doubled its chromosomes, perhaps in the fertilised egg, and so restored its fertility. In certain cultivated varieties of mulberry, the *3n* condition is maintained by apogamy, and the same is true of the wild species *Eupatorium glandulosum* and *Erigeron annuus*. Similar polyploid conditions are being found in many cultivated plants, including bananas, pineapples, oats, and dahlias, so that much more evidence concerning the precise manner of origin of these conditions ought to be obtainable.[2] Enough is already known to show that several different kinds of, for example, tetraploidy exist.

The development of sterility between species has undoubtedly played an important part in evolution. How this condition has come about is still a matter of speculation, but we are beginning to get some light on the subject. The old view that forms which produced fertile hybrids must belong to the same species has completely broken down, as has the converse conception that in plants, sterile pollen is a proof of hybridity. One of the most interesting features of tetraploidy is its relation to the development of sterility. As has been pointed out elsewhere,[3] if a tetraploid form such as *Œnothera gigas* arises in Nature, its hybrids

[2] Some of these subjects have been more fully discussed elsewhere Polyploidy, *Brit. Journ. Exptl. Biol.*, I, 153-182, 1924.
[3] NATURE, 1922, vol. 110, pp. 179, 447.

with its diploid parent must contain an unbalanced chromosome content, and this leads to the dropping out of chromosomes in later generations until the diploid number is restored.[4] The triploid form can only perpetuate itself by developing apogamy (as certain triploid species and varieties have done) or by doubling its chromosomes, thus producing a hexaploid form. In all three cases new centres of stability will be reached, which are starting points for fresh variations. The essential conditions for physiological isolation are produced, because the cross-breds will be unbalanced and unable to perpetuate themselves, while the original diploid and tetraploid forms will go on as independent lines of descent.

Blakeslee[5] and his collaborators have recently gone a step further and made the important discovery that the tetraploid mutation from Datura is almost completely sterile with its diploid parent. This is the first time that a form has been shown to appear in cultivation which is sterile with the form that produced it. In other respects it appears to be a complete parallel to the case of *Œnothera gigas*. It is thus proved not only that germinal changes can take place leading to new centres of variation, but also that they may be accompanied by practically complete sterility with the parent form. The origin of species which fail to cross with their parents, or of forms which produce sterile hybrids, is thus seen to be concerned in many cases with morphological changes in the chromosome content, such as tetraploidy.

In this way tetraploidy and the higher forms of polyploidy, as well as other types of chromosome change, have been of great importance in evolution, since they have the effect of physiological isolation even when there is no isolation in space. Genera and species which are tetraploid in comparison with related forms may be expected to have arisen in Nature in this way. Nor is this condition confined to higher plants, since various mosses and ferns, and Isœtes, are known to show similar conditions.

The study of chromosomes thus leads to results of far-reaching importance for evolution. It is of the highest importance for taxonomy in determining the relationships of species and genera. With advancing knowledge and quicker methods of examining chromosomes, the time should come when the description of a species is not considered complete until the morphology of its chromosome group is known, for visible chromosome differences, when they occur, throw important light on relationships. With further knowledge we shall doubtless learn much concerning the phylogenetic nature of the various kinds of chromosome change which have been outlined here. They suffice to indicate that there is a fundamental evolution of the germplasm, of which changes in specific characters are merely the external expression. Already as regards tetraploidy these changes have been experimentally analysed and we know something of the conditions which bring them about.

How the environment, acting on the organism, may have influenced other kinds of chromosome change we do not know at present. But it is well to remember that if a radium atom can undergo spontaneous changes and break-down, then the infinitely more complex physical arrangement involved in a group of chromosomes may be reasonably expected to undergo equally spontaneous changes, especially during the complicated process of meiosis. It may also undergo alterations in which the environment of the cell has only been very slightly concerned. As an additional means of investigating phylogeny, the chromosomes have already furnished evidence of the highest importance, and their further study will no doubt throw important light upon the methods of evolution.

Modern genetics has led us to deal, as Bateson has said, with the world of gametes which form the background for the visible inherited variations of species. The next decade of comparative and experimental work with chromosomes will bring the realisation that in the secular changes of the chromosomes, however controlled or determined, we have a means of understanding how the cell unit, and through it the organism, has varied in structure in the past from species to species. This gives a new line of approach, of fundamental importance, in the analysis of the processes of evolution. It is to be hoped that its significance will be recognised, not only by experimental evolutionists as an additional line of evidence in tracing phylogenies, but also by taxonomists as a necessary element in their discrimination of genera and species.

From a phylogenetic point of view, two important principles have emerged from the work of recent years in experimental evolution and other fields. One of these is the principle of parallel mutations, which introduces a new element of fundamental importance into the reconstruction of phylogenies. The original case of parallel mutations experimentally determined was that of the *lata* mutation from *Œnothera Lamarckiana* and from *Œ. biennis*, both mutants having 15 chromosomes and the same peculiarities of leaf and habit and sterile pollen, but each having the flower-size of the species from which it was derived. Innumerable cases of parallel variations are now known in plants, and many in animals. They appear to have originated as mutations. Vavilov, in particular, has directed attention to their frequency in cereals, Leguminosæ, and other families. When their significance is appreciated by systematists they will have a profound effect on present conceptions of relationships and phylogeny, for they show that many similar variations have occurred over and over again in unrelated groups.

The other principle to which I may make a brief reference has been emphasised particularly by palæontologists in recent years.[6] We may call it *orthophylesis* to avoid the special connotations of previous terms. It consists in the recognition of longer parallel phylogenetic trends in different lines of descent. What relation, if any, these orthophyletic trends bear to parallel mutations remains to be investigated. But it is possible that some of them, at any rate, as pointed out earlier in this paper, may be the result of changes initiated in the chromosomes. In any case the comparative study of chromosomes offers one of the most promising lines of advance in experimental evolution.

[4] See Gates, "The Chromosomes of a Triploid Œnothera Hybrid," *Ann. Bot.*, 37, 565-569, 1923.

[5] Blakeslee, Belling, and Farnham, "Inheritance inTetraploid Daturas," *Bot. Gaz.*, 76, 329-373.

[6] See Watson, D. M. S., Croonian Lecture, Royal Society, 1924 (NATURE, June 7, p. 841).

The Light emitted from Solidified Gases and its Relation to Cosmic Phenomena.

By Prof. L. VEGARD, University of Kristiania.

IN previous communications [1] I have given accounts of investigations on light emitted from solid nitrogen exposed to cathode rays and its bearing on the auroral spectrum. The conclusion was reached that in the auroral region the temperature was so low that nitrogen existed partly in the form of minute crystalline particles. If these particles are of molecular order of magnitude, the state is very much like a gas, from which, however, it differs in one respect. The constituent particles are not molecules with identical mass, but each particle may contain a more or less arbitrary number of atoms arranged in a space lattice characteristic of the solid state. This state, which is something between a gas and a solid, we shall call a pseudo-gaseous state.

Although it is difficult or perhaps impossible to produce this pseudo-gaseous state in laboratory experiments, still I was able to show that a layer of solid nitrogen when bombarded with cathode rays of small velocity gave a spectrum which was essentially the same as the auroral spectrum. In the green, the spectrum from solid nitrogen consisted of two bands, N_1 and N_2, corresponding to the auroral lines 5577 and 5230, and in addition it showed in the blue and violet the band-heads which are typical for the auroral spectrum.

The work has been continued at the Cryogenic Laboratory of Leyden and I have been able to study the new effect under varied conditions, with different kinds of rays, and I have also experimented on layers of various gases. In order to determine more exactly the position and structure of the bands, I have used a spectrograph of considerable dispersion. With the largest dispersion used, the distance between the yellow helium line (5875·6) and the green helium line (5015·7) was 27 mm.

I have obtained about a hundred spectrograms of the light effect from solidified gases and made a number of interesting observations which will be dealt with in greater detail in a later work. In this article I propose to give a short and preliminary account of some of my recent results.

Already in my first publication I mentioned that while the line N_2 was fairly sharp, N_1 was broad and covered the spectral region 5525-5660, and further it showed some structure. The spectrograms at larger dispersion [2] showed that N_1 had three maxima, one strong and two weak.

The position of the maxima varies somewhat with the experimental conditions. From one of my spectrograms with large dispersion I find that N_1 covers a region between 5528 and 5655. For the principal maximum I find $\lambda = 5555$, and for the two weak ones 5611 and 5649. Also with the greater dispersion, N_2 appeared as a single but somewhat diffuse line with a wave-length 5229·4, which agrees very well with the wave-length (5230) given in my first publications.

So long as we are unable to experiment on a pseudo-gaseous state of solid nitrogen, we cannot make an exact comparison between the wave-length of N_1 and that of the prominent green auroral line. Under the conditions of the experiments, N_1 does not define any definite wave-length, and we can merely state that N_1 is extending on both sides of the auroral line. The sharpness of the latter must be due to the smallness of the particles, and the prominent green auroral line is to be regarded as the limiting aspect of the band N_1, when emitted from solid nitrogen particles of molecular order of magnitude, which exist in free space.

I have been able to make some experiments which actually show that the bands get sharper when the particles are reduced in size. When an inert gas which contains traces of nitrogen is condensed on the cold surface, the layer will contain small nitrogen particles surrounded by an inert substance. In this state, we should expect nitrogen to behave in a similar way as if the particles existed in free space. Experiments were carried out in mixtures of argon and nitrogen. In one series I used canal rays, in another swift cathode rays; but in all cases I found that the N_1 band became narrower when the concentration of nitrogen became smaller.

At the same time I observed the remarkable fact that *the position of the principal maximum changes with the nitrogen concentration*. For small concentrations the principal maximum approaches a wave-length 5604. Thus with varying composition of the mixture the principal maximum oscillates between the values 5555 and 5604. The "secondary" maxima seem to disappear when the concentration of nitrogen is very small.

The motion of the principal maximum approximately follows the relation

$$\lambda_0 - \lambda_p = \frac{p}{100}(\lambda_0 - \lambda_{100}),$$

where λ_p is the wave-length corresponding to the percentage p of nitrogen and λ_0 and λ_{100} are the limiting positions.

The motion of the band may be due partly to the change of the average size of the nitrogen particles and partly to a mutual influence between argon and nitrogen. Perhaps an X-ray analysis of the crystalline mixture would give some information regarding this point. At any rate, the experiments indicate that a reduction of the size of the particles makes the band sharper, and that the position of the line corresponding to a pseudo-gaseous state need not coincide with any of the maxima observed in ordinary nitrogen under the conditions of my experiments.

The contraction of the bands does not seem to be essentially effected by change of temperature. By working under reduced pressure with liquid hydrogen, the temperature of the layer was lowered from 20° to 14° K.; but there was no contraction of N_1 to be observed, although a change of a few per cent. would have been detected.

The experiments in argon mixtures also give an interesting illustration of the extremely high emission power of solid nitrogen. Even very "pure" argon contained sufficient nitrogen to give a marked emission of N_1 and N_2, and the nitrogen afterglow. The addition

[1] Proc. Roy. Akad. Amsterdam, vol. xxvii. Nos. 1 and 2; NATURE, vol. 113, No. 2846, p. 716; C.R. Acad. Sc. t. 178, p. 1153.

[2] Spectra with larger dispersion were obtained about the middle of March.

of about 0·1 per cent. of nitrogen to the "pure" argon considerably increased the nitrogen effect.

As shown in my earlier communications, slowly moving cathode rays gave in the blue and violet just the same negative and positive band-heads as those typical for the auroral spectrum. The effect has since been photographed with a quartz spectrograph through a quartz window, and the spectrum in the ultraviolet showed the same positive band-heads as those observed in the auroræ.

When the layer is bombarded with a powerful beam of cathode rays from a Wehnelt cathode, a deep red luminosity appears near the layer, and the colour has the same appearance as a red colour very characteristic of the auroræ. A spectrum obtained on a panchromatic plate showed the same two red bands which I have obtained on auroral spectrograms. Thus from the system I am experimenting upon I get the characteristic bands and lines of the auroral spectrum from red to ultraviolet.

