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Against Foreign Pests.

THE history of agricultural pests suggests that there is a strong tendency for any creature imported from a foreign country, so long as conditions of food and climate favour its survival, to outrival native pests and to become a real burden in the land of its adoption. So often has this happened that many nations have taken the warning to heart and have adopted laws forbidding, without permit from the proper authorities, the importation of foreign creatures. Great Britain, always a little slow in admitting that science can teach it, has been content to place a ban upon certain insect pests which are liable to come unawares with food materials or other vegetation, but has made no provision against the open and deliberate importation of animals which harbour the possibility of much damage.

Such is the case of the musk-rat or musquash, to the importation and breeding of which in Scotland, for the sake of its fur, attention has already been directed in these pages. Indeed, we believe that the appearance of several notes in NATURE discussing the inordinate spread and the damage caused by the musk-rat in central and southern Europe, led to the investigation which has resulted in the first attempt in Great Britain to control the importation of the larger potential pests.

The musk-rat (*Fiber zibethicus* or *Ondatra zibethica*) is an American rodent somewhat resembling a small beaver, which, imported to Europe to be bred for its fur, has within the last twenty years spread enormously along the valley of the Upper Danube and has penetrated and colonised adjacent river systems, causing damage to flood-embankments and river-banks by burrowing, and to agricultural produce, especially green crops and roots. Bavaria and other States employ men trained and specially detailed to trap musquash, and in Bavaria alone as many as 33,000 have been destroyed in a year. Much controversy has arisen in Europe concerning the need or otherwise of prohibiting the musk-rat from countries yet free from its presence; for although central Europe has suffered heavily and has made many unsuccessful attempts to rid itself of the pest, in other parts—Finland is an example—breeding has been carried on successfully without, it is said, any untoward results. The difference seems to depend upon modifications in the rate of breeding and increase of numbers due to climatic

differences; but it cannot be forgotten that success in the breeding of fur animals depends upon rapid multiplication, and that the very countries which claim the musk-rat to be harmless are by that indicating that its commercial exploitation there is less likely to be an outstanding success.

In Scotland, musquash were imported for breeding purposes only in 1927, and at first all were bred in captivity. But by accident or otherwise various pairs have escaped, so that in three areas they are known to be at large, and in one Scottish district in 1929 as many as sixteen musquash 'huts' were seen at a time, an indication that conditions there seemed to favour that rapid multiplication of the animal which leads to plague conditions.

A few months ago, the Ministry of Agriculture and Fisheries, following upon an investigation made regarding the presence of musk-rats in wild conditions in Scotland, issued a notice requesting any person keeping and breeding musk-rats to inform the Ministry of the fact and of the number of the animals. Speedy action has followed the issue of that notice, for the Parliamentary Secretary to the Ministry, Earl de la Warr, has now introduced a "Destructive Foreign Animals Bill" to the House of Lords, where it was given a first reading. The text of the Bill, issued on June 24, indicates that power would be given to the Minister of Agriculture and the Secretary of State for Scotland, acting jointly, to prohibit by order, either absolutely or except under a licence, the importation into and the keeping within Great Britain of any animal of the species.

The occupier of any land who knows that musk-rats not kept by him under licence are to be found upon it, is required to give notice to the appropriate department, which may take all the steps necessary for their destruction. Anyone importing or attempting to import musk-rats without a licence at a time when this is prohibited, or failing to comply with the terms of his licence, or who turns loose or wilfully allows a musk-rat to escape, would be liable to various penalties. On the other hand, compensation would be paid to persons keeping musk-rats for profit in respect of loss caused by their being compelled to destroy the animals under an order. Special licences may be granted to persons wishing to keep musk-rats for exhibition or scientific research; but the granting of such special licences would have to be accompanied by special precautions, since musk-rats kept for exhibition or research which have escaped, are just as dangerous fellows as escapes from breeding-pens.

The Bill contains a section which adds enormously to its significance: power is given to extend its provisions to other destructive animals "of any foreign mammalian species".

We trust that this Bill, to which the House of Lords has granted a first reading, will make rapid progress through both Houses. Whether the musk-rat would ever become such a plague in Great Britain as the alien rabbit has turned out to be, none can tell; but where there is so great a risk it is wise to err on the safe side. Moreover, we should be but following the examples of Norway and Germany, both of which have deemed it necessary to prohibit the importation of this foreign pest.

As an Act, the new measure would signify an important progressive step in the laws relating to animals in Great Britain—a tardy recognition of the fact, from which we as well as other nations are suffering, that more may be involved in the thoughtless importation of strange animals than the importer can possibly conceive.

Anthropology and Native Administration.

IN a review entitled "The Anthropology of Africa" in NATURE of May 2, p. 655, Prof. B. Malinowski pleaded for a fuller acknowledgment of the science of man as a force in colonial affairs, as well as for its academic recognition in the more important universities of Great Britain. The subject, as a matter of fact, is only taught at three universities—Oxford, Cambridge, and London—and neither of the older universities has an established chair of anthropology, in spite of the glorious tradition of Tylor at Oxford and of Haddon and Rivers at Cambridge. The present organisation of the anthropological departments, with such teachers as Dr. R. R. Marett, Mr. Henry Balfour, and Mr. Dudley Buxton at Oxford and Col. T. C. Hodson at Cambridge, would well warrant a full chair at each university.

We are informed that at Oxford the amount of teaching in social anthropology exceeds the twenty hours mentioned by Prof. Malinowski. The course includes lectures in social anthropology by the Rector of Exeter (Dr. Marett), in colonial history by Prof. Coupland, in African economics by Mr. Henry Balfour, and in racial problems by Mr. Buxton—all subjects which come within the range of anthropological studies.

Col. Hodson writes that, so far as Cambridge is concerned, "Prof. Malinowski's statement that the

Colonial Probationers receive only twenty hours' tuition and that anthropology is not obligatory, needs correction. They receive forty hours' tuition, given by lecturers who have African administrative experience, and they are required to attend these lectures. It is hoped to increase and improve this in the immediate future."

These additional facts give further support to Prof. Malinowski's argument in favour of a general strengthening of anthropology in all the universities of Great Britain and of a greater interest being paid to it by administrative authorities. The difference between twenty, thirty, or even forty hours is not material. It is universally acknowledged that anthropology is necessary, and it is not a contentious point that two or even three score hours will remain a superficial smattering. On the other hand, it seems better that specialising should not begin so early as it does on the Continent, and that young men should take up a colonial career only after they have gone through the ordinary university course; and after this they cannot be asked to spend some five more years on a special colonial course.

There is one practicable method of getting over this difficulty which has already in part been adopted by the colonial authorities, and is receiving the serious consideration of the International Institute of African Languages and Cultures, which has its main seat in London. This is, that officers with a special interest in the application of anthropology to problems of native administration should be given study leave after their first or second term abroad. This involves the creation of refresher courses, and private tuition can be arranged at any of the three universities. Colonial Governments have been working on this system, though only to a limited extent, for some years, and it has given excellent results; it might well be more fully developed. It is important that all the universities where teaching in the subject is given should co-operate in the organising of such teaching and that here the University of London should not be passed over.

The combination of a brief anthropological training, such as is now given at Oxford and Cambridge, with refresher courses of a fuller nature, would provide a solution to a problem which becomes more and more urgent in colonial administration, namely, the problem of not over-burdening the young man eager to go out to the Colonies, and yet making it possible for him to gain, later on, the theoretical knowledge which is admittedly essential to his work.

African Settlement and the Origin of Rift Valleys.

(1) *Africa View*. By Julian Huxley. Pp. viii + 455 + 32 plates. (London: Chatto and Windus, 1931.) 15*s*. net.

(2) *Living Africa: a Geologist's Wanderings through the Rift Valleys*. By Bailey Willis. Pp. xv + 320 + 21 plates. (New York: McGraw-Hill Book Co., Inc.; London: McGraw-Hill Publishing Co., Ltd., 1930.) 20*s*. net.

THESE two books have much in common. They state the impressions formed during tours in East Africa by two highly trained scientific observers. The first is by a brilliant British biologist; the other by one of the most distinguished American geologists. Both authors have the philosopher's respect for first principles, high literary skill, keen insight on a wide range of subjects, and a sympathy which enables them to come to a friendly understanding with all sorts of men. Prof. Bailey Willis during an eight months' tour through East Africa travelled 8000 miles, from Pretoria to Baringo, through Rhodesia, Tanganyika Territory, Uganda, and Kenya, and down the Nile, to study the nature and origin of rift valleys. Prof. Julian Huxley's tour of four months in Tanganyika Territory, Uganda, and Kenya Colony was made on the invitation of a Colonial Office Committee to advise on native education.

Both books are highly complimentary to British administration; and the repeated testimony to its efficiency is especially gratifying from the American author, for he can be a candid critic, for example, upon the inferiority of the motor car that he used to its American equivalent. Both authors have returned deeply impressed by the superiority of indirect rule, as shown by the comparison between the results in Tanganyika Territory and in Kenya Colony; and the testimony of two such competent and different observers should be of special value at a time when the issues are being considered by the Joint Committee on East Africa of the two Houses of Parliament. Prof. Bailey Willis quotes with approval the passage in the Duke of Devonshire's dispatch of 1923 which introduced the phrase "the paramountcy of native interests".

(1) The larger part of Prof. Huxley's book is a lucid and suggestive discussion of the fundamental principles of East African administration. He is a warm champion of the system developed by Lord Lugard in Nigeria, which has been applied by Sir Donald Cameron in Tanganyika Territory and

by Sir William Gowers in Uganda, but is opposed by the Settlers' Association in Kenya Colony. The section of "Africa View" that carries most weight is that on education, on which Prof. Huxley writes with expert authority. He regards education as "the great adventure" and the most important and influential of all branches of public service in Africa. He visited many schools and all the chief educational institutions, including Amani, the biological research station, which has been re-established and is now under the directorship of Dr. Nowell. The position of Amani he regards as highly inconvenient, but he deprecates the current criticism that it has not yet been of help to East African agriculture and should therefore either be reduced or discontinued. He thinks that it should be left at work for five years and overhauled then if it has not begun to justify its existence. Both authors visited Mr. Swynnerton and are eulogistic of his anti-tsetse fly researches.

The question of education involves the problem of the missionaries, with whom Prof. Huxley is, in general, sympathetic. He recognises that they are the one section of the European population which is concerned primarily with the welfare of the natives and are therefore an invaluable check on any settlers who may look on the natives as mere 'labour-fodder'. He recognises that the position of the missionaries is strong owing to the generous financial and public support given to them from Europe, and that they represent a 'third estate' in the local realm. He deplores, however, the narrow outlook of some of them and suggests, in view of their political influence and the mischief done by some, that no missionary should be admitted without a sound training in social anthropology. The missions are especially important for their share in education; but some of the mission schools are so defective that he estimates that "only 30 to 40 per cent of the children put down as attending mission schools in East Africa were getting an education worth calling an education". Missionary co-operation in education there is indispensable, but needs control. The Colonial Office Education Committee for East Africa was established with an unduly high clerical bias. Prof. Huxley is emphatic that the natives must be allowed an education of which the basis is a knowledge of reading and writing; for the core of African primary education he recommends biology and geography. On the controverted issue of the language to be used in the schools, he adopts the conclusion, which Indian experience suggests as sound, that the elementary teaching should be in the local vernacular, followed by use of a lingua franca in the higher classes: the second language at present used is Suahili. Prof. Huxley regards that choice as justified in present circumstances; but he is anxious that it should not be permanently engrafted on to the system, and that it should be declared from the outset that English is to be adopted as the second language and Suahili either ousted or reduced to a very secondary position as soon as adequate teachers in English are available.

Prof. Huxley holds that the African can profit by ordinary education. He repudiates the assumption that the Negro is mentally much below the European. He rejects the helpless orphan conception of the Negro and all the policies based on it. He is prepared to believe that the races of Africa are "slightly below the races of Europe in pure intelligence and probably certain other important qualities"; but he is "perfectly certain" that, if so, the difference between the racial averages is small and that the great majority of Negroes and Europeans "overlap as regards their innate intellectual capacities". He is opposed to the implications of the report by the American Phelps-Stokes Commission on African education, which laid great stress on "community adaptation" and approved the settler policy that the education adopted should be designed to fit the natives for their subordinate status, and, as Prof. Huxley puts it, "in fact, to increase their docility and their output in the God-appointed *status quo*".

Prof. Huxley, though warm in his praise of many of the settlers, represents others as reactionary and as anxious to maintain a relation between Negroes and Europeans which is shown by the experience of West Africa and India to be obsolete and impracticable. He devotes one chapter to a criticism of the policy advocated in General Smuts's Rhodes Lectures, which, however, represent a compromise between the two extreme views. For General Smuts upholds the principle that the interests of natives must come first; he favours the segregation of the two races, the whites being given preference in the highlands and the natives in the lower land, the political independence of the native areas under a High Commissioner, and the appointment of an advisory council to act as intermediary between the East African Government and the Colonial Office.

(2) The most important section of Prof. Bailey Willis's book, which happens to be the least satisfactory in Prof. Huxley's, is his consideration of the nature of rift valleys. The investigation of that

problem was the purpose of Prof. Willis's journey and his results will be published in a future monograph, which will be of high value, as it will deal with the question more fully than any previous work on the subject. The main object of the writer's contributions was to establish the tectonic origin of the valleys, the possibility of which was denied by some British geologists. Their tectonic nature being now accepted, the exact mode of their formation is their main problem of current interest.

Prof. Bailey Willis is the leading champion of the theory that the valleys are due to the uplift of their sides owing to the horizontal compression of the crust, instead of to the subsidence of their floor owing to lack of support in consequence of the shrinkage of the internal mass of the earth. Prof. Willis therefore called them 'ramp valleys' instead of 'rift valleys'. He advocated this theory for the section of the Great Rift Valley in Palestine and went to Africa to see how far the explanation is applicable there. He found that the subsidence view is correct for the part of the Rift Valley for which it was expounded; but he holds that the rift valley along the Albert Nyanza was formed by the uplift of the walls along overthrust faults. The same action, to some extent, was suggested by Dr. Wayland (*Geog. Jour.*, 74, p. 133), whose description of the local rift valleys as "fracture valleys running along the crests of linear upwarps" combined with the "more or less continuous sinking of the rift valley floor" agrees with the view that the essential processes were, in order, upwarp, rupture, and subsidence. The existence of overthrust faults beside Lake Tanganyika is well known; but they are possibly far too old to have produced the rift valley. As the floor of Tanganyika is 1600 ft. below sea-level, Prof. Willis admits that it must have reached its position by subsidence. Prof. Huxley accepts the ramp-valley theory for the area for which its author has abandoned it, and adopts the existence there of a great high-level lake. The evidence for that lake is considered by Prof. Willis, who has had exceptional opportunities for the study of old lake terraces, and he denies its existence.

It would be premature to discuss Prof. Willis's theory of the origin of these valleys until the issue of his full work on the subject. He attributes the valleys to the expansion of vast subterranean discs by re-crystallisation of the constituents under the rise in internal heat. One such disc he believes to underlie the Victoria Nyanza, and its expansion has forced up the land along its margins and thus formed high ramps. The alternative view is that the rift valleys were caused by movements of the crust due to extensive subsidences, of which the largest formed the basin of the Indian Ocean and broke across the former continent of Gondwanaland.

Prof. Bailey Willis is the leading adherent of the permanence of oceans and continents. He thinks that the continents have been connected by isthmus-lands, like Central America, but that the main ocean basins have existed throughout geological time. He therefore denies the existence of Gondwanaland and, in reference to the rift valley in Palestine, the formation of the Levant by the foundering of its floor. In his discussion of the problem, he appears to consider that the supporters of the subsidence theory of rift valleys deny any uplift along their course or of their edges. But the subsidence of a band below a rift valley would have pushed the underlying material sideways; and this movement would have upraised the edges. Suess called this effect the *Aufwulstung* of the edges. Ruwenzori may have undergone some such uplift, though its topography, so far as can be judged from the maps, seems in favour of its having remained a high massif for a very long period.

Prof. Willis wonders how the gentle slopes up which the Uganda railway climbs on to the Mau plateau can be reconciled with the ordinary rift valley theory; but the features of that part of the margin of the rift valley appear due to the Oligocene faulting, and the scarp was not renewed by later faulting. Prof. Willis represents, on the tension and subsidence theory, that there must have been a line of super-Himalayan mountains along the Rift Valley in Kenya Colony, and says that there is no trace of any such mountain chain; but on the view that the subsidence of the Indian Ocean was accompanied by a widespread uplift in East Africa, the highest part need not have been more than a few thousand feet above the present margins. The irregularities in level of the margins of the rift valley appear all that need be expected as the relics of its drainage channels.

Amongst the many interesting contributions in Prof. Willis's volume is a record of an egregious failure of water divining, and the welcome term 'island-mounts' instead of *inselbergs*. But his statement that those who "said that Paul du Chaillu lied were wrong" repeats a widespread misunderstanding; they who said that the skins, which du Chaillu sold as those of gorillas that he had shot at close range when in deadly peril, had been caught in native traps, were unquestionably right.

J. W. GREGORY.

Human Monstrosities.

The Mystery and Lore of Monsters: with Accounts of some Giants, Dwarfs and Prodigies. By C. J. S. Thompson. Pp. iv + 256 + 32 plates. (London: Williams and Norgate, Ltd., 1930.) 15*s.* net.

MR. C. J. S. THOMPSON, who is known to medical men because of contributions made to the history of their art, has published, in book-form, gleanings he has gathered concerning the ancient lore of human monsters. His book will make a wide appeal, not only to those who are interested in the 'lore of monsters', but also to embryologists who are in search of the rarer aberrations undergone by the human body in the course of development. His text is clear and easy, and is enriched by many illustrations of 'prodigious births' which have adorned the records published by writers in former centuries.

Down to the end of the seventeenth century, it is difficult to know whether the abnormalities which are described had actually been seen by authors or only imagined. Lycosthenes, who wrote "Prodigiorum ac Ostentorum Chronicon" in 1557, illustrated by 1500 woodcuts, gives the following account of the 'terrible child' who was "born in Craconia of noble parents. It had bright fiery eyes, the mouth and nostrils like an oxe's. It had long hornes and a black fur like a doggs and on its breasts, faces like apes. It was splay-footed, and splay-handed. The feet were like swan's feet and it had a tayle twined upwards, that was crooked backwards about half-an-ell long. It was born and lived four hours and then spoke thus, '*Watch, the Lord our God comes*'."

The ancient Babylonians, Egyptians, and Greeks believed any combination of human and animal parts was possible; indeed, the study of ancient records is a study of human credulity rather than of embryological aberration. We are not surprised, however, that George Buchanan, the Scottish historian, who did so much to strip myth from truth in the records of his own country, should write rationally and with interest of monsters. "About this time (1490)," he says, "a strange kind of monster was born in Scotland. In the lower part of the body it resembled a male child, differing nothing from the ordinary shape of the human body, but the trunk and all other members became double and were distinct both in their use and appearance. The King caused it to be carefully brought up and educated, particularly in music, in which it wonderfully excelled. It learned different languages, and in their various inclinations the two bodies appeared to disagree between themselves, sometimes disputing, each preferring different objects and sometimes consulting for the common pleasure of both."

Mr. Thompson cites examples which taxed the learning of clergymen as well as of surgeons. The clergymen had to determine whether the monster was to be regarded as being made up of two souls or of only one, and whether, in baptising, two names had to be given or if one would suffice. The surgeon's perplexities were of a less metaphysical nature: Was the bond which joined two bodies of a kind which could be severed? If one part of the monster died, could the living part be saved? Modern surgery is now attacking these problems—often successfully.

In the eighteenth century, the study of monsters entered its scientific stage; schemes of classification, based on a knowledge of normal development, were devised; only in the present century did we enter the further stage of learning how monsters could be produced experimentally. Mr. Thompson has brought a wide and accurate knowledge to bear on "The Mystery and Lore of Monsters".

Biochemistry in America.

The Development of Physiological Chemistry in the United States. By Prof. Russell H. Chittenden. (American Chemical Society Monograph Series, No. 54.) Pp. 427. (New York: The Chemical Catalog Co., Inc., 1930.) 6.00 dollars.

THIS is a review of the evolution of physiological chemistry in the United States during the past fifty years. Prof. Chittenden has seen it all happen, from the starting of the first laboratory of physiological chemistry in Yale in 1874 until the present day, when practically every university in the country has a staff of competent investigators and well-equipped laboratories, besides the agricultural experiment stations and laboratories of the Government bureaux at Washington, which are the admiration of the scientific world.

At the beginning, it was necessary for American and British students to go to Germany for training—Chittenden went to Kühne in Heidelberg in 1878. A start had been made in Germany in the study of natural products, although the golden age did not commence for another decade, when Kossel and Emil Fischer in particular introduced more precise chemical accuracy into the field; the reproach that "Thierchemie ist Schmierchemie" had been too true.

The author traces the development of laboratories, equipment, societies, and journals, and then

gives a running commentary, arranged mainly under schools, on the workers whose activities have increased knowledge.

The work of W. O. Atwater on nutrition will always remain a classic, and his dietary studies led to the first standard diet. His work with the respiration calorimeter, later followed up with such success by Benedict, has been prolific of results.

The study of vegetable proteins was taken up energetically by Osborne from 1891 onwards; he produced more than one hundred publications, which form the basis of the chemical knowledge of this group.

H. D. Dakin's work on the amino acids and his β-oxidation hypothesis, that of Walter Jones on nucleic acids, of P. A. Levene on nucleic acids and the carbohydrate group, are only a few instances of the long list of positive achievements which are detailed. They suffice to show that the organic chemist has definitely entered the field of natural products. The task of unravelling their constitution and their molecular structure by analysis is near completion, many of them have been synthesised, a hint has been gained of their function, yet how much remains to be done. The best men in the best-equipped laboratories the world over have problems enough for many years to come. How, for example, are meat and milk made from grass? Will it take another half-century to answer this question?

The book is one of the American Chemical Society Monograph Series, and is produced in clear type with the high standard that characterises the series. E. F. A.

Short Reviews.

Die Beschneidung bei Mann und Weib: ihre Geschichte, Psychologie und Ethnologie. Von Felix Bryk. (Monographien zur Ethno-Psychologie, herausgegeben von F. Bryk und C. L. Hansen, Band 1.) Pp. x + 319. (Neubrandenburg: Gustav Feller, 1931.) 15·60 gold marks.

THE need for detailed monographs on genital mutilations has long been felt, and above all a sound and scholarly treatment of circumcision was desirable. This book, however, scarcely fulfils that want. It is a very general account of a number of different operations, but is without orderly plan, and the author has clearly been unable to deal satisfactorily even with the limited number of authorities he quotes, or to appreciate the vast distribution of the practices under discussion. Instead of confining himself to the matter on hand, he wanders off to discuss male infibulation, *ampliatio vaginæ*, perforation of the clitoris, and many other similar practices. The result of this is that the author becomes lost in his own maze: the very multiplicity of the customs bewilders him, and he ends by coming to few new conclusions at all. He quotes largely from Biblical sources, whilst failing to realise that the ideas of earlier civilisations were better worth his ink. Whilst rightly rejecting Reitzenstein's attempts to find evidence for circumcision in palæolithic times, he fails to understand that the ritual significance of the custom is the point on which his attention should have been focused.

According to the author, circumcision of the male arose partly at least from the desire to imitate domestic and other animals which were observed in copulation. To this was added the supposed desire on the part of early man to increase the ease of the process in himself, and the recognition of the hindrance a partial or total phimosis caused to him.

Thus this volume is merely a sketch of genital mutilations, and as such is useful for the purposes of summary. The illustrations are well chosen, the printing good, and the indexes of value. But as a guide towards solving the mystery of circumcision the book is not helpful. It is an epitome of current theories and we cannot pretend that these are convincing. Circumcision still awaits its shrewd interpreter. E. J. DINGWALL.

Femcifrede Logaritmer og Antilogaritmer (Five Figure Tables of Logarithms and Anti-Logarithms). By A. K. Erlang. Udgivet ved (edited by) R. E. H. Rasmussen. Pp. 48. (København: G. E. C. Gads Forlag, 1930.) n.p.

(2) *Addition-Subtraction Logarithms to Five Decimal Places.* By L. M. Berkeley. Pp. xii + 134. (New York: White Book and Supply Co., 1930.) 3.25 dollars.

(1) THIS is a clearly printed table of logarithms and antilogarithms to five places with a four figure argument and mean differences. A seven place table of $\left(1+\frac{r}{100}\right)^n$ for $n=1$ to 9 and $r=0{\cdot}00$ to $7{\cdot}50$ is appended.

(2) If a is greater than b, the addition logarithm of $\log a$ and $\log b$ is $A=\log\frac{a+b}{a}$ and the subtraction logarithm is $S=\log\frac{a}{a-b}$, so that $\log(a+b)=\log a+A$ and $\log(a-b)=\log a-S$. Evidently A and S are functions of a/b only so that $\log a-\log b$ can be used as argument for a table of A and S. The present table is arranged in triple columns corresponding to $\log n$, $\log\frac{n+1}{n}$, $\log(n+1)$ so that the central column is the addition logarithm of two logarithms which differ by $\log n$ and the subtraction logarithm of two logarithms which differ by $\log(n+1)$. This central column proceeds by unity in the last figure so that A and S are found without interpolation. The table is thus in effect a critical table, but is not arranged in the form usual in such tables. The use of addition and subtraction logarithms allows long trains of calculation to be performed without reverting to natural numbers, for

example $\sqrt[5]{(a^5+b^6+c^7)}$, $\cos b \cos c + \sin b \sin c \cos A$. Incidentally from the value of $\log n$ the table gives without interpolation $\log(n+1)$, $\log(n-1)$, $\log\frac{n+1}{n}$, $\log\frac{n-1}{n}$, and the logarithms of the reciprocals. This is a most useful table for five figure calculations with logarithms.

L. M. MILNE-THOMSON.

Advanced Trigonometry. By C. V. Durell and A. Robson. Pp. viii + 335. (London: G. Bell and Sons, Ltd., 1930.) 8*s.* 6*d.*

THIS volume, dealing mainly with analytical trigonometry, provides an excellent school course for senior scholars. It embraces the logarithmic, exponential, and hyperbolic functions; expansion in power series; projection and finite series, and complex numbers. No hesitation has been shown in using the methods of the calculus throughout, and a commendable feature is the development and application of the powerful principle of inequalities. The section devoted to complex numbers, occupying considerably more than half the book, is especially noteworthy for its clearness and sound treatment. As the authors point out, the interest and value of higher trigonometry lies in its being an introduction to modern analysis and, for this reason, the methods by which results are obtained are of more importance educationally than the results themselves. This is the basic principle upon which the book has been written.

