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The Understanding of Relativity.

NINE years have passed since the historic meeting at the Royal Society, Burlington House, on Nov. 6, 1919, when the British eclipse expedition announced the confirmation of Einstein's prediction, from the general theory of relativity, that starlight would be deflected by the gravitational field of the sun. Rarely has a scientific discovery, apparently so forbidding in character, been attended by such an outburst of interest and inquiry. The silent, matter-of-fact way in which relativity has been absorbed into the general scheme of physics stands in striking contrast to the fanfare with which it has been received by the general public. From the time of the Burlington House meeting onwards there has been a ceaseless procession of books, pamphlets, newspaper articles, lectures, pictures, even cinema films, dedicated to the task of making plain to the man in the street what relativity really means.

Even the most easily satisfied expositor can scarcely claim that a reasonably proportionate amount of success has been achieved. Few phenomena are more rarely encountered than a non-scientific man who understands relativity, or even one who claims to do so. It has become almost a commonplace that the theory is unintelligible to the ordinary person. One who affects to understand it is apt to be regarded with suspicion. The rumour has gone forth, and is widely accepted, that there are only three (or is it eleven ?) people in the world who know what it is all about. Judged solely by their results, the attempts to express relativity in ordinary language represent the most conspicuous failure of modern scientific exposition.

It is easy to find defects in many of the attempts. Some have been made by writers who themselves have a very hazy notion of the matter. Others are unintelligible and terribly dull. Others, again, are too much concerned with details, and present a skeleton rather than a spirit ; and so on. But all these things do not explain the situation. They are defects common to a certain proportion of all popular scientific works. Books on 'radio,' for example, can claim their share of them, yet the country is full of experts in this subject who have little physics and less mathematics. The cause of the failure to make relativity intelligible must be sought elsewhere. As a possible contributor to the failure, and a spectator of the efforts of many others, we may be permitted to record a few reflections for the consideration of future interpreters.

Undoubtedly the greatest difficulty in the matter is the universal idea that relativity is hard to understand. A prejudice of this kind is generally fatal to the acquirement of any knowledge, but it is particularly so in the case of relativity, first because it is accepted with such implicit trust, and secondly because it is not true. The real difficulty that besets the beginner in the subject is, not to *understand* what he is told, but to *believe* it. The look that meets the expositor is a look of incredulity, not of blankness.

Consider for a few moments any of the paradoxes which have created the illusion that relativity is unintelligible. What is there difficult to understand in the statement that if we watch a man moving quickly we shall find that his clock will not keep time with ours? Or that he will appear to have shrunk in the direction of motion, and we shall appear to have done so to him? The thing can be pictured by the dullest imagination; any child who has seen a clock or a yardstick can understand what it means. But it takes a child or a genius to believe that it would happen, and the ordinary man, being neither a child nor a genius, does not believe.

Finding the proposition incredible, the ordinary man thinks he must have misunderstood. There must be something he has not grasped, some unrealised factor in the matter which, if it could be laid hold of, would remove the paradox and take the 'nonsense' out of the business; and because he cannot find this mental philosopher's stone he concludes that he has not understood what he has been told.

If this diagnosis of the situation is correct, some modifications of the customary treatment are required. Illustrations designed to show how the phenomena can be pictured in the mind—such as those involving the properties of spherical mirrors, for example—become somewhat irrelevant. Ingenious and trustworthy though they may be, they merely illustrate what can be readily imagined without their aid, and so evade the main problem. Salvation must be by faith, and not by reason.

The aspirant must be persuaded that what seems too absurd and too simple to be the great principle of relativity is nevertheless just what he is seeking, and that he has already grasped it if he will only believe. Science is not often called upon to play the rôle of the 'hot gospeller,' but the teaching of relativity appears to furnish a situation in which, with some obvious reservations, it must do so.

The best mode of procedure has yet to be found, but the first step seems fairly obvious. The learner must be assured that relativity involves nothing in the slightest degree inconsistent with ordinary experience. The source of his unbelief is undoubtedly his failure to distinguish between what he has actually experienced and what he has been in the habit of extrapolating from experience. The paradoxes of relativity are concerned entirely with the latter, but he unconsciously attributes them to the former, and so there arises in him an undefined feeling that there is something wrong.

The ordinary learner does not realise that he has previously had no grounds at all for comparing his view of the world with that of an observer travelling at half the speed of light. He thinks his preconceived view inevitably follows from his experience of smaller speeds, and when he learns that relativity is in conflict with that view he thinks it must therefore be in conflict with experience. Unfortunately, many of the popular accounts of the subject tend to foster that belief.

The matter has a larger importance than the mere understanding of an abstract principle of science. It has a profound effect on the whole habits of thought of the person concerned. Once let the possibility be admitted that knowledge is not firmly grounded in experience, and the mind loses its anchor; "function is smothered in surmise, and nothing is but what is not." The moment a man, however humble and unspecialised he may be, loses the confidence to say, 'That is nonsense,' to anything which violates his experience, by whomsoever and in whatsoever name it may be pronounced, he has lost, if not his senses, at least everything that makes them significant. He has no longer any hold on the world, and has become a potential victim to any delusion or absurdity that he may chance to encounter. The most serious effect of the failure to realise the meaning of relativity is the tendency to lapse into this state of mind.

One or two examples must suffice. An article appeared recently in a widely read journal, by a writer in many respects deservedly popular, in which the effect of relativity on our knowledge of the material world was discussed. It was stated that a piece of matter was no longer a "solid entity enduring through time," but had become indefinitely "attenuated," and was "a series of momentary existents which only their resemblances to one another justify us in collecting together as appearances of the same thing." The idea that matter was a " hard, tangible something " was stigmatised as " the horse sense of the materialist."

It is clear that the words used—" solid," " attenuated," " hard," " tangible," etc.—cannot be taken literally, or the absurdity of the statements would be too obvious. They are metaphorical, and the impression the passage gives is that the material world has lost its stability, that it would not be surprising if the moon, say, suddenly disappeared or turned into green cheese, since " a series of momentary existents " with " only " a resemblance to one another might possibly terminate or take on a new form. The simple fact, that in order to get a unique *measure* of any portion of the material world we must state its relation to time and space as well as its mass—a fact which violates no experience and leaves the ' hardness ' or ' tangibility ' of the material world exactly where it was before—is diffused into a nebulous, metaphysical vagueness which a moment's reference to experience would suffice to discredit. But perhaps the most significant feature of this matter is that, in a journal with no lack of critical correspondents, no note of protest was sounded. Apparently the magic word ' relativity ' induced a kind of hypnotic state in which the subject passively accepted what he was told without regard to the facts of his everyday life. This is the natural result of the impression that relativity involves a denial of ordinary experience.

The reference to the ' materialist ' suggests another common error, namely, that in some way relativity has killed ' materialism ' as the word used to be understood. The essence of materialism is the belief that the physical world, which is apprehended by the senses, is the basis and source of consciousness. This belief is a deduction from experience, and those who really feel its force, whether they assent to it or not, know that it can be in no way affected by a change in units of measurement. The physicist may choose to speak of a stone as an ' event ' instead of as a piece of ' matter,' because he has found a more fundamental way of measuring its content, but the stone as an object of sense-perception, with all the properties which have made it a challenge to idealism, is still there. The recognition of the challenge may be " horse sense," but it remains sense ; and the opposite of sense is still nonsense.

Relativity represents a great advance of the vanguard of human thought. It is to be hoped that it will not result in a blind, chaotic drifting of the minds in the rear.

H. D.

The Secret of the Barnacle.

Barnacles in Nature and in Myth. By Edward Heron-Allen. Pp. xv + 180 + 8 plates. (London: Oxford University Press, 1928.) 15*s*. net.

THIS is a very delightful book, scholarly and whimsical, but it recalls just a little a reviewer's remark on a distinguished philosopher's " Secret of Hegel," that whether the author had understood the secret or not, the practical certainty was that he had kept it to himself; for after reading Mr. Heron-Allen's book we remain puzzled by the barnacle's secret—we mean, of course, its pseudo-secret, namely, its connexion with a goose. The real secret of the barnacle was solved by Dr. J. Vaughan Thompson in 1830 and 1835 in his famous researches, which showed what barnacles actually are and how they develop. On this point all zoologists are agreed ; the puzzle is to explain how barnacles got mixed up for centuries with barnacle geese. We had expected that Mr. Heron-Allen's ingenious mind and sleuth scholarship would have cleared the mist away. The book is extraordinarily learned, and though we confess we never heard of most of the authorities he quotes, we suppose they are all right. The learning is certainly anything but dull, for even the footnotes, mercifully relegated to fifty pages at the end, have an undeniable sparkle. There is also a generous sprinkling of interesting illustrations, some as quaint as quaint could be.

What, then, is our ungrateful disappointment ? It is that the learned author crowds down to three pages what seems to us the really interesting question : How did the barnacle myth arise and how did it persist for so many centuries ? Perhaps, however, the author has done all anyone could ; but in any case, after reading the book we are left rubbing our eyes ; and Mr. Heron-Allen confesses or complains, in company, we are told, with Aeneas Sylvius Piccolomini, sometime Pope Pius II., that the myth, urgently pursued, has " fled ever further from investigation, like a will-o'-the-wisp."

The gist of the history is that from the early thirteenth century onwards it was circumstantially stated that barnacles developed into goslings. The belief was so widespread that in some religious centres barnacle geese were allowed at dinner during Lent because " they are not flesh nor born of flesh." To this primary confusion there was added a secondary fancy that the birds grow on trees " towards Ireland on the sea," and that they fall off when nearly mature, those that fall on land coming to naught, while those that fall into the water swim off or fly off as geese. From the various accounts it is quite clear that this secondary absurdity was due to the fact that trees that had been flooded out to sea were sometimes tossed up again on the beach with barnacles attached. Although Vincent of Beauvais pointed out expressly that the bernacas " hang not from the ends of the branches, but from the trunks and the bark," this was not respected in subsequent woodcuts and descriptions. Hector Boece (*d.* 1536) indicates in regard to an Aberdeenshire tree that the barnacles it bore were engendered while the tree floated in the sea ; yet even he continues to describe some of the little creatures as " perfect shaped fowls."

From a barnacled tree thrown up as jetsam it is easy to pass to one that grew near high tidemark, and we cannot help thinking that the interpreters have not made enough of the superficial resemblance between barnacles and papilionaceous flowers. Five shell-valves on the crustacean and five petals in the flower afford a good basis for further homologising, just as plausible as that between the six pairs of biramose and setose appendages and the feathers of a bird. Yet when all is said, it is puzzling that there should persist century after century the quaintly absurd linkage of tree and crustacean and goose. This is the more puzzling, since so early as the thirteenth century Albertus Magnus had practically punctured the myth by asserting that he and his friends had seen the barnacle goose laying eggs in the ordinary fashion. One may doubt whether he was right in his identification of the barnacle goose, the breeding places of which in the far north were not known to ornithology until the twentieth century, but Albertus certainly discarded the barnacle superstition. Yet it prevailed, and so late as 1661 we find Sir Robert Moray reading a paper before the Royal Society, describing the " perfect sea fowl " within the valves. About the middle of the eighteenth century people began to be ashamed of the story.

In explanation of the origin and persistence of the myth, it has been suggested that mystery shrouded the development of the barnacle goose and the ship barnacle. But there were very numerous similar gaps in knowledge which did not worry the medieval mind. It has also been pointed out that the ship barnacle is a very striking creature on a small scale, and that no one knew where to fit it in. Oftenest it was called a mollusc, which was not happy. But the objection is that it was too early for a zoological puzzle to evolve a myth for a not very obtrusive organism.

Mr. Heron-Allen rejects the etymological or philological interpretation that two similar words of different origin, such as barnclake (dark goose) and bernaca, became mixed up so persistently that people were forced to give the bird and the barnacle a genetic affiliation. Our author lays most stress on the resemblance between the curled feet of the Cirripede and a bird's feather ; but this seems a slender basis for the superstructure. Perhaps it is fallacious to try to explain to ourselves how a Dark Age myth arose. We have to remember, what Dr. Singer has shown so well, that for many centuries men lost the ambition of making new knowledge and of seeing for themselves, and relapsed almost, if not quite, pathologically, into magical and superstitious ways of accounting for things.

The last chapter in the book deals with an interesting discovery made by the French zoologist Houssay and pursued by Sir Ray Lankester. It seems that on Mycenean pottery, perhaps 800 B.C., the evolution of a ship barnacle into a goose may be traced. Just as other objects, like fish, serpent, and swan, became in the course of generations of repetition conventionalised into mere symbols, so it looks as if a drawing of a ship barnacle with its stalk and its limbs may have gradually changed in the potter's hands into the image of a goose. It looks as if the barnacle had made a deep impression on the artistic mind ! J. A. T.

Enzyme Research.

Die Methodik der Fermente. Herausgegeben von Carl Oppenheimer und Ludwig Pincussen. Lieferung 1. Pp. x + 320. Lieferung 2. Pp. vii + 321-624. Lieferung 3. Pp. vii + 625-944. (Leipzig : Georg Thieme, 1928.) 28 gold marks each.

FOLLOWING the publication of the fifth edition of Prof. Oppenheimer's well-known treatise, " Die Fermente und ihre Wirkungen," it appeared desirable to compile a companion volume describing the methods that have been devised in carrying out researches on the subject. There were two alternatives. The first was to prepare a concise volume giving merely an outline of these methods ; the second was to prepare an extended treatise. Of these alternatives the latter was chosen, and the work has been carried out under the joint editorship of Profs. Oppenheimer and Pincussen, in collaboration with leading authorities drawn from all parts of the world. The complete work will form vol. 3 of "Die Fermente und ihre Wirkungen."

The first three parts (*Lieferungen*) only of the work are before us, and it is estimated that the whole will be completed with the publication of two more parts. According to the table of contents drawn up by the publishers, the treatise will be divided into three sections, each subdivided into chapters written by specialists.

Section 1 deals with general methods, physical, physico-chemical, and chemical methods. Following this are chapters on the preparation of sugars, polysaccharides, glucosides, fats, proteins, etc. The last part of the section is devoted to the preparation and purification of enzymes and the measurement of their activity. Section 2 is concerned with the different classes of enzymes—esterases, carbohydrases, nucleases, amidases, proteases, desmolases, and fibrin ferments. The third part up to p. 944 concludes with the commencement of the chapters on amidases. Section 3, commencing with Part 4, will deal with the detection of enzymes in biological objects, and clinical enzyme methods.

Adverse criticism of the different chapters is to some extent disarmed by the fact that those responsible for the text have been well chosen, the majority being well known authorities on the subjects on which they write. When we come to review the work as a whole, or rather the three parts before us, the case is a little different. At the present time scientific literature has reached such dimensions that it has long been found necessary to call halt, and the most drastic condensation is now practised by the editors of our scientific periodicals in regard to communications. The same necessity arises in regard to treatises on scientific subjects, and here duplication ought to be avoided so far as possible. In a book like the present, dealing with methods applied to the scientific investigation of enzymes, the text should, in our opinion, be restricted to a description of methods which are specific to the subject and not common to other fields of research.

In the opening chapters of the present treatise, 243 pages of text are taken up with descriptions—admirable in every respect—of methods of polarimetry, refractometry and allied physical methods, spectrophotometry, colorimetry, viscosity and surface tension, osmotic pressure, the determination of hydrogen ion concentrations and of electrical conductivity, and of the micro-chemical methods of elementary analysis. These are all subjects dealt with in works specially devoted to them. Again, in the chapters dealing with the preparation and properties of substrata covering 185 pages, we find a lengthy account of the preparation and properties of sugars, starch, glycogen, cellulose, glucosides, fats, and proteins, such as would scarcely be expected in such a treatise as the present one. We are sorry to find in the chapter dealing with the sugars that some of the information is not up-to-date, whilst the structure shown of some of the sugars is credited to the wrong authority.

The chapters describing the isolation and purification of enzymes commence on p. 428 and are not completed in the third part. The matter in the text is, so far as can be judged from that which is before us, germain to the subject of the treatise, and is a welcome compilation to a branch of knowledge which much needed piecing together in a concrete form. The chapter on methods of adsorption and elution, of which subject Willstäter is the pioneer, if a little verbose, is exceedingly useful; it covers 42 pages of text. The extraction of enzymes from animal and plant tissues and organs, and from yeasts and bacteria, is dealt with in a chapter entitled "General Treatment of Raw Materials for the Isolation of Enzymes," whilst another chapter is devoted to the isolation of enzymes from the lower cryptogams (including mould fungi) other than yeasts and bacteria. Following a short chapter on the culture of bacteria are others on the extraction of enzymes from plant tissues and seeds, and from the animal organs, whilst another describes the technique of operations for the isolation of secretions. The technique of methods for the manometric measurement of respiration and fermentation as well as for the measurement of the gas exchange during the aerobic and anaerobic respiration of plants, is dealt with in other chapters. The text dealing with specific enzymes commences on p. 701 and will be continued to the end of Section 2.

The few points alluded to will give some idea of the scope of the treatise and serve to indicate its general utility. There is no doubt that the work will be welcomed by the many and ever-increasing number of investigators who devote themselves to a study of that abstruse branch of chemistry concerned with enzymes. When the complete work is published, we shall be in a better position to deal with it.

In conclusion, we would throw out the suggestion that, following the example of Prof. Oppenheimer (who published a condensed edition of his first larger treatise under the title "Lehrbuch der Enzyme"), the authors should prepare a similar condensed edition with all the important references retained in the case of the present treatise. Such a volume would be exceedingly valuable to students as a laboratory text-book. ARTHUR R. LING.

The Association of Higher Plants and Fungi.

Mycorrhiza: an Account of Non-Pathogenic Infection by Fungi in Vascular Plants and Bryophytes. By Dr. M. C. Rayner. (*New Phytologist* Reprint, No. 15.) Pp. x + 246 + 7 plates. (London: Wheldon and Wesley, Ltd., 1927.) 21*s*. net.

THE chapters of this volume are already familiar to botanists, having appeared in the *New Phytologist* of 1926–27, and being reprinted here with slight emendations. To the more general biologist the title of the book may suggest a somewhat technical discussion of a particular and restricted problem, but in reality, making intimate contact as it does with horticulture, forestry, mycology, plant pathology, soil science, plant physiology and general biology, its interest is unusually wide. Further, it is well written and may be perused with interest by the more general scientific reader.

The fact that numerous vascular plants show a regular and characteristic yet non-pathogenic infection by fungi has been known for many decades, but the critical study of this relation may be said to date from the researches of Frank in Germany about forty years ago. The first half of this period was devoted primarily to the study of the structural relationship between fungus and host, and the last two decades to analysing the more physiological and biological aspects of the relationship.

Interest in these latter problems received tremendous impetus from the researches of Noël Bernard on orchid mycorrhiza, and this interest continues unabated. The first few chapters of Dr. Rayner's volume give an admirably clear picture of the development of research on the subject, and the way in which an issue, originally of almost parochial interest, has become more vital and inclusive until now it touches fundamentally many subjects not only of theoretical but also of immense practical importance. Excellent accounts are given of the part played by fungi in the growth of orchids and the development of orchid cultivation, and the ways in which the natural relationship may be utilised or circumvented by commercial growers. Equally valuable is the author's discussion of the recent researches of Melin, Peyronel, Falck, and others on the ecological and physiological significance of tree mycorrhiza and the application of experimental results to field conditions and forestry. A particularly interesting chapter is that devoted to a consideration of the tuberisation theories of Bernard and his modern disciple Magrou, especially in relation to tuber development in the potato, and one cannot but agree with the author's tentative rejection of their validity.

In her last chapter, Dr. Rayner, who is the most distinguished English student of these problems and whose researches during seventeen years have added greatly to our knowledge of the mycorrhiza of the Ericaceæ, summarises her views on the symbiotic relationship, coming to the final conclusion that "the possession of mycorrhiza is frequently of benefit to the vascular hosts, the nature and extent of such benefit depending upon the physical conditions of the environment and the physiology of the association in individual cases."

The author has been to immense labour in bringing together the widely scattered information on her problem and has achieved notable success in her synthesis and presentation. Here and there one notes points which might be commented upon, more especially when the author is discussing the actual fungi. Thus, fungi of the "*Rhizoctonia* group" (p. 72) are quite common and plentiful in most soils, as are the 'pelotons' or skeins in varied and numerous species of fungi growing in pure culture. These are trivial details, however, and on the whole the volume impresses one as being an extremely accurate and balanced discussion of the problems of mycorrhiza. The plentiful illustrations, full bibliography, and adequate index complete a book the author may well be proud to have written. W. B. B.

Our Bookshelf.

Air Ministry: Meteorological Office. British Rainfall, 1927: the Sixty-seventh Annual Volume of the British Rainfall Organization. Report on the Distribution of Rain in Space and Time over the British Isles during the Year 1927 as recorded by about 5000 Observers in Great Britain and Ireland. (M.O. 305.) Issued by the Authority of the Meteorological Committee. Pp. xvii + 290. (London: H.M. Stationery Office, 1928.) 15*s*. net.

THE volume of "British Rainfall" for 1927, which has just been published, is the sixty-seventh that has appeared since the British Rainfall Organization was founded by the late Mr. G. J. Symons in 1859, in order to standardise the methods of measurement of rainfall in the British Isles and to provide a means of ensuring that the observations made by amateurs should be preserved and be made available for purposes of research and statistical inquiry. When it is considered that the Organization, in spite of every effort, does not secure the co-operation of all private observers, and that notwithstanding this limitation no fewer than 4970 records are published in this volume, some idea is formed of the valuable material that would be largely wasted every year without some such organisation. It is satisfactory to note that 97 more records have been secured than were available for the 1926 volume.

Turning to the facts about the year's rain revealed by this latest volume, it is noted that over the British Isles as a whole, an excess of rain was measured in 1927 ; this is the fifth successive wet year. This fact suggests that some climate ' surge ' is in operation : the probability is 32 to 1 against such a run of wet years having arisen by ' chance.' Only four wetter years have occurred during the last sixty.

The general arrangement of the volume under review is similar to that of recent volumes. The heavy snowfall at Christmas in the south of England, after a considerable period during which the reputation of that season for snow has steadily declined, has inspired a special article by Mr. L. C. W. Bonacina on the snowfall of the half-century from 1876 to 1925. There is also a report by Mr. F. Hudleston upon experiments with raingauge shields : these experiments throw further light upon the problem of getting accurate measurements of rain in places unduly exposed to the sweep of the wind. There are in addition detailed discussions of cases of exceptional rainfall, and monthly, seasonal, and annual maps showing the distribution of rain over the British Isles for those periods.

Adsorption und Kapillarkondensation : Theorien der Adsorption und Kapillarkondensation von Gasen und Dämpfen an festen Oberflächen und in porösen Körpern. Von Erich Hückel. (Kolloidforschung in Einzeldarstellungen, herausgegeben von Richard Zsigmondy, Band 7.) Pp. vii + 308. (Leipzig : Akademische Verlagsgesellschaft m.b.H., 1928.) 20 gold marks.

IN this critical survey of the theories of the processes of adsorption, particular attention is directed to the limits of validity of the assumptions made in the various hypotheses, and the gaps between existing theories have been bridged by an application of the resources of modern physics. A unification of theory has been attempted, and the same basic principles have been applied to the whole range of adsorption phenomena. Irreversible processes—for example, chemical action—do not come within its scope ; the knowledge of these branches is too incomplete to warrant the extension of the theory to them. The book has been written with the aim of its being intelligible to a public possessing no great mathematical knowledge.

The unifying principle is found in the idea that the effective range of molecular forces is less than the molecular diameter. This idea runs like a silver thread through the fabric of the book. Its substantial accuracy is demonstrated by a mathematical analysis of strength of the electrical field extending from the surface of a crystal of rock-salt and calculation of the heat of adsorption of dipole molecules by this surface. This analysis, as was shown independently by Lennard-Jones, leads to heats of adsorption of the correct order. The formation of a more or less complete monomolecular layer in processes of adsorption is a consequence of the rapid decrease in the strength of the electrical field at the solid surface.

The properties of this film are examined in detail over the whole range of surface density, and linked up with the processes of capillary condensation which occur when gases below their critical temperatures are adsorbed in porous bodies. A simple treatment of the theory is found to be adequate for the interpretation of the major experimental facts ; minor deviations from the simple theory, however, are examined from the point of view of the dipole and quadripole nature of the adsorbed molecules and the electrical and Van der Waals' forces acting between them.

The volume stimulates the reader's interest in the complex interplay of molecular forces which give stability to the monomolecular layer on the surface of solids.

Artistic Creation and Cosmic Creation. By Prof. S. Alexander. (Annual Philosophical Lecture, Henriette Hertz Trust, British Academy, 1927.) (From the *Proceedings of the British Academy*, vol. 13.) Pp. 26. (London : Oxford University Press, 1928.) 1*s*. 6*d*. net.

THE usual theory of artistic creation is that the work of art, previous to its execution, " exists in the artist's mind as an image or intuition." In his Adamson lecture (" Art and the Material "), Prof. S. Alexander has already given reasons for believing that this conception is mistaken. On the contrary, the artist " does not in general first form an image (if he is a poet, say) of what he wants to express, but finds out what he wanted to express by expressing it ; he has, in general, no precedent image of his work, and does not know what he will say till he has said it, and it comes as a revelation to himself." The work of art is " a material thing . . . dyed through and through with meanings, and these meanings sustained and supplied by the appreciating mind." Thus the essence of the work of art is that in it " creative mind and the material are indissolubly fused." But in applying the analogy of the arts to the universe, " we must discount the finitude of the partners in the transaction." The infinite, being infinite, can have nothing outside itself upon which to work as an artist works on his material. The finitude involved in art must be stripped off ; we must abandon the idea of " a mind or spirit which precedes the world and creates it."

" We must look to the world in its simplest expression, and there we find something which corresponds to the essence of art, the complete fusion in it of something that corresponds to mind and something that corresponds to material. . . . It is itself uncreated, but is merely there. In it as in a matrix are formed the finite things which are said to be created. . . . There is no creator of it except itself; but it is the creator of all finites that come into being within it. . . . God, therefore, though not the creator of the Universe, is, so far as He is identical with the universe, creator of all the things within it." J. C. H.

Electrical Engineering Economics: a Study of the Economic Use and Supply of Electricity. By D. J. Bolton. Pp. xi + 305. (London: Chapman and Hall, Ltd., 1928.) 21*s.* net.

THE study of economics is of great importance to everyone. We should all know something about capital and interest, and sinking funds and depreciation. The question is whether we should be taught this at school or at college, or whether we should pick it up in our everyday work. We have heard an eminent engineer wax indignant because he had met a university graduate who did not quite understand what crossing a cheque meant. Another complained that few, if any, technical graduates knew at what stage in the transaction a purchase was completed. In questioning a young salesman on this point, he replied that he had bought a 'business' dictionary to which he referred when in doubt.