Now it is of great importance to see whether also positive rays might give the typical auroral spectrum. For this purpose a considerable number of experiments have been made with canal rays acting on nitrogen, hydrogen, and helium.

Exposed to canal rays, solid nitrogen emitted both N_1 and N_2; but in the blue, violet, and ultraviolet, the canal-ray spectrum was quite different from the typical auroral spectrum. In this spectral region the canal-ray spectrum was dominated by a series of diffuse bands, which extended far into the ultraviolet. Moreover, as has been shown before, the canal-ray spectrum has a number of strong lines not present in the auroral spectrum.

Thus neither in the solid nor in the gaseous state of nitrogen do the canal rays produce the nitrogen spectrum observed in the auroræ, and hence we conclude that by far the greater part of the auroræ must be caused by cathode rays.

Cathode rays which were produced by an induction coil and had a fairly large velocity corresponding to a spark-gap of 5-6 mm. between spheres 1 cm. diameter, gave a very brilliant effect, showing N_1 and N_2 very strongly. Under these conditions I also obtained the same series of diffuse bands as were obtained with canal rays, but their intensities were now relatively smaller.[3]

Nitrogen-argon mixtures were investigated both with canal rays and swift cathode rays, and some results with regard to the variations of N_1 have already been described. Not only N_1, but also the diffuse canal-ray bands in blue and violet, were seen to contract as the concentration of nitrogen became smaller, and at the same time each maximum moved towards shorter wave-lengths. When the layer of argon only contained small quantities of nitrogen, the bands were concentrated into fairly well-defined diffuse lines. In the blue and violet there were two bands, each of which was concentrated into one pair of lines, one pair at $\lambda=4523, 4473$, and the second at $\lambda=4236, 4211$.

These bands are no doubt one state of development of the two bands observed by Lord Rayleigh in the light from the night sky. This means that this light should be produced by fairly slow positive rays.

[3] It remains still to be shown that the bands in blue-ultraviolet are not produced by canal rays, either retrograde rays or rays produced by imperfect rectification of the current.

When the layer of solid nitrogen has been bombarded for some time with canal rays or swift cathode rays, the afterglow becomes very persistent. Two or three minutes after the rays are cut off the light intensity from the layer may remain practically constant for hours or perhaps for days. Usually the afterglow only shows the band N_2; but when the persistent afterglow is very strong, I have also observed N_1 and the bands in the blue.

When the liquid hydrogen disappears and the temperature of the layer gradually increases, the stored energy is suddenly released under intense light emission, showing N_2 very strongly, but also N_1 and the diffuse bands in the blue appear very strong. Thus N_1 and N_2 and the series of diffuse bands in the blue-ultraviolet are emitted in the afterglow and consequently from the very interior of the solid substance.

When the temperature of the layer increases to a certain point the appearance of the solid nitrogen suddenly changes. At the temperature of liquid hydrogen the layer resembles a piece of ice and sticks to the cold surface; but at a certain point the layer assumes a powdery form, and if it is somewhat thick it falls down from the cold copper surface. The existence of two modifications of solid nitrogen was discovered some years ago by means of cooling curves,[4] and the transformation is found to take place at a temperature of 35·5° K.

Now the energy stored in the afterglow radiates out at the very moment that the layer passes over into the other modification. The phosphorescent energy cannot exist in the modification which is stable above 35·5° K. This phenomenon is explained from the fact that the light given out by the afterglow is characteristic of the modification of solid nitrogen which is stable below 35·5° K., for if nitrogen in the other modification is exposed to cathode or canal rays, N_1, N_2, and the diffuse bands in the blue-violet are not emitted. The luminosity, which is very faint, shows a different spectrum and no afterglow.

This fact has a very important bearing on cosmic phenomena. In that part of the atmosphere where N_1 and N_2 are emitted the temperature must be below 35·5° K., and the isothermal surface 35·5° K. marks the transition between an upper layer very easily excited to light emission and a lower layer which has lost this high emission power.

In this way I think we get the explanation of the fact found by Lindemann that the meteor frequency as a function of altitude shows two maxima with a very marked minimum in between, for below the isothermal surface (35·5°) the meteors may often seem to disappear because they produce very little light until farther down they become luminous on account of heating. Now the height of this isothermal surface ought to be greater in the day than in the night, greater at the equator than at the poles, and greater in the summer than in the winter. Indeed, Lindemann has found that the height of the upper frequency maximum, caused by nitrogen below 35·5° K., increases from 75 km. in the winter to 85 km. in the summer.

The relative intensity of the lines N_1 and N_2 is of importance not only from a physical point of view, but also in connexion with the auroral problem. The

[4] W. H. Keesom and H. Kamerlingh Onnes, Proc. Roy. Akad. Amsterdam, 24, p. 1315.

intensity ratio N_1/N_2 increases generally with velocity and the density of the bombarding electric rays, and in nitrogen-argon mixtures it increases very much when the nitrogen concentration diminishes. With very small concentrations N_1 predominates as compared with N_2. This effect indicates that N_1/N_2 increases as the nitrogen particles get smaller, and it may thus account for the predominance of the auroral line 5577 in the auroral spectrum.

The great variability of N_1/N_2 makes it difficult to determine exactly the minimum cathode ray velocity necessary for producing the two bands. Perhaps they require the same velocity, only that the intensity of N_1 usually is very small at small velocities. At the present time, I have been able to follow N_2 down to velocities corresponding to 78 volts, and N_1 down to 165 volts.

A non-luminous layer of solid nitrogen was not made luminous by ultraviolet light from a condensed aluminium spark. X-rays, however, produced the ordinary afterglow.

When the layer is in the state showing the persistent afterglow, conditions are different. In this case light from an ordinary incandescent lamp with a tungsten filament produced a very marked increase in the intensity of the afterglow. In some cases the intensity underwent very marked periodic variations with periods of 5-6 seconds, and I could count 8-9 periods.

Layers of solid oxygen, ammonia, and argon have been bombarded with both cathode rays and canal rays, and a layer of nitrous oxide with canal rays only. With the exception of argon, the light effect was feeble and gave no afterglow. The fairly strong effect observed from an argon layer was to a great extent due to traces of nitrogen, which produced a weak afterglow and a strong emission of N_1 and the canal-ray bands of nitrogen. The afterglow showed only the line N_2 and no other visible light in the spectrum. Thus argon itself gives no afterglow, and the real argon effect, although somewhat stronger, perhaps, than in the case of oxygen ammonia and nitrous oxide, is an effect of the same type as shown by these gases.

The experiments on layers of various substances thus show that the light effect from nitrogen at temperatures below 35·5°, which is applicable to the auroral spectrum, is a light effect of a unique and singular type.

The Beam System of Radio Telegraphy.

THE paper read by Senator Marconi to the Royal Society of Arts on July 2, and published in the Journal of the Society for July 25, describing the results he has obtained over very long distances by short wave directional radio telegraphy, is one of great importance and marks an epoch in the development of long distance radio communication. Mr. Marconi reminds us that more than twenty-eight years ago he showed Sir William Preece the transmission and reception of signals over a distance of nearly two miles by a "beam" system, using short waves and reflectors. Curiously enough, at that time he could only transmit signals by means of an antenna over a distance of half a mile. The rapid and spectacular progress made, however, by the long wave system in those early days diverted attention from short wave research, although the latter could be emitted in beams in definite directions.

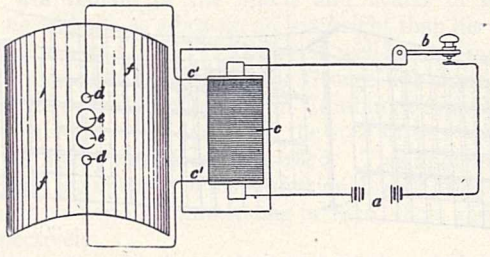

FIG. 1.—Spark transmitter and sheet metal reflector, 1896.

In 1899, Mr. Marconi read a paper to the Institution of Electrical Engineers in which he pointed out that a short wave system would be of value in connexion with lighthouses and lightships in foggy weather, enabling them to locate dangerous points. He also projected a beam of waves across the lecture room, a bell ringing only when the reflector faced the receiver (Figs. 1 and 2).

In 1916, in conjunction with Mr. C. S. Franklin, he again began to make researches with directive beams. The reflectors used at first were not solid sheets of metal, but consisted of wires forming a cylindrical parabolic reflector, the antenna forming the focal line of the cylinder (Fig. 3). The reflectors now used consist of a grid of antennæ and a grid of reflecting wires arranged parallel to one another (Fig. 4). Special arrangements have to be made so as to ensure that the phase of the oscillations in all the wires is the same. The great value of reflectors was demonstrated by experiment, the energy received being increased about two hundredfold by their use.

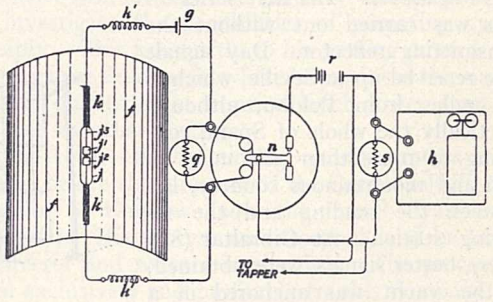

FIG. 2.—Coherer receiver and sheet metal reflector, 1896.

Many tests were carried out between the steam yacht *Elettra* and a small station erected at Poldhu which emitted waves about 100 metres in length, the frequency therefore being about 3,000,000. One definite result obtained was that the strength of the signals received during the hours of daylight varied inversely with the mean altitude of the sun over the space intervening between the two stations. It is wrong, therefore, to refer to distances covered during daylight as "day ranges." It shows also that the tests which were carried out partly within the tropics during the months of May and June were made under very unfavourable conditions.

The results prove quite definitely that the absorption factor given in the well-known Austin formula does not apply to short wave phenomena. It can be replaced by a factor which is approximately a linear function of the mean altitude of the sun calculated on the great circle of the earth which passes through the two stations. In regard to atmospheric disturbances and others, the origin of which is unknown, these appeared to be less troublesome during daylight than when working with a long wave system. During night time, even up to distances of more than 2000

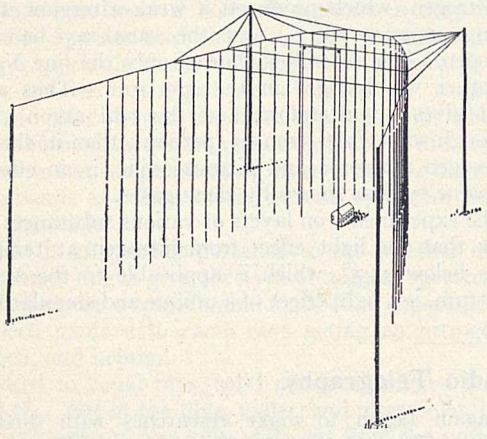

FIG. 3.—Parabolic vertical wire reflector, 1923.

miles, the signals received were so strong that extraneous disturbances caused no appreciable interference.

During the tests, the Poldhu transmitter consisted of eight glass valves in parallel, the input being only 12 kw. The radiated energy concentrated by the parabolic reflector in the direction of Cape Verde was about 9 kw. If no reflector had been used, about 120 kw. would have been necessary to get a beam in that direction of the same intensity. The receiving aerial was a vertical wire at a height of twenty metres above sea-level. The first series of tests was carried out without the transmitting reflector. Day signals were received up to Seville, which is 780 miles from Poldhu, although practically the whole of Spain, consisting of more than 300 miles of high and mountainous country, lay between the sending and the receiving station. At Gibraltar (820 miles), better signals were obtained, as the yacht was anchored in a more open space.

For greater distances the reflector wires were used at Poldhu. At Madeira (1250 miles) good signals were obtained, using 12 kw. at the sending station. At St. Vincent (2230 miles), Cape Verde Islands, it was still possible to get a few hours' daylight reception after sunrise and before sunset. The night signals continued to arrive with apparently unabated strength although the distance had been increased to about double what it was at Madeira.