The extreme rigour which characterises modern analysis is, as every teacher knows, quite out of place in a school course, with the consequence that many of the standard treatises are unsuitable for teaching purposes outside the universities. The present volume therefore, written by experienced teachers who fully appreciate the difficulties in the work of mathematical instruction, can be thoroughly recommended as a fresh and inspiring survey of a difficult section of school mathematics.

Rationalization. By Dr. James A. Bowie. Pp. 36. (London: Sir Isaac Pitman and Sons, Ltd., 1931.) 1*s.* net.

ONE of the best signs for the future of British industries is the interest now being taken in problems of industrial reorganisation. In this connexion, 'rationalisation' has frequently been proposed as a remedy for industrial ills, but the meaning of the term is vague and may serve indeed rather to obscure than to clarify discussion of these problems. Dr. Bowie has performed, therefore, a real service in providing a critical examination of its implications and methods in this pamphlet. Defining rationalisation as the *conscious* control and readjustment of industry, he points out that it has two sides: one external, concerned with the grouping of a large number of previously independent, competing enterprises, and the other internal, concerned with the efficient organisation within each unit of the functions of production, finance, personnel, and distribution. In examining the various implications of his subject, Dr. Bowie discusses such questions as vertical versus horizontal combinations, the mechanics of rationalisation, the planning of production, the problem of labour, the problem of control, and labour co-operation.

Constitution et thermochimie des molécules: les constituants moléculaires, les liaisons intramoléculaires, la valeur énergétique des liaisons. Par Albert Gosselin et Marcel Gosselin. Pp. vii + 231. (Paris: Les Presses universitaires de France, 1930.)

THIS volume contains a brief account of the three types of valency which are now generally recognised as definitely distinct in character. The descriptive portion is followed by thermochemical data on the heats of formation of compounds from which the thermal values for the energy required to rupture different bonds in complex molecules are calculated. These in turn are employed to elucidate the structure of numerous compounds. Some of the formulæ proposed, for example, $H_2\text{-}C\langle^{.H}_{.H}$ for methane, $H_2\text{-}N\text{-}.H$ for ammonia, and $NH\text{-}CO\text{-}NH_3$ for urea, are so different from those usually accepted, and the evidence advanced in favour of them is so problematical in character, that the book must be regarded as one which might be somewhat unsafe as a text-book. It does, nevertheless, contain many interesting observations on reactivity of organic compounds.

E. K. R.

Synthetic Inorganic Chemistry: a Course of Laboratory and Classroom Study for First Year College Students. By Prof. Arthur A. Blanchard and Prof. Joseph W. Phelan. Fourth edition. Pp. xii + 352. (New York: John Wiley and Sons, Inc.; London: Chapman and Hall, Ltd., 1930.) 15*s.* net.

THIS book contains a course of experiments and preparations in inorganic chemistry covering all the groups in the periodic system. Full details of the experimental procedure are given. The elementary theory of ionisation and that of mass action are included, and numerous questions and problems are given both in the text and at the ends of the chapters. The book is similar in plan to Biltz' "Laboratory Methods of Inorganic Chemistry", but is more elementary, and it provides a clear and useful course of experimental work in preparative inorganic chemistry, which could supplement the instruction in analysis usually given to degree students. Many of the preparations are suitable for pupils in the higher forms in schools.

Some Modern Mediums. By Theodore Besterman. Pp. xi + 189 + 4 plates. (London: Methuen and Co., Ltd., 1930.) 7*s.* 6*d.* net.

IN this book, the author has made a genuine attempt to present his case in a more or less unbiased manner. He is quite honest in his admission that several well-known mediums have turned out to be frauds. Mrs. Piper he considers perfectly genuine. So much evidence with regard to mediumistic performances consists of a 'has not been found out' attitude, that it is interesting to read evidence of a positive nature.

Deep Oil-Well Drilling.

IT is perhaps not generally known that the long-projected depth of a 10,000 ft. oil-well was reached recently by the drilling of a hole to 10,030 feet in Ventura County, California, by one of the leading petroleum corporations in that State. The well was actually a ' wild-cat ' put down to prove a possible extension of the Rincon field, though undoubtedly there was behind the venture a determination to create a depth record. Drilling was started in 1929, delay in completion occurring as a result of fire and technical difficulty last year.

This is the deepest oil-well, if not boring, in the world as yet on record. Apart from a matter of doubtful economics, especially in view of the present situation in the oil industry, the result undoubtedly is a great achievement in the history of petroleum engineering, and bears eloquent testimony to the high state of efficiency of both technical skill and plant existent in the industry to-day.

Deeper drilling for oil and deeper workings for other natural resources are contemplated and planned to-day with much vigour. Such propositions would have been condemned a few years ago. In the case of petroleum, while area may be limited for structural or other reasons, the possibility of productive oil-measures lying beneath the known pay-horizons is often considerable, particularly where a thick series of sediments comprising multiple reservoirs is involved. The limit to their exploitation is either that dependent on commercial policy or current economic conditions, or is one of plant design and performance. If cost is not a first consideration, it is clear from this new record that drilling equipment can be built and operated to carry a boring successfully to even greater depths ; in fact, it is unlikely that American oil engineers will rest until the two-mile hole has been drilled and until commercial production from such a distance has been realised.

It is this last factor which constitutes the steadying influence on any wild projects, since it pays no one to put down deep wells simply to finish up in an unproductive stratum, as was the case with this Californian well. Even supposing such a well is successfully drilled—that is, without unusual hazard in the shape of fire, abnormal water conditions, mechanical faults, bad deviation from the vertical, and so on—unless there is sufficient gas to cause the oil to flow easily to the surface, compressors and pumps have to be installed, and production costs mount up to a prohibitive level at the outset.

In other mining spheres, deep borings are usually of an exploratory character, with the view of subsequent underground developments calling for human activity at or near to the depths attained. Unlike oil, controlled mechanically from above, the winning of ore, for example, demands actual contact with the reserves, so that in the long run the depth limit in this case is that determined by physiological factors. Despite the great depths at which it is possible for man to work underground, it would seem inevitable that human endurance will place a limit on depth working sooner or later (it is clear from South African mining tendencies that that limit has not yet been defined), and that projects and accomplishments in the realms of oilfield drilling will far outstrip those in other fields of subsurface exploitation.

The influence which this deep oil-well drilling campaign has had throughout America, and incidentally in other countries as well, has been enormous. It is one of the primary causes of the existing glut of petroleum and market stagnation. Where formerly extension of productive area was sought superficially, geological field survey has given much of its place to subsurface calculations and extensions in the third dimension. Geophysical methods have played an important part in this reversal of technique. Other things being equal, the risks are probably far less in deepening a field where the log is known for some thousands of feet, than in opening up new territory ; probably the latter proposition is far more costly in any event. Where geological knowledge presupposes that older formations or horizons are potentially more productive than those long exploited, then, given the plant to penetrate successfully those lower levels, it is obviously rational to test the theory as thoroughly as possible. The fact that many of the wells already down can be deepened, thus saving the cost of complete new rigs, has also influenced this policy, and for some time to come it is evident that all over the world, where increased production of oil is sought, the American example will be zealously followed.

There is another and equally important aspect of the matter. The achievement of holes in the earth's crust to such depths as this Californian well should direct attention to the possibilities of making accurate physical measurements to confirm or modify data which have previously been based on calculation. It may be presumed that some scientific advantage was taken of the progress of this particular well, though we have not heard as yet that this was so. The measurements of thermal and pressure gradients, to cite only two lines of investigation, would be most valuable in such a case as this ; had the well been productive, comparisons between the oil and water from such depth and similar fluids from shallower horizons would furnish data, both chemical and physical, still much needed to square our ideas of petroleum genesis.

If deep oil-well drilling, as a technique, is to advance further (and there is little doubt but that in time it will do so), then, given the opportunity, science is likely to gain in yet another direction from industrial operation. Failure to bring in a two or three mile oil-well successfully may find its mitigation in the advancement of knowledge which carefully controlled operations should bring about. The 10,000 ft. oil-well establishes a record, but it also has been the cause of a great human effort to produce something better. This is perhaps its vindication, if such need be.

The German Bunsen Society in Vienna.

By Prof. FRITZ PANETH (Königsberg i. Pr.).*

THE German Bunsen Society for Applied Physical Chemistry and Electrochemistry holds a general meeting annually, and this year the meeting took place in Vienna on May 25–28. Some 350 physicists and chemists from Germany and Austria attended the meeting and, as is usually the case, there were present a number of representatives from several other countries, including Switzerland, Czecho-Slovakia, Hungary, Poland, Holland, Sweden, Spain, the United States of America, and Great Britain. From the last-named country no less than eight well-known chemists were present.

In the Bunsen Society it is customary to fix upon a main topic for the lectures, and this principle was again adopted. Last year the main topic was of an essentially theoretical nature, so that this year, in view of the fact that the Bunsen Society is intended to serve the interests also of applied physical chemistry, a topic of importance in technical work was chosen as the subject for discussion. The title was "Advances in the Science of Metals, and their Applications to Light Metals". The president of the Bunsen Society had invited five members to give lectures in the nature of a comprehensive survey on the selected theme, and these included Prof. G. Tammann, who celebrated his seventieth birthday during the meeting on May 28, and was the object of numerous expressions of esteem. Amongst others, there was an address written by Prof. Nernst, which was presented to him during the first session by the president of the Society, and in which his great services to the most divers branches of physical chemistry were emphasised.

The first comprehensive survey was given by Prof. R. Becker (Berlin) on "Electrical and Magnetic Properties of Metals". He commenced by pointing out that the old classical theory, which treated as a gas the whole of the free electrons present in a metal, is entirely inadequate in the face of two facts of experience; it is unable to explain either why the electrical resistance vanishes with diminishing temperature, or why the free electrons make no contribution to the specific heat. Both points are cleared up by two profound alterations which have to be made to the classical picture, according to quantum mechanics. The individual electron is not to be described as a point charge, but as a wave function, and the interference of the electron thus rendered possible brings about the disappearance of the resistance in a lattice which is not disturbed by thermal movement. On the other hand, Pauli's principle (Fermi statistics) becomes effective in the sense that the free electrons are unable to supply any appreciable contribution to the specific heat. The practical application of the quantum mechanical picture of the metallic state envisaged by modern theoretical physics is, for the time being, however, held up by mathematical difficulties.

The next lecture, by Dr. G. Masing (Berlin), was entitled "Age-Hardening, especially on the Basis of Experience with Light Metals and with Alloys of Beryllium". Masing started off from the effect discovered by Wilm in 1909 with duralumin, in which a marked hardening (*Vergütung*) of alloys can be attained by quenching the material from a high temperature, and afterwards storing it at ordinary temperatures. This phenomenon, which has been observed not only with alloys of aluminium, but also with alloys of copper and other heavy metals with beryllium or silicon, as well as with several varieties of steel, etc., has not hitherto found a wholly satisfactory explanation. It is certain that a necessary condition for the hardening is that supersaturated mixed crystals are produced by the quenching; hence we must assume that the hardening is somehow associated with an alteration of these supersaturated mixed crystals. On the basis of all the available evidence, especially the results of X-ray investigations, Dr. Masing was of the opinion that the hardening can be regarded generally as an accompaniment of the separating out of a second type of crystal from a mixed crystal. The details of this segregative process, and accordingly also of age-hardening, are probably different, however, for different alloys.

The third speaker was Prof. Tammann (Göttingen), on the subject of "Recrystallisation". It is well known that the structure of a specimen of metal can be fundamentally altered by rolling or forging. This is due to the fact that the crystallites become drawn out into plates or fibres by slipping on defined crystallographic planes. In this way the originally random orientation of the crystallites passes over into a more or less completely ordered form. The physical and chemical properties of the metal, as well as its elastic properties, change in this process, and we may thus assume that, as a result of the displacement along the slip-planes, an alteration takes place also in the atoms themselves. If we increase the temperature of the specimen, the original properties tend to return, and in every metal this recovery of the crystallites takes place within a different range of temperature. With further increase of temperature, fresh boundaries and individual small grains, which can be detected by etching, make their appearance in the plates or fibres. The orientation of the bodies with respect to each other is different, and for temperatures in the neighbourhood of the melting-point a random orientation of the grains is produced; at the same time the grains increase in size, and the last traces of the cold-working vanish.

In continuation of the subject, Dr. Sachs (Frankfurt a. M.) discussed "Problems of the Science of Metals in the case of Aluminium and

* Translated by Dr. R. W. Lawson.

Aluminium Alloys", whereby in particular he dealt with the technically important cohesional properties of individual crystals, of rolled alloys, and of cast alloys. Attention was directed to the relations between the plastic properties of metallic crystals and their lattice structure, and emphasis was laid on the differences which exist in the formation of alloys of aluminium as compared with those of copper, silver, and gold. Another aspect of aluminium alloys was discussed, namely, the complicated hardening effects, which may lead to increases by two orders of magnitude in the cohesive properties, as compared with the original modulus of shear of the crystal. Dr. Sachs is inclined to attribute this to changes in the homogeneous phase. Later, the harmful influence of a gas content on cast alloys was discussed theoretically, and finally he considered the process whereby aluminium is protected against corrosion by means of a compact oxide film produced electrolytically.

The last of the general surveys on the subject was presented by Dr. E. Schmid (Berlin-Dahlem). He discussed the "Physics and Metallography of Magnesium", in which connexion he dealt particularly with those differences which are based on the hexagonal crystal structure of magnesium and its alloys, in contrast to the large group of cubic technical metals.

The president of the Society had not only drawn up the programme of the session at which the five general surveys just mentioned were delivered, but he had also recommended that in the choice of the individual lectures preference should, so far as possible, be given to topics which are related in some way with the main topic of the meeting. Accordingly, in the other sessions at which freely selected individual lectures were delivered, topics taken from the science of metals were in many cases discussed. In view of the large number of these shorter papers—in all about sixty single papers were read—it is only possible here to direct attention briefly to a few of them.

Dr. W. Schmidt (Bitterfeld) dealt with the "Technology and Application of Electron-Metal", and made detailed statements on the components of this alloy, which is so valuable owing to its lightness, and also on the process of refining and the method of working it. Dr. W. Kaufmann (Frankfurt a. M.) reported on the "Vaporisation of Magnesium in a Vacuum", and illustrated his remarks by the demonstration of interesting preparations. Dr. Seith (Freiburg) communicated the results of experiments that he had performed in collaboration with Prof. Hevesy on "Diffusion in Metals". The diffusion of a metal in itself (self-diffusion) was treated as a limiting case of the diffusion of one metal in another (foreign-diffusion), and it was shown that in metals self-diffusion is always very slow, large velocities of diffusion only being able to manifest themselves in certain cases of foreign-diffusion. For example, the diffusion of gold in lead at 150° C. amounts to 4×10^{-3} cm.^{2} day^{-1}, whereas lead in lead at the same temperature has a diffusion coefficient of only 8×10^{-10} cm.^{2} day^{-1}. Papers by Dr. Pietsch (Berlin) and Dr. Schwab (Munich) dealt with the "Activity of Complex (*Mehrstoff*) Catalysts" and the question of the active centres in hydration catalysis.

More detailed reference may be made to the lecture by Prof. K. Przibram (Vienna), who presented a very illuminating contribution to the topic of the main lectures, more especially to the lecture of Prof. Tammann; Przibram has succeeded, in a special case, in permanently recording cinematographically the process of recrystallisation.

It is well known that rocksalt assumes a yellow colour under the influence of the rays from radium. The coloration takes place more rapidly and penetrates more deeply when the mineral has been subjected to a uni-directional pressure of more than 100 kgm./cm.^{2} before treatment with the rays; rocksalt which has been compressed by a force equal to the weight of a few thousand kilograms becomes almost black in a short time when rayed by means of radium. About two years ago Przibram observed that such specimens, after some time, again show clearer regions, which slowly grow. Since the deeper coloration of the compressed salt was attributable to disturbances of the crystal lattice, it was necessary to conclude that the reoccurrence of clearer patches was due to a progressive healing up of the disturbed lattice, that is, to recrystallisation, a conclusion which could be verified simply by cleaving the specimens, when large reflecting crystal surfaces were revealed as the cleavage planes of the clear patches, whereas the black part showed no cleavage. It could also be proved by means of X-rays that the clear regions again possessed an orderly crystal lattice.

A method thus presented itself of conveniently following up the recrystallisation of the compressed rocksalt, and even of recording it cinematographically by 'stealing a march on time'. The process in the production of the film was the following. A small slab of rocksalt was chosen, which, a few weeks after the above described treatment, revealed a beautifully regular and almost square grain of recrystallisation. Forty exposures of this slab were taken daily—twenty in the morning, one directly after the other, and likewise twenty in the afternoon—and this process was continued for a period of two months. The exhibited film showed first the compressed specimen of rocksalt traversed by cracks, with the above-mentioned clear recrystallised grain in the left upper quadrant. The gradual growth of this grain was clearly to be seen, and it was also evident that the marked horizontal crack separating the two left quadrants provided an insurmountable obstacle to the further growth; the corner of the grain approaching it became blunted. Apart from the first-mentioned grain, a number of other grains formed in the course of time, and these likewise grew, until finally a large part of the specimen appeared in the recrystallised state.

This first film illustrating recrystallisation is naturally still somewhat defective. There is, how-

ever, no doubt that when it has been arranged to take the photographs at regular intervals of, say, an hour, day and night, by means of an automatic device, it will be possible to undertake accurate measurements of the velocity of recrystallisation, with the aid of the film. The method is already very useful for the demonstration of the process of recrystallisation.

Mention should be made of a few papers which had no direct connexion with the main theme. Dr. Werner Kuhn (Karlsruhe) presented a communication on "Single and Superposed Absorption Bands and their Behaviour with respect to Optical Activity". With *d*-camphor Dr. Kuhn has found that an absorption band which has usually been considered single is in reality a superposition of a weaker and a stronger band. He was led to this view by the observation of certain deviations in the behaviour of camphor as compared with that of other optically active compounds. Dr. Fromherz (Munich) spoke on "A Spectroscopic Investigation of the Conditions of Dissociation of the Halides of Metals in Solution". Whereas the absorption curves of light in aqueous solutions of the halides of the alkali and alkaline earth metals are essentially independent of the concentration as regards their shape and position, up to the highest concentrations, new absorption bands of association products make their appearance alongside the absorption bands of the hydrated ions in aqueous solutions of lead, thallous, cadmium, and mercury halides, and they arise to an increasing degree as the concentration of the solutions is increased. From the spectral position of the bands and the dependence of their height on the concentration of the contributing ions, it has been possible to determine the nature of the association products, the dependence of the degree of association on the concentration, and hence the equilibrium of association in the solutions. Dr. Beutler (Berlin) gave an account of a piece of work which was concerned with dissociation as a result of collisions of the second kind, and in which, in particular, the splitting up of the hydrogen molecule into a normal and an excited hydrogen atom by means of excited neon atoms was followed up spectroscopically. Prof. W. A. Noyes (Urbana) pointed out that the formula proposed by Mecke on the basis of spectroscopic data for nitrogen dioxide O=N–O– is in good agreement with the views on 'shared' and 'unshared' electrons which have been derived from the chemical behaviour of nitrogen dioxide.

Dr. Frankenburger (Ludwigshafen a. Rh.) has continued with his collaborators the attempts to combine hydrogen or nitrogen with highly disperse metals. Their method is to separate iron or nickel from the vapour phase; the resulting metals, which are always at first in an extremely finely divided form, join up to form larger particles if this process of collective crystallisation is not suitably prevented. Frankenburger realises this by arranging that sodium chloride is deposited from the vapour phase simultaneously with the metal. When the molecular ratio NaCl : Fe was increased to 2000 or 3000, it was found possible to combine up to six molecules of hydrogen with each atom of the separated iron. We are here obviously dealing with weak affinities between metal atoms and gas molecules, forces akin to those of van der Waals in the gas theory. In the discussion, Prof. Biltz (Hannover) suggested that the phenomenon is perhaps in its nature related to the attachment of five or six molecules of water of hydration to the chemically non-reactive atoms of argon, krypton, and xenon.

Prof. Paneth (Königsberg) reported on the continuation of the investigations on free methyl and ethyl, which were intended to bring clarity with regard to the mechanism of the disappearance of the free radicals. If helium instead of hydrogen is used for the transport of the radicals, their activity falls off with the same velocity as in hydrogen; from this and from related observations it is concluded that a reaction takes place with the vessel walls. Whereas in a glass tube the radicals can be transported more than half a metre by a rapid gas flow, a metal mirror 1 cm. in length introduced into the tube suffices to bind the radicals quantitatively. On the basis of formulæ derived from the kinetic theory of gases by Prof. K. F. Herzfeld (Baltimore), we can calculate from these results that every free radical is bound by a single impact on a metal capable of reaction, whereas from amongst one thousand radicals incident on a glass wall only about one is not reflected. From the discussion on this paper we may direct attention especially to the remarks of Prof. Bodenstein (Berlin), who mentioned similar observations in the combination at glass walls of 2 Cl to form Cl_2.

It was decided to hold the next meeting of the German Bunsen Society at Münster, in the year 1932.

Obituary.

SIR HUGH BELL, BART., C.B.

THE north-east coast of England will have bitter reason to remember for long the first half of the current year, because this highly industrial corner of England has lost by death a greater number of its leading industrialists than can be remembered in any similar period. The names of such men as Sir Arthur Dorman, Sir Charles Parsons, Andrew Laing, Sir Archibald Ross, and now Sir Hugh Bell, all dead since the beginning of the year, show how severely it has suffered; such losses would be serious enough at any time, but at a time of crisis like the present, when men of experience, judgment, and knowledge are so badly needed, the loss is even exceptionally deplorable: for, as the above names show well enough, these were men who were known and honoured not only in their own district but also in all industrial circles throughout the world, and no one was better known or more highly honoured than the man whose loss we mourn to-day.

Sir Hugh Bell was born at Walker-on-Tyne on Feb. 10, 1844, and was thus more than eighty-seven years of age when he died, but fortunately he retained his keen intellect and active interest in affairs down to the end. He was the eldest son of a famous father, Sir Lowthian Bell, well known for his classical researches into the chemistry of the blast-furnace, and an ironmaster of high repute. The son received his first education at Merchiston Castle School, Edinburgh, but at fifteen years of age, in 1859, he went to Paris and studied chemistry at the Sorbonne under Ste. Claire Deville, continuing his studies afterwards at the University of Göttingen. His stay abroad was not, however, a very lengthy one, for in 1862, at eighteen years of age, he had returned to England and commenced to take part in the family business of ironmaking.

Sir Lowthian Bell was one of the first to appreciate the importance of the Cleveland ironstone, and thus played an important part in the development of modern industrial Middlesbrough, the centenary of the foundation of which was celebrated last week. Sir Lowthian Bell with his brothers erected blast-furnaces at Port Clarence, and Hugh Bell was made manager of these works. The father formed his business into a public company under the title of Bell Brothers, Ltd., in 1899, and Hugh Bell was the managing director; meanwhile, steel works had been added to the blast-furnace plant at Port Clarence. Sir Lowthian Bell died in 1904, and Sir Hugh Bell succeeded to the baronetcy in that year, and was made chairman of the company in succession to his father. Sir Hugh Bell continued to direct the fortunes of Bell Brothers, Ltd., until this became one of the important iron and steel making firms of the country. It was taken over in 1923 by Dorman, Long and Co., Ltd., Sir Hugh Bell becoming a director of that company, with his life-long friend, Sir Arthur Dorman, as chairman. After Sir Arthur Dorman's death on Feb. 12 of this year, Sir Hugh was made chairman of Dorman, Long and Co., Ltd., so that this great firm has had the sad experience of losing two chairmen by death within a few months of each other. Sir Hugh Bell was also chairman of the firm of Pearson and Dorman, Long, Ltd., the interests of which lay more particularly in the development of collieries in Kent, whilst he was also chairman of the Horden Collieries, Ltd., an important colliery in East Durham. It may be added as a matter of historical interest, which will, however, be fresh in the minds of most people, that Messrs. Dorman, Long and Co., Ltd., took over the famous firm of Bolckow, Vaughan and Co., Ltd., so recently as 1929, and Sir Hugh Bell necessarily took his share in this increased responsibility. He was also a director of the London and North-Eastern Railway Company and of numerous other technical and industrial concerns.

In 1869, Sir Lowthian Bell took a prominent part in the foundation of the Iron and Steel Institute, the object being to afford a free means of communication between all interested in iron and steel manufacture, especially in its technical and scientific aspects, deliberately excluding all questions connected with wages. The first meeting of the Institute was, appropriately, held at Middlesbrough, the late Duke of Devonshire having been the first president. Sir Hugh Bell, naturally enough, became an original member of the Institute, being at the time of his death one of the last living representatives of that class; he became president of the Institute in the year 1907, and occupied the chair for three years. The Bessemer gold medal, the highest distinction that the Iron and Steel Institute can award, was founded in 1873 by Sir Henry Bessemer, and it was awarded to Sir Hugh Bell in 1926 in recognition of his eminent services in the cause of iron and steel manufacture. He was also an original member of the Institute of Metals, founded in 1906.

Merely to recount the work of Sir Hugh Bell as a successful ironmaster would, however, be to give a very limited and one-sided view of his activities. He was, above all, a great public servant, and rendered services to the community of which it is difficult to speak too highly. He was Mayor of Middlesbrough on three occasions, in 1874, 1883, and 1910, and he played a prominent part in the conversion of the river Tees from a shallow, dangerous, and almost useless stream into a wide and navigable river, capable of accommodating some of the largest cargo carriers now afloat. This particular work was done by the Tees Conservancy Commission, which was founded in 1852, and of which Sir Hugh Bell was chairman for the last thirty years, during which his shrewd foresight and bold enterprise were instrumental in guiding the work of the Commission to its present successful issue. It is perhaps fortunate for the nation that Sir Hugh Bell's attempts at entering Parliament were unsuccessful; he contested Parliamentary elections on two occasions, first as a Unionist at Middlesbrough in 1892, and afterwards, when he had severed his connexion with the Unionist party because he disagreed with their fiscal policy, as a Liberal in the City of London in 1910. It is perhaps unnecessary to add that Sir Hugh Bell never missed an opportunity of showing his ardent adhesion to the principles of free trade.