The questions Mr. Bolton discusses, however, are not connected with law, except in so far as legal enactments limit methods of production or supply. It seems to us that the questions discussed are mainly concerned with finding out under what conditions we can supply most economically. Many of them are simply problems in finding maximum and minimum values, the solutions to which are sometimes difficult to find. Kelvin's problem, for example, which gives a method of finding the most economical size of conductor to use in supply, is given, and its limitations are explained.

These and many similar problems can often be solved, approximately at least, by graphical methods, and some of these methods are of practical use. We are not convinced, however, that it is necessary to make a special department of 'electrical engineering economics.' There is such an infinite variety of conditions of supply that it is impossible to comprise the solutions to all the problems that arise by means of formulæ.

Coloured Plates of the Birds of Ceylon. By G. M. Henry. With a short Description of each Bird by W. E. Wait. Part 1. Pp. v + 16 + 16 plates. (Colombo: Colombo Museum; London: Dulau and Co., Ltd., 1927.) 30*s.*

IN 1925 Mr. W. E. Wait brought out a most excellent handbook of the birds of Ceylon, illustrated with a few black-and-white plates. At the time it was felt that the value of this book would have been greatly enhanced had it been possible to bring out a certain number of coloured plates to illustrate it, but this was unfortunately a financial impossibility. It was fully realised, however, by the authorities of the Colombo Museum and the author himself that such illustrations were most desirable, and in 1926 the generous help of Dr. Casey Wood made the publication of these plates possible. The painting of the plates has been entrusted to Mr. G. M. Henry, whilst Mr. Wait has supplied a brief précis from his manual as letterpress to each plate. The present part contains sixteen plates, and it is intended to complete the work in four parts, after which it is possible that a further volume may be published.

Taking them as a whole, the plates are excellent. The attitudes of the birds are life-like and vigorous, showing that the painter is well acquainted with their life-history as well as with their museum skins. Whilst the artist is not equally happy in all his efforts—as, for example, in the plates of the Brown-capped Babbler and the Black-capped Bulbul—we think he has been exceptionally successful in his beautiful plate of the Spotted-winged Thrush and Palliser's Warbler. We look forward to the second part of this publication with great pleasure, and if the work is maintained at the present standard, it will undoubtedly be a great addition to the zoological literature of Ceylon and a worthy successor to Legge's great work.

Geheilte Knochenbrüche bei wildlebenden und in Gefangenschaft gehaltenen Tieren. Von Prof. Dr. E. Korschelt und Dr. Hermann Stock. Pp. iv + 176. (Berlin: Gebrüder Borntraeger, 1928.) 24 gold marks.

THE healing of fractured bones in wild animals (mammals, birds, reptiles, and amphibians) reveals the astounding adaptability of the natural forces of repair and the extent to which widely separated fragments can be joined up under natural conditions without the surgeon's assistance. The book is illustrated by numerous photographs and radiographs. In the bibliography of fifty-eight titles, fifty-six are German and none of them British, although, from the time of John Hunter, British anatomists and surgeons have taken special interest in this subject.

Aus dem Leben der Bienen. Von Prof. Dr. K. v. Frisch. (Verständliche Wissenschaft, Band 1.) Pp. x + 149. (Berlin: Julius Springer, 1927.) 4·20 gold marks.

THIS excellent and attractively produced little volume stands out in refreshing contrast with most elementary books on bee life, since it is the product of the author's original researches. Dr. K. v. Frisch is well known as an expert experimenter through his observations on colour sense, methods of recognition, feeding responses, and other features of the sense physiology of the bee. The book is to a large extent a summary of these researches, and we commend it to all interested not only in bee life, but also in general animal behaviour.

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.]*

Short Wave Echoes and the Aurora Borealis.

ON Feb. 29 of this year I received a letter from Engineer Jørgen Hals, Bygdø, Oslo, in which he says : "I herewith have the honour to advise you that at the end of the summer 1927 I repeatedly heard signals from the Dutch short-wave transmitter station PCJJ (Eindhoven). At the same time as I heard the telegraph-signals I also heard echoes. I heard the usual echo, which goes round the earth with an interval of about $\frac{1}{7}$ second, as well as a weaker echo about 3 seconds after the principal signal had gone. When the principal signal was especially strong, I suppose that the amplitude for the last echo 3 seconds after lay between $\frac{1}{10}$ and $\frac{1}{20}$ of the principal signal in strength. From where this echo comes I cannot say for the present. I will only herewith confirm that I really heard this echo."

Immediately I heard of this remarkable observation, it struck me that the wireless waves were reflected from those streams and surfaces of electrons to which I was led by theoretical investigations on the aurora borealis in my paper published in 1904 in *Videnskabsselskabets Skrifter*, Christiania ("Sur le mouvement d'un point matériel portant une charge d'électricité sous l'action d'un aimant élémentaire.") In reference to that paper, and the subsequent more complete one in *Archives des Sciences physiques et naturelles*, Geneva, 1907, one of the most striking features of the theory was that streams of electrons coming from without towards the earth were deviated by the earth's magnetic field in such a way that an immense space was formed free from electric particles, and having the shape of a torus described by revolution of an oval tangent to the magnetic axis of the earth at the centre. These results were also in full agreement with Kr. Birkeland's remarkable experiments with cathode rays directed towards a magnetic sphere, described in 1901 in *Videnskabsselskabets Skrifter* ("Expédition norvégienne de 1899–1900 pour l'étude des aurores boréales"). If now the wireless signals could penetrate the Heaviside layer, they would pass into this empty space, and might be reflected by the walls of the electrons forming its outer boundary. The long time interval between the principal signal and the echo agrees well with the immense dimensions of these toroidal spaces.

It was now very interesting to me to obtain more evidence of these remarkable echoes, and last spring and summer I organised a long series of observations, for which I am very much indebted to Dr. van der Pol, at Philips Radio, Eindhoven, for his very efficient work in sending signals, and further to Elektrisk Bureau, Oslo, to the Norwegian Telegraph Administration, and to Engineer Hals, for aid in arranging the reception of the signals. The observations were continued during October, but no certain evidence was obtained before Oct. 11. Eindhoven emitted during the afternoon very strong signals of undamped waves of wave-length 31·4 metres, and Hals and I heard very distinct echoes several times, the interval between signal and echo varying between 3 and 15 seconds, most of them coming about 8 seconds after the principal signal. Sometimes two echoes were heard with an interval of about 4 seconds. I immediately telegraphed the success to Dr. van der Pol at Eindhoven, and asked him to control and verify the effect. Next day I received the following telegram: "Last night special emission gave echoes here varying between three and fifteen seconds stop fifty per cent of echoes heard after eight seconds stop van der Pol."

After this it seems that we have here a new and remarkable phenomenon, the study of which may throw much new light on the electric currents in space outside the earth and on their connexion with the aurora borealis and magnetic storms. The variability of the phenomenon indicated by the observations agrees well with the corresponding variability of aurora and the magnetic registrations. CARL STØRMER.

The Expansion of Charcoal accompanying Sorption of Gases and Vapours.

IT has been emphasised in a recent paper (Bangham, *Phil. Mag.*, **5**, 737; 1928) that our knowledge of the sorption process must necessarily remain incomplete so long as attention is focused solely on the behaviour of the gas or solution, to the entire neglect of any concomitant effect on the solid sorbent with which it is in contact. It was shown by Meehan (*Proc. Roy. Soc.*, A, **115**, 199; 1927) that even such a rigid structure as a block of charcoal expands considerably when taking up carbon dioxide, the expansion being of the same order as the water-movements of building materials as determined in the experiments of Stradling. From the theoretical point of view the effect is discussed in broadest outline in the first of the papers mentioned, but it is clear that much experimental work is necessary before a fully developed theoretical treatment is possible.

A modified form of Meehan's apparatus, made to our design by Messrs. Becker, has enabled us to make some preliminary measurements of the linear expansion of charcoal which has sorbed known weights of water vapour at pressures short of saturation. It was found that the expansion is not—as one might have supposed—directly proportional to the quantity of vapour sorbed, but that the curve obtained on plotting the variables is concave to the *expansion* axis, even in the region where the pressure of vapour is a considerable fraction of the saturation pressure. Apart from providing fairly direct evidence—if such were lacking at this stage—for the chemical, as opposed to the capillary-condensation theory of sorption at such pressures, this fact appears to throw considerable light on the question of the usual form of sorption isotherm, since it indicates that the mechanical disturbance suffered by the solid during the sorption of a given quantity of gas becomes greater and greater as the sorption proceeds.

It is remarkable that, within experimental error, the expansion is directly proportional to the *square* of the sorption value. The data obtained for carbon dioxide are also in substantial agreement with this relation; they are, however, subject to certain corrections which can be estimated with accuracy only when the apparatus is cut down. The following table gives a summary of the results so far obtained :

	Water.			Carbon Dioxide.		
	s.	η.	$\frac{\sqrt{\eta}}{s}$.	s.	η.	$\frac{\sqrt{\eta}}{s}$.
Increasing sorption series	2·22	0·056	0·106	0·900	0·087	0·326
	5·18	0·226	0·092	1·227	0·149	0·315
	6·83	0·416	0·094	1·418	0·177	0·297
	8·59	0·626	0·092	1·557	0·232	0·309
	8·98	0·689	0·093	1·843	0·295	0·294
				1·980	0·338	0·293
Decreasing sorption series	7·40	0·475	0·093			
	5·78	0·231	0·095			
	4·21	0·139	0·089			

s = Sorption value in milligram molecules.
η = Expansion in arbitrary units.

No special attention was paid to the absolute measurement of the expansion, but a knowledge of the dimensions of the apparatus enables a rough comparison to be made with Meehan's results under corresponding conditions. The percentage linear expansion found by us to be caused by an atmosphere pressure of carbon dioxide works out at about 0·101 at a temperature of 30° C. Meehan found the percentages at 28° C. and 36° C. to be respectively 0·1292 and 0·1100 in the case of the pinewood charcoal used by him.

It will be observed that the quotient $\sqrt{\eta}/s$ is, on an average, rather more than three times greater for carbon dioxide than for water, so that the expansion caused by the sorption of any given number of molecules is between ten and eleven times as great in the one case as in the other. The difference is quite out of proportion to the difference of molecular size, whatever method is used as a basis of comparison.

While it is scarcely likely that the square-root relationship will prove to be of general application, it is at least significant that two substances so different in their general behaviour towards sorbents as carbon dioxide and water should both show this simple regularity. Experiments with other sorbents and sorbates are being proceeded with.

D. H. BANGHAM.
NAZIM FAKHOURY.
Egyptian University, Cairo.

Hamilton-Buchanan's Drawings of Indian Fish.

IN NATURE of May 12, p. 770, the following statement was made under " Research Items " in directing attention to my recent work on the MS. drawings of Indian Fish (Ham.-Buch. Collection): " In the first volume there are 22 plates of fish illustrations, representing 51 species, and the rest of the plates are of mammals ; the second and third volumes are drawings of birds made by Mr. Gibbons ; and the fourth are those of fishes, representing 150 species." I am afraid the writer of these notes has given wrong information. In the first volume there are only twenty plates of fish, and while in the second and third volumes there are some drawings by Mr. Gibbons, the majority of the plates are Buchanan's. The fourth volume contains delineations of 144 species.

I have now examined Buchanan's fish drawings preserved in the libraries of London with interesting results. Through the kindness of Lieut.-Col. R. B. S. Sewell, I have with me the Zoological Survey set (copies recently made) of the drawings in the Asiatic Society of Bengal. There is no doubt that the original drawings, of which Buchanan was deprived at the time of his departure from India in 1815, are those now in the possession of the Asiatic Society of Bengal. I have found a statement in Buchanan's own handwriting that he was not allowed to bring with him drawings of 144 species of fish. It seems to me certain that only 138 out of the 146 drawings listed by Day in vol. 4 (*Proc. As. Soc. Bengal*, pp. 195-209; 1871) are the originals which Buchanan left behind him. Drawings Nos. 34, 53, 62, 63, 64, 70, 71, 84 have been added afterwards to this set. The drawings of *Cyprinus chola* (Pl. LVIII, Fig. 3) and *C. dancena* (Pl. LV, Fig. 4), figured by McClelland, were missing when Day examined the set in 1871. There are four drawings in vol. 1, the originals of which are missing from vol. 4, namely, *Cheilodipterus panijus*, *Mystus chitala*, *Cyprinus curchius*, and *Cyprinus chagunio*. This gives us the original number of drawings belonging to Buchanan's collection—138 + 2 + 4 = 144.

In the library of the India Office are now preserved the originals of the drawings reproduced in the " Gangetic Fishes." In the same volume are five other drawings which were not used by Buchanan. These represent the following species : *Macrognathus armatus*, *Cyprinodon cundinga*, *Clupea purava*, *Mystus kapirat* and *Cyprinus sarana*.

In the library of the Linnean Society there are nine original drawings of Buchanan (probably out of a set of ten, one missing now), accompanied by the descriptions of ten species in Latin. These were sent by Buchanan to his friend Smith, the founder of the society, in 1799. All these nine drawings are figured in the " Gangetic Fishes," no doubt from the replicas of these very drawings.

The set referred to by Günther in the *Zool. Rec.* for 1869 is nowhere to be found in the British Museum (Nat. Hist.). It is probable, however, that Günther was referring to a large number of copies of Buchanan's manuscript fish drawings in the Calcutta and the India Office collection made by Major-General Hardwicke, and bequeathed to the Museum. Identifications in Günther's handwriting are to be found below some of these drawings, while the others bear references to " Gangetic Fishes " in Hardwick's handwriting. Some of these have been published, unfortunately without acknowledgment, in Gray's " Illustrations of Indian Zoology." Attention may also be directed to two or three copies of Buchanan's drawings among a set of Day's fish delineations, now preserved in the library of the Zoological Society of London.

These drawings are of special interest, for it seems to me likely that, in his descriptions of the Gangetic fishes, Buchanan greatly relied on them for the specific characters, at least in the case of quite a number of species. Thus, in the absence of any authentic types, these drawings may be considered as the types of the species described by Buchanan.

SUNDER LAL HORA.
British Museum (Nat. Hist.),
South Kensington, S.W.7.

Life and Sea Water.

THE leading article in NATURE of Oct. 6, p. 501, and Prof. F. G. Donnan's discourse, p. 512, recall attention to the conditions under which life may possibly have originated. This provides a certain playground for our ideas, romances, and inquiries; a playground with boundaries and with regions of special interest.

If blood-heat is about 35° C., or a little more in birds, and the optimum temperature for plant life about the same, this turns our thoughts away from the chill shores of north-east England to some tropic coast where rock pools may lie in hot sunshine between tides, evaporating and concentrating. The roughly 3 per cent solution we know as sea water is rather weaker than the 5 per cent normal saline of the physiological laboratory, where one must think of osmotic equilibrium or plasmolysis between tissue and fluid. Not that the density of the salt solution is the only thing that matters. Field and garden crops thrive best on a rather different mixture of salts demanding artificial additions of potassium, phosphates, and nitrates. How could such a nutrient solution have arisen under natural conditions ?

When sea water evaporates, the contained substances are deposited, and in a certain order ; some substances come out more readily, others less rapidly, than sodium chloride. Chapters of this order of deposition are recorded in the deep-sea floor, in the English Permian and Trias rocks, in the Stassfurt salt deposits, and in the terraces above the Dead Sea. There are manganese deposits in the deep sea, also silica and calcium carbonate. Silica and calcium carbonate come out as diatoms and foraminifera; sea water must be about a concentrated solution of these. Iron compounds and gypsum begin to come out before rock salt; the mother liquor saturated as to iron, calcium sulphate, and sodium chloride, still contains potassium, magnesium, bromides, and iodides. With concentrating liquors double salts appear—magnesium-potassium sulphates and chlorides, substances like kainite and carnallite. Their philosophy and the equilibrium conditions of their crystallising solutions are worked out by van 't Hoff. These are the potash salts so valuable as artificial fertilisers. Carnallite need not be despised in theory because too deliquescent to handle in practice.

If these fertilisers cherish life now, may they not have been essential conditions for the origin of life?

The rusting of iron depends on air, moisture, carbon dioxide, conditions curiously like those of life; further, rust is encouraged by ammonium chloride, discouraged by potassium cyanide. May we postulate meteoric or other metallic iron?

If colloidal iron or silica forms a framework within which processes like life processes may arise, must we not look for conditions under which they might form in Nature? May we not regard all integrations—precipitation, crystallisation, double-salt formation—as stages towards life? Huxley pointed out that the essential life processes were formations of more solid substances from liquid or from gas.

A crystal begun in a solution of one alum may go on building itself up in another. Iron or aluminium may continue the work begun by chromium or manganese, ammonium may continue potassium. How do we know that life is not a sort of chemical habit? Long before chlorophyll or hæmoglobin were evolved, complexes may have been initiated by copper or nickel or manganese, afterwards to be inherited by iron. Sodium silicate is conspicuously absent from collections of natural minerals. Where has it all gone? It almost must have been formed in the pre-geologic era and washed out afterwards.

Pools by a tropic seashore would be liable to dilution from rain and from streams as well as to concentration; and streams from a volcanic island might bring in many sorts of substances, including ammonia compounds; hot springs bring silica in solution. Hence all kinds of oscillating conditions may be postulated, and life involves such oscillations. With concentrating solutions cells divide, seeds ripen; with dilution cells swell, antherozoids escape, seeds sprout.

Darwin said, at most four or five ancestors for all living things; but may we not imagine many and various just not successful attempts at life, combinations just not viable, an almost infinite number of collateral ancestors who have left no descendants? Only a hint of other possible chains of chemical reactions in the iron and sulphur bacteria and all the specialised cells in the glands of higher animals.

HUGH RICHARDSON.

Stocksfield, Oct. 7.

Proposal to Establish a Size Limit for both Salmon and Sea Trout in the Baltic.

IN vol. 48 of *Rapports et Procès-Verbaux des Réunions* of the Permanent International Council for the Exploration of the Sea, recently published, six writers, each representing a country abutting on the Baltic, give accounts of the salmon and sea trout fisheries, and in one case, that of the Swedish biologist Gunnar Alm, particulars of the early river life and of the sea life of a considerable number of salmon are given (presumably from scale reading).

It is clear that *S. salar* in the Baltic, as in British waters, may remain one, two, three, or four years in the sea before ascending fresh waters to spawn; that fish from widely separated rivers mingle in their sea life, and that on this account very different sizes are caught together; and it also appears that small immature fish are taken in the spring off the shallow coasts of Sweden.

Drs. Andersson and Johansen summarise the results, note that the Baltic salmon fisheries are now being conducted more intensively than in former years, and that the stock of fish is seriously declining. They state that in any international action for the preservation of the fisheries, the first consideration is to allow more fish to ascend fresh waters to spawn, and that "the imposition of a size limit is designed as a means to prevent the capture of small salmon and to give the salmon an opportunity to spawn."

It is with some amazement, therefore, that one reads the recommendation that the size limit be 35 cm.

A fair number of sea trout under 14 inches are sexually mature, but no salmon can be expected to spawn at so small a size, in spite of the fact that a few precocious male smolts are found from time to time. The remarkable thing is that the figures supplied by Alm are themselves amply sufficient to show how futile for the purpose stated a size limit of 35 cm. would be.

If there is a desire to increase the numbers of potential spawners in the rivers of the Baltic, why decree that all the salmon of spawning size may be killed? If the exigencies of the fisheries or the established practices of the fishermen make it difficult to recommend a larger size limit, it would appear that regulative treatment by size limit should be abandoned.

From the fact that fish of all sizes are caught together, but more particularly from the fact that salmon commonly spawn quite late in life and when more than twice the length of 35 cm., and that very many fish spawn only once in their lives, it should be clear that regulative treatment by size limit is not suitable.

Might I say further that experience in other countries has gradually brought about a recognition of the guiding principle that the sea is the place where, with suitable regulation as to mesh of nets and means of capture, salmon and sea trout may be freely taken, and that the river is the place where those fish reproduce their species, and where, therefore, they should be protected from capture, or at least from such commercial fishing as would prevent a proportion of every run of fish getting past the nets allowed, and so reaching the spawning areas.

W. L. CALDERWOOD.

Edinburgh, Sept. 27.

Birth of Adders in Captivity.

THE adder (*Vipera Berus*) has her young about the end of August and the first week in September. The gestation period is 4½ months. It is unusual for a herpetologist to have a captured snake giving birth to young immediately after being caught, but such has been my experience on two occasions, the first on Aug. 29, 1905, and the second quite recently, on Oct. 1, 1928, the latter birth being on a later date than normal. The adder in this case was a healthy specimen measuring 23 inches in length. On being caught I noticed that it was a bit sluggish and lethargic in its movements, making very little effort to escape. There was nothing in its contour to suggest pregnancy beyond being slightly corpulent, and I was certainly very much surprised to find on opening its cage one morning eight days after capture a brood of eight young adders. They measured $4\frac{1}{2}$ inches in length and six are females and two males.

The young adders were all normal specimens except one, which had malformation of the maxilla and palate. It was not so active as the others, which very soon after birth developed a marked biting tendency. The viciousness of these creatures prompted me to test their toxicological properties. So I got them to bite an ordinary microscopic slide, when I found that no secretion was produced until the third day after birth. I mixed some of the venom with fresh pig's blood, and microscopic examination of the slide revealed that the blood underwent a comparatively rapid hæmolytic and agglutinative change, indicating that the poison in this short period had acquired its maximum potency.

This in itself is an interesting observation and worthy of being placed on record, since it established that the degree of virulence of adder's poison is not proportionately in keeping with the degree of the physical development of the creature.

I have said in another place that adders will not feed in captivity, but I thought that these youngsters might be induced to take food, because in their case they had no knowledge of the freedom of wild life: their world was circumscribed by the confines of their cage. One would therefore imagine that they would respond to Nature's call for sustenance; consequently I made special efforts to coax them to take suitable nourishment, but my efforts were fruitless: they stolidly refused to touch a morsel of food.

Mother and family are still alive and well; for adders will live for a long time without taking any food. The hibernation period begins early in October, and although it is now the 22nd of that month, these creatures show no sign of becoming sleepy or torpid. Adders will not hibernate in captivity.

I should like to mention that the female adder did not show any maternal instinct towards her offspring. This may have been due to the reptile being in captivity.

N. Morrison.
Beith Place,
Campbeltown, Argyll.

Components of Air in Relation to Animal Life.

Oxygen, since the time of Lavoisier, has been considered the vital component of the air: the 79·19 per cent inert part has had little use assigned it. Popular opinion had stated that animal life would be more efficient if these inert gases were replaced by oxygen. Carefully conducted experiments covering a period of six years have shown the following facts in regard to animal life and the components of the air.

Animals cannot live in an atmosphere of oxygen, nitrogen, carbon dioxide, helium, or argon alone. A series of thirty experiments, using representative varieties of animal life, has shown that in an atmosphere of pure oxygen with other conditions normal, life would cease after two to five days. As could be expected, the inert gases would not support life.

An examination of the lung tissue from a guinea-pig which had died in an atmosphere of pure oxygen showed marked evidences of inflammation and interstitial hæmorrhages. Cultures made from the lung tissue showed a heavy infection of *Bacillus coli* associated with a few staphylococci. The conclusion drawn from the autopsy was that an atmosphere of oxygen should not only rupture the lung tissue but also accelerate the growth of certain micro-organisms.

Animals were placed in an atmosphere of 99·97 per cent oxygen and the normal 0·03 per cent carbon dioxide. Death followed within two to five days as in the oxygen experiments.

An atmosphere was prepared which contained 87 per cent argon and 13 per cent oxygen. Mice lived forty-two hours under this condition. The respiration of the animals decreased slowly until death.

Argon 80 per cent and oxygen 20 per cent permitted life for ninety-two hours.

Argon 75 per cent and oxygen 25 per cent supported normal life. After ten days of confinement the animals appeared in better health than before the experiment. An atmosphere made up of $66\frac{2}{3}$ per cent argon and $33\frac{1}{3}$ per cent oxygen supported life. The animals after seven days' confinement were in poor health. The point of highest efficiency had apparently been passed. Helium 79 per cent and oxygen 21 per cent form an atmosphere under which animal life may exist normally.

The high specific gravity, 1·38 (air), of argon gas, probably accounts for its behaviour as an oxygen diluting agent. Experiments must be carried further before a scientific conclusion can be reached.

The preparation of synthetic atmosphere has practical applications in the field of aviation. Tubes of compressed oxygen and helium may some day furnish the respiration gases for high flying.

The study of the physiological effects of the air gases has only begun. The experiments will be carried further before an attempt is made to interpret the data thus far gathered.

J. Willard Hershey.
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Spectra of Intermetallic Compounds.

During the last few years it has been established, on the basis of spectroscopic and other evidence, that certain metals, for example, the alkali metals and mercury, are capable of forming di- or poly-atomic molecules in the vapour state. It is also known that the vapours of certain pairs of metals (for example, sodium-potassium, rubidium-cæsium, and their analogues, also magnesium + alkali, and mercury + alkali) contain molecules of volatile intermetallic compounds. Both types of molecule are most conveniently studied by their absorption spectra, and most of them have been discovered in this way.

The great sensitivity of the spectroscopic method renders it necessary, however, to proceed with caution, as band spectra due to unexpected impurities frequently make their appearance, and are often difficult to identify. Errors of this nature would appear to have entered into recent work on the band spectra of zinc, cadmium, and mercury (Mohler and Moore, *Jour. Opt. Soc. Amer.*, vol. 15, p. 74; 1927), and also into an investigation of mercury-thallium and indium-cadmium mixtures (Waring, Nature, vol. 121, p. 675; 1928; and *Phys. Rev.*, vol. 32, p. 435; 1928), as the same spectrum has been assigned two different origins —neither of them the true one—by the two different investigators. The greater part of the 'mercury-thallium' spectrum described in the latter papers is identical with one listed (though with some reserve) in the former under the heading of the 'cadmium' molecular spectrum. The true origin of this particular band system would seem to be the molecule of thallium chloride, as it is magnificently developed in very dilute vapour of that salt, under conditions precluding the presence of free metal. Similarly, the 'indium-cadmium' spectrum of Waring would seem to coincide with another set of 'cadmium' bands found by Mohler and Moore. The wave-length agreement is not so perfect as it is for the previous systems, but the bands are very diffuse and are difficult to measure. We have also experimented upon the conditions under which these bands are developed, and since they are eliminated by additions of small quantities of alkali metals to the vapours, and are enhanced by additions of oxygen, we conclude that they may arise from an association of cadmium and oxygen. From experiments now in progress, however, we suspect that they may be totally unconnected with cadmium, and that another and unidentified impurity is responsible for them.

We hope that a complete account of these and other experiments will shortly appear elsewhere. It is, unfortunately, not possible to include a wave-length comparison in this letter, for reasons of space; but it may be stated that the agreement is so good that there can be no doubt of the identity of the spectra.

J. M. WALTER.
S. BARRATT.
University College, London,
Oct. 12.

Contractions for Titles of Periodicals.