The strength of the night signals at St. Vincent was estimated to be about 500 microvolts per metre of aerial wire, and no trouble was experienced from any kind of interference. It was calculated that night signals would continue to be received at St. Vincent even if the power at Poldhu were reduced to the tenth of a kilowatt.

After this voyage, the station at Poldhu was improved, the power being increased to 20 kw. Since February of this year further tests have been made. A special short wave receiver was installed on the s.s. *Cedric*, and reception tests were carried out with Poldhu during a journey of the vessel to New York and back. No reflectors were used at either end. The results obtained confirm the earlier experiments. Daylight signals could be received up to a distance of 1400 nautical miles.

During this test one surprising result was obtained. Mr. E. T. Fisk, of Sydney, Australia, reported by cable that he could receive the Poldhu transmissions perfectly well every day at his house from 5 to 9 P.M. (G.M.T.). He also received them between 6.30 and 8.30 A.M. He used an improvised receiver consisting of a 2-stage high frequency tuned plate and grid with one rectification. Every word that was sent had been read, and Mr. Fisk stated that the signals were better than any he had received from the high power station at Carnarvon. Further experiments on communicating with Sydney were made, and consistently good results were obtained.

The experimenters conclude that during the morning period the waves start from England to Australia in a westerly direction. The waves cross the Atlantic and Pacific Oceans, a distance of approximately 12,220 nautical miles. In the evening they travel in an easterly direction over Europe and Asia. This is the shortest route, being only 9380 miles.

In Canada, at Montreal, reception was possible for sixteen hours out of the twenty-four. A successful wireless telephonic test was made with Sydney on May 30, the speech being intelligible and easily heard. It is noteworthy that this great distance was obtained without the use of a reflector at either end. The use

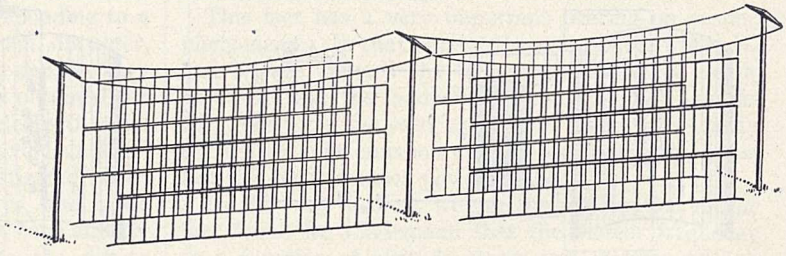

FIG. 4.—Vertical wire flat transmitting aerial and reflector, 1924.

of reflectors would doubtless be a great advantage in practice as it would both strengthen the received waves and cut out all the extraneous disturbances except any which are proceeding in the line of the beam.

The aerials used were never worked to anything approaching the limit of their carrying capacity. It would be quite possible in practice to superimpose several waves and thus send several services simultaneously from the same aerial. The speed of working obtainable by using short waves is very much higher than that obtainable by the long waves now in general use.

Mr. Marconi calculates that the speed of signalling with a 100-metre wave, having a frequency of three million, will probably be a hundred times as great as that obtained with a frequency of 30,000, which is of the order of those that it is proposed to use for the Imperial Stations.

Further tests in June last were made between Poldhu and a small receiving station at Buenos Aires in the Argentine (5820 miles). A parabolic reflector was employed to concentrate the energy stream towards the Argentine. Although the power radiated was only 17 kw., strong signals were received for more than ten hours a day at Buenos Aires.

Mr. Marconi is strongly of opinion that by means of these small and inexpensive stations a far greater number of words could be transmitted between England, India, and distant British Dominions than would be possible by means of the previously planned powerful and expensive stations. The communications also would be much more secret than that obtainable by any of the present systems. In conclusion, he expresses his high appreciation of the excellent work done by Mr. C. S. Franklin in this connexion.

Obituary.

SIR GEORGE BEILBY, F.R.S.

SIR GEORGE BEILBY died on July 31, in his seventy-fourth year, and when he had just laid aside the harness by which he had so long applied his talents with great effect in varied fields. His death caused widespread regret and directed attention to a notable record of public service in the linked relations of science, industries and citizenship. Fortunately for industry his early work brought him into close touch with the details of production as well as with scientific problems which confronted the chemical manufacturer. His skill and thoroughness in investigation, and his clear appreciation of the conditions of large scale work, enabled him to make successive additions of much value to the methods of industry. His relations with commercial production became such that he was in a position to follow up his researches in science by investigation of those of their applications which seemed to be promising. The success which from time to time attended his steady and enthusiastic labour enabled him to give to public purposes much of his energy, as well as to afford substantial support towards the advancement of science and the training of promising recruits for the ranks of scientific workers. Withal, the man and his life will remain in the minds and hearts of many, young and old, as a beacon no less bright than his work.

The son of Dr. G. T. Beilby, a well-known medical practitioner in Edinburgh, Sir George was born there in 1850. He was educated in Edinburgh schools and the University, and he joined the staff of the Oakbank Oil Company as a chemist in 1870. This appointment marked the opening of his professional work, which falls into three periods commencing in 1870, 1890, and 1914 respectively.

1870–1890.—A few years after joining the staff at Oakbank, Beilby became manager, and he held this position until about 1890; thus from 1870 to 1890 his work centred on the Scottish oil industry. He introduced improvements in several sections of the work, the most important being the use of large volumes of superheated steam which was passed into and through the spent shale in the retort, converting the carbon of the shale into water-gas and the nitrogen largely into ammonia. This procedure had several notable advantages, of which the main one was that it more than doubled the yield of ammonia—a result which saved the Scottish oil industry from extinction during the years of severe competition by petroleum.

The minor advantages of the process were: (1) the water gas, formed and heated in the lower part of the retort, conveyed heat internally to the shale in the upper portion, thus assisting to distil the shale at moderate heat; and (2) the removal of carbon from the spent-shale was practically complete, so that fires in the spent-shale "bings" which made these a nuisance in their neighbourhood were avoided. Beilby erected his original retort, operated on these lines, at Oakbank, but later he associated himself with the late Mr. James Young, who was experimenting on similar lines, and together they brought out the "Young and Beilby" retort (patented 1881), which is the prototype of the existing forms.

It is of interest to note that the use of steam in gas production with the purpose of recovering the nitrogen of the coal as ammonia was first proposed by Beilby, who practised it on an industrial scale at Oakbank Oilworks.

Towards the close of the first period of his work Beilby's attention had been attracted by the advent of the McArthur Forrest patents (1887) for the extraction of gold from its ore by means of cyanides. The probable demand for cyanides appeared to him to open an extensive field for chemical industry, and he proceeded to investigate the possibilities of preparing cyanide cheaply. This led shortly to his putting down a small factory near Edinburgh, where he produced the material in fair quantities at a price much lower than that reached by other makers.

1890–1914.—Beilby laid his cyanide process and its results before the directors of the Cassel Gold Extracting Co. of Glasgow (now the Cassel Cyanide Co., Glasgow). His process was accepted, and he became a director and partner in the firm. The process was used exclusively and profitably by this Company until 1900, when Castner introduced a new process for cyanide manufacture, on the development of which Beilby and Castner worked together. The improved process which they worked out was adopted by the Cassel Cyanide Company. At this time Beilby joined the board of directors of the Castner Kellner Alkali Co., Glasgow, and until the outbreak of war he took a leading part in the development of the two companies mentioned.

While this period consolidated Beilby's position as one of the pioneers and leaders of recent progress in chemical industries, it also brought to the front a parallel line of his activities in research—*the using of fuel*—and in this connexion it led to a steady increase

in the proportion of his time devoted to public work. Concurrently with his early work in the development of the recovery of ammonia from shale at relatively low temperatures, he had conducted experiments in steaming bituminous coal. From this onwards he never lost touch with the national problems of prevention of smoke and the economical use of coal. His work on fuel came prominently before the public when he took part in the inquiry of the Royal Commission on Coal Supplies in 1903. He then submitted an analysis of the purposes to which the British output of coal is applied and an estimate of the scope for economy attainable in each category of use by improved methods. His subsequent investigations were at first (1906–1912) directed to the production of a smokeless fuel for domestic purposes. The record of that work, communicated at the 1913 meeting of the British Association, showed that in treating comparatively non-caking coals satisfactory economic results could be obtained. The experiment was, however, discontinued, for the inquiries of the Royal Commission on Fuel and Engines for the Navy, 1912–13, gave a new and wider significance to low-temperature carbonisation. Lord Fisher was chairman of the Commission, and Beilby, as one of its members, could bring to the table not only full knowledge of ascertained fact, effective processes and attained results, but also a ready appreciation of the broad considerations specially relevant to the issues before the Commission. The Commission reported that the only means of rendering Great Britain to some extent self-supporting in the matter of fuel-oils lay in the development of a new carbonising industry founded on the distillation of coal at a temperature much below that used in gas-retorts or coke ovens.

1914–1923.—It was to the problem thus set to British science and British industry that Beilby gave of his best in the last ten years of his life. During the earlier War years his work and his thoughts were much diverted to other issues; but the fuel question was never far off.

When Lord Balfour, then First Lord of the Admiralty, formed the Board of Invention and Research with Lord Fisher as chairman, Beilby was naturally appointed to the Board. It is understood that in much of the great work with which that Board had to deal he proved most fertile in suggestion and wise in consultation and advice. On this section of his public service it may be recalled that in the King's birthday honours list for 1916 he was included among the new knights, being described as "a well-known chemist and inventor, who has specially studied fuel economy, and has rendered service to the Admiralty as a member of the Central Committee of the Board of Invention and Research, and in other ways."

In 1915, when it had been decided to reply in kind to the gas attacks first made by the enemy on the Ypres sector on April 22, 1915, Beilby was sent for by Lord Kitchener, at whose request he arranged that the Castner Kellner Company should provide a supply of liquid chlorine in cylinders. He became a member of the War Office Committee then formed to devise and test materials for offensive chemical warfare. On the formation of the Ministry of Munitions this matter was transferred to the new Ministry. Throughout these years Beilby gave his whole time to work for the Government, mainly in the Trench Warfare Department and its successor, in 1917, the Chemical Warfare Department. Needless to say, the work of the various advisory and supervisory War Research Committees was most strenuous and exacting. Beilby was indefatigable and resourceful always. He was much more. His calm, careful and sympathetic consideration of every intelligent suggestion or criticism were of great value in securing for the service the best use of the talents of the willing and able workers in the field. His individual contributions to scientific investigation of problems arising on appliances for attack or defence were always clear and definite; his guidance on points affecting design with the view of mass production or on suggestions for expediting manufacture was thoroughly practical. The anxieties of the time were many and often sudden. On such occasions Beilby was a great asset. His quiet manner, his refusal to be fussed, the personal sacrifices he made as a matter of course, and his consideration for all who worked with or under him, were of the highest value in the improvised organisations of the time.

But already in 1915 the Government had taken a first step to prepare for attacking the problems which would have to be faced on the advent of peace. A Committee of Council for Scientific and Industrial Research had been constituted, and in 1916 the Department of Scientific and Industrial Research was established, with a strong advisory council of men of science as the central feature in its organisation. Of this council Sir George Beilby was one of the original members. In its first year the council, recognising that fuel was at the root of British industry, advised that the Department should tackle the fuel problem. A year later, despite his other national work, Beilby was prevailed upon to accept the invitation to direct fuel research for the Department, put to him first by Lord Crewe, when Lord President of Council, and again by Lord Curzon when he succeeded to that office. The Fuel Research Board was set up in 1917 with Beilby as its chairman and as Director of Fuel Research.

The burden which Beilby thus took up was a heavy one, and at the initiation of the work he was closely engaged in the war activities indicated above. Moreover, the past strain had pressed him not a little and he had had to undergo an operation for appendicitis. While still feeling the effects of that, he had returned to his war work with his customary energy; indeed his spirit appeared to have carried him through without lasting effects.

The design, construction and equipment of the fine Fuel Research Station at East Greenwich were carried through under Beilby's personal supervision, so that the station, its possibilities, its organisation and its staff represent his conception of what is required as the centre of national investigation and research as to fuel production and the using of fuel. The development of the relation of the Fuel Research Board and of its central station to investigations carried out in coalfields and other laboratories had necessarily to wait for more normal conditions, but this, too, had been arranged and initiated before he regarded the organisation as being on a basis so secure that he was justified in demitting the office of Director of Fuel Research.

