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CONTENTS.

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Training for the Industrial Professions.

IN the formation of the great professional corporations of industrial intellect it is evident that there must be some condition of entry which shall make for a certain uniformity and shall satisfy the requirements of existing members. The essential principle on which all agree is that there must be proof of an adequate education in theory, along with a sufficient and comprehensive training in practice. This combination is ensured in various ways, but for those who aim at securing the hall-mark of inclusion within the appropriate professional institution there is now in Great Britain a scale of reasonably comparable requirements, based in every instance upon a proof of soundness of general and scientific education, with a guarantee at each stage that progressive professional or technical experience is being simultaneously acquired.

Schemes of this type have been adopted by the Institute of Chemistry, and the Institutions of Civil, Mechanical, and Electrical Engineers, among others. Qualification to register as student is given either by success in a special examination held by the institution concerned, or by production of evidence of having passed some recognised equivalent, such as the Matriculation examination of a university; and, in this connexion, it is interesting to note that among the requirements there is now in every case, in addition to a proved knowledge of science, a demand for a good training in English, and, at some stage, for knowledge of one foreign language.

Having thus entered, the student, with increase of experience, is led to further tests, and, with these satisfied and under the personal recommendation of those professionally competent, he may pass forward at appropriate ages to Graduateship, to Associate Membership, and in the end to full Membership of the institution chosen.

The subject-matter of these further examinations is almost entirely technical, and has to deal with the specialised knowledge required for the particular profession; but again, in lieu of this special examination, it is permissible to offer a recognised and approved equivalent in the shape of the degree of an approved university, or the diploma of an approved college. There is, as the student advances in his career, a gradual elimination of demand for those subjects which may be studied mainly for educational training in favour of those which are of direct professional importance.

The course of education and training followed is to give the power both to work and to think, ability not only to carry into performance with intelligence instructions given, but also to see possibilities of new design or process.

The success of this method adopted for the creation of a highly qualified and well-acknowledged directorate has been most evident, conspicuous alike in home employment and in foreign and colonial engagement. Certain broad principles have been laid down and enforced to ensure that a course of study, coupled with practical training properly supervised, has produced a satisfactory and prescribed result, and, in order to maintain for the corporate body a voice of accepted authority, the strictest conditions of admission have been enforced.

Until recently it has been with this part of the problem of training that the great engineering and chemical institutions have been principally concerned. Realising the vast potentialities and responsibilities of their professions, they have rightly demanded from those desirous of entering the highest qualifications obtainable. The direction of scientific industry has risen to demand the fullest knowledge of the relevant sciences; and it is to ensure the possession of this knowledge that each institution, jealous of its entrants, has laid down examinational tests which have been carefully considered by practical experts, and bear considerable weight in the formulation of higher schemes of study.

In every industry, however, it has to be recognised that success comes not alone through the guidance of a trained, well-informed, and open-eyed directorate, but that there must be also an adequate supply of skilled and educated under-officers and men. It is therefore of the greatest interest to notice the recent extension of activity of several of these high professional associations, which, with the assistance and active co-operation of the Board of Education, have now taken within their purview schemes of study and examination whereby opportunity of close association with the professional body is given to those skilled or scientific workers who are ready to devote the time requisite to follow an approved course of theoretical study, which for the National Certificates may be taken in evening or part-time classes.

It is to be hoped that this further advance, recognising unity of interest and consequent inter-dependence between the professional worker and those actually engaged in the operations of production, may lead to the creation of a band of officers of industry, competent to undertake the effective direction of one or more of the many departments into which the fabric of a great industrial undertaking is now divided, or to come forward to take charge at a call of emergency.

There can be no doubt that we have in this new and wider outlook, which has been brought about by wise co-operation of the highest representatives of our great industries with the Board of Education, a possibility of most far-reaching consequence, likely not only to influence with advantage the whole provision of relevant educational opportunity, but also to produce a far wider moral and psychological effect upon the worker, who will in this way be able to see opportunity of clearer relationship within one body between the man of directing professional qualification and himself.

British scientific industry has often in the past suffered from want of this association, and it is to be hoped that other professional institutions with industrial purpose may feel able to follow the enlightened example of those which have instituted a movement likely to bear the best of fruit.

A special feature of the schemes of collaboration so far arranged by the Institution of Mechanical Engineers, the Institution of Electrical Engineers, and the Institute of Chemistry with the Board of Education for the issue of National Certificates and Diplomas is the guarantee of standard vouched for by the appropriate institution in conjunction with the Board, along with the allowance of reasonable variation in arrangement of the subject-matter of the approved courses to ensure satisfaction of the needs of local trade specialisation. The examinations are conducted locally but under the surveillance of appointed central assessors. Certificates and Diplomas thus authenticated should be able to claim world-wide acceptance of value where similar work is required to be undertaken, while the schemes should give to the several institutions a most valuable means of encouragement towards the training of the higher grades of supervisory workers.

Evolution and Christian Faith.

(1) *Evolution and Christian Faith.* By Prof. H. H. Lane. Pp. xi+214. (Princeton: Princeton University Press; London: Oxford University Press, 1923.) 9s. net.

(2) *Origin and Evolution of Religion.* By Prof. E. Washburn Hopkins. Pp. v+370. (New Haven: Yale University Press; London: Oxford University Press, 1923.) 15s. net.

THE two books before us are of interest not only in themselves but also as illustrating important types of mental activity in America. Both books deal with religion. Yet the author of one is a professor of zoology and of the other a professor of Sanskrit. Prof. Lane writes from the Christian point of view, and combines an expert knowledge of biology with religious earnestness. His work is the outcome of a series of lectures in which he was asked by students to describe the theory of evolution and the salient facts on which it is based, and to discuss the effect of acceptance of the theory on "one's views of the Biblical account of Creation and of the Christian religion." Prof. Hopkins, on the other hand, is not a Christian apologist, but plainly sympathises with the religious syncretism which is not uncommon among American intellectuals. He seeks to disclose and, we suggest, sometimes exaggerates likenesses to be found in the advanced religions of mankind. He uses a singularly wide survey of the religious development of humanity to indicate the sort of faith which may emerge from the present clash of creeds and philosophies. He is learned, urbane, and detached.

Though the writers of the two books thus differ widely, they represent parallel developments of a characteristically modern movement. Throughout the nineteenth century there was a continuous battle between science and theology, or, to speak more definitely, between certain assumptions associated with but not essential to the Christian faith and the contradictory conclusions reached by modern investigation. Such a conflict was inevitable, for, as Prof. Gilbert Murray has justly said, the progress of human knowledge has been four times as rapid during the last hundred years as during any century since the Christian era began. The conflict, moreover, could have but one end: it necessarily resulted in the victory of "science." But, however complete the victory, the fact and value of religion remain. So it was to be expected that the victors themselves, once their triumph was assured, would turn to formulate an intellectual basis for religion. As the books before us indicate, they are now making their contribution to the restatement of theology; and theologians, learning from them, are using their own special knowledge for the same purpose.

It is well to insist that each type of specialist is needed for the work. Just as theologians half a century ago were contemptuous of the knowledge won by men of science, so now the latter often fail to realise that from the modern theologian there is much to be learnt. For lack of a theological training, the man of science who is a Christian is always in danger of stumbling into some form of "popular orthodoxy" which the theologian would repudiate. The scholar or man of science, unfamiliar with Christian theology, may easily make false generalisations from isolated statements, and, not seeing the wood for the trees, may lose sight of the essential features of the Christian *Weltanschauung*.

It is necessary to emphasise that Christianity is a synthesis. It is built upon the Gospels and their central Figure; and, of course, behind His teaching lay Jewish ethical monotheism. But the classical Creeds were developed by combining this basis with Greek philosophy and, especially, with ideas derived from Plato. In particular, it is assumed that goodness, beauty, and wisdom are absolute values: that they express the spiritual nature of the universe: that, because they have eternal value, they have eternal existence. The real world is thus the spiritual world, where these values exist eternally; and this world of ours is but an imperfect copy of a perfect archetype. Obviously the Gospel and this philosophico-religious setting form a harmony. Modern Christian theologians contend that this harmonious structure gains in strength when into it the conclusions of modern science are built. If, as we believe, they are right, changes due to modern discovery will not harm the fundamentals of Christianity, though some types of cherished picture-thinking will become obsolete.

(1) We will not attempt to describe Prof. Lane's "Evolution and Christian Faith." The main outlines of his argument will be familiar to all who have given some attention to the subject. As is common with American authors, he pays more regard to works by his own countrymen than to those of British thinkers. He writes clearly and argues fairly; and his book may be commended to those who desire to give to the science-student a clear perception of the inadequacy of materialism as a philosophy. He occasionally stumbles when he ventures outside his own realm of biology. For example, he says that Galileo, after 1632, "was thrown into prison, [and] treated with all the severity which his remorseless persecutors could devise, for the remaining ten years of his life." He obviously derives this statement from Draper's "Conflict between Religion and Science." It is inaccurate. In White's "Warfare of Science with Theology" there is a more exact account, with numerous references, of the persecution of Galileo. It was a deplorable business, but not quite so bad as Prof. Lane suggests.

To take another example, Prof. Lane, in writing of the Genesis accounts of Creation, reveals that Biblical scholarship is to him largely a *terra incognita*. He assumes that Moses is the author of the two cosmogonies of which fragments are preserved; and somewhat naïvely suggests that a modern "interpretation does not in any way convict Moses of ignorance nor deceit." Of course, the familiar first chapter of Genesis is a product of Jewish speculation of the time of the exile; and, though the second account of Creation may be some three centuries earlier, it comes from a document which no unprejudiced scholar would assign to Moses himself.

Prof. Lane does not clearly state his view of the nature of Biblical inspiration; and one might read his book without suspecting that he has any doubts as to the substantial infallibility of Scripture. With regard to miracles he suggests that they may be "in accord with some higher law of which the human mind can at present, at least, form no conception." But he is led from this legitimate belief to ascribe to Christ "knowledge which infinitely transcends our human powers." Such a view, though common, is heretical, because it impairs the perfect humanity of Christ. The orthodox formula, "very God and very Man," is both more subtle and more reasonable than is popularly realised.

Just as the technical theologian might demur to some of Prof. Lane's teaching, so the physicist might ask him to enunciate "the law of gravitation," which "holds universally in nature." But few who try to cover the ground over which the author moves could escape all its pitfalls. Taken as a whole, his work is an admirable defence of the position that there is no inherent antagonism between Christian theism and the biological doctrine of evolution. In England, save by Roman Catholics or extreme Protestants, the position is now generally accepted by Christians. Moreover, an increasing number of men of science recognise that evolution affords no secure basis for a materialist philosophy. As an interpretation of the facts presented by Nature and human nature, such systems as Haeckel's materialistic monism are inadequate. Philosophers, using all such facts, normally work towards theism or pantheism. English divines have not been slow to point out that the conclusions of modern science harmonise with the Christian outlook on human life and with the Christian interpretation of the universe. But in America there is still a widespread belief that evolution is destructive of the Christian faith.

Prof. Lane gives some amazing illustrations of the extent and effects of this mistaken fear. Mr. W. J. Bryan has led a campaign against evolution, the echoes of which are still reverberating from press and pulpit in the Middle Western States. Great religious congresses have declared evolution a "heresy." "The state of Kentucky came near enacting a law forbidding the teaching of this scientific doctrine in any school supported by public funds." A generation ago it seemed as if the Western World had finally escaped from the temper which led the Inquisition to hand over Giordano Bruno to be burnt. But the spectacle is now before us of a great democracy aflame with religious prejudice. Naturally, religion is being gravely harmed. Extreme Protestant and Roman Catholic seminaries get their supply of enthusiastic recruits, for fanaticism breeds a certain type of faith and devotion. But young men whose minds are open to the thought of the time are distracted or repelled by the conflict around them. Some believe their religious teachers; accept the view that evolution makes atheists—and become atheists. Others naturally resolve to find elsewhere than in the Christian ministry an outlet for their aspirations.

Doubtless many causes contribute to the religious obscurantism prevalent in America. But it is safe to say that one of the most effective is the bold, and sometimes extravagant, philosophico-religious speculation common in American universities. Partly owing to its mixed population and partly because of its geographical position between Europe and Asia, America produces learned men less sensitive than our own to the value of the Christian tradition. They try to survey with impartial superiority the varied manifestations of the religious spirit in Europe and Asia. They are aware of the intellectual poverty of much popular Christian thought. They view with cold and contemptuous detachment the strange and novel cults of which their own country is singularly prolific. They are attracted by the philosophical subtlety of Hindu speculation, and probably have no first-hand experience of the moral corruptions which pantheism shelters. The general effect of their teaching is rightly felt by ordinary men and women to be destructive of all religious certainty.

(2) Prof. Hopkins's "Origin and Evolution of Religion" is the sort of book to excite reactionary prejudice, for the half-educated reader will merely perceive that its values are wrong. To us it appears a mixture of wide learning and confused thought. The author gives an illuminating account of primitive religion as disclosed by modern anthropological research. As professor of Sanskrit at Yale, he naturally writes with authority of the development of Aryan religious ideas in India. He describes at length the evolution of Buddhism. He sketches the conflict, among the Greeks and Hebrews, between primitive religious beliefs and finer types of philosophico-spiritual understanding. "In Greece, a moral philosophy gradually developed apart from the gods. The Hebrews alone united ethics, religion, and an anti-polytheistic philosophy." He gives an account of the evolution of Christian theology which we find unsatisfactory. In his pages the complex movement which united Neo-Platonism to the Gospels is inadequately presented. Probably misrepresentation is inevitable in an author who can write that "it makes no religious difference whether God is regarded as essentially quite apart from or immanent in nature."

Prof. Hopkins, setting aside the Christian belief in absolute values, gives us utilitarian ethics. "The ethical law in respect of taking life is not *Thou shalt not kill* but *Thou shalt kill,* when killing aids the group. That is the reason why it was right to kill an Englishman in 1776 and a German in 1918 till November 11." Obviously it is impossible to place such teaching in the Christian scheme. But we do not see how it can be reconciled with the position which Prof. Hopkins finally reaches. "Whether called divine or not, one controlling conscious intelligence appears to exert its will towards the realisation of a moral ideal in which we participate." It seems to us that, if the implications of this conclusion are developed, the main postulates of Christian Platonism must be accepted. Such, at any rate, is the contention of some of our foremost English theologians. Men of science, interested in these matters, should study the *Confessio Fidei* which appears at the beginning of the second series of Dean Inge's "Outspoken Essays." They will find there no scientific obscurantism, and, at the same time, a powerful discrimination between the ethico-religious values of theism and pantheism which Prof. Hopkins might study with advantage.

E. W. BARNES.

Bacteria of the Soil.

Agricultural Bacteriology. By Prof. J. E. Greaves. Pp. 437. (London: Constable and Co. Ltd., 1922.) 21*s*. net.

WITH the large increase in agricultural experiment stations throughout the world, and with the growth in size and activity of such older stations as Rothamsted within the last ten years, there has been produced a vast amount of work dealing with the activities of bacteria in the soil, their relations to soil fertility, and the influence upon them of external conditions such as manurial treatment. Much of this work is disconnected, and suffers from a want of correlation with our knowledge of related subjects. There is a need, therefore, for text-books that will set in order the facts now established and point out the lines of development which our present knowledge is opening up.

Prof. Greaves has produced a book designed, not primarily for the expert, but to stimulate curiosity and inquiry in the student. The first portion is devoted to general bacteriology, discussing the morphology and schemes for the classification of bacteria, their chemical composition and physiology, and the influence upon them of external conditions such as temperature, heat, disinfectants, and salts. This is a very desirable arrangement, especially since the branches of applied bacteriology are to-day suffering from the backwardness of our knowledge of the fundamental problems of pure bacteriology. One feels, indeed, that the author would have done well to have emphasised more strongly the directions in which such knowledge is most needed. He has also included in this general section such subjects as the influence of heat, volatile antiseptics, and arsenic on soil bacterial activities. It would seem more reasonable to deal with these matters in connexion with the soil population, since the facts do not indicate a simple issue between the soil bacteria and the disinfecting agent.

The middle portion of the book deals with the soil flora and its activities, such as the production of ammonia and nitrate, the fixation of nitrogen, denitrification, cellulose decomposition, and the solvent action of bacterial metabolic products on soil minerals. At the conclusion are chapters on the relation of bacteria to water supply, sewage, dairying, food preservation, and various technical processes.

The completeness with which our present knowledge has been presented, varies very greatly in different parts of the volume. The most interesting part of the work is that which deals with the fixation of atmospheric nitrogen, where the main aspects of the subject are well put forward. Unfortunately, however, reference is omitted to some fundamental work on the soil micro-population without a knowledge of which the student cannot obtain a true picture of the activities of bacteria in the soil. Essential to this, for example, is some knowledge of recent work on the relation between bacterial numbers and the active protozoan fauna in field soil. In criticising Russell and Hutchinson's phagocyte theory of partial sterilisation, the author even states that "the work of Russell and Hutchinson does not consider the probability of the protozoa being in the soil as cysts." The existence of active protozoa in the soil was discovered by Martin and Lewin at Rothamsted in 1915, and, in the protozoology department, initiated there to investigate this subject, it has since been shown by Cutler and Crump (1920) that the numbers of active amœbæ and flagellates in field soil change from day to day, and that the increase and decrease of certain active amœbæ bear an inverse relationship to changes in bacterial numbers. The connexion between active protozoa and bacterial numbers is, therefore, established, with the consequent probability that, if this equilibrium be upset by some partial sterilisation process, such changes would ensue as were found by Russell and Hutchinson.

Again, in connexion with the production of ammonia from organic nitrogen compounds in the soil, the author does not emphasise how important is the nature of the energy supply available to the ammonifying organisms, which, apparently, are equally able to derive their energy from a non-nitrogenous source, and, where such compounds are available, may even assimilate ammonia and nitrate, thus causing a temporary loss of these compounds from the soil. The importance of this factor was pointed out by Doryland (1916). In the chapter on the decomposition of cellulose, there is no reference to the work, at Rothamsted, of Hutchinson and Clayton (1919) on the remarkable *Spirochæta cytophaga*, which led to a study by Hutchinson and Richards of aerobic cellulose decomposition as a whole, resulting in a process, now in practical use, for making artificial farmyard manure from straw.

It is admittedly impossible, in a book of this type, to cover all the work on bacteria in relation to agriculture, but, as this is the case, it would seem a pity that valuable space should have been given to such unimportant matter as, for example, the fanciful history of an individual phosphorus atom (p. 185).

The author has decided not to give references to literature quoted, but instead gives three or four papers with each chapter, which are selected as containing fuller references to the subject. In many cases, however, a student would find it difficult and sometimes impossible to trace the literature of work mentioned in the text. This, in the reviewer's opinion, is a serious defect. A text-book of this type, even though it be intended merely "to stimulate curiosity and inquiry," should, if it fulfils this purpose, lead the inquirer to a more intimate study of the subject, and, as stepping-stones to this more complete knowledge, good references to literature are essential.

There are some statements in the book which, through inadvertence, are incorrect or misleading. Thus it is stated (p. 35) that nitrogen-fixing bacteria must have atmospheric nitrogen and oxygen, but, in fact, some are anaerobic and probably all can utilise combined nitrogen where this is available. Again, the author says (p. 34) that "*most* plants cannot use nitrogen in the form of ammonia; it must be in the form of nitrates." But Hutchinson and Miller (1909) and also Prianischnikov (1916) found a considerable variety of plants that could utilise ammonia, and Hesselmann (1917) found forest soils that were devoid of bacteria capable of producing nitrate. These examples could be multiplied. Prof. Greaves has planned an interesting book, which, however, could be much more useful if some of the less important matter were omitted so that the present extent of our knowledge could be more completely covered.

H. G. THORNTON.

The Latin Works of Geber.

Die Alchemie des Geber. Übersetzt und erklärt von Dr. Ernst Darmstädter. Pp. x+202. (Berlin: Julius Springer, 1922.) 10*s*.

IN this book Dr. Darmstädter has given a German translation of the "Summa perfectionis," "Liber de investigatione perfectionis," "Liber de inventione veritatis sive perfectionis," "Liber fornacum," and "Testamentum Geberi," mainly, as regards the first four, from the edition published at Nuremberg in 1541. The texts of the Testamentum employed are those of the editions of Venice, 1542, and Danzig, 1682. The translator has included also an introduction on Geber and his writings, a list of manuscripts and printed editions of the Latin works, and many notes, together with a short glossary of alchemical terms. The book is illustrated with excellent reproductions of six plates from the 1541 edition, two from Libavius's Alchymia, 1606, and one other, of distillation, from a book published in 1512.

While Dr. Darmstädter's book is a noteworthy contribution to the voluminous literature on Geber, it cannot be said to have treated the matter comprehensively or altogether accurately. The questions of the identity of Geber and of the origin of his works "sind noch zu beantworten und sollen den Inhalt einer besonderen Arbeit bilden," but the author adopts uncritically the position of Berthelot and von Lippmann and dismisses, on entirely inadequate grounds, the possibility that "Geber" may be Jabir ibn Hayyan. The evidence on this point has recently been discussed in NATURE (February 10, p. 191 and February 17, p. 219), but it may be well here again to emphasise that practically the only facts mentioned in the Latin works which have not so far been found in the Arabic works of Jabir ibn Hayyan are the preparation of *aqua regia*, *aqua fortis*, and silver nitrate. It is significant that even such an unimportant fact as the blue copper flame, noted by Geber (p. 66), is also described by Jabir ibn Hayyan ("Book of Properties," chap. 3), and, I believe, in no other work earlier than the thirteenth century.

The list of manuscripts is incomplete. Thus there is a fourteenth-century MS. of the "Summa" in the Bodleian, and another in Trinity College, Cambridge, while in the Hunterian Library at Glasgow there is one of the thirteenth century. Dr. Darmstädter knew of no MSS. of the "Liber fornacum"; there is, however, one which professes to be a translation by Roger Bacon, in the British Museum (*Sloane*, 1118, ff. 60-71). It is probably of the fifteenth century. At Gonville and Caius College there is a fifteenth-century MS. of the "Secreta Secretorum in opere solaris et lunaris," attributed to Geber; the title corresponds with that of a work by Jabir ibn Hayyan, the "Kitāb sirr al-Asrār." The Bodleian MS., "Ad laudem Socratis dixit Geber" (fifteenth century), calls to mind the work of Jabir entitled "Musahhihat Socrat," mentioned in the "Kitāb al-Fihrist," but now lost.

The translation is good and in general accurate, but it seems a pity that it was made from printed editions and not from early manuscripts, when it would have been much more authoritative. The notes are clear and scholarly; the information they contain is largely derived from Prof. E. O. von Lippmann's "Entstehung und Ausbreitung der Alchemie." In view of the fact that copies of Geber's works are scarce, the present edition will be welcome to all chemists, for Geber had a pleasant style and his writings are full of interest and still worth reading. It is satisfactory, too, to see that the book is to be sold in England at what appears to be a very modest price.

It is perhaps fitting, in concluding this review, to ask the pertinent (but, it is to be hoped, not impertinent) question: "If Geber was not Jabir ibn Hayyan, who was he?"

E. J. HOLMYARD.

The Living Plant.

Botany of the Living Plant. By Prof. F. O. Bower. Second edition. Pp. xii+634. (London: Macmillan and Co., Ltd., 1923.) 25*s.* net.

THE publication of a second edition of Prof. F. O. Bower's excellent "Botany of the Living Plant" less than four years after the appearance of the original work shows that the volume has received the recognition it so justly deserved. This new edition has undergone a good deal of alteration, much of which has been made by the author as a result of criticisms and friendly suggestions.

The changes have certainly improved the book to a very considerable extent, the most important being the treatment of the Cryptogams and Gymnosperms, which occupy the second half of the work. Instead of these plants being arranged with the Coniferæ at the beginning and the fungi, bacteria, and algæ at the end, Prof. Bower now begins the second half with a very useful chapter on evolution, homoplasy, homology, and analogy. This new chapter serves to introduce the progressive series of plant forms the life histories of which are traced in evolutionary series from the simplest Thallophyta to the complex Gymnosperms in the chapters which follow.

The series of chapters, culminating in the ferns and conifers, is followed now quite logically by the chapters on "Alternation of Generations and the Land Habit" and on "Sex and Heredity," which, though they have very properly been transposed, come at the end of the book as formerly.

The appendix (A) on types of floral construction in Angiosperms then follows, and forms a useful introduction to the systematic study of plants; and appendix (B) on vegetable food-stuffs is followed by a carefully compiled index and glossary; these complete the volume as in the first edition.

Several minor alterations have been noticed in comparing the two editions, and they are all distinct improvements: in particular the new chapter on "The Living Cell" deserves special notice. This chapter is a very useful addition, since, in the first edition, the general physiological conditions of the plant cell were not treated so fully as is necessary for a proper understanding of that continuous living system of which the plant body consists.

In this new edition, after describing fully the cellular construction of plants, the structure of the several living units which compose the plant body follows naturally, and allows the succeeding chapters on the tissues of stem, leaf, and root, and on general physiology, to be fully appreciated.