OWING to absence from London I have only now seen Mr. Gomme's letter in NATURE of Sept. 22. I believe that among experts there is fuller agreement than either Mr. Gomme or the compilers of the "World List" would seem to admit on some of the rules which should govern the abbreviations of titles of scientific periodicals. Few, I think, would dispute the rules (*a*) that in an abbreviated title the abbreviations should follow the same order as the corresponding words in the full title of a journal as it appears on title-page or cover; and (*b*) that in a system of abbreviations the same contraction should not be called on to do duty for words of entirely different meaning. In my letter to NATURE of Aug. 25 I gave examples of what appeared to me to be infringements in the "World List" of both these rules.

Mr. Gomme seems to regard these infringements as unimportant so long as a searcher is able to consult at first hand the "World List," and has familiarised himself with its admitted vagaries, and possesses also a good knowledge of the titles of scientific periodicals to help him out in obscure cases. In thus advocating the "World List," Mr. Gomme overlooks the fact that when one is considering the universal adoption of a system of abbreviations for titles, regard must, in the first instance, be had to the requirements of scientific readers of all nationalities, of whom few will have ready access to the "World List," and still fewer will enjoy facilities that are at the command of a librarian of a large institution. To such readers the observance of the rules set out above, and of others which I have indicated in my letter of Aug. 25, is, I think, important. In their interest I would urge the soundness of yet another rule, laid down some years ago at the conference held in connexion with the International Catalogue of Scientific Literature, that abbreviated titles must be intelligible without a key.

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Oct. 15.

The Contraction of Pachyphase Chromosomes in *Lilium*.

IN the pachyphase of *Lilium pardalinum*, in specimens fixed with chromic-acetic-formaldehyde, and stained with iron-brazilin, there were estimated to be 2193 chromomeres, each usually consisting of two pairs of chromioles. The average diameter of the chromioles was estimated at 0·23 micron, and the average distance between the centres of neighbouring chromomeres was calculated as 0·67 micron. Hence it could be deduced that an approximation of the chromomeres until they were in close contact would decrease the total length of the bivalents from 1469 microns at pachyphase to 504 microns (at diplophase). But in *Lilium longiflorum*, the maturation divisions of which closely resemble those of *L. pardalinum*, the total length of the twelve bivalents at late diaphase and at metaphase (and also the total length of twelve of the split anaphase chromosomes) was only about 150 microns.

This remaining contraction, to less than one-third of the minimum size which could be attained by approximation of the chromomeres, was presumed to be probably brought about by zigzagging of the chromonema, or chain of chromomeres. Since the volume of chromatin was shown by measurements to increase to about ten times its bulk between pachyphase and metaphase, this zigzagging was not directly visible; but it was indicated by the corrugation of the chromosomes at all stages from late diplophase to first anaphase. The total contraction in length, from pachyphase to first metaphase, was found to be about the same in *Aloe purpurascens* as in *Lilium*.

JOHN BELLING.
Carnegie Institution of Washington,
Department of Genetics,
Cold Spring Harbor, N. York, U.S.A.,
Sept. 27.

The Depth of Field and Resolving Power of Optical Instruments.

IN his letter in NATURE of Oct. 27, Mr. T. Smith repeats in a slightly different form the matter contained in my letter in the issue of Oct. 13. If the wave-length were infinitesimal the geometric theory would be correct. With a finite wave-length it 'pays,' so far as definition is concerned, to reduce the lens aperture until the 'spurious disc' and the 'circle' of confusion due to part of the image being out of focus are of the same order. Airy's work relating to the 'spurious disc' is contained in a paper entitled "On the Intensity of Light in the Neighbourhood of a Caustic." This I read in 1871. In reference to the same subject, the late Lord Rayleigh quotes Verdet's "Leçons d'optique." This I have not seen.

Mr. Beck states (p. 650) that 'etched' lines at 140,000 to the inch have been resolved and seen by the eye. If the lines are etched it is certain that the surface is not flat, but grooved, and no doubt the depth of the grooves is sufficient to alter the length of the wave path enough to effect resolution.

A. MALLOCK.
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Exeter.

Salmon and Sea Trout Synonyms.

MY attention has been directed to your comments, on page 547 of NATURE of Oct. 6, on my collection of local and general names applied to salmon and sea trout. The article to which reference is made was merely an attempt in the first place to clear up some of the superfluities of popular nomenclature and local idiosyncrasy, which you rightly condemn; and secondly, to collate and preserve them in the interests of philology. Whilst admitting that the list would have been much increased in value had the area in which each name is used been indicated, it is regretted that this would not be feasible, owing to the fact that many of the terms are used in the same sense throughout the country.

ALBERT WADE.

A 200-inch Telescope.

WE are informed by Science Service, Washington, D.C., that what will be the world's largest telescope, with a concave mirror two hundred inches in diameter—twice that of the greatest existing instrument—will be under construction within a few months. This important announcement was made at the California Institute of Technology on Oct. 29. The funds will be provided by the International Education Board of New York, which administers some of the Rockefeller benefactions. "The interest of the Board is based chiefly upon the successful co-operation of the Mount Wilson Observatory and the California Institute, and their belief that the provision of additional means of furthering this joint work may lead to many new advances in astronomy, physics and chemistry," it was stated. "The full co-operation of the Carnegie Institution of Washington, of which the Mount Wilson Observatory is a branch, has been assured by the unanimous action of President John C. Merriam and the executive committee of the Institution, and by that of Director Walter S. Adams and other members of the Mount Wilson staff. The research policy of the new Astrophysical Observatory of the California Institute, which will be designed to supplement and not duplicate the Mount Wilson Observatory, will be determined by a joint committee representing the two institutions, aided by other leading investigators."

Dr. George Ellery Hale, honorary director of the Mount Wilson Observatory, and chairman of the Observatory Council of the Institute, described the plans on Oct. 29 in an exclusive interview to Science Service. "In designing this instrument," he said, "we shall have the collaboration of leading physicists and engineers as well as of astronomers and instrument makers. When the telescope is completed it will be used to extend our present researches in various directions, as in spectrum photography of the stars, direct photography of very faint celestial objects, and in radiometry, or the measurement of the heat from the stars. By making a special study of the various instruments and methods to be used in conjunction with the new telescope for these and other purposes, and by securing the co-operation of the ablest authorities, we expect greatly to increase the efficiency of the telescope.

"The equatorial mounting of the telescope will be designed by a group of experts, including Dr. J. A. Anderson, Dr. Francis G. Pease, and other members of the staff of the Mount Wilson Observatory, working in conjunction with several eminent engineers, opticians, and physicists. It is the great mirror, nearly 17 feet in diameter, double that of the largest that has yet been made, that will offer the most difficulty. We expect to make it out of fused quartz, and are much pleased by the cordial and generous offer of co-operation received from President Gerard Swope of the General Electric Company and Dr. Elihu Thomson, director of the Thomson Research Laboratory of this Company at West Lynn, Mass. Dr. Thomson is deeply interested in the problem, and has already succeeded in making quartz discs of considerable size. His method is to cast a quartz disc full of fine bubbles and to fuse a layer of very pure quartz, free from bubbles, on the surface, in which to grind the proper dish-shaped figure. Such a mirror behaves as well as a perfectly solid one, and has the advantage of being lighter.

"The great advantage of quartz is that it changes its form so slightly with temperature. With the 100-inch telescope now at Mount Wilson we must always be careful to avoid exposing the glass mirror to the heat of the day, and some changes often occur due to differences in temperature at night. With a quartz mirror the effect of temperature is too slight to give any trouble. We feel confident that by the time we are ready for the mirror, Dr. Thomson will have succeeded in making a quartz disc of the requisite size. Pyrex glass, which is much better than ordinary glass but not equal to quartz, might be used as a substitute if necessary."

Just how long it will be before the new telescope is in operation, it is at present impossible to tell, but it will doubtless be several years. The plans for the 200-inch telescope have no connexion with the project of Prof. George W. Ritchey for a large telescope at the Grand Canyon, in Arizona. Prof. Ritchey has been working in Paris for several years on a method of constructing large telescope mirrors in a cellular fashion, but it is not planned to employ his method in the 200-inch.

The exact location of the new telescope also remains to be decided. Perhaps it will be placed on Mount Wilson (5900 feet altitude), where there would be the advantage of proximity to the other observatory facilities. However, it is possible that the smoke, dust, and glare of electric lights from Los Angeles in the future, with the city's increased growth, may prove a disadvantage, especially because of the comparatively short focus of the instrument. Several other sites are therefore being tested in comparison with Mount Wilson.

The trustees of the California Institute have placed the entire project in the hands of a committee of the Executive Council of the Institute, consisting of Dr. Hale; Dr. Robert A. Millikan, director of the Norman Bridge Laboratory of Physics; Dr. Arthur A. Noyes, director of the Gates Laboratory of Chemistry; and Mr. Henry M. Robinson, well known for his work as a member of the Dawes Commission and in other international undertakings. Dr. John A. Anderson, physicist and astronomer of the Mount Wilson Observatory, will serve as executive officer of the Observatory Council, in direct charge of design and construction. They will be assisted by an advisory committee including Dr. Walter S. Adams, director of the Mount Wilson Observatory; Dr. Frederick H. Seares, assistant director; Dr. A. A. Michelson, of the University of Chicago; Dr. Charles G. Abbot, secretary of the Smithsonian Institution; Prof. Henry Norris Russell, of Princeton University; and Profs. Richard C. Tolman and Paul S. Epstein, and

Ira S. Bowen, of the California Institute. Mr. George Eastman, and Dr. C. E. K. Mees, director of his research laboratory, have offered fullest co-operation in the study of special photographic problems. Dr. Ambrose Swasey, chairman of the Warrer-Swasey Co.; Mr. Gano Dunn, president of the J. G. White Engineering Co., and recently chairman of the National Research Council; Dr. Frank E. Ross, of the Yerkes Observatory, and others equally well known, will aid in the work of design, and many other scientific workers especially qualified will be available for consultation.

Processes of Colour Photography.

By F. J. TRITTON.

COLOUR photography is one of the few branches of photography that has made relatively little progress of recent years; in fact, for the last twenty years there has been nothing fundamentally new to record, if a recent invention to be referred to later be excepted.

There has, however, been a steady improvement in technique and a series of variants on known processes, which have made plainer the limitations and possibilities of this branch of photography. Also, for some reason which is difficult to define, there has grown up a distinct re-awakening of interest in colour photography, which is perhaps best exemplified by the recent formation of the Colour Group of the Royal Photographic Society. Considering its youthfulness, this group has had a highly successful first year and seems likely to develop steadily. Possibly the undoubted popular interest in colour cinematography has had something to do with this revival of interest in colour among the photographic community.

The foundations of colour photography were laid by Clerk Maxwell, Ducos du Hauron, Chas. Cros, and a few others between 1857 and 1870, but practical applications could not be very successful since colour sensitive plates were unknown. The first step in this direction was the discovery of the colour sensitising action of certain aniline dyes by H. W. Vogel in 1873. From this the panchromatic plate has gradually evolved, and one of the most remarkable achievements of recent photographic manufacture has been the improvement in quality, speed, and trustworthiness of these plates, culminating just recently in the introduction of the Ilford Soft Gradation Panchromatic Plate, which seems to have been intended primarily for the portrait photographer, but should prove of particular value to the colour photographer when its capabilities are properly explored.

The first successful colour photographs on paper were made by the carbon process by du Hauron, and, despite the advances made, this process is still one of the best. Commercial carbon 'tissues' for trichrome printing were first introduced about 1906 and the formulæ were scarcely altered or improved until quite recent years, when three-colour carbro began to assume greater importance than its parent process. The first step in this direction was the Manly ozobrome process, but the real advance came when, in 1914, Manners introduced his Raydex process, which is now unfortunately extinct, although the inventor is very successfully using his process to produce commercial colour prints in America at the present time.

Meantime, the Autotype Company had introduced three-colour carbro, the materials for which were improved in 1926. In this process three bromide prints are made from the three separation negatives, and from these three carbro prints are made in the respective printing colours on transparent celluloid temporary supports. In this way the action of light is cut out, except in the making of the bromide prints, and a much greater degree of control is introduced. This control is not required for purposes of 'faking' the colour rendering, and, in fact, must only be used in strict accordance with certain set principles or else accurate colour reproduction is impossible. But it is found that with the straightforward carbon process it is frequently difficult to obtain accurate colour intensities owing to the negatives being of the wrong 'gamma' to suit the printing medium employed. With the three contrast grades of bromide paper always available, and with the control over contrast provided by the carbro process, this difficulty disappears. A further great advantage is the ability to enlarge to any convenient degree without extra trouble. The making of enlarged copy negatives was always fraught with many dangers owing to the probability of varying the contrast range of one or more of the negatives.

Provided reasonable care is taken at every stage and all the usual precautions are observed, there is not the slightest difficulty in retaining accurate register of the three colours in greatly enlarged three-colour carbro prints, and undoubtedly this process is now the one most favoured. It is of interest to note that it is now being commercially used in America, France, and England for the production of 'originals' from which three-colour blocks are being made.

In the processes so far mentioned the colours used are insoluble pigments dispersed in the gelatin layer, and in modern commercial 'tissues' or pigment papers they can be considered as completely stable and fast to light, so that the finished picture is permanent.

The other important class of colour prints is based on the use of dyes. The first commercial process was Pinatype, introduced in England in 1905, and still occasionally used. In this process, three 'print plates' coated with dichromated gelatin are exposed behind positives, prepared from the separation negatives, so as to produce differential tanning. When the excess dichromate has been washed out, the print plates are dyed up in the appropriate Pinatype dye, rinsed and squeegeed into contact with a piece of damp gelatin-coated paper. It is found that the untanned portions of the gelatin take up most dye and transfer it to the paper most readily, and, if the exposure has been correct, the tanned portions can be made not to transfer any dye. But in practice this is difficult to achieve, so that the high lights are nearly always stained and the process proved tedious. The dyes used are a special class only manufactured in Germany, the range appears to be limited, and they are not particularly correct as to colour. Compared to many dyes, their fastness to light is fairly good, but they cannot be described as permanent.

A later and much more satisfactory process is the Jos Pé, which again originates in Germany and uses the same dyes, only under a different name. The difference is that the print plate does not consist of an even layer differentially tanned but of a true relief image produced by washing away the soluble portion in hot water. This enables much cleaner and brighter prints to be produced, and some excellent work has been exhibited. In addition, the use of daylight printing is eliminated, since the print plates are gelatino-bromide plates exposed through the back and tanned by the use of a pyro developer deficient in sulphite. This has proved quite successful, but in my opinion pyro tanning is never able to produce the clean sharp image obtainable by chromium tanning.

Further improvements and simplifications along well-recognised lines in both the carbon and imbibition types of processes are very probable, but it is unlikely that they can ever solve the problem of colour photography and make it a process for the amateur.

Undoubtedly, the most important development in this branch of photography is the Martinez patent as improved by Colour Photographs, Ltd. The process is not yet quite ready for marketing, but extensive experimental work is being carried on and a number of demonstrations have been given and prints exhibited. In outline, the process consists in sensitising thin cellophane films in solutions which appear to be based on the use of light-sensitive iron salts. When dry these are exposed under the appropriate separation negatives to daylight or strong artificial light, when they print out very much like P.O.P., but the three types of film produce images which on fixing approximate very closely to the three primary colours. The fixing is a matter of extreme simplicity, water and dilute acid being used for the blue print, which belongs to the common prussian blue class, while hypo is used for the yellow print, and mercuric chloride fixes the red.

An extremely useful part of the invention is that it has been found possible to reduce the colour intensity of all three images; consequently, the correct colour balance can be obtained from any three partial colour images which are approximately accurate and slightly over printed, without having to make fresh prints. This has never been possible with any other process of colour photography; it has always been necessary to start again from the beginning if the print obtained was not accurate.

The three partial colour images are not transferred as in the carbon process, but the cellophane films are mounted one on top of the other, using a dilute gelatin solution as a cement.

The cellophane used has nearly all the properties which could be desired for such a process. Despite the fact that when wetted it stretches badly, it goes back to its original shape on drying and, most remarkable of all, it is truly elastic, so that if desired it can be stretched to obtain register. Also it will not scratch readily. If the three cellophane films were just cemented together on paper and dried they would curl very badly; this has been got over by the use of a thin sheet of celluloid as a support, the cellophanes being on both sides and so tending to curl in opposite directions.

Some of the prints by this process which have been exhibited are very fine and show accurate colour rendering, but artistically they are spoilt by the sheen on the surface, which is a necessity, since the image consists of sheets of polished cellophane. It is reported, however, that it will be possible to overcome even this. The prints obtainable are not likely to surpass in quality the best three-colour carbros, for example, but there is evidence that they will be distinctly easier to prepare and consequently should prove much more popular. Evidence as to the permanence of these prints over a period seems to be lacking.

There is another aspect of colour photography which is also being exploited by Colour Photographs, Ltd., namely, the production of a commercial 'tripack' which shall take all three negatives at once with any ordinary camera. The idea of the 'tripack' is by no means new, having been fully described in theory by Ducos du Hauron so long as forty years ago. Many inventors have tried their hand at the problems involved and several packs have been commercially marketed, but none has so far lived for long.

Perhaps the greatest difficulty is to obtain three different colour-sensitive emulsions which with unequal exposure but equal development will give negatives of the same contrast range or 'gamma.' Without this it becomes almost impossible to obtain accurate colour balance in both shadows and high lights. But with the resources of the modern emulsion maker, great improvements can no doubt be effected, so that many workers are eagerly awaiting the day when these packs are first marketed.

Some very good colour portraits taken in an ordinary camera with this pack have been exhibited, and it seems probable that the pack will prove most suited to this class of work rather than to outdoor photography, where the requirements as to sharpness and colour rendering are much more exacting.

In this 'tripack' three thin celluloid films are employed, the front one having a thinly coated blue sensitive emulsion and a dye which absorbs all the blue, the second a green sensitive coating and a dye which passes only the red rays, which fall on a special type of rapid red sensitive film. Theoretically this arrangement is quite simple and is the one which has been most frequently used, but it has the

(*Continued on p.* 701.)

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The Physics of the Universe.[1]

By Sir JAMES JEANS, Sec. R.S.

THE ancients were for the most part content to regard the universe as a theatre which had been specially constructed for the drama of human life. Men, and even the gods that man had created in his own image, came, lived, and disappeared after strutting their tiny hour upon a stage to which the eternal hills and the unchanging heavens formed a permanent background. While some thought was given to the birth of the universe, and its creation or emergence from chaos, very few thought of it as living its life and passing from birth to death in the same way as a man or a tree passes from birth to death.

In modern times the idea of secular change crept into the picture. Geologists began to study the earth as a changing structure, and astronomers to give thought to the evolution of the stars, recognising them as bodies which are born, live their lives of gradual change, and finally die. But the ultimate constituents of the universe, the atoms, were still supposed to be immune from change. The hypothesis that all matter consisted of permanent, indivisible, and unchangeable atoms, which had been advanced so far back as the fifth century B.C. by Leucippus and Democritus, remained practically unshaken until the end of the nineteenth century. The ageing of the universe was supposed to amount to nothing more than a re-arrangement of indestructible units which were themselves incapable of any sort of change or decay. Like a child's box of wooden bricks, the atoms made many buildings in turn.

ATOMIC CHANGES.

Then Crookes, Lenard, and, above all, Sir J. J. Thomson, began to break up the atom. The bricks of the universe which had been deemed unbreakable for more than 2000 years were suddenly shown to be very susceptible to having fragments chipped off; a milestone was reached in 1895, when Sir J. J. Thomson showed that these fragments were identical, no matter what type of atom they came from; they were of equal mass, and they carried equal negative charges of electricity, and so were called 'electrons.' Two years later, Lorentz's explanation of the newly discovered Zeeman effect provided evidence that the moving parts in atomic interiors were precisely similar electrons.

The series of researches so initiated were, after a few years, co-ordinated in the Rutherford view of atomic structure, which supposed the chemical properties and nature of the atom to reside in an excessively minute central nucleus carrying a positive charge of electricity, about which the negatively charged electrons described wide orbits. By clearing a space around the central nucleus, and so preventing other atoms from coming too near, these electronic orbits gave size to the atom. The volume of space kept clear by the electrons is enormously greater than the total volume of the electrons; roughly, the ratio of volumes is that of the battlefield to the bullets. The atom, with a radius of about 2×10^{-8} cm., has about 100,000 times the dimensions, and so about 10^{15} times the volume, of a single electron, of which the radius is about 2×10^{-13} cm. In all probability the 'nucleus' is even smaller than the electrons. The number of orbital electrons in an atom is called the 'atomic number' of the atom; it ranges from unity in hydrogen, the lightest and simplest of atoms, to 92 in uranium, which is the most massive and complex atom known.

Simultaneously with this, physical science was discovering that the nuclei themselves were neither permanent nor indestructible. In 1896, Becquerel had found that uranium salts had the remarkable property, as it then appeared, of spontaneously affecting photographic plates in their vicinity. This observation led to the discovery of a new property of matter, namely, radioactivity, and all the results obtained in the next few years were co-ordinated in the hypothesis of 'spontaneous disintegration' advanced by Rutherford and Soddy in 1903, according to which radioactivity indicates a spontaneous break-up of the atomic nuclei. So far from the atoms being permanent and indestructible, their very nuclei were now seen to crumble away with the mere lapse of time, so that what was

[1] The first Henry Herbert Wills Memorial Lecture of the University of Bristol, delivered at the University on Oct. 30.

once the nucleus of a uranium atom was transformed, after sufficient time, into the nucleus of a lead atom, and eight α-particles, which are the nuclei of helium atoms. Radiation is given off in the process, the radiation that affected Becquerel's photographic plates, and so led to the detection of the radioactive property of matter.

With the unimportant exceptions of potassium and rubidium, the property of radioactivity occurs only in the most complex and massive of atoms, being indeed limited to those of atomic numbers above 83. Yet, although the lighter atoms are not liable to spontaneous disintegration in the same way as the heavy radioactive atoms, the nuclei of these also are of composite structure, and can be broken up by artificial means. In 1920, Rutherford succeeded in breaking up the nuclei of atoms of oxygen and nitrogen by bombarding them with swiftly moving α-particles.

The success of this experiment led to the hypothesis, which has not yet been established beyond all possibility of doubt, that the whole universe is built up of only two kinds of ultimate bricks, namely, electrons and protons. Each proton carries a positive charge which is exactly equal in amount to the negative charge carried by an electron. The protons are supposed to be identical with the nucleus of the hydrogen atom; all other nuclei are supposed to consist of closely packed structures of protons and electrons.

In addition to containing material electrons and protons, the atom contains yet a third ingredient, namely, electromagnetic energy. Modern electromagnetic theory shows that all radiation carries mass about with it, one gram of mass being associated with 9×10^{20} ergs or $2{\cdot}15 \times 10^{13}$ calories of radiation. As a necessary consequence, any substance which is emitting radiation must also be losing mass; the spontaneous disintegration of any radioactive substance involves a spontaneous decrease of weight. The ultimate fate of a gram of uranium may be expressed by the equation:

$$1 \text{ gram uranium} = \begin{cases} 0{\cdot}8653 \text{ gm. lead.} \\ 0{\cdot}1345 \text{ gm. helium.} \\ 0{\cdot}0002 \text{ gm. radiation.} \end{cases}$$

Stated in a very general form, the phenomenon of radioactivity may be described as a transformation of material mass into radiation, or, to put it slightly differently, as the liberation of radiation by the destruction of material mass. Where 4000 gm. of matter originally existed, only 3999 gm. now remain, the remaining gram having gone off in the form of radiation.

Yet, the 3999 gm. of lead and helium contain precisely the same protons and electrons as the original 4000 gm. of uranium; we may then say that the 4000 gm. of uranium consisted of these electrons and protons together with 1 gm. of bottled-up electromagnetic energy which has since escaped in the form of radiation.

So far as terrestrial experience goes, this dissolution of mass into radiation is entirely a one-way process. Terrestrial rocks provide abundant evidence of uranium having continuously broken up into lead, helium, and radiation for the past thousand million years or more, but there is no evidence of the converse process ever having occurred. We must suppose that there is less uranium on earth to-day than there was yesterday, and that by to-morrow there will be still less. As a consequence, the earth each day radiates away a little more heat than it receives from the sun, and its mass continually diminishes. According to Jeffreys [2] the outward flow of radiation just inside the earth's surface is about $1{\cdot}9 \times 10^{-6}$ calorie per sq. cm. per second, all but about 13 per cent. of which arises from radioactive disintegration of the substance of the earth. We can calculate from this that radioactive disintegration causes the earth's mass to diminish at the rate of rather less than an ounce a minute; at this rate, terrestrial atoms are unbottling their energy and pouring it into space in the form of radiation. On earth at least the stream flows ever in the same direction; complex atoms giving place to simple, and mass changing into radiation. It is natural to ask whether a study of the physics of the universe reveals these processes as part only of a closed cycle, so that the wastage which we see in progress on earth is made good elsewhere. We stand on the banks of a river and watch its current ever carrying water out to sea, but we know that this water is in due course transformed into clouds and rain which replenish the river. Is the physical universe a similar cyclic system, or ought we rather to compare it to a stream which, having no source of replenishment, must cease flowing after it has spent itself? To answer these questions we must attempt first to trace our terrestrial stream back to its source.

The Origin of Terrestrial Radium and Uranium.

Radioactive atoms are of many kinds, but all have in common the property of spontaneous disintegration. The period of time required for this disintegration to occur varies enormously, some

[2] "The Earth," p. 83.

types of atoms having long lives of thousands of millions of years, while others have short lives of years, days, hours, or seconds, the most ephemeral of all being actinium-A, with an average life of only 0·002 sec. Let us take uranium and radium as being typical of the two classes.

Spontaneous disintegration reduces any store of radium to half in 1580 years, so that if a whole earth were built of pure radium only a single atom would be left after a quarter of a million years. Since the earth is many millions of years old, we may be confident that every atom of radium now on earth was born on earth. Soddy, Boltwood, and others have investigated the ancestry of radium. Its direct parent is found to be ionium, and it traces its descent back through uranium-X to uranium itself.

On the other hand, it takes 5000 million years for a store of uranium to diminish to half. As the earth was born out of the sun some 2000 million years ago, the greater part of any uranium it may have brought with it out of the sun would still be in existence. As we have no evidence of any uranium being born on earth, and as no parent substance is known out of which uranium could be born, it is reasonable to regard the earth's present store of uranium as the remains of a supply it originally brought out of the sun. An initial store of about 10^{19} gm. would suffice.

This uranium cannot have existed from all time, for the average life of a uranium atom is only about 7000 million years. How, then, did it come into being? Was it created in the sun, or did the sun, like the earth, start life with a supply which has continually diminished, and is destined ultimately to vanish entirely?

The answer to this question must of course depend on the age we assign to the sun, and an attempt to fix this takes us rather far afield.

The Ages of the Sun and Stars.