By the end of 1917, the first year of the work of the Station, the problem set by the Fisher Commission of 1913 had been solved in its scientific and technical aspects sufficiently to permit home production of fuel-oil under war-conditions if need had continued to press. Commercially it still stands a problem. The normal work of the Fuel Research Board has been noted from time to time in these columns. It therefore suffices here to say that the whole organisation is to all intents and purposes Sir George Beilby's creation. That early result of reference to the Board—the establishment of the method of charging for town gas by the "therm"—is now recognised as one of those little things which exercise prevailing influence to the advantage of producers and consumers alike.

Sir George Beilby was never without a side interest or hobby with a scientific bearing. He took a keen interest in colour photography and in microscopy. In the former he made himself expert in the use of the Lumière process in photographing mountain scenery in Switzerland and the Tyrol, and he applied it also in photomicrography. Indeed, some of his photomicrographs, prepared in 1913, were reproduced in a colour-plate published in NATURE of February 19, 1914. Microscopy, from being a hobby, became, and continued, for him a serious study. It was the only method of investigation which he could follow with satisfaction intermittently in casual short intervals in the busy daily life of a busy man. Faced, as a cyanide manufacturer, with the difficulty of finding any metal tube which would withstand the action of ammonia at 700° C. for any length of time, he turned to the microscope for suggestions as to the conditions of the problem.

From this Beilby was led to investigate the effects of various forms of mechanical work on the crystalline structure of metals, for example, the disturbances which occur in the processes of polishing and burnishing. As usual he spared no pains in making himself a master of the technique of the methods which he employed to study his subject from every angle. He made an experimental study of a number of solids in various states of aggregation. His researches in this field, which were ingeniously planned and most accurately carried out, were of an entirely novel kind. He gave an account of this work in the May lecture which he delivered to the Institute of Metals in 1911. In his book, "The Aggregation and Flow of Solids," 1921, he published collected statements of his work on this subject, including his more recent investigations. The facts he recorded are those which he established by most careful work and observation repeated time and again. These and the theory of the hard and soft states of metals which he put forward in 1911 had a profound influence for several years on the development of metallography, and gave rise to a variety of researches designed to test the range of application of his theory. In view of recent researches on the constitution of matter it is difficult to judge the precise form of the theory which will ultimately be accepted, but there can be no two opinions as to the magnitude of the service he rendered to the elucidation of the changes produced in metal crystals by mechanical work of all kinds.

As a citizen—indeed in all relations—Beilby systematically shunned publicity. Even in matters of public interest for which he did active work, his help was so unobtrusive that it was little known unless circumstances made his emergence unavoidable. Education, training for and in research, smoke prevention, each succeeded in identifying him, but these were by no means the limits of his active help in affairs. In 1877 Sir George married Emma, daughter of the Rev. S. Newnham, and Lady Beilby has been a devoted coadjutor in many of his public interests. With her he was early among those who worked for the admission of women to professions, and this cause appealed to him in the first instance in the critical case of medicine. Their interest in students, particularly students of science, began many years ago, and only few have even a general idea of the extent to which he coupled financial help with advice as to courses of training or subsequent experience. Sir George was one of the trustees of the Carnegie Trust for the Universities of Scotland, and he took a keen interest in the details of the work of that Trust. He was a fellow of the Royal Society, and one of the first members of the executive of the National Physical Laboratory formed by the Society in 1900 with Lord Rayleigh as chairman.

It was, however, the Glasgow and West of Scotland Technical College—now the Royal Technical College—which indented most fully on his ready help in council. He was co-opted as a governor of the college in 1900, and on the Board of Governors his wide knowledge of men of science and of industry soon commanded the confidence of his fellow-governors, and his foresight did much to secure that the building then being planned was conceived on an adequate scale. In 1903 he became convener of the sectional committee on the departments of chemistry, technical chemistry and metallurgy. The scheme of teaching and the nature of the laboratory courses and appliances adopted were novel at the time, but have since proved applicable in other places. In 1907, on the death of Sir William Copland just when he had completed the task of raising funds for the erection of the new buildings for the college, Sir George Beilby was elected chairman of the governing body.

The new buildings and equipment secure, the governors and staff strove strenuously, and with success, to raise the standard reached in the college teaching and to develop the training of promising students in methods of research bearing on industries. In 1913 the college was affiliated with the University of Glasgow and was included among the institutions recognised for grants by the University Grants Committee. The raising of the college ideals and the effective efforts towards improvement of practice were largely due to the all-prevailing influence and wise initiative of the chairman. His fine personality was a great asset in every development of the college and its work.

One example of this may now be mentioned. Sir George had been providing funds year after year to enable good men to remain at college for training in research methods for a year or more after completing their ordinary courses. When the results of this encouragement had become amply apparent he set about placing this help and cognate facilities on a

permanent footing. A "New Development Fund" was established and started by an anonymous contribution of 10,000*l.* Sir George was the donor. He was one of those who knew how to use money to good purpose. The fund was well opened, and although the war years checked its growth it now amounts to 65,000*l.*

Sir George Beilby's fine personality was a great asset in every development of the Royal Technical College and of its work. His touch with students was, however, of long standing and it was real, informal and elevating. His house in Glasgow was for years a place of resort for young men. Music had a home there—Sir George himself was an artist in music; he was also a first-class craftsman; he built his own organ, buying only the pipes, and much of the refinement of its mechanism was of his own invention. Conversation there on current topics never flagged in interest although it often strayed. Personal talk or counsel on individual aims or on difficulties over study always refreshed the visitor.

In our world of to-day—its science, its industries and its humanities—Sir George Beilby has been a notable exemplar of the "veray parfit gentil knight."

WE regret to announce the following deaths:

Sir William Bayliss, F.R.S., professor of general physiology in University College, London, on August 27, aged sixty-four.

Dr. John J. Stevenson, professor emeritus of geology at New York University and president in 1899 of the Geological Society of America, on August 10, aged eighty-two.

Current Topics and Events.

THE recent conference at Oxford on "The Scientific Approach to Religion" was a notable event and aroused a good deal of interest in the Press and the public. The change of tone is amazing since the famous Diocesan Conference at Oxford in 1864, when Disraeli strolled in and declared himself on the side of the angels and not of Darwin. Of course the battle had been won long before this, but it was well that Oxford should be the scene of so striking a reconciliation after the half-century. The notes struck were, the abandonment of final and exclusive dogmas either on the side of science or of religion, and the possibility of a man of science being a theist and Christian, and of the "religious" person accepting all or any of the established conclusions of science. We imagine that nowadays few people will be found to dispute any of these propositions. We all agree in general terms; the difficulties arise when we come to define them. This could be illustrated from almost any of the papers read. For example, Dr. Rollin stated that the point of the theists had been demonstrated that the world in its essence was a form of energy, and energy, so far as all our knowledge went, did not come from nowhere. But would such a doctrine satisfy any theist who thought out carefully what he meant, or would it have convinced Ostwald that he was a theist? The fact is that such an eirenicon as was proclaimed last week in Oxford is rather testimony of general goodwill, of a change of temper, and of a readiness to examine, than of definite agreement as to really disputable points. For what it was, we heartily welcome it and would not add a word to hinder so healthy a process. We need above all to strengthen the bases of our intellectual and social amity, but let us make sure of the strength of the stones we lay. It would be a disaster if they crumbled into sand when we began to raise the superstructure.

AT a recent meeting of the Wiltshire Archæological Society a discussion took place with reference to permission having been granted to a modern sect styling themselves "Druids" or "Church of the Universal Bond," who contemplate burying the ashes of their dead within the precincts of Stonehenge. The discussion was followed by a strong protest against this unseemly intrusion. It is only a few years since this well-known monument was handed over to the nation by a generous donor, and as it came thereby under the protection of H.M. Office of Works, it was hoped that this would effectually stop desecration and any future trouble. A question in the House of Commons regarding a rumour of the proposed burial of ashes, put by the member for the Salisbury Division to the First Commissioner of Works, elicited the reply that permission had actually been given. Apparently the Commissioner had been approached by the sect privately and gave the desired permission on his own initiative without consulting the Advisory Board or taking thought what the result might be. This deplorable attempt at vandalism is strongly resented in the County and by the public generally, who hold in reverence the mighty monument set up by our progenitors. The members of the "Church of the Universal Bond" have camped for a fortnight annually upon the downland about half a mile from Stonehenge, and the Office of Works, despite suffering irritation from them, generously gave permission for services to be held within Stonehenge. Instead of being grateful for this boon an insulting letter was sent in reply, asserting that the place belonged to the sect, and no advantage was taken of the concession. Apparently an attempt is now being made to secure a hold upon the place, and this move should be resisted vigorously and to the utmost by every one who has a regard for Stonehenge. It is ridiculous to think of a small and obscure set of people having the impertinence to arrogate a claim to this National Monument. With just as much reason another sect might arise calling themselves "Romans" and laying claim to Roman villas.

SPAIN is a country rich in archæological remains, and many are the investigators who have made notable discoveries there. English readers have been hearing from time to time about the work of Mrs. Wishaw and the founding of the Anglo-Spanish School of Archæology at Niebla, Huelva, in Andalusia. A long article on her discoveries appeared in the *Times* of August 23, and we have received the following note upon it from a contributor, M. C. B.:—Mrs. Wishaw's

investigations cover a rich and interesting field of Roman remains, including waterworks, etc., which is not dealt with in the article. Next, many finds have been made dating back to pre-Roman (Iberian) times. These discoveries include objects of pottery, etc., many of them exceedingly important. It is perhaps a pity that Mrs. Wishaw has not concentrated on these two fields where such valuable finds can be made, and where she has already done work of undoubted service to the archæologist. Her chief interest and object, however, seems to be to demonstrate that Upper Palæolithic man flourished at Niebla, even arriving at the stage of building walls and making pottery, and the recent article is largely devoted to this subject. Although the writer has not yet had occasion to visit the Niebla site itself, he has had the opportunity of seeing some examples of the stone industries, and he can only unhesitatingly suggest that, unless there is something further to show, nothing is as yet advanced which in the least proves the occurrence of Palæolithic man there. The specimens seen were, in his opinion, at earliest no older than the Neolithic Age. It is to be hoped that Mrs. Wishaw will continue her work, more especially on the later cultures. Spain possesses the advantage of having in the person of Dr. Obermaier, of the University of Madrid, one of the most brilliant of European prehistorians, and he would undoubtedly be willing to help at any time in dating the finds.

ON August 25 a report, unsupported by details, appeared in various newspapers to the effect that 9·4 inches of rain had fallen in six hours at Cannington, Somerset, during a "cloudburst." It has since been ascertained that 9·04 inches were measured at Brymore, one mile west of Cannington, at 9 A.M. on August 19. The observer estimated that, of this amount, 8·5 inches of rain and hail fell between 3 A.M. and 7·30 A.M. on this date. At the Bridgwater Water Works, Ashford, about one mile from the Cannington gauge, 4·50 inches were measured. Further particulars with regard to this downpour will be awaited with interest, and some suspension of judgment is necessary until the measurement has been finally confirmed. A fall of eight and a half inches at an average rate approaching two inches an hour is quite unprecedented in the British Isles, though this rate has of course been frequently exceeded in short periods. The total amount of 9·04 inches has only been exceeded on one previous occasion, namely at Bruton, Somerset, on June 28, 1917, when 9·56 inches fell. During the climax of that disturbance the rate of fall reached one inch per hour for two hours. A similar rate was observed in the great East Anglian rain of August 25-26, 1912. On the day of the recent "cloudburst," a depression was stationary over the northern part of the North Sea and shallow secondary disturbances were passing over the British Isles. The conditions were favourable for heavy local showers of a thundery character. No large amounts of rain were, however, measured at health resorts or Meteorological Office telegraphic reporting stations in south-west England. At Weston-super-Mare, the nearest station the observations of which are telegraphed to the Meteorological Office, the total fall for the twenty-four hours ending at 9 A.M. on August 19 was only 7 mm. (0·28 inch).

