THURSDAY, SEPTEMBER 10, 1903.

RECENT MINERALOGY.

Mineralogy: an Introduction to the Scientific Study of Minerals. By Henry A. Miers, D.Sc., M.A., F.R.S. Pp. xviii + 584; with two coloured plates and 716 illustrations in the text. (London: Macmillan and Co., Ltd., 1902.) Price 25*s.* net.

THE author of this work has various qualifications for the difficult task undertaken by him, a task which has occupied the leisure hours of many years of an otherwise busy life. For thirteen years he was closely associated with the most beautiful and extensive of mineral collections; during that time he became thoroughly familiar with such objects as are described in his book, and attained scientific distinction by reason of the thoroughness and delicacy of his varied scientific researches; further, he visited not only all the best collections in the world, but also many noted mineral localities, and viewed the specimens in their own homes. He introduced, and for several years taught, the subject of crystallography to the students of the City and Guilds Technical Institute, invited thereto, and encouraged therein, by that far-seeing and enthusiastic chemist Prof. Henry Armstrong; he thus prepared the way for the brilliant discoveries since made by his crystallographic pupil Dr. Pope, and at the same time not only became familiar with the difficulties met with by students, but was compelled to discover the best ways of surmounting them. During the last eight years he has been at Oxford as occupant of the Waynflete chair of mineralogy, in succession to the veteran mineralogist and crystallographer Prof. Maskelyne, and by his development of mineralogical study in that university has more than justified his appointment.

The volume, though announced to be merely "an introduction to the scientific study of minerals," immediately impresses even a superficial observer with the magnitude of the subject, for its pages are at once large and numerous (584). But the reader, on opening it, instead of being immediately repelled by the obvious details and technicalities of a difficult subject, is at once attracted by the artistic character of the workmanship, for both paper and type are excellent, and the pages are adorned with no fewer than 716 illustrations, most of them of a style to which we are quite unaccustomed. Every artist knows the difficulty of making even a fair representation of the aspect of minerals, and both authors and students have thus had to remain content with mere diagrammatic figures in illustration of mineral "habit." In this case the author has been able to make many experiments by presuming on his relationship and exercising the artistic patience of a sister; as a result, they have evolved a series of figures most of which leave little to be desired; these are process reproductions of shaded drawings of actual, not imaginary, specimens, and, through the emphasis given by the artist to the leading lines of the figures, are as good substitutes, in two dimensions, for the actual specimens as can be wished. Among the most striking are Figs. 402, flos ferri; 407, calcite showing conchoidal fracture and cleavage; 422, diamond; 437, cryolite; 447, blende; 478, corundum; 486, rutile; 506, quartz twinned; 519, chrysoberyl; 554, witherite; 587, chiastolite; 627, harmotome. For the diagrammatic figures of crystals, the author is indebted partly to the same artist, Miss J. Miers, and partly to the assistant, Mr. R. Graham, whom he has trained in crystallography and perhaps represented, on p. 263, in the very act of crystal measurement. Further, there are two coloured plates which have been executed at the Oxford University Press by the three-colour collotype method, and are the outcome of much experiment; unfortunately, the method is as yet found to be too costly for general use. One of these plates represents the simple biaxial figure shown by a section of an orthoclase crystal when viewed in the polariscope by blue, green, and red monochromatic lights respectively; the other represents the complex figure yielded by the same section when viewed by white light. The actual chromatic effect of the "inclined dispersion" so characteristic of the mineral is thus beautifully reproduced by photography instead of being diagrammatically represented, as is usually the case, by a more or less plausible arrangement of colours. The trouble taken, and the expense incurred, to obtain this result are characteristic of the book in general.

The author himself points out that the treatise is no exhaustive introduction to the study of mineralogy, and that he has deliberately abstained from giving a systematic account of the modes of occurrence of minerals, their geological distribution, their origin, their alterations, and their artificial production. Indeed, the account and discussion of the essential characters of only the more prominent of the minerals which are so common as to be found in all museums occupies a volume which, to put it mildly, is quite as large as a student of average strength can conveniently carry about and handle; the other subjects are of necessity left for treatment in one or more later volumes.

The present volume is divided into two nearly equal parts; the first deals with the properties of minerals in general (286 pages); the second gives a description of the more important species (244 pages); these are followed by 28 pages of tables and a most elaborate and useful index (22 pages). One of the tables gives in a compact form a classified arrangement of the mineral species and a simple chemical formula for each, thus enabling the mind to grasp more readily some of the chemical relationships of the species. Of the tables useful in the practical determination of minerals, the most noteworthy are those giving the arrangement of the species according to the increasing magnitude of the mean refractive index, the birefringence, the optic axial angle, and the specific gravity respectively.