As might well be expected from such a man, he took the keenest possible interest in everything pertaining to technical education, and received honorary degrees by several universities, including the degree of D.C.L. from the University of Durham and that of LL.D. from the Universities of Oxford, Leeds, and Sheffield. He was a member of the Board of Governors of the Imperial College of Science and Technology, but his closest connexion with technical education was through Armstrong College in the University of Durham. Sir Lowthian Bell had been a member of the council of this College, first known as the Durham College of Physical Science, up to his death, and soon thereafter Sir Hugh Bell was elected to a seat on the council. The constitution of the College was reconstructed in 1909 under the University of Durham Act, and Sir Hugh Bell became the first chairman of the College council in 1910. He held this important post for many years, during which again his shrewd judgment and keen intellect were of the greatest

value to the College. Pressure of work caused him, however, to relinquish the chair in 1923, and it is significant of the aims of Armstrong College that he was succeeded by Dr. Cecil Cochrane, whose connexion with iron manufacture is too well known to need emphasising here.

Sir Hugh Bell was a notable exception to the widely held view that an able father does not produce an able son. Although in this case both father and son were distinguished ironmasters, it must, however, be admitted that their mentalities were of an entirely different order. Sir Lowthian Bell will be remembered best for his scientific acquirements and their application to technology, whilst Sir Hugh Bell's fame is not that of a man of science, but of a man who devoted his brilliant abilities and keen insight to the service of the community. It is not too much to say that he would have been eminent in any profession or career that he had cared to take up. It is a curious comment on the lives of these two great men that Sir Lowthian Bell, eminent as his scientific acquirements were, is now seen to have thrown back the industries of coke-making and of pig-iron production, to which he devoted his life, many years by his obstinate preference for the old-fashioned beehive to the more modern retort-oven coke. The future may possibly show that his brilliant son may have retarded the progress of the nation to a similar extent by his obstinate adherence to old-fashioned free trade principles. He appeared to disregard entirely the wise saying, *Temporibus mores sapiens sine crimine mutal*, and did not seem to realise that a policy which might have been entirely right and sound at one period of the world's history, might be disastrous under different conditions.

As is perhaps only natural in the case of a man who has succeeded in living to an age beyond that of most others, the closing years of Sir Hugh's life were saddened by the loss of many dear to him; here it is only necessary to mention the death of his gifted daughter, Gertrude Bell, who died in July 1926, and that of Lady Bell, who died a little more than a year ago.

The whole record of the life and activities of the man whose loss we mourn is that of a man of keen and penetrating intellect, a brilliant speaker, an advanced thinker, and a shrewd observer, whose keenness was, however, tempered by the geniality of his character, a man who devoted his great gifts unselfishly and unsparingly to the service of his fellow-men.

HENRY LOUIS.

THOUGH the Science Museum at South Kensington was established in 1857, the development of its collections had lagged far behind those representing art; but in 1909 a number of people distinguished in science and representing technical institutions sought an interview with the President of the Board of Education in order to represent the urgent importance of developing its collections and of providing more suitable buildings for their accommodation. The result of the representation thus made was that a Departmental Committee was appointed in the following year, of which Sir Hugh Bell was the chairman, its terms of reference being to consider and report upon the condition and the future development of the Science Museum and the Geological Museum.

Sir Hugh Bell took the keenest interest in this task, and under his guidance the Committee prepared a detailed report, which was adopted by the Board, laying down the lines which the development of the Museum has since followed. The report proposed the replacement of the old buildings by others of modern type, of which the eastern and centre blocks were to be completed as soon as practicable, but the outbreak of war delayed the execution of this plan and only the former of these has as yet been constructed.

In 1913 Sir Hugh Bell was appointed chairman of the Advisory Council of the Science Museum, and in this capacity for eighteen years he watched over the development of the collections and their exhibition in the galleries of the new building in accordance with the plan devised by his Committee. Difficulties and delays occurred from time to time, and on all such occasions his tact, influence, and ready help were of the greatest value in overcoming them. He took a wide view of the influence which the museums at South Kensington might, he thought, exert, and he strongly advocated a general policy of co-operation in which each museum would not only work out its own line of policy but should also look out for and develop contact with the others in order that the various aspects of human endeavour might be more fully represented.

The Science Museum owes more to Sir Hugh Bell than to anyone, and by his death it has lost a wise counsellor, a ready helper, and a valued friend.

PROF. H. WILDON CARR.

BY the death of Prof. Herbert Wildon Carr, which took place on July 8 at Los Angeles, at the age of seventy-four years, philosophy has lost an enthusiastic student and exponent, and philosophers in many countries a friend greatly respected for his single-minded devotion to learning and beloved for his generosity and kindness of heart.

Wildon Carr's life had some of the features of a romance, including (one may be permitted to say) a singularly fortunate and happy marriage. Born in circumstances which precluded a prolonged education, he had to go out into the world at the age of fourteen. But even at that tender age he had already marked out for himself what was to be the real business of his life, and addressed himself deliberately to the task of winning as soon as possible a financial competence in order that he might thereafter devote himself to philosophy. Not often have the dreams of boyhood worked out more completely 'according to plan'. For in due course Wildon Carr enjoyed in succession the status of a member of committee of the London Stock Exchange and of a president of the Aristotelian

Society and honorary professor of philosophy in the University of London.

Nevertheless, all did not go smoothly; for the youth who set out on the philosophical quest in high hopes found himself as a man brought up against the blank wall of Humean scepticism. At a memorable dinner which Carr gave in 1911 in honour of Henri Bergson, he pictured in moving terms the sadness of his intellectual plight and hailed the French philosopher with gratitude as his rescuer. Students who have followed Wildon Carr's work during the last twenty years will, indeed, recognise how powerful an impulse he received from Bergson—an impulse which, reinforced by the later influences of Croce and Gentile, carried him forward to his own monadistic idealism.

Wildon Carr's development as a philosopher is dealt with below by another hand. It is, however, fitting to emphasise here what he did for philosophy and philosophers, apart from his output as a writer. For many years he was the honorary secretary of the Aristotelian Society, and from the death of Shadworth Hodgson onwards to the time when the state of his own health compelled him to seek sunnier skies, he might almost be said to have been himself the Society. This does not mean that he ruled it as an autocrat, seeking to make its voice his own. On the contrary, there was never a more generous appraiser of an opponent's merits, nor a scholar who sought more earnestly to let all sides of a question have the best exposition and the fairest hearing. Nor did an older philosopher ever keep a more watchful eye upon promising beginners or give them more encouragement.

Under Carr's kindly and inspiring rule the Aristotelian Society was for many years a forum where most of the notable thinkers of the day debated most of the living philosophical issues. His associates during those fruitful years knew how dear the welfare of the Society was to him, and how generously he spent upon it both his time and his material means. The solid work done by it under his guidance will be an enduring part of the monument he has left behind him; while so long as those who knew him and worked with him still live, the memory of his singularly gracious and generous personality must continue to "smell sweet and blossom". T. PERCY NUNN.

IN speaking of Carr's philosophy, it is particularly difficult to separate the philosopher from the man. Like his first teacher, Shadworth Hodgson, he, if any man of my time did, lived the philosophic life, and, after his success in business enabled him to retire, he devoted himself entirely to cultivating philosophy in himself and others. Yet he remained rather a centre of philosophers than of philosophy, and his work was an influence rather than an achievement. He taught us, through his own devotion and through the affection he inspired, to feel that we were fellow-workers in one subject, however different in our methods of approach; and I scarcely like to think what we shall do without him. Nor was it only philosophers he brought together; he also brought science and philosophy into their wholesome and natural contact. He believed that philosophy and science belonged together, and that philosophy could not be indifferent to changes in scientific ideas such as his time had witnessed. In this he was surely right. The work of the Aristotelian Society in the last twenty years is a standing witness to his success in this effort and to its fruitfulness.

Carr owed both his strength and his weakness to his open-mindedness; and the personal hold he had over philosophers of such differing views was only the other side of his candour and his intense effort to understand and assimilate. His own originality and independence showed itself in the tenacity with which he worked out a doctrine for himself, while making use of what he was continually learning from them. You would call him markedly suggestible, and impulsive as well, so that, as each successive thinker like Bergson or Croce or Einstein or Gentile fascinated him, he devoted himself to expounding them with enthusiasm. When I knew him first, he was still a disciple of Hodgson. Afterwards he leaned towards a Humean idealism, and the idealism which began thus early he never ceased to entertain under some form or other. In the end he worked his way to a kind of Leibnizianism which was very much his own. But, as anyone may see from his latest constructive pronouncement, "Cogitans Cogitata", it retained plain traces of the doctrines that had influenced his mind, and it would be an interesting and profitable task to follow him from his phase of discipleship up to that of mastery.

Carr's readiness to accept from others may have disturbed some persons; for my part, I admired rather the independence with which he converted them to his own uses, and always, even without assenting to him, I found him one of the most interesting and stimulating minds among my contemporaries. I still have the feeling that in dealing with relativity he was over-hasty in his deliverances. I subscribe to Bertrand Russell's statement that relativity is of immense importance to philosophy but that we do not yet quite know in what way. Carr had no doubt. He thought it had dethroned Newtonianism to make way for Leibnizianism; and I expect he was, in general, right. There was, however, a want of special authority about what he said when he was expounding the new science as science, and I understand his exciting some impatience among those who knew. But he showed philosophers the way, and that it was our duty to find material for our philosophy in a thorough understanding of this new mode of scientific thought. It would be an evil day for metaphysics if a great change should occur in men's minds about the science of things and we philosophers should go our way as if nothing particular had occurred.

In philosophy there has been a marked tendency in recent years to revert to Leibniz and monadism, but to treat the monads not as windowless, like Leibniz's, but as communicating. Carr would have nothing of it, and insisted that the monads were

completely independent of each other, each "expressing" itself (the word is his own) through its own activity in its own world of what is commonly called reality or external reality. The true reals are thus the monads, the so-called world of knowledge is ideal. The crux of any such theory is its solipsism, but he avowed and defended that attitude. He evaded the objection to solipsism by making community with other individuals part of the essential nature of each individual. I do not myself see how if the universe is each man's expression, it can still contain individuals who, like himself, are independent centres of activity. Often, however, as I pressed this point upon him, he did not seem to feel that it presented a real difficulty, and he seemed to think he had met it by reference to speech and mutual intercourse. In the same way he seemed to me to make the special interpretations by individuals of the physical world too exclusive of each other, and to forget that the very pith of the doctrine of relativity is that physical laws are the same in form for every observer. Leibniz himself had God and the pre-established harmony to save his monadism: but for Carr, God was but a part of the world of each monad; and this, to my mind at least, presents difficulties.

Carr's explicit philosophy is chiefly contained in the work I have mentioned and the earlier "A Theory of Monads". But besides these and his expository books, there were others, which show what a wealth of knowledge he had, outside strict philosophy or only partially related to it; in particular, two books which he published during his Californian period, "Changing Backgrounds in Religion and Ethics" and "The Unique Status of Man". When I happened once to speak to him enthusiastically of Pascal's "Pensées", with which I had made acquaintance quite late in my life, I found that the book had been his constant companion for many years.

His assiduity and industry were immense, and if his friends knew well the sweetness of his character, the amount of work he accomplished is a witness to the strength and persistence of it. To my mind, Carr's work has been for the philosophy of our time a refreshment, and even, with all allowance for its shortcomings, a fecundation; and I must not forget the singular beauty and simplicity of his style of writing, which reflected his own directness and candour of mind.

S. ALEXANDER.

MR. ERNEST NOEL.

MR. ERNEST NOEL, who died at his home, Dulaney House, Patching, Sussex, on May 20 at the age of ninety-nine years, was the doyen of the Geological Society of London. Elected into the Geological Society in 1849—P. Martin Duncan, who afterwards became a fellow of the Royal Society, was also among the chosen in that year—he had been eighty-two years on its roll, a span probably without parallel in the annals of English scientific bodies. At the date of Noel's election (he was then living at Hornsey), Sir Charles Lyell occupied the presidential chair, and Charles Darwin was a member of council. Such circumstances had provided many interesting reminiscences of contemporaries and original workers in geological and general science. Born on Aug. 18, 1831, Mr. Noel was the second son of the Rev. the Hon. Baptist Noel, who himself was the tenth son of Sir Gerard Noel, and brother of the first Earl of Gainsborough (second creation). Mr. Noel was educated at Edinburgh and Trinity College, Cambridge.

T. E. J.

News and Views.

THE summary by Sir James Jeans of a series of lectures on the annihilation of matter, delivered by him during his recent visit to the United States, which we publish as our supplement this week, is a characteristically skilful presentation of the case for the reality of this process, of which he has for some time been convinced. Although, as he indicates, the doctrine of the permanence of matter has been a leading feature of the greater part of the history of science—it dates at the latest from the time of Aristotle—supporters of the opposite idea have never been wanting. It appears to be peculiar to our own time, however, that they are to be found among followers of the 'experimental philosophy'. Yet, fantastic as the idea would have seemed to the physicists of a few generations ago, it is impossible, after considering the evidence which Sir James Jeans so ably summarises, to dismiss it as unworthy of scientific attention. The process is mathematically possible; it is certainly not fundamentally inconsistent with modern atomic theory; it provides a plausible explanation of a physical observation—the highly penetrating radiation; and it appears to be the only means of bringing order into the perplexing mass of data concerning the constitution and history of the stars. The cumulative effect of these facts, even if they are not strictly additive, is considerable, and it is not surprising that the hypothesis of annihilation is being treated with marked respect.

GENERAL acceptance of the idea, however, is out of the question until more facts of observation are available. Sir James remarks that "the majority of astronomers think it probable . . . while many, and perhaps most, physicists look on the possibility with caution and even distrust". It is perhaps for that reason that he has devoted the greater part of his discussion to the physical evidence. While his diagnosis of the situation is, perhaps, not very inaccurate, it is scarcely a fundamental one. The reaction of the man of science—whether he be physicist or astronomer—to the idea will depend on his mental constitution. The passage from mathematical possibility to physical

actuality is traversed much more easily in some minds than in others. Physicists have been known whose enthusiasm has sometimes triumphed over their scientific scepticism, and, on the other hand, even an astronomer may demand more than an æsthetic satisfaction in co-ordinating his observations. It would be a mistake to suppose either that the astronomer has a more elastic scientific conscience than the physicist or that the physical evidence for the annihilation of matter is less than the astronomical. The simple fact is that the hypothesis of the annihilation of matter is a legitimate, useful, and stimulating one, with at least as great a probability as any alternative that has been suggested, but that it awaits further observational and experimental data for its final assessment. In the meantime, we may be thankful that in these matters we have both pioneers and critics of the highest quality.

AT a meeting of the Council of the Royal College of Surgeons of England, held on July 9, Lord Moynihan was elected president, for the sixth year in succession. This constitutes a record in the annals of the College. Although an election to the presidential chair is made annually, it has become the custom to extend the office to three years. Only once before has this term been exceeded, when the late Sir William MacCormac was elected president five years in succession—1896–1901. During Lord Moynihan's presidency, research laboratories have been opened in connexion with the museum of the College, and research scholarships have been endowed to permit young men who intend to become surgeons to devote one year or more to experimental research. Research scholars are encouraged to maintain their connexion with their hospitals and to continue their participation in clinical work.

ON the eve of his re-election to the presidency of the College, Lord Moynihan laid the foundation-stone of an institute for surgical research—to be known as the Buckston Browne Farm for Surgical Research. The object of this farm is to permit the research students of the Royal College of Surgeons to carry out experiments on animals kept under the most favourable conditions. The erection and endowment of this invaluable addition to the equipment of the Royal College of Surgeons has been made possible by the munificence of one of its fellows, Mr. George Buckston Browne, who is giving £100,000 to the College in order that it may complete its scheme of research. Mr. Buckston Browne, as readers of NATURE will remember, purchased Down House, Charles Darwin's home for forty years, endowed it, and handed it over, with its grounds, 23 acres in extent, to the custody of the British Association. More recently, he bought 13 acres of land adjoining the western side of the Down House property and beautifully situated. This land he has conveyed to the Royal College of Surgeons, and it was a site on these new fields which was the scene of the ceremony in which Lord Moynihan played the leading part on July 8. In laying the foundation-stone, he said that owing to the great beneficence of a fellow of the College, they were laying the foundation-stone of an institute for experimental research which would add the one remaining link required for the proper development of surgery in Great Britain. The donor of the institute, in reply to Lord Moynihan, said that they had been able "to bring the great genius of John Hunter, who did so much to throw light on the living processes of the human body, alongside of the home of that other great genius, Charles Darwin, who did so much to emancipate the human mind from superstition. Both men are now brought together on a sacred spot in Kent." Mr. Buckston Browne's gift has been rightly described as the most beneficent ever made by a surgeon for the advancement of his profession.

To mark the occasion of its jubilee, the Society of Chemical Industry has issued a special number of *Chemistry and Industry* which will undoubtedly appeal to all who are interested in the historical aspect of applied chemistry. The earlier part of the issue is devoted to an account, not hitherto available in compact form, of the formation and development of the Society, which has been very closely identified with the growth of the chemical industry in Great Britain, and to an illustrated series of biographies of past presidents and medallists, amongst whom are numbered such distinguished men of science as Sir William Ramsay, Sir William Crookes, and Sir James Dewar. The second half of the volume, consisting of reprints of twenty-one of the more important papers which have been read before the Society during the past fifty years, indicates the wide range of topics which fall within the scope of the Society's activities. The reprints include the paper read by Sir Oliver Lodge before the Liverpool Section in 1886 on "The Electrical Deposition of Dust and Smoke, with Special Reference to the Collection of Dust and Fume, and to a Possible Purification of the Atmosphere"; Weldon's account of "Some Recent Improvements in Industrial Chemical Processes", read in 1882; Mr. William Macnab's fascinating story of "Some Achievements of Chemical Industry during the War in this Country and in France" (1922); and Sir William Pope's Royal Institution discourse on "Faraday as a Chemist" (1925). Apart from the event which its appearance commemorates, the issue is of importance on account of the great historical value of its contents.

THE Safety in Mines Research Board has issued its paper No. 66, being a report upon haulage accidents in collieries, and, as usual, the report is issued at the nominal price of 6*d.* so as to be available to all interested in colliery work. The subject is one of very great importance, first, because next to falls of ground, haulage accidents claim the largest number of victims in collieries, and in some districts are even the most prolific cause. Whereas it is quite true that the proportion of fatal to non-fatal accidents due to haulage is much less than that due to certain other causes, such as explosions of firedamp or coal dust, nevertheless, the very large number of non-fatal accidents show that the subject is one worthy of

investigation. An interesting table in the report shows that whilst the number of fatal accidents per thousand persons employed has, roughly speaking, been halved since 1873, that due to haulage accidents is practically unchanged in that period, and this fact alone shows that the subject is worthy of serious investigation.

THE problem is a difficult one on account of the great variations, not only between different districts but also between different colleries in the same district. Thus, it is pointed out that there is a high rate of haulage accidents in Northumberland and Durham, and it is suggested that this may be due to the prevalence of bord-and-pillar working in this coalfield, involving a large use of pony haulage and of young lads in charge of the ponies. Again, it is pointed out that in one of the Scottish collieries the highest accident rate is nearly thirty times the lowest accident rate. The report naturally makes no definite recommendations as to what steps should be taken to decrease the number of accidents, that not being the object of the Committee; its work was simply to prepare a scheme for investigating possible methods of reducing the number of haulage accidents, and accordingly the Committee makes a number of recommendations for research, which appear to be thoroughly sound and well warranted by the conditions, although the Committee itself points out that many of these accidents "are due to causes which could only be overcome by a change in human nature".

THE small tortoise-house behind the old reptile-house—now converted into a bird-house—at the London Zoological Gardens has just been refitted as a tropical house; the atmosphere is most convincingly tropical, and one side is fitted up as a greenhouse-aviary, with stone-plants, rockwork, and a little streamlet and pool. Here are located a pair of African jacanas (*Actophilornis africanus*) and some interesting passerine birds, pittas, sunbirds, sugar-birds (Cœrebidæ), and small tanagers. On the other side there are three compartments, two tenanted by platyrhine monkeys, including a howler, and the third by the first hoatzin ever exhibited here. It is interesting to note that, just as the anatomy of this peculiar bird points to several different groups, so do some of its actions recall groups different again—it has the crouching walk and squatting pose on a perch of the cotton-teal or goslets (*Nettopus*) and the upthrow of the wings on alighting of the sandpipers. With the exhibition of this type the number of scientifically important bird-families yet to be exhibited is reduced to five—the todies, jacamars, puff-birds, finfoots, and the Mesitidæ of Madagascar. In the present reptile-house, an important acquisition is that of specimens of the Australian frilled lizard *Chlamydosaurus*, an agamid species so rare in captivity that it has only once been exhibited before. It has to rely for notoriety on its frill, its power of rearing and running on its hind-legs being now known to be shared by several other lizards, notably by the iguanid *Basiliscus*.

THE practice of shooting all abnormal varieties of birds is so prevalent that it is worth while to direct attention to a case recorded by Mr. M. Mason in the *Field* of June 20, in which a white hen grouse was protected instead. The result was that she lived to rear four broods, being at last found dead and torn in her fifth year. Of her offspring, many were pied and one cream-coloured, but no white was found in the second generation. Although it was suspected that her death was due to an eagle, her survival for so long may perhaps be attributed to the reduction in the number of predatory birds by modern game-preserving, but the fact that her offspring so soon lost any trace of her abnormal colouring indicates that other causes besides natural selection by enemies contribute to limit white colouring; it must also be remembered that though a brown protective plumage is so very common among game birds, and generally characterises the females even where the males are conspicuous, yet hens may be green, in *Rollulus*, and black in *Acomus*, while *Crossoptilum tibetanum*, a large, conspicuous bird, is nearly all white in both sexes and at all seasons.

CAPT. C. W. HUME has written protesting against our suggestion that truth had been sacrificed to propaganda in certain statements in "The Animal Year Book". Clearly he has not read our comments carefully, for although we gave page references to two particular statements, his reply omits to mention one and deals with another of which we made no mention and which is on neither of the pages quoted. But the kernel of the whole matter seems to us to be this. If cruelty is to be measured by the amount of suffering borne by the victim, the same punishment may have different cruelty values even in different men, for it will depend upon their sensitivity. Therefore the statement that the degree of pain suffered by a lower animal trapped by the leg is "roughly comparable to crucifixion" suffered by the much more highly organised and, moreover, self-conscious human being, is, to put it bluntly, rubbish. If, on the other hand, cruelty is to be measured by the intention of the torturer as well as by the suffering of the victim, the other statement we referred to is even less accurate, namely, that the torture inflicted by the steel-toothed trap and the common snare is on a par with the medieval torture of human beings. For, apart from the facts of comparative sensibility we have stated above, the deliberately designed tortures of human beings devised for the sole purpose of causing pain stand in a category by themselves. We do not wish to minimise the sufferings caused by steel traps; surely there is no need to exaggerate them.

MESSRS. Cooke, Troughton, and Simms have produced a simple instrument known as "The Orientator", for enabling architects, builders, house-agents, and others to determine visually from plans the direction in which the sun's rays will fall on any window, building, or wall during winter or summer. It consists of a flat metal ring, to the central end of a radius of which is attached a thread terminating in a small ball representing the sun. A portion of a second ring (which, if complete, would form a short

(*Continued on p.* 111.)

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The Annihilation of Matter.*

By Sir JAMES JEANS, F.R.S.

THROUGHOUT the greater part of the history of science, matter was believed to be permanent, incapable either of annihilation or of creation. Yet a large amount of astronomical evidence now seems to point to the annihilation of matter as the only possible source of the energy radiated by the stars. A position has thus been reached in which the majority of astronomers think it probable that annihilation of matter constitutes one of the fundamental processes of the universe, while many, and perhaps most, physicists look on the possibility with caution and even distrust. I have thought it might be of interest to attempt a survey of the present situation in respect to this question.

The Astronomical Evidence.

The astronomical argument for the annihilation of matter is based, not on the intensity of stellar radiation, but on its duration. No transformation of a less drastic nature than complete annihilation is found capable of providing continuous radiation for the immense periods of time throughout which the stars have, to all appearances, lived. For, with one conspicuous exception, to be discussed later, all available methods of estimating stellar ages are found to indicate that the stars, as a whole, have already lived through periods of millions of millions of years.

Some of these methods depend on the rate of gravitational interaction between adjacent stars; for example, the velocities with which the stars move through space show an approximation to equipartition of energy, such as must have required millions of millions of years for its establishment. The individual members of the groups of stars known as moving star clusters appear to have had their courses changed by the gravitational pull of passing stars to an extent which again indicates action extending over millions of millions of years. The same is true of the orbits of visual binary stars. In each of these three cases, the clock we use has for its unit a time analogous to what is called the 'time of relaxation' in the theory of gases; in this comparison the single stars correspond to monatomic molecules, and binary stars to diatomic molecules, while the disintegration of a moving star cluster provides the counterpart of the process of gaseous diffusion.

These estimates of stellar ages are, of course, valid only if we assume that the changes in stellar motions and arrangements are produced solely by the gravitational pulls of other stars. Other causes are conceivable, and must indeed contribute something—pressure of radiation, bombardment by stray matter in space, or by the atoms of cosmic clouds diffused through space. But calculation shows that the contributions from these sources are quite negligible. Indeed, when we take them into account, the discussion of stellar movements is no longer a problem of astronomy, but of physics; we have to treat the stars as Brownian 'particles' in a physical medium. When they are so treated, we find that the starry medium has a temperature—in the sense in which we speak of the temperature of moving Brownian particles—of the order of 10^{62} degrees. Both individual and binary stars exhibit the equipartition of energy which corresponds to a temperature of this order, whence it is obvious that physical agencies such as pressure of radiation and atomic pressures, which are in equilibrium with far lower temperatures of the order only of 10^4 degrees, cannot have made any appreciable contributions to the establishment of this equipartition; they act as mere drags on the stellar motions, tending on the average to check their speed.

In a second class of binary stars, the spectroscopic binaries, the two components are so close together that the gravitational pull from passing stars is approximately the same on each, and so cannot exert the differential action which would change the relative orbits of the constituent masses. Clearly

* The substance of lectures delivered before the Universities of Princeton, Yale, and Harvard on May 23, 26, and 27 respectively, under the auspices of the Franklin Institute of Pennsylvania.

there can be no question of any approximation to equipartition of energy in the internal motions of these systems. Nevertheless, it is possible to trace a steady sequence of configurations, beginning with almost circular orbits in which the two constituents are practically in contact—this being probably the condition of a system which has just formed by fission—and proceeding to orbits which are far from circular in shape, in which the components are at a substantial distance apart. It seems likely, although not certain, that this sequence is one of advancing age; when the parent star first breaks up to form a binary, the newly formed system starts at the first-mentioned end and moves gradually along the sequence. Now observation shows, beyond all doubt, that the stars at the far end of this sequence are substantially less massive than those at the beginning. We know the rate at which the various types of stars are radiating their mass away in the form of radiation, and from this we can calculate the time needed to produce the difference of mass which is observed to exist between the two ends of the sequence; again it proves to be a matter of millions of millions of years. Here the clock we use is the rate of outflow of radiation from a star, or its equivalent, the rate of loss of mass.