THE Royal Society of Western Australia, as part of the commemoration of the Kelvin centenary, has instituted the award of a gold medal for research. The medal will ordinarily be awarded every four years, and the first recipient is Dr. William J. Hancock. This is awarded in recognition of the part which Dr. Hancock has played in the development of radiography and radiotherapy in Australia since the discovery of X-rays. Until recently Dr. Hancock was the Government Electrical Engineer and is an honorary member of the Institution of Engineers of Australia. Those who took up the practice of X-rays soon after their discovery had many difficulties to overcome, and for a long time their pioneer work entailed real scientific investigation, the results of which rarely found their way into print. Nevertheless, it was largely due to these men who began to apply X-rays for medical purposes that the technique has evolved on the present lines. Unfortunately, few of these pioneers escaped injury from the rays they were using, and we regret to learn that Dr. Hancock is not an exception in this respect.

IN the Faraday lecture of the Chemical Society, which has appeared in the July issue of the Society's journal, Prof. R. A. Millikan devoted attention to certain aspects of atomic structure which are receiving particular attention at the present time, especially from the spectroscopists. As a preliminary he insisted upon the very definite nature of the proof we now possess of the existence of the electron, citing in this connexion his own famous experiments with the oil drop, which the latest researches in his laboratory have rounded off in a very convincing manner. Then, after summarising our knowledge of the nucleus atom, and emphasising the success of the orbit theory as worked out by Bohr and his followers, in particular Sommerfeld, he proceeded to describe briefly some recent experiments carried out by himself in collaboration with Mr. I. S. Bowen. Working with the so-called hot spark, in extreme vacua, these investigators have succeeded in obtaining spectra emitted by atoms which have, in extreme cases, lost as many as six of their "outer" electrons. In the first group of the periodic table they find evidence for the existence of "stripped" atoms, *i.e.* atoms which have lost all their outer electrons, of all the elements from lithium to nitrogen, the last-named having, of course, lost five electrons: in the second group they have obtained stripped atoms of all the elements from sodium to sulphur, which involves a loss of six electrons in the last-named. This constitutes a notable extension of the work of Prof. A. Fowler and of Prof. Paschen, who have obtained respectively the spectra of doubly and trebly ionised silicon, and of doubly ionised aluminium. For the identification of the lines, Prof. Millikan has derived much support from the increase of doublet separation with nuclear charge, which agrees well with the Sommerfeld relativity formula applied to his assumptions. Further consideration of his results has led

Prof. Millikan to conclude that the electrons possess inverse-square-law fields of force at orbital distances. The detailed account of this work has not yet been published, and will be awaited with keen interest by all physicists. It may be noted that Prof. Millikan comments unfavourably on the static atom, which he calls the "loafer electron theory," to express in brief the conception of "electrons sitting around on dry goods boxes at every corner, ready to shake hands with, or hold on to, similar loafer electrons in other atoms." He also objects to the term "proton," preferring "positive electron."

PROF. FREDERICK SODDY, professor of chemistry in the University of Oxford, has been elected a foreign member of the Reale Accademia Nazionale dei Lincei of Rome.

PROF. A. S. EDDINGTON, Plumian professor of astronomy and experimental philosophy in the University of Cambridge, has been elected an honorary member of the American Astronomical Society.

IT is stated in the *Times* that a French pilot, Lieutenant Thoret, has made a record gliding flight at the aerodrome of Les Alpilles, near St. Rémy-en-Provence. He remained in the air with the engine of his machine stopped for 9 hr. 8 min. The previous record was held by a German airman, who was in the air for 8 hr. 42 min.

FOR the past year, Dr. J. J. Simpson, Keeper of Zoology in the National Museum of Wales, Cardiff, has given a weekly chat on some natural history subject from the British Broadcasting Company's studio in Cardiff. He has dealt in one series with British mammals, and these are to be published shortly in book form by the Sheldon Press. He has now started a new series on "Romances of Natural History," and has already dealt with "The Eel," "Aquaria," "Sticklebacks," "The Honey Bee," "The Tadpole," "Our British Reptiles and Amphibians, etc.," and will, during the next few weeks, talk on "The Mayfly," "The Sponge," "The Salmon," "The Lamprey," etc. It is noteworthy that the Cardiff station was the first to inaugurate a series of such talks, and from the correspondence received it is evident that they are stimulating a wide interest in natural history. It was inevitable that such would be the case, because the various subjects are dealt with in non-technical language, and must appeal to a large public both juvenile and adult.

MR. F. EDWARDS, 83 High Street, Marylebone, W.1, has just circulated Catalogue No. 461 (British Empire Series, No. 4), containing particulars of nearly 800 books, engravings, and drawings relating to Africa. Copies are obtainable from the publisher upon request.

THE autumn announcement list of Messrs. Edward Arnold and Co. contains two memoirs which should appeal to readers of NATURE, namely, "The Life of John William Strutt, Third Baron Rayleigh, O.M.," by his son, the present Lord Rayleigh, and "Huia Onslow," by his widow, Muriel Onslow. Lord Rayleigh over a long period was a frequent contributor to NATURE, and a short series of articles on "The Iridescent Colours of Insects" by Mr. Onslow appeared in our columns not long before his death.

AMONG the autumn announcements of Messrs. Longmans and Co. is a book by Prof. S. J. Hickson entitled "An Introduction to the Study of Recent Corals," in which attention will be given to the structure by which corals capture and digest their food, the colours they display in life, and the means by which they propagate their kind. A description of the structure of the soft parts of the coral and of its appearance when alive will be given wherever possible in the description of the genera.

ERRATUM.—In issue of August 30, p. 302, col. 1, line 32, for "as well as the study of science, that of letters" read "the study of science, as well as that of letters."

Our Astronomical Column.

ENCKE'S COMET.—This comet was of magnitude 14 at the end of July, but it has been rapidly approaching both sun and earth, and should now be visible with ordinary telescopes, especially before September 10, as the moon will be troublesome after that date. The following ephemeris, for Greenwich midnight, is from the B.A.A. Handbook:

	R.A.	N. Decl.	log r.	log Δ.
Sept. 5.	5h. 53·0m.	36° 46′	0·0845	9·9948
9.	6 21·4	37 10	0·0621	9·9670
13.	6 53·2	37 7	0·0378	9·9406
17.	7 28·2	36 28	0·0113	9·9170

The comet is nearest to the earth on September 30, and to the sun on October 31. It is due south about 7 A.M., but from its high northern declination it is observable in the east shortly after midnight. On September 5 it is near θ Aurigæ, on September 17 some 4° north of Castor. It should be followed until about October 20, after which it is inconveniently near the sun, and rapidly moving south.

ABSORPTION IN THE ATMOSPHERE.—M. J. Baillaud describes, in the *Comptes rendus* of the Paris Academy of Sciences, May 26, observations on the coefficients of transmission of light of different wave-lengths by the atmosphere, made at the Pic du Midi Observatory. A curve resulted, more or less parallel to that obtained by Rosenberg at Göttingen, but with somewhat higher values, and agreeing still better with that of Abbott and Fowle taken at Mount Wilson. On October 21, 1921, however, the values for small wave-lengths, about 380 mμ, were abnormally small, the curve running into the normal curve for longer wave-lengths. It was noticed that, although the sky was very clear, hoar frost was deposited on the outside wall of the observatory, and it is suggested that there may be a special absorption band for water vapour, which has not as yet been observed in the laboratory, when it is in the unstable state which precedes condensation. In support of this hypothesis, the observation of Nichols and Pacini, that the short wave-lengths are weaker in proportion to the long ones in light from clouds than in that from the clear sky, is brought forward. It does not seem possible that the abnormal absorption was due to ozone, as the amount of this gas required to produce the effect would be some seventeen times larger than that normally existing in the atmosphere.

Research Items.

THE DISTRIBUTION OF CALAMITIES.—Four months ago attention was directed in these columns (vol. 113, p. 653) to a proposal to study the distribution of calamities such as earthquakes, epidemics, floods, etc., under the auspices of the International Red Cross Committee and of the League of Red Cross Societies. A chief feature of this proposal was the issue of a quarterly review, *Matériaux pour l'étude des calamités*, to be edited by M. Raoul Montandon. We have now received the first number of this journal containing articles by the editor on the geography of calamities, and by M. Louis de Launay on earthquakes and volcanoes, as well as notices of memoirs bearing on the subject. The main object of the movement is the relief of suffering among populations affected by great calamities, and the editor urges that a useful preliminary step in the organisation of relief would be the publication of an atlas of the world showing clearly the site and extent of all catastrophes.

ACTIVE PHILIPPINE VOLCANOES.—The Bulletin for April 1922, recently published, in 1924, with the authority of the Government of the Philippine Islands, contains an article on the above prepared under the direction of Rev. José Algué, S.J., Director of the Weather Bureau of the Manila Central Observatory. Data relative to the Philippine volcanoes were previously published in 1901 and 1903. Since then volcanic events have been described in the Bulletins of the Weather Bureau, and observations of particular volcanoes were undertaken chiefly by the geologists of the Bureau of Science. The author mentions that the Apo and Sarangani extinct volcanic chain is in line with the Sanguire group, which is still active, lying about 200 kilometres south of Sarangani, across the north-east part of Celebes Sea. A prominent peak or cone of the Apo group is Matutum; this is a very old volcano, its local name Matutum meaning "has burnt" or "fire out." With reference to the group Makaturing and Ragang, the author is inclined to believe that all the historic eruptions attributed to the former occurred in the latter. Dealing with volcanoes on Luzon Island, especial reference is made to Taal volcano, said to be probably the lowest in the world. It rises in the centre of Lake Bombon, in 14° 2′ N., 120° 57′ E.; the altitude of the lake is less than a metre above sea-level, and the highest wall of the crater is about 300 metres. The last eruption occurred in 1911 and annihilated everything around within a radius of several kilometres, causing about 1300 deaths.

CURRENT METER RATING.—The rating of a current meter for recording the discharge of streams is, of course, an important procedure, and every care is essential in order that the rating shall be carried out under conditions approximating as closely as possible to those obtaining in the actual observations. The customary method of calibrating a meter is to draw it through still water at known speeds, simultaneously observing the corresponding speeds of the rotor. The objection has been raised that this is merely a record of parallel and uniform stream line flow, taking no account of variations in the speed and direction of the filaments of water characteristic of ordinary river discharge. Such variations are generally grouped under the designation of turbulence. In NATURE of June 14, p. 872, we referred to a turbulence gauge designed by Mr. B. H. Wade of the Egyptian Ministry of Public Works to record the effects of turbulence in connexion with the computation of discharge in the river Nile. We have now received a copy of Physical Department Paper, No. 14, issued by the same service, in which Dr. P. Phillips discusses certain experiments which he has made on the rating of current meters by means of a new rating apparatus, brought into use at Abbassiya Water Works, by which the three essential observations (time, revolution of rotor, travel of carriage) are recorded automatically, so eliminating personal errors. This apparatus has been found to give results agreeing closely with the makers' average rating curve, and with the rating of the United States Bureau of Standards. It records a smaller number of revolutions per minute for the same velocity than does the old apparatus at Giza, the difference ranging between 2 and 5½ per cent. for different velocities. The new apparatus is explained with the aid of diagrams and photographs.