Specialists in one branch of botany or another may perhaps feel that sufficient space has not been given to one or other aspect of botanical science, which now covers so wide a field; but, as Prof. Bower very justly says in his preface to the first edition, "No attempt has been made after encyclopedic writing," and we feel that it is well for the student who is to be introduced to the plant as a living organism that the author has confined himself so admirably to the object on which he embarked, and has succeeded in producing a book which is certainly the standard British work on general botany.

Our Bookshelf.

War: Its Nature, Cause, and Cure. By G. Lowes Dickinson. Pp. 155. (London: G. Allen and Unwin, Ltd., 1923.) 4*s.* 6*d.* net.

WITH his usual convincing sincerity, Mr. Dickinson sets out the unanswerable case against war. He appeals especially to younger men to realise what the nations have done, what they are doing now, and what it must all lead to unless the issue is honestly faced, and every one makes up his own mind clearly as to whether he wants war or not. For readers of NATURE as such, the book would therefore have no immediate interest were it not that the author brings into some emphasis the relations of science and men of science to warfare.

If mankind does not end war, war will end mankind. If this has not been true in the past, it is true now because modern war is linked with modern science, which, if the chief hope for the world, is also its chief menace. Men of science have in consequence more than average weight in deciding whether war is to continue or not; and some at any rate of them will not fail to be moved by Mr. Dickinson's appeal to bring all the prestige and intelligence of natural knowledge on to the side of those who mean to end war. He suggests that chemists and physicists and others who might be concerned should collectively and internationally announce that they did not propose to communicate to governments anything which would be useful in war—an impossible proposition, as the author would know if he had more acquaintance with the history and mode of progress of scientific knowledge and with the ingenuity with which men who are determined to kill will degrade every scrap of human information to their end. But it is no impossible chimera that men of science should refuse to help in applying their special knowledge to the prosecution of war, and should let it be known that if war is to continue it must be waged without their assistance. Mr. Dickinson, at any rate, will be satisfied if they will read his book, reflect honestly and plainly on the implications of what he has to say, and bring to their conclusions the same independence and clarity that they apply to their daily work. It is difficult to believe that there will be many who after doing this will still be on the side of war. A. E. B.

British Museum (Natural History). Guide to the Exhibition Galleries of Geology and Palæontology. Pp. 64. (London: British Museum (Natural History), 1923.) 1*s.*

THE Keeper of Geology, in his preface to this small book, says, "It is merely a guide, not an introduction to the study of fossils." Those familiar with official scientific publications may appreciate the modesty and wisdom of this statement. But intelligent members of the general public, for whom the book has been written, will soon find that the statement errs on the side of diffidence; they will say, "This is not merely a guide, but a remarkably good guide"; and, taking it with them round the galleries, may discover to their advantage that it is one of the best short introductions to the study of fossils in the English language.

The casual visitor to these magnificent geological collections is often bewildered by the multitude of objects and oppressed by the strangeness of nomenclature. With this guide he will be led in an orderly and logical manner through the whole series of exhibits, his attention being directed only to outstanding features of each group; the systematic names are explained in everyday terms and the essential characters of the fossils are made clear, while no opportunity is lost of showing how the forms of these extinct creatures throw light upon their habits and phylogeny. Thus a great deal of sound information is woven into a readable story, which does not neglect human interest but links up the fossils with their discoverers or with some apt reference to literature or history. Who will not be tempted after reading of Thomas Hawkins to look up his descriptions of the hunt for Ichthyosauri, or to renew an acquaintance with "The Chambered Nautilus" of Oliver Wendell Holmes?

Dr. F. A. Bather, the author, has rendered good service to palæontology and to the public at a time when there was never more need for a straightforward introduction to this valuable and fascinating branch of knowledge, understandable by the ordinary man. J. A. H.

The Microscope: A Practical Hand-book. By L. Wright. Enlarged and rewritten by Dr. A. H. Drew. Pp. 287. (London: Religious Tract Society, n.d.) 5*s.* net.

IN the earlier chapters of this book an excellent account is given of the fundamental principles of optics, the practical optics of the microscope, and of the simple and compound microscopes. The salient features of a number of microscope stands by various makers are detailed and many of the instruments figured. Accessories, dark ground illumination, and methods for testing objectives are also described, together with manipulation and photo-micrography. Separate chapters are then devoted to the various objects of microscopy, such as pond and insect life, animal and vegetable histology, and others, with directions for manipulating and mounting them. The sections on staining have been revised and brought up-to-date and new stains and methods introduced. Thus, directions are given for the demonstration of mitochondria, the Golgi apparatus, karyokinesis, etc. The book contains a mass of accurate information, is profusely illustrated, and can be cordially recommended, not only to the beginner, but also to many who have already passed the elementary stage.

Organic Chemistry: or, Chemistry of the Carbon Compounds. By Victor von Richter. Edited by Prof. R. Anschütz and Dr. H. Meerwein. Vol. 3: Heterocyclic Compounds. Translated from the Eleventh German edition by Dr. E. E. Fournier d'Albe. Pp. xviii+326. (London: Kegan Paul and Co., Ltd.; Philadelphia: P. Blakiston's Son and Co., 1923.) 25s. net.

THE present volume, like the two preceding ones, is a useful guide to organic chemistry for general laboratory use, but it suffers from the same defect in being out-of-date. Heterocyclic derivatives of phosphorus and arsenic, for example, do not appear in the index, nor, apparently, in the text. References to English work are given to the German *Centralblatt,* without the names of the authors, and one gathers the entirely incorrect impression that organic chemical work is confined almost exclusively to Germany. The nomenclature is not always that adopted in England; the quinoline nucleus is numbered according to a system which has not been in use in this country for many years. The best method of preparation of a substance is not specially indicated, and not enough distinction is made between methods of *preparation* and methods of *formation.* Until English chemists supply their own needs, however, such books will have to be used.

Atoms. By Prof. Jean Perrin. Authorised translation by D. Ll. Hammick. Second English edition revised. Pp. xv+231. (London, Bombay and Sydney: Constable and Co., Ltd., 1923.) 8*s.* 6*d.* net.

THE second English edition of Prof. Perrin's inimitable book has been carefully revised in accordance with the eleventh French edition, and a certain amount of new matter added for the first time. The latter covers, for example, Perrin's new theory of radiation and chemical change, and there is a complete list of isotopes at the end of the book. Of the original work it is scarcely necessary to say anything: it has become a scientific classic, and is at the same time an account of the latest views on the subject. The translation has been well done, and the meaning is clearly rendered. In one or two cases (*e.g.* p. 112) "ou bien" has been translated "better," which is not its meaning in the examples cited.

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 Crossed-Orbit Model of Helium.

THE spectrum formula

$$\nu = \mathrm{N}\left[3 - \frac{7}{4\pi}\mathrm{F}\left(\sin\frac{i}{2}\right)\right], \quad . \quad . \quad . \quad (a)$$

proposed for helium in my letter of March 1 (NATURE of April 28, p. 567), was shown to yield, for $-\cos i = \frac{1}{2}$, the correct ionisation potential and, for $\frac{4}{5}$, $\frac{2}{3}$, $\frac{3}{5}$, $\frac{5}{9}$, the four Lyman lines; with that corresponding to the former as the limit. The deduction of this formula (on lines by no means classical) and the attitude to be taken with regard to the "negative" results obtained in the meantime by Dr. Kramers by means of classical mechanics (*Zeits. f. Physik*, 13, 312) have been fully explained in a paper appearing in the June issue of the *Astrophys. Journal*, and need not be repeated here. The purpose of this letter is to point out some further peculiarities of the formula (*a*) as such, which will be seen to bring order into the apparently queer correlation given before.

If the simple rational values of $-\cos i$ are ordered in descending magnitude, namely,

$$\frac{4}{5}\ \left(\frac{3}{4}\right)\ \frac{2}{3}\ \left(\frac{5}{8}\right)\ \frac{3}{5}\ \left(\frac{4}{7}\right)\ \frac{5}{9}, \quad . \quad . \quad . \quad (b)$$

every second, bracketed one, covers no observed line, while the others represent orderly the first four members, $m = 1$, etc., of the Lyman series $o\mathrm{S} - m\mathrm{P}$. Extrapolating the regular sequence of the last three fractions by

$$\left(\frac{6}{11}\right) \text{ and } \frac{7}{13},$$

one would expect the former to cover no line and the latter to represent the line $o\mathrm{S} - 5\mathrm{P}$, which, though hitherto not observed, can be expected with confidence. Now, with Lyman's oS and the usual 5P, this line should lie at $\lambda_5 = 512{\cdot}1$, while formula (*a*) gives, for $\cos i = -7/13$, $\lambda = 512{\cdot}3$. Again, turning to the left-hand end of the sequence (*b*), the next fraction $\frac{5}{6}$ naturally suggested itself as worth trying. For this value of $-\cos i$ ($i/2 = 73{\cdot}221°$, $\mathrm{F} = 2{\cdot}6642$) formula (*a*) gives $\lambda = 601{\cdot}2$, which is very close indeed to the "single line at $600{\cdot}5 \pm 0{\cdot}3$," repeatedly obtained by Lyman. As I understand from Prof. Lyman himself, he feels reasonably certain that it is genuine and that it belongs to the spectrum of helium. Moreover, from the semi-empirical point of view, the "combination" line $o\mathrm{S} - 1\mathrm{S} = 198{,}300 - 32{,}033$ would lie at $\lambda = 601{\cdot}3$, which is still closer to our result.

Thus, gathering the scattered items, we have, as an extension of (*b*), the following correlation (in which the bracketed numbers cover no observed lines):

$$\underset{o\mathrm{S}-1\mathrm{S}}{\frac{5}{6}}\ \Bigg|\ \underset{\lambda_1}{\frac{4}{5}}\ \left(\frac{3}{4}\right)\ \underset{\lambda_2}{\frac{2}{3}}\ \left(\frac{5}{8}\right)\ \underset{\lambda_3}{\frac{3}{5}}\ \left(\frac{4}{7}\right)\ \underset{\lambda_4}{\frac{5}{9}}\ \left(\frac{6}{11}\right)\ \underset{\lambda_5}{\frac{7}{13}}\ .\ .\ .\ \underset{\lambda_\infty}{\frac{1}{2}}. \quad . \quad (c)$$

Notice that, according to Prof. Lyman, the arc spectrum of He contains no lines in addition to those here covered. The regular intermittency of (*c*), so far as the members $o\mathrm{S} - m\mathrm{P}$ are concerned, is manifest. The position of $o\mathrm{S} - 1\mathrm{S}$—the "queer" line, as Dr. Compton of Princeton called it—is correspondingly queer. Yet even this, though only a combination line, fits into the further remarkable regularity of the whole sequence (*c*), to wit, that the differences between the successive fractions are all of the form $1/np$, thus $5{\cdot}5 - 4{\cdot}6 = 1$, $4{\cdot}4 - 3{\cdot}5 = 1$, $3{\cdot}3 - 4{\cdot}2 = 1$, and so on. This curious feature was first noticed by my friend Prof. A. S. Eve of Montreal only after the whole array (*c*) was spread over the black-board in a recent lecture at the Bureau of Standards. It may thus be said to have grown out spontaneously, and certainly did not influence the writer in constructing the proposed formula.

So long as intra-atomic dynamics is awaiting its final shaping from modern groping attempts at a suitable modification of ordinary mechanics, every such regularity of correlation, no matter how "magical" in appearance, seems worthy of noticing, as a possibly helpful hint how to alter the old laws for intra-atomic purposes. LUDWIK SILBERSTEIN.

129 Seneca Parkway,
Rochester, N.Y., May 15.

Symmetry of Calcium Thiosulphate Hexahydrate.

CALCIUM thiosulphate hexahydrate, $CaS_2O_3 . 6H_2O$, is usually quoted in works on crystallography as an example of the triclinic asymmetric class, C_1^1—perhaps as the only known crystal which definitely represents this type of structure. It is described in Tutton's "Crystallography" (new edition, p. 280, old edition, p. 285), and, in more detail, in Groth's "Chemische Krystallographie," vol. 2, p. 676. In the latter we read

$CaS_2O_3 . 6H_2O$. Asymmetric. Sp. gr. 1·872.

$a : b : c = 0{\cdot}7828 : 1 : 1{\cdot}5170.$

$\alpha = 72°\ 30'$, $\beta = 98°\ 34'$, $\gamma = 92°\ 45\frac{3}{4}'$.

The process by which symmetrical crystals are built up from less symmetrical material has been recently described by Sir William Bragg ("The Significance of Crystal Structure," Trans. Chem. Soc., 1922, vol. 121) and G. Shearer ("The Relation between Molecular and Crystal Symmetry as shown by X-ray Crystal Analysis," Proc. Phys. Soc., February, 1923). In the latter paper the author suggests that Nature never uses more molecules than are absolutely necessary for the purpose; that is, no more than N asymmetrical molecules will be used in the construction of a crystal of "symmetry-number" N, or, if the symmetry of the molecules be that of some class n, then no more than N/n will be used. Up to the present this hypothesis seems to be justified. In all organic crystals that have been examined in Sir William Bragg's laboratory not one has yet been found to contradict it. In all cases there has been no evidence to show that polymers of chemical molecules have been used, but, on the contrary, abundant evidence to show that the ultimate structural bodies correspond to the simple chemical molecules. Furthermore, it has been shown that, in general, the symmetry of a crystal is of a higher type than that of the molecules from which it is built—a rule which seems to be almost universally true. Especially with complex molecules does Nature resort to the device of combining a molecule with its digonal or its enantiomorph before using them to construct a Bravais lattice.

In view of these considerations it seemed very probable that, should a truly asymmetric crystal be obtained, its space-lattice would be found to be constructed of asymmetric groups of atoms corresponding to single chemical molecules; that is, it would be found to contain only one molecule per fundamental cell. Such a case seemed to be presented by $CaS_2O_3 . 6H_2O$, and, indeed, it was expected that X-rays would show it to be a simple triclinic lattice of single asymmetrical molecules, obeying, of course, the law of rational indices, but exhibiting no symmetry operation beyond that of identity.

By means of the Bragg ionisation spectrometer an examination of this crystal has been carried out. The results are in full agreement with a *two-molecule* cell (Table I.).

TABLE I.

Plane.	Spacing.		Approx. Intensities (Height of Peak).			
	Calc. on 2 per Cell.	Obs.	I.	II.	III.	IV.
001	10·66	10·66	32	40	21	17
011	6·93	6·84	15	23	22	2
012	5·04	5·04	11	23	3	..
010	7·09	7·04	46	24	22	..
$0\bar{1}1$	5·23	5·21	8	110	2	1
$0\bar{1}2$	3·76	3·77	63	45	4	..
$0\bar{2}1$	3·10	3·10	1	10	..	..
$0\bar{1}3$	2·86	2·86	90	7	..	..
100	5·76	5·76	18	47	1	2
101	4·79	4·80	0	7	13	7
201	2·69	2·66	11	5	..	..
301	1·84	1·84	8	0	..	..
$1\bar{1}0$	4·48	4·48	32	5	4	..
$1\bar{2}0$	3·03	3·03	18	17	2	..
$1\bar{3}0$	2·19	2·18	11	4	..	..
$2\bar{1}0$	2·67	2·67	31	2	0	..
110	4·46	4·46	0	70	5	0
210	2·66	2·66	7	14	..	..
111	4·23	4·23	96	18	13	..
211	2·57	2·57	9	2	..	..
$1\bar{1}\bar{2}$	4·08	4·08	70	9	2	..
$1\bar{1}\bar{1}$	4·65	4·65	55	45	15	..

Of course, we might now argue that this does not prove anything, since the theory of space-groups takes no cognisance of the structure of the ultimate asymmetric units, but confines itself to the number and relative orientations of these necessary to produce one or other of the 230 homogeneous point-systems. Theoretically, it is just as easy to conceive of a crystal of the class C_1^1 being built from a two-molecule cell as from a one-molecule cell. In the former case it would simply mean that to construct an asymmetric lattice, Nature, at variance with her usual procedure, had used an asymmetric polymer of the chemical molecule instead of the single molecule.

In spite of this, it is here suggested that $CaS_2O_3 . 6H_2O$ is *not*, after all, the unique example of the triclinic asymmetric class, but only one of the many examples of the pinakoidal class C_i^1. The following reasons are given for this: (1) in all complex crystals so far examined, the ultimate structural unit has proved to correspond to the chemical molecule; and (2) there is a mass of evidence to show that the crystal symmetry, as deduced from a study of facial development and etched figures, is often of a lower type than the true structural symmetry as deduced from X-ray data (and generally confirmed by other indications). An interesting paper dealing with this subject has recently been contributed by E. T. Wherry, *Am. Journ. Science*, September 1922; but as a few well-known examples of this pseudo-symmetry we may cite potassium chloride (cubic holohedral, *not* pentagonal icositetrahedral), diamond (cubic holohedral, not hexakis-tetrahedral), cuprite (cubic holohedral, not pentagonal icositetrahedral), wulfenite (tetragonal holohedral, not pyramidal), and ammonium chloride (not pentagonal icositetrahedral, but either hexakis-tetrahedral or holohedral). The last-named is especially interesting since it has been examined by several workers. It now seems conclusive that its structure is what was originally suggested (Bragg, "X-rays and Crystal-Structure," p. 158), that it belongs not to an enantiomorphous class of the cubic system but to a class showing planes of symmetry (probably hexakis-tetrahedral—see R. W. G. Wyckoff, *Am. Journ. Science*, December 1922). With such crystals as these we must class many of the co-ordination-compounds of the type $\{Me'''(X_3'')\}R_3 . nH_2O$ examined by F. M. Jaeger ("Recherches sur le principe de Pasteur," *Rec. d. trav. chim. d. P. B.*, tome xxxviii.). Though substances of this type are very strongly optically active, many of their crystals appear to lack the characteristics of the enantiomorphous classes.

These few examples will suffice to show that it has become unsafe to argue from form development and etched figures, that, for example, the hitherto accepted evidence for placing $CaS_2O_3 . 6H_2O$ in the asymmetric class is not trustworthy. It is becoming increasingly clear that the boundary conditions of a crystal are often so different from the conditions obtaining inside the structure that not only the growth but also the inverse process of solution (etched figures) leads to a definite *under*-estimate (in most cases) of the real internal symmetry.

On the other hand, all the evidence so far is now in favour of placing $CaS_2O_3 . 6H_2O$ in the pinakoidal class, since the cell contains two molecules, and, by analogy with other known structures, these may be taken to be centro-symmetrical with respect to each other. It is true that this latter supposition cannot yet be proved, because in the triclinic system the two molecules, provided they are so orientated as to be centro-symmetrical with respect to each other, may occupy any relative positions in the cell. However, X-rays certainly show that the *smallest* cell which repeats through space contains two chemical molecules, and that there is no evidence that they are alike. The inference then is that they are the inversions of each other and that the complete structure is in reality centro-symmetrical. In this connexion it should be noted that two other triclinic crystals have also been thoroughly examined, namely, anhydrous racemic acid and racemic acid monohydrate. If only for chemical reasons, there is no doubt that these two crystals are built of molecules which are inverse to each other, and X-rays again show that the smallest cell which repeats through space contains *two* chemical molecules only.

If we knew more about the intensities of X-ray reflections, we should be able to prove that the two molecules in the cell of $CaS_2O_3 . 6H_2O$ are inverse to each other, but for the present this is impossible. For the same reason, no attempt has been made to fix the atomic positions in the cell. An examination of the optical properties would be highly desirable, with the view of detecting rotatory polarisation, should any be shown. Such a test would then be practically decisive.

For the preparation of the crystals which have been examined, I wish to express my indebtedness to Mr. C. P. Proctor, of the Chemical Laboratory, University of Birmingham.

W. T. ASTBURY.
Physics Department,
University College, London.

A Method of Photographing the Disintegration of Atoms and of Testing the Stability of Atoms by the Use of High-speed Alpha Particles.

WHILE the experimental work of Rutherford demonstrates the disintegration of the nuclei of the atoms of six elements of odd atomic number to give long-range hydrogen nuclei, it does not show whether shorter-range products of disintegration are emitted. It occurred to one of the writers several years ago that the photographic method of C. T. R. Wilson would be the best means easily available of actually testing the stability of the nuclei of atoms for the different types of disintegration, particularly when the particles emitted have a short range. In the earlier applications of this method polonium has been used almost exclusively as the source of α-particles. The α-particles thus emitted have a relatively small kinetic energy, so the evidence obtained from the photographs is not of much value in its bearing on nuclear stability. The writers have therefore used the high-speed α-particles from thorium C′, with a velocity of $2{\cdot}05 \times 10^9$ cm./sec., or 0·688 c.

In an earlier letter (NATURE, January 27, p. 114) we gave a photograph showing the sharpest collision obtained in ten thousand exposures, the α-particle being turned through an angle of about 125°. The sharpest collision given by Blackett (Proc. Roy. Soc. A, 103, p. 79 (plate 3)) is less sharp, since the α-particle is turned through an angle of 110° or less. Fig. 1 shows two views, taken from directions perpendicular to each other, of a collision between an α-particle and the nucleus of an atom of air. This is the sharpest collision we have obtained by taking twenty-one thousand photographs. In this case the α-particle is turned through an angle of 165°, so that the lines which show the track of the α-particle before and after the collision exhibit a sharp angle equal to 15°.

In an ordinary collision the initial track of the α-particle splits into two branches beyond the point where the collision takes place. One of these is due to the rebounding α-particle, and the other to the forward track of the nucleus which is hit. If this nucleus were to disintegrate during the collision or quickly enough afterward, an additional track would emerge from the point of collision, and this would be due to the fragment, such as a hydrogen nucleus or an α-particle, which is ejected. It is possible, too, that electrons or other additional particles might

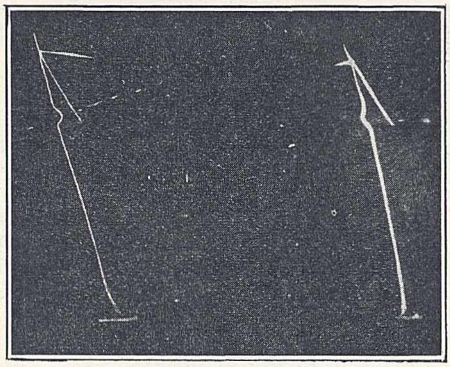

FIG. 1.—α-ray track which splits into three branches after a collision. The upward loop in the initial track is due to the diffusion of electrons out of a region partly robbed of water vapour by an earlier track.

also be emitted, so that the track might split into even more than three branches. However, all of the particles thrown off may not produce visible tracks. Thus the tracks given by high-speed electrons are faint, and are sometimes invisible in parts of the gas which have been robbed of their water vapour.

The extremely sharp collision photographed in Fig. 1 exhibits the very interesting phenomenon that the original track splits into *three branches at the point of collision, which is exactly the characteristic to be expected if the bombarded atom disintegrates.* The film on which the photograph was taken shows the lines at the point of collision much more plainly than the reproduction, and a study of the black lines on the film as seen under the microscope indicates that the third particle is shot diagonally upward, exactly from the point of collision as nearly as this can be determined by a microscopic examination of both of the views (taken at right angles). The great relative brightness of the track of this particle is due to the fact that the camera gets a "head-on" view. The discussion of the momentum relations will be left to a more complete paper, but it may be stated that, so far as we are able to determine, the collision does not exhibit conservation of momentum if the particle which shoots upward is left out of account. If this could be definitely proved it would give remarkably substantial evidence, in addition to that of the number of tracks, that a disintegration has occurred.

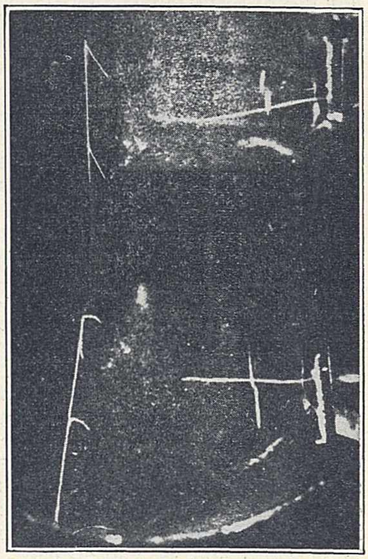

FIG. 2.—Nearly parallel curved tracks of particles ejected backward. Probably these are due to electrons.

Bumstead, and later Wilson, have secured photographs of the tracks of δ-rays, supposedly due to electrons pulled out of the non-nuclear systems of the atoms through which the α-particle passes. These tracks are extremely short, and are most easily seen when the expansion in the ionisation chamber is not too high. Fig. 2 shows an entirely new type of secondary track. Here what appear to be electrons are thrown out a great many times as far as in the δ-rays, and in a different direction. The two electron tracks curve upward, show a backward motion, and are remarkably close to being parallel. They differ so markedly from those of the δ-rays that they may be considered as a different type of ray. They may be designated as ζ-rays.

Altogether about eighty thousand tracks have been photographed. From the assumed dimensions of a molecule in air it may be estimated that each α-particle passes through between 100 and 200 thousand atoms, so approximately 10 billion atoms have been shot through, with the result that only three nuclear collisions have resulted in which the initial α-particle has been given a *retrograde* motion. In only one of these, as illustrated in Fig. 1, has the collision been very direct. The photographs show many other interesting relations which cannot be discussed here.

WILLIAM D. HARKINS.
R. W. RYAN.