Part i. is subdivided into four books, treating of (1) crystalline properties (179 pages); (2) general properties (23 pages); (3) relations between the properties (30 pages); (4) description and determination of minerals (44 pages). Of the three latter and shorter books, the second contains a chapter on the chemical properties, more especially with regard to the problem of the classification of species; the third contains several articles which have not previously found their way into text-books of mineralogy (pp. 228–41); they relate to the crystalline form and physical properties of "solid solutions," and are especially useful in the discussion of the felspars; the fourth contains a chapter on the determination of minerals, and affords many useful and practical hints suggested by a long experience.

The first book is by far the longest, and is itself divided into two nearly equal sections; the first (98 pages) deals with the geometrical properties of crystals, the second (81 pages) with their physical properties. It may be objected that it is impossible to give to the student, within the compass of 98 pages, an adequate idea of the theory of crystallography, but it must be remembered that, in a work on mineralogy, minute crystallographic detail would be out of place; such detail is already given to the student in the special treatises of Prof. Maskelyne ("The Morphology of Crystals"), of Prof. Lewis ("A Treatise on Crystallography"), and of Mr. Hilton ("Mathematical Crystallography and the Theory of Groups of Movements"). What the mineralogical student requires is a brief sketch of the whole subject to enable him to grasp the general bearings; this the author has given, and it is all that should be expected from him. It may be mentioned that the author has sought to bring about uniformity of nomenclature of the thirty-two classes of symmetry by coming to an understanding with Prof. E. S. Dana, the editor of the well-known "System of Mineralogy"; but notwithstanding their agreement we find it difficult to reconcile ourselves to a nomenclature which compels one to say that a crystal of cinnabar (HgS) belongs to the quartz class; the systematic nomenclature suggested on p. 280 seems more full of promise. Attention may be directed to the form of student's goniometer, as improved by the author, which is figured on p. 101, and also to the convenient goniometer designed by him for fixing on the stage of a microscope (p. 178).

The chapters treating of the optical properties (70 pages) will probably be the most generally appreciated by students, owing to the great use made of these properties in the determination of the mineral constituents of rock-sections by means of the polarising microscope. It gives to the student a sufficiently precise sketch of the subject without entering into mathematical discussions, and proves once more that it is possible to give to the student an idea of the optical characters of biaxial crystals without any unsatisfactory hypothesis as to optical elasticity and its variability with crystallographic direction.

Part ii., which gives a description of the more important mineral species, is subdivided merely into sections dealing with the various mineral groups. It differs from other works of a similar kind in that it is in great part readable, instead of being a mineralogical dictionary. The readable part and the dictionary part are kept quite distinct from each other, both in position and in the size of type. Further, there is no attempt to give long lists of localities; these are left to be sought for in the books of mere reference; the author is satisfied, and doubtless the student will be satisfied, with descriptions of specimens from the more noteworthy localities, and with accounts of the more important modes of occurrence, and of these we think the author has made a judicious selection. As for the readable portion, it is full of interesting and valuable information.

The author has a simple and pleasant style which attracts the reader, occasionally relieving the technicality with a touch of the driest humour, as, for instance, when he finds it convenient (p. 350) to treat dihydric oxide as a member of an anhydrous series.

The English student of crystallography and mineralogy is to-day in a happy position as compared with his forerunners; his path is continually made more and more easy by the publication of excellent text-books; but there will long remain sufficient inherent difficulty to prevent these subjects of study from losing their educational value, and, as regards research, the recent discovery of radium in the long-known mineral pitchblende shows that the statement made by the alchemist several centuries ago is still true—"a man may consume his whole life in the study of a single mineral without arriving at the knowledge of all its qualities."

SCHOOL MATHEMATICS.

A Junior Geometry. By Noel S. Lydon. Pp. vi+171. (London: Methuen and Co., 1903.) Price 2*s.*

Technical Arithmetic and Geometry. By C. T. Millis, M.I.M.E. Pp. xiv+254. (London: Methuen and Co., 1903.) Price 3*s.* 6*d.*

The Modern Arithmetic for Advanced Grades. Woodward Series. By Archibald Murray (Harvard). Pp. 464. (St. Louis: Woodward and Tiernan Printing Co., n.d.)