IMPLANTATION OF THE HUMAN OVUM.—Prof. J. H. Teacher has contributed to the summer number of the *Journal of Obstetrics and Gynæcology* (vol. 31, No. 2) an important paper on the implantation of the ovum and the early development of the trophoblast in man. That the human ovum burrows into the uterine mucous membrane, parasite-like, destroying tissue and provoking inflammatory and reparative reactions, has been recognised for some years. This memoir contains an account of the further discovery that the closure of the decidua reflexa is effected by an apparatus developed from those ectoderm cells of the ovum which are the last to enter the mucosa tissue. This apparatus unites with the uterine epithelium and afterwards with the other tissue of the lips of the aperture through which the ovum has passed. For the complete structure the author suggests the term "operculum deciduæ." The recognition of this apparatus has led to the identification in the human ovum of a polar arrangement similar to that found in the hedgehog and in the guinea-pig. The ovum, therefore, may be described as having an entering or implantation pole and an adhering or closing pole, and it is this polarity which determines the position of the embryonic rudiment in the blastocyst and the situation of the placenta. The operculum, which differs from the Traeger of the rodent in taking no part in the formation of the placenta, usually becomes detached from the blastocyst when its function of closing the aperture has been fulfilled, a shield of fibrin being formed by thrombosis in the implantation cavity and so closing the passage from within. Prof. Teacher finds that the conclusion formerly arrived at by himself and Prof. Bryce that there are two generations of trophoblast (a primitive or implantation and a placental trophoblast) is entirely justified. These and many other cognate matters are dealt with in this memoir. It is illustrated by fifteen magnificent plates (some coloured), the cost of which has been defrayed by the Carnegie Trust for the Universities of Scotland. The material used in the investigation consisted of the original "Teacher-Bryce" ovum, first described in 1908, and a new human ovum of somewhat later age. The recent literature of the subject containing accounts of other early ova is referred to so as to facilitate a comparative study of the various processes described.

DIFFUSION AS A FACTOR IN ORE DEPOSITION.—In a paper on "Some problems of diffusion, with special reference to the study of ore deposits" (Science Reports of the Tohoku Imperial University, 3rd Series, vol. 2, Nos. 1 and 2, pp. 105-185), Manjirô Watanabé gives the results of some investigations on diffusion, amplifying the work done previously by Liesegang and others, but giving special attention to

the bearing of diffusion phenomena on ore genesis. Following Liesegang's method, experiments were made with gelatin media. Experiments were made also with kaolin, sand and calcium carbonate, in order to approximate more closely to natural conditions of ore deposition. As reacting materials, the sulphates, carbonates, nitrates and chlorides of common metals, sodium and barium sulphides, ammonia, and sodium carbonate or bicarbonate were employed. The velocity of diffusion with simultaneous precipitation was investigated, and a new equation proposed for the expression of diffusion velocity under these conditions. This equation is $x/\sqrt{z} = K(Z - z)/Z$, where z is the time and x the distance of diffusion, Z the time from the commencement of diffusion to the critical point of precipitation, and K is the velocity coefficient or the value of $x/\sqrt{z}$ at the commencement of diffusion. An examination of the magnitude of diffusion effects in Nature led to inconclusive results, but it is inferred that, contrary to the claim made by some previous workers, the effect of increased temperature in promoting diffusion is comparatively small; and that it takes more than 10,000 years for diffusion to take place over a distance of 100 metres. Other problems investigated include rhythmic precipitation, zonal or differential precipitation, and the action of various solutions diffusing into colloidal precipitates of metallic compounds. The order of stability of various sulphides in acid solutions, from more stable to less stable, was found to be as follows: silver sulphide, copper sulphide, lead sulphide, zinc sulphide and ferric sulphide.

THE ECONOMIC UTILISATION OF COAL.—In the June number of *State Technology*, the journal of the Institute of Professional Civil Servants, Mr. H. E. Weaver has an article on coal, directing attention in simple language to facts long recognised by fuel experts but little appreciated by the general public: that this commodity is an ever-wasting national asset and that its combustion in open grates is little short of calamitous. The proper utilisation of coal lies in its scientific carbonisation, the refinement of its many and varied products, as in the case of petroleum, and their economic use under the best conditions in national, industrial, and domestic life. To a large extent the coal-gas industry has pointed the way, and there is little doubt that its development to its present important position is due not so much to the actual production of gas as a common form of heat energy, as to the numerous and invaluable by-products to which its preparation gives rise. As is well known, the products resulting from retorting coal can, apart from the gases evolved, be grouped into two main classes—tar and ammoniacal liquor; the former is the basis of a wide range of oils, including anthracene, themselves the starting-points for the production of benzol, naphthalene, cresols, creosote, anthracene, to mention only a few compounds; linked up to the refinement of these products are a host of distinctive technical processes resulting in the manufacture of motor fuel, explosives, disinfectants, preservatives, drugs, and perfumes (mainly from treating benzol, toluol or xylol), the production of dyes from naphthalene, with alizarine and further dyes from anthracene; the solid products in the form of pitch and other hydrocarbons are likewise capable of refinement for the particular purposes to which they are to be put. From the ammoniacal liquor are prepared the valued ammonium salts and ammonia itself, cyanides, and sulphur compounds. One has only to remember the significance of cyanide in the South African gold industry to realise its importance as a factor which has made that industry possible. There is, in effect, such a wealth of possibility in the lumps of coal which we casually put on our domestic fires, that our action must seem little short of desecration to the "spirit of coal," cleverly portrayed on the posters issued by the Gas Exhibit Committee at the British Empire Exhibition, to which, and also to the instructive gas exhibit, the author rightly directs public attention.

THE PRODUCTION OF HIGH-VELOCITY β-RAYS BY THE ACTION OF HARD β-RAYS—M. J. Thibaud has studied the β-rays produced by bombarding U, Pb, W, and Ag with the high-energy γ-rays of RaC (*C.R.* Paris Acad. Sci., July 21). The following table gives in the first line the symbol of the element employed as secondary radiator, in the second the energy in kilovolts required to detach an electron from the K level, and in the following the energies in kilovolts of the observed β-rays.

U.	Pb.	W.	Ag.
117	89·3	69·5	25·6
1004	1034	1057	1100
1122	1151		
1650	1677		

When the energies in the first line are added to those in the following lines, the energies of the γ-rays liberating the β-rays are found to be 1123, 1241, and 1763 in kilovolts; a γ-ray with energy 605 kilovolts has been previously found. All the important lines of the high-velocity β-ray spectrum of RaC, with one exception, are due to a photo-electric effect of the penetrating large quantum γ-rays. When radium is in contact with another element, there are two corpuscular emissions, giving similar spectra more or less shifted with regard to one another, the first being about four times as intense as the second. This agrees with the view of Ellis that the atom emitting the γ-ray has the greatest probability of absorbing it, and producing photo-electrons.

CONDUCTIVITY OF METALLIC VAPOURS.—Work has been done on the conductivity of metallic vapours in flames by a number of investigators, but Dr. E. Zachmann, in the July number of the *Annalen der Physik*, shows that a number of precautions which are necessary in order to measure the true conductivity have previously been neglected. He develops the theory and describes a very complete investigation of the vapours of the alkali metals. Two devices were adopted to prevent electrons from heated electrodes from penetrating into the flame; the hot surface of the Meker burner employed was made the anode, and electrons from it were driven back into it by the applied E.M.F.; the cathode stood above this, and was divided into a central portion of copper with a circular horizontal surface, surrounded by the horizontal surface of a metallic grid, which formed a guard ring; both portions of the cathode were water cooled. It was possible to adjust the flame so that, over a considerable vertical length, it could be shown that the field intensity was nearly constant. The probe electrodes employed were investigated theoretically and experimentally, and the best form for them was determined. It was found that the conductivity of the vapours of the alkali metals is proportional to the square root of the concentration in the flame, which agrees with the theory; it varies as the square root of the atomic weight of the metal, and increases rapidly with increase of temperature. It also appears that the production of electrons is almost entirely due to collisions between the metal atoms and the gas molecules of the flame, very few being due to collisions between two metal atoms.

Recent Industrial Research in Cotton.[1]

THE volume of memoirs before us includes eight summaries of the current literature on such properties of cotton and cotton materials as are studied in more detail in the majority of the twenty-three other original papers. Although the plant is the source of supply of raw cotton, it is strange that these memoirs contain only one summary of existing literature on the application of botanical knowledge to immediate cotton industrial needs. The reason is that little trustworthy literature on this important subject exists.

The summaries are well compiled, and the length of the appended bibliographies (one includes 200 references) illustrates the care taken in their production. They are invaluable to scientific workers, in cotton and other allied textile materials, who are outside the British Cotton Industry Research Association.

The original papers are contributions from the botanical, physical, chemical, and physico-chemical departments of the Shirley Institute. Papers on the measurable characters of raw cotton, the morphology of the cell-wall of the cotton hair—which embodies some excellent photo-micrographs—and the conditions causing, and the prevention of, mildew in certain dyed cloths, form the bulk of the contribution from the botanical side. It is stated that infection of a cloth with a moisture content of 7·8 per cent. developed in nine weeks. Since raw cotton will absorb this quantity of moisture on exposure to an atmosphere of 0·66 relative humidity, which is far below the average value for the Lancashire district, the oft-recurring appearance of mildew in the raw material is not surprising.

The physical papers on the behaviour of cotton yarns under alternating stresses are characterised by the enormous number of tests made. Periodic variations which have previously been established in yarns tested by continuous loading methods, are found, in many cases, either to have disappeared or to have been considerably modified. Also, as neither of the two methods of testing is directly applicable to the study of stress effects in cloth, it is very doubtful whether, at this stage, the results obtained from thousands of tests on the peculiarity of any one yarn, very often the product of poor workmanship or the effect of efforts to increase production in the mill, are worth the highly trained labour expended on them. The writer is well aware of the variability of yarns spun under the best conditions, but cannot this be paralleled in the large scatter of rounds about a target engaged by a gun well and truly laid ? A good gunner knows well that a comparatively long bracket is sufficient information to enable him to register the target roughly, if many other targets are to be registered in a limited time. Later, the interesting targets are then given the further attention which appears to be adequate.

The physical papers on the rigidity and plasticity of cotton hairs are very carefully done. It is doubtful whether the determination in absolute units of the coefficient of rigidity of a cotton hair, with its characteristically open structure, can be justified, especially when the influence of the relative humidity of the atmosphere on the physical constants of the hair is almost ignored. The force required to bend a dry cotton hair is greater than the force to bend the same hair containing 20·0 per cent. of moisture, even though the wet hair has the greater cross-section. The work on the plasticity of cotton hairs is of much higher order, and the magnetic torsiometer employed in this investigation is a cleverly designed instrument, well suited to the continuous measurement of small forces.

Two good methods of measuring the lustre of doubled yarns are described. The first is a direct photographic, and the second a photometric, method, in which the intensity of the light reflected from the yarn is compared with the intensity of light transmitted through a ground glass screen, illuminated in a controlled manner. A satisfactory method of measuring the lustre of yarns has been much needed, and the definiteness of the results obtained with the photometric method is encouraging. The general utility of the investigation is marred by the absence of information on the mercerising process used in preparing the yarn, on which process the lustre of yarns so much depends.

The investigations on the chemical constituents of the benzene extract from American cotton, and the volatile products derived from cotton by the action of water and sodium hydroxide at 40 lb. pressure, almost lead one to ask whether there is anything which cotton does not contain. The detailed examination of the extracts reveals the skill and patient labour involved.

Braidy's method of determining the copper number of modified and unmodified cotton cellulose has been found satisfactory after critical examination. The application of the results of colorimetric and titrimetric methods of determining the quantitative absorption of methylene blue by cotton cellulose of varying purity to the control of the bleaching process, to the detection of oxidation of cellulose (over-bleaching), and to the distinction between some raw Egyptian and American cottons, is perhaps the most interesting of the chemical contributions. The absorption of methylene blue by cotton cellulose is shown to vary directly with the ash content, thus confirming the conclusions of Rona and Michaelis and opposing the views of Bayliss.

On the physico-chemical side, work on the properties of starches used in sizing yarns is described. The results of the investigation on the moisture-absorbing properties of thin films of cooked starch bear a striking resemblance to those obtained on the moisture-absorbing properties of cotton. The botanical origin of the starch is found to have no appreciable bearing on the moisture-absorbing power. In contradistinction to this, the viscous properties of pastes made from maize and farina starches are shown to differ considerably.

Using a more sensitive form of the Justin-Mueller turgometer, the swelling of cotton cellulose in sodium hydroxide solutions has been examined. Although this attempt to find a means of eliminating discrepancies due to differences in the visible structure of cotton hairs was not successful, some interesting structural changes are noted.