Science and Economics.

MAY I bring this correspondence back to earth by recalling that I based my deduction that no one even pretended to understand the present economic system upon the fact that, although the age is as far ahead of any preceding epoch in the science of producing wealth as it is in astronomy or chemistry, yet millions of folk are (1) without decent means of subsistence, (2) idle? My impression, in directing the attention of scientific men to this problem, was that a very little of the original thought which they habitually devote to more abstract questions would give the solution of this one. But I scarcely bargained for NATURE being so widely read as to render it necessary for me to meet philosophical arguments.

Mr. Leisenring, who devotes four of your valuable columns to a defence and elucidation of the philosophy of the system challenged, looks characteristically for a change of ideals to bring about the readjustment which he admits to be most urgent. Now, what was there reprehensible about the ideals of the nineteenth century? Was it not the ideas which were upside down? I need not follow him in his fanciful descriptions of and deductions from my views, though, indeed, it is a novelty for readers of NATURE to be told that a proposal to ascertain the physical basis of economics is tantamount to an attempt to baulk human evolution and to impose upon man an inferior order of existence. Surely most of us thought that the ascertainment and understanding of the laws of Nature were preliminaries to governing and directing them to human ends. Eastern proverbs notwithstanding, the achievements of one age in this field are the starting-point of those in the next. Your correspondent seems to confuse the methods of science with those that apply to the government and direction of men at the hustings, on the battlefield, in the Courts and theatres, and by the general Press. Such confusion is widespread, and the results of scientific progress need to be safeguarded and made "fool-proof" from the interference of the humane genius.

However, I cordially agree, and have myself remarked, that the original great rulers of the world were under no such vulgar delusions as are current to-day about gold and money. Mr. H. O. Weller recently told me that Kublai Khan's currency was of *papier mâché*, and that some of his coinage is extant. The important point to them was not what the coin was made of, but whether they issued it. My description of the present financial system as counterfeit was in allusion to the fact that less than 1 per cent of the money functioning as such is authorised by the King and issued by the Royal Mint. Olden-time rulers issued the currency, but that also is "inverted." Since millions are (1) destitute, (2) idle, the presumption is that, although many may understand perfectly the art of making money, the reason which makes this, necessarily, a royal prerogative is now not understood by any one.

I am sorry if the laws of evolution preclude, and the annals of history do not record, an absolute innovation, and I cannot defend the word "absolute," since innovations are necessarily relative. But it will be in the memory of many that recently there was a war, and, before a shot had been fired, a moratorium terminated the old financial system. The public credit became necessary to maintain solvency. Though it would be rash to predict that in the future the old system may not be restored in a modified form, it does not appear imminent. On my analysis it is difficult to see how the public credit can be dispensed with. For what else is behind the colossal accumulation of indebtedness which we have inherited from the age of irreproachable ideals and inverted ideas? The honest intentions to meet "promises to pay," and the ability to perform what this industrial age and its ideals demand, were quietly transferred to the broader shoulders of the public during the hubbub preceding Armageddon. The rope has been lengthened and its end attached to a larger neck. The ultimate basis of credit has been widened, but from the point of view of physics it is still credulity.

The spontaneous increment of wealth is subject to the laws of thermodynamics, like all conversion of natural resources, whether to useful or useless forms. You may *measure* it, so long as it exists to measure, by the spontaneous increment of debt, and the philosophy of usury is much more interesting no doubt than thermodynamics, and is likely to counteract the unemployment engendered by the achievements of the latter science, even among those who, like your correspondent, find life tends to become uninteresting. So you can measure the horse-power of an engine by braking it, or the content of a pot, not only by filling it when empty but also by emptying it if it be full. For any other purpose than mere measurement, however, to try to fill a leaky pot, or to run an engine with brakes on, is foolish. So long as wealth production was not understood, the virtues of gold or usury or other magical influence could be invoked. But that time is past. Until Mr. Lane Fox Pitt came to the rescue with his euphemistic theory of psychological inversion (NATURE, May 19, p. 670), I found it difficult to discuss these matters without giving offence. I fear, however, that a system of economics based on a philosophy of usury imagines the process of emptying to be a reversible cyclic process—that the pot is emptied back into the clouds rather than into the ocean.

To come to the concrete, I have a method of producing, more economically than any other person, the goods that the community desire. Is that a collateral security? No: but if I have a block of receipts for the wealth blown up in the Napoleonic wars, known as Consols, or any other gilt-edged security, I can obtain the community's credit at any time, without the necessity of being able to produce anything at all. The process is almost too incredibly Gilbertian to discuss in NATURE. But clearly there is something very different in practice from primitive philosophic conceptions of credit, since the power to pledge the community's credit is vested, not with those with ability to produce but with those with ability to consume, though the powers of consumption may date back to some remote forerunner of the modern patriot in the Napoleonic era, and the goods consumed then may have already been paid for many times over.

The use of mechanical energy made possible an enormous, if finite, increase of the *revenue* of wealth. This annual *revenue*, by the simple process of dividing it by the rate of interest, say 0·05, is multiplied by twenty or "capitalised." The capital, however, differs from the earlier forms of credit, such as land or factories (that is, until they become obsolete and tumble down), in being non-existent, and this difference I submit is fundamental. It is also under the necessity of increasing according to an exponential law without limit, which is physically absurd.

FREDERICK SODDY.

[We regret to be unable to devote space to further correspondence on this subject.—EDITOR, NATURE.]

A Puzzle Paper Band.

PROF. C. V. BOYS's puzzle (NATURE, June 9, p. 774) is a deal less puzzling (as he doubtless knows) if we begin it at the other end. Instead of making the long belt with its two loops which he describes, and then trying to reduce it to the well-known half-twist "double surface" (cf. *e.g.* Forsyth's "Differential Geometry," p. 296) of double thickness, let us begin by laying two strips of paper one on the other;

then with a half-twist bring the ends together, and fasten the corresponding ends each to each. Our half-twist will have brought one end of the lower strip into contact with the other end of the upper strip; and what we then obtain, on opening out, is the long loop (or "worble," to use Maxwell's word) with its two curls, which Prof. Boys starts with. We have simply *split* into two sheets our original one-sided, one-edged surface, and obtained a new *bifacial* surface thereby, precisely as Mr. B. M. Sen explains in his recent paper on "Double Surfaces" in the Proc. Lond. Math. Soc.

We may vary the experiment by starting with three sheets (or with five) instead of two. The middle sheet or strip, joining on to itself, will always remain the half-twisted loop, the unifacial surface; while each adjacent pair of strips will constitute a bifacial surface such as Prof. Boys describes. The median loop will involve, or link together, all the others; but the manner in which these latter interlace with one another is more complicated. The problem of how to split an anchor-ring into two rings, interlinked with one another, is a simple corollary.

It is somewhat curious at first sight, but obvious after all, that we arrive at precisely the same result whether we split our sheet, or cut it longitudinally. Begin with one broad strip, joining its ends together into the half-twisted unifacial surface; then make one continuous longitudinal cut, not far from the edge. This single cut gives us two complete loops, one being the border and the other the median zone of our broad strip. The median band has its properties unaltered; it is still the half-twist unifacial surface, only narrower than before. The other, on which our scissors have bestowed a second edge, is the bifacial surface which Prof. Boys calls his "puzzle band." D'ARCY W. THOMPSON.

44 South St., St. Andrews,
June 19.

Active Hydrogen by Electrolysis.

WENDT and Landauer (Jour. Amer. Chem. Soc., March, 1922, p. 513) failed to get any evidence for the presence of active hydrogen, generated by the action of an acid on a metal, or by the electrolysis of a solution of KOH. Similar results were also obtained by Y. Venkataramaiah (Proc. Sci. Assoc. Maharaja's College, Vizianagram, July 1921, p. 2). We have repeated the experiments, and find that hydrogen is actually activated when a conducting solution is electrolysed. We electrolysed a solution of dilute sulphuric acid, employing a platinum tube with a large number of pin-holes bored in it, and using a current varying from 3 to 15 amperes. While the electrolysis was going on, compressed nitrogen was bubbled through the solution, through the platinum electrode, to see if any ammonia were formed, as Wendt and Landauer found that active hydrogen combines with nitrogen to form ammonia. After a run of nearly twelve hours, the presence of ammonia was tested in the resulting solution. The result was positive.

Another method was also tried, using an iron tube as an electrode. It is known that nascent hydrogen diffuses through metals like iron even at ordinary temperatures. So it was found convenient to diffuse nascent hydrogen through the iron tube and test for the presence of active hydrogen by drawing it over cold powdered sulphur, the presence of hydrogen sulphide being tested for with a lead acetate paper. Here also a positive result was found.

The experiments with a metal and an acid are not yet successful. The failure in the case of the experiments of Wendt and Landauer, in our opinion, is due not only to the difficulties in removing the spray but also to the action of active hydrogen on the spray itself. Certain preliminary experiments conducted by us show that active hydrogen is decomposed by the spray with the formation of hydrogen peroxide.

It is a pleasure to note from the latest number of NATURE to hand (May 5, p. 600), that Prof. A. C. Grubb has succeeded by an ingenious experiment in demonstrating the presence of active hydrogen in the hydrogen generated by the action of hydrochloric acid on magnesium.

Y. VENKATARAMAIAH.
BH. S. V. RAGHAVA RAO.

Research Laboratories, Maharaja's College,
Vizianagram, S. India,
May 28.

The Transfinite Ordinals of the Second Class.

THERE is a theorem in the transfinite calculus that any ascending sequence of ordinal numbers of the second class has a limit which is also of the second class. This theorem is important, being wanted to prove that the aggregate of these ordinals is unenumerable.

Now consider the set of numbers 1, 2, 3, ω, $\omega+1$, $\omega+2$, $\omega.2$, $\omega.2+1$, ω^2, ω^2+1, etc. The mode of formation is that each number exceeds the preceding one by unity, except that if the plan we are following leads us to a limit we write down only a finite number of numbers according to that plan, and then write down the limit and the limit increased by unity, and so on. The set is normally ordered, and each element has an immediate predecessor, whence we easily see that it is a sequence. But it cannot have any limit in the second class, for if the limit is α the sequence must contain α and $\alpha+1$.

Does this contradiction with the first theorem show that the ordinals of the second class form an "inconsistent" aggregate? It differs from that of the Burali-Forti paradox in that we do not assume that our aggregate has an ordinal number before we get the contradiction. It agrees with it in that no contradiction arises if we consider segments only of the aggregate of ordinals. H. C. POCKLINGTON.

5 Well Close Place, Leeds.

Shakespeare and the Indian Meteors of 1592.

WITH reference to Mr. Denning's remark in NATURE, June 23, p. 848, I beg leave to point out that the word in Persian for west, namely *khāwar*, also means east, and so it may be that the passage in the Akbarnama means that the meteors were travelling from east to west and not from west to east.

Dean Inge lately observed in a lecture that there was a mystery about what Shakespeare did in the last five years of his life. May it not be that he was travelling in Europe or on the high seas when he saw so many stars shoot madly from their spheres ("Midsummer-Night's Dream," Act II., Scene II.)? There is another allusion to meteors, "Yon fiery o's and eyes of light," in Act III., Scene II., where Lysander speaks of Helena's eyes. This seems to show that Shakespeare's mind was running upon stars and meteors.

I may mention that in a letter to me Sir Sydney Lee seemed to say that there was something in my suggestion, and referred to another topical allusion to natural phenomena in "Romeo and Juliet."

H. BEVERIDGE.

53 Campden House Road, London, W.8.

The Production of Single Metallic Crystals and some of their Properties.

By Prof. H. C. H. Carpenter, F.R.S.

METALS and alloys are composed of aggregates of crystals. These do not, as a rule, possess plane faces, that is, the external forms of crystals. They are joined together at boundaries which have been produced by the meeting of a number of crystals growing simultaneously, and are usually irregular in outline. It is generally assumed that on cooling, crystallisation starts in the liquid metal or alloy from a number of centres, and proceeds with a velocity and in a manner characteristic of the metal and the conditions under which it has been cooled. The resulting boundaries may approximate to plane surfaces, but are more usually curved and irregular. These crystals are called "allotriomorphic" to distinguish them from "idiomorphic" crystals, which do possess plane faces and are characteristic of most mineral substances and artificially prepared salts. Moreover, they are usually very small and cannot be distinguished without the aid of a microscope. It is true, that in the case of large castings weighing many tons, crystals of several cubic inches capacity have been formed and afterwards isolated. The great majority of metals and alloys, however, which have been cast and hot-worked, have from 150 to 300 crystals to the linear inch, corresponding to from 3,375,000 to 27,000,000 crystals in a cubic inch. Frequently the size is even smaller, especially in the case of steels. The crystals are still more minute in severely drawn wires, and from figures given by Sykes it appears that in molybdenum wire there may be as many as 5000 to the linear inch.

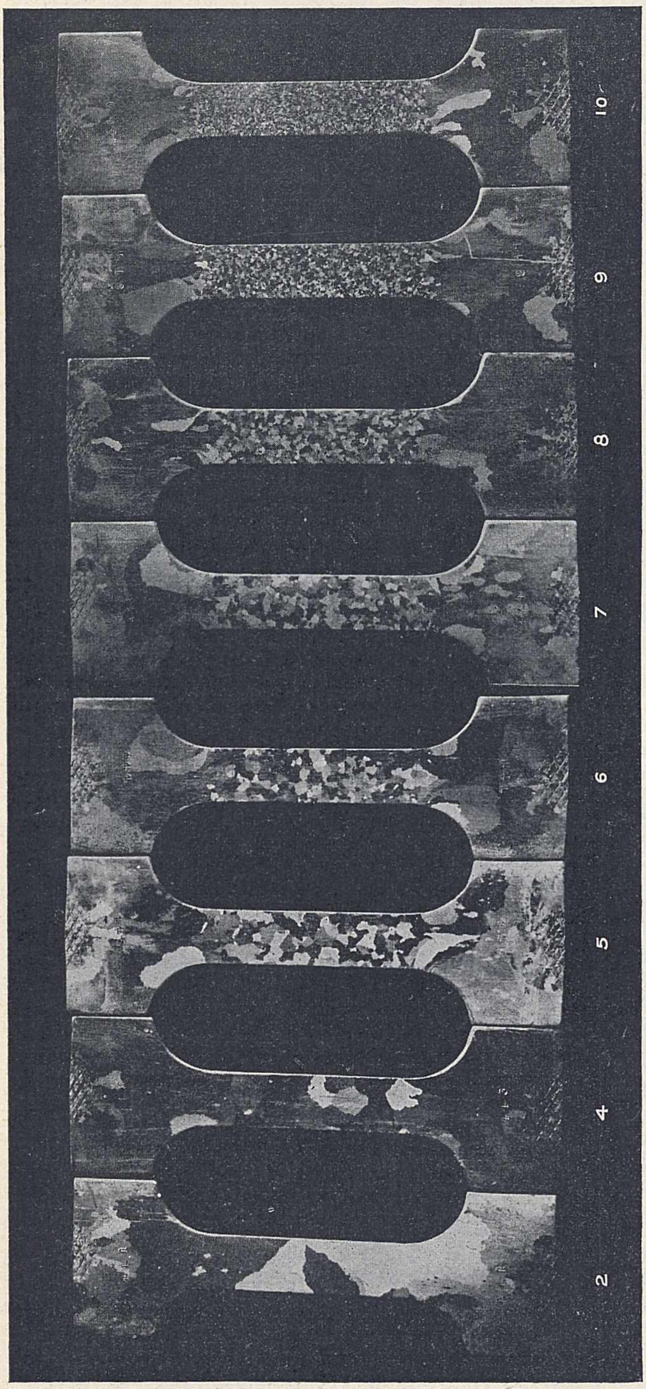

Fig. 1.—Showing diminishing size of crystals with increase of strain in the parallel portion of the testpieces. By permission of the Institute of Metals.

The properties of metals and alloys are the properties of these aggregates of minute crystals. Sauveur was the first investigator to show, about eleven years ago, that by carefully straining and afterwards heating metals, much larger crystals could be produced, and he suggested that there was a critical stress which produced the largest crystals. Later, other investigators, notably Rüder, Chappell, Jeffries, and Hanson, showed that if a metal was locally deformed and then heated, exceptionally large crystals were formed at some distance from the point at which the strain is most severe. About two years ago Miss Elam and the writer succeeded in converting the whole of the parallel portion of aluminium testpieces, whether in the form of sheets or bars, into a single crystal, which indeed extended for some distance up into the curved shoulders of the testpieces, forming an irregular boundary line. The crystals varied in volume from 0·5 to 2·0 cubic inches, and it has been possible to compare some of their properties with those of the aggregates of small crystals, of which this metal is usually composed. Experiments have also been carried out with iron, copper, silver, and tin, but with less success, although in all cases it has been possible to grow crystals very much larger than those contained in the original metal.

In the production of large crystals of aluminium the adjustment between mechanical strain and the temperature of heating is extremely important. This point is clearly brought out in Fig. 1, which shows how the crystal size may be varied in aluminium according to the degree of strain. The eight test-pieces shown, after a preliminary heat treatment to remove work-hardness and render the crystals equiaxed, were subjected to degrees of tensile strain varying from two to ten per cent. extension on three inches of the parallel portion of the testpiece. After this they were all heated to 550° C. and kept thus for six hours. Finally, they were etched in a ten per cent. solution of sodium hydrate. It will be seen that the crystals in the testpiece extended two per cent. are very coarse, and that as the strain is increased the crystal size diminishes until at ten per cent. it has become quite small. But there is a further point to be noted, namely, that in all the eight cases shown, large crystals have also formed in the broad heads of the testpieces, where the strain must have been less.

The problem which we set ourselves was to convert the crystals, numbering about 1,687,000, in the parallel portion of a testpiece 4 in. × 1 in. × 0·125 in., into a single crystal. Three treatments, two thermal and one mechanical, are necessary. The testpiece in the original condition was cold-rolled, and as a result the crystals were very much elongated and worked into one another. It had first to be heated so that it might be completely softened and new equiaxed crystals of approximately uniform size produced. The most suitable temperature was found to be 550° C. and the time six hours. It had next to be strained to the required amount, which was equivalent to a tensile strain of 2·4 tons per square inch. Finally, it had to be heated so that the potentiality of growth conferred by strain could be brought fully into operation. This was a somewhat lengthy operation, and involved a heat treatment beginning at 450° C. and finishing at 600° C. over a period of about 100 hours. After these treatments, on an average about one testpiece in four is converted into a single crystal over the parallel portion. Sometimes this space is occupied by two, three, or even four crystals, but never by more than that.

The production of these very large crystals has enabled us to determine the tensile properties of single crystals and compare them with those of the aggregates of minute crystals of which such bars are usually composed. In the latter case very uniform results are obtained, the ultimate stress varying from 4·5 to 4·7 tons per square inch, and the percentage extension on three inches being from 36 to 38. The values obtained in tests of specimens consisting of single crystals varied, however, from 2·80 to 4·08 tons per square inch, while the extension varied from 34 to 86 per cent. measured on three inches. These variations in properties were accompanied by differences in the method of stretching and the types of fracture which have provided a means of classifying them.

Speaking broadly, five types may be distinguished. In certain cases the testpieces narrowed in breadth gradually from the shoulders towards the fracture, and the metal necked sometimes almost to a point. In other cases the testpiece remained broad, losing sometimes only one per cent. in breadth, but became very thin. In the third case the testpiece both narrowed and thinned uniformly, and a noticeable feature of this type is the sloping of the sides, so that the section after pulling is no longer a right-angled parallelogram but one with acute and obtuse angles. Slip bands were usually well marked, and were inclined to the axis at different angles. In the fourth type the testpieces not only narrowed and thinned but in addition necked at the fracture, and in all cases a sideways slip was evident. In the fifth type may be included all the testpieces which produced twin crystals on being pulled. No signs of these were visible before stress was applied. In some cases only a few twins resulted, while in others the testpiece was twinned all over. In every case the testpiece buckled and crumpled to a certain extent, owing to the shifting of portions of the sheet into a twinning position. These differences in the method of distortion and fracture are due to differences in the original orientation of the crystal in the testpiece.

Monocrystalline testpieces were also prepared in round bars of diameter 0·564 and 0·798 of an inch

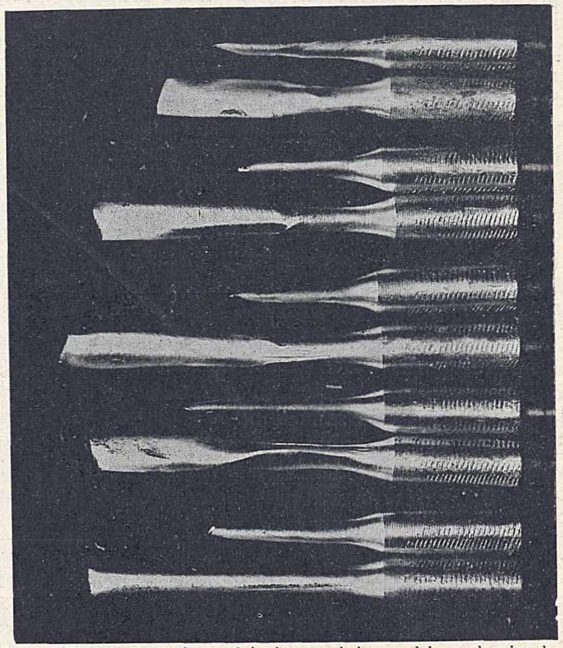

FIG. 2.—Fractured testpieces of single crystals in round bars, showing how in each case the bar draws down in one dimension and produces a wedge-shaped (double-grooved) fracture. By permission of the Institute of Metals.

respectively. The deformation of these testpieces under tensile stress was very remarkable, and deserves special mention. On one hand, a bar consisting of the usual aggregate of small crystals drew down with a roughening of the surface, the maintenance of a circular cross section, and a cup-and-cone fracture. On the other hand, the single crystals flattened very much in one dimension, whereas the other dimension differed but little from the original diameter of the bar, and the end result was not a cup-and-cone fracture but a double groove. The bar when subjected to tensile stress slipped principally on one plane, which subsequent investigations by Mr. G. I. Taylor and Miss C. F. Elam have shown to be an octahedral plane. When it began to break it drew down sharply in the same direction in which it had thinned, and a lens-shaped area was formed. As the bar pulled apart this became flatter and flatter; it parted first at each side and then in the middle. The final result was a curious double-grooved fracture with flow lines. Fig. 2 shows the fractured testpieces of five single crystals in round bars. In each case the two fractured halves are shown, one placed with the broad and the other with the narrow side facing the camera.

A word must be said about the crystallography of aluminium. Hull was the first to investigate the structure of aluminium crystals in a finely crystalline aggregate by X-ray analysis, and he concluded that the pattern thus obtained corresponds to a face-centred cubic lattice, *i.e.* the grouping of the atoms is such that there is one at each corner of the cube, and one in the centre of each face, making a total of fourteen in all. This corresponds, as Colonel Belaiew has recently pointed out, to an octahedron situated within a cube. Sir William Bragg and Dr. Müller have kindly examined our single crystals, and find that they conform to the same pattern. They belong, therefore, to the cubic system, and must have properties consistent with those of that group which possesses the highest degree of symmetry both external and internal. Investigations of the crystals in this system indicate that as regards certain properties they are isotropic, while as regards others they are anisotropic. In the former category come the properties of conducting light, heat, electricity, and expansion. In the latter are grouped elasticity, cohesion, and conduction of sound. In such cases, however, the properties are closely related to the symmetry, since the maximum and minimum values have been found to coincide with the axes of symmetry.

Accordingly, the variations in the tensile properties of the testpieces which have been described are due to differences of cohesion in different planes which do not all contain the same number of atoms. Although the single crystals obtained in the sheet and bars were formed in the same shaped testpieces in both categories, it was obvious that their original orientation relative to the axis of the testpiece varied considerably. Indeed, it may not have been precisely the same in any two of the cases tested. The shape of the testpiece alters when stress is applied, since slip and deformation take place only on certain planes, and the changes in shape observed correspond to the attempt of the crystal to accommodate itself to the stress. Such changes were much greater in some tests than in others.

It is not possible within the limits of this article to discuss the two questions, (1) why abnormally large crystals form on heating after a small deformation, and gradually decrease in size as the deformation increases; and (2), to take the extreme case, why, after a particular degree of deformation, it is possible to form a single crystal from an aggregate of several millions. Those interested in the matter may be referred to the author's original publications with Miss Elam.[1] It may, however, be stated that the conditions for the production of a single crystal in a testpiece consisting of the usual aggregate of small crystals are considered by us to be, that every crystal in the complex must be strained a certain amount, and that one of them is strained rather more than the rest. This particular crystal may be regarded as being in the condition of critical strain, and ultimately all the other crystals align themselves upon it after sufficient heating. When this condition is realised, the testpiece consists of a single crystal. We have taken up the experimental investigation of the deformation of the testpiece by X-ray analysis, and are hoping that the result of this will show what it is that happens when a testpiece is strained to the critical amount and subsequently heated.

[1] Journal of the Institute of Metals, No. 2, 1920, pp. 83-131. Proceedings of the Royal Society, V. 100a, pp. 329-353. Journal of the Iron and Steel Institute, No. 1, 1923.

The Royal Asiatic Society.