The Junior Arithmetic, being an Adaptation of the Tutorial Arithmetic, suitable for Junior Classes. By R. H. Chope, B.A. Pp. viii+363. (London: W. B. Clive, 1903.) Price 2*s.* 6*d.*

MR. LYDON'S book, which is meant for young pupils, has many good points and a few bad ones. Like many other very recent books on geometry, it ignores Euclid's order, method, and language. In this way it appeals more readily to the understanding of the pupil than the orthodox Euclidean works do; but the definition "a straight line is one which lies 'evenly' between its extreme points," and the words "notice that the line you have ruled lies evenly between its extreme points A and B," show a strong conservatism. The pupil will indeed be clever if he can give a clear indication of the thing which he notices. The use of the terms *vertical* and *horizontal* in the following manner must be very strongly condemned:—

> "When a straight line is drawn upright on the paper it is called a *vertical* line, when drawn in a slanting direction it is called an *oblique* line, and when drawn level on the paper it is called a *horizontal* line."

Early teaching of this kind is responsible for the flagrant misuse of the terms *vertical* and *horizontal* which is so frequently exhibited by draughtsmen and students of engineering.

Again, the definition of an angle—" an angle is the difference in direction of two lines drawn from a point "—has nothing really quantitative about it, and should be used rather as a familiar *description* than as a quantitative definition.

After the definition of parallel lines—" parallel lines are such as are the same distance apart throughout their whole length "—we have the warning " be careful to distinguish between parallel and horizontal," which unintelligibility is, doubtless, in some way connected with the strange conception of *horizontal* above noticed.

We are now done with the blemishes; for the rest we have nothing but commendation. The book is divided into a series of lessons, each of which is followed by several exercises in the copying of various figures and patterns on squared paper, accompanied by arithmetical calculation. The little pupil is led easily into the subject, and he meets with nothing like severe reasoning until lesson vii. is reached. The grouping of propositions and constructions is throughout very good, and the chapters on areas particularly excellent. The most useful propositions of Euclid's books ii. and iii. are included, and the concluding lessons deal with loci, ratio and proportion, similar figures, &c., and include a large number of important problems, theorems, and constructions. This portion of the book (the most important) can scarcely be improved upon, and, indeed, for this part of the subject, we do not know of any work for beginners which deserves higher commendation.

The book by Mr. Millis can be very strongly recommended as one the study of which should go hand in hand with that of books on purely deductive geometry. It begins with the definitions and figures of geometry, and the use of instruments for the solutions of the problems which are usually treated of in geometrical drawing. Then follows the treatment of fractions, vulgar and decimal, their nature being explained and illustrated by geometrical construction. Contracted methods of multiplication and division are explained. The nature of ratio and proportion follows, and then the enlargement and reduction of figures, square root, propositions relating to areas—in the whole of which work arithmetic goes hand in hand with geometry. After the usual figures of elementary plane geometry are dealt with, conic sections and irregular curvilinear figures are taken, and their properties illustrated by arithmetical examples, with the use of squared paper. Simpson's rule and Henrici's method are explained. The last third of the book deals very fully with the mensuration of solids.

The pupil who uses this work will receive a thorough drilling in neat and accurate drawing—a thing which was very much needed when Euclid held sole sway in the schools.

Mr. Murray's book is a sequel to the work which we noticed some months ago. It is meant for teachers, inasmuch as no answers are given to the various questions. Comparing the work with either of the two books on arithmetic now noticed, it would appear that in the American schools the subject is taught in a very leisurely manner, since there is nothing of a very advanced nature in this work, and a great deal of the mere elements is included. This, of course, may in the end make for thoroughness. It seems somewhat strange that addition and subtraction of decimals are employed in the beginning (p. 31, &c.), while the subject of decimals is subsequently taken (p. 127, &c.) and treated *ab initio*.

Arithmetic and a certain amount of elementary algebra go hand in hand in the book—an arrangement which makes things simple for the beginner; but the purpose of several pages on very elementary algebra at the end of the chapter on percentage is not clear.

The metric system is, of course, explained and illustrated, but the large amount of space devoted to English weights and measures, with their antediluvian lawlessness and complexity, induces sad reflections on the utter waste of time which we impose upon our youth.

The chapter on " Computations and Approximations " contains a useful exposition of the use of squared paper for the plotting of curves and the determination of missing values by graphic interpolation. As compared with our English works, the most striking characteristic of this book is, perhaps, the absence of complexity and useless difficulty in the various examples. It is a merit of the author that he is very particular about the accurate use of language—a great desideratum in these days of slipshod writing, when English grammar and a logical arrangement of thought are steadily vanishing from our scientific treatises.

Teachers everywhere will find the work very helpful and suggestive for a natural and logical way of teaching the subject to young pupils, inasmuch as the methods employed are the result of many years' practical experience in the work of instruction.

Mr. Chope has prepared a treatise of the usual kind on arithmetic. It contains a very large collection of examples illustrating the various rules, and is just as good a handbook of the subject as the student can desire.

THE NEURONE THEORY.

Die Neuronenlehre und ihre Anhanger. By Dr. Franz Nissl. Pp. vi+478. (Jena: Gustav Fischer.) Price 12 marks.