In a classical paper published in 1878, Clerk Maxwell studied the behaviour of a gas whose molecules were supposed to be massive points repelling one another with a force which varied inversely as the fifth power of the distance. There was no possibility of direct collision, since the molecules were supposed to be of infinitesimal size, but as each molecule threaded its way through its fellows, pairs occasionally approached so close as to influence one another's motion much as a direct collision would have done. At each such encounter a transfer of energy took place, the general tendency being towards equalising energies; the molecule with the greater energy of motion was ever being slowed down, and that with the lesser energy speeded up. If the molecules were of different weights, their continued encounters tended to bring about a state in which heavy and light molecules all moved with the same energy, the lighter molecules making up for the smallness of their mass by the rapidity of their motion.

It was no new discovery that the molecules of a gas tended to assume such a state. This had been known for some years, but Maxwell's investigation gave a means of calculating the time required to bring about this final state of 'equipartition of energy.' Maxwell calculated a time, which he called the 'time of relaxation,' such that all deviations from the final state of equipartition of energy were reduced to $1/e$ (37 per cent) of their original value in this time. For ordinary air it is found to be about $\frac{1}{6\times10^{9}}$ sec.

Maxwell's massive points, repelling according to the inverse fifth power of the distance, do not form a particularly good model of a gas, but on changing the law of force to an attraction varying as the inverse square of the distance (the law of gravitation), we obtain an absolutely realistic model of the stars, the diameters of the stars being so small in comparison with their mean distances apart that the possibility of direct collisions may be ignored entirely. Just as Maxwell calculated the 'time of relaxation' for his ideal gas, we can calculate it for a collection of massive points, having the masses and mean distances of the stars and attracting according to the law of gravitation. It proves to be of the order of millions of millions of years. After interacting on one another for a certain number, then, of millions of millions of years, the stars must attain to a final state of equipartition of energy, in which the average energy of all types of stars is the same, regardless of their mass.

So far back as 1911, Halm had suspected an approximation to equality in the energies of massive and light stars, and suggested that the velocities of the stars, like those of the molecules of a gas, might conform to the law of equipartition of energy. A more exhaustive investigation by Seares in 1922 showed the supposed approximation to be real. Table I. shows the average total velocity (C) obtained for stars of different types having different mean masses.

Everywhere, except in its first two lines, the table reveals a marked approximation to equality of energy of motion. The last ten lines show a range of 10 to 1 in mass, but the average deviation of energy from the mean is only 9 per cent. This equality of energy can only be attributed to the gravitational interaction of the stars. For if it were produced by any physical agency, such as pressure of radiation, bombardment by molecules, atoms or high-speed electrons, this agency, as the last column of the table shows, would have to be in thermodynamical equilibrium with matter at a temperature of the order of 2×10^{62} degrees. Since no such temperatures are known in Nature, we must conclude that the observed equality of energy is the result of gravitational interactions extending over millions of millions of years. The stars must, then, have an age of this order of magnitude.

Other lines of astronomical investigation lead to the same conclusion; I will limit myself to one. A number of stars are 'binary,' consisting of two distinct masses which travel through space in double harness, describing closed orbits about one another because neither can escape from the gravitational hold of its companion. The single stars we have just discussed may appropriately be compared to monatomic molecules, but these binary stars must be compared to diatomic molecules. Energy can reside in their orbital motion as well as in their motion through space. Again we find that endless gravitational encounters must result in equipartition of energy, both from star to star and also between the different motions of which each binary system is capable. Further, when this final state is reached, the eccentricities of the elliptic orbits must be distributed over all values from $e=0$ to $e=1$ in such a way that all values of e^2 are equally probable.

Table I.—Equipartition of Energy in Stellar Motions.

Type of Star.	Mean Mass, *M*.	Mean Velocity, *C*.	Mean Energy, $\frac{1}{2}MC^2$.	Corresponding Temperature.
				Degrees.
Spectral type *B*3	19.8×10^{33}	14.8×10^{5}	1.95×10^{46}	1.0×10^{62}
„ *B*8·5	12·9	15·8	1·62	0·8
„ *A*0	12·1	24·5	3·63	1·8
„ *A*2	10·0	27·2	3·72	1·8
„ *A*5	8·0	29·9	3·55	1·7
„ *F*0	5·0	35·9	3·24	1·6
„ *F*5	3·1	47·9	3·55	1·7
„ *G*0	2·0	64·6	4·07	2·0
„ *G*5	1·5	77·6	4·57	2·2
„ *K*0	1·4	79·4	4·27	2·1
„ *K*5	1·2	74·1	3·39	1·7
„ *M*0	1·2	77·6	3·55	1·7

This final law of distribution of eccentricity of orbit is independent of the size of the orbit, but the 'time of relaxation' which measures the rate of approach to this final state is not. For the eccentricity of orbit is a differential effect, arising from the difference of the gravitational pulls of a passing star on the two components of the binary, and when these components are close together the passing star can get no grip on the orbit. For visual binaries, in which the components are usually hundreds of millions of miles apart, the 'time of relaxation' is again millions of millions of years, but it is a hundred times as great as this for the far more compact spectroscopic binaries.

The following table, compiled from material given by Aitken, shows the observed distribution of eccentricities:

Table II.—The Approach to Equipartition of Energy in Binary Orbits.

Eccentricity of Orbit.	Observed Number of Spectroscopic Binaries.	Observed Number of Visual Binaries.	Number in Final State.
0 to 0·2	78	7	6
0·2 „ 0·4	18	18	18
0·4 „ 0·6	16	28	30
0·6 „ 0·8	6	11	42
0·8 „ 1·0	1	4	54

As we should anticipate, the spectroscopic binaries show no approach to the final state; most of them retain the low eccentricity of orbit with which they start life. The visual binaries show a good approach up to an eccentricity of about 0·6, but not beyond. The deficiency of orbits of high eccentricity may mean that gravitational forces have not had sufficient time to produce the highest eccentricities of all, but part, and perhaps all, of the deficiency must be ascribed to the observational difficulty of detecting orbits of high eccentricity.

Clearly, however, the study both of orbital motions and of motions through space points to gravitational action extending over millions of millions of years. In each case there is an exception to 'prove the rule.' In the former case, it is provided by the spectroscopic binaries which are so compact that their constituents can defy the 'pulling-apart' action of gravitation; in the latter case it is provided by the *B*-type stars which are so massive, possibly also so young, that the gravitational forces from lesser stars have not greatly affected their motion.

This and other lines of evidence, when discussed in detail, agree in suggesting that the general age of the stars is probably between five and ten million million years. It may even be possible to fix the age of the sun within the narrower limits of seven and eight million million years.

The Origin of Solar Uranium.

We now have all the data for discussing the origin of the radioactive atoms in the sun and stars. Thorium, the longest-lived of all radioactive substances, is reduced to half its original amount after 15,000 million years of spontaneous disintegration. A mass of pure thorium equal to the sun (2×10^{33} gm.) would be reduced to a single atom within three million million years. For uranium, with a half-value period of 5000 million years, the corresponding time is less than a million million years. When the earth was born the sun's age was greater than either of these times, so that the earth's portion of radioactive matter must have been generated during the sun's life in the sun itself.

The only possible escape from this conclusion would seem to lie in the supposition that the lives of atoms of uranium and thorium are in some way enormously prolonged by intense heat and fierce bombardment such as occur in the sun's interior. We cannot absolutely rule such a possibility out, but it is difficult to see any single consideration which could be adduced in its favour from the side either of experimental or of theoretical physics, and, in the present state of our knowledge, it would seem reasonable to disregard it.

Assuming that these atoms were born in the sun, the problem of the manner of their birth takes us to the very heart of present-day theoretical physics.

Let us consider, in some detail, two processes which occur on earth: the change of atomic make-up through a readjustment of electrons, and the change of nuclear make-up through spontaneous disintegration.

At first sight the two processes seem very dissimilar. The radioactive transformation of the nucleus is spontaneous, in the sense that nothing that we can do either expedites or hinders it. Each atom of uranium carries its own future history written inside it. It lives its appointed life serenely undisturbed by external accidents of heat or pressure; when its hour strikes it will cease to exist as uranium and will proceed to disintegrate into lead, helium, and radiation. Its nucleus slips back to a state of lower energy, the lost energy being put in evidence as emitted radiation. On the other hand, the change produced in ordinary atoms by electronic rearrangement is extremely susceptible to external physical conditions. Every spectroscopist knows how to chip off one, two, or even three electrons from the atom at will. Nevertheless, as was first made clear in a remarkable paper which Einstein published in 1917,[3] the difference is merely one of degree and not of kind.

The electrons in an atom are free to move from one orbit to another, and as the various possible orbits have different energies, the atom constitutes, to some extent, a reservoir of energy. For example, the hydrogen atom consists of a single proton as central nucleus, and a single electron revolving round it. According to Bohr's theory, the electron can revolve in orbits whose diameters (or major axes) are proportional to the squares of the natural numbers, 1, 4, 9, 16, 25. . . . The differences of energy between the various orbits are easily calculated; for example, the smallest two orbits differ in energy by 16×10^{-12} erg. If we add 16×10^{-12} erg of energy to an atom in which the electron is describing the smallest orbit of all, it crosses over to the next orbit, absorbing the 16×10^{-12} erg in the process and so becoming temporarily a reservoir of energy holding 16×10^{-12} erg. If the atom is disturbed, it may of course discharge the energy at any time, or it may absorb still more energy and so increase its store. But if it is left entirely undisturbed, the electron must, after a certain time, lapse back spontaneously to its original smaller orbit. If it were not so, Planck's well-established law of black-body radiation could not be true. In this process the atom ejects 16×10^{-12} erg of energy in the form of radiation and, as a consequence, experiences a diminution of mass to the extent of $1{\cdot}8 \times 10^{-32}$ gm. Thus a collection of hydrogen atoms in which the electrons describe orbits larger than the smallest possible is similar to a collection of uranium atoms in that the atoms spontaneously lapse back to their states of lower energy as a result merely of the passage of time, losing mass and emitting radiation in the process.

We have spoken of adding 16×10^{-12} erg of energy to a hydrogen atom in its state of lowest energy. We cannot of course do this simply by pouring miscellaneous energy on the atom, and expecting it to drink it up. The hydrogen atom only accepts energy which is offered it in the form of radiation of precisely the right wave-length; it treats all other radiation with complete indifference. Every atom is selective in the sense in which a penny-in-the-slot machine is selective; if we pour radiation of the wrong frequency on to an atom we may reproduce the comedy of the millionaire whose total wealth

[3] *Phys. Zeitsch.*, 18, 122; 1917.

will not procure him a box of matches because he has not a loose penny, or we may reproduce the tragedy of the child who cannot obtain a slab of chocolate because its hoarded wealth consists of farthings and halfpence, but we shall not disturb the hydrogen atom.

This selective action of the atom on radiation is put in evidence in a variety of ways, but is perhaps most simply shown in the spectra of the stars. Light of all wave-lengths streams out from the hot interior of a star and bombards the atoms which form its atmosphere. These atoms drink up that radiation which is of precisely the right wave-length, but have no interaction of any kind with the rest, with the result that the radiation which is finally emitted from the star is deficient in just these particular wave-lengths. This is shown by the star showing an *absorption spectrum* of fine lines. As the atoms in the star's atmosphere absorb this radiation they move to orbits of higher energy, but in course of time they lapse back to their old orbits, and in doing so emit energy in the form of radiation of precisely these same wave-lengths. This does not, as might at first be thought, exactly neutralise the absorption of radiation, because the absorbed radiation was all travelling outwards, whereas the emitted radiation travels in all directions at random. Thus, if we view the atmosphere tangentially, as we can do with the sun's atmosphere at a total eclipse, we observe the same spectrum, no longer as an absorption but as an *emission spectrum* ; it no longer consists of dark, but of bright lines—the ' flash ' spectrum.

Any atom, or indeed any other electrical structure, will select the radiation of suitable wave-length from all the radiation which falls on it, and use the energy of this radiation in rearranging its electron orbits. The amount of energy ϵ that the atom absorbs is connected with the wave-length λ of the radiation by the quantum relation $\epsilon\lambda = hC$, where h is Planck's constant ($6{\cdot}55 \times 10^{-27}$ erg sec.), and C is the velocity of light. The quantity ϵ of energy given by this relation is called the ' quantum ' of light of wave-length λ, and the wave-lengths of the radiation which any electrical structure selects are determined by the condition that the corresponding quantum of energy shall just suffice to shift its electrons from one orbit to another. Radiation will also be absorbed if its quantum provide sufficient energy to tear the electron out of the atom altogether, and set it travelling through space as a free electron. All radiation of which the wave-length is less than a certain critical limit fulfils this latter condition.

The more compact an electrical structure is, the greater the energy necessary to disturb it ; and the greater the quantum of energy ϵ, the shorter the wave-length of the corresponding radiation. It follows that a very compact structure can only be disturbed by radiation of very short wave-length.

As a rough working guide we may say that any structure will only be disturbed by radiation whose wave-length is less than 860 times the dimensions of the structure. The energy needed to separate two electric charges $+e$ and $-e$, at a distance r apart, is e^2/r, and, in general, the energy needed to rearrange or break up a structure of electrons and protons of linear dimensions r will be comparable with this. If λ is the wave-length of the requisite radiation, the energy made available by the absorption of this radiation is the quantum hC/λ. Combining this with the circumstance that the value of h is very approximately 860 e^2/C, we find that the requisite wave-length of radiation is about 860 times the dimensions of the structure to be broken up. In brief, the reason why blue light affects photographic plates, while red light does not, is that the wave-length of blue light is less, and that of red light is greater, than 860 times the diameter of the molecule of silver nitrate ; we must get below the ' 860-limit ' before anything begins to happen.

The wave-length of the light emitted by an atom when it discharges its reservoir of energy is precisely the same as that of the light absorbed when it originally stored up this energy, for as the two quanta of energy are the same, the corresponding wave-lengths are the same. It follows that the light emitted by any electrical structure will have a wave-length of about 860 times the dimensions of the structure. For example, ordinary visible light has a wave-length equal to about 860 atomic diameters.

Atomic nuclei, like the atoms themselves, are structures of positive and negative electrical charges, and so ought to behave similarly with respect to the radiation falling upon them. The radiation which the atomic nuclei emit, and consequently also that which they are prepared to absorb, is, however, of far shorter wave-length than that emitted or absorbed by complete atoms. Ellis and others have found, for example, that the radiation which is emitted during the disintegration of radium-B has wave-lengths of 3·52, 4·20, 4·80, 5·13, and 23×10^{-10} cm. These wave-lengths are only about a hundred-thousandth part of those of visible light. The reason is, of course, that the nucleus has only about a hundred-thousandth part the dimensions of the atom.

Since the wave-length of the radiation absorbed or emitted by an atom is inversely proportional to the quantum of energy, it follows that the quantum of energy needed to 'work' the atomic nucleus is about 100,000 times as great as that needed to 'work' the atom. If we compare the hydrogen atom to a penny-in-the-slot machine, nothing less than five-hundred-pound notes will work the radioactive nuclei.

Yet radiation of the wave-lengths just mentioned ought to be just as effective in rearranging the nucleus of radium-*B* as that of the longer wave-length is effective in rearranging the hydrogen atom. At least such radiation ought to precipitate the disintegration of radium-*B*. Whether it could ever be effective in forming radium-*B* out of radium-*C* and atoms of helium (or α- and β-particles) is a somewhat different question; possibly other conditions of which nothing is known must be fulfilled in addition to the presence of radiation of the appropriate wave-length.

Probably also the radioactive nuclei, like those of nitrogen and oxygen, could be broken up by a sufficiently intense bombardment, although the experimental evidence on this point is not very definite. If so, each bombarding particle would have to bring to the attack energy equal at least to that of one quantum of the radiation in question, and this requires it to move with an enormously high velocity.

In passing, we may notice that processes of the general type we have just been discussing form the hope of those modern alchemists who aspire to obtain gold by the transmutation of other metals. In its widest form, their ambition is to combine the electrons and protons of base metals with the third atomic ingredient, namely, electromagnetic energy, so as to form atoms of gold. Any success they may achieve will probably result in a gain of knowledge to abstract science rather than of wealth to themselves, since one of the ingredients they must necessarily use, namely, energy or radiation, is so expensive as to render the final product excessively costly. It would need at least an appreciable fraction of an ounce of energy to produce an ounce of gold, and with electric power at even a farthing per Board of Trade Unit, energy and radiation cost eleven million pounds per ounce. Whatever the gold standard may have to fear on the political side, it would appear to be thoroughly impregnable on the side of physics and chemistry.

Every wave-length of radiation has a definite temperature associated with it, namely, the temperature at which radiation of this particular wave-length is most abundant. We recognise this when we speak of a red-heat or a white-heat, and, although we do not do so, we might quite legitimately speak in the same way of an ultraviolet heat or an X-ray heat. The wave-length and the associated temperature are connected through the well-known relation:

$$\lambda T = 0{\cdot}2885 \text{ cm. degree.}$$

When this particular temperature begins to be approached, but not before, radiation of the wave-length in question becomes abundant; at temperatures well below this it is quite inappreciable.

We have seen that radiation of short wave-length is needed to break up an electric structure of small dimensions, and as we now see that short wave-lengths are associated with high temperatures, it appears that the smaller a structure is, the greater the heat needed to break it up. On combining the relation just given between T and λ with that implied in the rough law of the '860 limit,' it appears that a structure of dimensions r cm. will begin to be broken up by temperature-radiation when the temperature first approaches $1/3000r$. Atoms, for example, whose general dimensions are of the order of 10^{-8} cm., begin to be broken up when the temperature approaches 30,000 degrees; nuclei, whose general dimensions are of the order of 10^{-13} cm., must remain unaffected until the temperature approaches 3,000,000,000 degrees.

To take a more precise instance, yellow light of wave-length 6000A. is specially associated with the temperature 4800 degrees. At temperatures well below this there is no yellow light except such as is artificially created. Stars, and all other bodies, at a temperature of about 4800 degrees, are of a yellowish colour and show lines in the yellow region of their spectrum. These lines occur because yellow light removes the outermost electron from the atoms of calcium and similar elements. When a temperature of 4800 degrees begins to be approached, but not before, rearrangements of the electrons in the calcium atom begin to occur. This temperature is not approached on earth (except in the electric arc and other artificial conditions), so that terrestrial calcium atoms in general are at rest in their states of lowest energy. Einstein's paper of 1917 showed it to be a necessary deduction from Planck's law of black-body radiation that a collection of calcium atoms in other states would behave precisely like atoms of radioactive substances to the extent of spontaneously slipping back to states of lower energy.

Just as calcium atoms in the cool temperatures of the earth simulate the behaviour of radioactive atoms, so radioactive nuclei, if raised to a sufficiently high temperature, would simulate the behaviour of calcium atoms in the hot atmosphere of a star. The shortest wave-length of radiation emitted in the transformation of uranium is about $0{\cdot}5 \times 10^{-10}$ cm., and this corresponds to a temperature of 5,800,000,000 degrees. When some such temperature begins to be approached, but not before, the constituents of the radioactive nuclei begin to rearrange themselves, just as the constituents of the calcium atom do when a temperature of 4800 degrees is approached.

We must probably suppose that rearrangements can also be effected by bombarding the electric structure with material particles. If so, the temperature at which bombardment by electrons, nuclei, or molecules would first begin to be effective is precisely the same as that at which radiation of the effective wave-length would first begin to be appreciable; the two processes begin at the same temperature.

We have seen, then, that the apparent difference between the behaviour of the calcium atom and of the uranium nucleus reduces, in theory, to a mere difference of temperature, although in practice the difference is all the difference between 5000 degrees and 5,000,000,000 degrees. The lower temperature is approached or exceeded in the atmospheres of most stars, so that the calcium atom is continually rearranging itself in these atmospheres, as is shown by the presence of the *H* and *K* lines of calcium in most stellar spectra. It is unlikely that the higher temperature is approached anywhere in the universe, although exceptions, arising from our ignorance rather than our knowledge, must possibly be made in favour of the centres of certain 'white-dwarf' stars and of the spiral nebulæ. Apart from these, no place is known hot enough to have any appreciable effect on the transformation, either by synthesis or by disintegration, of the radioactive elements, and we must conclude that they behave everywhere in the same spontaneous fatalistic way that they do on earth; nowhere is there sufficiently intense heat to cause them to vary their conduct.

Thus solar uranium, which, as we have already seen, must have been born in the sun, can scarcely have been born out of the synthesis of lighter elements, and so must have originated out of the disintegration of heavier elements. The position with respect to solar uranium is precisely analogous to that we have already reached in respect of terrestrial radium, but there is the outstanding difference that we know the ancestry of terrestrial radium, whereas we do not know that of solar uranium. But ancestry there must be, so that we are led directly to the conjecture that the sun must have contained, and presumably must still contain, atoms of atomic weight greater than that of uranium; astronomical evidence leads independently to the same conclusion. We are led to contemplate terrestrial uranium merely as the present generation of an ancestry that extends we know not how far back. The complete series of chemical elements contains elements of greater atomic weight than uranium, but all such have, to the best of our knowledge, vanished from the earth, as uranium also is destined to do in time.

Table III. above shows the wave-lengths of the radiation necessary to effect various atomic transformations. The last two columns show the corresponding temperatures, and the places, so far

TABLE III.—THE MECHANICAL EFFECTS OF RADIATION.

Wave-lengths (cm.).	Nature of Radiation.	Effect on Atom.	Temperature (Degrees abs.).	Where Found.
7500×10^{-8} to 3750×10^{-8}	Visible light.	Disturbs outermost electrons.	3,850° to 7,700°	Stellar atmospheres.
250×10^{-8} to 10^{-8}	X-rays.	Disturbs inner electrons.	115,000° to 29,000,000°	Stellar interiors.
5×10^{-9} to 10^{-9}	Soft γ-rays.	Strip off all or nearly all electrons.	58,000,000° to 290,000,000°	Central regions of dense stars.
4×10^{-10}	γ-rays of radium-*B*.	Disturbs nuclear arrangement.	720,000,000°	?
5×10^{-11}	Hardest γ-rays.	..	5,800,000,000°	
$4{\cdot}5 \times 10^{-12}$	?	Building of helium atom out of hydrogen.	64,000,000,000°	
2×10^{-12}	Highly-penetrating radiation.	Disintegrates nuclei.	150,000,000,000°	
$1{\cdot}3 \times 10^{-13}$	?	Annihilation or creation of proton and accompanying electron.	2,200,000,000,000°	

as we know, where this temperature is to be found. In places where the temperature is far below that mentioned in the last column but one, the transformation in question cannot be affected by heat, and so can only occur spontaneously. Thus it is entirely a one-way process. The available radiation is not of the right wave-length to work the atomic slot-machine, so that the atoms, absorbing no energy from the surrounding radiation, are continually slipping back into states of lower energy, if such exist; they continually transform their mass into radiation, while the converse transformation of radiation into mass cannot occur.

For the sake of completeness, the table has been extended so as to include certain other phenomena, not so far discussed, to which we now turn.

The Annihilation of Matter.

Every square centimetre of the sun's surface discharges radiation out into space at the rate of about 1500 calories a second, from which we can calculate that the sun's total mass is diminishing at about 250,000,000 tons a minute. Whereas the flow of mass from the earth's surface, a total loss of about an ounce a minute, is about equal to the flow of water from a dripping tap, the flow of mass from the sun's surface is about 150 times the flow of water over Niagara. Many stars lose mass even more rapidly; S. Doradus loses mass at the rate of about 45,000,000 Niagaras. The earth's loss of mass is readily explained in terms of radioactive disintegration, but this fails entirely to explain the enormously greater loss experienced by the sun. Furthermore, the earth's loss of mass is probably replaced many times over by falls of meteors and cosmic dust, but no one has ever suspected or suggested any source of replenishment of the masses of the sun and stars which is at all comparable with their known loss.

Thus the sun's loss of mass is cumulative and has in all probability gone on at its present, or at an even greater, rate throughout the whole of its vast age of some seven million million years. Indeed, astronomical evidence makes it fairly certain that younger stars radiate more energetically than older stars. When allowance is made for this, it is found that the sun must have radiated many times its present mass during its life of seven million million years; it must have been many times as massive at birth as it is now, and of every ton it originally contained only a few hundredweight remain to-day. Since no form of radioactive disintegration with which we are acquainted results in such a diminution of mass as this, we are forced to suppose that something still more fundamental is responsible for the sun's diminution of mass and emission of radiation. Of each thousand atoms that the sun contained at its birth only a few dozen remain to-day, and we can only conclude that all the rest have been annihilated and their mass set free in the form of radiation. This transformation of atoms into radiation, although unknown to terrestrial physics, must clearly be one of the fundamental physical processes of the universe.

The Universe as a Heat-Engine.

General thermodynamical theory shows that every natural system tends to move towards a final state of maximum entropy by steps such that, statistically speaking, the entropy increases with every step. In calculating this entropy, classical thermodynamics regarded the chemical atoms as indivisible, indestructible, and immutable; the system consisted merely of permanent atoms and energy, and maximum entropy was attained when this energy was partitioned between the kinetic and potential energies of the atoms and the energy of radiation travelling freely through space, in such a way that no possible redistribution could make the entropy greater.

Modern knowledge shows this scheme of thermodynamics to be totally inadequate. So far from atoms being the eternal unchangeable bricks of the universe, modern science finds them subject not only to constant change, but also to total destruction. Not only do their nuclei change their retinue of attendant electrons, but they themselves both crumble away into simpler nuclei, and dissolve entirely into radiation. Furthermore, energy can reside in other forms than those just enumerated; it can be used, stored, and transformed in changing electron orbits inside the atom, in breaking up atoms, in rearranging and breaking up the atomic nuclei and so transmuting the elements; it can be liberated by the complete annihilation of matter. Neither total energy nor total mass is any longer constant; the conservation both of mass and of energy has disappeared from physics, and only a kind of sum of the two is conserved.

The End of the Universe.

The final state of the universe must be such that the entropy cannot be increased even by transmuting the elements or changing atoms into radiation. It could, of course, be calculated readily enough if the necessary new and enlarged scheme of thermodynamics were available, but competing schemes are in the field. The Bose-Einstein scheme leads to one result, the Fermi-Dirac scheme to another; the results on both schemes have been worked out by Jordan.[4]

The two schemes lead to the same result in one particular limiting case, and this limiting case happens to give a wonderfully close approximation to the state of the universe as a whole. The limiting case is that in which space is almost empty of matter, a specification which sounds like nonsense until we find some common standard by which an amount of matter may be compared with an amount of space. If we measure an amount of matter by the amount of space it occupies, then the 'emptiness' of space is one of the commonplaces both of modern physics and of modern astronomy. It is not merely a question of the 'emptiness' of the atom, which has already been noticed. Hubble[5] has estimated that if all the matter within about 100 million light-years of the sun were uniformly spread out, it would have a mean density of the order of only about 10^{-31} gm. per cubic centimetre, so that even the very 'empty' atoms would be at several thousand million times their diameters apart.