By F. E. Pargiter.

The Royal Asiatic Society of Great Britain and Ireland was founded in London on March 15, 1823, by the distinguished Sanskrit scholar, Henry Thomas Colebrooke, supported by others interested in Oriental matters, to investigate (as he announced) the history, civil polity, institutions, customs, languages, literature, and science, ancient and modern, of all countries in Asia. This removed the reproach that, while similar societies had been formed at Calcutta, Bombay, Madras, Paris, and elsewhere, Great Britain had done nothing. The charter was granted on August 11, 1824, and under it the Society is governed by a council of twenty-five members, including the president, director, vice-presidents, and other officers, elected annually at general meetings.

The Society was well supported by the East India Company and many eminent men, and prospered and developed its activities. It appointed a "Committee of Correspondence," which embarked on far-spread measures to receive and communicate information about Asiatic matters. From the copious donations that it received it began a library and a museum. To utilise the Oriental MSS. collected in English libraries it established the "Oriental Translation Committee and Fund" in 1828, to publish translations of approved works in Oriental languages, and this was liberally supported, and published thirty volumes in the next four years. The scheme included measures to benefit Asia and Europe materially; hence, when trade with India and China was thrown open in 1833–34, the Society formed a "Committee of Agriculture and Commerce" in 1836, and this collected valuable information about coffee, sugar, opium, and other important commercial products and their improvement. The Society published three quarto volumes of "Transactions," containing papers read before it, in 1827, 1830, and 1833, and began an annual "Journal" in 8vo form in 1834.

The early enthusiasm, however, gradually declined; the membership fell and the financial position caused anxiety. Then came the time of the Cuneiform discoveries by Major (afterwards Sir) Henry Rawlinson, who found the great Behistun and other inscriptions in Persia, eclipsing those reported by earlier travellers. He communicated them to the Society in 1838, solved the problem of their decipherment in 1844, and announced his results in 1846. These were received by the public with much incredulity, but the Society gave him its cordial support and set apart certain volumes of the Journal for their publication. Opinion turned after a time, and the Society became the centre of a great literary movement. His work, however, never reached completion in those volumes, because excavations by Botta, Layard, and others at Nineveh and Babylon brought out overwhelming material; new duties trenched on his time, and other scholars finished what he had so well begun.

Notwithstanding the interest of these revelations, the Society's condition remained anxious, for local societies in the East appropriated much local inquiry; its efforts to aid commerce became exhausted, and it developed more towards learned research, while Oriental studies attracted little public interest. The committees of correspondence, of Oriental translation, and of agriculture and commerce gradually fell into neglect, and a later effort to revive them had but transient success. The East India Company had generously subsidised the Society, and the loss of its patronage on its abolition in 1858 caused discouragement. The Government after some vacillation continued the subsidy, yet the Society's fortunes still continued low. It changed its abode in 1869, and through want of room made over its museum to the India Office.

The tide turned, however, when Mr. Vaux became secretary in 1877 and devoted himself to the Society's welfare, and more interest in Oriental studies began to be manifested then among the educated. The late Prof. Rhys Davids became secretary from 1887 to 1905 and edited the Journal, and enhanced the improvement. The Society's course since then has been one of steady expansion and influence, and its Journal has risen to acknowledged excellence with a wide and attractive range of subjects. The membership consists of those "resident" within fifty miles from Charing Cross and "non-residents," and also thirty honorary members elected from among eminent foreign scholars.

To reward British erudition the "Gold Medal Fund" was inaugurated in memory of Queen Victoria's Jubilee, and the medal was awarded in 1897 to Prof. Cowell, and since then triennially. Two other funds were established in 1903, the "Public Schools' Gold Medal Fund" and the "Prize Publications Fund." Under the former a prize medal has been awarded yearly on an essay on some Oriental subject in competition among the boys of the public schools. A new "Oriental Translation Fund" was started privately in 1891 and transferred to the Society afterwards, and it began a "Monograph Fund" in 1902. By these three funds many treatises have been issued, and the proceeds of the sale of published books provide the means of printing fresh works. Thus the Society encourages Oriental research, honours Oriental learning, and makes the results public, free of expense to the authors. Another fund, the Forlong Fund, is managed by the Society for the benefit of students at the School of Oriental Languages.

The Society is now established at 74 Grosvenor Street, London, W., and completed its hundredth year on March 15 last. It has issued a centenary volume, displaying its history and the achievements of its members in research, and will celebrate the event by a reunion of Orientalists and festivities on July 17-20. It has a very large and comprehensive library of about 30,000 volumes, important collections of MSS. in many Oriental languages, portraits and busts of eminent members, and valuable objects of antiquity and art. Its most outstanding figures have been its three directors, H. T. Colebrooke (1823–37), Prof. H. H. Wilson (1837–60), and Sir H. Rawlinson (1862–95), and its late president, Lord Reay (1893–1921).

The Journal abounds with articles elucidating all the subjects mentioned in the inaugural discourse regarding all the countries of Asia and those in Africa into which Mohammedanism overflowed, and India has occupied as much attention as all the other countries combined. Archæology has been a leading subject, especially since exploration has brought ancient inscriptions and other material to light from Asia Minor to Further India, and the old texts have become available for study. The Society's representations have largely contributed to archæological enterprise in India. Ancient remains have been examined, inscriptions deciphered, coins read, language and literature investigated, and religion studied. The researches have been so varied, that it is impossible to speak of them here except in general terms. They have not only amplified what was known of the ancient world, but have also reconstructed kingdoms and history that had vanished, disclosed much of the course of civilisation and religion through Asia, and revealed unknown languages that have perished.

Obituary.

PROF. JOHN CHIENE.

JOHN CHIENE, late professor of surgery in the University of Edinburgh, to which chair he had succeeded on the death of James Spence in 1882, and held for twenty-eight years, died on May 29 at the age of eighty. Chiene does not claim a record in this journal on account of original scientific work—for scientific inquiry was not much in his line—but he was deeply impressed with the importance of it, and, though not himself an experimenter, he set up in the University the first teaching laboratory of bacteriology and surgical pathology in the United Kingdom. To quote the words of his pupil Sir Harold Stiles, who now occupies the chair once held by Syme and Lister, "Chiene set the example, in the academic teaching of surgery, of cultivating the subject as a science so that its art might be better taught and promoted. . . . He spared neither time nor money to encourage research by his assistants."

Chiene may be said to have belonged to the school of anatomical surgeons; but he had been Syme's house-surgeon and John Goodsir's demonstrator, and from both of these distinguished men he inherited the habit of scientific thought and logical expression. He was a very successful lecturer on operative and systematic surgery in the extra-mural school, and in this way prepared himself for his still greater success as a university professor.

When Lister came back to Edinburgh from Glasgow in 1869, the feud between the followers of Syme and those of Simpson was simmering out, but by no means forgotten. At that time John Chiene and John Duncan were the most prominent younger surgeons in that city. Both were among Lister's adherents, but Chiene was more than a mere adherent; he became at once a devoted disciple. Every day found him working and studying in Lister's wards, and as years went on he was more and more closely associated with Lister's work.

During his nine years' stay in Edinburgh, Lister was acquiring a world-wide reputation; but among his colleagues he met with sharp criticism from his opponents and only lukewarm support from his friends. Even Annandale, his successor in the chair of clinical surgery, though professedly a convert to the antiseptic doctrine, was not altogether successful in practising it. It was, therefore, most important when Lister went to London in 1878 that some trusty follower should remain in Edinburgh to keep the torch burning there, as Sir Hector Cameron was manfully doing in Glasgow. That trusty follower was found in Chiene. He was now in a very influential position, and he advocated the cause of antiseptic surgery by example and precept with great success until the younger men, Lister's pupils and his own—now themselves middle-aged—had succeeded to the various University chairs and hospital appointments; by which time Lister's principles, though not the details of his practice, had come to be recognised as orthodox and universally followed.

Edinburgh would, of course, like the rest of the world, have become fully enlightened in due time, but it can scarcely be doubted that the period of twilight would have been more prolonged if it had not been for Chiene's whole-hearted and persevering efforts.

Dr. W. d'E. Emery.

By the death of Dr. Walter d'Este Emery on June 19, pathology has lost a keen disciple, and his acquaintances a loyal friend. Emery was a distinguished student of Queen's University, Birmingham, and St. Bartholomew's Hospital, London. After junior appointments held at his schools, he became assistant bacteriologist to the Laboratories of the Royal Colleges of Physicians and Surgeons. Later, he was lecturer on pathology and bacteriology in the University of Birmingham and Hunterian professor at the Royal College of Surgeons. Coming to London, he held various appointments, finally being made lecturer on pathology and bacteriology, and director of the Laboratories, King's College Hospital, a post he had to relinquish some two years ago on account of ill-health.

Emery was the author of "Clinical Pathology and Hæmatology," which passed through several editions and contains many practical hints, the outcome of his wide experience, and of "Immunity and Specific Therapy," which at the time of publication in 1909 presented an excellent critical survey of the extensive literature on these subjects. He was keenly interested in the problem of cancer, and a supporter of the parasitic hypothesis of the causation of this malady, arguments in favour of which are clearly set forth in another small book, "The Formation of Tumours." He published papers on the opsonic index and Wassermann reaction, and devised a simple method of complement fixation for the diagnosis of tuberculosis. He also contributed articles to Cheyne and Burghard's "Surgical Treatment," and Rose and Carless's "Surgery."

Emery was a bacteriologist and serologist of the first rank, and in later days a competent morbid histologist. Throughout his career he was overburdened with routine work; with more opportunity, it can scarcely be doubted his output of research work would have been larger. R. T. H.

Miss A. C. Breton.

We regret to record the death on June 15, at Barbados, of Miss Adela C. Breton at the age of seventy-three.

For more than thirty years Miss Breton travelled extensively and studied in many parts of the world, and her ready pen and keen powers of observation made her letters a delight to her friends. She had considerable talent as an artist, and utilised this gift to advantage in the pursuit of her archæological investigations. In Japan, for example, she made a very thorough study of the temples in a series of large water-colour drawings. Her name, however, will best be remembered in connexion with her expeditions to Mexico—which she visited thirteen times—and other parts of Central America, for the purpose of studying the antiquities of that region. In her travels in Mexico in the early 'nineties she rode on horseback, accompanied by one Indian only, a feat which in those days required both courage and much power of endurance. At the suggestion of Mr. A. P. Maudslay, she undertook to copy in water-colour the mural paintings of Chichen Itza in Yucatan, and produced a remarkable series of records of great beauty and high scientific value, unfortunately still unpublished. Miss Breton was also responsible for the copy of the pre-Columbian map of Mexico City, preserved in the National Museum of Mexico, and of the map of the Valley of Mexico, by Alonzo de Santa Cruz, in the University of Uppsala, which were published in Mr. Maudslay's translation of the "Conquest of Spain," by Bernal Diaz de Castillo. Of the former, Mr. Maudslay says it "needed long familiarity with Mexican picture-writing and topography to accomplish so successfully."

Miss Breton's great accuracy and industry served her and her readers well in the many papers on American archæology and other subjects which she contributed to scientific journals. She was a regular attendant at the meetings of the International Congress of Americanists, and was to a very large extent responsible for the organisation of the meeting held in London in 1912.

We regret to announce the following deaths:

Sir James Reid, Bt., Physician in Ordinary to Queen Victoria, King Edward, and King George, on June 28, aged seventy-three.

Sir Benjamin Simpson, formerly Sanitary Commissioner and Surgeon-General with the Government of India, on June 27, aged ninety-two.

Mr. S. S. Hough, F.R.S., H.M. Astronomer at the Cape of Good Hope, on July 8, aged fifty-three.

Current Topics and Events.

WE print as a supplement to this issue a discourse on muscular work by Prof. A. V. Hill, who will shortly be added to the physiological strength of University College, London. In it Prof. Hill shows how the original work of Fletcher and Hopkins on the production of lactic acid in muscles, the quantitative relationships between glycogen and lactic acid established by Meyerhof, and Prof. Hill's own elegant measurements of heat production, can now be added together into a coherent account of muscular contraction. The actual process which produces the mechanical energy is an explosive decomposition of glycogen into lactic acid, and the mechanism by which shortening of the muscle is caused—though this is of course speculative—is the neutralisation of this acid by bases; these are detached from their combination with proteids, which thereby lose their electrical charges and rearrange themselves in space. This part of the process is anaerobic, and the oxygen which is such a paramount necessity for the achievement of muscular work is needed not for the contraction but for the process of recovery. In this a portion of the lactic acid is oxidised, and provides the energy for the reconstitution of the bulk of the acid to glycogen. It thus becomes clear how it is possible for a man to do for short periods muscular work of a severity which requires sooner or later much more oxygen than he can possibly obtain through his lungs while the work is going on. Hence a man can for a short time run into debt for oxygen and obtain what he needs after the work is finished. For exercise of longer duration this shortage of oxygen cannot be progressively increased, and a man's capacity for it will depend mainly on his capacity for taking in oxygen and circulating it quickly to the tissues. Prof. Hill shows how well the actual record performances for flat racing over various distances fit in with the theoretical considerations. Athletic skill is also determined largely by dexterity in the economical performance of muscular work.

AT the meeting of the Council of the Royal Society on July 5, it was decided to use the larger part of the income arising from Sir Alfred Yarrow's gift of 100,000*l.* for the endowment of research, which was announced in February last, in the direct endowment of research by men who have already proved that they possess ability of the highest type for independent research. To this end a number of professorships will be founded, of type similar to the Foulerton professorships which were founded by the Society in 1922 for research in medicine. The professors will be expected to devote their whole time to scientific research, except that they may give a limited course of instruction in the subjects of their research to advanced students. There is at present a tendency to regard scientific research as a secondary occupation for men whose primary occupation is the teaching of students. The intention of the Royal Society in founding these professorships is to promote the recognition of research as a definite profession.

THE Royal Asiatic Society will celebrate its centenary during the four days, Tuesday to Friday, July 17-20, and the proceedings will be initiated by a reception of the delegates from other societies and bodies at the Royal Society's Rooms, Burlington House, at 10.30 A.M. on Tuesday, when H.R.H. the Prince of Wales has graciously consented to be present. This will be followed by a luncheon given by the Government to the delegates at Claridge's Hotel, and at 3.15 the delegates will meet their sectional chairmen at the Royal Asiatic Society's House, 74 Grosvenor Street, for an important part of the proceedings will be the reading of papers. For this purpose, the whole field of the Society's investigations has been divided into four sections: (1) the Ancient Far East (China and Japan); (2) the Ancient East (Babylonia, Assyria, Egypt, Palestine, etc.); (3) India (including Persia and Ceylon); and (4) Islam. On Wednesday, the morning sessions will be devoted to papers and discussions thereon; in the afternoon a visit will be paid to the School of Oriental Studies in Finsbury Circus, and the Lord Mayor has kindly promised to hold a reception at the Mansion House at 4 o'clock. Thursday and Friday mornings will be occupied by sectional meetings and papers, but the afternoons will be left free to permit the delegates and other associates to make personal arrangements as they may desire, taking advantage of their visit to London. The proceedings will close with a banquet at the Hotel Cecil at 7.30 P.M on Friday. Foreign visitors may enrol themselves on Monday, July 16, at the Society's House, and on Tuesday at the Royal Society's Rooms. Meanwhile any further information may be obtained from the Society's House.

THE list of honours recently issued contains the names of the following men distinguished for their scientific work or associations:—*Baronet*: Sir Anthony A. Bowlby, president of the Royal College of Surgeons. *Knights*: Dr. G. F. Blacker, dean of University College Hospital Medical School; and Prof. W. M. Flinders Petrie, Edwards professor of Egyptology, University College, London. *C.B.*: Mr. R. J. Thompson, assistant secretary, Ministry of Agriculture.

DR. T. ROYDS has been appointed director of the Kodaikanal and Madras Observatories in succession to Mr. J. Evershed, who retired on February 25 last.

SIR STEWART STOCKMAN, Chief Veterinary Officer and Director of Veterinary Research to the Ministry of Agriculture and Fisheries, has been elected president of the Royal College of Veterinary Surgeons.

AT the Cambridge meeting of the Society of Chemical Industry the following officers were elected for the year 1923–24:—*President*: Dr. E. F. Armstrong. *Vice-Presidents*: Dr. T. H. Butler, Mr. F. H. Carr, Prof. G. G. Henderson, Mr. E. Mond. *Ordinary Members of Council*: Prof. P. P. Bedson, Dr. R. T. Colgate, Prof. A. R. Ling, Dr. J. Reilly.

THE Report of the Norwich Castle Museum Committee for 1922 gives a picture of the beautiful fifteenth to seventeenth century house known as Strangers' Hall. For many years Mr. Leonard G. Bolingbroke has been filling this with examples of English furniture and domestic appliances, as well as with many relics directly connected with the history of Norwich. He has now generously presented the freehold of the building and his collections to the city, and there was a ceremonial opening on July 4 by the Lord Mayor of Norwich.

APPLICATIONS are invited for the post of Superintending Testing Officer under the Mines Department of the Government. The person appointed will superintend the testing work at the Mines Department Experimental Station in regard to safety lamps, electrical apparatus, etc., and the work of analysing samples of mine dust and mine air. Applications, accompanied by copies of two recent testimonials, should be sent by, at latest, July 21 to the Under-Secretary for Mines, Mines Department, Dean Stanley Street, S.W.1.

THE summer conversazione of the Natural History Museum Staff Association was held in the Board Room on July 4, and was attended by about sixty members of the Staff and visitors. The specimens exhibited were mainly devoted to the exposition of symbiosis, but some dealt with the recent eruption of Mt. Etna, and a demonstration was given of crystals used in wireless telephony. Messrs. W. Watson and Sons, Ltd., showed their latest forms of microscopes and other optical apparatus.

THE Belfast Naturalists' Field Club has issued the programme of its sixty-first session, 1923-24, and is to be warmly congratulated on its vitality through the years of Continental warfare and the still more trying years of civil disorder that ensued. Under the presidency of Mr. J. A. S. Stendall, a varied series of excursions has been arranged, mostly within the county of Antrim, which covers so wide a field of botanical and geological interest. One of the most ambitious of these outings, to the majestic and rarely visited volcanic neck of Slemish, took place on June 16. We are glad to note that Mr. R. J. Welch, on whom the Queen's University of Belfast has recently conferred the honorary degree of M.Sc., remains one of the most active promoters of the educational aspects of the Club, and that he is devoting especial attention to the development of the junior branch.

THE Minister of Health has appointed the following committee to inquire into the use of preservatives and colouring matters in food: Sir H. C. Monro (chairman), Prof. W. E. Dixon, Sir A. D. Hall, Dr. J. M. Hamill, Mr. O. Hehner, Prof. F. Gowland Hopkins, Dr. G. R. Leighton, Dr. A. P. Luff, Dr. C. Porter, and Mr. G. Stubbs. The committee is to report: "(1) Whether the use of such materials or any of them for the preservation and colouring of food is injurious to health; and, if so, in what quantities does their use become injurious. (2) Whether it should be required that the presence of such materials and the quantities present in food offered or exposed for sale should be declared." The secretary of the committee is Mr. A. M. Legge, of the Ministry of Health, Whitehall, S.W., to whom all communications should be addressed.

THE annual meeting of the Chaldæan Society was held at the rooms of the Royal Astronomical Society on Wednesday, July 4. In the absence of the president, the chair was taken by the treasurer, Dr. J. K. Fotheringham, of the University Observatory at Oxford. Reports of work from various local centres were presented. That from Ipswich was considered a specially successful and encouraging record of the season's work. It was reported that the Chaldæan Expedition to Wallal in Australia for the observation of the solar eclipse of 1922 had been completely successful,—being the only expedition sent from England that had met with success. Mr. Clark-Maxwell had now returned, but Mr. Hargreaves was going on to Mexico for observation of the eclipse this year, where Mr. Philip Myring intended to join him. The editor of the *Chaldæan* reported a growing appreciation in library and scientific circles, and expressed his thanks to a number of distinguished astronomers for the support they had given him. He would continue to pay special attention to the needs of amateurs and beginners. The following officers were re-elected for the ensuing twelve months: *President*, Mr. J. Hargreaves; *Treasurer*, Dr. J. K. Fotheringham; *Secretary*, Mr. E. W. Foster; *Librarian*, Mr. G. S. Clark-Maxwell; and editor of the *Chaldæan*, the Rev. D. R. Fotheringham.

ATTENTION may be directed to the following reports which have been recently received: A. E. Verrill (Canadian Arctic Expedition Reports, vol. viii.) describes the Alcyonaria collected by the expedition and gives a revision of a number of other Canadian genera and species, and describes the Actiniaria, adding notes on interesting species from Hudson Bay and other Canadian localities. Both these reports are excellently illustrated. F. Johansen (in vol. vii.) contributes an account of the biology of the Crustacea found in some of the Arctic lagoons, lakes, and ponds, and a detailed report on the Euphyllopoda of the American Arctic.

WE have received the fifth volume (1922) of Experimental Researches and Reports, published by the Department of Glass Technology of the University of Sheffield, and collected from the Journal of the Society of Glass Technology. These papers have been mentioned in NATURE as they appeared. There are papers on the action of chemical reagents on glassware, the determination of the durability of glass, as well as on more technical matters. The presidential address by Prof. Turner dealt with "The British Glass Industry, its Development and Outlook," and contains some interesting historical material. One "outlook" is interesting to the layman: "It would not be difficult, if the glass manufacturer set about it in earnest, to write up a fearful account of the many-headed hydra, reptiles, and bugs that infect food not protected by glass, and, on the strength of the fright so administered, soon work up a trade the extent of which might be enormous."

THE new catalogue of second-hand books (No. 225) of Messrs. W. Heffer and Sons, Ltd., Cambridge, is of a miscellaneous character, but it contains many works likely to be of interest to readers of NATURE, *e.g.* those dealing with folk-lore, occult literature, and Egyptology. A useful section is that devoted to foreign literature.

MESSRS. NEGRETTI AND ZAMBRA, of 36 Holborn Viaduct, London, E.C.1, have recently sent us a spirit thermometer of a useful pattern for indoor use. It is mounted on a metal frame, the graduations in degrees Fahrenheit being black on a white ground. The bulb is protected by a strong guard made as a part of the frame.

MR. VALENTINE DAVIS, of Noddfa, Wistaston, Crewe, is organising a holiday course in Chamonix, on August 17-September 1. It is proposed to make excursions to various glaciers and passes, using Chamonix as headquarters, and the flora of the district, the geology of Mont Blanc, and similar field-studies will be made. Particulars can be obtained from Mr. Davis.

MESSRS. GEORGE ROUTLEDGE AND SONS, LTD., have ready for publication part 3 of the third edition of Sonnenschein's "The Best Books: a Classified Bibliography." It deals with history and biography, and historical collaterals, and contains particulars of some 24,000 books. The fourth and concluding part will, it is hoped, be published at the close of the present year. It will deal with the sciences, industries, arts, literature, and philology, and contain complete indexes of authors and subjects.

DR. W. BROWN is bringing out through the University of London Press, Ltd., under the title of "Talks on Psychotherapy," the course of lectures recently delivered by him at King's College, London. It will deal with the subjects of functional nerve disease, psycho-analysis, abreaction and transference, the libido theory and melancholia, auto-suggestion, etc. Other books to be published by the same house are three by Dr. Cyril Burt on "The Sub-Normal School Child," entitled respectively "The Young Delinquent," "The Backward and Defective Child," and "The Unstable and Neurotic."

Our Astronomical Column.

CORRECTION TO THE LONGITUDE OF BORDEAUX OBSERVATORY.—A note in the *Journal des Observateurs* for June, by J. Trousset and L. Gramont, contains the rather surprising announcement that the accepted value of the longitude of the Bordeaux Observatory is a second of time in error. This was based on an elaborate determination, made in 1881 by MM. Rayet and Salats, both observers and instruments being interchanged. The amount is altogether beyond the probable error of the determination, and presumably arose from some systematic error in marking the seconds on the chronograph tapes, or some similar cause.

The error was detected by the reception of the Paris wireless signals at Bordeaux, and a new determination of the longitude was then made by means of these signals. The resulting value of the longitude of Bordeaux west of Greenwich was $2^m\ 6{\cdot}564^s$, the mean error being $0{\cdot}023^s$. The old value, printed in the Nautical Almanac, is $2^m\ 5{\cdot}51^s$.

The new determination, though only just published, was made in April and May 1921; presumably it was in use throughout 1922 in the wireless time signals sent out from Bordeaux and received at Greenwich. The mean difference between the Greenwich times of receipt of the Paris and Bordeaux signals was only $0{\cdot}04^s$.