Against these various estimates must be set one piece of evidence which, if interpreted in the most obvious way, seems to point in exactly the opposite direction. This is, that the remote extra-galactic nebulæ all show a shift of their spectral lines to the red, the amount of shift being approximately, although not exactly, proportional to the distance of the nebula. If this is interpreted in the most direct way, as a Doppler effect, the nebulæ must all be scattering away from us and from one another in space, at so great a speed that the whole universe doubles its size about once in every 1400 million years. Such a rate of increase seems quite inconsistent with the estimate which assigns ages of millions of millions of years to the stars. Calculation suggests that the original radius of the universe must have been of the order of 1200 million light-years (Eddington), while the present radius of the universe appears to be only of the order of 2000 million light-years (de Sitter). If these estimates could be treated as exact, we could fix the age of the universe definitely at just more than 1000 million years, which is substantially less even than the age of the earth as indicated by its radioactive rocks. No one would claim any great degree of exactness for either of these estimates, especially the second, yet the general situation seems to forbid that the universe can have been doubling in size every 1400 million years throughout a period of millions of millions of years.

Although alternative interpretations are tenable, none of them seems entirely convincing, and the present situation is extremely puzzling. While there is obviously room for much difference of opinion, many astronomers consider it likely that some other explanation of the apparent recessions of the nebulæ will be found in time, in which event the road will be clear for the acceptance of ages of millions of millions of years for the stars, as suggested by the main bulk of astronomical evidence.

If such ages are provisionally accepted, calculation shows that the average star has already emitted many times its total mass in radiation; in other words, the average star must have started life with many times its present mass. Indeed, the sequence of spectroscopic binaries gives us a sort of picture of the life-history of a typical star. It starts with anything from ten to a hundred times the mass of the sun, and ends with a mass comparable to, or even less than, that of the sun. It is difficult to see where the enormous weight of the newly-born star can have been stored if not in the form of material atoms, or at any rate of material electrons and protons. Thus we are led to suppose that the life-history of the star is one of continual annihilation of its substance, the electrons and protons annihilating one another, and providing the energy for the star's radiation in so doing. Such, at least, is the conjecture suggested to us by astronomy; the testing of the conjecture rests with physics.

Highly Penetrating Radiation.

If any direct evidence of this process of annihilation is to be obtained, it seems most likely that it will be found in the highly penetrating radiation which McLennan, Rutherford, and others discovered in the earth's atmosphere at the beginning of the present century. The reason, as we shall see later, is that here, and here alone in the whole of physics, we are dealing with photons of radiation whose mass is comparable with that to be expected in photons resulting from the annihilation of electrons and protons. In the last few years, this radiation has been studied in great detail by Hess, Millikan, Regener, and many others. Their investigations scarcely leave room for doubt that the radiation enters the earth's atmosphere from outer space; for which reason it is often described as 'cosmic radiation'.

It was at first taken for granted that this radiation must be of the nature of γ-radiation, since its penetrating power was greater than seemed pos-

sible for any kind of corpuscular radiation. This reason is now known to be inadequate, theoretical investigations having shown that corpuscular radiation, consisting of either α- or β-particles, might conceivably possess as high a penetrating power as the observed radiation.

Other arguments have, however, stepped into the breach, and show very convincingly that the radiation cannot be of the nature of either α or β radiation. The central fact is, in brief, that radiation which consisted of charged particles would be influenced by a magnetic field, whereas cosmic radiation is not. An electron or other charged particle in motion acquires magnetic properties in virtue of its motion; the faster it moves, the greater the force which a magnetic field exerts upon it. Now the penetrating power of the radiation under consideration is so great that it could only be attained by charged particles, if these were moving with very high speeds indeed. If a swarm of such particles became entangled in the earth's magnetic field, their high speed of motion would cause them to describe spiral paths coiled quite closely around the earth's lines of magnetic force, with the result that they would fall far more abundantly near the earth's magnetic poles than elsewhere. Epstein [1] estimates that for a shower of electrons to have the penetrating power of cosmic radiation, they would have to move with the energy produced by a fall through about 1000 million volts, and has calculated that the incidence of electrons moving with this energy would be limited entirely to comparatively small circles surrounding the two magnetic poles. Actually the observed radiation falls so evenly on the different parts of the earth's surface that no variations have ever been detected. Members of the B.A.N.Z. Antarctic Expedition [2] found the same intensity of radiation within 250 miles of the south magnetic pole as they had previously measured in South Australia, and as others had found in the United States, Canada, and the North Atlantic. This seems to leave little room for doubt that the radiation is of the nature of very hard γ radiation.[3]

At first, some experiments by Bothe and Kohlhörster seemed to throw doubt on this conclusion. They had placed two Geiger counters, one vertically above the other, and found that the number of coincident discharges in the two counters was just about that which would be expected from purely geometrical considerations, if the radiation was corpuscular. Of course, the radiation which produced these ionisations was not necessarily the primary radiation which fell on the earth from outer space. Any primary radiation, as it traverses the atmosphere, is bound to produce secondary radiation of a variety of kinds, and any one of these might have been the immediate cause of the ionisation observed by Bothe and Kohlhörster. The primary radiation which first enters the earth's atmosphere might quite conceivably be electromagnetic, while the ionisation might be produced by a secondary corpuscular radiation.

To examine this possibility, Bothe and Kohlhörster placed a block of gold between their two counters. This naturally caused a reduction in the number of coincidences, and from the amount of the reduction it was possible to calculate the penetrating power of the radiation which actually effected the ionisations. It was found to be approximately the same as that of the primary radiation. So far, then, everything could be explained by supposing that it was the primary radiation itself which produced the ionisations in the counters, and that this was corpuscular in its nature.

Recently this explanation has been tested by Moss-Smith [4] and found wanting. He extended the apparatus used by Bothe and Kohlhörster, by mounting yet a third counter vertically below the original two, and first verified that the number of coincident ionisations in all three counters was that which their geometrical arrangement would lead us to expect. Now if the radiation which produced these ionisations were corpuscular, it ought to be deflected by a magnetic field. For example, if a sufficiently strong magnetic field were inserted between the second and third counters, the third counter ought to be entirely shielded from the radiation which had passed through the first two counters, so that the number of coincident ionisations in the first two counters would remain as before, while the number in the third counter would fall to zero. Moss-Smith found that this did not happen. Although his magnetic field had many times the strength needed to shield the third counter completely, its insertion had no effect on the number of coincident ionisations. This showed that the ionising radiation was not corpuscular, and as Bothe and Kohlhörster had already shown that the ionising radiation was probably identical with the primary radiation, it confirmed the theoretical arguments of Millikan and Epstein, which proved the primary radiation to be of the nature of γ radiation.

The Mode of Production of the Radiation.

If the primary radiation is of the nature of γ radiation, as these arguments and experiments

seem to show, its origin ought to be disclosed by its penetrating power. Such radiation consists of photons, which may be compared to bullets, all moving with the same speed—the velocity of light. Their penetrating power accordingly depends solely on their mass, and a theoretical investigation enables us to deduce the one from the other. Every photon is, however, produced originally by an atomic upheaval, and its mass is exactly equal to the decrease of mass which the parent atom experienced as the result of this upheaval. For example, if the atom was one of hydrogen and the upheaval consisted of annihilation, the photon resulting from this annihilation must have a mass exactly equal to the original mass of the hydrogen atom, namely, $1{\cdot}66 \times 10^{-24}$ gm. Or again, if a proton and an electron mutually annihilate one another in any atom whatever, thus reducing its atomic weight by unity, the mass of the resulting photon must be equal to the combined masses of the proton and electron in situ in the atom, which again, except for a small 'packing-fraction' mass, is equal to the mass of a hydrogen atom.

The most effective means of investigating the penetrating power of cosmic radiation is to sink suitable apparatus to varying depths below the surface of a lake, and observe the ionisation produced by the incidence of the cosmic rays after absorption by varying depths of water. Observations of this type have been performed with great care and skill by Millikan, Regener, and others.

Their results are none too easy of interpretation. L. H. Gray has shown [5] that there is a sort of softening effect continually in progress by which the absorption of a quantum of energy produces a recoil electron, which in turn produces radiation of energy comparable to, although somewhat lower than, the energy of the original quantum. After the radiation has travelled through a certain thickness of absorbing material, the observed ionisation no longer gives a true measure of the intensity of the primary radiation which has escaped absorption, but of this primary radiation in equilibrium with all its softer secondary components.

When this complication has been allowed for, the ionisation curve gives the intensity of the true primary radiation which remains after passing through varying thicknesses of absorbing matter. If this primary radiation consists of a mixture of constituents of different and clearly defined wavelengths, so that it has a line spectrum in the language of ordinary optics, these different constituents will have different coefficients of absorption. In such a case, it ought to be possible to analyse the observed curve into the superposition of a number of simple exponential curves, one for each constituent of the radiation.

Actually, it is found that this can be done. Different experimenters do not obtain results which are altogether accordant, but all agree in finding that there is a long stretch, near the end of the range of the radiation, over which its intensity decreases according to a simple exponential law. This can only mean that one particular constituent of the radiation is so much harder than the others that it persists in appreciable amount after traversing a thickness of matter which has completely absorbed all the softer constituents. Regener, who has studied the problem in great detail, finds that the hardest radiation of all has an absorption coefficient of 0·020 per metre of water. Other experimenters have found values which agree with this to within about 10 per cent.

The mass of the photon can be deduced from the observed absorption coefficient μ of the radiation, by the use of a theoretical formula given by Klein and Nishina.[6] This can be written in the form

$$\mu = \frac{2\pi N e^4}{m^2 c^4} f\left(\frac{M}{m}\right),$$

where M is the mass of the photon, m of an electron, e, c have their usual meanings, and f represents a fairly complicated function of M/m. In all the applications of the formula to cosmic radiation, M/m is quite large, and for such values of M/m, f assumes the form

$$f\left(\frac{M}{m}\right) = \tfrac{1}{4}\left(\frac{M}{m} + 2 \log \frac{2M}{m}\right).$$

These formulæ are calculated on the supposition that the absorption is caused by N electrons per unit volume, and that these are entirely free. This last condition can never be fully realised in Nature, since every electron is bound, more or less closely, to other electric charges. If an electron is bound to a system of mass m', we can allow for this binding by increasing m in the formula by a fraction of m', the fraction being large or small according as the coupling is tight or loose. Thus a loosely coupled electron behaves almost like a free electron, but an electron coupled tightly to a massive system, such, for example, as a proton or an atomic nucleus, behaves like an electron of very great mass, and the formula shows that this has no appreciable absorbing power.

The Klein-Nishina formula has been tested by comparing it with observation for γ-rays. In the case of the lighter elements, it gives values whch agree well with the observed absorption, provided all the extra-nuclear electrons are treated as free, while the nuclear electrons are disregarded entirely. It is natural to disregard these, because the coupling of nuclear electrons in the lighter elements is known to be so close that even the hardest γ-rays make but little impression on them. This is true for the lighter elements only; in the case of lead, Chao[7] has found an additional scattering of the hardest γ-rays, which he believes to be of nuclear origin. In other words, he finds that some at least of the nuclear electrons in lead are not so closely coupled as to resist the onslaught of the hardest γ-radiation. Still less, then, can they be so closely coupled as to resist the incidence of the far more massive photons of cosmic radiation. From theoretical considerations of a very general nature[8] it appears probable that in dealing with cosmic radiation, the N in the Klein-Nishina formula should refer to all electrons, nuclear as well as extra-nuclear, and not merely to the latter. A further term ought also to be added to represent scattering by nuclear protons, but calculation shows that this is entirely insignificant in amount. The result of taking the nuclear electrons into account is to replace atomic number by atomic weight, so that the absorption by a given thickness of matter becomes strictly proportional to the mass of the matter, and absolutely independent of its nature, except possibly in so far as a further small absorption, caused by photoelectric action, may depend on the latter. The effect of this is to double, or more than double, the capacity of all atoms except hydrogen for absorbing cosmic radiation; it increases the absorbing power of water to 80 per cent above the value usually calculated.

The following table shows the absorption coefficients (per metre of water) which I have calculated for the radiation produced by the synthesis of iron and by the annihilation of 1 and 4 protons respectively, with their accompanying electrons. The calculation is based on the Klein-Nishina formula, all electrons, including the nuclear electrons, being treated as absolutely free:

Process.	$\frac{M}{m}$.	Calculated μ (per metre, water).	Observed μ (Regener).
$56H \rightarrow Fe$	876	0·136	..
$+, - \rightarrow 0$	1845	0·071	0·073
$4+, 4- \rightarrow 0$	7380	0·020	0·020

The last column gives the absorption coefficients of the two most penetrating constituents of cosmic radiation, as analysed by Regener. Their agreement with the figures in the preceding column is probably well within errors of observation and analysis, and is rather too good to be attributed with much plausibility to mere accident; the odds against a double agreement, within 5 per cent in one case and 2·7 per cent in another, being about 3000 to 1. This seems to me to suggest quite strongly that the most penetrating constituent so far observed in cosmic radiation may originate in the annihilation of an α-particle and its two neutralising electrons (the components of a helium atom), while the next softer constituent may originate in the annihilation of a proton and its one neutralising electron (the components of a hydrogen atom).

An alternative possibility, which was first suggested by Millikan and has been championed mainly by him, is that the cosmic radiation may result from the building of electrons and protons into atoms. Yet the hardest constituents of the cosmic radiation appear to be far too hard to be produced by the synthesis of iron, while Millikan himself considers that the synthesis of heavier elements is probably ruled out by their rarity in the universe. If, as I have suggested, the annihilation of matter is the true origin of the two hardest constituents of the cosmic radiation, then it becomes possible to suppose, with Millikan, that the softer constituents are produced by the synthesis of simple atoms into complex. Many will, however, hesitate to accept such a mixed origin for the radiation. It certainly seems simpler to suppose that the two hardest constituents, and these alone, form the fundamental radiation, while all other constituents represent mere softened or degraded forms of these. Yet this supposition brings its own difficulties, since if we measure the intensity of the radiation by its ionising power, the supposed secondary radiation is found to have many times the ionising intensity of the primary. But whatever the origin of the softer constituents may be, the two hardest constituents, with their photons equal in mass to the atoms of hydrogen and helium respectively, appear to provide weighty evidence that matter can be, and is, annihilated somewhere out in the depths of space. If we can assume that this process occurs on a sufficiently large scale, this supposition brings order and intelligibility into a vast series of problems of astronomy and cosmogony in a way in which no other suppositions can.

The Place of Production of the Cosmic Radiation.

Various suggestions have been made as to the place of origin of this highly penetrating radiation. Many of them are put out of court by the fact, which must now, I think, be regarded as well established, that the radiation is nearly constant in intensity at all times of day and night,[9] any variation being, at most, of the order of one part in 200. There seems to be a real variation of this amount, but in the main it appears to follow the variation of the barometer. Millikan considers that it is adequately explained by fluctuations in the absorbing power of the air blanket formed by the earth's atmosphere. It was at one time suggested that the radiation might consist of electrons ejected from thunder-clouds high up in the earth's atmosphere, or of electrons moving with enormous speeds acquired by drifting through electrostatic fields in space, the potential gradients in these fields being slight, but the potential differences immense simply on account of the vast extent of the fields. Even if the radiation could still be treated as corpuscular, it would be very difficult to reconcile either of these suggested origins with the steadiness and uniformity with which the radiation falls on the earth's surface.

The fact that the intensity of the radiation is very approximately independent of both solar and sidereal time seems to show that no appreciable part of the radiation comes from the sun or stars. Counting the sun as a star, we receive more than 100,000,000 times as much starlight at midday as at midnight, yet apart from the purely local 'barometer' effect just mentioned, we receive the same intensity of the radiation at both times. The fact that the intensity is approximately independent of the position of the Milky Way seems to show that the bulk at least of the radiation must come even from beyond the confines of the galactic system, thus justifying the name 'cosmic radiation'.

Where, then, does the radiation originate? For reasons which will be clear at the end of our quest, it is simpler to conduct our search in time rather than in space. The average density of matter in space is probably of the order of 10^{-30} gm. per c.c., and in each second of its existence, a beam of cosmic radiation passes through a layer of space 3×10^{10} cm. thick. Thus every second it passes on the average through 3×10^{-20} gm. per sq. cm. of its cross-section. We have, however, seen that the hardest constituent must pass through 50 gm. per sq. cm. before it is reduced in intensity by one per cent, and this requires an average time of 16×10^{20} seconds, or about 5×10^{13} years—a period which, on any reckoning, is greater than the age of the stars; its intensity is reduced to $1/e$ times its original value after 5×10^{15} years, which is greater, so far as we know, than the age of the universe.

Thus, to an approximation, we may think of the hardest constituent of the cosmic radiation as indestructible, since the universe has not yet existed long enough for any appreciable amount of it to be absorbed. To a slightly less good approximation, the same is true of the softer constituents. This leads us to regard space as being permeated with all, or nearly all, of the cosmic radiation which has ever been generated since the world began. The rays come to us as messengers, not only from the farthest depths of space, but also from the remotest eras of time. And, since we cannot produce cosmic rays on earth, their message appears to be that the physics which prevails out in these far depths of space and time is something different from our terrestrial physics: different processes result in different products. So far as we can read the riddle of the rays, one at least of these processes appears to be the annihilation of matter, although whether this annihilation is taking place now, or occurred only in the remote past, or even only at the beginning of the world's history, we have no means of knowing; all that the rays show is that somewhere and sometime in the history of the universe, matter has been annihilated.

Similar remarks may be made with respect to the softer constituents. Millikan believes that these originate in the synthesis of complex atoms out of lighter ones, and so argues that the act of creation is still in progress. But these softer constituents also have such high penetrating powers as to be virtually indestructible. Even if Millikan's interpretation of the origin of these rays were established, it would only prove that synthesis of matter had occurred somewhere and sometime during the long past history of the universe; it would not prove that any such synthesis was still in progress.

Indeed, the fact that the radiation does not vary in intensity with the position of the Milky Way may be thought to suggest that it is merely a relic of past eras in the history of the universe. It may be argued that if the radiation were still being generated, the huge mass of the Milky Way, comparatively close to our doors, would surely make its influence felt. It is, however, possible (and, I

think, likely) that the radiation is still being generated in extra-galactic nebulæ of earlier type than the galactic system; it may be that they only emit this radiation before they condense into stars; and that the atoms which can produce such radiation in the galactic system are all shut up inside the stars, so that the radiation is transformed into starlight before it reaches us.

Millikan has estimated that the total amount of cosmic radiation received on earth has about a tenth of the energy of starlight, sunlight not being counted in. Near the earth, the energy of radiation from the stars is intense enough to raise space to a temperature of about 3·5 degrees absolute, whereas the energy of cosmic radiation will raise this space only to about 2 degrees absolute. Out in the inter-galactic darkness the position is reversed. Here the feeble starlight and star-heat from distant galaxies can at most raise space to a fraction of a degree above absolute zero, but the intensity of cosmic radiation is probably the same as nearer home, corresponding to about 2 degrees absolute. Space as a whole appears likely to contain far more of cosmic radiation than of light and heat, although in assessing this fact, we must remember that cosmic radiation is virtually endowed with immortality, whereas ordinary radiation, in the form of light and heat, is not. The total annihilation of all the matter in the universe would raise space to about 10 degrees absolute, so that the cosmic radiation we observe could be produced by the annihilation of quite a small fraction of the universe.

This is not surprising, since the cosmic radiation which pervades space is necessarily quite distinct from the similar radiation which astronomers regard as the source of stellar light and heat. The annihilation of matter in stellar interiors would produce radiation of exactly the same high frequency as the observed cosmic radiation, but as this radiation fought its way outwards to lower temperatures, and finally to outer space, it would be continually softened, by a long succession of Compton encounters, until it finally emerged in the familiar form of starlight—ordinary temperature radiation at anything from 1650° abs. to about 60,000° abs.; none of it could reach the earth in its original form.

The mere fact of its not having been completely absorbed shows that the cosmic radiation we receive on earth cannot have passed through more than a few kilometres of stellar matter at most; its penetrating power, high though it is, will not carry it through a greater thickness of matter than this. Consequently, it can scarcely have been generated at a place where the temperature was more than about 100,000 degrees. We must suppose that it originated fairly near to the surfaces of astronomical bodies, or, more probably still, in unattached atoms or molecules in free space. In contrast to this, the radiation which provides the energy poured out by the stars was probably generated in their central regions. Thus it must have been generated in matter at very high temperatures, while the similar radiation we receive on earth must have been generated at comparatively low temperatures.

Physical Principles.

According to classical theories of electro-magnetism, any acceleration of a moving electron is accompanied by an emission of radiation, of amount given by the well-known formula of Larmor. Thus an electron, describing an orbit in an atom of, say, hydrogen, must continually radiate energy away, so that the orbit will continually shrink.

The quantum theory replaces this continuous emission of energy by a succession of discontinuous emissions; at each moment there is a definite calculable chance that the orbit will shrink in size by a finite amount, and emit a photon in the process. The orbit of lowest energy is anomalous; when an electron is describing this orbit, no further shrinkage in orbit or emission of radiation is possible.

The concept of annihilation of matter removes this anomaly by providing a state of still lower energy, in which proton and electron have both disappeared in radiation. The energy emitted in the process of annihilation corresponds, of course, to that which would be emitted continuously on the classical electro-dynamics while the orbit was shrinking to zero radius.

Although neither the new quantum theory nor the theory of wave mechanics in any way predicts that this process must actually happen, they are in no way definitely antagonistic to its occurrence. Certain forms of both, on the whole, seem rather to favour the possibility, but theoretical calculation based on these does not at present agree with numerical estimates derived from astronomical evidence. Dirac[10] has recently calculated the probability of annihilation given by the new quantum theory, and obtained a value which is substantially too large; according to his calculations, the universe ought to have dissolved into radiation long ago. Or, to put the same thing in another way, the stars ought to radiate energy far more furiously than they do.

The general principles of the quantum theory show that annihilation of matter might either

occur spontaneously, after the manner of radio-active disintegration, or might be incited by a sufficiently high temperature, like the atomic changes which produce ordinary temperature radiation. The second process will only occur when the matter is traversed by photons with energy equal to that set free by annihilation of matter; the requisite temperature is found to be of the order of a million million degrees. Now it is quite impossible that the cosmic radiation we receive on earth can have originated in regions where the temperature approaches this; indeed, we have seen that it can scarcely have been more than 100,000° or so. Thus this radiation can only have originated from spontaneous annihilation. Cosmic radiation can, and very possibly does, provide evidence of the spontaneous annihilation of matter at low temperatures, but it cannot, from the nature of the case, give any evidence of annihilation being produced by high temperatures, since any radiation so produced could never get out to empty space.

There seem to me to be two strong reasons for supposing that this latter process is not operative in the stars, and that any radiation which is produced by annihilation inside the stars must be produced spontaneously, like the cosmic radiation which is produced outside.

In the first place, if the generation is not spontaneous, the temperature at the star's centre must be of the order of a million million degrees. An immensely steep temperature gradient would be needed to connect this temperature with that of a few thousand degrees at the surface of the star, and so steep a gradient can only be reconciled with the observed flow of heat out of the star by postulating a very high opacity for the stellar material. It has so far proved impossible to reconcile such a high value for the opacity with the theoretical value given by Kramers.

The second reason is as follows. If the generation of energy results from high temperature, the rate of generation will involve a factor of the usual type $e^{-Mc^2/RT}$, where M is the mass annihilated. As the temperature increases from zero up, this factor first becomes appreciable when RT begins to be appreciable in comparison with Mc^2. This happens at the temperature of about a million million degrees already mentioned. When this temperature is first approached, the exponential term is increasing very rapidly in comparison with the temperature T. But a dynamical investigation shows that when this happens, the star must be very unstable. In brief, the emission of appreciable radiation would be accompanied by instability in the star, so that the very stable structures we describe as stars cannot radiate by means of this mechanism. The dynamical result has, it is true, been rigorously proved only for a simple, and very idealised, model of stellar structure; but general thermodynamical principles show that any structure in which a small change of physical conditions results in a very great liberation of heat, is likely to be unstable—in brief, it is in an explosive state.

On the other side, there is one strong argument against supposing that stellar radiation is produced by spontaneous annihilation of matter; it is that if the sun's heat were produced by the spontaneous annihilation of its atoms, we might expect that the earth's atoms would be subject to spontaneous annihilation at an equal or similar rate. Yet calculation shows that annihilation at even a ten-thousandth part of this rate would make the earth too hot for human habitation. Clearly, then, no appreciable annihilation of matter can occur inside the earth. This must be formed of atoms of a kind which do not undergo spontaneous annihilation, and if the sun derives its heat from the spontaneous annihilation of atoms, these must be of a different kind from the atoms of which our earth is formed. This is not in itself unreasonable; from the mode of the earth's formation, its atoms can be a sample only of those in the sun's outer layers. If we conjecture that those kinds of atoms which undergo spontaneous annihilation are of very great atomic weight, and so sink to the interiors of the stars, this difficulty disappears, and with it the problem of why no cosmic radiation is received directly from the Milky Way.

[1] *Proceedings: National Academy of Sciences*, Oct. 1930.
[2] NATURE, **127**, 924, June 20, 1931.
[3] Millikan, Dec. 29, 1930, Lecture at Pasadena, reprinted in NATURE, **127**, 167, Jan. 31, 1931.
[4] *Physical Review*, April 15, 1931.
[5] *Proc. Roy. Soc.*, **122**, p. 647.
[6] NATURE, **122**, p. 398, Sept. 15, 1928.
[7] *Physical Review*, Nov. 15, 1930.
[8] NATURE, **127**, 594, April 18, 1931.
[9] V. F. Hess, NATURE, **127**, 10, Jan. 3, 1931.
[10] *Proceedings of Cambridge Philosophical Society*, July 1930.

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cylinder) is fixed to it at such an inclination that if the first ring is horizontal the edges of the second follow respectively the paths of the sun in the sky at the summer and winter solstices. Any one instrument is, of course, suitable only for a single latitude. The instrument is placed on the plan with the centre of the horizontal ring over the window or wall in question and with an appropriately marked point in the north direction, and the thread is stretched by holding the ball between the fingers. When the thread rests against an edge of the inclined ring (on which a scale is engraved giving the hours of the day) its direction is therefore that of the sun's rays at the corresponding solstice. Observation of the plan from above then shows immediately what obstacles to sunlight, if any, are encountered. The makers point out that since the declination of the sun changes only slowly near the solstices, the instrument is trustworthy for a considerable portion of the year; but an obvious improvement would seem to be the provision of slits in the inclined ring, through which the thread could pass to represent the sun's rays at intermediate times. The instrument can be supplied for any latitude, north or south. It weighs 1 lb. and is 6 in. in diameter at the base. It is constructed of stout brass, which is chromium-plated to resist corrosion and to prevent soiling of the plans. The cost is £2 2*s*.