We can express this emptiness of space in a more fundamental manner. The energy set free by the total annihilation of 1 gm. of matter is equal to C^2 or 9×10^{20} ergs, so that the total annihilation of all the matter of the universe, assuming an average density of 10^{-31} gm. per cubic centimetre, would only provide an energy-density of 9×10^{-11} ergs per cubic centimetre, which would raise the temperature of space from absolute zero to about 10 degrees abs. The emptiness of space is indicated by the lowness of this temperature in comparison with the temperatures, as shown in Table III., which are necessary to effect atomic and sub-atomic changes If we make the approximation of neglecting 10 degrees in comparison with the temperature of 2,200,000,000,000 degrees which corresponds to the annihilation or creation of electrons and protons, the various schemes of statistical mechanics give the same result for the number of electrons and protons left undissolved into radiation. Independently of the size of the universe, the dominating factor in this number is $e^{-mC^2/RT}$; and as the index of the exponential is the ratio of the two temperatures just considered, the number is entirely negligible. Thus the final state of maximum entropy is one in which every atom has dissolved away into radiation, or at least every atom which is capable of so doing. This conclusion must, I think, be admitted quite independently of any particular scheme of statistical mechanics. The approximation that space is empty may be stated in the alternative form that the extent of space is enormously great; space, regarded as a receptacle for radiant energy, is a bottomless pit. In the terminology of the older mechanics, space has so many degrees of freedom that there can be no thermodynamical equilibrium so long as any energy is concentrated in matter. In more modern language, there are so many phase-cells associated with detached radiation, that the chance of any energy being found elsewhere is negligible.

The road by which the universe travels to this final state is disclosed by Table III. The last column is seen to contain entries only in its upper half; the temperatures necessary to effect the processes dealt with in lower half of the table are so high that, to the best of our knowledge, they are not to be found anywhere in the universe. When these latter processes occur, then, they are everywhere spontaneous; they are unaffected by the actual temperatures, and so absorb no radiation. Thus, the transformation, 'mass $\rightarrow$ radiation,' occurs everywhere, and the reverse transformation nowhere. There can be no creation of matter out of radiation, and no reconstruction of radioactive atoms which have once broken up. The fabric of the universe weathers, crumbles, and dissolves with age, and no restoration or reconstruction is possible. The second law of thermodynamics compels the material universe to move ever in the same direction along the same road, a road which ends only in death and annihilation.

The Beginning of the Universe.

The end of this road is more easily discerned than its beginning. The atoms which are now annihilating themselves to provide the light and heat of the stars clearly cannot have existed as atoms from all time; they must have begun to exist at some time not infinitely remote, and this leads us to contemplate a definite event, or series of events, or continuous process, of creation of matter. If we want a naturalistic interpretation of this creation, we may imagine radiant energy of any wave-length less than $1{\cdot}3 \times 10^{-13}$ cm. being poured into empty space; such radiation might conceivably crystallise into electrons and protons, and finally form atoms. If we want a concrete

[4] *Zeitsch. f. Physik.*, **41**, 711; 1927.
[5] *Astrophys. Jour.*, **64**, 368; 1926.

picture, we may think of the finger of God agitating the ether. We may avoid this sort of crude imagery by insisting on space, time, and matter being treated together and inseparably as a single system, so that it becomes meaningless to speak of space and time as existing at all before matter existed. Such a view is consonant not only with ancient metaphysical theories, but also with the modern theory of relativity. The universe becomes a finite picture whose dimensions are a certain amount of space and a certain amount of time; the protons and electrons are the streaks of paint which define the picture against its space-time background. Travelling as far back in time as we can brings us not to the creation of the picture, but to its edge, and the origin of the picture lies as much outside the picture as the artist is outside his canvas. On this view, discussing the creation of the universe in terms of time and space is like trying to discover the artist and the action of painting by going to the edge of the picture. This brings us very near to those philosophical systems which regard the universe as a thought in the mind of its Creator, and so reduce all discussion of material creation to futility.

Both these points of view are impregnable, but so also is that of the plain man who, recognising that it is impossible for the human mind to comprehend the full plan of the universe, decides that his own efforts shall stop this side of the creation of matter.

Atomic Transformations.

The transformation of uranium into lead and helium involves a drop of energy, but in the lighter elements the energy-change is in the reverse direction. Four atoms of hydrogen are more, not less, massive than an atom of helium, so that their energy-content is greater. Thus helium can never disintegrate spontaneously into hydrogen, although four atoms of hydrogen might spontaneously unite to form an atom of helium. They could not unite other than spontaneously, except possibly as a rare accident, since the temperature of transformation, 64,000,000,000 degrees, is higher than occurs in the universe. Whether they ever unite even spontaneously remains an open question on which opinions differ. Millikan at one time suggested this process as the origin of the highly penetrating radiation which bombards the earth from outer space, but recent observations rule this interpretation out; the observed wave-length of the radiation is too short, so that the radiation must originate in something more fundamental even than the transformation of hydrogen into helium. Whether any such process can be found, short of the complete annihilation of matter, remains to be seen; personally, I feel doubtful.

Millikan has recently suggested that this radiation may result from electrons and protons falling together and forming atoms in regions outside the stars. As a collection of oppositely charged particles could not remain uncombined for long, he postulates a continual creation of protons and electrons out of the stray radiation of the stars; matter is continually being annihilated in the interior of the stars, and re-created outside them. This gives a cyclic universe which might go on for ever.

Like all other cyclic universes, however, it clashes with the second law of thermodynamics. A universe which is not in a state of maximum entropy moves irreversibly along the path of increasing entropy and so cannot be cyclic; one which is already in such a state must be macroscopically dead, and so cannot be cyclic in any sense perceptible to us. Indeed, it is easy to find the exact spot at which Millikan's concept comes into conflict with the second law of thermodynamics; it is that we cannot have protons and electrons transformed into radiation at a high temperature and then have the process reversed at a lower temperature.

Some may not regard this as a fatal objection to the scheme in question. All our discussion has been based on the supposition that the laws of physics remain valid at enormously high temperatures and under conditions entirely outside our experience. Consequently, all our conclusions can be avoided, and everything can be put back in the melting-pot, by the single hypothesis that the laws which govern matter out in space differ from those which govern matter on earth. Yet we have only found it necessary to assume the simplest and most fundamental of physical laws, namely, the second law of thermodynamics and the broad general principles of the quantum theory; and it is hard to imagine that such wide laws fail outside our laboratories. The obvious path of scientific progress would seem to lie in the direction of inquiring what consequences are involved in supposing these laws to be of universal scope, and then testing these consequences against the ascertained facts of observational astronomy. So far as present indications go, astronomy, so far from challenging these consequences, goes half-way out to meet them.

Apart from transitory rearrangements of atomic electrons, the fundamental changes in atoms consist in transitions to states of lower energy. Under the classical electrodynamics, an electron describing a circular orbit of radius r about a charge E lost energy at a rate $\frac{3}{2}E^2a^2C/r^4$ (Larmor's formula), and this caused the radius r to decrease at a calculable rate; the charges inevitably and spontaneously fell towards one another. The quantum mechanics replaced this steady fall by a sequence of sudden drops, but according to Bohr's correspondence principle the rate of fall remains statistically the same, at any rate so long as the orbits are large, as on the classical electrodynamics; that is to say, the sum of the radii of the orbits of a whole crowd of atoms decreases through spontaneous jumps at just the same rate as though their motion was governed by the old mechanics. The spontaneous degradation of energy we have had under consideration is now seen to be the natural extension into quantum territory of that implied in Larmor's classical formula. Had it not been for this degradation of energy, the atoms would have been perpetual motion machines; Larmor's formula prohibited that. The quantum theory seemed at first to remove the prohibition and reconstitute the atom a perpetual motion machine. Then came Einstein's famous paper of 1917, which made it clear that even under the quantum theory perpetual motion was banned; spontaneous degradation of energy was shown to be implied in Planck's formula for black-body radiation. Once again, then, perpetual motion disappears from physics, and the grit in the bearings, which ultimately brings the machine to rest, is the natural quantum theory analogue of that which would have brought the machine to rest in the classical electrodynamics. Long ago we used to call it the interaction between matter and ether.

There appears to be one exception. The classical electrodynamics ruled out perpetual motion machines entirely. The new physics also rules them out, but permits the conspicuous exception of atoms in their state of lowest energy; these can go on in perpetual motion to all eternity, because there is no state of lower energy to which they can drop.

Is this exception real or is it only apparent? In a sense a state of still lower energy is reached when the electric charges, let us say of the hydrogen atom, fall into one another and the atom dissolves into radiation. We could remove the apparent exception from the new physics, and dismiss perpetual motion machines entirely from science, by supposing that after moving for a certain very long time in its state of lowest energy the hydrogen atom dissolved spontaneously into radiation. This might be dismissed as mere idle speculation were it not that the most fundamental physical process in the universe as a whole appears to be precisely this spontaneous dissolution of atoms into radiation.

If this kind of spontaneous dissolution should prove to be the true mechanism of the transformation of astronomical matter into radiation, then clearly bare nuclei and free electrons must be free from annihilation. Thus the conjecture may claim some support from the circumstance that the 'white dwarf' stars, in which the atoms are broken up completely, or almost completely, into their constituent nuclei and electrons, emit exceedingly little radiation; their substance would seem to be immune from annihilation. If the conjecture should ultimately prove its claim to acceptance, the main physical processes of the universe could all be included in one comprehensive generalisation, and the speck of radium which we watch in the spinthariscope would symbolise all the happenings of the physics of the universe.

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great disadvantage that the red sensitive film or blue ' printer ' is at the back and must therefore of necessity lack definition, both on account of the thickness of the films and still more because of the scatter due to the silver grains of the two emulsions through which the red light has had to pass. This defect is quite noticeable in the negatives and still more in the prints, since it is the blue printer which mainly defines the contours of the subject. It is true, however, that this difficulty is nothing like so serious as it was in the earlier packs, because it is now possible to make relatively transparent emulsions which will retain their high speed, and also the rapidity of modern panchromatic emulsions make short exposures quite feasible.

The collection of colour prints on exhibition at the seventh International Congress of Photography recently held in London showed that a high degree of skill has been attained by various workers, but, except among a very few, there is still a tendency to photograph objects because they have ' colour ' rather than because of their artistic beauty, so that a collection of colour prints frequently has an appearance of crudity and brilliance which the exhibits taken individually do not justify.

This, however, is a stage which will be got over as colour photography becomes more popular, as there is every reason to believe that it will. With the increasing number of inventors now concentrating on its problems, and with the parallel advances in colour cinematography, it is evident that colour photography may confidently look forward to a brilliant future, and perhaps some day the inventor's dream may be realised of a grainless colour negative from which paper prints in full colour may be obtained by a single exposure.

On the Study of Popular Sayings.[1]

By Prof. EDWARD WESTERMARCK.

WHEN I set out to gain some personal experience of native customs and beliefs and made Morocco my field of research, Sir James Frazer's "The Golden Bough" directed my attention to many facts that otherwise, in all probability, would have escaped my notice. It offered suggestions and explanations, which were none the less valuable because they were not always applicable to the particular data that came under my observation; and it brought home to me the great lesson, never to rest content with recording the mere external modes of native behaviour without endeavouring, so far as possible, to find the ideas or sentiments underlying them. For this reason I desire to render homage to my great teacher by stating some general results of my experience as a field anthropologist.

It has been said to be a difficult or hopeless task to try to discover why people perform rites and ceremonies, that directly one approaches the underlying meaning of rite or custom one meets only with uncertainty and vagueness. This view is not confirmed by my own observations in Morocco, where I generally found the natives to have quite definite ideas about their rites. But the direct inquiry into these ideas is not the only way in which they may be ascertained. The most convincing information is often obtained, not from what the natives say *about* their rites, but from what they say at the moment when they perform them. To take a few instances. That the fire-ceremonies practised in Morocco, as in Europe, on Midsummer Day or on some other particular day of the year, are purificatory in intention is obvious from the words which people utter when they leap over them or take their animals over the ashes. The Moorish methods of covenanting, which always imply some kind of bodily contact, for example, by the partaking of a common meal, derive their force from the idea that both parties thereby expose themselves to each other's conditional curses; and the idea that food eaten in common embodies such a curse is very clearly expressed in the imprecation addressed to a faithless participant.

These customs, and the sayings connected with them, have led me to believe that the very similar methods—such as a sacrificial meal—used by the ancient Hebrews in their covenanting with the Deity were intended, not, as has been supposed, to establish communion, but to transfer conditional curses both to the men and their god. That one idea underlying the Moorish custom of tying rags or clothing to some object connected with a dead saint is to tie up the saint, and to keep him tied until he renders the assistance asked for, is directly proved by words said on such occasions. Some similar idea may perhaps be at the root of the Latin word for religion, *religio*, if, as has been conjectured, this word is related to the verb *religare*, to tie. It might have implied, not that man was tied by his god, but that the god was in the religious ritual tied by the man.

While a saying uttered on the occasion when a rite is performed is apt to throw light on the meaning of the rite, there are other sayings that can themselves be explained only by the circumstances in which they are used. This is the case with a large number of proverbs. It has been said that the chief ingredients which go to make a proverb are ' sense, shortness, and salt,' but the most essential characteristic of all is popularity, acceptance and adoption on the part of the people. Figurativeness is a frequent quality, but there are also many sayings recognised as proverbs that contain no figure of speech. On the other hand, there is scarcely a proverb that does not in its form, somehow or other, differ from ordinary speech. Rhythm, rhyme, and alliteration are particularly prominent features.

The proverbs of a people may be studied from different points of view. In many cases their study has been the pursuit of philologists, who have been mainly interested in the linguistic aspect of

[1] From an evening discourse, being a Frazer Lecture in Social Anthropology, 1928, delivered at the British Association meeting at Glasgow on Sept. 7.

the subject. But as a source of information on the language spoken by a people, its proverbs must be handled with caution, as they may contain expressions which are not found in the native idiom, but belong to another dialect from which the proverb has been imported, or, as is often the case with Arabic proverbs, have been taken from the literary language, which in many respects differs from the modern vernaculars.

Another method of studying proverbs is to examine their diffusion. Peoples have at all times been taking proverbs from each other. Among the nations of Europe we find a very large number of identical, or almost identical, proverbs which obviously have a common origin. Very many of our proverbs have been borrowed from the Romans, who themselves had borrowed many of theirs from the Greeks, and another great source has been the Bible. Others have come from the medieval monasteries, or been introduced into Europe by Jews or Arabs. The wanderings of proverbs are a fascinating study, but one beset with considerable difficulties. The resemblance between proverbs may have another cause than diffusion, namely, the uniformity of human nature, which makes men in similar situations think and feel alike. The real test of a common origin is not the mere similarity of ideas and sentiments expressed in the proverbs, but the similarity of former expression, of course with due allowance for modifications that are apt to occur when a saying is adopted from another language and transplanted into a new soil.

There is a third way of studying proverbs, which is primarily concerned with their contents as a subject of sociological or psychological interest. That in the proverbs of a people are found precious documents as regards its character and temperament, opinions and feelings, manners and customs, is generally recognised. Lord Bacon said that "the genius, wit, and spirit of a nation are discovered by their proverbs." There may be some exaggeration in statements of this kind, as many of the proverbs are not indigenous. But, on the other hand, a foreign proverb is scarcely adopted by a people unless it is in some measure congenial to its mind and mode of life ; it may be modified so as to fit in with its new surroundings ; when sufficiently deeply rooted it may in turn influence the native habits of thought and feeling ; and if it does not succeed in being acclimatised in its adoptive country, it will wither and die.

Not infrequently some of the proverbs of a people contradict the teaching of others. Such incongruities may be more apparent than real. Proverbs may have the form of categorical imperatives on account of their necessary brevity, and in such cases their one-sidedness has to be corrected by others dealing with particular circumstances that modify the general rule. Moreover, as people are not all alike, one maxim may appeal to one person and another different maxim to another. There is, further, the distinction between proverbs that represent ideals and others that are based on realities which do not come up to these ideals. But it must not be assumed that a people's proverbs on a certain topic always tell us the whole truth about their feelings relating to it. The Moorish sayings concerning women and married life may serve as a warning. They are uniformly unfriendly or thoroughly prudential, and might easily make one believe that the men are utterly devoid of tender feelings towards their wives. But here we have to take into account their ideas of decency. It is considered indecent of a man to show any affection for his wife ; in the eyes of the outside world he should treat her with the greatest indifference.

Proverbs are not merely reflections of life, but also play an active part in it ; and this functional aspect of the matter should engage the attention of the student. Proverbs teach resignation in adversity, they give counsels and warnings, they are means of influencing the emotions, will, and behaviour of others, as they may influence one's own, whether they are shaped as direct commands, or are statements of some experience drawn from life, or are expressions of approval or admiration or of disapproval or contempt. The exceedingly frequent use of proverbs in Morocco, as in other countries with a Semitic culture, bears testimony to their great social adaptability. The proverb is a spice by which anybody may add piquancy to his speech ; it shortens a discussion, it provides a neat argument which has the authority of custom and tradition, it is a dignified way of confessing an error or offering an apology, it makes a reproof less offensive by making it less personal. One reason for the great popularity that proverbs enjoy among the Moors is their desire to be polite ; thus a proverb is often an excellent substitute for a direct refusal, which might seem inappropriate or rude. It also stops a quarrel and makes those who were cursing each other a moment before shake hands and smile ; and it is used as a kind of *'ar*, implying a conditional curse, to compel a person who has suffered an insult to forgive the offender. Proverbs are thus conducive to goodwill and peace.

If proverbs are to be studied from the points of view I have advocated—without any desire to prejudice other methods of study—it is, of course, necessary to know their intrinsic meaning, and this imposes upon the collector a task which has seldom been satisfactorily accomplished. Many proverbs are no doubt perfectly intelligible without an explanation ; others are only apparently so, because they easily suggest an interpretation which is not the correct one ; and others cannot even deceive us, because they defy any attempt to unriddle their occult meaning. I cannot, therefore, strongly enough insist on the necessity of recording the situations in which proverbs are used, unless the collector has made sure that they have no other meaning but that which they directly express.

When we are sure of the intrinsic meaning of proverbs, and only then, we can find a reasonable solution of a problem that has proved a constant stumbling-block to collectors and compilers, namely, their classification. If proverbs are to be treated as a source of information for the sociological or psychological study of people, they cannot, as has usually been the case, be arranged simply in alphabetical order by the first letters of the first word. They must be grouped according to the subjects or situations on which they have a bearing, and be accompanied with all explanations necessary for the right understanding of their import and implications. Proverbs that are applicable in different situations may have to be repeated under different headings; but to judge by my own experience, such repetitions need not be very many.

If due attention is bestowed upon the collection of proverbs, we may hope that the scientific study of them will keep pace better than hitherto with the progress made within other branches of folklore.

News and Views.

WHATEVER differences of opinion may exist with regard to Sir James Jeans's deductions concerning the origin and destiny of the physical universe, they have at least the cardinal virtue of making us think. His latest presentation of his views on these matters, which we publish as our supplement this week, is certainly no exception to the rule. The story he tells, with his customary skill in arranging his material and illustrating difficult points by telling analogies, leaves the reader sitting long in his chair, musing on old problems in the light of the new knowledge. In some respects the outlook has changed almost beyond recognition from that of our fathers and grandfathers; in other, and perhaps deeper, respects it remains very much as it has always been. The idea of a degradation of the physical universe by a series of sudden mutations appears to have taken the place of the old conception of a continuous process, and the change, from the point of view of the ordinary thinker, is by no means a superficial one. Spontaneous changes, such as those of radio-activity, have an air of mystery about them. Why should one atom of uranium suddenly undergo a metamorphosis while its apparently exactly similar neighbour remains unchanged for thousands of years? Fifty years ago such a conception would have been regarded as unscientific—a return to magic rather than a step forward. The quantum theory as a whole, in fact, when considered in detail, contains an element of arbitrariness which would not have been permitted in the older physics. It is only when we come to statistical results that law and order once more resume their reign. There still seems to be no escape from the second law of thermodynamics. If our view of the process of degradation of the universe has changed, the degradation itself still seems to be a fact, and in the place of an ultimate universe of dead, cold matter, we have an ultimate universe of dead, cold radiation. The difference scarcely seems a matter of vital concern.

DEGRADATION has an unpleasant sound, and it may be that the picture that Sir James Jeans draws will seem to many a gloomy and forbidding one. It can scarcely be repeated too often that any ideas now possible on such a subject as the fate of the universe can be regarded as little more than the first glimpse of a vast ocean from a point on the shore. They seem complete and self-contained because, like the ocean, they are necessarily bounded by a horizon, but the skyline must not be mistaken for a real limit. The very compactness of our view of the cosmic process is perhaps itself a sign that we have not reached finality. It is not for science to 'believe because it is impossible,' but in these matters we may well take the conjugate course of disbelieving because it is possible. But, at the same time, tentative attempts to survey the universe are not on that account to be dismissed as useless. After we have heard all that modern men of science have to say, we may have to come out by the same door that in we went, but we shall have heard great argument and come out wiser than before. Perhaps for the present we can learn no greater wisdom than that a degradation of the physical universe is not necessarily a degradation of the world of spirit. Sir James Jeans has already told us that it is only on the dead ashes of matter that life can begin to exist. Might it not be that only in the dead smoke of radiation can life attain its fullest development?

HEARTY congratulations are due to Dr. James W. L. Glaisher, F.R.S., mathematician, who on Monday next, Nov. 5, celebrates his eightieth birthday. Born at Lewisham, he was educated at St. Paul's School, afterwards proceeding to Trinity College, Cambridge, where he graduated second wrangler. A teacher of great distinction in mathematical science, embracing the whole of his working life, Dr. Glaisher has earned the esteem and gratitude of a host of academical pupils. Author of many original papers, most of the special mathematical journals in Great Britain owe editorship or guidance to his dutiful and long-continued labours. Dr. Glaisher has been twice president of the Royal Astronomical Society. In 1908 the London Mathematical Society awarded him the De Morgan medal, and in 1913 the Royal Society allotted him the Sylvester medal. He was president of Section A (Mathematical and Physical Science) at the Leeds meeting of the British Association in 1890. Dr. Glaisher's father, founder of the Meteorological Society, and pioneer in scientific ballooning, who himself, it may be recalled, passed the span of eighty years, is remembered in particular for his balloon ascent with Coxwell, the aeronaut, to a height of seven miles.

DR. CHARLES NICOLLE, director of the Pasteur Institute of Tunis, who has just been awarded the Nobel prize for medicine for 1928, in consideration of his work on typhus fever, is one of the most distinguished of living epidemiologists. His researches on typhus, which have been continued for more than twenty years, are of the utmost importance, as they have done so much to throw light on the causation of the disease and have greatly contributed to its effective prevention. Nicolle was the first to show that typhus fever could be transmitted from man to the chimpanzee, from which it could be passed on to the lower apes. Further investigations revealed that the guinea-pig could also be successfully inoculated with the blood of a typhus patient, though the symptoms so produced were not so severe as in the experimental disease in the monkey, but merely consisted in a rise of temperature. The agent in transmitting the disease in man was shown by Nicolle to be the louse, especially *Pediculus vestimenti*, and to a less extent *Pediculus capitis*, while other parasites such as fleas, bugs, and mosquitoes had no such action. Lastly, Nicolle proved that the injection of the serum of convalescents from typhus fever conferred an immediate though transient immunity on those exposed to the disease. It may be noted in this connexion that in conjunction with E. Conseil, Nicolle was the first to show that the serum of measles convalescents possessed a similar protective value, and was thus the pioneer of a prophylactic method which has been widely used on the Continent. The value of the work of Nicolle and his assistants, which has been confirmed by all the other investigators of typhus, has been repeatedly illustrated in combating epidemics, particularly during the War, when the destruction of lice was found to be the most effective method of controlling the disease.

ON Oct. 25 the Bishop of Oxford unveiled a tablet in the Church of St. Peter-in-the-East, Oxford, to the memory of James Sadler, the "First English Aeronaut." Sadler was born in High Street, Oxford, in 1753 and died in George Street on Mar. 27, 1828. He was buried in the churchyard of St. Peter-in-the-East. The tablet has been erected by the Royal Aeronautical Society. Nothing is known of Sadler's early life except that, like his father, he was a confectioner. His first aerial voyage was made at dawn at Oxford, on Oct. 4, 1784, in a Montgolfier or hot-air balloon, and lasted about half an hour. The following year he made other ascents, but then turned his attention to chemistry, becoming assistant to the professor of chemistry at Oxford; from 1796 to about 1807 he was chemist to the Board of Naval Works at the Admiralty. He endeavoured to improve the steam engine and experimented on air-pumps, blasting, naval guns, and muskets. With the suppression of the Board of Naval Works, however, Sadler fell on hard times; but friends came to his assistance, and for a few years he again turned his attention to aeronautics and was well known for his ascents from Bristol, Cambridge, London, Brighton, Dublin, and other places.

AT the annual meeting of the Institution of Mining Engineers on Oct. 24, the president, Prof. H. Louis, presented the medal of the Institution to Sir Henry Hall "in recognition of his long and distinguished services in the advancement of the science and technology of mining." Sir Henry Hall was born at Sedgefield in the county of Durham, and served his time at the Haswell Colliery in the same county. He was appointed H.M. Inspector of Mines in the Swansea district in 1873, and in the following year was appointed Chief Inspector of Mines of the Liverpool district, to which the North Wales district was afterwards added, and he continued to hold this position until his retirement from the inspectorate in 1908. His work as an inspector was highly appreciated by all with whom he came in contact, his sound knowledge of all mining matters and conspicuous fairmindedness being universally appreciated. His main work was in connexion with the part that coal dust plays in colliery explosions. According to his own statement, his attention was first directed to this subject about 1874, and in 1890 he performed his famous experiments by which he demonstrated that coal dust, even in the absence of gas, could produce violent explosions. He gave evidence on this subject in the following year before the Commission appointed to investigate the matter, and in 1893 published his well-known report on "Coal Dust Explosions in Mines." Even after his retirement his advice and opinions were constantly resorted to on all mining matters, and it can fairly be said that there are few men who have rendered better service than has Sir Henry Hall to the coal-mining industry of Great Britain.

THE decision of the British Broadcasting Company not to undertake an experimental demonstration of radiovision by the Baird Company at present, has probably come as a surprise to many. Though it is difficult to judge when the art is sufficiently advanced to meet the public demand for entertainment, we should have thought that arrangements might have been made for the Baird Company to give a few experimental demonstrations from one of the B.B.C. stations which could be received by those of the public who are interested. The public would then be in a better position to judge whether broadcasting radiovision in Great Britain was desirable or not. In the United States the WGY station at Schenectady has been broadcasting a complete drama called 'The Queen's Messenger' by radiovision. It seems to have been rather crude. The actor's head and facial expressions were faithfully transmitted, but when it came to action, merely the actor's hands pouring out a glass of wine, giving a ring, or holding a revolver could be seen. Each actor had to work in front of a white screen, a background which gave definiteness to his features. He was constrained to act within a very limited area and his features were heavily 'made up.' Those of the audience who knew the difficulties in the way were appreciative. Unfortunately, the optimistic accounts which have appeared in the press will lead to the disappointment of many who see the radio pictures for the first time. We see no reason, however, why preliminary experiments should not be permitted.