SILICON LINES IN B-TYPE STARS.—In the determination of the radial velocities of B-type stars, the wave-lengths of the lines of silicon are constantly being used, but the values employed have not been referred to modern standards of wave-lengths. The lines in the spectrum of silicon alter as the temperature is increased and the enhanced or ionised lines occur as doublets and triplets alternately and are known as Si II, Si III, and Si IV as first differentiated by Sir Norman Lockyer. A new determination of the wave-lengths of those lines has just been completed by Mr. H. Barrell in the laboratory of Prof. Fowler (Mon. Not. R.A.S., vol. 83, p. 322), and he gives both the adopted values in International Units and in Rowland's scale. While the instrument employed in the determination was not the one that was most desired, since the latter is still in detention in Russia, that employed gives, as is stated, "the desired redeterminations with every possible precaution to ensure a high degree of accuracy." As the silicon wave-lengths are in very general use it is important that these new values should be widely known; they are briefly summarised below:

Group of lines.	Adopted values in I.A.	Probable errors.	Wave-lengths in Rowland's Scale.
Si II . . .	3856·021	±0·001	3856·165
	3862·592	0·002	3862·737
	4128·053	0·001	4128·207
	4130·884	0·001	4131·038
Si III . . .	4552·611	0·002	4552·782
	4567·824	0·002	4567·995
	4574·737	0·002	4574·908
SI IV . . .	4088·863	0·001	4089·016
	4116·104	0·002	4116·257

A VARIABLE OF VERY SHORT PERIOD.—Mr. F. C. Jordan, of Alleghany Observatory, contributes a note to *Astron. Journ.*, No. 821, on a star of magnitude about $11\frac{1}{2}$, on the same plate with the Cepheid variable S Comae; the period of light-variation is only $2^h\ 50{\cdot}8^m$, the light-range being 0·73 mag. The light-curve is very pointed at minimum, there being no stationary interval. There is none at maximum either, but the curve is here rounded, not pointed. From comparison with some similar curves it is thought likely that the star is of the Beta-Lyræ type rather than the Algol type; in this case the period will have to be doubled. The two portions of the curve are so alike that in this case the two stars must be very similar in size and brightness. It is feared that the star is too faint to decide the matter by spectroscopic determinations of the radial velocity.

The approximate position of the star for the equinox of 1900 is R.A. $12^h\ 28^m\ 4^s$, N. Decl. 27° 16·1′.

Research Items.

CANCER IN THE UNITED STATES.—The incidence of cancer in the United States is discussed by Dr. F. Hoffman in an article in the *World's Health* for May, p. 18. In the general registration area, the cancer death-rate has increased from 74·4 in 1911 to 83·4 in 1920 per 100,000 population, but in some of the individual States is much higher, and, making all allowances, the conclusion is that cancer is seriously on the increase. A dangerous phase of the cancer problem is that alleged cancer cures are gaining in popularity, with results disastrous in the end. Dr. Hoffman states that having personally investigated the incidence of cancer among Indian tribes in the south-west and in Bolivia, he is satisfied that malignant disease in any form, and particularly cancer of the breast, is extremely rare.

THE TEETH OF PILTDOWN MAN.—In the *American Journal of Physical Anthropology* (vol. vi., April-June), Dr. Aleš. Hrdlička publishes an important contribution to the study of the phylogeny of man in a paper on the dimensions of the first and second molars, and their bearing on the Piltdown jaw. Dr. Hrdlička has subjected to a detailed analysis the recorded measurements of these two molars in man, and has made a careful examination of the material in the U.S. National Museum. As a result, his conclusions are that the Piltdown molars are longer and have a lower index than any group of modern men; as compared with early man they exceed in length all prehistoric molars except one or two first molars from Krapina, and, with one exception, present the lowest breadth-index; in breadth they are ordinarily human. When compared with the apes it is clear that they do not belong to this group, though nearest in proportion to the gorilla. Of the fossil apes, the teeth most closely resembling the Piltdown teeth are those of *Dryopithecus rhenanus*, Pohlig, of the Bohnerz Alb. Dr. Hrdlička's general conclusion is that the Piltdown teeth, primitive as they are, belong to very early man or to his very near precursor, while he suggests that the resemblance to the late Miocene or early Pliocene human-like teeth of the Bohnerz Alb. may legitimately raise the question whether man may not have evolved altogether in Western Europe.

HUMAN SACRIFICE AS A RAIN CHARM IN NORTHERN RHODESIA.—In January last a report appeared in the *Times* which stated that eighty natives had been arrested in Rhodesia for complicity in a case of human sacrifice due to witchcraft. This report was of peculiar interest in view of the fact that the natives of this region, which lies about forty-five miles beyond Mount Darwin, just on the boundary of Portuguese territory, are noted for their addiction to witchcraft in a form which presents some remarkable parallels to the traditional rites and practices of European witches. From the evidence given at the trial, of which an account is given in the *Times* of June 26, it would appear that in this instance it was not a case of witchcraft in the generally accepted sense. The sacrifice was offered by the Mtawara tribe to propitiate Mwari, the Great Spirit of the tribe, and thus bring to an end a drought which threatened the tribe with disaster. Mwari has two wives. One came some generations ago from a branch of the tribe living in what is now Portuguese territory and was domiciled within a circle of trees, presumably a sacred grove. This wife, Mashongavudzi, is an old woman, past child-bearing, whose husband is dead. At her death her place is taken by another old woman who assumes the same name. The second wife, Nechiskwa, is chosen from the family of Gosa, the chief of the branch of the tribe in Portuguese territory, when a child—the present holder of the office is about nine years old—and must remain a virgin throughout her life. She is the Rain Goddess. When there is a drought Gosa sends an offering of *limbo* (coloured cotton print) to the Mwari, which is placed near the throne of the Rain Goddess. If rain fails to follow, Mwari is angry because some one has seduced his wife. The only remedy is that the culprit should be sacrificed by fire. In this case suspicion fell on a son of the chief who is in charge of the wives of Mwari—an office which has descended to him from his ancestors. The accused man was duly offered up as a sacrifice by burning and, curiously enough, rain followed in twenty-four hours.

KATA-THERMOMETER STUDIES.—Dr. Leonard Hill's campaign against the stagnant, warm atmospheres which are encouraged by many of the modern plans of warming and ventilating buildings is steadily gaining the success it deserves. Cool moving air and local radiant heat mean a cool head and warm feet, which is the ideal state for human comfort and efficiency. The stimulating qualities of an atmosphere depend on its temperature, humidity, and movement, and in the kata-thermometer Dr. Hill introduced an instrument which gives directly a measure of the cooling and evaporative powers of the air; *i.e.* the properties which through their action on the skin determine the pleasantness for man. "The Kata-thermometer in studies of body heat and efficiency" (Medical Research Council Special Report Series, No. 73, 1923) gives a mass of data collected by Dr. Hill, Dr. H. M. Vernon, and others, under a variety of conditions ranging from boot and shoe factories to imitations of shipwrecked sailors in the wind tunnel at Hampstead. There is also a discussion of the theory and practice of the instrument and a description of a recording apparatus designed by Dr. E. H. J. Schuster. The section on the relation of general metabolism to kata-thermometer readings raises a question of considerable importance to which no answer seems to be yet available. Atmospheres which are "good" by Dr. Hill's standard increase metabolism, and more food is needed and desired. Riding on the top of a bus, for example, instead of inside, means, as he points out, a greater expenditure on food. It is also generally agreed that it promotes general healthiness and vigour. But why is it that a high rate of metabolism is better for the body than a low rate? The effect may be essentially psychological, but the point requires discussion. The whole report will well repay detailed examination.

TSETSE FLIES.—The April issue of the *Bulletin of Entomological Research* contains a report of Drs. W. B. Johnson and L. Lloyd on tsetse fly investigation in the northern provinces of Nigeria. The authors bring forward evidence showing that sleeping sickness can appear and become epidemic in localities where the only tsetse carrier present is the species *Glossina tachinoides*, and it is at least probable that this insect is responsible for the disease in certain localities where it abounds and the usual carrier *G. palpalis* is rare, or wanting. Both *G. palpalis* and *G. tachinoides* suck the blood to a considerable extent of the non-mammalian fauna—probably that of reptiles. The two species can thrive where the wild fauna is reduced to its possible minimum, and *G. tachinoides* where man is almost the only available host. The authors anticipate that the work of controlling the latter species will resolve itself into a study of the problems of clearing the jungle, since curtailment of its food supply does not appear likely to be effective. In the same journal Dr. G. H. D. Carpenter contributes an article on the use of artificial breeding places as a means of control of *Glossina palpalis*. The breeding places took the form of low thatched sloping roofs erected over suitable loose soil in localities where the fly is known to abound. The insects used the shelters as convenient places for depositing their larvæ, which very soon afterwards pupate. The result of the catches from these shelters showed that in some cases they were superior to the natural places selected by the flies. It is concluded that, although the method affords a ready means of collecting material for laboratory investigations, it is ineffective as a means of destroying the Glossina without other measures. After very nearly a year the number of pupæ deposited showed no appreciable diminution.

BRITTLE-STARS OF THE PHILIPPINES.—The Smithsonian Institution has recently published, as volume 5 of its Bulletin 100, a memoir by Prof. R. Koehler on the Ophiurans collected by the *Albatross* in Philippine and Samoan waters. Out of the 227 species discussed, 68 are new, and these include examples of 5 new genera. Since many of the other species had previously been inadequately described, they too now receive full description and illustration. The illustrations are entirely photographic, a method which Prof. Koehler claims as the only satisfactory one for the systematist. When the photographs are as good and as well-reproduced as are most of Prof. Koehler's, and when, as here, enlarged photographs of details are provided, then, on the whole, we agree with this claim. But even when all the conditions are fulfilled, explanatory diagrams are a most welcome addition. The classification adopted is that of Matsumoto, with a few modifications of detail (but why Lœmophiurida instead of Læmophiurida ?). The work has been translated from the French by Mr. Austin H. Clark into clear and easy English: we would observe only that the English for "Lyon" is "Lyons."

FOSSIL BISON FROM CENTRAL MINNESOTA.—From a peat swamp overlying the iron ore at the Sagamore Iron Mine, Riverton, Minnesota, bones of *Bison occidentalis* have been recovered which form the subject of a paper by Mr. O. P. Hay (Proc. U.S. Nat. Mus., vol. lxiii., art. 5). The bones were at or near the bottom of the peat, which overlies drift beds determined to be of about mid-Wisconsin age, so that *Bison occidentalis* lived in Minnesota until the middle of the last glacial stage, but how much longer cannot now be determined. Whether the presence of the remains of *Bison bison*, that also occurred in the peat, indicates that the two animals were at one time contemporaneous in that region, or whether the existing buffalo arrived there after the other had become extinct, is uncertain.

GIANT HORNLESS RHINOCEROS FROM MONGOLIA.—In 1913 Mr. Forster Cooper described under the name of *Thaumastotherium* (afterwards altered to *Baluchitherium*) *osborni* a huge rhinoceros-like animal of which he had unearthed the remains on his expedition to Baluchistan. A second species, *B. grangeri*, was discovered at Loh, central Mongolia, in 1922 by the third Asiatic expedition of the American Museum of Natural History. This new species is now described by Prof. H. F. Osborn (Amer. Mus. Novitates, No. 78), who further makes the genus the type of a new subfamily—Baluchitherinæ. The author considers that the Baluchitheres will prove to be unique, large animals of the age (Upper Oligocene, or Miocene) in which their remains occur, and that they were typical browsers feeding on the branches of trees as do elephants and giraffes. When the neck was elevated and stretched the animal would have attained a height of about fifteen, or possibly sixteen feet. A restoration is given which shows that at the shoulder Baluchitherium was twice the height of the Indian rhinoceros with which it is compared.

LATE MESOZOIC BATHOLITES AND ORE-DEPOSITS IN JAPAN.—While the attention of geologists is being justly redirected to the major "revolutions of the globe," and to the relative rapidity of their culminating episodes, it is well to note the evidence of intervening epochs of unrest. The "Laramide revolution" of Schuchert, which is held by many to have heralded the great days of Andean crumpling, can be traced back to "epeirogenetic" movements in the Rocky Mountain area in late Cretaceous times; and these are now seen to have had "orogenetic" analogues on the other side of the Pacific. Here we may observe, as a corrective of too rigid doctrine, that the folding took place on the eastern side of a continental mass. Prof. T. Kato of Tokyo (*Japanese Journ. of Geol. and Geogr.*, vol. i. p. 77, 1922) describes the intrusion of huge batholites of quartz-diorite and granite into Jurassic strata in central Japan, and he traces the famous copper-ores of the Yamahara district in the province of Mimasaka to a late Mesozoic epoch of unrest. The first result of the igneous intrusions was the contact-metamorphism of the sedimentary series. Then, at a temperature a little below the critical point of water, tourmaline and fluorspar were produced; and the sulphide ores, including copper and iron pyrites, pyrrhotine, and zinc-blende, followed, and permeated the invaded areas. Veins of quartz and calcite mark the final stage. A neat diagram on p. 99 shows the succession of igneous types, closing with rhyolites that reached the surface. Volcanic manifestations continued into Cainozoic times; but the epoch of maximum disturbance is assigned to the close of the Mesozoic era. The paper is written in English and is very well illustrated by photographs.

PETROGRAPHY OF DRILL-CUTTINGS FROM OIL-WELLS.—One of the first attempts in the United States towards the intensive petrographic examination of rock-samples obtained while drilling oil-wells, is described in an advance chapter (H) of bulletin 786 of the United States Geological Survey, by Messrs. J. Gilluly and K. C. Heald. Their report deals with the stratigraphy of the El Dorado oilfield, Arkansas. Petrographic methods of correlation of strata have come into prominence in England and in several of the British-owned oilfields within the last seven or eight years, but, so far as we know, little attention has been paid by oil-geologists in the United States to this phase of exploratory work. The authors rely entirely on the lithological characters of the samples, on their differentiation according to the amounts of sand, clay, and lime present, while limonite, lignite, or glauconite are specifically indicated where sufficiently obvious. Any fossils found are also carefully studied in conjunction with this petrographic investigation, a collaboration to be highly commended. It is, however, unfortunate that the authors did not go a great deal further with their petrographic work; the "heavy" detrital minerals (*i.e.* those having a specific gravity greater than 2·8) furnished by the samples would have formed a much more definite basis of comparison and discrimination between the beds involved, and zoning would have been facilitated accordingly. Authigenous constituents of sediments vary qualitatively and quantitatively within small limits far more than the more stable detrital grains do, and for this, if for no other reason, the study of the "heavy" minerals is always desirable. Notwithstanding the neglect of these constituents, however, the authors have grouped their samples into ten zones, comprising parts of the Tertiary and Upper Cretaceous formations in the district; such zones are of incalculable value to the drillers and others engaged in exploring the field, but it would be interesting to know how far such zones were confirmed or contradicted by similar work based on "heavy" mineral assemblages.

BRACHYSTEGIA, A TROPICAL SOURCE OF FIBRE AND TIMBER.—Messrs. J. Burtt Davy and J. Hutchinson describe fifty-four species of Brachystegia in the *Kew Bulletin*, No. 4, 1923. This genus is confined to equatorial Africa, and is so dominant in the vast forest area extending between the Limpopo Zambesi watershed and the Katanga Plateau at the head waters of the Congo River, and from Nyasaland to the Angola Highlands, that this plant formation might well be termed "Brachystegia Forest." All species are trees with fibrous bark, sometimes containing tannin, and the natives of Central Africa use this bark for an extraordinary variety of purposes. Brachystegia bark cloth is used for making grain sacks and game nets, the fibres of some species being used for the manufacture of cord and rope of all sizes and for all purposes. Before the widespread introduction of cotton goods, the principal clothing of the native was bark cloth made of fibrous sheets beaten out of the bark of several species of Brachystegia. The timber of some species is described as hard and durable and suitable for building purposes, that of others as too soft. Undoubtedly both fibrous bark and timber may have many industrial applications, but the first step towards economic development is a clear idea of the different species of the trees and their different possibilities. To this end the taxonomic study in the *Kew Bulletin* should have great value, as one of the authors has studied the plants in their native habitat and a first attempt is made to indicate what different species are probably intended by the vernacular names used by the natives.

LIBERATION OF PRUSSIC ACID FROM THE PLANT LEAF.—The highly toxic properties of hydrocyanic acid have caused the accumulation of a considerable literature upon the subject of its production in plant tissues from cyanogenetic glucosides under various conditions. The problem is obviously not simple, and, as occasional cases of stock poisoning are traced to this source, its study has economic as well as scientific interest. F. J. Warth has recently studied the liberation of prussic acid from the tissues of the Burma bean (*Phaseolus lunatus*), and supplies some very interesting data in the Memoirs of the Department of Agriculture in India (Chemical Series), vol. vii. No. 1. He points out that the amount of prussic acid produced differs materially according to whether the leaves are dried rapidly in the sun or slowly in the shade. In the sun-dried leaf, hydrolysis takes place with evolution of prussic acid, and if the dried leaf be plunged into boiling water further large amounts of the acid are given off; this effect is not produced with the fresh leaf or slowly-dried leaf. It appears that in the slowly dried leaf the enzymic balance approximates to that in the normal leaf, and in this balanced system prussic acid appears to be further changed as rapidly as it is released by enzymic hydrolysis of the glucoside; indeed, both fresh leaf and slowly dried leaf show some capacity to cause the disappearance of additional acid, if added to water containing the crushed or powdered leaf material.

SHORT-WAVE DIRECTIVE RADIO TRANSMISSION.—Franklin and Marconi have shown that when the wave-lengths used in radio transmission are less than 20 metres it is not difficult to get directive transmission. For transmitting news and music, broadcast directive transmission is not wanted, but for broadcast reception it can be usefully employed, as by its means interference disturbances may be reduced to a minimum. Its principal use is in connexion with point-to-point communication, *i.e.* direct communication from one transmitting to one receiving station. In particular it will be useful in the new methods adopted of transmitting photographs by radio and for the remote control of mechanisms. In paper No. 469 published by the Bureau of Standards, F. W. Dunmore and F. H. Engel give the results of experiments with directive radio transmission on a wave-length of 10 metres. As a reflector they use a series of forty vertical parallel wires all of which lie on the surface of a parabolic cylinder. It is so mounted that it can be rotated about a vertical axis. The focal length of the parabolic section was made one-quarter of a wave-length, 2·5 m. (8 feet 2·4 inches). Each of the wires was tuned to 10 metres, and they were spaced 30·47 cm. apart. A 50-watt three-electrode valve of the coated filament type was used as a generator. Radiation characteristic curves are given from which it appears that at least 75 per cent. of the radiated power is confined to an angle of 40°. It was noticed that with this type of transmission the absorption by buildings and other metallic structures was very pronounced.

WEATHER AT EASTBOURNE IN 1922.—Eastbourne Borough Council has recently issued its annual report of the meteorological observations for the year 1922. The records have been kept continuously since 1887, a period of 36 years, so that valuable statistics are available as to the weather and climate of this much-favoured health resort. Observations are supplied to the Meteorological Office and are included in the Weekly, Monthly, and Annual Weather Reports, as well as in the Daily Report of Health Resorts. In addition to the observations at Eastbourne the report comprises similar results for other health resorts scattered over England, taken from the Meteorological Office returns, from which it can be seen that Eastbourne occupies a position with a fairly equable temperature, with a large amount of sunshine, and with a rainfall by no means excessive. The mean air temperature in 1922 ranged from 59·2° F. in August to 41·6° F. in January, and the mean for the year was 49·9° F. The duration of sunshine ranged from a mean of 10·40 hours per day in May to 1·76 hour per day in December, the mean for the year being 4·80 hours per day. The mean monthly rainfall for 1922 ranged from 4·31 in. for January to 0·61 in. for May; the total for the year was 28·10 in. The prevailing winds were from the west and north-west, though in most recent years the prevailing winds have been from between south-west and north-west. From this prevailing direction the air has to pass over the South Downs before reaching the town, and, mixing with the air over the sea, may often account for a fair amount of fog in the Channel, in the neighbourhood of the *Royal Sovereign* Lightship, and frequently may render the air somewhat humid over the land.

The International Air Congress, 1923.

THE second International Air Congress since the War was held in London on June 25-30. It was attended by about 600 members representing no less than 20 countries. The Duke of York was president of the Congress, and the Duke of Sutherland, Under-Secretary of State for Air, chairman of the committee. The Congress was opened on June 25 with an address from the Prince of Wales. During the week the meetings for papers and discussion were held in the buildings of the Institution of Civil Engineers. Three days were devoted to these, while two were utilised in visits to works and places of interest to the members. Thus on Tuesday a large party visited the Royal Aircraft establishment at Farnborough, while on Thursday the National Physical Laboratory attracted many interested members.

In addition to the official gatherings, receptions were given by the Lord Mayor and the Duchess of Sutherland, while on Friday afternoon the Secretary of State for Air and Lady Maude Hoare entertained the Congress at a garden party at which the Duke and Duchess of York were present. Saturday was devoted to a final meeting, with the Secretary of State for Air in the chair, at which a number of resolutions were passed. The Congress then adjourned to Hendon to view the Royal Air Force Pageant, and the week closed with a successful banquet, with the Duke of Sutherland in the chair. Colonel Lockwood Marsh, secretary of the Royal Aeronautical Society, was secretary of the Congress, and received the very cordial thanks of the Congress for the admirable arrangements by which its success was secured.

For the papers and discussions the Congress divided into four groups, as follows:—(A) Aerodynamics, construction and research; (B) power plants—fuels, lubrication, airscrews, etc.; (C) air transport and navigation; and (D) airships.

In each of these a number of interesting and important papers were read; the papers, with the discussions, will be issued shortly in book form. Readers of NATURE will probably find most to interest them in Group (A).

Some fifty years ago Lord Rayleigh directed attention to the effect of circulation of air round a cut tennis ball, having spin, as well as forward velocity, in modifying the motion of the ball and causing it to follow a curved path. In his well-known book on aerodynamics, Lanchester applied the same idea to account for the lift on an aeroplane wing, and described the manner in which the vortex system set up round the wing was completed by two series of trailing vortices shed off from each wing tip. These carry away part of the energy and thus give rise to a portion of the drag—known now as the induced drag—which resists the motion of the aeroplane.

Lanchester's work was descriptive and its importance was scarcely recognised; numerical results, figures, and mathematical calculations were needed before its great value was grasped. We now see that it contains the solution of the problem; the intuitive eye of the genius forestalled the slower methods of the mathematician, though laborious calculations and the work of expert draughtsmen and experimenters were necessary to establish its fundamental truths. Several of the most important papers in Section A were devoted to this subject.

Starting from the known solutions of the flow round an infinite cylinder moving uniformly in a fluid in which there is circulation round the cylinder, Joukowsky and Kutta transformed the motion into one about a long cylindrical body having a section resembling that of an aeroplane wing, but with an infinitely thin trailing edge. They obtained an expression connecting the lift on such a wing supposed to be of infinite aspect ratio—*i.e.* infinitely long in comparison with its width in the direction of flow—with the circulation. The motion is thus two-dimensional in planes at right angles to the length of the wing.

One of the stream-lines near the tail leaves the wing at right angles to its upper surface, and unless this point coincides with the trailing edge the motion breaks down and the velocity becomes infinite. By adopting a suitable value for the circulation the stagnation point can be brought into close coincidence with the trailing edge, the motion becomes steady, and the lift can be determined; the value so found is, however, some 20 per cent. too great, and the theory does not account for the drag. There would be no resistance to the motion of such a wing.

Major Low, in one of the papers read to the Congress, gave an interesting account of a draughtsman's method of applying the Joukowsky theory to a wing of any form.

This simple two-dimensional theory was modified by Prandtl and his school. He assumes the wing to shed vortices all along its trailing edge from the centre outwards, forming a vortex sheet which at a little distance behind the aeroplane rolls up into a single long vortex trailing away from each wing tip in a direction opposite to that of motion, as in Lanchester's suggestions. Thus the circulation, and hence the lift, falls off as one passes outwards along the wing; and, assuming a law for its decrease, Prandtl obtains an expression for the lift on a wing of finite aspect ratio, and, by taking into account the effect of the trailing vortices, for the drag considered as due to the action between these and the wing vortex—the induced drag. This accounts for a large percentage of the observed drag. In England, Mr. Glauert has done much in connexion with this theory, which has been applied to the interference of the channel walls on a model under test, to the theory of the propeller leading to Froude's coefficient of 0·5 for the induced flow near the propeller, and to other problems. Mr. Glauert's paper gave an important résumé of the present position.

But there is a fundamental difficulty: the fluid is treated as inviscid, and in such a fluid the motion of a body will not set up vortices; the body will experience no drag. Air is viscous, and the value of the kinematic coefficient of viscosity has an important bearing in aerodynamics, while the shearing forces set up by the viscosity depend on the rate of change of velocity in the direction normal to the flow. Now, since the fluid, if viscous, is at rest relative to the body at all points of its surface, the rate of change of velocity, and therefore the viscous shear, will be greatest close to the surface. The Prandtl theory supposes that such viscous forces are sensible only throughout a very thin film surrounding the surface, which suffices to set up the circulation, and that outside this film the equations of an inviscid fluid may be used.

Prof. Bairstow in his paper, after a reference to his recent communication read before the Royal Society, suggested that an attempt to relate the circulation theory to the fundamental equations of motion, taking viscosity into account, would lead to a determination of the friction on the surface of the aerofoil, thus giving that part of the drag which is omitted from the Prandtl theory. Promising work on these lines is in progress in the Aeronautical Department of the Imperial College, South Kensington, which is thus beginning its work as a centre of advanced research.