AN international festival of folk-dancing is to be held in Copenhagen on July 25, when representative teams from all Scandinavian countries, including Finland, Greenland, and the Faroe Islands, will attend. An English team of members of the English Folk-Dance Society will also take part. The festival should be of the greatest æsthetic and scientific interest, especially as some of the dances—those from the Faroes, for example—must be of considerable antiquity, and in certain cases suggest, almost unquestionably, an ancestry to be traced ultimately to a form of sun worship. Folk-dancing is becoming increasingly international, and thus, when the dances of different countries are seen side by side, affords exceptional opportunities for the comparative study of survivals of primitive custom and belief. For example, in the year-book entitled "In Northern Europe 1930", edited by Mr. Rolf Gardiner, there are accounts of expeditions to East Prussia, Silesia, and the Baltic towns, as well as a description of the English tour of the German singers, when they were accompanied by English dancers. Further, the English Folk-Dance Society is arranging to visit Paris for a demonstration on July 25 in the British Music Society's English week at the Colonial Exhibition, and it is hoped to bring Transylvanian dancers to England next January. An endeavour is also being made to organise an international festival on a large scale, to be held in London in 1936.

A NOTABLE advance in naval machinery has been made in the destroyer H.M.S. *Acheron*, of which some particulars are given in an illustrated article in the *Engineer* for June 26. The *Acheron* is one of the 'Acasta' class, being 312 ft. long and of 1330 tons displacement, but whereas the *Acasta* and other vessels have a working steam pressure of 300 lb. per sq. in., the steam pressure in the *Acheron* is 500 lb., with a total steam temperature of 750° F. instead of 600° F. The engines have been built by the Parsons Marine Steam Turbine Co., Ltd., and the hull and boilers by Messrs. J. I. Thornycroft and Co., Ltd. In the *Acheron* there are two sets of turbines, each consisting of one high pressure, two intermediate, and one low pressure turbine, and one astern turbine coupled to the shaft through double-reduction gearing. The designed shaft horse power is about 34,000. The three boilers are of the three-drum Thornycroft type, the drums being of forged steel, machined inside and outside, while the solid-drawn steel tubes are $1\frac{3}{4}$ in. in diameter. Superheaters and pre-airheaters are fitted. In an exhaustive series of trials, the oil consumption at full power was 0·608 lb. per shaft horse power per hour, while the water consumption was 7·77 lb. per shaft horse power per hour. At ten per cent full power, the oil consumption per shaft horse power per hour was 0·92 lb. and the water consumption 12·87 lb.

THANKS to the generosity of S. and H. Behn, the house in which A. M. Ampère, the great French physicist, spent his boyhood and youth has been presented to the French Society of Electricians. The house is situated at Polémieux-les-Mont-d'Or, about nine miles north of Lyons. The society has published an account of the ceremonies that took place on the occasion when they took possession of the house and fixed a plaque at the entrance commemorating the name of Ampère. Speeches were made by well-known physicists and engineers, and Paul Janet gave an interesting account of the life and work of the great physicist. Born in 1775, his youth was spent in troublous times. In 1793, when he was only eighteen years of age, his father was executed on the scaffold—a victim of the Revolution. Ampère's work on the mathematical theory of electricity has been of the greatest help to physicists and engineers. He died at Marseilles in 1836, but in 1869 his remains were transferred to Montmartre Cemetery. The name of ampere has been universally adopted for the practical unit of electric current.

THE fifth triennial meeting of the General Assembly of the International Research Council was held at Brussels on Saturday, July 11, when the new statutes were approved and adopted. By these the name of the organisation is changed to that of the 'International Council of Scientific Unions', and full liberty is left to the International Unions to develop their activities in the way best suited to each. Dr. George Hale was elected president in succession to M. Picard, who has retired. The other members of the new executive committee are: General G. Ferrié and Prof. U. E. Nörlund, vice-presidents; Dr. P. Pelseneer and Prof. F. A. F. C. Went, members; and Sir Henry Lyons, general secretary.

THE Human Betterment Foundation (Pasadena, California) has issued a pamphlet on "Human Sterilisation". It is pointed out that eugenic sterilisation, by means of vasectomy in the male and

salpingectomy in the female, carries no stigma or humiliation and does not unsex the individual in any way except in making parenthood impossible. Twenty-five States in the Union now have sterilisation laws on their statute books, and some six thousand operations of this nature have been performed. Following up the cases, it was found that six patients out of seven were satisfied with the operations. Many feeble-minded girls have married after sterilisation and these marriages have been reasonably successful in the great majority of cases. Whereas three-fourths of these girls were sex delinquents before sterilisation, only one in twelve has been a sex offender since. This is good evidence that sterilisation will not increase delinquency when it is made part of a well-organised system of probation and parole. The conditions and safeguards under which sterilisation is performed in Californian institutions are described.

THE following appointments have recently been made by the Secretary of State for the Colonies: Mr. J. De Verteuil, agricultural chemist, Trinidad, to be agronomist, Trinidad; Mr. A. J. W. Hornby, agricultural chemist, Nyasaland, to be assistant director of agriculture, Nyasaland; Mr. W. T. O. Maidment, assistant superintendent of agriculture, Gold Coast, to be agricultural officer, Uganda.

DR. E. C. S. DICKSON, of the Department of Physics, University of Manchester, has written pointing out that the demonstration of the Thomson effect described by Mr. W. Band in NATURE of June 27, p. 975, will also be found in Geiger and Scheel's "Handbuch der Physik", vol. 1, p. 330 (1926), in a large collection of lecture experiments that does not appear to be so well known as it deserves.

THE Swiss Society of Natural Sciences will hold its 112th annual session at La Chaux-de-Fonds and Le Locle on Sept. 24–27, under the presidency of Dr. C. Borel. On the first day, Prof. A. Piccard will give a lecture on his recent ascent into the upper atmosphere in a sealed car attached to a balloon, and Dr. C. Perret will exhibit a film on the life of bees. On Sept. 27, there will be two lectures. The first will be given by Prof. P. Arbenz on the geological history of South Africa and its camp sites, and the second by Prof. Pérez on rhizocephalods parasitic on hermit crabs. Several excursions to places of interest have been arranged in connexion with the meeting. The secretary of the meeting is M. A. Vuille, Numa Droz, La Chaux-de-Fonds.

A DETAILED programme has now been issued for the International Illumination Congress, which is to be held in Great Britain on Sept. 1–19. Provision is made for visits to London, Glasgow, Edinburgh, Sheffield, Buxton, and Birmingham, following which the sessions of the International Commission on Illumination will be held at Cambridge. An item of outstanding interest in the London programme is the proposed trip to the Port of London, returning to the Tower of London and Westminster by river, so that the illuminated buildings on the riverside may be seen. Throughout the visits to the cities named, the technical sessions, at which more than a hundred papers will be presented, will alternate with agreeable trips and social events. During the proceedings at Cambridge a lecture will be given by Sir Arthur Eddington. Membership of the Congress is open to anyone interested in illumination on payment of a registration fee of £2. Those desiring to take part in the Congress should communicate with the honorary general secretary (Col. C. H. S. Evans, 32 Victoria Street, London, S.W.1) without delay.

THE Medical Supply Association, Gray's Inn Road, W.C.1, has issued a catalogue (T.L. 20) of new models of X-ray apparatus and appliances, and electric wax-baths. Ultra-violet light fluorescence cabinets are listed. These consist of a chamber housing a quartz mercury vapour lamp, the rays from which pass through a window of 'filter' glass which screens off the visible or luminous part of the radiation and allows only the ultra-violet or invisible radiation to pass. By this means the fluorescence of various substances may be observed, such as fats, drugs, papers, precious stones, chemicals. It may also be employed for the detection of forged notes, fraudulent erasures, etc., as well as for the examination of certain skin diseases.

THE Ministerio de Agricultura of the Argentine Republic has published a well-illustrated and instructive pamphlet on the commercial breeding of rabbits for the market—"Explotación del Conejo en la Argentina" (1931, 75 pp.). It deals fully with the best methods of housing, feeding, and tending generally the breeds of chinchilla, angora, castorrex, and others, which have become popular in recent years. But, as a furrier expressed it recently to the present writer, you may call the fur what fine name you will, it remains rabbits' fur none the less, with all the weaknesses to which rabbits' fur is heir, from the furrier's point of view.

IN view of the rarity of the book and of its importance to students of the Mollusca, a facsimile reprint of those parts of the "Beschreibung der Naturalien-Sammlung der Universität zu Rostock" by H. F. Link, 1806–8, which refer to Mollusca, is being prepared for issue on Oct. 1. The edition is limited to 150. Copies may be obtained on application to Mr. J. R. le B. Tomlin, 23 Boscobel Road, St. Leonards-by-Sea, Sussex, or to Mr. R. Winckworth, 71 Whitworth Road, London, S.E.25, who are preparing the reprint. The price will be £1 or 5 dollars, post free. Advance subscribers may receive a copy at 15*s.* or 3.75 dollars, post free.

PART 6, fascicle 2, of "Diptera of Patagonia and South Chile", has been published by the British Museum (Natural History). It comprises the families Phoridæ (supplement), by A. Schmitz; Platypezidæ and Pipunculidæ, by J. E. Collin; Sphæroceridæ, by O. W. Richards; and Eplydridæ, by E. T. Cresson, jun. Four new genera and a number of new species are described in detail, the descriptions being accompanied by ten text-figures and a half-tone plate.

THE co-operation of the school child in the matter of personal and general hygiene can only be positively

achieved by a simple communication of the outstanding facts about health and disease. For classwork, the series of thirteen coloured health and hygiene charts recently produced by Messrs. G. Philip and Son, Ltd., will be found a help; they have been produced with the aid of Dr. Winslow, of Yale University. A descriptive booklet for the teacher is appropriately written by Prof. V. H. Mottram.

Two 43-page pamphlets record additions made to the Hull Museums. The additions are of many kinds, but records of ancient forms of travel and of the slave trade, and relics of the old-time whaling, for which Hull was famous, predominate. Many of the specimens are illustrated, and are described or commented upon in readable paragraphs, which have been reprinted from the *Hull Daily Mail*. The descriptive paragraphs are to be commended as affording more matter of interest to the general reader, and therefore better museum publicity, than the bare lists of the names of objects which some museums serve up in the daily newspapers.

THE Director of the Peabody Museum of Natural History, Yale University, Dr. R. S. Lull, and the Trustees are to be congratulated upon the excellence of the "Special Guides" to the collections which have just been issued. The first two numbers, the forerunners, we trust, of a longer series, have been written by Dr. Lull to explain "The Evolution of the Horse Family" and "The Evolution of the Elephants and Mastodons". They are simply written, clearly paragraphed, well illustrated, and sell at the modest price of 15 cents (31 and 40 pages respectively). Such pamphlets should do more than blatant propaganda for the spread of knowledge of evolution in the United States.

AN exhibition of publications of the League of Nations opened on July 14 at the Old Court House of Messrs. J. and E. Bumpus, 350 Oxford Street, W.1. The publications of the League, the International Labour Office, and the World Court will be simultaneously on view. During the ten years of its existence the League has already published some 3000 documents and periodicals, and last year alone more than 1,500,000 copies were printed, numbering over 61,000 pages. More than six hundred publications will be exhibited, with historical documents, maps, photographs, etc., and also the latest and most important books relating to the origin, work, and history of the League. During the exhibition, which will be open for a month, short lectures will be given by experts at 3.30 P.M. on Mondays, Wednesdays, and Fridays.

MESSRS. Baillière, Tindall and Cox are publishing shortly for the Bentham Trustees the "International Address Book of Botanists" which has resulted from the resolution of the fifth International Botanical Congress, 1930. This will be on lines somewhat similar to Dorfler's "Botaniker Adressbuch", and will contain the names of 13,000–14,000 botanists and botanical institutions, etc., in all parts of the world. These will be arranged alphabetically by countries, printed in the majority of cases in the language of the country, and provided with an index of personal entries and geographical indices. The low price of 12*s*. 6*d*., or 13*s*. post free, is rendered possible owing to the assistance the International Committee has received from the Bentham Trustees and the Carnegie Corporation of New York.

APPLICATIONS are invited for the following appointments, on or before the dates mentioned:—An assistant pathologist at the Swansea General and Eye Hospital—The Secretary-Superintendent, General and Eye Hospital, Swansea (July 20). Teachers of science and technical subjects and of woodwork, metalwork, and technical drawing, at the Chelmsford Mining and Technical Institute, Dinnington, Yorkshire—A. Rayner, 151 Cross-hill, Ecclesfield, near Sheffield (July 21). A laboratory attendant and storekeeper in the chemistry department of the University of Leeds—The Registrar, University, Leeds (July 24). A demonstrator in the engineering test laboratory and the physics laboratory of the Royal Naval Engineering College, Keyham—The Adviser on Education, Admiralty, Whitehall, S.W.1 (July 27). A full-time lecturer in zoology at the Chelsea Polytechnic—The Principal, Chelsea Polytechnic, Manresa Road, S.W.3 (July 29). A lecturer in architecture at Armstrong College—The Registrar, Armstrong College, Newcastle-upon-Tyne (July 31). A demonstrator in chemistry in the University of Aberdeen—The Secretary, University, Aberdeen (Aug. 15). A head of the Department of Entomology of the Rothamsted Experimental Station—The Secretary, Rothamsted Experimental Station, Harpenden (Sept. 11). Assistant keepers in some or all of the departments of zoology, entomology, geology, mineralogy, and botany of the British Museum (Natural History)—The Director, British Museum (Natural History), Cromwell Road, S.W.7. A technical assistant for calculation and experimental work in connexion with aero engine investigations under the Directorate of Technical Development of the Air Ministry—The Chief Superintendent, Royal Aircraft Establishment, South Farnborough, Hants. A technical assistant for experimental metallurgical work under the Directorate of Technical Development of the Air Ministry—No. A. 502, The Chief Superintendent, Royal Aircraft Establishment, South Farnborough, Hants. A lecturer on elementary electrical engineering, for evening classes at the Borough Polytechnic—The Principal, Borough Polytechnic, S.E.1. An assistant master for mathematics and elementary science at the Cambridge and County School of Arts, Crafts, and Technology—The Education Secretary, County Hall, Cambridge. A junior demonstrator in physiology at the University of Durham College of Medicine—The Registrar, College of Medicine, Newcastle-upon-Tyne. A Clothworkers scholar for research in the physical properties of wool and other fibres in the University of Leeds—The Clerk to the Senate, University, Leeds.

ERRATUM.—In the article entitled "Modern Whaling" in NATURE of July 11, p. 56, line 17, for "1925" read "1905".

Letters to the Editor.

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

The Excitation Potentials of Metallic Lithium.

A LARGE amount of work has been published on the excitation potentials of metals (the so-called excitation of soft X-rays). On account of the very great complexity, no precise correlation has been achieved between these experiments and the results of the theory of metal structure. But—especially in view of the scarcity of spectroscopic data on metals—it would seem that there should be, concealed in these results, information of fundamental importance for the theory of metals, if only we knew how to use them. The chief essential for any such use is to attain the utmost possible simplification, and thus, just as the theory of atoms was built up from results on hydrogen, one is led to the study of the excitation potentials of metallic lithium.

It happened that no experimental data on lithium metal exist. Experiments were therefore undertaken. The method used was similar to that of Richardson, with some refinements. The lithium metal was distilled on to a copper anode at a suitably high temperature to prevent so far as possible the condensation of impurities. The radiation from the lithium falls on a copper sphere and the photoelectric current which results is measured by an accurate balance method. Thus one can plot the intensity of the radiation from the lithium, as measured by the photoelectric current, against the voltage of the electrons producing it. A sudden increase in slope in this curve at a definite voltage indicates an excitation potential of metallic lithium.

The photoelectric current was found to start with a voltage of 6 volts. A further break was found at 9 volts. Then the curve runs quite smoothly, and finally almost linearly to 51·5 volts, where there is a very large break, in which the slope is immediately about doubled. A further smaller break occurs at 57·5 volts. Then again the curve runs quite smoothly and no breaks whatever are found so far as has been investigated (up to 400 volts).

Lithium metal consists of a lattice of nuclei each with two K-electrons; the outer electrons of the lithium atoms combine together to form the set of conduction states of the metal, which are known to have a voltage range of the order of 10 volts. It seems fairly safe to assume that the lower breaks obtained correspond to transitions among the conduction electron states.

There remains the K-radiation of the lithium metal, and one is forced to associate this with the breaks at 51·5 and 57·5 volts. By applying a voltage correction of the order of 2 volts, we may allow for the acceleration of the exciting electrons in passing through the surface field of the lattice and state that the minimum excitation potential for the K-radiation of lithium metal is about 53·5 volts.

On the analogy of ordinary hard X-rays, one might picture the excitation process as follows. An electron is ejected from a K-level either through the crystal surface or into one of the upper conduction levels, the deeper conduction levels being assumed to be filled up. The latter process requires the minimum energy. Then an electron may drop back into the empty K-level from any conduction level with the emission of radiation. Thus we might expect a K-spectrum extending over about 10 volts below the critical point; and since probably the emission process involving the least energy would be the most likely, we might suppose that the greatest intensity in the spectrum would be concentrated at the low energy end of the spectrum.

Some experiments on the velocity analysis of the photoelectrons, ejected from the copper by the radiation excited in the lithium by 300-volt electrons, did not confirm this picture. Though rendered slightly inconclusive by the considerable 'loss of velocity' effects which occur in the energy range of the lithium K-radiation, they indicated that the maximum intensity in the K-spectrum is concentrated near the excitation point, namely, at about 53 volts, and there appears to be some radiation up to 60 volts energy, though none beyond.

However this may be, an apparent difficulty certainly arises when we compare the value 53·5 volts of the critical potential with the value of the K-ionisation potential of the lithium atom which has been accurately calculated by Braunbek.[1] The value is 64·6 volts and thus there is a discrepancy of 11 volts to be accounted for. Any attempt to explain it as a perturbation of the K-level due to close packing is out of the question, as it would lead to the spontaneous explosion of the metal.

The low value obtained was therefore surprising and has led to great care being taken in the experiments to verify the result. The fact that the photoelectric current is always proportional to the primary current to the lithium shows that the observed excitation potential corresponds to a single process excitation.

To interpret the result, we must suppose that there are empty levels into which the K-electron can be transferred at the base of the conduction electron system, so that the K-electron does not have to be taken through the energy levels of the conduction electron system, but can stay in a level at the base of the conduction electron levels. In the unexcited state all such levels are certainly filled. But when a K-electron is removed, the state of affairs becomes radically changed owing to the altered screening of the nuclear charge. I am greatly indebted to Prof. Bohr for pointing out that this altered screening will in itself create new levels round an atom in the lithium lattice which will not be filled. The new levels will correspond to a smaller total energy than the normal conduction electron levels. Thus the K-electron can be excited into one of these new levels and a *resonance* radiation will be emitted just as would be the case with free atoms. This process, of course, does not preclude the excitation of K-radiation by ionisation.

We may add that experiments in progress with beryllium metal, though the results are not so simple as with lithium, lead to similar conclusions.

H. W. B. SKINNER.

H. H. Wills Physical Laboratory,
University, Bristol.

[1] *Zeit. f. Phys.*, **63**, p. 156.

Evidence for the Spin of the Photon from Light-Scattering.

IT is well known that in the encounters between molecules and photons, exchanges of energy occur which are rendered evident by the observed changes in frequency of the scattered light. Whenever in such an encounter a molecule gains or loses spin-energy, there is a corresponding change in its angular momentum, which can only be explained on the assumption that there is an equal and opposite change in the spin-moment of the photon. This involves definite consequences for the state of polarisation of the scattered

light, and opens up the possibility of demonstrating experimentally the existence of angular momentum in radiation.

The general principle involved is sufficiently illustrated by considering the case of a photon which is circularly polarised and is scattered without change of direction by a molecule the axis of spin of which coincides with the axis of circular polarisation. If the spin of the molecule is unaffected by the encounter, the scattered photon retains its original character. On the other hand, if the molecule gains two additional units of angular momentum, the photon will alter in frequency and at the same time *change over from right-handed to left-handed circular polarisation* or vice versa. The considerations are naturally not so simple in the general case in which the molecule is arbitrarily orientated and the photon is scattered in a direction not coinciding with the primary ray. It may be shown that besides the reversal of the sign of circular polarisation in the forward direction, there would also result a depolarisation of the scattered light, which would be specially evident in directions transverse to the primary rays.

It may be remarked that similar phenomena should also be observed when, as the result of an encounter with the photon, a change in spin-energy of the molecule is superimposed on a change in its vibrational state. On the other hand, a change in vibrational state alone would not give rise to the effects indicated.

It may be noted that certain interesting observations recently reported by Hanle and by Bär [1] find a natural explanation in the considerations set out above. In support of the view that the scattered radiations exhibiting strong depolarisation or reversal of circular polarisation involve rotational transitions, it may be mentioned that the lines exhibiting such effects are usually diffuse, while lines which are well polarised are usually sharp and intense.

C. V. RAMAN.
S. BHAGAVANTAM.

210 Bowbazar Street,
Calcutta (India),
June 15.

[1] *Die Naturwissenschaften*, vol. 19, pp. 375 and 463; 1931.

Absolute Rates of Heterogeneous Gas Reactions.

FOR a decomposition reaction catalysed by a surface, in which the catalysis depends upon the formation of an adsorption complex (in adsorption equilibrium with the gas phase) and subsequent thermal activation and break-up of the complex into new molecular species which then evaporate, simple analogy with the theory of homogeneous reactions leads to an expression for the rate: $K = f.n.e^{-E/RT}$, where K is the number of molecules reacting per sq. cm. per second, n is the number adsorbed per sq. cm., f is frequency with which an adsorption complex undergoes a change in its total energy content (analogous to collision frequency for a homogeneous reaction), and $e^{-E/RT}$ is an approximate expression for the chance that after any particular energy change the complex is left with energy exceeding E. E is a quantity specific for the complex and not merely for the reaction.

When the complex in question consists of some simple molecule (NH_3, N_2O, HI) attached to the catalyst surface atoms, then every molecule may be supposed to decompose, at least so far that the completion of the act is inevitable, within an interval less than $1/f$ after activation; a reasonable value for the order of magnitude of f is clearly that of atomic vibration frequencies, here taken as 10^{12}.

The application of this is limited to surfaces of known area and uniform activity for the reaction in question. The catalysts which come nearest to fulfilling this condition are smooth metallic surfaces (for example, drawn metal wires). As a practical criterion, when the reaction can be shown to have a constant activation energy over a hundred- or thousand-fold velocity range, there is strong presumption that all parts of the surface which catalyse the reaction at all are uniformly active. The following calculations have been made for reactions on heated wire catalysts where catalyst poisoning by the products is demonstrably absent.

Kinetically zero order reactions: Here n is taken as the number of molecules in a close-packed layer, and E is equal to the Arrhenius constant A.

Reaction.	K. Exp.	K. Calc.
NH_3 decomposition on tungsten.[1] $A = 38700$ $T = 904°$	4×10^{17}	4×10^{17}
NH_3 decomposition on tungsten.[2] $A = 41500$ $T = 1316°$	2×10^{19}	13×10^{19}
NH_3 decomposition on molybdenum.[3] $A = 53200$ $T = 1228°$	$5\text{-}20 \times 10^{18}$	2×10^{18}
Dissociation of Pt(CO) complex.[4] $A = 31800$ $T = 650°$	4×10^{16}	2×10^{16}

There seems to be no reason why the atomic vibration frequency factor should not be applied to the desorption of adsorbed molecules attached by a definite linkage to the surface atoms; to reactions in which the de-sorbed molecule carries with it an atom of the metal; to reactions in which the solid grows at the expense of the adsorbed molecules with which it reacts, as in the deposition of nickel from the carbonyl.

Kinetically first order reactions: It has been pointed out that the Arrhenius constant now requires a correction equal to the heat of desorption.[5] But this may be extended to take into account the absolute magnitude of n as a function of p and T, by means of the Boltzmann e-law for the density of molecules in a region of potential energy L, identifying this region with a layer extending for one molecular diameter (taken as 3×10^{-8} cm.) from the surface. The expression appropriate to the linear adsorption underlying the first order kinetics comes out to

$$n = p_{\text{bars}} \cdot e^{\frac{L}{RT}} \cdot \left\{\frac{2{\cdot}2 \times 10^8}{T}\right\}.$$

Then
$$K = f \cdot p_{\text{bars}} \left\{\frac{2{\cdot}2 \times 10^8}{T}\right\} e^{\frac{L-E}{RT}}$$

and
$$\left(\frac{d \log_e K}{dT}\right)_p \times \frac{A}{RT^2} = \frac{E-L}{RT^2} - \frac{1}{T},$$

so that
$$K = p_{\text{bars}} \cdot f \cdot \left\{\frac{2{\cdot}2 \times 10^8}{T}\right\} e^{-\left(\frac{A+RT}{RT}\right)}.$$

(In hot wire experiments at very low pressures the gas phase concentration round the wire would not vary as $1/T$; the RT term in the energy of activation drops out, and T in the term in curl brackets must be taken as the temperature of the gas phase.)

The use of the Boltzmann expression when the adsorbed molecule has potential energy of vibration relative to the surface, being in fact held to the surface in virtue of just this potential energy, is not strictly justified, but should give the order of magnitude of n

correctly. The important thing is that if n can be calculated in this way it is not necessary to know E and L separately.

Reaction.	K/pbars. Exp.	K/pbars. Calc.
HI decomposition on platinum.[6] $A = 13800$ $T = 836°$	6×10^{12}	22×10^{12}
N_2O decomposition on gold.[7] $A = 29000$ $T = 1211°$	4×10^{11}	4×10^{11}

The agreement in all these cases is probably good enough to be significant. The zero order HI decomposition on gold [8] provides a clear-cut exception, the rate being 5×10^4 times greater than the calculated rate of activation. The difficulty of accounting for a *greater* rate suggests that the reversibility of this reaction, in the adsorbed layer before the iodine diffuses away, is the reason—this could have the effect of increasing the apparent value of E.

It should be interesting to repeat this calculation on other suitable catalytic reactions when the material becomes available.

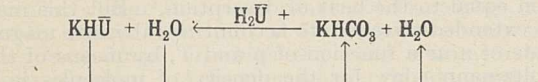
B. TOPLEY.

The Sir William Ramsay Laboratories of Inorganic and Physical Chemistry, University College, Gower Street, W.C.1, June 12.