AT Edinburgh, on Oct. 25, the Secretary of State for Air discoursed to the Royal Geographical Society of Scotland on the dramatic way in which a novel and untried auxiliary arm has achieved the status of the Third Fighting Service. We are warned that the problem of air defence demands increasing expenditure. In some mitigation, the policing of uncivilised frontiers is found less costly with judicious use of the air arm, and fascinating glimpses were given of the effect of a flying display on the primitive mind. The application of air transport in unsettled territories is full of promise, but critical comment might be made on the claim that civil aviation offers any serious competition to established railways and shipping lines, and the idea of mass migration by air within the British Empire has a somewhat airy basis. Civil aviation must be regarded at present mainly as a reserve, almost immediately available in emergency, to which the recent development of light aeroplane clubs promises an appreciable contribution. Expenditure in this direction may well produce better returns than further direct military expenditure, at least up to an appreciable proportion.

IN the somewhat optimistic references to airships in Sir Samuel Hoare's address, there is a welcome note of caution on the experimental nature of R100 and R101. The argument that we must build because others were building lost its force when the *Shenandoah* accident restricted American activities drastically. The argument is now used on the other side, that because British airships are being built, therefore the U.S.A. must do so too. The latest German airship is much smaller and less costly than the new British airships. The suggestion that it also is " as we believe, far inferior in design and construction to our own," seems less than probable, and it is a pity that the technical advisers should inspire such premature awards to their own ability. Apart from the question of airships, which is likely to remain contentious for some time to come, the speech commands confidence as a fair and balanced summing up of our air position in its vital relation to the security of Great Britain.

STUDENTS of living creatures will find much of interest in the series of animal paintings by Mr. C. E. Swan, on view in the Art Gallery at 14 Brook Street, New Bond Street, W.1. The paintings, fifty-two in number, are in the main studies of mammals, and especially of the larger carnivora. Lovers of the London 'Zoo' will here discover the portraits of some of their old favourites. Mr. Swan knows his animals, and he is particularly happy in rendering their expressions, as may be seen (to mention but three examples) in " Marcus " (No. 45, the well-known orang which lived some time ago in the 'Zoo'); in " Bos Caffer " (the African buffalo, No. 5); and in " Wandered from the Lair " (the two lion cubs looking at a snake, No. 26). The different characters of these two cubs may readily be perceived and understood by anybody who has ever made an intensive study of the various characters of a family of young carnivores. The paintings will remain on exhibition until Nov. 6.

THE lecture on " Science in Western Civilisation," which Mr. J. B. S. Haldane delivered to the Fabian Society on Oct. 25, was a reasoned plea for science in government, or, more correctly, the 'scientific viewpoint' in national affairs. Mr. Haldane would be satisfied if the Cabinet contained one member with a knowledge of science equal to a second class in the Cambridge Natural Science Tripos, Part I. Motor taxation, he suggested, must have been devised by a lunatic. Commenting on science in journalism, the lecturer said that the *Times* announced the production of the compound of helium and mercury as an important item of news, when full particulars had been published in NATURE some weeks before. On eugenic questions, he drew opposite conclusions from Dean Inge and Major Darwin. If the wish to leave adequate fortunes restricted the size of families, why not abolish hereditary wealth ? Forecasting the future, some of those present might expect to see synthetic foods and drugs, such as cocaine and morphine. Russia was trying to inculcate a scientific outlook and habit of thought, and was doing valuable research work, especially in genetics ; but he refused to predict whether its form of national organisation would survive economic tests. Appropriately for a Labour gathering, he insisted that the scientific man is usually a manual worker. The lecture was followed by a large audience with sustained interest and, at its conclusion, elicited questions, in reply to one of which Mr. Bernard Shaw was assured that he (Mr. Shaw) was not a scientific man.

RECENT additions to the British Museum (Natural History) include the following :—In the Department of Zoology, a specimen of the Congo race of Lord Derby's Eland (*Taurotragus derbianus congolanus*), one of the most important accessions of recent years, has been received from Sir Charles Markham, Bart. The Congo race is very closely allied to the typical Derby Eland, from West Africa. The eastern race from the Lado Enclave (*Taurotragus derbianus gigas*) is frequently referred to as the Giant Eland ; in general proportions, however, the Lado animal does not markedly exceed either the typical Derby Eland or the Congo form. To the collection of birds have been added seven examples of the Altai Snow Cock (*Tetrœgallus altaicus*), a large grey bird about the size of a hen Capercaillie, and grey all over with the exception of the breast, which is white. These birds were purchased in Smithfield Market, a large number having been imported in cold storage from the Altai Mountains in Central Asia, where the bird is not uncommon at altitudes over 7000 ft. above sea-level. Other species are found in the different mountain ranges of Northern Asia. The Geological Department of the Museum has received a collection of more than 400 specimens of London Clay fossils, collected bed by bed at Bognor, Sussex, by the donor, Mr. E. M. Venables.

AN interesting addition to the Mineral Collection in the British Museum (Natural History) is a large block (139 lb.) of willemite ore from Franklin Furnace, New Jersey, specially presented by the New Jersey Zinc Company for demonstrating the fluorescence of minerals in ultra-violet rays. The pale-green willemite (zinc silicate) is intermixed with snow-white calcite, pink rhodonite, and black crystals of franklinite. Under the influence of the ultra-violet rays, the willemite shines up with a brilliant green and the calcite with a rose-red glow, producing a very striking effect. Another valuable present is a large isolated and doubly terminated crystal of quartz (rock-crystal) weighing 34 lb. recently collected on the Piz Nor, Tavetsch valley, Switzerland, presented by Mr. F. N. Ashcroft. The Department of Botany has purchased 652 specimens of Indo-Chinese plants from the classic locality in which

Joannes de Loureiro made in the eighteenth century the collection (now in the Department of Botany) on which his "Flora Cochinchinensis" (1790) was based.

THE Director of the Meteorological Office is investigating the violent 'whirlwind' which struck the West End of London on Monday evening, Oct. 22, and has asked for the loan of the records of recording barometers or any other recording meteorological instruments from anywhere within a radius of about 20 miles of Charing Cross. Up to Oct. 26, he had received 92 communications, of which 74 were accompanied by barograms, and many contained other valuable information. From the records received it appears that the disturbance moved northwards along a straight track of small width, from near Victoria Station to Euston, passing near Piccadilly Circus and Oxford Circus. It then continued in the same line with diminished intensity. Barograms on the track differ from those off it in showing an additional very sudden fall and recovery of the barometer as the disturbance passed. They tend to confirm that the phenomenon had many of the characteristics of an American tornado. Disturbances of a similar kind occurred in other parts of England on the same occasion, in particular at Bromley, Kent, and near Hythe, Southampton. Records should be addressed to the Director, Meteorological Office (M.O. 12), Air Ministry, Kingsway, W.C.2.

PROF. RAYMOND A. DART, professor of anatomy in the University of the Witwatersrand, Johannesburg, has been elected a corresponding member of the Italian Institute of Human Palæontology, Florence, "in recognition of their deep appreciation of the distinction he has achieved in their branch of science." The membership of the Institute is restricted to 50 Italians and 50 corresponding members.

PROF. W. E. DALBY will give an address to the London Local Section of the Institute of Metals, on Nov. 8, at 8 P.M., at the Royal School of Mines, South Kensington, S.W.7, on "The Plastic Contour." Prof. Dalby will deal with his own work on the mechanical properties of materials. The meeting is an open one, for which tickets can be obtained on application to the Hon. Secretary, Mr. W. T. Griffiths, c/o The Mond Nickel Co., Ltd., Victoria Station House, London, S.W.1.

THE reform of the British patent system is the subject of a report which is to be issued by the British Science Guild next week. Eighteen months ago the Guild appointed a committee to study the problems which arise in this connexion, under the chairmanship of Dr. W. H. Eccles. The members of the committee included well-known inventors, research workers, barristers, patent agents, and ex-officers of the Patent Office, and it is understood that they will put forward about fifty proposals of a practical character for the general improvement of the system and the remedy of existing anomalies and hardships. It is now twenty years or more since the last extensive amendment of the patent laws in Great Britain took place, and the time is undoubtedly ripe for a thorough overhauling, in the light of the experience gained during that period, of this vital factor in industry.

MR. CECIL L. HORTON, of the Department of Lands, Jerusalem, writes to point out that the equation between the month of August and the Moslem month of Muharram in our Calendar of Customs and Festivals (see NATURE, Sept. 1, p. 334) is incorrect. The Moslem year being divided into lunar months, there is no fixed correspondence between the Islamic and Roman calendars. He adds that in the current year the 1st Muharram occurred on June 18, and next year will fall about June 7. Mr. C. A. Silberrad, of Forest Side, Epping, also writes to point out that in our note on his correction in reference to the Moslem year (see NATURE, Sept. 29, p. 489) it should have been made clear that the maximum variation of twenty-two days was in respect of the Hindu solar-lunar year only, whereas the Moslem calendar works back eleven days in each Christian year, and a whole year in thirty-three Christian years. In the course of this cycle of thirty-three years any Moslem festival occurs approximately thrice in every month of the Christian year.

MESSRS. Bernard Quaritch, Ltd., 11 Grafton Street, W.1, have just published Catalogue No. 420 of second-hand books on botany, agriculture, early medicine and surgery, forestry, fruit-culture, gardens and gardening, herbals, modern medicine, and tobacco. Of the 1800 works listed, many are exceedingly rare. The catalogue should be of great interest and value to librarians and others.

APPLICATIONS are invited for the following appointments, on or before the dates mentioned :—A research assistant and demonstrator in geology in the University of Leeds—The Registrar, The University, Leeds (Nov. 5). A graduate assistant to teach physics and electro-technology at the Junior Technical School and the Technical College, Barrow-in-Furness—The Director of Education, Town Hall, Barrow-in-Furness (Nov. 7). A professor of economics in the University of Adelaide—The Agent-General for South Australia, Australia House, Strand, W.C.2 (Nov. 20). A professor of mathematics in the University of Western Australia—The Agent-General for Western Australia, 115 Strand, W.C.2 (Dec. 18). A lecturer in economics and public administration in the Department of Adult Education of University College, Nottingham—The Registrar, University College, Nottingham. A Drapers' Company research scholar in dyeing at the Huddersfield Technical College—The Principal, Technical College, Huddersfield. A junior assistant under the Directorate of Explosives Research of the Research Department, Woolwich—The Chief Superintendent, Research Department, Woolwich, S.E.18.

ERRATUM.—The first sentence in the third paragraph of the letter by Messrs. Aborn and Davidson, entitled "X-Ray Studies of the Structure of Salts Adsorbed on Cellulose," in NATURE of Sept. 22 (p. 440), should read: "Investigations were made both with starch and with cellulose in the form of filter paper."

Research Items.

ROCK-PAINTINGS IN THE LIBYAN DESERT.—In *Antiquity* for September, Mr. D. Newbold describes a number of rock-paintings not previously seen by Europeans from various localities in the Libyan Desert. These were visited in the course of two expeditions in 1923 and 1927. Stone implements and pottery were also collected. The object of the expeditions was to examine archæological evidence with the view of the elucidation of the ethnological history of the area, to which there are references going back so far as the eighteenth dynasty in the Egyptian monuments. The rock pictures are here classified into four groups: (*a*) Bushman—late palæolithic or early neolithic; (*b*) Early Libyan—early neolithic, predynastic, and Old Empire; (*c*) Middle Libyan—Middle and Late Empire down to the introduction of the camel into the Sudan, that is, the early Meroitic period; and (*d*) Roman, medieval and modern. For (*b*) and (*c*) there are references to Libyans in the Egyptian monuments; for the latter half of (*c*) the evidence of Greek and Roman geographers and a few vague references in native 'Histories'; and for (*d*) the same authorities and Arabian geographers. In the areas visited, of which the pictures are here described, Owenat shows examples ranging from the earliest to the third period, Nukheila, Zolat el Hammad, and Um Tasawir examples from the second and third, while those at Qalaat el Wish and Abu Sofian are of the last modern period. The Kordofan pictures are difficult to date.

AN EARLY DRAWING OF A FLORIDA CHIEF.—In Volume 81, No. 4, of the *Smithsonian Miscellaneous Collections* is reproduced for the first time a drawing of an Indian 'King,' Saturioua, a Timucua chief in Florida in 1564. The drawing was executed by Jacques Lemoyne de Morgues, who accompanied Laudonnière to America in the reign of Charles IX. of France. Lemoyne was attached to the expedition as artist to map the coast and sketch the natives and their dwellings. Apparently his are the first drawings of Indians known to have been brought to Europe. They were reproduced by De Bry, who also published the artist's notes, purchased from his widow, in 1891. Among the published drawings is one of Saturioua in the act of performing a ceremony before he set out on an expedition against his enemies. The ceremony, of which two accounts are extant, consisted in part in scattering water towards his followers who sat round him in a circle, and then pouring the water on the embers of a fire so that his enemies might be quenched in like manner. The newly published drawing shows the chief at the moment when he has completed the ceremony with the bowl still in his hand. Lemoyne afterwards settled in England, possibly on account of being a Huguenot, and lived with Sir Walter Raleigh. It is possibly due to his influence that Raleigh's expedition to Virginia in 1585 carried an artist, whose instructions were very similar to those given to Lemoyne twenty years before.

RESULTS OF OPERATIONS FOR CANCER OF THE BREAST.—The Ministry of Health has recently issued another report on cancer, dealing with the late results of operation for cancer of the breast, based upon an analysis by Dr. Janet Lane-Claypon of 2006 cases occurring in the practice of general hospitals in eight county boroughs (*Reps. on Pub. Health and Med. Subjects*, No. 51). Arrangements were made for ascertaining the fate of all patients submitted to operation for breast cancer, assessed over periods of 3, 5, and 10 years after operation. The type of growth has apparently little influence on the success or otherwise of operation. Early operation before the growth has spread beyond the confines of the breast is most important. When treated at this stage the percentage of survivals to 10 years is 73; when the disease has spread, the corresponding percentage falls to 13. Unfortunately, not more than 25 per cent of the hospital patients operated on are at this early stage. The nature of the operation performed is also very important, and the radical operation involving complete removal of the breast and underlying tissue with clearance of the axilla is generally to be preferred. Contrary to common belief, the prognosis was not worse in younger persons. The main lesson of this report is that a 'lump' in the breast of an adult woman calls for diagnosis and treatment without avoidable delay. If the lump be not cancerous, the anxieties of the patient are relieved; if it is cancerous, delay spells disaster, whereas treated by early operation the prospects are excellent.

BIOLOGICAL STABILITY OF THE ARISTOCRACY.—An investigation of the information contained in *Burke's Peerage* leads F. A. Woods to the conclusion that wealth and power do not lead, as is so often asserted, to idleness, sterility, and degeneracy. On the contrary, there are good reasons for considering aristocracy to be in many ways superior to the masses of mankind. Of 622 British peers in *Burke's Peerage* (1921), 334 are continuously aristocratic in the direct male line of their family trees to as early as the year 1450. Old families, then, do not become decrepit because of their old age, but in a general way families that once acquire high social position retain the high level. The author analyses the causes which contribute to this biological stability: ambition, capacity for advancement, family pride, marriage in the same social stratum, desire to leave heirs, and so on, any or all of which may be ingredients in the biological inheritance of the families concerned (*Jour. Heredity*, September 1928).

FERTILE MARE MULES.—A. H. Groth describes a very unusual case of fertility in a mule in the September issue of the *Journal of Heredity*. In 1920 a female mule, then twenty years of age, was reported to have given birth to a live female offspring sired by a jack. The two animals were acquired for observation by the Agriculture College of Texas. The colt developed into a dark bay mule showing no more characters of sire than an ordinary mule. The parent, "Old Beck," was mated unsuccessfully to a jack in 1921, but successfully to a bay saddle stallion in 1922, the result being a bay stallion colt in almost every respect like his sire. This animal has developed into a nicely balanced horse of saddle type, of remarkable intelligence, but showing a mule characteristic in his dislike to cross streams and ditches. He has been mated with several mares, one of which produced a bay stud foal. The original mare mule has, since the birth of her second foal, been mated on several occasions with jacks, but has had no further progeny, nor has success attended the mating of the older colt with stallions, jacks, or her half-brother. A second communication in the same journal records the birth of a "sure-enough" foal of a mare mule, sired by a jack, in Nebraska. The mare has been bred back to the same jack, and is believed to be again in foal.

THE DISTRIBUTION OF BRITISH SHEEP.—An analysis of the present-day distribution of breeds of sheep in the British Isles has led J. E. Nichols to some interesting conclusions regarding the climatic conditions best fitted for each breed (*Jour. Textile Institute*, September 1928). It is assumed that in the case of sheep, as amongst wild animals, the distribution of each race or species is related to an optimum series of environmental conditions, so that there has come to be an association of definite types with definite environments, and the success of sheep-breeding involves the cultivation of the suitable type for particular local conditions. These conditions can be defined for British breeds of sheep. By considering together temperature and rainfall, it may be considered that the most suitable climatic environment for the Down breeds is a monthly rainfall of 2 inches or less from about February to June, with a mean temperature of not less than 37° F. for January and February; for the lowland long wools, the rainfall may rise to about 2¼ inches with the same temperature conditions; while for the mountain and moorland types, the most suitable months for lambing are those during which the figures for rainfall and temperature most closely approach 3 inches and 40° F. respectively. It can also be said that generally the breeds which are most widely distributed in altitude are those which can withstand the greater number of rainy days.

SHALLOW-WATER ANTHOZOA OF HAWAII.—The late Prof. A. E. Verrill (1839–1926), of Yale, spent the last two years of his life in Hawaii and devoted much of his time to collecting on the reefs. His incomplete paper on the Hawaiian Anthozoa has been prepared for publication as *Bulletin 49* (1928) of the Bernice P. Bishop Museum, Honolulu, by Prof. C. H. Edmondson. Gorgonians and Alcyonacea appear to be almost lacking in shallow water and on the coral reefs of Hawaii, although both groups are abundantly represented around the Polynesian islands. A thin, encrusting, soft Alcyonacean, referred to a new genus *Sarcothelia*, and species of *Allogorgia* and *Euplexaura* of probable Hawaiian origin are described. Thirteen new species of Actiniaria, three new Zoanthids, and two new Antipathes are also described. One of the Actiniaria is *Sagartia pugnax*, which is carried about as a commensal in the chelæ of two species of small crabs—*Lybia* (*Melia*) *tesselata* and *Polydectus cupulifera*. Prof. Edmondson confirms Dr. Borradaile's statement that when the actinians are removed the crab immediately picks them up again, and he also states that when *Tealopsis nigrescens* (actinians of very different colour and appearance) were provided, the crab seized them and carried them about even when they were much too large. Prof. Verrill was apparently not aware that the anemone which he described as *Sagartia pugnax* had been referred by Prof. Duerden in 1903 to the genus *Bunodeopsis*.

MIOCENE MOLLUSCA FROM FLORIDA.—The monograph on "The Molluscan Fauna of the Alum Bluff Group of Florida," by Julia Gardiner, to which attention has already been directed (NATURE, Jan. 22, 1927), has now been completed by the publication of a fifth part (*U.S. Geol. Surv.; Professional Paper*, 142 E). This contains the account of the Tellinacea, Solenacea, Mactracea, Myacea, and one Brachiopod (*Discinisca aldrichi*, n. sp.). The Alum Bluff group exhibited conditions of unstable temperature and marked an epoch exceptionally favourable to the recording of environmental changes in a shifting and developing molluscan fauna.

SOUTH AFRICAN CHITONS AND CHITON PHYLOGENY.—A series of South African chitons collected by Lieut.-Col. Turton have now been described by Mr. E. Ashby, who appends a list of the known forms from that region (*Proc. Malac. Soc. Lond.*, vol. 18). Holding that the discovery of the fossil form *Protochiton* has largely removed difficulties that faced systematists when dealing with the classification of the group, the author considers that the phyla Acanthochitonidæ and Lepidopleuridæ were developed along parallel lines from the palæozoic stock in which the insertion plate is absent, and that it is therefore desirable that the Lepidopleuridæ should not be included under the suborder Eoplacophora but should form the most primitive family under the suborder Chitonina.

MUTANTS OF *ŒNOTHERA LAMARCKIANA*.—Around this plant, a classic in the study of mutation, a vast literature has arisen which may somewhat obscure the salient facts from all but the specialist student. Probably all students of genetics will therefore find useful a brief analysis of the different types of mutants in this plant, which is published by Hugo de Vries and R. R. Gates in the *Zeitschr. für induktive Abstammungs- und Vererbungslehre*, **47**, 275-286, 1928. The account is illustrated by photographs of some of the main types, taken by Prof. Gates in the experimental garden at Lutteren. Seven primary mutants are described; all are trisomic, that is, they have the normal 14 chromosomes, 7 from each gamete, and then in each case they have one extra, but it is assumed that in each case it is a different one of the seven chromosomes that is thus doubled, and that this fact is closely connected with the different characters of the mutant. Three other trisomic mutants arising from *Œ. Lamarckiana* are known as accessory mutants because they arise more frequently (up to 9 per cent of the progeny) from certain primary mutants; on the other hand, these accessory mutants never give rise to the primary mutants. Then there are the well-known polyploid mutants, with multiple sets (21 or 28) of chromosomes. One of these, *semi-gigas*, gives rise to a number of secondary mutants. Whilst in the primary mutants the pollen is normal and the extra chromosome is carried only in a proportion of the ovules, in certain homozygotic mutants both pollen and ovules carry the same hereditary characters. Thus from unstable half-mutants of this type, by ordinary Mendelian segregation, 25 per cent of stable isogamic mutants are obtained and 25 per cent of empty seeds.

DISEASES OF THE RASPBERRY.—*Special Bulletin*, Number 178 of the Agricultural Experiment Station of the Michigan State College, issued June 1928, contains a useful survey, by C. W. Bennett, of the diseases of the raspberry. This plant is cultivated to a considerable extent in Michigan, where there are probably 10,000 acres under cultivation with this fruit, so that with a large number of varieties grown in close proximity, valuable experience must have been gained of most of the pests encountered during the cultivation of this fruit. Several varieties of virus disease are recorded. These have so far usually been grouped together under the term of 'yellows,' but Bennett distinguishes between 'curl,' 'mosaic,' and 'streak'; of these, 'mosaic' seems the most common. For all of them control seems restricted to 'roguing,' with prevention of aphis infestation. Typical crown-gall is described for raspberry, also a rust, an anthracnose, a wilt, powdery mildew, and a blight of the cane and another of the spur. A leaf-spot is described, but as usual is of little economic importance. Red varieties of raspberry seem to act as carriers of virus diseases which do them little harm, but produce serious damage when they spread to the black varieties. The symptoms of these various diseases are described, and the causal organism defined, except of course for the virus diseases. Probably the anatomy of the raspberry shoot, in which a resistant endodermis forms along the internode at an early period and continues into the base of the leaf and the axillary bud (NATURE, vol. 119, p. 35, Jan. 1, 1927), explains why many of these diseases only do serious harm when attacking the young shoots of the current year's canes.

EFFECTS OF MOISTURE CHANGES ON BUILDING MATERIALS.—The Department of Scientific and Industrial Research has recently issued a *Building Research Bulletin* (No. 3) by R. E. Stradling on the effects of moisture changes on building materials. Disintegration of material may occur through water entering into chemical combination with certain constituents, such as lime formed during the firing of a brick or tile made from clay with a high chalk content. The effect of frost is also under investigation, but it is uncertain whether the freezing of wet stone in England is responsible for much damage. Considerable decay may be caused at the junction of two kinds of material by the solution of some constituent of one layer followed by its crystallisation in the other. Building materials frequently contain 'sorbed' water which is in a condition intermediate between the water of chemical combination and 'free' water, and the rôle played by such water is being carefully studied. The sorption of moisture causes an expansion of the material, which is followed by a contraction when the humidity of the air decreases. Considerable strains are thus set up and failures may occur, especially at the junction of materials having different moisture expansions.

AN EASILY REGULATED SELENIUM RESISTANCE.—A form of selenium resistance, showing behaviour analogous to that of the ordinary selenium cell, is described by Prof. Lavoro Amaduzzi in the *Rendiconti della Reale Accademia delle Scienze dell' Instituto di Bologna* for 1926 (recently received). It is prepared by incorporating graphite uniformly in the fused selenium, and spreading the mixture in a layer on a plane strip of steatite. Two parallel metallic wires, constituting the poles or electrodes of the cell, may be pressed lightly on to the layer, and if one of these be fixed, movement of the other in one direction or the other will increase or diminish the resistance of the cell.

KRYPTON AND XENON.—A process described by M. Georges Claude in the issue of *Comptes rendus* of the Paris Academy of Sciences for Oct. 8 seems likely to make krypton and xenon available in relatively large quantities. It appears that the great difficulty encountered hitherto in their preparation with ordinary liquid air plant has been that instead of remaining dissolved in the higher boiling parts of the liquefied oxygen, they were largely carried away mechanically in the spray formed in fractionation. M. Claude therefore proposes to feed the liquid oxygen into the top of a species of rectifying column, where the ascending vapour is washed thoroughly by descending liquid, with the result that the small quantity of liquid that ultimately reaches the bottom is now rich in the heavy components. This is drawn off, and its krypton and xenon content raised from one part in a thousand to two parts in a hundred, by removal of part of the oxygen by combustion with hydrogen; the residual gas is then absorbed on silica and fractionated, yielding almost half of the krypton and xenon that was present in the air originally taken into the liquefier. The feature of the new apparatus is that existing machinery is readily adapted to include it, and M. Claude estimates that a big installation, such as that at Boulogne, which uses 3000 cubic metres of air per hour, could produce several tens of litres of krypton gas in a day's working, and about one-tenth this amount of xenon.

LIGHTING AEROPLANE ROUTES.—A summary of an American report on the applications of lighting for various novel purposes is given in the *Illuminating Engineer* for September and October. In the United States there are about 6000 miles of air routes which are provided with beacon lights not more than 10 miles apart, and illuminated intermediate landing fields 30 miles apart. The beacon lights are erected on steel towers about 70 feet high, at the bases of which are chrome yellow arrows 56 feet long which indicate the line of flight. For daytime identification the number of the beacon is painted in black on the arrow. The beacon develops a beam the intensity of which is about two million candle-power. Its axis is elevated about two degrees above the horizontal and it makes six revolutions per minute. The intermediate landing fields usually have two landing strips at right angles to one another, each of them being about 500 feet wide and 2000 feet long. The boundaries of the landing strips are marked out by white lamps; green lights mark the favourable approaches, and lamps in red globes are mounted on all neighbouring obstructions. Successful experiments have been made on controlling landing field floodlights by switches actuated either by the noise of the aeroplane or by a whistle of distinctive tone sounded from the aeroplane. Artificial lighting of areas devoted to recreational purposes is now extensively used, and it seems probable that baseball will soon be played at night time under artificial lighting. Under water lamps have been used for studying tropical marine life off the coast of Haïti. Both clear and coloured lamps were used, and the power of light to attract certain kinds of fish was demonstrated. In agriculture the attraction that light has for certain insect pests has been utilised in luring them to destruction.