To turn to other parts of the discussions in Group (A), mention must be made of a most important paper by Mr. Handley Page on the slotted wing. The author gave the most recent details of his wind-channel tests on his device for enabling the pilot to increase effectively the lifting power of the wing. This enables him to land at a much lower speed than would be otherwise possible. Reference must be made to the paper for the figures; it must suffice to say that in the case of one section known as Airscrew 4 the maximum lifting coefficient was increased from 0·7 to 1·1, while for the well-known section R.A.F. 15 the increase was from 0·55 to 0·95. The meeting was pleased to hear from the representative of the Royal Air Force that the full-scale tests, so far as they had been completed, were successful.

Methods of measurement in experimental work were discussed in various papers. Col. Robert, of the Technical Aeronautical Service of France, gave a detailed account both of the precautions necessary to secure accuracy in the results and of the delicacy of the tests, thus confirming the experience of the workers at the National Physical Laboratory, Teddington. Our French colleagues are to be congratulated on the possession of the new air-channel which is now being installed. The channel is 3 metres, say 10 ft., in diameter, and the maximum air speed 30 metres, or about 100 ft. per second. The standardisation, or rather the intercomparison, of methods of research was discussed by Sir Richard Glazebrook in his paper dealing with the international tests now in progress. Mr. Southwell described the most recent apparatus at the National Physical Laboratory, and Mr. M'K. Wood dealt with the accuracy of model results and their comparison with full-scale work.

Among the other papers, one by Mr. Baumhauer, of the Dutch Institute for Aeronautics, on the methods of computing wing sections, met with general approval, while Mr. North's paper on the technical development of the aeroplane aroused much interest. It must suffice to mention them, together with the papers on stability by Mr. Barlow; on control at low speeds, by Mr. M'K. Wood; and on testing of strength, by Mr. Douglas. Another paper by Messrs. Baumhauer and Groning dealt with the vibrations of an aeroplane wing, a subject which is being investigated both at the National Physical Laboratory and at Farnborough.

It will be obvious from the above that those members of the Congress who attended Group (A) were kept fully occupied with interesting and important problems.

And now to conclude; limits of space forbid anything but the briefest reference to the other papers, not that they were less interesting or less important than those of Group A. There is no one better able to speak on airship travel than Major Scott, with his experience of two voyages across the Atlantic. Colonel Richmond is an authority on airship structure, while Signor Nobili has acquired a world-wide reputation from the success of the Italian ships. Some comparison of their performance with those of our own non-rigids would be interesting. Moreover, full-scale experimental work, if airships are to be constructed on a scientific basis, is still required, though our knowledge has been increased by recent American work.

Members attending Group B were interested in various papers connected with engines, such as Mr. Charlton's account of the crude oil engine, Wing-Commander Hyne's description of engine work at Farnborough, and the communications on lubrication by Dr. Stanton, Mr. Evans, and Mr. Hersey, while on Wednesday morning the discussion on air mails and the development of commercial aviation by General Williamson, Jonkherr van Hemstede, and Mr. Handley Page attracted a large and attentive audience to Group C. In every way the Congress proved a great success, and its members acclaimed Sir Samuel Hoare's toast at the concluding meeting, "To our next merry meeting, Brussels, 1925."

The National Physical Laboratory, Teddington.

ANNUAL VISITATION.

ON Tuesday, June 26, the General Board of the National Physical Laboratory made the annual visitation to the Laboratory. As is customary on this occasion, a number of members of scientific and technical societies and institutions, government departments, and industrial organisations were invited, and the Laboratory was open for inspection. The visitors were received in the new aerodynamics building by Sir Charles Sherrington, chairman of the Board, Sir Arthur Schuster, and the director of the Laboratory.

Since the last visitation the Laboratory has been somewhat extended, and Victoria House, acquired a few years ago to meet the anticipated increased demands of the work, has been converted for the use of the Physics Department. Most of the temperature work involving the testing and standardisation of mercury, resistance, and optical pyrometers is carried out here, in addition to the investigations of the newly created sound section. The Metallurgy Department has been provided with much-needed increased accommodation by the addition of a new story to the Wernher Building, in which a number of offices and small laboratories, as well as a special room for high temperature work, have been equipped.

A very large number of interesting exhibits were shown in the various departments. It is, however, impossible to do more than describe briefly a few of the more noteworthy, which show the wide range of phenomena, from the highly theoretical to the severely practical, which the Laboratory is called upon to investigate.

In the Aerodynamics Department the wind-tunnels were shown in operation. In the duplex wind-tunnel, which has a working portion 14 ft. wide, 7 ft. high, and 80 ft. long, two motors of 200 h.p. develop wind speeds up to about 110 ft. per sec. (75 miles per hour). A test on a Bristol Fighter aeroplane was demonstrated in which, on a model ($\frac{1}{5}$ full size) having a motor-driven airscrew, an experimental investigation of the effect of slip-stream on the behaviour of the plane is being carried out. The "whirling arm," which is driven through a worm gear by a 12-h.p. motor giving speeds of advance up to 50 ft. per sec., was shown employed in the determination of the pressure distribution on ellipsoids travelling in circular paths. This has an important application in the deduction of the stresses imposed on the hull of an airship which is turning.

Another interesting exhibit showed an electrical method of determining the stream-lines of an inviscid fluid past an aerofoil of any given section. It can be shown theoretically that the equipotential lines of a system consisting of an insulated conductor between two charged parallel plates are identical in form with the stream-lines in a perfect fluid flowing parallel to the plates past the same conductor. By the use of exploring electrodes connected to telephones through a three-valve audio-frequency amplifier, it is possible to determine positions of the electrodes which reduce the sound in the telephones to a minimum, and hence obtain the equipotential lines of the system, or the stream-lines for the case of fluid flow.

In the Engineering Department a new method of testing the efficiency of gear-boxes was shown in which the difference of the input and output powers is measured directly and not as a difference. The method consists of the observation of the torque produced as a consequence of the difference of the input and output powers when the gear-box was supported in a tilting frame. Apparatus was shown for the study of explosions in closed vessels. This has an important application in the design of internal combustion engines where it is desirable that the explosions should occur under the most favourable conditions of temperature and pressure of the mixture. This is, of course, largely influenced by the compression ratio, which is, however, limited in effect by detonation or "knocking" at high compression ratios.

In connexion with the experimental study of roads and road materials a new plant for the preparation of bituminous macadam was exhibited. The plant consists of two units, one for mixing sand, etc., at a temperature of 600° F., and the other for mixing the aggregate with bitumen. It is capable of mixing about six tons of road metal per hour. Other exhibits included apparatus for the investigation of fatigue under uniform bending moment, and its correlation with the microstructure of the material; the endurance of ball-bearings under axial loading; and the hardness of materials as tested by their ability to resist scratching by a diamond.

The main exhibit in the William Froude National Tank was the method of determination of the stresses liable to be set up in the rudder heads of ships when the rudder is altered in certain definite ways. The problem is one on which attention was focussed during the War, when even with vessels which were classed A1 at Lloyd's damage to stearing gear was of much more frequent occurrence than was anticipated. For this purpose a ship model capable of independent motion and external control was under observation from the travelling carriage of the tank, and the effect of putting the helm over at various rates and through different angles investigated. The experiments show that it is possible to add more than 50 per cent. to the strain on the rudder head by changing the helm too quickly.

Other exhibits included apparatus for determining the stresses on a rudder behind a fin plate with twin screws, and for the determination of the resistance, rise, and angle of seaplane models in motion.

In the Metrology Department standard weights were exhibited. In this connexion it is interesting to note the experiments of the Laboratory on a new material, stellite, as a substitute for platinum for standard weights. Stellite, which is an alloy of chromium, cobalt, and tungsten, is exceedingly hard, and tests made on these weights show that it has great promise as a platinum substitute. The weights have been under observation for two years, and have shown that stellite possesses great stability; weights made of it remaining constant to less than 1 part in 10,000,000 over that period.

A new gear-measuring machine was also exhibited; with this machine it is possible to measure the pitch of teeth, tooth-shape, and thickness, concentricity of teeth with the gear axis, parallelism of teeth with the axis, radial symmetry of teeth, and the pitch diameter. By ingenious arrangements the profile of the successive teeth can be magnified and made visible on a smoked glass and examined by projection methods, while the variation from uniform motion of two gears in mesh can also be critically examined.

A travelling microscope, in which many of the errors prevalent in the usual form of travelling microscope are eliminated, was demonstrated. In addition, the instrument, by suitable gearing, gives results simultaneously in inches and centimetres to a ten-thousandth of an inch or centimetre.

The exhibits in the Electrotechnics Division included the experimental arrangements for precision resistance measurements, for research on buried cables, for the determination of the errors of current transformers, and for the photometric measurement of lamps. An interesting demonstration of the attraction of the suspended particles in oil to electrodes at high potentials showed how such impurities can diminish the insulating properties of oils used for insulating high-tension apparatus. The illumination building in which experiments on the window efficiency of rooms are carried out was also open for inspection.

The end hardening of gauges, which was investigated in conjunction with the Metrology Department, was also shown here. The gauge is made one electrode in a furnace and passes a heavy current through a piece of graphite, which is thereby heated to a high temperature. The portion of the gauge in contact with the graphite thus attains a temperature considerably above the critical temperature for steel, and on dropping into water all the portion which was above the critical temperature is very effectually hardened. In this way only a very small proportion of the material of the gauge is interfered with in the hardening process.

The Wireless Division's exhibits consisted of apparatus for measuring both the direction and intensity of the electro-magnetic field from a distant radio transmitting station, and for applying these measurements to the study of the propagation of electro-magnetic waves over the earth's surface. To assist in this study of radiation problems, a transmitting station using both damped and undamped waves has been erected. An earth screen is employed at this station with various forms of antennæ. Apparatus was also shown for the absolute measurement of the amplification produced by a valve amplifier at audio-frequencies: this is used for the testing and investigation of both valves and their coupling transformers.

In the Radiology Division a Bragg spectrometer was shown in operation for the examination of the structure of metals and alloys. The method is a modification of the powder method of determining crystal structure, and has been extended to several systems of alloys, including copper and aluminium, copper and nickel. In each case it is found that in solid solution the solute atom enters into the lattice of the solvent by substitution. The structures of such metallic compounds as $CuAl_2$ and AgMg have also been determined by this method. Apparatus consisting of a spherical ionisation chamber for the investigation of the scattering of X- and γ-rays was also shown. This problem is of interest in connexion with deep therapy treatment using X- or γ-radiations, where, unless suitable precautions are taken, it is possible to obtain several times the desired exposure due to the scattering effect of surrounding tissues.

In the General Physics and Heat Divisions the exhibits were mainly of apparatus for determining the thermal constants of materials. Among these were a special calorimeter for use with substances that react with water, new forms of immersion heaters for use at high temperatures, and apparatus for determining the thermal conductivity of metals up to within a few degrees of their melting-points. Other apparatus exhibited was concerned with the production of sounds of constant intensity and frequency, and with the reflecting and absorptive properties of materials for sound waves. A high vacuum two-stage mercury pump was also shown, by which pressures of less than 10^{-6} mm. of mercury can be obtained with a supporting pressure of 4 mm. of mercury. The exhaustion speed for both gases and vapours is extremely high, and drying chemicals are unnecessary. The pump and its connexions throughout are of steel, and the system is vibrationless and noiseless.

Among other important exhibits in the Metallurgy and Chemistry Departments was an induction furnace in which metals of the highest melting-point can be readily melted by the agency of eddy currents induced in them from a surrounding high-frequency current. Models illustrating the internal constitution of alloys consisting of three or four metals were also shown, together with a number of interesting microphotographs showing the structure of copper containing oxygen and the deformation of metals under the action of cutting tools.

In the Optics Division various forms of apparatus used in colorimetric work were on view, together with demonstrations of the methods used in determining the optical constants of lenses, prisms, optical glass, and the performances of optical instruments. An interesting and simple shadow method of showing up striæ and lack of homogeneity in glass was shown.

In the Electrical Standards Division various methods of measurement of electrical properties at radio- and audio-frequencies were demonstrated.

River-terraces and Glacial Episodes.

A. PENCK'S view, that the infilling of valleys with glacial detritus in Central Europe indicates an ice-extension, while the subsequent erosion of the deposits indicates an ice-retreat and therefore an interglacial episode, has received wide acceptance, and has been applied to areas where other causes may have brought about the facts observed. A. Heim in Switzerland has kept in view the effect of general movements of elevation or depression on river-erosion and valley-choking respectively, and teachers in the British Isles are not likely to have omitted such factors from their explorations of existing features in the homelands. W. Soergel, on the other hand (see NATURE, vol. 108, p. 464, 1921) has felt that the infilling of the valleys round the Rhine-vale and the subsequent erosion must be due to climatic changes rather than to earth-movement, and that much of the infilling is due to frost-action.

There seems to be a feeling in Holland that valley-terraces and "drift" accumulations in the northern lowlands have been unduly linked up with those of the Alpine area, and Prof. J. van Baren has issued a critical paper in English, bearing the long but expressive title, "On the correlation between the fluvial deposits of the Lower-Rhine and the Lower-Meuse in the Netherlands and the glacial phenomena in the Alps and Scandinavia" (Mededeelingen van de Landbouwhoogeschool, 1922; Wageningen: H. Veenman, 1922; price f. 2.50). He lays stress on changes in the position of the sea-level and on tectonic movements generally, and even ascribes to the latter many cases of disturbance in deposits that have been regarded as glacial and as pressed on by the Scandinavian ice-front. In his desire to be free from the incubus of glaciers in the central and northern Rhine-vale, he reverts (p. 13) to the old suggestion that rock-surfaces may be striated by the sliding of stones down mountain-slopes. There is a good deal in recent Dutch discussions of the subject that van Baren desires to make more widely known, and a good deal that will seem to be a challenge to British workers, who have felt that sound conclusions have been reached in regard to the problems of the East Anglian "drifts." The author's beautiful photographic illustrations show how much may be done with the unpromising materials of modern clay-pits.

Dr. C. H. Oostingh (Ber. Oberhess. Gesell. für Natur u. Heilkunde zu Gieszen, vol. 8, 1922) treats of the "Geschrebe südhicher Herkunft in Holland und den benachbartein Gegenden," and, like van Baren, is opposed to the suggestion of any glaciation by land-ice of the hills about the central Rhine. He regards the blocks from the south, of which he has made careful collections throughout Holland, and which are very often angular, as transported by ground-ice floating down the rivers. He asks also for more complete petrographic information as to the materials in the English Forest Bed that have been attributed to the denudation of Germany and the Ardennes. His extensive bibliography will aid numerous English workers in this field.

University and Educational Intelligence.

BIRMINGHAM.—At a degree congregation held on July 7, the Vice-Chancellor (Sir Gilbert Barling) conferred the honorary degree of Doctor of Laws on Dr. F. W. Aston, in recognition of his distinguished contributions to scientific knowledge.

The degree of D.Sc. was conferred (*in absentia*) on Mr. C. S. Fox for a thesis on "The Bauxite Deposits of India," and other papers on geological subjects. The degree of M.D. was conferred on the following:—J. C. Brash, C. C. Elliott, R. J. Gittens, A. P. Thomson, and G. H. Wilson. There were 26 successful candidates for the degree of M.Sc., 94 for the honours B.Sc., 68 for the ordinary B.Sc., and 29 for the degrees M.B., Ch.B.

BRISTOL.—Prof. J. W. McBain is to give a dedication address in connexion with the opening of the Chemical Laboratory at Brown University, Rhode Island, United States.

The degree of Bachelor of Agriculture (B.Agr.) has been established in the Faculty of Science. The curriculum for the degree occupies 5 years, two of which will be spent in the University (including the Agricultural and Horticultural Research Station, Long Ashton), two years in the Royal Agricultural College, Cirencester, and the remaining year on a selected farm.

CAMBRIDGE.—Mr. G. C. Steward, fellow of Gonville and Caius College, has been appointed fellow and lecturer in mathematics at Emmanuel College. Mr. A. H. Davenport has been appointed fellow and bursar of Sidney Sussex College.

The Syndicate appointed to consider the regulations for the Jacksonian professorship on the vacancy caused by the death of Sir James Dewar, recommend that it be defined to be a professorship of natural experimental philosophy as relating to physics and chemistry, and suggest that a professor should be appointed whose work would advance the knowledge of chemical physics on the lines of recent physical, atomic, and molecular research. The exact method by which such researches may lead to finding a cure for the gout—one of the prime duties of the professor according to the will of the founder of the chair—may at present be left to the speculations of the curious.

The Chemical Department Syndicate has issued a report on the extension of the buildings of the Chemical Laboratory, showing an expenditure on buildings and equipment during the last four years of more than 75,000*l*. The annual report of the Observatory Syndicate refers to work on proper motions of stars, by plates exposed through the glass and measured superposed film to film on old plates taken with the Sheepshanks Equatorial 15 to 20 years ago. The chief points of interest in the report of the director of the Solar Physics Observatory are an account of Mr. C. T. R. Wilson's most recent work on β-ray tracks, continued investigation on the distribution of calcium flocculi and prominences on the sun, the preparation and publication of a revised list of unknown lines in celestial spectra, and work on coarse diffraction spectra by crossing a prism and a grating as originally suggested by Prof. Merton.

The Jubilee Celebration of the Cambridge University local lectures was celebrated on July 6-9 by a conference on various aspects of extra-mural teaching.

ST. ANDREWS.—Prof. J. Read, professor of organic chemistry (pure and applied) since 1916 in the University of Sydney, has been appointed to the chair of chemistry and the directorship of the Chemistry Research Laboratory. Prof. Read may be regarded as the founder of the first school of organic chemistry in the Southern Hemisphere.

RESEARCH bureaus have, during the past three or four years, been created by boards of education in many large and some small cities in the United States. Ten years ago there were none of these organisations: now there are upwards of 45. An account of the constitution and functions of a score of them, published last January by the Bureau of Education, Washington, shows that while in every case they collect and digest facts relevant to the problems with which the boards have to deal, they vary widely in importance and scope. Some resemble the cost-accounting department of an industrial concern, others a military intelligence branch, and all have something of the character of the special inquiries and reports department of our own Board of Education. A city in which this kind of development has been most noticeable is Detroit. Here a highly enterprising and influential Department of Instructional Research has been at work since 1914, formulating educational policies to be carried out throughout the city-school system and watching their operation. It works through its own staff-director, three assistants, four regular clerks, from three to twelve extra clerks, and a department of supervision with separate sections for health, English, exact sciences, social sciences, vocational education, and fine arts, and in close association with a department of special education responsible for psychological measurements, assignments to proper classes and direction of education of "atypical" children. A separate Bureau of Statistics and Reference, with five officers and eight clerks, was organised in 1918. At Indianapolis the research department cost in 1921–22 11,500 dollars, and "in dollars and cents has more than paid its way in watching leakages in receipts and expenditures, and in suggesting more efficient methods of doing things with smaller expenditures."

THE West Indian Agricultural College in Trinidad, which was opened on October 16, 1922, by Sir Samuel Wilson, Governor of Trinidad and Tobago, has now nearly completed the first academic year of its existence, and this first year has been one of great promise and encouragement. *Via colendi haud facilis*—the motto chosen for the College—is a very apt one, and it is well that those in authority with regard to Colonial affairs at home have come to regard tropical agriculture as so serious a pursuit that it has been deemed necessary to found a college for the study of tropical agricultural matters. The prospectus for the coming academic year has just been issued, and in addition to containing information as to College regulations and administration, it gives detailed particulars of the various courses of instruction. Arrangements are made for a diploma course which occupies three years and leads up to a diploma in tropical agriculture. Facilities are also afforded for special study by graduates of other universities and colleges who desire to extend their knowledge of subjects pertaining to tropical agriculture, and to undertake investigations into these matters under tropical conditions. Arrangements for a course in sugar technology, which is one of the subjects for the diploma course, are not yet fully completed, but it is proposed to erect a model sugar factory without delay. It is to be hoped that officers trained in British colleges and universities who have been selected to fill agricultural posts in the Colonies will either be sent to Trinidad to take a special course of study before taking up their appointments, or will be given facilities for carrying out special research at the College during one of their periods of leave. If the College can be used for the further training of our Colonial agricultural officers in the manner suggested, very great benefits will accrue to agricultural enterprises throughout the Empire.

THE Imperial Education Conference, opened by the Duke of York on June 25, concluded its sittings on July 6. This is the second conference officially convened, the first having been held in 1911. A previous conference, held in 1907, was organised by the League of Empire. The current conference was fully representative of education within the Empire in its official aspects. The Irish Free State and Northern Ireland were represented for the first time. The subjects discussed included the qualifications of teachers and mutual recognition of teachers' training and service throughout the Empire, vocational training, leaving certificates, rural education, the bi-lingual problem, native education, and various administrative questions. On the question of school examinations, Dr. H. Murray, of Nova Scotia, made the important suggestion that certificates should state the subjects taken and the percentage of marks gained in each subject, the several universities being left to determine whether or to what extent each certificate should be accepted for matriculation. He thought that, except in special subjects, the value for the Dominions and India of external examinations conducted by examining bodies in Great Britain was apt to be overrated. Mr. W. T. McCoy, of South Australia, urged the establishment of a Bureau of Education for the Empire. He acknowledged the excellent work done by the Department of Special Inquiries of the English Board of Education, but pointed out that there was no book or authoritative publication which supplied information and statistics of education in the Empire in a handy form. To the maintenance of such a Bureau, he suggested, all the dominions, colonies, and dependencies should contribute. In the evenings addresses were given followed by discussion, the most important being by Sir Robert Baden-Powell on character training and a brilliant address by Sir Charles Lucas on "The Island and the Empire." An educational exhibition was organised in the Home Office Industrial Museum and Westminster Training College, which was opened by Mr. Wood, president of the Board of Education. Hospitality was lavishly provided for the delegates, including a dinner given by the Government, under the presidency of Mr. Wood.

Societies and Academies.

LONDON.

The Royal Statistical Society, May 19.—A. L. **Bowley**: Death-rates, density, population and housing. The death-rates and infant mortality rates in the urban districts of England in the years 1911–13 were examined with a view of testing their relationship to the crowding of town populations. In Greater London, for example, the death-rate in districts where on the average there were 100 people to 100 rooms tended to be 12·7; where there were 110 people to 100 rooms 13·9, and so on in arithmetical progression. Six regions were considered separately, namely, Greater London, South of England, Lancashire and the West Riding, North-eastern coal district, Birmingham and South Staffordshire, and the North of England. In the North, generally speaking, the death-rates were higher and crowding and overcrowding more prevalent than in London and the South.—J. C. **Dunlop**: The misstatement of age in the returns of the census of Scotland. Age-periods, one including ages under 6 and the other ages 17 to 92, were discussed. A considerable amount of error persists, but greatly reduced in quantity—a change at least partly ascribable to an alteration of the wording of the age question in the schedule issued to householders at the census of 1921.

Royal Meteorological Society, May 20.—Dr. C. Chree, president, in the chair.—J. E. **Clark** and I. D. **Margary**: Report on the phenological observations in the British Isles, 1922. An exceptionally cool and sunless summer was experienced after mid-June. Before this a fairly mild winter followed by a cold early spring made fruit blossom late. Heat and sunshine of exceptional intensity signalised the latter part of May and early June, resulting in unusually rapid flower and insect development. Ripening was very late, however, especially in the north and Highlands, much hay being ruined or not cut till late September. The dry October and November enabled southern farmers to get well ahead with ploughing and sowing. The isophene flower chart shows little divergence from the lines giving the 30 years average, on account of the acceleration due to May and June. The migrant records indicate a similar sudden speeding up of their movements. As a consequence of the previous favourable summer and autumn there was a remarkable display of blossom and fair fruit crops despite the untoward summer.—T. G. **Longstaff**: Meteorological notes from the Mt. Everest expedition of 1922. A systematic record of temperature was kept on the outward march, at the base camp at 16,500 feet, and at the various climbing camps. Night temperatures were taken with minimum thermometers exposed to the sky on wooden boxes about one foot above the ground. Day temperatures were taken with sling thermometers. The lowest night temperature experienced on the outward march, April 12 to May 1, was 8° F. on April 13 and 19, at a height of 14,000 ft. The mean reading was 15° F. The lowest night temperature recorded during the expedition was −12° F. on May 27 at Camp III. at a height of 21,000 ft. The notes refer only to April, May, and part of June, and on the northern side of the main Himalayan axis of elevation. Totally different conditions prevail on the southern side, and the change from one to the other is abrupt. On the north side of Mt. Everest the snow-level is put at 20,000 ft., and glaciers descend to 16,500 ft. Owing to extreme dryness, evaporation is very rapid. Above 25,000 ft. snow disappears quickly with melting. Probably the constant high winds greatly assist this phase.