[1] Hinshelwood and Burk, *J.C.S.*, **127**, 1105.
[2] Kunsman, Lamar and Deming, *Phil. Mag.*, **10**, 1015.
[3] Burk, *Proc. Nat. Acad. Sci.*, **13**, 67.
[4] Langmuir, *Trans. Farad. Soc.*, **17**, 641.
[5] Hinshelwood and Topley, *J.C.S.*, **123**, 1014.
[6] Hinshelwood and Burk, *J.C.S.*, **127**, 2896.
[7] Hinshelwood and Prichard, *Proc. Roy. Soc.*, A, **108**, 211.
[8] Hinshelwood and Prichard, *J.C.S.*, **127**, 1552.

Excretion of Uric Acid.

A STUDY of the excretory system of the blood-sucking bug, *Rhodnius prolixus*, has led to the formulation of the following theory of uric acid excretion in that insect:



It is supposed that the upper parts of the four Malpighian tubes secrete a solution of acid urates from the blood into the lumen, and that in the lower parts water and base are re-absorbed, leading to a precipitation of the insoluble uric acid. Thus there is a continuous circulation both of water and of base.

The evidence on which this theory is founded is, briefly, as follows: (1) There are striking histological differences between the upper two-thirds and the lower third of the tube, and uratic granules are confined to the lower third. (2) Neutral red and other vital dyes are taken up from the blood by the cells of the upper segment, and from the lumen of the tube by the cells of the lower segment. (3) Ligation of the tubes at various levels shows that uric acid (or urate) is secreted by the upper segment, and that there is no secretion into the lumen in the lower segment. (4) From 80 to 90 per cent of the uric acid in the urine is not combined with base. (5) Free uric acid is so insoluble that, if it were being excreted in saturated solution in the upper segment, and water re-absorbed in the lower segment, the four Malpighian tubes of this insect (which is 2 cm. long) would have to deal with 20 c.c. of fluid per diem in order to eliminate the daily output. By the mechanism indicated above, they would have to deal with only 0·4 c.c. per diem. (6) The contents of the tubes are faintly alkaline (pH 7·2) in the upper segment, definitely acid (pH 6·6) in the lower segment. A saturated solution of uric acid is about pH 6·5.

A full account of this work will be published shortly; but the object of this letter is to direct attention to the possibility of the same mechanism being employed in the elimination of uric acid by reptiles and birds. The probability of a circulation of water through the excretory system of these animals has long been recognised, and the possibility of a circulation of base is suggested by the following data. Uric acid is present in the blood in the form of urates. In the urine of the snake, Kohler [1] found that 83 per cent of the uric acid was free; and in the urine of hens 90 per cent is free.[2] Therefore, if all the uric acid is derived from a glomerular filtrate, base must have been re-absorbed. On the other hand, if the uric acid is secreted in solution by the tubules, since acid urates of sodium and potassium are from thirty to sixty times as soluble as free uric acid (at least in pure water), the suggested mechanism would afford a substantial economy of work.

It would be interesting to know if there is other evidence for this mechanism.

V. B. WIGGLESWORTH.

London School of Hygiene and Tropical Medicine.

[1] Kohler, *Hoppe-Seylers Zeitschr.*, vol. 70; 1910.
[2] Szalagyi and Kriwuscha, *Biochem. Zeitschr.*, vol. 66; 1914.

The Peroxidation of Hydrocarbons during Combustion in Air.

PROF. BONE has quoted in his letters with regard to the mechanism of combustion several interesting experimental results which he considers confirm the hydroxylation theory. He has recently directed attention to the finding by Dr. D. M. Newitt and Mr. A. E. Haffner of methyl alcohol in the oxidation products of methane and states that this has "shown conclusively that the slow oxidation of methane proceeds throughout in accordance with the hydroxylation theory".[1]

The presence of methyl alcohol in the oxidation products of methane can, however, be explained with equal success by the Engler-Bach peroxidation theory of combustion (1897) recently developed by Callendar and Mardles, Moureu and co-workers, and others (1926). According to the peroxide theory of combustion, the primary reaction is the formation of a moloxide or activated peroxide which catalyses the gaseous reaction and is responsible for autocatalysis and autoxidation.

Callendar and Mardles pointed out [2] that with paraffin hydrocarbons alkyl hydrogen peroxides might be formed by the simple inclusion of the oxygen molecule in a CH grouping, as, for example, in the following equation with methane:

$$\begin{matrix} H \\ HCH \\ H \end{matrix} + O_2 = \begin{matrix} H \\ HCOOH \\ H \end{matrix}$$

Methane + Oxygen molecule. Methyl hydrogen peroxide.

It will be observed that in the formation of methyl hydrogen peroxide there is no atomic separation in the oxygen molecule as is required by the hydroxylation hypothesis

$$\begin{matrix} H \\ HCH \\ H \end{matrix} + O = \begin{matrix} H \\ HCOH \\ H \end{matrix}$$

Methane + Oxygen atom. Methyl alcohol

The molecular disruption of the primary peroxide results in the formation of alcohols, esters, glycols, acids, aldehydes, hydrogen, etc. Rieche and Hitz [3] have shown that methyl alcohol can be formed from methyl hydrogen peroxide by decomposition. Similarly, alcohols are formed by the decomposition of ethyl hydrogen peroxide or dimethyl peroxide.[4] These peroxides are formed primarily from ethane during slow combustion according to the Callendar and Mardles hypothesis, namely:

$$C_2H_6 + O_2 \begin{cases} \nearrow CH_3OOCH_3 \longrightarrow CH_3OH + HCHO \\ \text{Dimethyl peroxide.} \quad \text{Methyl alcohol.} \quad \text{Formaldehyde.} \\ \searrow C_2H_5OOH \longrightarrow C_2H_5OH \\ \text{Ethyl hydrogen peroxide.} \quad \text{Ethyl alcohol.} \end{cases}$$

It is interesting to note that methane is unique amongst the paraffin hydrocarbons in having a very low temperature coefficient of gaseous reaction, especially with rich mixtures. This rather suggests that autoxidation by the moloxide occurs to an important extent.

E. MARDLES.

Air Ministry Laboratory,
Imperial College of Science, S.W.7.

[1] NATURE, **127**, p. 481, Mar. 28, 1931.
[2] *Engineering*, Feb. 4, 1927.
[3] *Ber.*, **62**, 2460; 1929.
[4] Rieche, *Ber.*, **61**, 951; 1928.

Velocity of Sound in Tubes: Ultrasonic Method.

FOLLOWING the experiments of Boyle and Froman,[1] further work has been done on the velocity of sound in liquids contained in tubes, and the experimental observations now appear to be satisfactorily explained.

A theoretical investigation shows that the frequencies, at which selective absorption of the longitudinal wave occurs, correspond to those of the resonant radial vibrations in the column of liquid. The radial frequencies are principally dependent upon the diameter of the containing tube and the properties of the liquid, the material and thickness of the tube wall being of much less importance. The selective absorption is caused by the energy of the longitudinal vibration being converted into a radial vibration. At the absorbing frequency the longitudinal wave is scarcely propagated at all, and the radial oscillation is very strong.

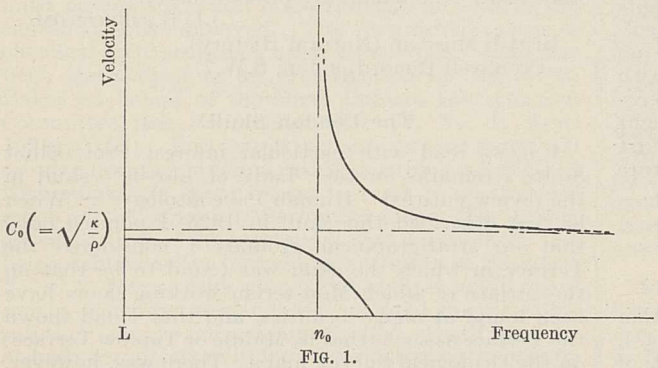


FIG. 1.

The theoretical curve (Fig. 1), which agrees well with experiment, indicates that for a range of frequencies just above the absorbing frequency (n_0) the velocity tends to have two different values, one high and the other low. This explains the experimental difficulty, noted by Boyle and Froman, in obtaining good stationary waves in this region.

The double-velocity effect is due to the fact that the wave-form below the absorbing frequency is different from what it is above, and the low-frequency type of vibration tends to persist slightly beyond the critical frequency. It may be remarked that in the absorbing region the wave is far from plane, but it becomes more and more so as the frequency becomes more removed from this region.

That there are two distinct types of vibration, one before and the other after the resonant radial frequency, has been experimentally verified by measuring the particle velocities for both cases with a Rayleigh disc.

Absorption of the longitudinal wave has also been measured and found to occur not only at the fundamental radial frequency but also at harmonics of it, the experimental and calculated frequencies agreeing very well.

It is to be noted that, following the usual procedure for sound, velocity has been plotted against frequency, whereas in optics (compare curves showing selective absorption) it is customary to plot refractive indices against wave-lengths. The optical method is rather illogical, because changes in refractive index mean changes in velocity and hence in wave-length; it is the frequency which is not affected by the absorbing medium. What is really plotted in optics is the refractive index (corresponding to λ_0/λ) against λ_0, where λ_0 is the wave-length that *would* have obtained if there had been no absorption. Velocity (actual) against frequency (actual) appears to be a much better method of expressing the facts.

Complete papers, covering the theoretical and experimental work outlined above, are shortly to be published elsewhere.

GEO. S. FIELD.

National Research Laboratories,
Ottawa, June 16.

[1] NATURE, Oct. 18, 1930.

Control of Prickly Pear by the Cochineal Insect.

THE note in NATURE of June 27, p. 989, on the eradication of prickly pear in South Africa suggested that information about the use of *Dactylopius tomentosus* in the tropics might be of interest. The insects were imported by me into South India by courtesy of the Ceylon Government entomologist.

The object was to destroy clumps of *O. dillenii* in which dangerous snakes were harbouring around business premises. The insects would therefore be called, rather quaintly, in Australia 'private cochineal'.

The commencement of attack by a colony is very slow. For about two months in a shady clump, or perhaps twice as long in an exposed clump, no effects are generally visible. A few weeks after the attacks become visible the insects have overtaken the vegetable growth, and this is symptomised by heroic efforts of the plant to produce fruit; collapse quickly follows, and the insects then appear to concentrate upon producing winged males. It almost seems as if this were a consequence of starvation or the changed composition of the decaying juices. A good sign of the extreme selectiveness of the *D. tomentosus* is the fact that grass and weeds spring up untouched immediately a cactus clump collapses. Further evidence of this habit was also obtained when the *D. indicus* destroyed *O. monacantha* without touching the adjacent *O. dillenii*, in South India.

Indian farmers applied to me for infected stems, and cleared many thousands of acres simply by throwing these into objectionable clumps. Official attitude was not enthusiastic, but tolerant; European unofficial

opinion was nervous; in fact, conditions were exactly as described in the Australian official papers before the Australian Government had decided to encourage private efforts.

Provided that no enemy (such as the Australian beetle) is found in Africa, it will be advantageous to employ biological control, because it introduces no poisons into the soil, and in the long run it enables a specified amount of labour to deal with the maximum area. For very intensive action, it might pay to cut tracks through dense areas by chemical means to facilitate broadcasting of the insects.

C. T. JACOB.

Glemham, Harpenden Road,
St. Albans, June 28.

The late Sir Francis Ogilvie.

SIR FRANCIS GRANT OGILVIE, who died last December, was Principal of the Heriot-Watt College from 1886 to 1900, taking office when the fortunes of the Watt Institution and School of Arts were merged with those of George Heriot's Hospital.

The work which Sir Francis did was of a pioneer character in the College and he laid down the lines which have since been successfully developed. He touched other fields of activity in each of which his scientific knowledge and administrative genius were of great service. In the Royal Scottish Museum, of which he was director from 1900 to 1903, as principal assistant secretary for Science and Art in the Board of Education from 1903 to 1910, as director of the Science Museum, South Kensington, from 1911 to 1920, and as chairman of the Geological Survey, he left his mark on each branch of activity. His work in organising the Forth Division Submarine Miners from 1887 to 1900, and in the Trench Warfare Research Department, 1915 to 1917, gives an indication of the wide range of his interests and the usefulness of his services.

It has been thought desirable by a number of old students that Sir Francis Ogilvie's connexion with the College should be recognised in some definite way. The suggestion of a fund to establish an annual prize has found favour, and I have received donations towards such a fund from a number of old students and members of the College, and from former colleagues and friends of Sir Francis. There are, no doubt, others who would wish to be associated with this memorial fund, and I should be glad to receive and acknowledge any contributions which they might wish to make. In this way the name of the first principal will be definitely brought before future students year by year.

J. CAMERON SMAIL.

Heriot-Watt College,
Edinburgh, June 29.

Alchemical Apparatus.

MY colleague Prof. Earp has directed my attention to an article in the *Journal of Hellenic Studies* (vol. l, p. 109; 1930) by F. S. Taylor, entitled "A Survey of Greek Alchemy", in which the suggestion is made that the apparatus called a 'water bath' (bain-marie) by Berthelot ("Introduction à l'étude de la chimie des anciens", Paris, 1889, p. 146) is really a small charcoal brazier. I had already explained this point in some lectures given three or four years ago in connexion with the course in the history, principles, and method of science in the University of London, and it is quite clearly stated in my book, "Everyday Chemistry" (Macmillan, 1929, p. 68), published in the year preceding Mr. Taylor's paper. The use of the apparatus in the operation of *kerotakis* is connected with the practice of encaustic painting, in which the four colours, black, white, yellow, and red, were (according to Pliny) the first to be used. These four colours are very important in the theories of Demokritos of Abdera, and reappear in an alchemical sense in the traditions ascribed to Demokritos in the earlier treatises, in which the process of transmutation is closely related to painting and dyeing.

J. R. PARTINGTON.

East London College,
Mile End Road, E.1.

Forestry Research in Great Britain.

MR. J. RAMSBOTTOM in a letter in NATURE of June 20, p. 927, states that little or nothing has been done in Britain concerning investigations on tree mycorrhiza, and that no one has been wholly engaged in its study. Mr. Ramsbottom has overlooked the fact that Dr. M. C. Rayner has been engaged whole-heartedly on these problems for several years, having previously given much attention to the mycorrhiza of other plants. At the Johannesburg meeting of the British Association in 1929, a research committee was appointed to facilitate Dr. M. C. Rayner's whole-time researches on "Mycorrhiza in Relation to Forestry", and this Committee was reappointed in 1930. Valuable results have been obtained in these investigations, which will be published in due course.

F. T. BROOKS
(Chairman, British Association Research Committee on Mycorrhiza in Relation to Forestry).

Botany School, Cambridge.

THE Editor of NATURE has kindly submitted the above letter to me for any comment I may care to make upon it. The object of my letter was to direct attention to the need of greater opportunities for research, which by taking a wider view of the interrelations of different organisms will benefit forestry in the only way which will count with practical men. I took into account the work mentioned by Mr. Brooks, with other investigations which are in progress. In so far as one investigator is 'whole time' (though not in the sense I meant), the necessary small correction may easily be made in my previous letter.

J. RAMSBOTTOM.

British Museum (Natural History),
Cromwell Road, London, S.W.7.

The London Skull.

I HAVE read with particular interest Prof. Elliot Smith's remarks on the 'Lady of Lloyds'' skull in the review entitled "Human Palæontology".[1] When he first described this skull in 1925, I pointed out[2] that on stratigraphical grounds I considered the Terrace in which the skull was found to be that on the surface of which Mousterian working floors have been found at many localities, and that I had shown the Terrace as such (that is, Middle or Taplow Terrace) on the Geological Survey maps. There was, however, some discrepancy between this view, based mainly on the mapping of the deposits, and that of the palæontologists, who assigned the Central London deposits to a post-Mousterian date. When making the geological survey of the area I considered this view and concluded that it was based on grounds insufficient to outweigh the stratigraphy. It is therefore highly satisfactory to me to find that in Prof. Elliot Smith's weighty opinion the human palæontology confirms my decision.

C. N. BROMEHEAD.

Geological Survey Office,
14A Parliament Street, York, June 30.

[1] NATURE, **127**, 963, June 27, 1931.
[2] NATURE, **116**, 819, Dec. 5, 1925.

Research Items.

Cult of the Sacred Bull in Ancient Egypt.—Mr. O. H. Myers contributes to *Discovery* for July an account of the past season's excavations carried out by the Egypt Exploration Society in the Bucheum, or burial-place of the sacred bull, at Armant, near Luxor. The Baqaria, or burial-place of the mothers of Buchis, near by, was also excavated. The Bucheum was functioning from the thirtieth dynasty to the time of Diocletian. Numerous stelæ in the Bucheum, some in situ, make it possible to assign most of the bulls to the ruler who inducted them, and in the Baqaria the evidence from a variety of sources, in conjunction with that from the Bucheum, enables the mothers of many of the sacred bulls to be identified. The Bucheum is roughly T-shaped, the base of the T being the entrance to a sloping ramp. Many tombs are situated half-way down this ramp; but the greater number are along the cross passage. In accordance with Egyptian idiosyncrasy, the earlier tombs are well-made solid sarcophagi cut from one stone and well spaced, but they degenerate through a stage of well-built sarcophagi of neatly dressed blocks to badly dressed blocks and finally to burials in the passage itself. A series of stelæ ranging from the time of Darius III. to Diocletian alleges a personal interest in Buchis on the part of the rulers, including the Roman emperors, and it is stated with doubtful credibility that Cleopatra VI. herself brought the bull up the river from Karnak for his induction. The site has proved disappointing in the matter of the objects found. A Nemes vase in green faience inscribed "Beloved of Osiris Buchis the King Nekht-Hor-Heb" and a fine group of bronzes, including two inscribed situlæ and a Kebeh vase, and stone and faience amulets are the most notable. A good corpus of pottery has been constructed.

Spermicidal Power of Chemical Contraceptives.—Effective birth control by means of chemical contraceptive agents must depend upon their spermicidal power and their mode of application, and such agents must be non-toxic and non-irritating, at least in the concentrations employed. The spermicidal power of chemical contraceptives upon guinea-pig sperms has been the subject of an investigation by Mr. J. R. Baker on behalf of the Birth Control Investigation Committee (see *Jour. Hyg.*, vol. 31, No. 2, April 1931, p. 189). Full details of the technique employed are given, and some comparative experiments indicated that guinea-pig sperms seem to react to spermicides much in the same way as human ones. The killing concentration of 36 substances was determined, this being defined as the lowest concentration in the series 2, 1, 1/2, 1/4 per cent, etc., which suffices to kill every guinea-pig sperm suspended in a special glucose-saline solution (simple saline is unsuitable) in half an hour at body temperature in four consecutive experiments, and the following figures are the killing concentrations per cent. Mercuric chloride and formaldehyde were the most active, 1/256; hexyl resorcinol, 1/64; soaps, 1/32; potassium permanganate, 1/16, and phenol, 1/2. Acetic and lactic acids, 1/32, and citric acid, 1/16; it is the concentration of hydrogen ions which determines the activity of acids. Some of the commonly used contraceptives are relatively inactive; thus, quinine hydrochloride and sulphate, and chinosol, only act at 1/2, while boric acid, magnesium sulphate, and alcohol fail to kill at 2 per cent. Certain very poisonous substances, such as potassium cyanide, prussic acid, and strychnine hydrochloride, have very slight spermicidal power, and active disinfectants are not necessarily good spermicides. Foaming mixtures containing tartaric acid and sodium bicarbonate, as in effervescing pessaries, seem to be active without the addition of a spermicide, and could probably be used alone as contraceptives. Details are given of the structure of the guinea-pig sperm and of the effect of changes in osmotic pressure upon it. Spermicides generally act upon the acrosome in the head of the sperm, and it either becomes shrunken and distorted or swells and bursts. The characters for an ideal chemical contraceptive are formulated.

Air-pressures upon a Bird's Wing.—A very remarkable photograph of a Montagu's Harrier about to land at its nest is reproduced in *British Birds* (June 1931). The upper wing-coverts are ruffled up as if by a breeze blowing from the rear of the bird. Lieut. R. R. Graham, in a short article discussing the photograph, supplements his earlier descriptions of the part played by the feather-arrangements in the wing in regulating air-pressures upon the wing (*British Birds*, June and July 1930). The wing is in a 'stalled' condition, held flat against the air-stream, with the result that eddies of air swirling round the hind margin into a region of reduced pressure, have actually blown up the feathers from behind. The photograph also shows the tips of the primary feathers separated, so that they form a 'slotted' device, comparable to the Handley-Page slot in aeroplanes, which adds greatly to the efficiency of the wing-tips by smoothing out the air-stream passing over the fore margin of the wing.

Transformation of Scales in Goldfish.—In order to discover what changes take place in scales transplanted from any part of the body to the lateral line, Yasumasa Mori has carried out a series of experiments upon goldfish (*Jour. Fac. Sci. Imp. Univ. Tokyo*, Sect. 4, vol. 2, p. 185; 1931). Lateral line scales were pulled out, and in their places scales from an area outside the lateral line were inserted. It was found that the transplanted scale becomes a lateral line scale, acquiring all the organs of the lateral line, a bony sheath, a sense organ in the lumen, a nerve regenerated from the torn stump of a branch of the lateral nerve, blood-vessels, and a pore penetrating the scale. The growth of the new structures generally commences beneath the pore of the preceding scale, and where a series has been transplanted the anterior individual acquires the new organs much more rapidly than those posterior to it. The whole process of transformation generally takes about two months, but in very rapid cases complete transformation has been observed in one month.

Symbiosis of Fungus and Scale Insect.—The relations between the fungus *Septobasidium retiforme* and the scale insect *Aspidiotus osborni* are discussed by J. N. Couch (*Quart. Jour. Micr. Sci.*, vol. 74, pt. 3, 1931). The fungus forms flat patches on the bark of oak and other trees in North Carolina and is entirely superficial, never penetrating the tissues of the tree. Such patches provide a home and protection for the scale insects, which suck the juices of the host plant, grow, and finally reproduce their young in vast numbers. These young may settle down beneath the same fungus under which they were born and repeat the cycle, or they may crawl out to other fungus-insect colonies, or settle on clean bark. These last are responsible for the dissemination of the fungus. Some of the young become infected with the fungus soon after they are born, the infecting fungal cell or cells entering the circulatory

system and there developing numerous coils which absorb food from the insect. A number of the insects are finally killed and used up by the fungus; others, though infected, may digest the fungal haustoria and survive to reproduce. While the fungus within the insect's body has been developing, the hyphal threads which make up the fungal floor of one of the patches have more or less overgrown and covered the insect's body. As soon as the insect moults the second time the fungal threads which have grown over its body from the floor pass under the moulted skin, and coiled hyphæ from within the insect's body anastomose with the hyphæ outside. Thus a colony of *Septobasidium* is not descended from a single spore but is composed of many strains. The thick roof of fungus affords protection to the scale insects against extremes of temperature, against drying and the attacks of parasitic hymenoptera. The association of fungus and insect is regarded as symbiotic.

Oranges and Arsenates.—The chemical changes observable in ripening oranges during the last hundred days of their growth have recently been studied in some detail by Copeman (*Trans. Roy. Soc. S. Africa*, **19**, 107; 1931). Particular attention has been paid to the contrast between normal oranges and those from trees which had been sprayed with lead arsenate to combat the attacks of insect pests. The general results agree in showing an increase in soluble solids in the juice during ripening, and this includes nitrogen, ash, and also sugars. Of the latter, sucrose, glucose, and fructose appear to be in equilibrium during this stage of development, since their relative proportions remain constant although the total amounts increase. Acidity, however, progressively decreases, and this decline is much more marked in fruits from trees receiving arsenate sprays. The oranges from sprayed trees thus have a characteristically insipid flavour owing to their low acid content. The effect is considered to be due chiefly to an intensification of respiration produced by arsenates; and since the effects of arsenates are metabolic in character, variations in the mode of application of the spray are not likely to remove the deleterious effects. New methods of combating insect pests in citrus culture must therefore be sought.

The Origin of Acid Igneous Rocks.—The problem of the association of acid and basic rocks (for example, granite with gabbro and rhyolite with basalt) is discussed from a new point of view by Prof. A. Holmes in the *Geol. Mag.*, June 1931. It is pointed out that inside the oceanic province bounded by the circum-Pacific belt, granites and rhyolites are totally lacking, and that these rocks are produced only where pre-existing acid rocks occur of the types that characterise the continental blocks. The distribution of the cone-sheets of such British Tertiary centres as Mull and Ardnamurchan makes it clear that the magmatic reservoirs from which they were fed rose to within three miles of the surface; that is to say, the reservoirs invaded the granite shell through a thickness of four or five miles. Consideration of the problem of what happened to the granitic material that previously occupied the place of the reservoirs leads to the conclusion that it became fused in situ. A source for the necessary heat is found in the upward transfer of heat by convection currents within the deeper basaltic portion of each reservoir. It is shown, by comparing the thermal gradient maintained by convection with that expressing the rise of fusion point with depth, that temperatures well above the fusion point can be reached in the upper part of a reservoir, thus providing an excess of heat, which becomes available for fusing the rock-material of the bounding walls and roof. It is also pointed out that the operation of convection is fatal to the possibility of deriving a granitic differentiate from a parental basaltic magma, though it is not denied that in appropriate circumstances, where convection does not operate, such differentiation may be locally achieved.

Fluctuations in Cosmic Radiation.—It has been reported at various times that the intensity of the cosmic radiation is not constant, but that it depends upon meteorological and extra-terrestrial conditions. A discussion of a number of the supposed fluctuations, based partly upon new measurements of high accuracy made by himself by an ionisation method, is given by G. Hoffmann in the issue of the *Zeitschrift für Physik* for June 13. There appear to be definitely at least two distinct influences of major importance, one being effective with the more penetrating components of the radiation, and the other with the weaker components, which are cut off by putting a relatively thin shield over the apparatus. With the harder rays, there is a pronounced inverse dependence upon the barometric height; when the graphs for the intensity of this radiation and the barometric pressure are plotted suitably on the same time base, one is closely the mirror image of the other. Presumably it is a question of absorption of radiation of extra-terrestrial origin in the atmosphere, although, as Millikan has pointed out, the dependence upon pressure also involves the temperature of the air. For the more easily absorbed rays, the new measurements of Hoffmann show a variation with the temperature of the air; their intensity increases with increase in temperature, a fluctuation of about ten per cent of the total ionisation going with a change in temperature of ten degrees. This could possibly be connected with movement of emanation and radioactive material in the air, but no correlation between the amount of the soft radiation and the direction or strength of the wind was found. Hoffmann remarks that the problem of establishing unambiguously a dependence of the intensity of the radiation upon sidereal time is a very difficult one.