Although these memoirs are an encyclopædia of information on the measurable properties of raw, spun, and chemically treated cotton, there is comparatively little cross-connexion or generalisation. They might be compared favourably with a Greek temple in the first stages of construction. The foundations have been thoroughly explored, and a number of pillars have been begun at very short spacial intervals. We are hopeful that the superstructure will be worthy of the stoutness of the supports; meanwhile, those who are only interested in the commercial value of the knowledge can trust in this solidity until such time as the superstructure takes a form which they can recognise. F. P. S.

[1] Shirley Institute Memoirs, vol. 2, 1923. Pp. vi+394+v. (Manchester: British Cotton Industry Research Association, 1924.) n.p.

Orchard Heating in the United States.

MUCH progress has been made of late years in the study of fruit growing, especially with reference to orchard heating and the development of more accurate methods of predicting low temperatures and counteracting their damaging effects. Special information has been given in the U.S. *Monthly Weather Review* for different districts, notably for North Carolina, in Supplement No. 19, published last year; and the *Monthly Weather Review* for December last has an article on "Damaging Temperatures and Orchard Heating in the Rogue River Valley, Oregon," by Mr. F. D. Young, Meteorologist, and Mr. C. C. Cate, Plant Pathologist. Observations made in the past with regard to temperature are utilised by the authors.

The pear is the principal fruit crop of the valley, but so far less has been done in determining the damage by cold to this crop than to peaches, apples, and apricots. A large part of the article deals with the actual comparisons of the pear crops harvested from adjoining protected and unprotected orchards during the seasons of 1921 and 1922, and partially with 1923. The cold due to radiation with a clear sky is the special lowering of temperature dealt with. The upper and less protected parts of the tree feel the effect of radiation more fully. Fruit blossoms were examined and the extent of damage noted for the different exposures under examination, and from 150 to 350 blossoms were cut open and examined in determining percentages of damage at each count. The protected orchard is equipped with a various number of oil-heaters, ranging from about 9 to 250 2-gallon lard-pails to the acre. Graphs are given showing the range of temperature at unheated check stations and at heated orchards, the heating, in examples shown, making a difference of 4° to 8° F. The great value is clearly the maintenance of night temperature above the damaging point, say above about 30° F.

Excellent photographs are given showing the development of pear blossoms and fruit at different dates of progress, and of fruit in which the seeds have been damaged or undamaged by frost. Photographs also show the crop, in number of pears at different heights on the tree; for example—ground to 6 ft., 6-10 ft., 10-14 ft., and above. Also the cropping in boxes from respective trees in protected and unprotected orchards—ranging from more than 20 boxes to a single box—is given.

In one of the largest pear and apple orchards in the Rogue River Valley, orchard heaters have been used during the past thirteen years, and during that time the fruit crop has never been materially reduced through frost-damage. A rougher method of orchard heating was previously adopted, but it was far less efficacious.

Although the discussion under review deals only with the Rogue River Valley, it is stated that the effectiveness of orchard heating, where properly handled, applies with equal force in preventing damage by frost in Western Oregon and in the entire States of California and Washington. Detailed studies in southern California show that orange groves can be protected against outside temperatures of 18° F., and the protective value of heating is generally accepted by citrus growers throughout the State.

The economic phase of orchard heating has been intentionally ignored, although the authors give a few convincing facts in support of the cost incurred, and they note that, in the Pacific Coast States, orchard heating is generally practised only in the colder portions of each district.

University and Educational Intelligence.

LONDON.—Applications are invited for the William Julius Mickle fellowship of the value of at least 200*l*., to be awarded to the man or woman who, being resident in London, and a graduate of the University, has in the opinion of the Senate done most to advance medical art or science during the preceding five years. Applications must be received before October 1 next. Particulars may be obtained on application to the Academic Registrar, University of London, South Kensington, S.W.7.

THE University of the Witwatersrand, Johannesburg, gives in its Calendar for 1924 an interesting sketch of its origin and development. From 1916, when the Witwatersrand University Committee was formed for the purpose of developing the South African School of Mines and Technology, first into a full University College and ultimately into a University, progress has been very rapid, the number of students in each of the years 1916 to 1923 having been: 77, 173, 191, 301, 635, 812, 983, 1106. The University, formally opened in October 1922, has now fully organised Faculties of Arts, Science, Medicine, Commerce, Engineering, and Law, and a teaching staff of a hundred professors and lecturers.

THE United States National Research Council has published in Bulletin No. 38, particulars of more than 400 foundations of fellowships and scholarships for advanced work in science and technology. The compilation is provided with a subject index which shows that about 170 foundations are for research in pure science, 140 for research in technology, and 65 for medical research. A comparison with Appendix xxiv. of the British Empire Universities Yearbook seems to show that it is a much commoner practice among American than among British universities to admit to candidature graduates of institutions other than those in which the fellowships, etc., are tenable. The practice has obvious advantages, especially in the case of a university which has achieved pre-eminence in the advanced teaching, or facilities for the advanced study of, one or more branches of knowledge. From one point of view it is complementary to the practice of giving travelling fellowships.

AN Education Week is being organised for November 17-23 by the United States Bureau of Education in co-operation with the National Education Association (representing the school teachers of the United States) and the American Legion. The celebrations are to be distributed over the week thus: Monday, Constitution Day—"The Constitution: the bulwark of democracy and happiness"; Tuesday, Patriotism Day—"The United States flag is the living symbol of the ideals and institutions of our republic"; Wednesday, School and Teacher Day—"The teacher: the guiding influence of future America"; Thursday, Illiteracy Day—"Informed intelligence is the foundation of representative government"; Friday, Physical Education Day—"Playgrounds and athletic fields mean a strong healthy nation"; Saturday, Community Day—"Service to Community, State, and Nation is the duty of every citizen"; Sunday, For God and Country Day—"Religion, Morality, and Education are necessary for good government." For each day, appropriate topics and slogans are suggested. Conspicuous among those for the first two days are the following: Revolutionists, communists, and extreme pacifists are a menace to our constitution's guarantees of life, liberty, justice, security, and opportunity; the red flag means death, destruction, poverty, starvation, disease, anarchy, and dictatorship; stamp out revolutionary radicalism.

Early Science at the Royal Society.

September 6, 1664. Sir Robert Moray produced a letter of Mons. Huygens, dated at the Hague, mentioning an instrument devised by him for measuring the velocity of descending bodies; as also, a new observation concerning Saturn, made the last spring at Rome, by Campani, viz., that the circle of Saturn had covered a part of its sphere above, and had been covered thereby below, even with a little shadow upon the circle below, and upon the sphere above: which observation Mons. Huygens looked upon as confirming his system, which himself had made.

1666. Sir Theodore de Vaux presented a paper of enlumineure which was recommended to Mr. Evelyn to peruse. This gave occasion to mention that Mr. Povey had intimated, that, upon the society's desire, Mr. Peter Lely, Mr. Cooper, and Mr. Streeter would perhaps not be unwilling to communicate to them the several curiosities and varieties of painting. Whereupon it was ordered, that Mr. Povey, Mr. Evelyn [and others] should be desired to meet and consider together what particulars were fit to inquire into, and thereupon to discourse with the said masters.

September 7, 1663. Dr. Wilkins put the company in mind to improve their former consideration of making an history of the weather, in order to build thereupon an art of prognosticating the changes thereof: And he suggested, that it might be recommended to some of the members of the society, to make constant observations, at least of the most considerable changes of weather: in order to which, Mr. Hooke was desired to engage therein, which he did; and Dr. Wilkins undertook to recommend the same to Dr. Power. It was also thought proper that Dr. Wren should be written to, to send to the society a scheme of his weather-engine, formerly proposed, in order to see whether it needed any addition or not. Sir Kenelme Digby related, that Dr. Dee by a diligent observation of the weather for seven years together, acquired such a prognosticating skill of weather, that he was, on that account, accounted a witch.—Mons. Huygens presented a paper from his father Mons. Zuylichem containing a description of a new kind of candlestick, by means of which, the candle upon it gives more light than two torches together, consumes less wax, frees from the inconvenience of smoking in the narrowest room, and needs no snuffers. The paper was ordered to be translated from the French.

September 10, 1662. It was ordered, that at the next meeting experiments should be made with wires of several kinds of the same size, viz., silver, copper, iron, etc., to see what weight would break them; Mr. Croune being appointed curator of this experiment.—Dr. Wren was reminded of prosecuting Mr. Rooke's observations concerning the motions of the satellites of Jupiter.—A proposition was offered by Sir Robert Moray about the planting of timber in England, and the preserving of what was then growing.

September 11, 1661. Two committees were appointed to propound experiments, one consisting of Dr. Goddard, Dr. Wilkins [and others] for the city of London; and the other consisting of the lord Viscount Brouncker, Sir Robert Moray, Sir Paul Neile [and others] for Westminster.

September 12, 1679. There was a discourse about ways of vision, from the assertion of Mr. Hooke, that a man used to see things always inverted would in time judge, that he saw them as they are. Sir John Hoskyns remarked, that looking at the sun or stars through a small hole made in paper caused them to appear less than to the naked eye. Dr. Croune gave the reason of the sun's appearing bigger near the horizon from the dilating of the pupil.

Societies and Academies.

PARIS.

Academy of Sciences, August 4.—M. Guillaume Bigourdan in the chair.—A. **Lacroix**: A new type of meteoric iron found in the desert of Adrar, Mauritania.—F. E. **Fournier**: An unpublished safety manœuvre for preventing collisions between steamships during fog.—A. **Haller** and R. **Cornubert**: Study of two symmetrical and unsymmetrical dimethylpentanones. Symmetrical dimethylcyclopentanone condenses with benzaldehyde in the presence of hydrochloric acid, giving a compound $C_{21}H_{22}O_2$: the unsymmetrical dimethylcyclopentane behaves differently, giving a true benzylidene compound.—Gabriel **Bertrand** and Hirosi **Nakamura**: A new case of physiological mutation in mice.—P. **Sergesco**: Some inequalities of Landau and Lindelof concerning monogene functions.—J. **Cabannes** and A. **Lepape**: The diffusion of light by krypton and xenon. The polarisation of the light diffused transversely by a pure inert gas is not total.—J. **Guinchant**: Rôle of the atmosphere in the propagation of Hertzian waves. Effects analogous with mirage in the case of light waves can be produced with Hertzian waves. The state of the lower atmosphere may be an essential factor in the propagation of radio-telegraphic waves. The changes in intensity and of direction of the waves, the differences in receiving during day or night, and influence of the seasons may be readily explained by normal meteorological variations.—André **Job** and René **Reich**: The catalytic activation of ethylene by organo-metallic nickel. A solution of phenylmagnesium bromide, to which a little anhydrous nickel chloride has been added, rapidly absorbs large volumes of ethylene. Subsequent addition of water gives ethane, ethylbenzene, styrolene and diphenyl, but no benzene.—H. **Gault** and Mlle. M. **Urban**: The soluble cellulose esters of the higher unsaturated fatty acids.—Max. and Michel **Polonovski**: The nitroso and benzoyl derivatives of eserine.—Ch. **Maurain** and L. **Eblé**: A photographic recording seismograph with three components.—MM. **Rothé**, **Lacoste**, **Bois**, Mlle. **Dammann** and Mme. **Hée**: Study of the propagation of the La Courtine explosions.—E. F. **Terroine**, Mlle. S. **Trautmann** and R. **Bonnet**: The energy yield at the expense of the carbohydrates in the growth of the higher plants.—L. **Emberger**: Cytological observations on the bulb of *Lilium candidum*.—M. **Couvreux**: New observations on the photomotor reflex.—P. **Vlès**, P. **Reiss** and E. **Vellinger**: Potentiometric measurements of the P_H of the substance of the eggs of the sea-urchin. For the crude egg substance, the P_H appears to be between 5 and 5·5 before loss of carbon dioxide; it rises to about 6·2 when this gas has been eliminated.—Ch. **Dhéré**, A. **Schneider** and Th. **Van der Bom**: The photographic determination of the fluorescent spectra of hæmatoporphyrine in various solvents.—J. **Régnier**: The variation of the anæsthetic power of cocaine hydrochloride as a function of the proportion of hydrogen ions. The rapidity of anæsthesia is much more rapid for alkaline than for acid solutions. With high P_H, anæsthesia is complete in two minutes.