Optical Society, June 14.—Mr. T. Smith, vice-president, in the chair.—S. G. **Starling**: Levels and level bubbles. The factors affecting the efficiency of levels of the bubble form are discussed. Benzol, xylol, chloroform, alcohol, and ether are used in levels; the physical properties of these, and also of petroleum ethers distilled at various ranges of temperature, are given. A new method is described of obtaining calibration curves, by photographing the image of the bubble in a plane mirror, so that the position of the bubble upon the scale is obtained for successive tilts given to the tube. The relations between temperature and width and depth of bubble are obtained, and the results applied to an explanation of the "constant" bubble of Messrs. E. R. Watts and Son, Ltd., which has the same length at all temperatures.—E. W. **Taylor**: The primary and secondary image curves formed by a thin achromatic object glass with the object plane at infinity. The shapes of the primary and secondary image curves formed by a thin simple lens of an object plane at infinity can be readily determined. The image curves in the case of a double object glass of ordinary thickness, and with the inner curves approximately in contact, correspond very closely to those of a simple lens of the same power, and are only very slightly affected by the use of different glasses.—T. F. **Connolly**: A new form of balloon theodolite. The instrument is designed primarily for the observation of drifting balloons where it is desired to follow closely and consecutively the movements of the balloon and to note periodically the time and the simultaneous altitude and azimuth observed. The horizontal and vertical circles are brought together in such a way that a single index serves for reading both. A large field achromatic magnifier is so arranged that a "stand off" view is secured. The usual vernier has been abolished and replaced by a single index. Estimations of the degree intervals are made on each circle to 0·1°.

Geological Society, June 20.—Prof. A. C. Seward, president, in the chair.—K. S. **Sandford**, A. S. **Kennard**, B. B. **Woodward**, and R. C. **Spiller**: The river-gravels of the Oxford district. Ancient river-terraces occur in the headwater region of the Thames basin, west of the Chilterns, and maintain the same curve as the thalweg of the present rivers with which they are associated. There is no discontinuity of the terraces of the headwater tributaries of the Thames at their confluences near Oxford. Three terraces are identified above the present flood-plain. Below the lowest are flood-plain gravels, and a sunk channel has been identified. Each terrace contains a warm-climate fauna, with *Elephas antiquus*. The Proboscidea are represented by a suite of forms, from *Elephas antiquus* of archaic characters to the Siberian mammoth. The warm-climate fauna lingers long in the area. Palæolithic implements are scarce; unabraded specimens are of Acheulean culture.—L. **Dollo** and P. T. **de Chardin**: The deposits of Palæocene mammalia in Belgium. The four known deposits in Belgium at Erquelinnes (Hainaut), Orsmael (Brabant), Leval (Hainaut), and Vinalmont (Liège), containing Palæoçene mammalia, are of Sparnacian age (=Upper Landenian). They have yielded remains of marsupials, Insectivora, Carnivora, rodents, Condylarthra, Amblypoda, perissodactyls, and primates. No remains of Thanetian mammalia have been discovered in Belgium, and therefore the continuance into the Sparnacian of Belgium of the genus Adapisorex recorded from the Thanetian of Cernay is noteworthy.

PARIS.

Academy of Sciences, June 18.—M. Guillaume Bigourdan in the chair.—M. Mesnager: An indefinite thin plate, uniformly loaded, supported by points regularly spaced.—Marcel Brillouin: The possibility of studying the phenomena of radiotelegraphy on reduced models. A model constructed on the scale of one-thousandth could be made to serve many useful purposes. The modifications necessary to secure similitude are discussed.—P. Sergesco: Symmetrisable nuclei.—Serge Bernstein: The extremal properties of polynomials and of integral functions on a real axis.—Bertrand Gambier: Minimal curves: curves of constant torsion: Bertrand curves. The deformation of the paraboloid and hyperboloid of revolution.—A. Petot: The mode of working of automobile brakes.—Etienne Œhmichen: The flights carried out at Valentigney (Doubs), on April 28 and May 1, 1923, on the helicopter "Œhmichen-Peugeot, No. 2." A detailed account of two flights with this machine.—Max Morand: The electromagnetic radiation of electrified particles.—L. Fraichet: The magnetic testing of steels under traction. Elastic limits. The variations in the magnetic state of a steel under varying load show a permanent molecular change at a point named by the author "the true elastic limit." This point is lower than that corresponding to a permanent extension of the bar; the ratio between the "true elastic limit," thus defined, and the limit of proportionality is 0·7 to 0·95 for ordinary steels after annealing, and 0·5 to 0·65 in ordinary steels after tempering.—Paul Woog: Some phenomena of the superficial alteration of glass, capable of detection by high-tension currents. The phenomena described depend upon the presence of a layer of sodium carbonate on the glass and its absorption of traces of water from oil, resulting in changes of electrical conductivity.—Léon Guillet and Marcel Ballay: The influence of cold hardening on the resistance of metals and alloys. The changes in the electrical resistance of metals produced by cold hardening are less than 4 per cent. All the pure metals examined (except lead and tin) showed increased resistance. A brass (68/32) showed a 21 per cent. increase of resistance. In all cases, annealing restores the original resistance.—A. Dauvillier: Paramagnetism and the structure of the atom.—P. Job: The complex ions formed by silver salts and ammonia or the substituted ammonias. The equilibrium constant of this reaction has been studied by measuring the potential differences between a silver electrode and two solutions containing silver nitrate and silver nitrate plus amine at varying temperatures. Results are given for ammonia, diethylamine, ethylenediamine, and hexamethylenetetramine.—Marcus Brutzkus: Contribution to the theory of internal combustion motors.—L. Hackspill and A. Conder: In the ordinary method of manufacturing liquid carbon dioxide, the gases from the combustion of coke are absorbed by cold potassium carbonate solution, and the pure carbon dioxide required for compression recovered by heating the potassium bicarbonate solution thus obtained. Investigation of a case of rapid corrosion of the condenser of a compression plant showed that ferric nitrate was being produced. This has been traced to oxides of nitrogen produced during the combustion of the coke. These are fixed by the alkali, but small quantities of nitric oxide can arise from the interaction of carbon dioxide and potassium nitrite, and this is the source of the corrosion.—Max and Michel Polonovski: Di-iodomethylates in the eserine series.—Mlle. Brepson: The formation of soils in the region of Saulieu (Morvan). In this region the process of soil formation is simple, and is due to the decomposition of the subjacent rock under the influence of atmospheric agents: the action of wind or streams plays only an insignificant rôle.—J. Barthoux: Observations relating to the genesis of certain manganiferous deposits.—C. E. Brazier: The magnetic agitation at Parc Saint-Maur and at Val-Joyeux, and its relation with solar activity. The variations of the solar activity show no relation with the position of the earth in its orbit, while the magnetic agitation has a clear seasonal variation. For this reason the amplitude of the annual variation of the magnetic agitation is compared with the solar activities, 10-year periods corresponding with definite solar conditions being chosen. This annual variation of amplitude follows fairly well the changes in the solar activity.—Fernand Obaton: Experimental researches on the reddening of cherries. The reddening of cherries depends on the temperature, and light has no direct action on the phenomenon: a study of the respiratory coefficient showed that an absorption of oxygen accompanies the reddening process.—A. Goris: The chemical composition of *Monotropa Hypopitys*.—Ch. Kilian: Coefficients of utilisation and velocity of growth in fungi.—Emile Haas: The undulation of fatigue in different regions of the spectrum.—A. Desgrez, H. Bierry, and F. Rathery: The action of insulin on glycæmia and acidosis.—P. Benoit: Ovogenesis and segmentation of *Myriothela Coksi*.—L. Mercier and R. Poisson: A case of accidental parasitism of a Nepa by infusoria.—A. Policard and G. Mangenot: Cytological researches on the condition of the oil in oleaginous seeds. The ripe seed.—Maxime Ménard: Ten cases of pregnancy after treatment of fibroma of the uterus by X-rays.—J. Chevalier and Fernand Mercier: The pharmacodynamic action of the insecticidal principle of pyrethrum flowers.

PERTH (W.A.).

Royal Society of Western Australia, December 12.—Mr. E. de C. Clarke in the chair.—L. Glauert: (1) Contributions to the fauna of Western Australia, No. 3. A new species of burrowing crab is described. (2) *Cidaris comptoni*, sp. nov., a cretaceous echinid from Gingin. This is the first fossil sea-urchin to be described from Australian cretaceous formations. Affinities are noted with echinids from the white chalk of England and lower cretaceous beds of N. Africa, Sinai, and India.—R. J. Tillyard: The Embioptera or web-spinners of Western Australia. The history of the insects as revealed by Palæozoic fossils is described. The previously recorded *Oligostoma hardyi* and a new species, *O. glauerti*, are discussed.—L. Glauert: An annotated list of lizards from Wallal. The list includes one new species.—C. A. Gardner: Second contribution to the flora of Western Australia. Eight new species are described, one establishing a new genus and introducing the family Ericaceæ into the West Australian flora.

March 13.—Mr. E. de C. Clarke in the chair.—E. S. Simpson: Secondary sulphates and chert in the Nullagine series. In the softer beds of the Nullagine (Keweenawan ?) series, which covers large areas in the north-west of Western Australia, gypsum, epsomite, tamarugite, pickeringite, copiapite, alunite, and jarosite occur as vein fillings, efflorescences or imbedded crystals. Chert is widespread as hill-cappings and waste therefrom. The paragenesis of the minerals is detailed and their origin traced to weathering of pyrite and marcasite concretions which are abundant in the series. New analyses of the minerals are given, also the striking chemical differences between the ground-waters of the Nullagine area and of the Dry Lake region.—L. **Glauert**: Contributions to the fauna of Western Australia, No. 4. A freshwater isopod, *Phreatoicus palustris*, sp. nov., recently found in the swamps and small lakes near Perth, is described. The animal is closely allied to species found on Mount Kosciusko (5700 ft.) and Baring Tops (5000 ft.) in New South Wales; on Mt. Wellington (3800 ft.), Tasmania; on Dividing Range (2000 ft.), Victoria; on Table Mountain (2000 ft.), S. Africa; and in New Zealand, blind, in wells. Its distribution suggests former land connexion between New Zealand, Australia, and S. Africa.—T. H. **Withers**: An Australian cretaceous cirripede. Additional material from Gingin shows that a barnacle previously described by R. Etheridge, junr., as *Pollicipes* (?) *ginginensis* is a species of Calantica (Scillælepas).

April 10.—Mr. E. de C. Clarke in the chair.—A. D. **Ross** and R. D. **Thompson**: Magnitude observations of the star Beta Ceti obtained since the recent reported outburst. The reported increase in intensity can be explained by the fall into the star of a body of planetary size.—E. O. G. **Shann**: The present position in international exchange. A critical discussion is given of the various schemes to regain stability.

SYDNEY.

Linnean Society of New South Wales, March 28.—Mr. G. A. Waterhouse, president, in the chair.—G. A. **Waterhouse** (annual address): (1) Biological survey of Australia. Attention was directed to the slaughter of Australian marsupials for the sake of their skins, and to the export of enormous numbers of birds. The scientific interest of the fauna is evidenced by the number of collecting expeditions visiting Australia. The protection of the flora is a necessary corollary of any attempt to protect the fauna, and support is given to a recent suggestion to preserve the forests of all those portions of New South Wales which are more than 4000 feet above sea-level. (2) A further account of breeding experiments with the Satyrine genus Tisiphone. An account of the family from an orange female caught at Port Macquarie, April 17, 1922. This female had probably not laid any eggs before her capture, and she laid 14 eggs in captivity, from which 12 butterflies were obtained. The family shows, in the general shape of the forewing markings and the absence of the hindwing band, a closer approximation to *abeona* than to *morrisi*; the colour of three-fourths of the specimens is that of *abeona* rather than *morrisi*, but the size and coloration of the ocelli approximate rather to *morrisi* than *abeona*.

Mr. A. F. Basset Hull, president, in the chair.—R. **Greig-Smith**: The high temperature organism of fermenting tan-bark. Pt. ii. In the process of white-lead manufacture, the spent bark, before being again used, is subjected to a preliminary fermentation in which moulds play a part. Several that were isolated were able to convert cellulose into soluble products capable of being attacked by the high-temperature organism. The tempered bark contains humic acid as a typical constituent, and this substance is fermentable. Tempering is clearly a biological process in which the woody matter of the bark is altered to substances that can be fermented by the high-temperature bacterium.—J. **McLuckie**: Studies in symbiosis. No. 3. A contribution to the morphology and physiology of the root-nodules of *Podocarpus spinulosa* and *P. elata*. The development of the root-nodules of these two species of Podocarpus, the method of infection of the roots by the bacteria, the distribution of the bacteria in the cells, and of the fungal hyphæ which are frequently present, are discussed. The nitrogen-fixing power of the organism causing the nodule formation has been estimated.—G. F. **Hill**: New Termites from Central and South-East Australia. One new species of Coptotermes and two new species of Eutermes are described. The Australian termite fauna now comprises 6 species of Coptotermes and 28 species and 1 variety of Eutermes.—T. G. **Sloane**: Studies in Australian entomology. No. xviii. Synoptic tables of the Australian species of the genera Dyschirius, Craspedophorus, and Dicrochile are given, and a table of genera of the tribe Odacanthini—introducing 2 new genera.

CALCUTTA.

Asiatic Society of Bengal, June 6.—S. L. **Hora**: The adhesive apparatus on the toes of certain geckos and tree-frogs. It appears probable that all such adhesive apparatus consist of mere friction devices.—M. J. **Seth**: A manuscript Koran in classical Armenian.—L. R. **Rau**: On the age of the Uttatur marine transgression. The fossils in the lowermost Uttatur deposits and their correlation with foreign equivalents appear to show that the term "Cenomanian transgression," now generally employed for this encroachment of the sea on land in Southern India during cretaceous times, does not faithfully represent it in point of time and has to be modified so as to accord with an older age.—R. **Chanda**: (1) Note on the discovery of supposed Neolithic writing in India. The inscription on one neolith is evidently a modern date in Arabic numerals. The other object is not a neolithic artifact, and the letters are probably scratches. (2) Prof. Mazumdar on the dates of the Sanchi inscriptions. A fifth test letter, *dha*, for distinguishing post-Mauryan Brahmi.—N. K. **Majumder**: Siddhānta-Sekhara of Sripati. A brief introductory account of an important treatise on Indian astronomy, Siddhānta-Sekhara, by the reputed Indian astronomer, Sripati, of the eleventh century A.D. Recently a copy was discovered in the Trivandrum Palace Library, and a few other copies in the Government Oriental Manuscripts Library of Madras.—C. B. **Kloss**: On Blyth's bulbul (*Xanthixus flavescens*). Specimens from North Cachar are sufficiently different from specimens collected in Arrakan to be accepted as representing a new sub-species.—P. C. **Mahalanobis**: A first study of the head-length of Bengal castes and tribes. A biometrical analysis of the head-length of 36 Bengal castes and tribes.

Official Publications Received.

Records of the Survey of India. Vol. 16 (Supplementary to General Report, 1920-21). Annual Reports of Parties and Offices, 1920-21. Prepared under the direction of Col. C. H. D. Ryder. Pp. iv+140+10 maps. (Dehra Dun: Trigonometrical Survey.) 4 rupees; 8s.

Canada. Department of Mines: Mines Branch. Summary Report of Investigations made by the Mines Branch during the Calendar Year ending December 31, 1921. Pp. 346+20 plates. (Ottawa: F. A. Acland.)

Mellon Institute of Industrial Research of the University of Pittsburgh. Tenth Annual Report on the Industrial Fellowships of Mellon Institute, by Edward R. Weidleim, for the Institute's Fiscal Year, March 1, 1922, to March 1, 1923. Pp. vi+20. (Pittsburgh, Pa.)

Proceedings and Reports of the Belfast Natural History and Philosophical Society for the Session 1921-22. Edited by Arthur Deane. Pp. viii+131. (Belfast.) 5s.

Report of the National Research Council for the Year July 1, 1921, to June 30, 1922. Pp. iv+85. (Washington: Government Printing Office.)

Diary of Societies.

TUESDAY, JULY 17.

ROYAL ANTHROPOLOGICAL INSTITUTE (Special Meeting), at 8.15.—Dr. D. E. Derry: The Discovery of Fossil Human Bones in Egypt, possibly of Pleistocene Age.

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Muscular Exercise.[1]

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

Introduction.—Muscular exercise is a subject in which most people are interested. It is fortunate therefore that, in this direction, physiology has made greater progress into the intimate working of the body than perhaps in any other. The means by which bodily movements are carried out is muscle. Muscle is the red meat. There are three kinds of muscles: the voluntary muscle of the trunk and limbs, governed—or at any rate governable—by the conscious will of the individual; the involuntary muscle of the blood-vessels, of the alimentary and excretory, the so-called vegetative, system; and the cardiac or heart muscle, the muscle which pumps the blood round the body.

Muscle from the microscopic point of view is made up of a large number of similar thin fibres, about $\frac{1}{500}$ inch in diameter, and made of a jelly-like substance, running more or less parallel to one another. They are liberally supplied with minute blood-vessels from which they obtain their supplies of oxygen and food.

The voluntary muscle fibre is long and regular, and has obvious and characteristic cross-striations. The involuntary muscle fibre is smooth and long, with obvious nuclei, and generally occurs in thin sheets. It shows no sign of cross-striations. The heart muscle is vividly cross-striated, but its fibres are shorter and connected physiologically with one another, not running regularly in considerable lengths, their directions corresponding to the lines in which the walls of the heart are required to shorten, in order to expel the blood efficiently.

The voluntary muscle is excited by a voluntary, a so-called medullated nerve: the involuntary muscle by an involuntary, a non-medullated nerve: the heart beats automatically of itself, though its beats can be influenced reflexly through two nerves.

In function the muscles differ very widely from one another. The voluntary muscle moves very rapidly, indeed in some small animals the rapidity of its response is almost incredible—one knows the amazing quickness of a little bird jumping from twig to twig, but this is as nothing compared with the speed with which some small insects move their wings, a speed which one can detect from the high-pitched note they emit. The voluntary muscle is very powerful; it is usually "geared up" to increase the quickness of movement of the limb to which it is attached; if the flexor muscles of the arm of a powerful man were connected directly to a heavy load, they could lift a weight of about half a ton.

The voluntary muscle is very efficient for movements of moderate speed: it is very wasteful, however, if used to maintain a force for a long time, or if required to contract, either very rapidly or very slowly. The involuntary muscle, on the other hand, moves only very slowly: it takes seconds to perform what a voluntary muscle can do in a few tenths or hundredths of a second; it is very economical, however, in maintaining a force for minutes, or hours, for intervals maybe thousands of times longer than would be enough to produce complete fatigue in a voluntary muscle. The heart muscle moves at an intermediate speed: in man from 40 to 200 times a minute, depending on his health and training and state of exercise: in little animals faster, in large animals slower: it beats only—it never maintains a contraction—it would, so to speak, lift a weight up and down, but it could never keep it supported: it is amazingly infatiguable—it has a first call on the oxygen of the blood, and it can perform the most prodigious athletic feats.

A muscle's function is to "contract." The word contraction—drawing together—very well defines the activity of muscle: its volume does not alter when it contracts: like a piece of elastic it merely draws—or attempts to draw—its ends together. The sheaths of the muscle fibres are continued as tendons, and these tendons are attached to bones, so that when the muscle draws together the bones revolve about their common joint, and movements are produced. In heart muscle, the whole organ, in the form of two pumps, with inlet and outlet holes and suitable valves, is simply a closed vessel with powerful contractile walls which—by their drawing together—expel the blood into the arteries and around the body.

The fibres of voluntary muscle are bound together into anatomical and functional bundles—the so-called muscles—doing special duties in special ways and in special distributions. If a muscle be required to move through a long distance its fibres are parallel to the length of the muscle and long: if it be required to

[1] Discourse delivered at the Royal Institution on Friday, February 16.

move only through a short distance, but to exert a more powerful pull, its fibres run partly across the length of the muscle, they are shorter, and there are more of them: length of movement is sacrificed to strength.

Nervous Control.—The muscles have their activities controlled and co-ordinated by the nervous system. Partly this co-ordination is conscious and voluntary; mainly, however, it depends upon involuntary reflex control. In the body, in addition to the ordinary sense-organs is a complex and very important sensory system — the proprioceptive system — which deals mainly, or only, with the position, translation, and rotation of the body, with the stresses and strains in the muscles, with the positions and movements of the limbs. This system keeps the nervous system informed about the movements, passive or active, of the body, and about the strains and stresses, passive or active, of the muscles: and when anything happens, with amazing rapidity and almost unerring accuracy, the appropriate reaction is made, so that the balance or the posture is maintained, the integrity of the body is safeguarded, and the end in view is reached. Efficiency and skill at games, power and economy in violent effort, the faculty, in the literal sense, of falling on one's feet, all depend upon these quick, silent, overmastering, and generally unconscious reactions, dictated by the nervous system on the receipt of urgent messages from tendons, joints and muscles, or from the little sense organs associated with the ear.

Skill, power, and economy of muscular effort depend upon the effectiveness of these reactions; partly this muscular sense can be acquired, partly it is inborn, partly it is conscious or semi-conscious (though always inarticulate), partly it is reflex and instinctive: in any case it represents a highly developed and a very beautiful and important property of the nervous system. The instinctive skill, quickness, and economy of the gymnast or climber, of the mechanic, airman, tennis player, or athlete, depend upon a vivid and readily reproducible picture in the brain or nervous system, *a picture*, as Pear puts it, *of muscular exercise in terms of the sensations which effective and successful movements produce*. This lecture is intended to deal more particularly with quite another aspect of muscular exercise. To stress the energetic side of exercise, however, without any note on its intellectual and co-ordinative side, would give quite a false impression of the interest and variety of the subject.

Energetics.—Let us turn now to what one may call the energetics of muscular activity, of the capacity for doing work, or producing movement, of the cost of that work—of what we call "efficiency"—and of the conditions which limit that capacity—of what we call "fatigue." When a muscle contracts it can do work, which can be measured in gm. cm., or in ft. lb. This capacity for doing work seemed to physiologists to be the primary thing, until it was realised comparatively lately that *force*, rather than *work*, is the fundamental product of muscle. To maintain a state of contraction—even when no work in the mechanical sense is being done, as, for example, in pushing an immovable object, or in holding a weight at a fixed level—is just as tiring and expensive as actually to do mechanical work. The function of a muscle, therefore, is to pass from one state of stress to another state of stress without necessarily altering its length at all: if its load, or the resistance to its motion, be such that the muscle can shorten when its tension rises, it will of course do work in the mechanical sense: if, however, it maintain its state of tension without shortening at all, it will, none the less, require energy and become fatigued. Indeed, one knows that the most fatiguing exercise is to hold something, say at arm's length, without moving it up or down, without therefore doing any work at all in the mechanical sense.

Isolated Muscle.—Fortunately, for physiology, muscles can be isolated, and made to continue their function of contracting for days after removal from the body. It is easy to keep a frog's isolated muscle alive, in the sense at any rate that it will react to a stimulus, for many days. Moreover, the chief function of a muscle, indeed in a cold-blooded animal the only function, is simple and easy to detect and measure: the function of movement, of maintaining a posture, of exerting a force, is so extremely important to the animal that a very large proportion of its body has been devoted to this single highly differentiated purpose. Fortunately also it is easy to apply an artificial stimulus to a muscle, the electric shock, which produces no injurious effects and leaves the muscle ready to react again in a similar way a large number of times. A single sharp burst of electric current excites the muscle fibre to give the simplest and most fundamental unit of physiological response, the muscle twitch. In a twitch the tension rises, attains a maximum, and then falls again to zero, the whole cycle occupying anything from a small fraction of a second up to several seconds, depending upon the nature and condition of the muscle.

Now, in a voluntary muscle it is often—indeed almost always—necessary to maintain a force, or to exert a pull, for a finite and determinate time, not simply to give a tug and have done: and in such muscle this continuous pull can be produced by a rapid succession of stimuli each occurring before the effect of the previous one has passed off. One's own muscles do not appear to be obviously unsteady when exerting a voluntary effort: it can easily be shown, however, by a delicate electrical device that 40 to 50 obvious vibrations per second occur in them, and that they are really reacting discontinuously to a rapid stream of stimuli: even the shortest voluntary contraction of which the human muscles are capable is due to a volley of impulses shot at it, along the nerves, by the brain. Each separate unit of effort, however, which goes to make up the complete contraction is expensive—each requires energy just as each stroke with a pump requires energy. It is obvious, therefore, why the *maintenance* of contraction is expensive and fatiguing.

Fatigue.—Nearly all the recent and important advances in muscle physiology have resulted from a study of the phenomena of fatigue. We all know that there is a limit to muscular exertion, a limit which is set by what we call fatigue. If an able-bodied man take exercise at a very small rate, *e.g.* by walking, he remains comparatively untired for long periods: if he takes exercise more violently he becomes tired more quickly: if he exerts himself with the extreme effort of which he is capable, he is completely exhausted in less than a minute. There are many different kinds of fatigue, but the one we are discussing now, from the study of which so much light has been shed on the nature of muscles, is the extreme athletic fatigue which results rapidly from very violent effort. By it the finest athlete in the world may be overcome within a minute. It is a simple and comparatively intelligible thing. We can reproduce it readily in isolated muscle, deprived of its circulation. Let us subject an isolated frog's muscle, every second or two, to an electric shock, and record its contraction · we find that the response changes in a regular and progressive way, the force exerted becoming less, the contraction being developed rather more slowly and continuing much longer, relaxation being much drawn out. Finally, the muscle becomes inexcitable. Now in the intact animal, in man, we know that even extreme fatigue is rapidly recovered from, and this recovery is attributed to the circulation. If the circulation be hindered by a cramped position recovery is slower. If the fatigued isolated muscle be left in a chamber free of oxygen, no sign of recovery occurs: if, however, it be left in oxygen, in a few hours complete recovery will take place, and the muscle will now be capable of repeating its previous effort.