Propagation of Electromagnetic Waves.—Interesting speculations as to the laws governing the propagation of wireless waves are given by Prof. H. Nagaoka of Tokyo in a paper published by the Institute of Physical and Chemical Research, No. 297 (April 1931, Tokyo). He points out that the presence of a highly ionised layer in the upper atmosphere—the Kennelly-Heaviside layer—has for a long time been assumed as a working hypothesis to explain the phenomena of transmission. It is now generally believed to consist of two or even three layers at different heights. It merely indicates that the number of free electrons varies at different heights in the atmosphere. The reflection of the waves at the bounding surface between gases is not so sharp as that between solids. The wave path turns round sharply, passing through an apex. He proves that at the apex where the wave begins to bend downwards the electron density is proportional to the square of the frequency. The density of electrons varies with the altitude of the sun, and is therefore a function of the latitude as well as of the solar declination. If observations were made for a year in different stations scattered over the world, the nature of the distribution of electrons in the upper atmosphere could be determined. The problem calls for international co-operation. To explain the presence of silent zones in short-wave transmission it is necessary to assume two conducting layers. The electron density which determines the wave-path varies for several reasons. The number of electrons coming from the sun and reaching the earth's

atmosphere is much affected by the number of sunspots, by auroral displays, and magnetic storms. The day and night variation can be satisfactorily explained, but sunrise and sunset fading needs further study. Auroræ are a great hindrance to wireless working, as they produce sudden and violent changes in electron density. Meteoric showers have a much smaller effect. Reasons are given for supposing that helium plays an important part in forming conducting layers. There are many natural gas springs in America that have been emitting helium for countless generations.

Production of High Vacua.—For many years certain materials have been used in lamps and vacuum tubes for removal of traces of gas, these being known as 'getters'. Two classes of getters are in use: (i) Those acting as adsorbents (active charcoal, copper oxide, thoria, etc.), (ii) those having great chemical activity (alkali metals, alkaline earth metals, phosphorus). Phosphorus is generally used in lamps. In the May number of the *Journal of the American Chemical Society*, Andrews and Bacon describe comparative experiments on the efficiencies of calcium, barium, magnesium, sodium, and phosphorus, deposited as thin coatings on the walls of bulbs or tubes, from the point of view of the attainment of vacuum. They report pressures of about 10^{-7} mm., the lowest measured pressure yet reached by other workers in the laboratory (of the General Electric Company) being less than 5×10^{-9} mm. in a gauge connected with a large tube of well degassed charcoal immersed in liquid air. The main result of the present experiments was that differences in the previous treatment of the getters are of far greater importance in the removal of gas than differences among the getters themselves. Poorly degassed materials absorb residual gas slowly and reach equilibrium at higher pressures than those attained by more gas-free material. These pressures do not depend on temperature in the range 0°-90°.

The Oxidation of Iodide by Persulphate.—A study of the velocity of oxidation of iodide by persulphate ion, described by King and Jacobs in the May number of the *Journal of the American Chemical Society*, is of interest both from the point of view of experimental technique and the Brönsted theory of reaction velocities as correlated with the Debye-Hückel theory of ion activity. Instead of titrating the iodine liberated, the authors added a small amount of thiosulphate and determined the time of first appearance of iodine by a photoelectric cell circuit with a long absorption cell of solution. This permitted the use of very dilute solutions, to which alone the theoretical equation could be expected to apply. Agreement with a linear curve of the logarithm of the velocity constant plotted against the square root of the ionic strength, as required by theory, was found up to the value 0·06 of the abscissa. Above this, there was an increasing negative deviation. When the ionic strength is made up largely of univalent ions, the best straight line extrapolates to log $k_0 = -1{\cdot}075$, whilst with a large proportion of bivalent ions it extrapolated to $-1{\cdot}06$. The difference is considered to be significant, though small, and it may be due to the inaccuracy of the Debye-Hückel equation for bivalent and tervalent ions, even in very dilute solutions. This deviation has been previously found, and can be qualitatively explained.

Astronomical Topics.

Tree-Rings and the Sunspot Cycle.—The researches of Dr. A. E. Douglass on the correlation between the growth-rings in trees and the sunspot cycle have given a probable sunspot curve for many centuries. A *Science News Bulletin* issued by Science Service, Washington, D.C., dated June 23 announces a further development of his work. He has carried the study of the rings in certain districts back to the date 700 B.C.; by examining the timbers in some ancient Indian buildings he was able to give the dates when the trees were cut, and thus to date the buildings. Dr. Antevs, of the University of Stockholm, has found correlation between the structure of clay layers in ancient lake-beds and the sunspot cycle. Both the tree-rings and the clay layers are supposed to depend directly on the rainfall, so it is really the latter that is correlated with the sunspots.

The work of both Dr. Douglass and Dr. Antevs has been honoured by the award of Research Corporation prizes, given through the Smithsonian Institution.

The Distance of Nova Pictoris.—The April issue of *Mon. Not. Roy. Ast. Soc.* contains a paper by Dr. Spencer Jones, giving the details of this investigation. Direct trigonometrical measures gave the negative parallax $-0{\cdot}009''$, with a probable error of $0{\cdot}007''$. This could only be taken as an indication that the distance is very great. An estimate was reached on the assumption that the increase of light was due to an expanding shell or series of shells of gas emitted by the star. The rate of expansion is assumed to have been uniform between the outburst and the maximum of light; it is also assumed that the effective temperature did not vary during this period. The rate of increase in the radius per day was calculated as 5·77 times the original value, while the spectroscope indicated a velocity of approach of 65 km./sec., which becomes 77 on allowing for the recession of the centre, which is 12 km./sec. Allowing for the fact that this is an integrated value over the whole disc, the parallax is deduced as $0{\cdot}0015''$, and this value is found to be practically independent of the initial temperature. At maximum the radius would be 384 times that of the sun. The absolute magnitude is deduced as 3·15 before the outburst and $-7{\cdot}9$ at maximum.

A Possible Cometary Observation by Bessel in 1832.—Bessel observed an object that he described as a nebula on Nov. 8, 1832; its position for the equinox of 1825·0 was $2^h\ 42^m\ 5{\cdot}56^s$, N.Decl. 36° 46′ 46·7″. Many subsequent observers have found a faint star of mag. 9·3 in this place, but none of them could see any nebulosity round it; there is a note to this effect in "New General Catalogue". Prof. Schulhof suggested many years ago that there might have been a comet superposed on the star when Bessel observed it. The writer of this note has recently noticed that, if it was a comet, it may have been Tempel's comet of the November meteors. If so, the date of perihelion would have been Oct. 30, 1832, which is not very far from the date indicated by the recent calculations of the Computing Section of the British Astronomical Association. If this identity should be correct, the next perihelion passage will occur in November or December 1932. If the Bessel object was Tempel's comet, it would have been extremely near the earth at the time; the earth perturbations would probably be large enough to account for the small corrections needed by the elements to make them represent Bessel's observed position. There was quite a rich shower of Leonids in November 1832, though it was apparently surpassed by that of Nov. 12, 1833. Owing to the shift of the node, Nov. 17 is the probable date this year, and Nov. 16 in the two following years. The watch should be kept on neighbouring nights also, as it is difficult to predict the position of the meteors with great precision.

Research in Industry.

IN a lecture on "Research in Industry and Rationalisation", delivered before the Society of Swedish Engineers in Great Britain on May 27, Mr. Axel Y. Enström discussed the way in which research and rationalisation have become indispensable factors for the economic development of industry. Science and research have now come to be marshalled among the working tools of industry in daily use, and the post-War period can supply many examples of the fruitful association of scientific and industrial research. Mr. Enström considers that Sweden's ability to attain a position in the world's markets has largely depended on the purposeful incorporation of scientific research, well-equipped laboratories, and a highly qualified staff with her industrial activity. There are now in Sweden about fifty works' research laboratories, which employ some six hundred persons and represent all the large industrial undertakings. The total cost of the industrial research carried on in Sweden is probably about four to five million crowns.

Discussing the special characteristics of scientific and technical research, Mr. Enström suggested that spontaneous research, such as Röntgen's discovery of the Röntgen rays, is typical of the former, and the systematic research which Hertz based on Maxwell's equations is typical of the latter. Even in systematic research, however, fundamental or scientific research, as well as a high standard of scientific technique, may be essential. Disregard of fundamental scientific principles may lead to enormous waste in technical research, especially in experimental plant work. After such technical investigations on a metallurgical process in Sweden, involving an outlay of several millions, had been abandoned as fruitless, scientific investigations on the interaction of ore particles and gases yielded a solution. The importance in technical research of a thorough knowledge of the fundamental physical and chemical sciences cannot be overstressed, but such a combination is difficult to find.

Other factors in technical research which may eliminate much wastage of time and labour are mathematical analysis of the possibilities at an early stage in the investigations, and the thorough study of the information already existing either in the literature or in technical sources before experimental work is undertaken. Related to these factors is the standard of experimental technique of the investigator and his knowledge of the possibilities and limitations of that technique. Similar qualities are increasingly involved in technical analysis and process control, and the essential factor in all the scientific control and development of industry may thus be briefly described as clear thinking.

In this description it is easy to include rationalisation, which, like technical research, aims at improving, increasing, or cheapening production. While suggesting that discussion as to whether the continued displacement of labour by machinery is justifiable is premature, Mr. Enström considered that rationalisation must progress with natural necessity. We have no general view of the correct proportion between direct production for consumption and production of machinery or tools. Economic history suggests that equilibrium is continually re-established on a fresh basis when the proportion is disturbed. Standardisation is an important element in rationalisation, and the research work on manufacturing processes not only leads to standardisation of processes and improved efficiency but also may frequently have a far-reaching rationalising effect. The application of scientific principles and methods of investigation to industrial problems inevitably leads sooner or later to the application of the same principles and methods to the conduct of the whole industry. Technical research and scientific management are thus two important aspects of rationalisation, and the future of industry largely depends on our ability to produce industrial leaders competent to evaluate these factors, with the economic, social, and other factors involved.

The Flying Fox in Australia.

TWO years ago, Mr. F. N. Ratcliffe was appointed by the Commonwealth Council for Scientific and Industrial Research to obtain for it as complete a picture as possible of the flying fox (*Pteropus* spp.) population of Queensland and New South Wales, its significance and extent, the relations of the different species one to another, the nature and cause of their migrations, the individual and collective habits of the animals, and the extent and value of the economic losses involved. Fruit-growers had at times complained loudly of orchard depredation by this pest and demanded governmental action to exterminate it. The Council was somewhat sceptical about the alleged facts: hence this inquiry, which received financial support from the Commonwealth, New South Wales, and Queensland Governments. Mr. Ratcliffe has now completed his work, and furnished to the Council a report which is not only most interesting reading but also is admirably fearless in its criticism of current ideas and practices.

Four species of flying fox are found in Australia: *poliocephalus*, *Gouldi*, *conspicillatus*, and *scapulatus*. They are practically confined to coastal areas, and their numbers, which cannot be accurately assessed, must amount to many millions in the numerous 'camps' scattered along a north–south stretch of some two thousand miles. There has, no doubt, been a diminution in numbers as settlement has progressed in New South Wales and South Queensland, the present population amounting probably to only about half that of early days. As in the past, so to-day, the principal food of all species is undoubtedly blossom, chiefly of eucalypts, and Mr. Ratcliffe has been forced to the conclusion that the current opinion that the fox is guilty of appalling destruction in fruit plantations is a gross exaggeration, so far at least as the commercial fruit crop of Queensland is concerned. Attacks on orchards are more an indication of general food shortage than evidence that cultivated fruit is an essential part of the animal's food supply. Such fruits as bananas, pineapples, citrus, pawpaws, and apples are, as a matter of fact, too hard for the weak dentition of the little red fox (*P. scapulatus*), which is equal in numbers to all the other species put together. *P. poliocephalus*, however, finds no difficulty in attacking these, when ripe: though here again it is important to remember that normally all these fruits, except perhaps citrus, should be picked for market while still unripe and therefore unattractive to the foxes. In other words, if the growers harvest these particular crops in satisfactory fashion, the loss to the commercial fruit industry in Queensland resulting from flying fox infestation should be almost trifling.

One must not forget, however, that what may be

called 'back garden' fruit is usually left on the trees until almost, or quite, ripe, and therefore is far more attractive to, and more readily attacked by, the bats than the greener product. This probably accounts for far more general popular outcry against the animals than the actual economics of the situation justify. Still, looking at the matter merely from a business point of view, if the fox is not a menace to the large-scale commercial industry, there would seem to be little valid reason for any considerable expenditure of public money on its control.

Nevertheless, big losses occasionally occur, notably where soft fruits (figs, peaches, nectarines, etc.) are grown. The problem presented by these is much greater in New South Wales than in Queensland. Hence Mr. Ratcliffe has felt it necessary to discuss critically various methods which have been proposed for coping with the trouble. Control through direct destruction by shooting, he rules out as a physical and economic impossibility. Attack by contagious or infectious disease is probably hopeless. There is now such a mass of experience indicating the improbability that control can ever be brought about in this way that it seems not worth while even to initiate experiments. The use of poison gases in the camps is almost impracticable and, on good evidence, ineffective. Flame guns are useful to an extent, but objectionable in many respects, including that of the cruelty involved. As for the 'scalp bounty' system, as adopted by Queensland, Mr. Ratcliffe's condemnation of it is as emphatic as it is just. He shows that in one important area, if every penny of the money provided by the Pests Destruction Board as bounty were spent solely on foxes, at 3*d*. per animal, the total destruction would probably be less than 1 in 200 of the normal population. Even then, *P. scapulatus*, because the least intelligent species, would usually be the most heavily hit: as it is also the least troublesome, money spent on it would be sheer waste.

Apart, however, from attempts at mass control, much protection might be afforded in small localised areas by systematic use of deterrents and poisons by the fruit-growers, and recommendations are made for the encouragement of such practices.

It seems, then, that the economic significance of the bat trouble in Australia is not really very great; it has certainly been exaggerated. The fox is a nuisance rather than a pest, affecting chiefly the small home grower and not the commercial fruit industry. Possibly, as Mr. Ratcliffe suggests, the reason for the prevalent exaggeration is partly psychological. The bat is nocturnal, noisy and smelly, and usually infested with parasites; in fact, decidedly detestable. It is no wonder, perhaps, that Mr. Ratcliffe found astonishing numbers of individuals prefacing their information regarding the foxes with a statement that they were "stinking, lousy brutes". Such an attitude is not without significance when one is seeking an unbiased assessment of the economic importance of a nuisance.

Be that as it may, the upshot of this very interesting inquiry should be to convince Australia that one, at least, of her pests is not so bad as it has been represented, and is not likely to become any worse. This will be some comfort to the Council for Scientific and Industrial Research, which finds decreasing funds and increasing responsibilities to be matters of grave embarrassment at the present time. A. C. D. R.

Young's Theory of Colour Vision.*

ALTHOUGH Thomas Young is well known as the founder of a theory of colour vision, his contributions to the theory are limited to two or three short paragraphs, and there is no evidence that he himself attached much importance to them. He was the first who, starting from the well-known fact that there are three primary colours, sought for the explanation of this fact, not in the nature of light, but in the constitution of man. He wrote: "Now, as it is almost impossible to conceive each sensitive point of the retina to contain an infinite number of particles each capable of vibrating in perfect unison with every possible undulation, it becomes necessary to suppose the number limited, for instance, to the three primary colours—red, yellow, and blue . . . and each sensitive filament of the nerve may consist of three portions, one for each principal colour." He afterwards took red, green, and violet as the three primary colours. His other statement regarding colour is in connexion with Dalton's colour-blindness, of which he says: "It is much more simple to suppose the absence or paralysis of those fibres of the retina which are calculated to perceive red".

Although the three component theory as developed by Clerk Maxwell, Helmholtz, and others accounted well for many of the facts of colour mixture, it had also to account for other phenomena of vision, such as visual acuity, the luminosity curve, hue discrimination, simultaneous and successive contrasts, and colour-blindness. Recent work by Hecht and others has succeeded in solving many of these problems.

The determination of the luminosity curve, which physicists still persist in calling the 'visibility' curve, has been the subject of such accurate investigation that it can now be regarded as one of the soundest scientific data in the whole realm of vision.

Dalton may be regarded as initiating the scientific study of colour vision, and later work by Seeback and Clerk Maxwell strongly supports the view expressed by Young that cases of colour-blindness are reduced forms of normal vision. On this theory, the neutral points of the spectrum as seen by protanopes and deuteranopes are excellently explained by the points of decussation of their two remaining curves.

The fact that yellow is psychologically as distinctive a colour as red, green, or violet, and physiologically shows no evidence of composite character, was long regarded as a strong argument against the trichromatic theory, until Hecht proved conclusively that the sensation of yellow could be experienced by fusing binocularly the sensations produced by appropriate red stimulation to one eye and green stimulation to the other.

Research since Young's day has done nothing to bridge the gap between the physiological and the psychological response, but considerable progress has been effected by Holmgren, Kohlrausch, Lucas, and Adrian in elucidating the physiological response itself. The results of these workers on the photochemical reaction of the visual purple, and the accompanying changes in electrical potential of the retinal structures, all tend to show that the fundamental phenomena of vision all manifest themselves in the retina.

Finally, the researches of Pieron, especially those on colour responses to black and white stimuli, and those of Allen on induction effects as shown on the persistency curves resulting from previous stimulation of the retina by monochromatic light, all have a distinct confirmation bearing on Young's theory.

* Substance of a paper read by Sir John H. Parsons, F.R.S., before the Optical Society on June 11.

Taste and Chemical Constitution.

THE relationship between physiological action and chemical constitution has been investigated for a number of compounds by animal experiment, when it is easy to compare and contrast the effects on a variety of systems of closely related substances. In spite of much work on the subject, no wide generalisations are yet possible, although it has been frequently shown that a very slight alteration in the molecule may enhance or decrease a particular physiological action: as an example may be mentioned the varying pressor effects of adrenaline and compounds closely related to it. The question is still less susceptible to investigation when the relationship between chemical structure and taste or smell is considered, since the experimental subject must be man and the investigator has to rely upon his subject's subjective sensations and cannot measure objectively the effect of his stimulus.

There is no generally accepted classification of odours, but tastes are usually divided into four groups —sweet, sour, salt, and bitter. No comprehensive generalisation has yet been discovered, however, for the relationship between taste and chemical constitution. It has usually been supposed that different people will taste the same compound, although perhaps with different degrees of intensity. A. L. Fox, of Wilmington, Delaware, U.S.A., has, however, recently found that whereas some people find that phenyl thiourea has an extremely bitter taste, others will state that it has no taste at all. As a result of numerous trials, he has found that about 60 per cent can taste it, whilst to the other 40 per cent it has no taste. The intensity of the bitter taste in the former group varied considerably. The division into the two groups was not a question of sex, age, race, colour, or family: of a pair of identical twins, one tasted it, the other did not.

A variety of thioureas was then examined: all had a bitter taste to some people, no taste to others: the list included *p*-ethoxy phenyl thiourea, and a number of other phenyl thioureas, naphthalene thioureas, diphenyl thiourea, and 2, 2′ dimethoxy, 5, 5′ dimethyl diphenyl thiourea. With diorthotolyl thiourea, however, the group of non-tasters was large, since some of those who had tasted all the previous compounds failed to taste this. With di-para-tolyl thiourea the taste was first sweet, then bitter. Dicrotyl thiourea and dibenzyl thiourea were also bitter to the tasters, but thiourea itself had an unpleasant taste to both groups, and tetramethyl thiourea appeared sour to both. The bitterness, therefore, appeared to be associated usually with compounds containing a benzene or naphthalene ring and thiourea: removal of the sulphur atom and replacement with oxygen can completely alter the taste, since *p*-ethoxy phenyl urea has a very sweet taste.

The failure of certain people to taste the bitterness of these thioureas is analogous to the failure of people to smell certain verbenas, as observed by Blakeslee. Some people found certain verbenas very fragrant, whilst to others they appeared to have no smell. With other verbenas, however, the two groups were reversed. It is, in fact, a well-known phenomenon that the sense of smell is very capricious, certain people being much more sensitive to some odours than others. It is obvious that this inability to smell or taste must be borne in mind when experiments are carried out on the relationship between the sensation and chemical constitution: errors may be avoided by the use of a sufficient number of subjects.

University and Educational Intelligence.

ABERDEEN.—At the graduation ceremony held on July 8 the honorary degree of LL.D. was conferred, among others, upon Prof. John Garstang, John Rankin professor of the methods and practice of archæology in the University of Liverpool. The ordinary degree of D.Sc. was conferred upon W. A. Carr Fraser, for a thesis entitled "Critical Studies in Hæmocytometry".

LONDON.—The external degree of D.Sc. in chemistry has been conferred on Aruppillai Kandiah (private study), for a thesis entitled "Studies in Dicyclic Systems. Part I. The Chemistry of 2-Substituted cis- and trans-Hexahydrohydrindenes. Part II. The Influence of cis- and trans-Hexahydrohydrindene Nuclei on the Carbon Tetrahedral Angle".

DR. T. J. DRAKELEY, head of the Chemistry Department and School of Rubber Technology at the Northern Polytechnic since 1919, has been appointed principal of the Polytechnic in succession to Dr. R. S. Clay, as from Jan. 1, 1932.

A VACATION course for teachers will be held at Bingley Training College on July 29–Aug. 12. The opening lecture, entitled "The Educational Revolution and its Steps of Progress", will be given by Prof. Patrick Geddes, on the first evening. Other evening lectures include Prof. T. H. Pear on "Learning how to Study" and Dr. G. H. Green on "Racial Bias and International Understanding". In the work of the senior school, the question of biology will be dealt with by Prof. R. D. Laurie throughout the course, and Sir Percy Nunn will deal with mathematics. A summer vacation course for physical training will be held at the Grammar School, Ilkley, on Aug. 3–15. Application for entrance to either course should be made to the Education Officer, County Hall, Wakefield, Yorks.

THE directors of Messrs. H. K. Lewis and Co., Ltd., booksellers and publishers, held a reception on July 9 to inaugurate their new building at the corner of Gower Street and Gower Place, adjoining University College, London. Designed by Mr. J. R. Moore Simpson, the new building is of steel-framed construction, faced with stone to harmonise with the adjoining College buildings, and part of the accommodation on the upper floors is reserved for the use of the College. Sir Gregory Foster, who presided over a large company, including many of the staff of University College, wished success to the firm in their enlarged undertaking. He was supported by Prof. Thane, who discussed 'text-books', stressing their increasing size in recent years, an increase not fully justified. Messrs. Lewis, established in 1844, now include, in addition to their main activity of bookselling, a publishing department, circulating library, and second-hand book department. As publishers they have specialised in medical books, and their catalogue includes many honoured names in the medical world, such as Jenner, Burdon Sanderson, Lister, and Osler. In addition to books, scientific journals are published, including the *British Journal of Dermatology*, *British Journal of Experimental Pathology*, and the *Clinical Journal*. A large stock of anatomical models, diagrams, and charts is available. The record of the firm is one of continuous growth, with every indication of acceleration owing to the new accommodation. A pleasing feature of the reception was the general recognition of the work of booksellers, publishers, and librarians as contributors to scientific and educational progress.

Birthdays and Research Centres.

July 12, 1863.—Dr. L. CH. ALBERT CALMETTE, For.Mem.R.S., sub-director of the Pasteur Institute, Paris.

I am conducting researches on snake venoms, anti-venomous serums (1892–1900); bubonic plague and serotherapy; tuberculosis, mechanism of infection, and preventive vaccination of babies with B.C.G.

July 22, 1865.—Sir RICHARD A. S. REDMAYNE, K.C.B., consulting mining engineer, professor of mining in the University of Birmingham, 1902–8, and H.M. Chief Inspector of Mines, 1908–20.

My object of chief investigation now in progress is the freeing of coal from the seam by non-inflammable means. The importance of this is obvious when one considers the great loss of life in gassy and/or dry and dusty coal-mines from explosions initiated by the flame of explosives.

A commercially possible process for the liquefaction of coal is a subject worthy of investigation. Were it possible to liquefy coal profitably the whole outlook of the coal-mining industry of the world, and Great Britain in particular, would be transformed for the better.

The commercial production of beryllium is also a subject to which attention might usefully be given. The importance of beryllium as a valuable alloy with copper, aluminium, and other metals has emerged recently.

The devising of an economical method of extracting alumina from bauxite containing 8 per cent and more of silica; as well as the extraction of alumina from lower grade ore generally, including clays, deserve attention. The high-grade ores of aluminium (bauxite) are not very extensive, and it is in the highest degree desirable with the greatly increasing importance and output of aluminium that a practicable and profitable means of extraction of alumina from the lower grade ores and, if possible, from clays generally should be found.

July 24, 1856.—Prof. ÉMILE PICARD, For.Mem.R.S., member of the French Academy, and permanent secretary of the Paris Academy of Sciences.

J'ai de l'intérêt pour l'analyse mathématique, la théorie des fonctions et la théorie des nombres. J'ai publié divers ouvrages sur l'histoire et la philosophie des sciences.

Societies and Academies.

LONDON.

Geological Society, June 17.—**Olaf Holtedahl**: Some general structural features of the arctic and adjacent regions. The huge region comprising the Canadian and the Baltic Shields and the areas lying between them represents a sort of structural unit which may be more or less symmetrically divided by two lines, one north and south, the other at right angles to it, crossing each other in the central part of Greenland. Although Baffin Land and the western zone of Fennoscandia had a somewhat different history in ancient geological times, yet each may be regarded as the reflected image of the other, both consisting of mountain ranges with the highest elevation on the side bordering the adjacent deep sea area. In the northward continuation of these two zones, in Ellesmereland and Spitsbergen respectively, and at the north end of Greenland, are other zones where the distribution of the various formations tells of a somewhat similar inclination of the earth's crust; an inclination away from central Greenland, the previously mentioned structural centre. Thus there is, in a roughly ring-shaped belt, an inclined elevation of recent, probably younger Tertiary, date, and it seems a natural conclusion that this particular elevation has been of fundamental importance in the gathering of snow, which in Quaternary time developed into the modern ice-fields, the centre of which coincides with the above-mentioned structural centre.—**James Archibald Douglas** and **William Joscelyn Arkell**: The stratigraphical distribution of the cornbrash: (2) The north-eastern area. Attention has been chiefly confined to the brachiopod zones, and their distribution throughout the area is indicated by a detailed account of many typical exposures. Further readjustment of Buckman's zonal table has been found necessary in respect of the zones of *Tegulithyris bentleyi* and *Obovothyris stiltonensis*. The evidence for and against penecontemporaneous erosion is discussed.

PARIS.