August 11.—M. Guillaume in the chair.—A. **Lacroix**: The meteoric irons of Senegal and the Sahara.—A. A. **Guntz**: The energy set free in phosphorescence.

CALCUTTA.

Asiatic Society of Bengal, August 6.—Satya Churn **Law**: *Parus major cinereus* breeding in the 24 Perghanas. Two instances of the breeding of this

bird in the suburbs of Calcutta in the district of 24 Perghanas are recorded. Hitherto there was nothing on record about its nidification in this district.—Satya Churn **Law**: Kālidāsa and the migration of birds. Migration may not have been understood by Kālidāsa, but the phenomenon itself did not escape him. Scattered about in his works are passages which unmistakably refer to this peculiar feature of bird-life, and there are many expressions relating to birds which can be explained only with reference to the migratory phase of their life.—Bisvesvar **Bhattacharyya**: The age of the Padmā. Literary and historical argument in support of the thesis that the Padmā or lower course of the Ganges grew to its present size not during the 16th century A.D., as commonly held, but perhaps during the 14th, or even 13th, century.—Bimala Charan **Law**: The Aśmakas or Assakas in ancient India. A discussion regarding the name and origin of the Assaka tribe and a brief account of its traditional history as may be gleaned from Brahmanical and Buddhist literature.—J. H. **Hutton**: Some carved stones in the Dayang Valley. Descriptive of a little-known group of carved menhirs at Kasomari-pathar near Jamugiri, hitherto only known from a brief description by Bloch in 1905. A connexion may exist between the stones and surviving ceremonies of the Naga tribes.—A. **Grignard**: Our Romanised Hindustani-English dictionaries: their partial inefficiency and its remedies.—Lily **Strickland-Anderson**: Some notes on the customs of the Khasi people of Assam.

Official Publications Received.

Meddelanden från Statens Meteorologisk - Hydrografiska Anstalt. Band 2, No. 2: Mälarens Isförhållanden vintrarna 1917/18–1921/22. Av J. V. Eriksson. Pp. 20+4 plates. 3 kr. Band 2, No. 3: Nederbördskartor över Sverige. Av Axel Wallén. Pp. 8+3 plates. 2 kr. (Stockholm.)

Abisko Naturvetenskapliga Station. Observations météorologiques à Abisko en 1922. Faites et rédigées par Bror Hedemo. Pp. iv+66. (Stockholm.)

Statens Meteorologisk-Hydrografiska Anstalt. Årsbok, 4, 1922. 3: Vattenstånden vid Rikets kuster. Pp. 25+5 plates. 4 kr. Årsbok, 5, 1923. 2: Nederbörden i Sverige. Pp. 172+1 plate. 5 kr. (Stockholm.)

U.S. Department of Agriculture: Weather Bureau. Cloud Forms, according to the International System of Classification. Pp. 22. (Washington: Government Printing Office.)

Twickenham Public Library. Thirtieth Report, 1923–24. Pp. 12. (Twickenham, Middlesex.)

Technical College, Bradford. Prospectus of Part Time Courses. Prospectus, Session 1924–25. Pp. 192+26 plates. (Bradford.)

Northampton Polytechnic Institute, St. John Street, London, E.C. Announcements, Educational and Social, for the Session 1924–1925. Pp. 240+4 plates. (London.)

London County Council. Lectures and Classes for Teachers: Handbook for the Session 1924–25. Pp. 74. (London: County Hall, S.E.1.)

Agricultural Experiment Station of the Rhode Island State College. Bulletin 197: The Examination of Eggs from Infected and Immunized Hens, with Germicidal Tests on Albumen and Blood Serum. By Henry G. May. Pp. 47. (Kingston, R.I.)

The Cordwainers Technical College, Eagle Court, St. John's Lane, E.C.1. Prospectus of Classes in Boot and Shoe Manufacture and Making, Leather Goods Manufacture and Leatherware Art Work, Day and Evening Classes, Session 1924–5. Pp. 43. (London.)

Southern Rhodesia Geological Survey. Short Report No. 16: Interim Report on the Geology of the Country South of Umsweswe, Hartley District. By A. M. Macgregor. Pp. 18. (Salisbury, Southern Rhodesia.)

The Animal Products Research Foundation of the University of Adelaide. Third Annual Report, 1923. Pp. 4+21+3+9+12. (Adelaide.)

Queensland. Department of Mines: Queensland Geological Survey. Publication No. 273: Mesozoic Insects of Queensland. By Dr. R. J. Tillyard and B. Dunstan. Part 2. By R. J. Tillyard. Pp. 175-506+19 plates. (Brisbane: A. J. Cumming.)

The British Dyestuffs Industry 1856–1924. A Booklet issued by the British Dyestuffs Corporation, Ltd., on the occasion of the British Empire Exhibition, 1924. (Manchester: 70 Spring Gardens.)

British Empire Exhibition, Wembley. The Imperial Institute Exhibit in the Pavilion of His Majesty's Government. Pp. 30. (London: Imperial Institute.)

Department of Commerce: Bureau of Standards. Scientific Papers of the Bureau of Standards, No. 490: Spectra and Critical Potentials of Fifth Group Elements. By Arthur E. Ruark, F. L. Mohler, Paul D. Foote, and R. L. Chenault. Pp. 463-486. (Washington: Government Printing Office.) 10 cents.

United States Department of Agriculture. Department Bulletin No. 1218: Horse-Flies; Biologies and Relation to Western Agriculture. By J. L. Webb and R. W. Wells. Pp. 36+4 plates. (Washington: Government Printing Office.) 10 cents.

Board of Education. Report for the Year 1923 on the Science Museum. Pp. 20. (London: H.M. Stationery Office.) 9*d*. net.

Experimental Researches and Reports published by the Department of Glass Technology, The University, Sheffield. Vol. 6, 1923. Pp. 230. (Sheffield.)

Contributions from the Princeton University Observatory. No. 6: Photometric Researches. The Eclipsing Variables Y Camelopardalis, S Z Herculis, R S Vulpeculæ, R Canis majoris, R Y Aquarii. By Raymond Smith Dugan. Pp. 66. (Princeton, N.J.)

Smithsonian Institution: United States National Museum. Bulletin 99: East African Mammals in the United States National Museum. By N. Hollister. Part 3: Primates, Artiodactyla, Perissodactyla, Proboscidea, and Hyracoidea. Pp. viii+164+57 plates. 40 cents. Bulletin 104: The Foraminifera of the Atlantic Ocean. Part 5: Chilostomellidæ and Globigerinidæ. By Joseph Augustine Cushman. Pp. v+55+8 plates. 15 cents. (Washington: Government Printing Office.)

Department of the Interior: Bureau of Education. Bulletin, 1924, No. 2: Industrial Schools for Delinquents, 1921–22. Prepared by the Division of Statistics of the Bureau of Education under the Supervision of Frank M. Phillips. Pp. 22. (Washington: Government Printing Office.) 5 cents.

Smithsonian Institution: United States National Museum. Contributions from the United States National Herbarium. Vol. 22, Part 7: The North American Species of Aristida. By A. S. Hitchcock. Pp. viii+517-586. (Washington: Government Printing Office.) 10 cents.

Department of the Interior: United States Geological Survey. Water-Supply Paper 520-B: Additional Ground-Water Supplies for the City of Enid, Oklahoma. By B. Coleman Renick. Pp. ii+15-26. Bulletin 747: Geologic Literature on North America. By John M. Nickles. Part 2: Index. Pp. 658. 65 cents. Mineral Resources of the United States, 1921. Part 1: Metals. Pp. iv+130A+599-617. (Washington: Government Printing Office.)

Annual Reports of the Academy of Natural Sciences of Philadelphia for the Year ending November 30, 1922. Pp. 98+8 plates. (Philadelphia, Pa.)

Year Book of the Academy of Natural Sciences of Philadelphia, 1923. Pp. 96+9 plates. (Philadelphia, Pa.)

Museums of the Brooklyn Institute of Arts and Sciences. Report upon the Condition and Progress of the Museums for the Year ending December 31, 1923. By William Henry Fox. Pp. 60+3 plates. (Brooklyn, N.Y.)

The Journal of the Royal Horticultural Society. Edited by F. J. Chittenden. Vol. 49, Part 2, July. Pp. 139-304+lxxi-cxxvii. (London: Vincent Square, S.W.1.) 7*s*. 6*d*.

Sir John Cass Technical Institute, Jewry Street, Aldgate, E.C. Syllabus of Classes, Session 1924–1925. Pp. 107. (London.)

Smithsonian Miscellaneous Collections. Vol. 67, No. 9: Cambrian Geology and Paleontology, IV. No. 9: Cambrian and Ozarkian Brachiopoda, Ozarkian Cephalopoda and Notostraca. By Charles D. Walcott. (Publication 2753.) Pp. 477-554+plates 106-126. Vol. 75, No. 1: Cambrian Geology and Paleontology, V. No. 1: Geological Formations of Beaverfoot-Brisco-Stanford Range, British Columbia, Canada. By Charles D. Walcott. (Publication 2756.) Pp. 51+8 plates. (Washington: Smithsonian Institution.)

Report for 1923 on the Lancashire Sea-Fisheries Laboratory at the University of Liverpool and the Sea-Fish Hatchery at Piel. Edited by Prof. James Johnstone. Pp. 129. (Liverpool.)

Diary of Societies.

MONDAY, SEPTEMBER 8.

INSTITUTE OF METALS (at Institution of Mechanical Engineers), at 8 P.M.—W. M. Corse: Recent Developments in Non-Ferrous Metallurgy in the United States, with Special Reference to Nickel and Aluminium-Bronze. (Third Annual Autumn Lecture.)

TUESDAY, SEPTEMBER 9.

INSTITUTE OF METALS (at Institution of Mechanical Engineers), at 10 A.M.—R. J. Anderson and E. G. Fahlman: A Method for measuring Internal Stress in Brass Tubes.—D. H. Andrews and Prof. J. Johnston: The Application of the Ideal Solubility Curve to the Interpretation of Equilibrium Diagrams in Metal Systems.—Dr. G. D. Bengough and R. May: Seventh Report to the Corrosion Research Committee of the Institute of Metals.—E. H. Dix, Jr., and Lieut. A. J. Lyon: Comparative Results on Copper-Silicon-Aluminium and other Aluminium Alloys as obtained on Separately Cast Specimens and Specimens cut from a Crankcase Casting.—D. M. Fairlie and G. B. Brook: The Determination of Sodium in Aluminium.—R. Genders: The Extrusion of Brass Rod by the Inverted Process.—Dr. D. Hanson and Grace W. Ford: Investigation of the Effects of Impurities on Copper. Part II. The Effect of Iron on Copper.—D. H. Ingall: The Relationship between Tensile Strength, Temperature, and Cold-Work in some Pure Metals and Single Solid Solutions.—Dr. H. Moore: The Effect of Progressive Cold-Rolling on the Brinell Hardness of Copper.—Sir Thomas K. Rose and J. H. Watson: Experiments on the Working of Nickel for Coinage.—F. W. Rowe: (*a*) Some Experiments on the Effect of Casting Temperature and Heat-Treatment on the Physical Properties of a High-Tin Bronze; (*b*) Some Experiments on the Influence of Casting Temperature and Mass on the Physical Properties of Admiralty Gun-Metal.—Tomojiro Tanabe: Studies in the Aluminium-Zinc System.—T. H. Turner and W. E. Ballard: Metal Spraying and Sprayed Metal. (A selection of above Papers will be presented in abstract and discussed.)

INSTITUTE OF MARINE ENGINEERS, at 6.30.—J. L. Hodgson: The Measurement of Pressure.

WEDNESDAY, SEPTEMBER 10.

INSTITUTE OF METALS (at Institution of Mechanical Engineers), at 10 A.M.—(A selection of the Papers given above will be presented in abstract and discussed.)