The realisation, especially by Fletcher about twenty-five years ago, of the extreme importance of this observation led directly to the most striking advances in our knowledge of the working of muscle. Recovery from fatigue is possible only in the presence of oxygen, and it was natural to suppose that the oxygen was used to oxidise some waste product, the presence of which acted unfavourably on the muscle. The next great step was due again in part to Fletcher, this time in co-operation with Hopkins. Lactic acid was known to occur in muscle, and Fletcher and Hopkins found the lactic acid to be increased by exercise, and diminished or abolished by recovery in the presence of oxygen. Furthermore, there appeared to be a certain definite maximum, beyond which the lactic acid content of the muscle could not be driven, even by the most vigorous stimulation: clearly this corresponded to the maximum effort a muscle could make. What was the function of this lactic acid, was it indeed to be the keystone of the bridge which physiologists were building from physics and chemistry on one hand to muscular activity on the other?

Heat-production.—Muscles, in activity, give out heat. External mechanical work is produced by the muscle with an efficiency of only about 25 per cent. Hence for every 25 ft. lb. of energy turned into external mechanical work at least 75 ft. lb. are degraded into heat inside the body. In a maintained contraction, in which no actual work is done, all the energy used is turned into heat: while in such movements as running, the energy is indeed turned in part into kinetic energy, which, however, is chiefly reabsorbed into the body as heat, owing to the jolts and jerks and rapid movements of the limbs, just as the energy of a motor car on a bumpy road is absorbed largely as heat in the tyres. In a single muscle twitch the rise of temperature is only about 0·003° C., and if one wishes to measure to 1 per cent.—and for some purposes one must measure to 0·1 per cent.—it is necessary to read to the nearest 0·00003° C. This can, however, be done, and with the wonderful electrical measuring instruments now available it has become comparatively easy. It is worth doing, because the heat accompanies, and is a measure of, the chemical processes occurring in muscular activity, and its production can be followed continuously, and so made to give us the time course of those chemical processes.

If the electrical record of the thermal response of the muscle to stimulation be carefully analysed, it is found that the heat-production is by no means simple in its time relations. In the first place, if the muscle be in oxygen, there is an evolution of heat lasting for many minutes after the contraction is over: and this evolution of heat is not small, but actually larger in total extent than the heat which occurs early in the contraction. In the absence of oxygen this delayed heat almost disappears. Clearly it is somehow connected with the recovery process Fletcher had noticed in an exhausted muscle, which we all know in our own bodies; it is accompanied, as Fletcher and Hopkins had shown, by a disappearance of lactic acid. The recovery heat-production occurs more rapidly at a higher pressure of oxygen. This agrees with what we know of recovery from exertion, or exhaustion, in man: breathing pure oxygen, instead of air, enormously increases its speed and completeness. Moreover, the magnitude of the recovery heat-production told one what happened to the lactic acid in recovery. One knew how much lactic acid was produced in a given contraction; one knew, therefore, how much lactic acid was removed in the complete recovery from that contraction: if it were all oxidised the heat evolved could be calculated: actually the amount observed is only about 1/6th of the amount calculated: hence the lactic acid removed in recovery, or at any rate its chief part, is not removed by oxidation, but in some other way.

Apart from this delayed heat-production associated with recovery, one might have expected the rest of the heat to be given out rapidly, more or less ex-

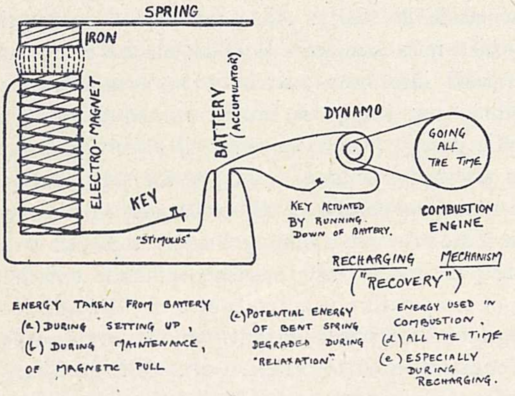

FIG. 1.—Electromagnetic analogy to the working of muscle.

plosively, at the commencement of contraction. Contraction has been likened to the explosion of a cartridge: the muscle suddenly gives out heat and develops force. This force, however, represents a state of elastic potential energy in the muscle, and when the muscle relaxes this potential energy disappears, and we should expect it to reappear as heat. Actually the analysis of the heat-production in the single twitch shows that about 60 per cent. of it is evolved in the initial process of setting up the contraction, 40 per cent. of it in the final stage of relaxation. If the contraction be prolonged, there is in addition a prolonged evolution of heat, lasting as long as the contraction, the rate of heat-production being proportional to the force maintained.

There are, therefore, four phases in the heat-production of muscle, corresponding (1) to the development, (2) to the maintenance, and (3) to the disappearance of the response, and finally (4) to recovery therefrom. A simple physical picture of the system is given (Fig. 1) by an electromagnet, pulling on a piece of iron attached to a spring: a key: a battery: and a dynamo (driven by a combustion engine of some kind) to recharge the latter. Energy is consumed in setting up the pull of the electromagnet, energy is being consumed all the time in maintaining the pull, energy—the potential energy of the magnetic field and the spring—is liberated when the current is broken, and energy is used in recharging the battery.

This picture has recently been given a more concrete chemical form. In contraction the lactic acid comes from glycogen; in recovery the lactic acid is restored as the glycogen from which it came, apart from a small proportion—about $\frac{1}{6}$th—which is oxidised to provide energy for the restoration. In the setting up of the contraction, therefore, lactic acid is liberated; in relaxation it is neutralised: it somehow produces the mechanical response by the action of its acidic part upon the structural protein elements of the muscle fibre. Protein is a weak acid at the hydrogen ion concentration of the body, and the structural elements of the muscle are in effect highly ionised sodium (or potassium) salts of protein. These structures therefore have a negative electric charge, all along their length, each element of the structure repelling every other element. The localised production of lactic acid causes the formation of sodium (or potassium) lactate, and of undissociated protein acid: the protein structure is discharged electrically: its elements cease to repel each other, and shortening occurs. It is well known that if the surface charge of mercury, in contact with sulphuric acid, be changed by conduction from outside, there results a change of surface tension, and so a movement of the mercury. This principle is utilised in the capillary electrometer, and would seem to have been employed by Nature in the muscle. The heat associated with contraction is due to the chemical formation of lactic acid from glycogen. As soon, however, as the lactic acid is free it is neutralised by the alkalies of the muscle, and relaxation sets in, the heat produced in relaxation being due to the chemical process of neutralisation. To maintain a contraction therefore requires a balance between the rate at which lactic acid is produced and the rate at which it is neutralised. Finally, in recovery, the neutralised lactic acid is slowly removed and restored, by the working of some unknown recovery mechanism, by which 5 parts of it are restored, and 1 part oxidised to supply the necessary energy.

Exercise in Man.—Our knowledge of the nature of muscular work in man has been derived largely from a study of the amount of oxygen used, and the various characteristics and time-relations of the oxygen supply. The subject of the experiment carries a large bag on his back (Fig. 2) and by means of a mouthpiece containing two valves, and a pipe and tap, he can breathe in fresh air from the outside atmosphere and expire it all automatically into the bag. A sample of the expired air can be collected for any desired interval. An analysis of it, a measurement of its volume, and a knowledge of the composition of the inspired air, allow a determination of the oxygen taken in and the

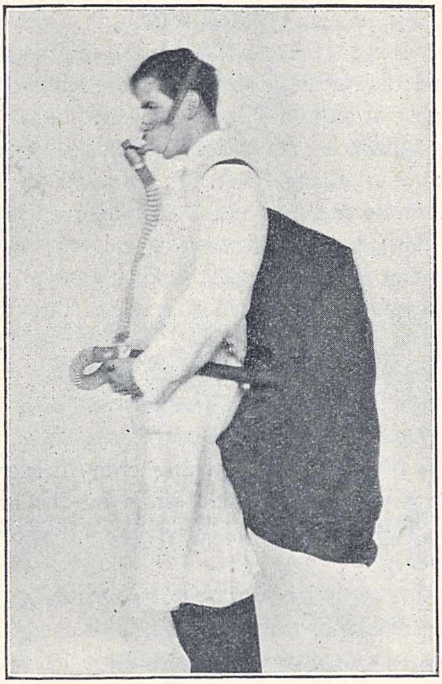

FIG. 2.—Bag, pipe, tap, valves, and mouthpiece used to investigate the gaseous exchanges of man during running.

carbon dioxide produced. From these the amount of energy used by the man during the period in question can be calculated. A point immediately brought out is (as in the isolated muscle) that the oxygen must be regarded, not as being used during the actual exercise itself, but in recovery, each element of the oxygen

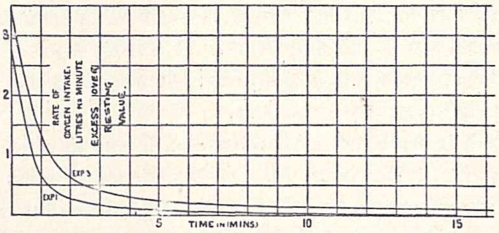

FIG. 3.—Oxygen intake in recovery after exercise : exercise ends at time o.

consumption corresponding to recovery from a previous element of the exercise (Fig. 3).

Many kinds of exercise have been investigated, for example bicycling, swimming, climbing, walking, running, ski-ing, and skating, and even the laborious process of pushing a motor bicycle up a hill! The two main types of muscular exercise are: (*a*) very violent exercise lasting for a short time, and (*b*) prolonged exercise of a more moderate kind.

Violent Exercise.—Let us take first the case of very severe exercise, for example, that of a man running 100 yards at top speed. The first personal impression which one forms of such severe exercise is that immediately after it, and often for a comparatively long time after it, panting occurs. The oxygen taken in is used almost entirely in recovery. In one experiment a good runner ran 225 yards in $23\frac{2}{5}$ seconds, and in the succeeding quarter of an hour recovered from his effort and used an extra $8\frac{3}{4}$ litres of oxygen in so doing. Such exercise, if it *could* be continued indefinitely, would require about 22 litres of oxygen every minute, but from other experiments the subject is known to be incapable of taking in more than about 4 litres per minute. Hence, during the most violent effort of which he was capable, he was using energy at about $5\frac{1}{2}$ times the rate that would have been possible had it been necessary for him to depend upon a contemporary supply of oxygen.

The "record" is held by a man of 46, who by means of a rapid quarter-of-a-mile run, followed by violent gymnastic exercise for 30 seconds, succeeded in making himself so exhausted that $13\frac{1}{4}$ litres of oxygen had to be used in recovery. This amount of oxygen would have maintained him quietly in bed for about an hour! It is clear that the body can get energy "on credit," which it has to repay after the exercise is over, by taking in later an extra amount of oxygen. It acts in the same manner as an accumulator, which can be run down at a very high rate for a short time and recharged afterwards. The discharge process is the formation of lactic acid from glycogen: in recovery this is reversed, the energy for the reversal being provided by combustion. The maximum lactic acid production in the muscle determines the limits of exercise, and the magnitude of the "maximum oxygen debt."

Prolonged Exercise.—Let us now discuss the case of exercise continued for a long time. By the most extreme effort of the respiratory system, a healthy man can take in about 4 litres of oxygen every minute. Consider, then, the case of a man taking exercise for a long time, say for an hour, during which time he will take in and use anything from 150 to 240 litres of oxygen. An oxygen "credit" even of $13\frac{1}{4}$ litres is only a small fraction of the oxygen which he can actually take in during the hour of exercise. Hence, he is limited in such types of exercise, not by the magnitude of the "debt" to which the body can submit, not, that is to say, by the lactic acid maximum of his muscles, but chiefly by the maximum rate at which he can take in oxygen. The oxygen is brought to the lungs by the movements of respiration, thence diffuses through the lungs into the blood, which is pumped round the body to the active limbs and muscles. The amount of oxygen, however, which can be carried by the blood is comparatively small, namely, only about $\frac{1}{5}$th of its total volume.

The efficiency of the mechanism by which the oxygen is carried round in the circulating blood depends very largely on the efficiency and capacity of the heart. For prolonged vigorous exercise a powerful and efficient heart is essential. If, however, the lungs be too small the oxygen pressure in them will fall too rapidly when a given amount of oxygen is carried away by the blood, and the smaller the lungs the shorter will be the time (for a given blood-flow) during which each drop of blood lingers in them in contact with the air. The smaller the lungs, therefore, the less opportunity will the blood have of collecting its required oxygen: the smaller the lungs and the less efficient their ventilation, the lower will be the pressure of oxygen in the arterial blood.

Now the heart is an extremely vigorous and hard-working organ, and it has the first call upon the oxygen which is carried by the blood. The coronary artery takes blood directly from the aorta, and carries it round the heart muscle itself. If the lungs be small, or their ventilation inadequate, or their walls too impermeable, the pressure of oxygen in the arterial blood will begin to fall; consequently the heart itself will get a lower pressure of oxygen—it will slow up or give a less effective beat, the blood-flow will be slowed, and the oxygen pressure in the blood will rise again to another higher value. Thus a balance will be reached in which each unit in the double mechanism is working at its limiting capacity, and one will find in athletes, who are capable of long-continued effort, that there is a combination of (*a*) a vigorous and efficient heart, and (*b*) capacious lungs capable of rapid and extensive ventilation.

A vigorous output of blood by the heart requires a vigorous return of blood to the heart. On the venous side of the small capillaries which feed the muscles with oxygen, there is little pressure left to drive the blood along to the heart. In the veins, therefore, the flow of blood is largely determined by the activity and movements of the body. The veins are provided with valves, and the alternating movements of the limbs and muscles help to pump the blood along the veins. If the body be rigid the arteries and capillaries are constrained and the blood-flow is hindered, while the veins get none of the rhythmic changes of pressure which tend to pump the blood along them, and so they fail to supply the heart with blood. Such exercise as holding oneself up with arms bent, in a gymnasium, on a pair of rings, is not in itself violent, and would not, if it *could* be continued, require an amount of oxygen comparable with running, even at so slow a pace as eight miles an hour. In such exercise, however, an extremely violent contraction in the very muscle that requires the energy almost entirely prevents the supply of blood to it, no oxygen is received, lactic acid rapidly accumulates, and exhaustion sets in.

Similarly, in such types as rowing, in which part of the body is in a state of stress during a large part of the time and the rhythmic movements are relatively slow, the supply of oxygen is more difficult. Consequently rowing appears to strain the heart more often than other kinds of athletic effort. For an easy and vigorous circulation no exercise seems to compare with running on the flat; here the movements are very rapid and the muscles are rigid during only a fraction of each cycle; consequently the blood can run through very easily, and it gets helped along in the veins by the jolts and jerks and shakes which the body receives, and by the rapid rhythmic pressures which are applied to the veins by the movements of the limbs. Thus from the point of view of taking as much exercise in a given time, with as little strain on the heart as possible, running is probably superior in type to any kind of exercise.

The function of the heart in exercise is so important that a vivid appreciation is desirable of the extraordinary tasks it sometimes undertakes. A subject of $11\frac{1}{2}$ stone weight succeeded in taking in about 4·2 litres of oxygen in a minute, while running round a track at about 9 miles per hour carrying a bag and breathing through valves and mouth-piece. Now the amount of oxygen which the blood can take in and give out, as it circulates once through the body, is certainly not more than about $\frac{1}{7}$th of its own volume. Hence at least 7 times 4·2 litres of blood per minute, *i.e.* about 30 litres, were circulating round his body during this experiment. The largest water-tap in an ordinary house has an output which is poor when compared with that of a human heart. It is little wonder that the heart goes wrong sometimes: the wonder is that this happens relatively so seldom.

An Example from Athletics.—The way in which the capacity of the body for exercise depends upon the supply of oxygen, actual or potential, can be illustrated by an example from athletics. A certain subject is capable of taking in about 4·2 litres of oxygen per minute; let us assume that his maximum oxygen credit is 13·2 litres, as found by Lupton in another subject. Suppose that at the end of a race his oxygen supply, actual or potential, is completely exhausted. Then clearly if he runs for a minute he has $(4{\cdot}2 + 13{\cdot}2) = 17{\cdot}4$ litres to spend altogether: if he runs for two minutes $(2 \times 4{\cdot}2 + 13{\cdot}2) = 21{\cdot}6$ litres altogether, or 10·8 litres per minute: if for five minutes, 34·2 litres altogether, or 6·8 litres per minute. The reason why he can run faster in a short race than in a long one is that his average rate of expenditure of oxygen can be higher. Now the following table gives the best performances, at various flat distances, of this subject, together with calculations therefrom, on the above assumptions:

Distance.	¼ mile.	⅓ mile.	½ mile.	1 mile.	2 miles.
Time	53 sec.	1 m. 17 s.	2 m. 3 s.	4 m. 45 s.	10 m. 30 s.
Average speed, metres per min.	455	419	392	339	306
Oxygen available in this time (lit.)	17	18·6	21·8	33·1	57·3
Oxygen requirement per min. at this speed (lit.)	19·2	14·5	10·6	7·0	5·5

If, therefore, the maximum rate at which a fit man can run a given distance does depend only upon the amount of oxygen he can obtain (*a*) out of income

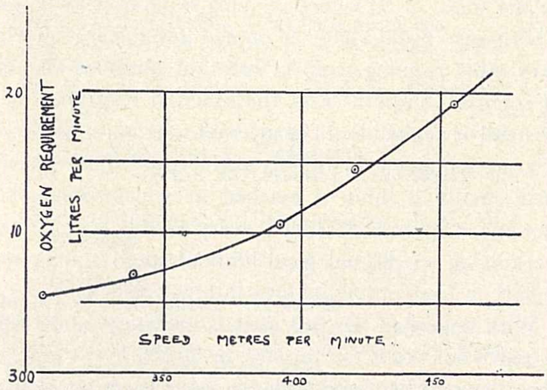

FIG. 4.—Oxygen requirement per minute for running at different speeds: *calculated* from the data in the previous Table.

through the lungs and circulation, and (*b*) on credit, then, knowing the maximum intake and the maximum credit, one can calculate the requirement at the different speeds. Running at 306 metres per minute, apparently about 5·5 litres of oxygen per minute were required; at high speeds much more; at the highest speeds enormously more (Fig. 4).

It is instructive therefore to inquire, by direct experiment, whether the oxygen requirement of running really has the value we have calculated, whether it really rises so rapidly as the speed of running is increased. The oxygen can be measured as before. It is necessary to take into account not only the oxygen actually taken in, but also the increase in the oxygen debt during the period of running. The subject stands at rest and measures his resting oxygen consumption; he runs 100 yards at the required speed; during the run and in the following fifteen minutes his oxygen intake is measured; from this is subtracted the oxygen he would have used had he remained at rest the whole time; the remainder is the oxygen consumption due to the exercise, during and in complete recovery from it. The result is exactly as shown in the figure: the measured oxygen requirement rises continuously as the speed is increased, attaining enormous values at the highest speeds. Hence we may conclude that the maximum time for which an effort of given severity can be maintained is determined mainly by considerations of the oxygen supply, actual or potential, to the active muscles.

Economy of Movement.—This leads us to the important practical question of what is called the "efficiency" of movement. Clearly if a given movement can be carried out more economically, *i.e.* at the expense of less energy, then less oxygen will be required for it, and its maximum duration can be increased. It seems probable that the difference between a good long-distance runner and a bad one may often be due, not to the fact that the good runner has a more effective mechanism for supplying his muscles with oxygen, but rather to the fact that he carries out his movements with greater economy. In any category of muscular effort the unpractised person will use inappropriate muscles and movements, or will use the appropriate muscles with an inappropriate force or rhythm. Some people's nervous systems are naturally athletic: the pictures they form of muscular movement, in terms of the sensations which it gives them, are clear, vivid, and sharp: they realise easily, from its subjective aspects, the most economical, the most effective, and the most convenient manner in which to employ and co-ordinate their various muscles, both in the power, the phase, and the rhythm of their several responses. Other people are clumsy, ineffective, and uneconomical.

If the timing of the valves of a motor, or the timing of the spark, be wrong, or if the valve clearance be not correct, the efficiency drops; so it is in an animal: if the muscles do not react with one another in the right phase, with exactly the requisite force, and in the appropriate rhythm, the movement becomes uneconomical. This economy of effort can, in part, be taught: but just as all the practice in the world will not turn some quite intelligent people into mathematicians, so all the practice in the world may never turn some quite powerful and well-developed people into first-class athletes. Training and practice are essential, but they can only build on an aptitude already there. If a subject use his muscles uneconomically, if—so to speak—the timing and clearance of his valves be wrong, he will need an excessive supply of oxygen. Consequently he will be an ineffective athlete, or an ineffective workman: he is uneconomical. Athletic prowess depends not only upon a large oxygen supply, but upon a low oxygen requirement.

Mechanical Efficiency.—Finally, let us consider the "mechanical efficiency" of muscular movement in its more technical sense, of work done divided by energy utilised in doing it. The mechanical efficiency of a steam engine may be from 5 per cent. to 20 per cent.: of a gas engine it may be higher, say up to 30 per cent. In man, the mechanical efficiency of muscular movement may be as high as 25 per cent.; the remaining 75 per cent. loss of energy is a serious thing: to what is it due? It seemed, from the purely physico-chemical point of view, that an efficiency of 100 per cent. was conceivable: the free energy of the oxidation of foodstuffs is very large. We know, however, that the body has been organised so that it can go on for a while without sufficient oxygen; it is like an accumulator: it can be discharged and then recharged: it can run into debt for oxygen, and pay off its debt afterwards.

If an animal like man were forced to live within his "oxygen-income," and were able only to make efforts which were possible on his contemporary oxygen supply, he would be a very feeble creature: only about $\frac{1}{6}$th as energetic (for short-lived effort) as he actually is. Moreover, oxidation in the body is a very slow thing; it takes minutes to complete, and it would be a disadvantage to take three minutes over every muscular movement. Hence the mechanism of the muscle has been evolved and differentiated on a different plan: oxidation is not the chemical reaction which directly and immediately provides the mechanical energy of the muscle: the actual process which produces the mechanical energy appears to be some kind of explosive transformation of a glucose di-phosphoric ester into lactic acid, and the subsequent physical or physico-chemical reaction of this lactic acid with the protein structures of the muscle. In recovery the lactic acid is restored, about $\frac{5}{6}$th of it, to the precursor from which it came, the remaining $\frac{1}{6}$th (or its equivalent amount of glycogen) being oxidised to provide the energy for the reversal. Mechanical energy is liberated only in the first stage, which appears to have a very high "efficiency"—probably about 100 per cent. In the recovery stage, however, 150 units of heat are liberated by oxidation for every 100 units in the initial stage, and this reduces the efficiency of the whole cycle to about 100/250, *i.e.* to about 40 per cent. Apparently, therefore, a big reduction in efficiency is effected simply by taking proper account of the recovery process, and is due to the need the animal often experiences of taking violent exercise, so to speak, "on credit."

Even so, however, 40 per cent is far higher than the efficiency actually found in man: the remaining reduction of efficiency is due to two other factors: (*a*) to the rapidity of the usual type of muscular movement, and to consequent frictional loss inside the muscle; and (*b*) to the physiological effort associated with *maintaining* a contraction.

With regard to (*a*), muscle is made up of a viscous material, not unlike egg-white or treacle, with a fine network of membranes, fibres, and tubes throughout it: the joints, the tendons, the connective tissue, the blood-vessels and the blood within them, are similarly of a viscous nature. Now, when a viscous fluid is forced to flow, mechanical energy is wasted and turned into heat: the faster it is made to flow, the more energy is degraded. But when a muscle changes its form, and produces a movement in a limb, the tissues have all to fall into a new form, viscous fluid has to flow into a new disposition, energy is degraded into heat: and in the more rapid movement we should expect more energy to be wasted. Experiment amply confirms this expectation: the frictional loss is greater, the greater be the speed of movement. This explains why it is so laborious to pedal a bicycle on too low a gear, and why very rapid running requires such an enormous amount of energy. In both cases the external resistance may be small or negligible. The internal resistance, however, is large, and increases directly as the speed of movement, until finally a limit is reached at which no further increase in speed is possible; every muscle fibre is then working to its physiological limit of speed and power, merely in overcoming its own internal resistance.

With regard to (*b*), just as it is inefficient and tiring to move our limbs too rapidly, or on too low a gear, so also it is inefficient and tiring to move them too slowly, or on too high a gear. This simple observation gives us the clue to the third and final reason why the efficiency of muscular contraction is relatively so low; a contraction which continues too long requires energy to maintain it, as well as energy to set it up, and from the point of view of doing external work the *maintenance* of contraction is ineffective. Experiments were made in which the heat produced by a muscle was determined as a function of the duration of the stimulus exciting its contraction. After an initial outburst of energy associated with setting up the contraction, the heat-production increases uniformly as the duration of the stimulus is increased. Hence we see why slow and prolonged movements are inefficient: a large and unnecessary part of the energy is used in maintaining the contraction. This is the phenomenon we all know in our own bodies: to attempt to lift a thing which is too heavy for us to move is more tiring than actually to lift a thing we can move, even though no work at all —in the mechanical sense—be done in the former case.