MOTIONS OF ELECTRONS IN GASES.—There is a widespread feeling that the investigations of the motion of slow electrons in gases which have been made in the Electrical Laboratory at Oxford are incompatible with other experiments having a similar aim which have been performed elsewhere, and a recent statement to this effect has drawn the reply from Prof. J. S. Townsend which appears in pp. 511-523 of vol. 120 of the *Proceedings of the Royal Society*. There is no doubt that some of the adverse criticisms that have been levelled against his work would not have been made if his postulates and results had been more carefully examined. In other instances, the issue is less clear, but quite apart from controversial points, Prof. Townsend's contributions to the subject are unquestionably fundamentally important. To mention only two results, it has been established by him, or under his direction, that the collisions of slow electrons with molecules are almost perfectly elastic if no quantised transitions are excited in the interaction, and also that the mean free path of an electron depends upon its velocity of agitation. Again, as he points out, his work has been accepted as being of importance by the compilers of many of the standard text-books on the electrical properties of gases, particularly in its relation to sparking potentials; nor is there really any indication that the usefulness of his conceptions is exhausted, since in at least two recent instances, to which he does not refer, they have been applied with conspicuous success to fresh problems in gaseous conduction—by Dr. I. Langmuir and H. Mott-Smith to the action of a magnetic field upon the mercury arc, and by Prof. K. T. Compton and P. M. Morse to the theory of the so-called normal cathode fall of potential in a cold Geissler discharge.

The International Institute of Bibliography.

ANNUAL MEETING AT COLOGNE.

THE annual meeting of the Brussels Institut International de Bibliographie was held at Cologne on Sept. 18 and 19, and by invitation of the Oberburgermeister, Dr. Adenauer, the proceedings took place in the Petite Salle des Congrès of the 'Pressa' Exhibition. Delegates of a number of institutions in different parts of the world, interested in bibliography and bibliographical methods, were present. The Science Library, South Kensington, was represented by Dr. S. C. Bradford.

The proceedings were presided over by Prof. A. F. C. Pollard, of the Imperial College of Science, South Kensington. In his introductory address, Prof. Pollard, reviewing the organisation of the International Institute, suggested that a central daughter bibliographical society should be formed in each country in order that individuals and institutions interested in bibliography and bibliographical methods might become members of their national society, and instanced the recent formation in London of the British Society of International Bibliography (British Section of the Institut International de Bibliographie).

Prof. Pollard then proceeded to indicate the possible relation of these societies to the Institut International de Bibliographie for the purpose of securing international uniformity of bibliographical method and the application of the universal decimal classification which had been so highly developed by the Institut. He hoped that by such means the extensive but wasteful energy expended upon the innumerable bibliographies at present published upon almost every branch of learning, and in many instances utilising extraordinary and useless methods of subject matter reference, might be directed into the production of bibliographies usefully indexed upon the simple and universal system advocated by the Institut. In the field of science some of these bibliographies might replace the International Catalogue of Scientific Literature, the cessation of which was a great loss to science.

Prof. Pollard pointed out that the Optical Society of London was the first scientific society in England to adopt these methods for indexing its *Transactions*. If all scientific societies agreed to act in the same uniform manner, and these several indexes were collected and published as specific bibliographies by the central body or Institut International de Bibliographie, accurate and detailed references to scientific literature would be produced with maximum economy and minimum effort. Such an international organisation for scientific literature, if it ever came about, might be extended to all fields of intellectual activity, and a gigantic machine could be established to index the world's rapidly increasing mass of literature. This was not an impossibility, for it only required concerted action, financial support, and the use of the powerful bibliographical tools which had been offered to the world by the Institut for the last twenty-three years.

The morning of the first day was occupied by the business of the Council, and in the afternoon the meeting of the Commission de la Classification Decimale was held. The function of this important commission or committee of the Institut is principally concerned with the periodical revision of the decimal classification, which by the aid of many collaborators in different parts of the world is ably conducted by M. Donker Duyvis, of Deventer. During the discussion upon the new edition of the Classification Decimale Universelle, now in course of preparation, it was stated that the Science Library was preparing an English index, the German Committee had decided upon a German translation of the work, and that in Czechoslovakia a translation had already been started.

On the following day the assembly, consisting of all members of the Institut and numerous delegates, convened to receive reports and hold discussions during which many interesting activities were brought to light. In particular, Dr. Huet, of Brussels, is producing by the help of collaborators an extensive bibliography of dentistry. Czechoslovakia gave evidence of the application of the international decimal classification in many directions. A remarkable feature of these deliberations was the unanimous tribute paid by a number of representatives of various municipal bodies to the great utility of the international classification for the efficient and rapid selection of any required detail from municipal archives, a very severe test of practical utility.

MM. Paul Otlet and H. La Fontaine, the original founders of the Institut International de Bibliographie in 1895, directed attention to the necessity of finding a suitable home for the Universal Bibliographical Repertory, consisting of 13,667,816 moveable index cards at present housed at the Palais Mondial at Brussels, which may shortly have to be removed. They hoped that it might be possible to find a suitable place for this enormous index in Geneva.

Dr. Uhlendahl, director of the German library at Leipzig, who also represented the Association of German Booksellers and the International Union of Librarians, pointed out, in his vote of thanks to the president, that the number of German librarians present was an indication of the interest taken in the methods of the Institut in Germany, and referred to the satisfactory progress made in various directions as shown by the reports received at the conference.

The Oberburgermeister of Cologne invited the members of the conference to luncheon in the Rathaus, and those who were present will not readily forget his liberal hospitality or the comfortable accommodation he afforded the members of the conference in the 'Pressa' Exhibition.

S. C. BRADFORD.

Economics of Production.

DISCUSSING "Medieval Economic Theory in Modern Industrial Life," Prof. Mauritz Bonn, of Berlin, before Section F (Economic Science and Statistics) at the recent Glasgow meeting of the British Association, stated that the chief feature of medieval economic theory was probably the conception of production as a mere physical act of turning out goods. The money value side of it was of no importance. In strict accordance with this conception, distribution proper, outside physical transportation, was rather despised. Price was a kind of simple computation of different costs; costs being equivalent to actual outlay and the necessary expenses of maintaining a status of living. The price was 'just' when the return to the producer covered these elements.

The scarcity of goods caused by the War in many countries brought the conception of physical production again to the forefront. Inflation enormously strengthened this conception. The less trustworthy the purchasing power of money, the more important was the possession of actual goods. The scramble for goods led to the theory that prices ought to pay, not for the actual cost of production of the goods sold, but for their cost of reproduction.

War and inflation had had a great influence on the fate of the purely commercial classes. Distribution was considered a mere parasitical undertaking. This reduced position of commerce enabled the manufacturing element to push forward with a policy they had embarked upon before the War—the ousting of the trader. The tendency which was visible in Germany before the War of industrial concerns trying to eliminate the trader by erecting their own distributing agencies greatly increased as the result of voluntary or compulsory cartellisation. The purely physical conception of production was most clearly visible in the attitude taken by business people in their relation of creditor and debtor. The debtor in their minds was a producer who carried out technical and economically important functions. The creditor, if not an industrial producer himself, was a kind of leech sucking the lifeblood of the industry. These views, influenced no doubt by a very short-sighted self-interest, were clearly akin to the medieval attitude to usury. Even since stabilisation has been accomplished, these views have not changed very much. The theory of prices underlying development in what might be called the era of competition, had been due to the conviction that low prices were a boon to society and that economic progress was identical with slowly falling prices. The medieval theory was the same in so far as consumers' interests came first. It believed, however, in stability, as without some stability the functional income of the producer could not be maintained.

The theory that falling prices conferred a benefit on mankind is now being deserted. Instead of it, a theory is growing up that rising prices, by giving a stimulus to production, are the real solution of social problems. First came Protection, which tried to raise prices for certain selected privileged goods, its advocates maintaining all the time that the general level of prices would not be affected. Then came inflation, with its spurious boom, which owing to rising prices was supposed to expand production. When carried out to its bitter end, as it was in Germany, it certainly had not produced the much-advertised benefits. After these not over-favourable experiences with wholesale inflation came the theory of homœopathic inflation, its advocates maintaining that by proper dosing of credit, stabilisation of sorts could be secured. Prices must not be allowed to fall under any conditions; wherever there was a tendency to fall, the issue of credit or the floating of loans abroad must prevent them sagging.

The theory of stabilised prices, which in its practical bearing was eagerly absorbed by business men, who cared nothing for its theoretical meaning, was closely affiliated to the medieval conception of maintaining a certain social order and a certain individual income. This is clearly demonstrated by the practice of many cartels. The question to be discussed is not free competition or monopoly; it is the peculiar form of monopoly aimed at or achieved by some influential cartels. The type of cartel in question is an agreement by which the individual works bound themselves to trade their produce by some sort of joint selling agency and to restrict their output if necessary. Now this sort of cartel is not based on any modern conception of efficiency. It standardises inefficiency at the cost of the consumer.

When comparisons have been made between trusts and cartels, cartels have always been praised for the maintenance of a number of separate enterprises. Where in a trust the initiative of leadership is reduced to a single head or to a small group of persons, the parties of a cartel continue as individual 'Captains of Industry.' As a matter of fact, they remain technical managers of their individual concerns, freed from the necessity and possibility of selling the produce they turn out. They are utterly divorced from the mere business side of their job, the marketing of their goods. The price fixed by the syndicate must be high enough to yield an income, though these works are run at half capacity and ought not to be run at all. It had often been said that the price must be high enough to keep the worst concern going. The trust need not be badly financed, but it is almost a law of Nature that the firms forming a cartel must. A trust may have many of the advantages claimed by the cartel, though some form of control was required. Real progress in a capitalistic world is, however, impossible without writing off, whereas cartels are essentially a well thought-out system of maintaining inflated capital values. The right to profit, to rents, and even to unearned increment, which the capitalistic system has conceded to private enterprise, must be counterbalanced under the system by a corresponding obligation to loss.

Examinations—The New Compromise.

THE Departmental Committee on Examinations for Part-time Students was appointed in 1927 "to inquire and report as to the arrangements for the examination of students attending part-time schools under the regulations for further education, with particular reference to the place and value of examinations as an element in training for industrial, commercial, and professional activity." Its report has just been published (London: H.M. Stationery Office, 1*s*. net), and contains chapters—notably those on the purpose of examinations and the planning and conduct of examinations—which should be read by all teachers. It will be of special interest to teachers in technical institutions, since they particularly will be affected by its recommendations.

Briefly, the report recommends a compromise. For some years now there has been a sharp division between supporters of the purely external and of the purely internal systems of examination. Indeed, the controversy which the report is expected to settle may be traced back to 1911, when the Board of Education's Circular 776 withdrew the old Science and Art Examinations and gave freedom to institutions to organise internal examinations, the final certificate of which would be endorsed by the Board. But it appears that the scheme has not been widely used, and the weakness would appear to have lain in the fact that many part-time classes are taught by part-time teachers who are sometimes not expert in setting and marking papers. But this was not the only cause of the failure of purely internal examinations. Most part-time students take courses in order to benefit vocationally. They therefore need a certificate of which employers all over Great Britain will recognise the value. The certificate granted by a school as a result of an internal examination does not yet fulfil that condition.

Many teachers have naturally desired to retain the principles of Circular 776, which they regarded as a charter of freedom, and the time will doubtless come when those sound principles will be found generally practicable. In the meantime, the present report sees the value, particularly in their possibilities of counting such important things as laboratory and home work, of internal examinations. But it also sees their present defects, and has decided upon a compromise in the form of modified external examinations. It envisages a system in which they are conducted by unions of local education authorities throughout Great Britain.

Whether such groups of unions will, in fact, do all the report expects, is not a matter upon which any pronouncement can be made now. From the recommendations made, however, it may be possible that ultimately a more ideal system can be built. It is a pity that, in the report itself, no mention was made of the future possibilities when the obstacles to the excellent principles of Circular 776 will be swept away. If examination, as the report wisely shows, is an educational function, hope still stays with the idealist: for in education "nothing is constant but change."

Origin and Structure of the Viviparidæ.

Two exceedingly important papers by Dr. Baini Prashad have appeared, nominally concerned only with the Viviparidæ, but in reality covering far wider ground (*Mem. Indian Mus.*, vol. 8).

The first deals with the recent and fossil Viviparidæ and constitutes a study in distribution, evolution, and palæogeography. The author attempts to determine the taxonomy of the family, the dispersal of which he considers to have taken place along the freshwater streams. The ordinary zoogeographical regions are of no value for the Viviparidæ, which are, therefore, considered here according to the continents and countries in which they are found, a sketch map being appended. The fossil members are treated on similar lines and genealogical trees given. The various sculptured forms are held to have been independently evolved in the different regions, and their palæogeography is discussed so far as it has a bearing on the subject in hand.

Setting aside Garwood's *Viviparus carbonarius*, for reasons which some will consider insufficient, the author holds that the Viviparidæ arose from the common stem of the families Trochidæ and Turbinidæ in the early Jurassic period, not, however, from a common ancestral form, but polyphyletically, taking to freshwater life in at least four regions, namely, western Europe, North America, peninsular India, and Australia. The probable time of origin in each area, the evolution of the different subgenera, and the lines of migration are then discussed.

Dr. Prashad's second paper, "On the Mantle and Shell of the Viviparidæ," was undertaken in continuation of the work of his late chief, Dr. T. N. Annandale, on the problem of the shell sculpture in the family. After a preliminary historical sketch of the relation between the shell and the animal in Gastropoda, the author passes to a detailed study of the mantle of the Viviparidæ, the important difference of which, contrasted with that of other gastropods, lies in the development of special processes on the mantle margin of the embryos, some of which also persist in the adults. There are three primary and a number of secondary and tertiary processes which correspond to the ridges or sculpture on the shells. The section dealing with the shell is in matter of fact an able summary of all that is known concerning the structure and formation of gastropod shells as a whole and should be overlooked by no malacologist.

The paper concludes with a "Review of the Literature on the Embryonic Shell-gland and Associated Structures in Mollusca," and a bibliography. The plates, five in all, are excellent specimens of photolithography, and the whole work (pp. 167) reflects the greatest credit on those responsible for its production, including the Zoological Survey of India, which in a sense is the parent of it.

University and Educational Intelligence.

Cambridge.—Mr. C. Warburton, Christ's College, has been re-appointed demonstrator in medical entomology. Miss A. S. Dale, Newnham College, has been elected to the Michael Foster research studentship in physiology. Mr. H. J. Pfister, of the University of Birmingham, has been nominated to use the University's table at the Zoological station at Naples for one month.

London.—The new statutes have been submitted to His Majesty in Council. Eight weeks from the commencement of term will be allowed for petitions. We understand that a petition has been presented by a member of Convocation for the disallowance of certain statutes nullifying or restricting the privileges of Convocation in relation to the appointment of its clerk and the approval of new statutes. The same petition objects to the exclusion of the Royal College of Science, London, from the list of Schools of the University in the Faculty of Science, on the ground that the College became a School of the University in the Faculty of Science under the statutes of 1900 and has not lost that status. The statutes were sealed by the Commissioners on July 23, 1928.

Oxford.—On Tuesday, Oct. 23, Congregation had two measures before it, both of which raised questions of interest to scientific men. By the first of these it was proposed to curtail the present permission of research students in letters or science to reckon periods of residence in vacation towards their statutable terms for the degrees B.Litt. or B.Sc. respectively. It was pointed out by Prof. E. B. Poulton that the opportunities for the requisite study were at least as open in vacation as in term, and that the effect of the proposed statute might well be to put great difficulty in the way, for example, of aspirants to the science degree domiciled in distant countries and with limited periods of leave. The preamble was rejected by 88 votes to 80.

The second, a decree supported by the Provost of Worcester and Dr. J. Wells, and opposed by Sir Harold Hartley and Mr. A. H. Smith, proposed the acceptance of a generous gift of £10,000 by Prof. Joseph Wright towards the cost of extending the Taylorian Institution along the front of St. Giles's. Ungracious as it seemed to decline so munificent an offer, it was felt that the conditions attached to the gift were not in the best interest of the institution concerned, nor ultimately in that of the University. The question of provision for the future housing and extension of the Ashmolean collections, of unique scientific and archæological value, is involved; and it appeared to the majority that a more considered and wider scheme was called for than that recommended by Council. The decree failed to pass, there being 92 votes for it and 121 against.

An equally liberal gift of £10,000 from Capt. Brynar Owen and Mr. W. J. Mallinson for the purpose of engineering research in connexion with the Institute of Agricultural Engineering was gratefully accepted.

The Institution of Chemical Engineers announces that application forms and particulars of the associate-membership examination for 1929, together with a memorandum on "The Training of a Chemical Engineer," may be had from the Honorary Registrar of the Institution, Abbey House, Westminster, S.W.1. The application forms referred to must be returned by Dec. 15.

Calendar of Customs and Festivals.

November 3.

ST. WINIFRED—Virgin and Martyr.—The well of St. Winifred at Treffynnon, also known as Holywell, was at one time one of the best known and most frequented wells in Great Britain. The cult of the Saint at this spot has with some probability been traced to Saxon times, but it unquestionably superseded an older worship. It was much frequented by pilgrims, and was noted for its healing qualities. The rites took the usual form of circumambulation, bathing, kissing certain stones, and a large number of votive offerings, especially crutches, bore witness to its healing qualities. A small spring near the great well was noted for the cure of weak eyes, sufferers offering crooked pins.

November 5.

GUNPOWDER PLOT. GUY FAWKES DAY.—The public celebration of the discovery of the plot to blow up King and Parliament on Nov. 5, 1605, has now fallen into disuse, though its memory is preserved in the discharge of fireworks by children, and the parade of ' guys ' about the streets on Nov. 5 and preceding days with the object of raising a few coppers. The appropriate and widely distributed rhymes beginning "Remember, remember the fifth of November," are still sometimes heard. Public celebration lasted well into the nineteenth century, and so late as the 'seventies it was recorded that the Yeomen of the Guard searched for any barrels of gunpowder which might be hidden in the vaults of the Houses of Parliament. In London one of the biggest of the bonfires was lit at the corner of Lincoln's Inn Fields on the Great Queen Street corner, when sometimes as many as two hundred cartloads of wood and more than thirty ' guys ' were consumed. The processions were not always of a peaceful character, and rival ' guys ' from different districts sometimes became involved in fights of a more or less serious character.

Among the butchers of Clare Market the celebrations took on a special character. One of their number personated the ' guy ' and, being seated in a cart with a prayer book, was drawn about in the company of an executioner and priest. A select party with marrow bones and cleavers headed the procession, while others solicited alms which were spent at the ale-house on a feast at the end of the day.

At Harlington, under date 1683, half an acre of land was given for the benefit of the bellringers of the parish to provide them with a leg of pork for ringing the bells on Nov. 5.

The Fifth of November custom is widespread in England, and although the accompanying rhymes vary in detail, essentially they are identical. Certain variations in custom are recorded which are not without significance. In Oxfordshire the verses were recited while the fuel was being gathered, and were held to render lawful the appropriation of any old wood. The operation was known as ' going a-progging.' At Lewes a torchlight procession took place, those participating being dressed up, with blackened faces. Effigies were cast into the fire when it was at its highest. At Marlborough a dozen or more formed a ring around the fire and they then followed one another round it in a circle, holding thick club-sticks over their shoulders, while others standing outside the circle beat the sticks of those in the circle with similar sticks as they passed. All shouted at the top of their voices. This lasted for about half an hour, and was repeated at intervals until the fire died out. In the West Riding of Yorkshire for some weeks before, a store of the cake called Parkin was prepared which was solemnly eaten on the day. At Doncaster the town waits played on the church steeple, for which they received sixpence.

A further indication of the ritual character of the Fifth of November festival is afforded by Lincolnshire and Yorkshire belief and practice. Some seventy or eighty years ago it was held that on Nov. 5 any farmer's son or, in some localities anyone, could shoot at will on neighbours' farms or their preserves. It is recorded that between 1805 and 1825 everyone who could procure a gun would turn out to shoot, and no one thought of preventing them.

The survival of these variations in practice points to what at one time must have been a more elaborate ceremonial. The Marlborough custom is very distinctly of a religious and sacrificial character. The widespread Fifth of November fire has clearly taken the place of the Samhain fires of Wales, Scotland, and Ireland.

November 6.

ST. LEONARD.—A French nobleman of the court of Clovis I. converted by St. Remigius, who became a monk remarkable for his charity towards prisoners, and died in 559. His miraculous efforts in releasing prisoners continuing after his death, he was canonised. An Ordinance of Worcester, published in 1240, ordained that his day should be kept a half-holiday, and that on it there should be no labour except that of the plough. In one of the Essex manors dues on animals, especially pigs, were payable on this day for the privilege of the manorial woods.

October-November.

In the Bombay Presidency on the twelfth day of the dark half of the month Kārtik, some villages of the Thana district of the Bombay Presidency worship the deity Waghoba or Waghya. The cowherds collect a quantity of milk and prepare a mixture of cooked rice and molasses. They then proceed to the stone image of the deity in the jungle and besmear it with new red lead, pour sweet milk over the stones, pray for the protection of the cattle, and partake of the remaining milk. An interesting ceremony, which recalls the English ' beating the bounds,' is performed at Agashi and neighbouring villages, when a goat and some cocks are sacrificed to the spirits in the cemeteries and at the boundary of the village. A goat decorated with garlands and red powder is made to walk round the village three times at night accompanied by the villagers, who scatter parched rice as they pass. This is called ' binding the boundary ' and protects the cattle and crops. No farmer dares sow his seed until this rite has been performed.

November.

In Malabar, in connexion with the cultivation of the second crop, a ceremony is held in honour of the god Muni in the month of Thulam (November). Each barn has its own Muni represented by a block of granite beneath a tree. He is the protector of cattle and field labourers, and arrack, toddy, and blood are necessary ingredients of his worship. In well-to-do families a goat, in the poorer a fowl, is sacrificed to him, the officiating priest being a Nayar or a Cheruman. The goat or fowl is brought before the god and a mixture of turmeric and lime sprinkled on it. If the animal shakes, the god is satisfied. The fact that the officiating priest is a Cheruman is significant, as they are serfs. The prominent position that they and other servile tribes take in these ceremonies is interpreted as a mark of recognition that they were once masters of the land, a fact to which Kipling refers in connexion with the Bhils in one of his Indian stories.

Societies and Academies.

SYDNEY.

Linnean Society of New South Wales, Aug. 29.—**C. P. Alexander**: The Tanyderidæ (Diptera) of Australia. The family Tanyderidæ is represented by ten recent and fossil genera; of these, three genera with four species are here recorded from the Australian subregion.—**Rev. H. M. R. Rupp**: Terrestrial orchids of Barrington Tops. During a visit paid in January last, abundant material of *Diuris venosa* was obtained. Southern forms discovered on the plateau were *Pterostylis falcata*, *P. decurva*, *Prasophyllum Suttonii*, and *Chiloglottis Gunnii*; while evidences of *Adenochilus Nortonii*, hitherto only recorded from the Blue Mountains, were found. Altogether, 23 species of terrestrial orchids were collected. Two species of *Prasophyllum* are described as new.—**F. H. S. Roberts**: A revision of the Australian Bombyliidæ (Diptera). Part 2. This part includes the revision of the subfamily Bombyliinæ. Five genera are placed in this subfamily, namely, *Bombylius*, *Systoechus*, *Sisyromyia*, *Dischistus*, and *Anastœchus*. 36 species are described, 15 of which are regarded as new. The genus *Anastœchus* is recorded for the first time from Australia.—**G. A. Waterhouse**: Notes on Australian Lycænidæ. Part 6. New subspecies of *Candalides heathi*, *Miletus apollo*, and *Pseudalmenus chlorinda* are described. *Miletus delicia* ab. *duaringæ*, originally described from a single male, is the northern race of this species, while *Philiris* is a genus distinct from *Candalides*. The species *Lycœna? byzos* Boisd., described in 1832, is considered to be a *Miletus*, identical with the specimens of *M. hecalius* found near Sydney.

WASHINGTON, D.C.

National Academy of Sciences (*Proc.*, Vol. 14, No. 8, August).—**Robert E. Burk**: The thermal decomposition of ammonia upon mixed surfaces of tungsten and platinum. The velocity of decomposition is greater on a surface alloy than on an equal area of either tungsten or platinum, and the temperature coefficient is smaller. This points to separation of the atoms forming the bond as the mechanism.—**Linus Pauling**: The crystal structure of topaz. Using the co-ordination theory of ionic crystals, it is assumed that the fundamental polyhedra are an octahedron of anions (oxygen and fluorine) about each aluminium ion and a tetrahedron of oxygen ions about each silicon ion. Four layers of these polyhedra form an arrangement giving a space group of V_h^{16}, and the unit contains 4 $Al_2SiO_4F_2$.—**Sam Lenher and Farrington Daniels**: The intensive drying of liquids. Organic liquids were sealed up in glass and quartz tubes with phosphorus pentoxide. After about four years, certain of these, containing benzene and carbon tetrachloride, were opened and the boiling points determined. No abnormal rise of boiling points was observed.—**Oliver R. Wulf**: (1) A progression relation in the molecular spectrum of oxygen occurring in the liquid and in the gas at high pressure. Several bands just to the red of complete absorption (about 2400 A.) appear to be due to the molecule O_4.—(2) The heat of dissociation of oxygen as estimated from photochemical ozonisation.—**G. L. Clark, A. J. King, and J. F. Hyde**: The crystalline structures of the alkaline earth metals. Calcium, strontium, and barium of purity exceeding 99·9 per cent have been prepared for X-ray analysis, great precautions being taken against oxidation. Barium crystallises in the cubic system, the unit cell contains two atoms, and its constant is 5·04 A.; the intensities of the lines indicate a body-centred cubic lattice. Strontium did not give sharp lines; possibly there is a transition point at room temperature between two or more modifications.—**C. J. Davisson and L. H. Germer**: Reflection and refraction of electrons by a crystal of nickel. Further observations support the view that electron refraction in the optical sense is a property of the crystal, and that the indices are greater than unity. At bombarding potentials below 150 volts, however, the value of the refractive index seems to change with wave-length, and may be dependent on the order of the reflection.—**Irving Langmuir**: Oscillations in ionised gases. Oscillations of small amplitude (less than 0·2 volt), and of frequencies up to $1·2 \times 10^9$, have been observed; an explanation is offered (*v.* NATURE, Oct. 20, p. 626).—**Robert A. Millikan and G. Harvey Cameron**: Evidence that the cosmic rays originate in interstellar space. Experiment shows (1) the abundance of positive and negative electrons in interstellar space; (2) that these electrons condense into atoms; (3) that these atoms aggregate under their gravitational forces into stars; (4) that occasionally a positive and negative electron in the interior of a star are transformed into an ether pulse. If this atom-building process is going on, it is reasonable to suppose that the supply of positive and negative electrons is continually being replenished by the condensation, by some unknown mechanism, of radiant heat.—**Carl Barus**: The displacement interferometry of barometric pressure.—**Jared Kirtland Morse**: The structure of acetylene. If the carbon atom be represented by a cube, the nucleus being at the centre and the *L*-electron positions at the corners, a model acetylene molecule can be built up, the constants of which agree with those determined from analysis of the infra-red band spectrum, as has previously been described for ethane and methane.—**E. R. Hedrick**: On derivatives of non-analytic functions.—**G. Y. Rainich**: Radiation and relativity (2).—**Gordon T. Whyburn**: Concerning plane closed point sets which are accessible from certain subsets of their complements.—**Joseph Miller Thomas**: Incomplete systems of partial differential equations.—**Th. Dobzhansky**: The effect of temperature on the viability of superfemales in *Drosophila melanogaster*. The viability of superfemales, which carry three *X*-chromosomes and two sets of autosomes, is greatest at about 20° C. Both high and low temperatures increase the breaking apart of the attached *X*-chromosomes.—**A. V. Bock, P. S. Bauer, and J. H. Means**: Preliminary note on the elastic hysteresis of the human aorta. The arch of the aorta is tied on to a water-mercury manometer, and after increasing the internal pressure monotonically to a maximum, the pressure is decreased by steps, the internal volume of the aorta being measured at each step. The loss of heat energy can be calculated, and also the efficiency. Assuming that the metabolic demands of the human system at 78 years are the same as before advanced changes occur in the arterial system, 45 per cent of the heart's energy output is lost as heat, compared with 25 per cent at 41 years, or the work of the heart must increase 20 per cent as a result of arteriosclerosis to maintain the same blood flow.