Acedemy of Sciences, May 26.—**Charles Nicolle** and **Ugo Lumbroso**: The immunity following a natural attack and cure of trachoma against an experimental re-inoculation of the virus.—**A. F. Holleman** was elected *Correspondant* for the section of chemistry.—**Long**: The W surfaces.—**Maurice Potron**: A fundamental theorem of the theory of finite continued groups of transformations.—**Marcel Winants**: Determination of a function of functions by means of an integral equation.—**Teissié-Solier**: The conditions of use of a Pitot tube and the impulse of a turbulent jet on a plate.—**J. Le Roux**: The impossibility of a law of gravitation for an aggregate comprising only two material points.—**Ch. Sadron**: The ferromagnetic saturation of elements other than iron, nickel, and cobalt, and the periodic system.—**L. Bull** and **Mlle. Suzanne Veil**: The optical study of the secondary Liesegang rings.—**L. Bert** and **R. Annequin**: A new method of synthesis of einnamic aldehyde and its homologues substituted in the nucleus. $C_6H_5 . CH_2 . CH : CHCl$, ω-chlorallylbenzene is converted into $C_6H_5 . CH_2 . CHCl . CHCl_2$ (or the corresponding bromine compound), and this, by heating with sodium ethylate in excess, into the diethyl acetal of cinnamic aldehyde. The reaction is general, and can be applied to the preparation of homologues of cinnamic alhehyde.—**J. D. Strelnikov**: The influence of the solar radiations on the temperature of the bodies of insects. The body temperature of insects is raised by exposure to the sun, and the organism of an insect is very sensitive to slight changes in the surrounding medium.—**Michel Polonovski** and **Albert Lespagnol**: Two new sugars from human milk, gyrolactose and allolactose. In the course of analyses of human milk by the ordinary polarimetric and reduction methods the divergences found suggested the presence of sugars other than lactose. Two new sugars have been isolated as the result of a long series of fractional crystallisations, and these have been named gyrolactose and allolactose. The properties of these two sugars are found to explain the abnormalities found on analysis.

CAPE TOWN.

Royal Society of South Africa, April 15.—**B. Farrington**: Vesalius on vivisection. This paper is a translation of the last chapter of the *De Humani Corporis Fabrica* of Vesalius, which bears the title "Some Observations on the Dissection of Living Things". Though Vesalius did not advance the study of physiology to anything like the same degree as he did the science of anatomy, his book is, none the less,

in the words of Sir M. Foster, "the beginning not only of modern anatomy but of modern physiology". The physiological experiments described by Vesalius have a direct connexion with the series of observations on living animals that enabled Harvey to demonstrate the circulation of the blood.—**J. H. Power**: On the herpetological fauna of the Lobatsi-Linokana area. An unexpected result of the author's collecting at Linokana was the discovery, in many cases, of different species, of certain genera, from those found at Lobatsi. The two localities are connected by a narrow valley between two ranges of hills, seemingly an admirable condition for ensuring that the reptile and amphibian faunas should be the same. The list of species collected materially extends the range of many species. The relationships of *Gerrhosaurus flavigularis* and *G. nigrolineatus*, and *Bufo tuberculosus* and *B. regularis gutturalis*, are discussed.—**J. W. C. Gunn and D. Epstein**: The reaction of *Xenopus* to digitalis. It has been stated that in *Rana* there are unexplainable variations in the response to digitalis as shown by the differences in the minimal lethal doses in individual animals on any one day, in groups of animals from day to day and in other ways. Such variations are not seen with *Xenopus* even when kept in captivity for several months. It is therefore superior to *Rana* for the biological assay of digitalis by any of the frog methods.—**D. Epstein, J. W. C. Gunn, E. Epstein, and G. Rimer**: The adrenal secretion of *Xenopus lævis*. Morphologists claim that no adrenal bodies are present in *Xenopus*, and various hypotheses have been brought forward to account for the absence of these glands. The authors have shown experimentally the presence of adrenaline in extracts of the kidneys of *Xenopus*. The kidney tissue itself contains no adrenaline, but the active substance is derived apparently from thin yellow streaks present on the ventral surfaces of the kidneys. These streaks probably represent the adrenal glands of *Xenopus*. This has been confirmed histologically by the demonstration of chromaffin tissue.

CRACOW

Polish Academy of Science and Letters, Feb. 9.—**J. Fridrichson**: The fluorescence of manganese vapour.—**Mlle. M. Ney**: The enlargement of diffused lines without change of frequency in the Raman effect. A study of the lines diffused in quartz and in benzene shows that a marked widening of the lines occurs in benzene, but in quartz at 180° C. and at 500° C. no such widening can be observed.—**T. Tucholski**: The spectra of metals obtained by explosive reactions. Studies of the spectra obtained by the explosion of metallic picrates. Explosion spectra are essentially flame spectra, but with some additional characteristic features. The explosion temperatures are between 1900° C. and 3200° C.—**T. Banachiewicz**: An application of the periodograms of Sir Arthur Schuster.—**W. Swietolawski, Mme. M. Rybicka, and Mme. W. Solodkowska**: An adiabatic microcalorimeter adapted to the measurement of the specific heat of solid and liquid substances. A study of the conditions of working with the microcalorimeter, with special reference to the correction for the gas contained in the apparatus and to the error introduced by evaporation or adsorption of water.—**W. Swietoslawski and Mlle. E. Bartoszewiczowna**: (1) The application of the adiabatic microcalorimeter to the determination of the heat of adsorption and of vaporisation. The quantity of liquid required in these determinations is 0·01–0·1 gm., and the errors are 0·2–0·7 per cent for heat of vaporisation and 0·6–1·7 per cent for heat of adsorption.—(2) The determination of the heat of vaporisation in the fatty alcohol series with the adiabatic microcalorimeter.—**W. Jacek**: The velocity of the solution of marble in acids.—**M. Karasinski**: The determination of fluorine as CaF_2 according to the method of Berzelius. Instead of adding sodium carbonate to secure an easily filtrable precipitate, the author attains the same result by evaporation to dryness and gentle ignition, followed by extraction with water.—**K. Dziewonski and J. Moszew**: The synthesis of α-ethylacenaphthyl ketone.—**St. Kreutz**: Heulandite occurring in the Tatra granites and the volcanic rocks in the neighbourhood of Cracow.—**St. Kreutz**: Crystals of topaz from Jahodenka in the neighbourhood of Horoszki (Wolhynie).—**S. Kozik**: The optical properties of mixed crystals of ammonium and sodium tartrate and of rubidium and sodium tartrate.—**J. Broder**: The diabases of Niedzwiedzia Góra and the formations which accompany them. Chemico-petrographic study.—**J. Zerndt**: Megaspores, characteristic fossils of the productive carboniferous strata.—**W. Szafer**: The ancient diluvial flora of Hamernia on the Lubaczówka.—**Mlle. M. Ziemba**: Biological researches concerning the flowers of the eastern Carpathians.—**M. Gieysztor**: Contribution to the knowledge of the Rhabdocœles of Spain.—**St. Markowski**: Researches concerning the helminthological fauna of the Corvidæ of Poland.—**A. Kulczycki**: The physiological degeneration of the striated muscles.—**Mlle. S. Vrtel**: Histological researches concerning the thyroid gland. The thyroid gland of selacians.—**J. Tur**: New studies on diplogeneses with abortive centres.—**St. Wajda**: Cytological researches on the secretion of the thread-producing glands of the larvæ of Trichoptera.—**J. Wilburg**: The development of the blood-vessels in the foot and toes of *Sus scrofa domestica*.—**M. Rose**: The cellular structure of the cortical substance of the brain of the rabbit.—**W. Heinrich and T. Strzembosz**: The function of the capillary vessels with respect to concentration of attention.

GENEVA.

Society of Physics and Natural History, Mar. 5.—**Fern. Chodat and Suzanne Kann**: Study of the diurnal course of transpiration of two alpine plants. These experiments were made at the Bourg St. Pierre alpine garden at an altitude of 1650 metres. For *Eryngium*, the authors have detected two clear maxima at 10.30 A.M. and 3.30 P.M. respectively. *Adenostyles alliariæ*, a plant requiring shade, has, on the contrary, constant transpiration from morning to evening.—**Fern. Chodat**: The action of light upon cellular permeability. The author interprets the experiments described above as being due to the higher proportion of rays of short wave-length at high altitudes. This explains the difference which exists between the transpiration of plants at low and high altitudes.—**Louis Deshusses and Jean Deshusses**: The distribution of the pyrethrins in the pyrethrum flower. The stems contain from a tenth to a fourteenth of the total pyrethrins found in the flower of the same growth. Hence, in the preparation of pyrethrum insecticides in the form of extracts or powders, it is necessary to take this fact into account: this is very important from the point of view of the toxic power of the product obtained.

LENINGRAD.

Academy of Sciences (*Comptes rendus*, No. 19, 1930).—**B. Segal**: A generalisation of Brun's theorem.—**I. Balanovskii**: The computation of rectangular coordinates of basic stars on astrophotographic charts.—**E. Semičev**: The fundamental features of electro-

dynamic relations in electromagnetic machinery. In no electrodynamic process is the electromagnetic energy completely transformed into mechanical work. In other words, every electrodynamic process in which the system accomplishes positive, or negative, mechanical work is characterised by some reactive energy taking part in it.—I. Kablukov and F. Perelmann: The heat of combustion of certain organic halogenic compounds. Determinations of the heat of combustion of dichlorethylene, chloroform, chlorbenzene, dibromethylene, bromoform, and brombenzene.—N. Williams: Hydrogenation of some derivatives of furfurane.

Comptes rendus, No. 20, 1930. — F. Loewinson-Lessing, V. Mitkevitch, and A. Turcev: Experiments in the artificial magnetisation of limonites. Limonites submitted to magnetisation in the electromagnetic field of 2500 gauss, after having been heated to 400°-500° C., do not exhibit any proportionality of the intensity of the magnetisation and the content of the ferrous oxide. The magnetisation depends on the degree of trituration and is more intense in the case of powdered substances. There is a direct relation between the intensity of magnetisation and the manganese content.—B. Brunovski and K. Kunasheva: The radium content of certain plants.—V. Vernadskii: The concentration of radium by plants. Determinations of the radium content of *Lemna* and of the water in which it lives proved that the plant concentrates up to 200 and even 477 times as much radium as is in the water, there being a great difference between plants from different localities. In some cases, it is impossible to detect radium in the water, but its concentration in the plant is very high.—N. Prokopenko: The deposits of solid kaolin in the Dzhungarian Alatau.—E. Litchko: Observations on the regeneration of the extremities in the axolotl under the influence of X-rays. Local radiation for 60 minutes does not affect the regenerative abilities. When the whole animal was subjected to the radiation for 16 minutes but one foot was screened, that foot was able to regenerate, though the animal could not survive more than two months.

Comptes rendus, No. 21.—S. P. Kostychev, V. Gvaladze, and P. S. Eliasberg: The formation of pyruvic acid in lactic fermentation. A method is described for the isolation of the pyruvic acid in the presence of sugar.—V. Gulevitch: Methyl-guanido-oxalic acid (creaton) as a constituent part of muscles. The formula of the creaton was found to be HN : C (NH_2) . $N(CH_3)$. CO . COOH. It is possible that creaton, like glutathione, takes part in the oxidation processes of the organism.—L. Kantorovitch: Certain developments of the polynoms of S. N. Bernstein.—B. Numerov: The interpretation of gravimetric observations in the case of a single surface of contact.—B. Numerov: The construction of isograms after observations with a gravitational variometer.—B. Barovskii: Description of a new species of the genus *Macrolycus* Waterh. (Coleoptera, Lycidæ). *Macrolycus æmulus*, sp. n., is described from the Ussuri region and Manchuria.

Comptes rendus, No. 22.—A. A. Borisiak: Charles Depéret (obituary).—N. Nasonov: On *Acrorhynchus baicalensis* Rubtzoff (Turbellaria, Rhabdocœla) from Lake Baikal. This species does not belong to the genus *Acrorhynchus* and is more closely allied to *Kainocystis*, so that it cannot be considered a representative of marine Rhabdocœla.—M. A. Menzbier: The combination of factors to which the origin and the development of terrestrial vertebrates is due. Free movement of the head is connected with the replacing of the branchial apparatus by lungs, this leading to the final victory of aerial over aquatic respiration.—L. Kantorovitch: Certain developments of the polynoms of S. N. Bernstein (2).—N. Terebinskii: Experimental studies of the faults of cardiac valves.—N. O. Olenev: Scientific results of the expeditions in 1928 and 1929 to Kazakstan for the study of parasites of domestic animals. A list of parasites, with their hosts, is given.

Comptes rendus, No. 23.—A. Tugarinov: A fossil ostrich from Transbaicalia. Fragments of ostrich eggs have been found in several localities. The structure of the shells shows some relation to the recent North African ostrich, but there are considerable differences.—V. Barovskii: Description of a new species of the genus *Pyropterus* Muls. (Coleoptera, Lycidæ) from Transcaucasia. *Pyropterus shelkonnikovi*, sp. n.—A. A. Birula: A preliminary communication on the rodents from the quaternary deposits in the Crimea. The quaternary fauna included 18 species of rodents, while at present there are only 14 in the Crimea.—B. A. Kusnečov: A new species of jumping mouse (*Alactagulus shitkovi*, sp. n.) from Semiretchie.—P. Schmidt: Two rare Japanese sharks, *Proscyllium habereri* Hilgendorf and *Apristurus macrorhynchus* Tanaka. Synonyms and supplementary description of the two species mentioned.

MELBOURNE.

Royal Society of Victoria, April 9.—O. A. Mendelsohn: Some observations on the bacterial count of sea-water as determined by samples taken at intervals on a voyage between Australia and Europe.—R. B. Withers: On the development of the tabulate coral, *Pleurodictyum megastomum*. The author works out the mode of growth of the *Pleurodictyum megastomum*, Dun, Yeringian (Upper Silurian) of Victoria, Australia. To the eighth corallite, growth proceeds on a definite plan by budding from the initial corallite. This neanic stage is followed by the ephebic stage, when the corallum enlarges without further addition of corallites. The gerontic stage is characterised by the irregular growth of a second ring of corallites, and the insertion of others by intermural gemmation. *Pleurodictyum lenticulare*, Hall sp., Lower Helderbergian (Lower Devonian) of North America, develops in a similar manner.

PRAGUE.

Czech (Bohemian) Academy of Arts and Sciences (Second Class, Natural Sciences and Medicine), Dec. 12.—M. Pelíšek: The rolling of a helix on a congruent helix.—R. Lukes: The action of Grignard's reagent on *N*-methyl pyrrolidon; new synthesis of substituted pyrrolines. Chief products were *1*-methyl-2-alkyl-pyrrolins next to *1*-methyl-2 . 2-dialkyl-pyrrolidins. The former were isolated as perchlorates, the latter as picrates.—V. Prelog: The sapogenin of beetroot. Chromic acid oxidises sapogenin to a ketonic acid and di-hydroxy-lactone. With sulphuric acid it yields carbon monoxide, hence its carboxyl is bound to a quaternary carbon atom; the action with tetranitro-methane indicates inactive double linkages.—L. Šimek: Graphical solution of reactions and axial forces in a special plane system of rods.—L. Seifert: A system of surfaces of third order which touch a given surface of third order in points of plane intersection.—B. Brauner: A philological note concerning some terms of modern scientific nomenclature.

Jan. 16.—F. Záviska: Notes on the study of universal ether. Critical remarks on the theory propounded by V. Posejpal.—K. Domin: Geobotanical

excursion to the mountain Vysoká in the Little Carpathians.—**F. Němejc**: Seeds of *Alethopteris rubescens*.—**A. Glazunov**: The nature of a crystallisation centre. From one crystallisation centre grows a series of crystals forming one, usually heterogeneous, grain (crystallite).

Mar. 6.—**J. Petrbok**: Molluscs of the Pleistocene terrace of the Danube near Russe in Bulgaria.—**K. Petr**: The separation of roots of algebraic equations according to the real parts.—**B. Dratvová**: The problem of causality.—**Hrubý**: Biometric observations on blossoms of *Anemona nemorosa* L.—**L. Borovansky and Pexiderová**: The growth of the body and the progression of ossification in girls from birth to eighteen years of age.

Official Publications Received.

BRITISH.

A Vertical Optical Bench and its use in Practical Light. By Prof. Mohd. A. R. Khan. Pp. 20. (Madras: Diocesan Press, Vepery.)

Proceedings of the Royal Physical Society, Sessions 1928-29, 1929-30, 1930-31. Vol. 22, Part 1. Pp. 74. (Edinburgh: Oliver and Boyd.) 6*s*.; to Fellows, 5*s*.

Madras Fisheries Department. Administration Report for the Year 1929-30. By Dr. B. Sundara Raj. (Report No. 1 of 1931, Madras Fisheries Bulletin, Vol. 25.) Pp. vii+104+6 plates. 14 annas. Report on a Systematic Survey of Deep-sea Fishing Grounds by S.T. *Lady Goschen*, 1927-28. By Dr. B. Sundara Raj. (Report No. 3 of 1929, Madras Fisheries Bulletin, Vol. 23.) Pp. 153-187+3 charts. 1.8 rupees. (Madras: Government Press.)

Department of Scientific and Industrial Research. Building Science Abstracts. Vol. 4, New Series, No. 5, May. Abstracts Nos. 748-959. (London: H.M. Stationery Office.) 9*d*. net.

The Indian Forest Records. Entomology Series, Vol. 16, Part 3: Immature Stages of Indian Coleoptera (8). (Cerambycidae, contd.) By J. C. M. Gardner. Pp. 41+3 plates. (Calcutta: Government of India Central Publication Branch.) 1.2 rupees; 2*s*.

The Scientific Journal of the Royal College of Science. Vol. 1: containing Papers read during the Session 1930-1931, before the Imperial College Chemical Society, the Royal College of Science Natural History Society, the Royal College of Science Mathematical and Physical Society. Pp. 158. (London: Imperial College Union.) 3*s*. 6*d*. net.

Journal of the Marine Biological Association of the United Kingdom. New Series, Vol. 17, No. 2, June. Pp. 277-615. (Plymouth.) 12*s*. 6*d*. net.

Transactions and Proceedings of the Royal Society of South Australia (Incorporated). Vol. 54. Edited by Prof. Walter Howchin, assisted by Arthur M. Lea. Pp. iii+215+9 plates. (Adelaide.) 14*s*.

The Civil Servant's Share of the National Income. By G. D. Rokeling. (Reprint of three Articles from *State Service*, April, May, June, 1931.) Pp. 20. (London: The Institution of Professional Civil Servants). 3*d*.

Proceedings of the Geologists' Association. Edited by A. K. Wells. Vol. 42, Part 2, June 25th. Pp. 87-216. (London: Edward Stanford, Ltd.) 5*s*.

The Journal of the Institute of Metals. Vol. 45. Edited by G. Shaw Scott. Pp. xii+429+59 plates. (London.) 31*s*. 6*d*. net.

Hull Museum Publications. No. 170: Roman Pottery and Kilns at Throlam, near Holme-on-Spalding Moor, East Yorkshire. By Philip Corder and Thomas Sheppard. Pp. 35. No. 171: The Architectural Gems of East Yorkshire. By Thomas Sheppard. Pp. 32+8 plates. No. 172: Recent Additions. Edited by T. Sheppard. Pp. 19. No. 173: Exhibition illustrating the Architecture of Modern Transport, in the Mortimer Museum, Carr Lane, June 1st to July 12th, 1931. Pp. 16. (Hull.)

Records of the Geological Survey of India. Vol. 65, Part 1. Pp. 187. (Calcutta: Government of India Central Publication Branch.) 2.12 rupees; 5*s*.

Memoirs of the Department of Agriculture in India. Botanical Series, Vol. 17, No. 6: The Effect of some Meteorological Conditions on the Growth of Punjab-American Cotton. By Trevor Trought. Pp. 137-154. (Calcutta: Government of India Central Publication Branch.) 7 annas; 9*d*.

Proceedings of the Royal Irish Academy. Vol. 40, Section A, No. 1: The Spectrum of the Cathode Glow in Nitrogen and other Gases. By Dr. K. G. Emeleus and Olive Hall. Pp. 10. (Dublin: Hodges, Figgis and Co.; London: Williams and Norgate, Ltd.) 6*d*.

The National Central Library, formerly the Central Library for Students. 15th Annual Report of the Executive Committee, 1930-31. Pp. 48. (London.)

Journal of the Chemical Society. June. Pp. vi+1313-1627+x. (London.)

Transactions of the Institute of Marine Engineers, Incorporated. Session 1931, Vol. 43, No. 5, June. Pp. 203-260+xliv. (London.)

FOREIGN.

Instituts Nationaux à l'Étranger. Pp. 124. (Paris: Institut International de Coopération Intellectuelle.) 15 francs; 2*s*. 6*d*.

Meddelande fran Lunds Astronomiska Observatorium. Ser. 2, Nr. 57: Streams among Stars with large Proper Motions. By W. Gyllenberg. Pp. 37. 2 kr. Lund Observatory Circular. No. 3, May 31. Pp. 35-66. Annals of the Observatory of Lund. No. 2: On Structural Properties of Open Galactic Clusters and their Spatial Distribution; with an Appendix containing a Catalogue of 471 Objects. Academical Dissertation by Per Collinder. Pp. A64+B62+16 plates. (Lund.)

Koninklijk Magnetisch en Meteorologisch Observatorium te Batavia. Verhandelingen No. 23: Gemiddeld aantal regendagen op Java en Madoera in de vier opeenvolgende, voor iedere plaats droogste maanden van het jaar. Door Prof. Dr. J. Boerema. (With English Summary: Average number of rain-days in Java and Madoera during the driest four consecutive months of the year.) Pp. 25. (Batavia: Landsdrukkerij.)

Proceedings of the Academy of Natural Sciences of Philadelphia, Vol. 83. Angolan Birds collected during the Gray African Expedition, 1929. By W. Wedgwood Bowen. Pp. 263-299. (Philadelphia.)

Transactions of the San Diego Society of Natural History. Vol. 6, No. 22: Descriptions of New Birds from the Mountains of Southern Nevada. By A. J. van Rossem. Pp. 325-332. (San Diego, Calif.)

Suomen Geologinen Toimikunta: Geologiska Kommissionen i Finland: Bulletin de la Commission Géologique de Finlande. No. 91: Pre-Quaternary Rocks of Finland; Explanatory Notes to accompany a General Geological Map of Finland. By J. J. Sederholm. Pp. 47, with Map. (Helsinki.) 30 Fmk.

Bulletin of the American Museum of Natural History. Vol. 59, Art. 7: Pleistocene Exploration and Fossil Edentates in Florida. By Walter W. Holmes and George Gaylord Simpson. Pp. 383-418. Vol. 61, Art. 7: South American Lizards in the Collection of the American Museum of Natural History. By Charles E. Burt and May Danheim Burt. Pp. 227-395. (New York City.)

State of Connecticut: State Geological and Natural History Survey. Vol. 9, Bulletins 43-48, 1928-1930. Pp. iii+100+168+32+97+294+94+95 plates. (Hartford, Conn.)

Japanese Journal of Physics. Transactions and Abstracts, Vol. 6, No. 1-2. Pp. v+15+32+3 plates. (Tokyo: National Research Council of Japan.)

Science Reports of the Tokyo Bunrika Daigaku. Section A, Nos. 7-12: On Vector Quantity, 2: Vector Quantity is Reducible from a kind of Probability, by Suminosuke Ono; On the Relative Intensities of the Balmer and Paschen Lines, by Uzumi Doi; Large Displacements in the Spectrum of Singly Ionized Oxygen, by Kwan-ichi Asagoe; Some Peculiar Types of the Secondary Lichtenberg Figures, by Kwai Umeda and Mitsuo Shôyama; On the Reversal-like Phenomena of the Balmer Lines of Hydrogen, by Hideo Nagashima; A Method of Laboratory Device to record the Period of a Pendulum Motion, by Mituo Syóyama. Pp. 85-147+plates 5-11. 90 sen. Section A, No. 13: On the Modulus of some Integral. By Iôichi Kakeya. Pp. 149-157. 15 sen. (Tokyo: Maruzen Co., Ltd.)

Zoologica: Scientific Contributions of the New York Zoological Society. Vol. 9, No. 13: Growth and Age in the Great Tortoise of the Galapagos. By Charles Haskins Townsend. Pp. 459-474. (New York City.)

Carnegie Institution of Washington. Publication No. 406: The Temple of the Warriors at Chichen Itzá, Yucatan. By Earl H. Morris, Jean Charlot, Ann Axtell Morris. Vol. 1. Pp. xix+485. Vol. 2. Pp. viii+170 plates. (Washington, D.C.: Carnegie Institution.) 20 dollars.

CATALOGUES.

Catalogue of Fine Chemical Products for Laboratory Use; including Organic and Inorganic Chemicals, Analytical Reagents, Standard Stains, Indicators. (July 1931.) Pp. 132. B.D.H. Ureameter Outfit. Pp. 4. (London: The British Drug Houses, Ltd.)

Electro-Chemical Apparatus embodying Electro Analysis of Metals, Electrometric Determination of Hydrogen Ions, and Conductivity of Electrolytes. (List No. 80c.) Pp. 44. Catalogue of Surplus Stock Apparatus including Balances and Weights, Glassware (Graduated and Ordinary), Hardware, Metal and Porcelain Ware. (List No. SS 101H.) Pp. 20. (London: A. Gallenkamp and Co., Ltd.)

Diary of Societies.

FRIDAY, JULY 17.

INSTITUTION OF MUNICIPAL AND COUNTY ENGINEERS (South Midland District Meeting) (at Winchester Street, Acton), at 2.15.—W. G. Cross: Some Recent Works in Acton.—S. W. Slight: New Sewage Pumping Station.—H. Atkinson: New Works Depot.

TUESDAY, JULY 21.

ROYAL SOCIETY OF MEDICINE, at 5.30.—General Meeting.

LONDON NATURAL HISTORY SOCIETY (at London School of Hygiene and Tropical Medicine), at 6.30.—Informal Meeting.

CONGRESSES.

JULY 17 TO 25.

BRITISH MEDICAL ASSOCIATION (at Eastbourne).

JULY 24 TO 30.

BRITISH COMMONWEALTH EDUCATION CONFERENCE (at Bedford College).—Subject: EDUCATION IN A CHANGING EMPIRE:—

Education in India.
Individual Education.
Modern Psychology in Education.
Examinations and Tests.

JULY 26 TO 31.

INTERNATIONAL CONGRESS ON RADIOLOGY (at Paris).

SUMMER MEETING.

JULY 18 TO 23.

INSTITUTION OF ELECTRICAL ENGINEERS (in Northern Italy and Western Switzerland).