Official Publications Received.

BRITISH.

Professional Schools Post-Graduation Courses: Specialist Studies in the Universities and University Colleges of Great Britain and Ireland, Session 1928-9. Pp. 39. (London: Universities Bureau of the British Empire.)

Bulletin of the Raffles Museum, Singapore, Straits Settlements. No. 1, September. Pp. ii+44+2 plates. (Singapore.) 60 cents; 1*s.* 6*d.*

Records of the Geological Survey of India. Vol. 60, Part 4. Pp. 313-432+xxix+plates 26-39. 2.12 rupees; 5*s.* Vol. 61, Part 3. Pp. 207-325+plates 21-25. 2.12 rupees; 5*s.* (Calcutta: Government of India Central Publication Branch.)

University College of Wales, Aberystwyth: Welsh Plant Breeding Station. Seeds Mixture Problems: Competition. By R. G. Stapledon and Wm. Davies. (Series H, No. 8, Seasons 1921–1928.) Pp. 162. (Aberystwyth.) 3s. 6d.

Ceylon. Administration Report of the Director of Agriculture for 1927. Pp. D33. (Colombo: Government Record Office.) 75 cents.

Proceedings of the Royal Society of Victoria. Vol. 40 (New Series), Part 2. Pp. 57-107. (Melbourne.)

Ceylon: Department of Agriculture. Technical Reports for the Year 1927. Pp. 11+15+6+10+40. Reports of Divisional Agricultural Officers for the Year 1927. Pp. 22+18+22+22. (Colombo.)

University College of North Wales. Calendar for Session 1928–29. Pp. 409. (Bangor.)

The Journal of the Institution of Electrical Engineers. Edited by P. F. Rowell. Vol. 66, No. 382, October. Pp. 1005-1100+xxxii. (London: E. and F. N. Spon, Ltd.) 10s. 6d.

Air Ministry: Aeronautical Research Committee. Reports and Memoranda. No. 1148 (M. 54): The Behaviour of a Single Crystal of α-Iron subjected to Alternating Torsional Stresses. By Dr. H. Gough. Work performed for the Engineering Research Board of the Department of Scientific and Industrial Research. (E.F. 200.) Pp. 34+24 plates. 2s. 3d. net. No. 1153 (Ae. 318): Experiments with the Family of Airscrews in Free Air at Zero Advance. By H. C. H. Townend, W. S. Walker and J. H. Warsap. (T. 2549.) Pp. 10+6 plates. 1s. net. (London: H.M. Stationery Office.)

Journal of the Royal Statistical Society. Vol. 91, Part 4. Pp. 463-632+xii+vii. (London.) 7s. 6d.

University of London: University College. Calendar, Session 1928–1929. Pp. lxxx+10+491+lxxxi-cxciv+39. (London.)

FOREIGN.

Department of Commerce: Bureau of Mines. Technical Paper 434: Geophysical Prospecting; some Electrical Methods. By A. S. Eve and D. A. Keys. Pp. v+41. (Washington, D.C.: Government Printing Office.) 10 cents.

Report of the Aeronautical Research Institute, Tôkyô Imperial University. No. 39: Über die Herstellung und die mechanischen Eigenschaften des Duralumins. Von Masaharu Goto, Sin-ichi Fukuta, Sadao Horiguchi und Tenji Nagai. Pp. 271-403. 1.30 yen. No. 40: On the Inverse Wiedemann Effect and its Allied Phenomena. By Tatuo Kobayasi, Hiroto Okumura and Kinmatu Simamura. Pp. 405-460. 0.61 yen. No. 41: On the Effect of Temperature Changes upon an Altimeter. By T. Sasaki, K. Hattori, I. Hagiwara and R. Tate. Pp. 461-496. 0.40 yen. (Tôkyô: Kôseikai Publishing Office.)

Union Géodésique et Géophysique Internationale. Troisième assemblée générale, Prague, Septembre 1927. Procès-verbaux des séances de la Section de Météorologie. Pp. 104. (Rome: G. Bardi.)

Department of Commerce: Bureau of Standards. Research Paper No. 1: Accelerated Tests of Organic Protective Coatings. By Percy H. Walker and E. F. Hickson. Pp. 17+4 plates. 5 cents. Research Paper No. 2: Measurement of the Tread Movement of Pneumatic Tires and a Discussion of the Probable Relation to Tread Wear. By W. L. Holt and C. M. Cook. Pp. 19-28+3 plates. 5 cents. Research Paper No. 3: Absolute Methods in Reflectometry. By H. J. McNicholas. Pp. 29-73. 10 cents. Research Paper No. 4: Interferometer Measurements of Wave Lengths in the Vacuum Arc Spectra of Titanium and other Elements. By C. C. Kiess. Pp. 75-90. 5 cents. Research Paper No. 5: Analysis of Bauxite and of Refractories of High Alumina Content. By G. E. F. Lundell and J. I. Hoffman. Pp. 91-104. 5 cents. (Washington, D.C.: Government Printing Office.)

CATALOGUES.

A Catalogue of Important and Rare Books on Botany, Agriculture, Forestry, Fruit-Culture, Gardens and Gardening, Herbals, Early and Modern Medicine and Surgery, Tobacco. (No. 420.) Pp. 148. (London: Bernard Quaritch, Ltd.)

Oxford University Press General Catalogue, 1928. Pp. xii+490+169. (London: Oxford University Press.)

Heat Treatment Bulletin, No. 41: The Hardening and Tempering of High Speed Steel. By A. R. Page. Pp. 7. (London: Wild-Barfield Electric Furnaces, Ltd.)

Catalogue of recent purchases of Important Works on Botany, Zoology, General Literature, etc. (No. 6.) Pp. 16. (London: John H. Knowles, 92 Solon Road, S.W.2.)

Early Newspapers, including Magazines, Periodicals and Journals of Learned Societies. (Catalogue 510.) Pp. 36. (London: Francis Edwards, Ltd.)

Catalogue of Important Botanical and Horticultural Works. (No. 163.) Pp. 38. (London: Dulau and Co., Ltd.)

Diary of Societies.

FRIDAY, NOVEMBER 2.

ROYAL SOCIETY OF MEDICINE (Otology Section), at 10.30 A.M.—S. Hastings: Presidential Address.—Dr. J. K. Love: A Classification of Deafness Based on the Effect of Deafness on Efficiency in Life.—Dr. T. A. Clarke: On Hearing Tests.

INSTITUTION OF ENGINEERING INSPECTION (at Royal Society of Arts), at 5.—A. H. Mundey: Die Casting.

ROYAL SOCIETY OF MEDICINE (Laryngology Section), at 5.—H. B. Tawse: Some Unsolved Problems of Rhino-laryngology (Presidential Address).

ROYAL COLLEGE OF SURGEONS OF ENGLAND, at 5.—Sir Arthur Keith: The Evolution of the Human Foot and its Bearing on Orthopædic Disorders of the Foot.

PHILOLOGICAL SOCIETY (at University College), at 5.30.—E. D. P. Evans: Wye Rivers.

INSTITUTION OF PROFESSIONAL CIVIL SERVANTS (at Surveyors' Institution), at 5.30.—Sir A. Daniel Hall: Samuel Pepys, Civil Servant and Fellow of the Royal Society (Lecture).

NORTH-EAST COAST INSTITUTION OF ENGINEERS AND SHIPBUILDERS (at Mining Institute, Newcastle-upon-Tyne), at 6.—E. G. Barrilon: From Theoretical Hydrodynamics to Practical Ship Design.

WOMEN'S ENGINEERING SOCIETY (at Lyceum Club, 138 Piccadilly), at 6.15.—Miss Rose E. Squire: History of Factory Legislation in Great Britain.

SOCIETY OF CHEMICAL INDUSTRY (Manchester Section) (jointly with Manchester Sections of Institute of Chemistry, Society of Dyers and Colourists, and Manchester Literary and Philosophical Society) (at Engineers' Club, Manchester), at 7.—Sir John Russell: Application of Chemistry in Modern Farming.

ROYAL PHOTOGRAPHIC SOCIETY OF GREAT BRITAIN (Pictorial Group, Informal Meeting), at 7.—Miss Agnes B. Warburg: Light and Space.

SOCIETY OF CHEMICAL INDUSTRY (South Wales Section) (jointly with Institute of Chemistry) (at University College, Swansea), at 7.30.—M. Jones: X-Rays (Lecture).

JUNIOR INSTITUTION OF ENGINEERS, at 7.30.—Cinematograph Film showing the Principle, Construction, Erection, and Operation of the Babcock Boiler.

GEOLOGISTS' ASSOCIATION (at University College), at 7.30.—Annual Conversazione.

ROYAL SOCIETY OF MEDICINE (Anæsthetics Section), at 8.30.—I. W. Magill: Endotracheal Anæsthesia.

SATURDAY, NOVEMBER 3.

ROYAL INSTITUTION OF GREAT BRITAIN, at 3.—Rev. T. E. R. Phillips: Recent Observations and Discoveries respecting the Planets (I.).

MONDAY, NOVEMBER 5.

ROYAL SOCIETY OF EDINBURGH, at 4.30.—Prof. T. J. Jehu: Obituary Notice of Dr. John Horne.—J. Mackie: Mathematical Consequences of Mental Ability.—J. R. Thompson: The General Expression for Boundary Conditions and the Limits of Correlation.—T. P. Black: Mental Measurement: the Probable Error of some Boundary Conditions in Diagnosing the Presence of Group and General Factors.—W. F. P. McLintock and J. Phemister: A Gravitational Survey over the Buried Kelvin Valley at Drumry near Glasgow.—*To be read by title*:—Sir T. Muir: The Theory of Bigradients from 1861 to 1919.—Dr. L. N. G. Filon: On a Quadrature Formula for Trigonometrical Integrals.—Prof. E. T. Whittaker: On the Theory of Mathieu Functions.

ROYAL INSTITUTION OF GREAT BRITAIN, at 5.—General Meeting.

ROYAL COLLEGE OF SURGEONS OF ENGLAND, at 5.—T. W. P. Lawrence: Demonstrations of Surgical Specimens.

SOCIETY OF ENGINEERS (at Geological Society), at 6.—C. R. Enock: The Future of Engineering in the Light of Modern Economic Industrial and Political Conditions.

INSTITUTION OF ELECTRICAL ENGINEERS (Mersey and North Wales (Liverpool) Centre) (in University, Liverpool), at 7.—W. T. Townend: Some Considerations of the Economics of Electric Power Production.

HUNTERIAN SOCIETY OF LONDON, at 7.30.—Dr. H. Dearden, Dame Madge Kendall, Sir St. Clair Thomson, Miss Lena Ashwell, and I. Back: Discussion on The Doctor on the Stage.

ROYAL INSTITUTE OF BRITISH ARCHITECTS, at 8.30.—Presidential Address.

ROYAL GEOGRAPHICAL SOCIETY (at Æolian Hall), at 8.30.

ROYAL SOCIETY OF MEDICINE (Disease in Children Section), at 8.30.—Discussion on Fibrosis of Lung.

SOCIETY OF CHEMICAL INDUSTRY (London Section).—H. S. Rowell: A New Carbonisation Test for Lubricating Oils.

TUESDAY, NOVEMBER 6.

ROYAL COLLEGE OF PHYSICIANS OF LONDON, at 5.—Dr. G. F. Still: The History of Pædiatrics to the End of the 16th Century (Fitzpatrick Lectures) (I.).

ROYAL INSTITUTION OF GREAT BRITAIN, at 5.15.—Prof. H. L. Callendar: Co-aggregation *versus* Continuity in the Change of State from Liquid to Vapour (Tyndall Lectures) (II.).

ZOOLOGICAL SOCIETY OF LONDON, at 5.30.—Eleanor M. Brown: Exhibition of two Diatoms *Navicula subsalina* and *Cyclotella kuntzingiana*.—R. J. Wilkinson: Exhibition of Lepidoptera to illustrate a hitherto unrecognised Principle of Coloration.—Mary L. Hett: The Comparative Anatomy of the Palatine Tonsil.—J. R. Norman: The South American Characid Fishes of the Subfamily Serrasalmoninæ, with a Revision of the Genus *Serrasalmus* Lacépède.—Oldfield Thomas: Delacour Exploration of French Indo-China. Mammals. III. Mammals collected during the Winter 1927-1928.—G. Arrow: A Revision of the African Coleoptera belonging to the family Languriidæ.—S. Hirst: On some Australian Species of Trombidiidæ.

MINERALOGICAL SOCIETY (Anniversary Meeting), at 5.30.—F. A. Bannister: The so-called "Thermokalite" and the Existence of Sodium Bicarbonate as a Mineral.—W. A. Wooster: The Piezo-electric Effect of Diamond.—F. N. Ashcroft: Exhibit of Minerals Recently Collected in Switzerland.

INSTITUTION OF CIVIL ENGINEERS, at 6.—Sir Brodie Haldane Henderson: Presidential Address.

ILLUMINATING ENGINEERING SOCIETY (at Lighting Service Bureau, 15 Savoy Street), at 6.30.—J. S. Dow: Report on Progress during the Vacation.—C. C. Paterson: The International Illumination Congress in the United States.—Reports on Progress in Gas and Electric Lighting.

INSTITUTE OF METALS (Birmingham Local Section) (at Engineers' Club, Birmingham), at 7.—F. W. Spencer: Drop Forging and Machine Forging.

ROYAL PHOTOGRAPHIC SOCIETY OF GREAT BRITAIN (Pictorial Group), at 7.—Late T. H. Greenall: Some Slides of Southern Italy.

INSTITUTE OF METALS (North-East Coast Local Section) (at Armstrong College, Newcastle-upon-Tyne), at 7.30.—Prof. C. H. Desch: Deformation of Metals.

NORTH-EAST COAST INSTITUTION OF ENGINEERS AND SHIPBUILDERS (Middlesbrough Branch) (at Cleveland Scientific and Technical Institution, Middlesbrough), at 7.30.—W. G. Richards: Chairman's Address.

WEDNESDAY, November 7.

Electrical Association for Women (at E.L.M.A. Lighting Service Bureau, 15 Savoy Street), at 3.—E. E. Hoadley: The Electricity Supply Act, 1926.
Royal Society of Medicine (History of Medicine Section), at 5.—Dr. P. Gosse: Pirate Surgeons.—P. Flemming: The Medical Aspect of the Mediæval Monastery.
Geological Society of London, at 5.30.—Dr. L. F. Spath: The Recent Landslide in the Isle of Wight.—S. G. Clift and Dr. A. E. Trueman: The Sequence of Non-Marine Lamellibranchs in the Coal Measures of Nottinghamshire and Derbyshire.
Institution of Electrical Engineers (Wireless Section), at 6.—Comdr. J. A. Slee: Chairman's Address.
Institution of Heating and Ventilating Engineers (at Caxton Hall), at 7.—G. A. Cottell: Heating and Domestic Installations—the Insurance Point of View.
Society of Chemical Industry (Glasgow Section) (jointly with Institution of the Rubber Industry) (at Royal Philosophical Society, Glasgow), at 7.15.—W. H. Nuttall: Electrical Insulating Materials from a Chemical Standpoint.
North-East Coast Institution of Engineers and Shipbuilders (Graduate Section) (at Bolbec Hall, Newcastle-upon-Tyne), at 7.15.—E. Hinchliffe: Chairman's Address.
Leicester Literary and Philosophical Society (Chemistry Section) (at Museum, Leicester), at 8.—Dr. L. Hunter: The Rôle of the Halogens in Organic Chemistry (Presidential Address).
Society of Public Analysts and other Analytical Chemists (at Chemical Society), at 8.—J. Grant: Improved Method for the Determination of Small Quantities of Antimony in the Form of Stibine.—H. R. Ambler: Analysis of Small Samples of Gas.—E. Lester Smith: Determination of Unsaponifiable Matter in Oils and Fats.—P. Arup: Composition of Irish Butter.—Dr. H. B. Dunnicliff: Volumetric Determination of Mercury.
Royal Society of Arts, at 8.30.—Sir George Sutton, Bart.: Fifty Years of British Industry.
Royal Society of Medicine (Surgery Section), at 8.30.—Sir Holburt Waring: Surgical Education and Surgical Practice in the Future.
Royal Microscopical Society (Biological Section).

THURSDAY, November 8.

Royal Society, at 4.30.—Prof. S. B. Schryver and E. J. Candlin: Investigations on the Cell Wall Substances of Plants, etc.—S. Dickinson: Experiments on the Physiology and Genetics of the Smut Fungi.—Isabella Gordon: Some Further Studies in the Development of the Skeleton in Echinoderms.—Ruth Deanesly: A Study of the Adrenal Cortex in the Mouse and its Relation to the Gonads.—Prof. W. J. Dakin: (*a*) Anatomy and Phylogeny of Spondylus, with a Particular Reference to the Lamellibranch Nervous System; (*b*) The Eyes of Pecten, Spondylus, Amussium, and Allied Lamellibranchs, with a Short Discussion on their Evolution.—Prof. C. E. Walker: Artefacts as a Guide to the Chemistry of the Cell.—Prof. F. F. Blackman and P. Parija: Analytic Studies in Plant Respiration. I.—P. Parija: Analytic Studies in Plant Respiration. II. The Respiration of Apples in Nitrogen and its Relation to Respiration in Air.—Prof. F. F. Blackman: Analytic Studies in Plant Respiration III. Formulation of a Catalytic System for the Respiration of Apples and its Relation to Oxygen.—Prof. R. R. Gates and F. M. L. Sheffield: Chromosome Linkage in certain Œnothera Hybrids.
London Mathematical Society (at Royal Astronomical Society), at 5.—Prof. G. H. Hardy: Prolegomena to a Chapter on Inequalities (Presidential Address).
Royal Society of Medicine (Balneology Section), at 5.—Dr. G. L. K. Pringle: Presidential Address.
Royal College of Physicians of London, at 5.—Dr. G. F. Still: The History of Pædiatrics to the End of the 16th Century (FitzPatrick Lectures) (II.).
Royal College of Surgeons of England, at 5.—C. H. Fagge: Axial Rotation, Purposeful and Pathological (Bradshaw Lecture).
Royal Institution of Great Britain, at 5.15.—Capt. G. Pitt-Rivers: The Clash of Culture (II.). Culture-Clash in a Maori Village.
Child-Study Society (at Royal Sanitary Institute), at 6.—P. C. Buck: Music and the Child-Mind.
Institution of Civil Engineers (Birmingham and District Association) (at Chamber of Commerce, Birmingham), at 6.—A. E. Sadler: Modern Methods of Sewage Disposal.
Institution of Electrical Engineers, at 6.—W. B. Woodhouse: Overhead Electric Lines (Illustrated by a Cinematograph Film).
Institution of Municipal and County Engineers (at Deptford Town Hall), at 6.—B. H. Knight: Granite Setts in and around London: Some Factors Affecting their Wear: Description of Micro-Structure of Granite Setts.—W. J. Pickering: Exhibition of Rock Cutting Methods.
Institution of Structural Engineers, at 6.30.—Lieut.-Col. J. Mitchell Moncrieff: Presidential Address.
Royal Photographic Society of Great Britain (Colour Group—Informal Meeting), at 7.—F. P. Baynes: Lecture.
Institution of Electrical Engineers (Dundee Sub-Centre) (at University College, Dundee), at 7.30.—J. S. Lilly: Notes on Installation and Maintenance Risks.
Institute of Metals (London Local Section) (at Royal School of Mines), at 7.30.—Prof. W. E. Dalby: The Plastic Contour.
Optical Society (at Imperial College of Science), at 7.30.—T. Smith: (*a*) On Systems of Plane Reflecting Surfaces; (*b*) Reflecting Systems for Image Inversion.—Dr. L. C. Martin and T. C. Richards: The Relation between Field Illumination and the Optimum Visual Field for Observational Instruments.
Royal Aeronautical Society (at Royal Society of Arts), at 7.45.—Wing-Comdr. T. R. Cave-Brown-Cave: The Machinery Installation of 'R 101.'
Royal Society of Medicine (Neurology Section) (Clinical Meeting at West End Hospital for Diseases of the Nervous System, Out-Patient Department, Welbeck Street), at 8.

FRIDAY, November 9.

Faraday Society (at Royal Institution), at 3.30.—Sir Oliver Lodge: Some Debatable Problems in Physics (Spiers Memorial Lecture).
Royal Society of Arts (Indian Meeting), at 4.30.—J. W. Madeley: Town Water Supply in India.
Royal Astronomical Society, at 5.—Dr. W. M. Smart: On the Frequency Distribution of Restricted Proper Motions.—M. A. Ellison: Micrometrical Measures of the Potsdam Double Stars, made with the 10-in. Refractor of the Armagh Observatory.—K. Nakamura: Observation of Meteors from Skjellerup's Comet, 1927 *k*.—Prof. S. Chapman: The Electrical Conductivity of Stellar Matter.—Dr. W. J. S. Lockyer: A Wide Absorption Band in some *B*-type Stars.—W. M. H. Greaves and H. W. Newton: Magnetic Storms and Solar Activity, 1874–1927.—Prof. E. A. Milne: (*a*) The Theoretical Contours of Absorption Lines in Stellar Atmospheres; (*b*) Ionisation in Stellar Atmospheres: Generalised Saha Formulæ: Maximum Intensities and the Determination of the Coefficient of Opacity.—Prof. S. Chapman: On the Radial Limitation of the Sun's Magnetic Field.
Institution of Electrical Engineers (London Students' Section), at 6.15.—T. M. C. Lance and others: Discussion on Loud Speakers.
Institution of Mechanical Engineers (Informal Meeting), at 7.
Junior Institution of Engineers, at 7.30.—Annual General Meeting.
Keighley Association of Engineers (at Temperance Institute, Keighley), at 7.30.—C. H. Carter: Precise Length and Angular Measurement.
Institute of Metals (Sheffield Local Section) (in Applied Science Department, Sheffield University), at 7.30.—Prof. F. C. Thompson: Flow in Metal Shaping Processes.
Oil and Colour Chemists' Association (Manchester Section) (at Milton Hall, Manchester), at 7.30.—B. Campbell: Nitrocellulose Finishes.

SATURDAY, November 10.

Royal Institution of Great Britain, at 3.—Rev. T. E. R. Phillips: Recent Observations and Discoveries respecting the Planets (II.).
Institution of Mechanical Engineers (Glasgow Branch) (at Glasgow).—Dr. A. McCance and J. Jefferson: Steel Castings.
Physiological Society (at London Hospital Medical College).

PUBLIC LECTURES.

FRIDAY, November 2.

University College, at 5.30.—Dr. J. S. Owens: Smoke Pollution of the Air and Public Health. (Further Lectures on Nov. 9 and 14.)

SATURDAY, November 3.

Horniman Museum (Forest Hill), at 3.30.—F. W. Edwards: A Naturalist's Trip to the Southern Andes.

TUESDAY, November 6.

Westfield College, at 5.15.—Prof. Charles Grant Robertson: The Map of Europe. (Succeeding Lecture on Nov. 20.)
King's College, at 5.30.—Prof. A. Cock: Baron von Hügel.

WEDNESDAY, November 7.

Royal Institute of Public Health, at 4.—Dr. T. F. Cotton: Diseases of the Heart and Blood Vessels in relation to Industrial Occupations.
King's College, at 5.30.—Dr. F. A. P. Aveling: The Indebtedness of Industry to Pure Science: The Human Factor.
School of Oriental Studies, at 5.30.—Prof. A. Meillet: Les origines du vocabulaire européen. (Succeeding Lectures on Nov. 8 and 9.)
University of Leeds, at 8.—Lieut.-Comdr. R. T. Gould: The Greatest of all Navigators—Captain Cook.

THURSDAY, November 8.

Bedford College for Women, at 5.15.—Prof. J. G. Robertson: The Spirit of Travel in European Literature in the 17th and 18th Centuries.
University College, at 5.30.—W. N. Weech: Roman Remains in Northern Africa.

FRIDAY, November 9.

University College, at 5.30.—W. L. Cook: The British Coal Industry.

SATURDAY, November 10.

Horniman Museum (Forest Hill), at 3.30.—J. E. S. Dallas: Swiss Scenes and Flowers.

CONGRESSES.

November 3.

Sociological Society, Leplay House, and Tours Association (at London Day Training College).

At 10.30 a.m.—Reports on the Work done during the past Year by Leplay House Sociological Society and Leplay House Tours Association.

At 11.15 a.m.—Social Studies in Majorca.—Miss M. Maplesden: Geology and Flora in Majorca.—G. Morris: Some Notes on Swedish Lapland.

At 2.30.—C. C. Fagg: Some Results of the Croydon Survey.

At 4.45.—A. Farquharson, and Group Leaders from the Tours Students' "Camp," 1928: Field Studies at St. Peter.

November 19–24.

International Conference on Bituminous Coal (at Pittsburgh, Pa., U.S.A.).—Among the subjects to be discussed are:—Fixed Nitrogen, The Liquefaction of Coal, Low Temperature Distillation, High Temperature Distillation, Power from Coal, Coal Tars, and Oils, Complete Gasification of Coal, Origin of Coal, Coal Washing, Pulverised Coal, Catalysts, and the general aspects of the Bituminous Coal Industry.