ONE approaches this work with rather mixed feelings. While there is no doubt that an exhaustive survey of our present knowledge in any branch of science is certain to well repay the investigator, yet a book of the magnitude of the one now under consideration, which contains only a controversial view of already known facts, without introducing anything beyond what is familiar to us, leaves on the mind of the reader something of a feeling of weariness, and a suspicion that the same amount of labour would have been better expended in quarrying fresh knowledge rather than reshaping the blocks that have been already brought out. The author himself has realised this, and in the preface gives the reasons which induced him to give the present form to the book. That even scientific men are too prone to take a plausible hypothesis as proved, and to fill in the little gaps in the observed facts with more or less probable assumptions, is unfortunately true in many branches of research besides the one in question, and the work even of an *advocatus Diaboli* may be of value if only to point out the places in the theory where these assumptions occur. Particularly has this been the case in the domain of nerve physiology, and the present volume is a useful corrective.

The earlier part of the book is occupied with a historical review. Commencing with Waldeyer, His and Forel, Dr. Nissl gives an account of the origin and development of the neurone theory, with the various additions, alterations, and subtractions made by Hoche, Münger, Verworn, and the other investigators who have treated the subject. Allowing for a little very pardonable controversial bias, the summary is a just and able one, and Dr. Nissl's comments are well conceived; so that, although there are a few points on which different opinions may be held—for example, as to the weight to be attached to the work of Forel—yet, as a whole, we may take the history of the neurone theory here presented to us as the most complete and trustworthy one yet published.

The latter part of the book contains the author's reasons for dissenting from the generally received opinion of the structural unity of the elements known as "neurones." He points out that the idea of contact of nerve elements as opposed to that of continuity is not necessarily dependent on the neurone theory, and that the present methods of microscopic technique are not sufficient to give a final answer in the matter. The conclusion is therefore not so much that Dr. Nissl's own views are necessarily correct as that the rival opinions of the authors already mentioned have not sufficient basis in observed facts, and should be received with very much more reserve than has commonly been the case. It is not, however, possible to give a fair abstract of Dr. Nissl's contentions within the compass of a review, and the book itself must be consulted for further details. It will be found to well repay careful reading, though the unwieldy size, the absence of an alphabetical index—partly made up for by very full chapter-headings—and the fact that, following the German custom, the author has given no summarised conclusion, render it difficult without considerable labour to disentangle the essential from the non-essential portions of the treatise.

OUR BOOK SHELF.

The Cloud World, its Features and Significance. By Samuel Barber. Pp. xii+139. (London: E. Stock, 1903.) Price 7*s.* 6*d.*

IN this volume Mr. Barber's object has not been to write a scientific treatise on cloud formation, but rather to put before us his own carefully made observations, and "to commend to the tourist, the cyclist, and the city man a delightful and refreshing field of study which may add a charm to a summer holiday." With this object the book has been illustrated with a large number of excellent photographs and sketches, and contains many hints on the prognostic value of different appearances of the sky. We cannot help thinking that it would have gained in value if Mr. Barber had added, or, better still, prefaced, a short chapter on the classification of clouds adopted by the International Committee. This would have familiarised his readers with the generally accepted terminology of the subject; the glossary partly answers this purpose, but it enumerates so many different cloud forms that it might become confusing to one entirely unfamiliar with the subject.

When dealing with the physics of the atmosphere Mr. Barber is distinctly less happy. Though the book is not a scientific treatise, it ought not to contain statements such as the following.

In discussing the question of the suspension of water particles in the atmosphere we read, "The mechanical problem is exactly analogous to that of a bird's flight. If the bird is shot it drops for want of a propelling force: just so with the water vapour. It is not sufficient to assume the vesicular form of water in cloud molecules; we should need to assume a higher temperature in the air enclosed by the vesicles than in the surrounding atmosphere. How can this be maintained, especially at great elevations?" The hypothesis that clouds consist of hollow water vesicles received its death blow about the middle of last century when Stokes calculated the limiting velocity of a falling drop; since that date the suspension of water globules in the atmosphere has ceased to be a stumbling block to physicists. A few pages later we find the statement, "Various forces affect water and ice particles; *e.g.* heat, electricity, gravity between particles, gravity towards mountains and other prominences, gravity to the earth, and last, but not least, the force of crystallisation. . . . Let anyone watch the formation of ice crystals on still water, and he will have an idea of the extent of this force." Are we to understand from this that "gravity towards mountains" affords an explanation of the tendency of clouds to form near the summit of a mountain?

The reader who is inclined to make the study of the appearance of the sky his hobby will find much to interest him in the descriptive part of the book, but he must be prepared to take many of the physical explanations it contains *cum grano salis.*

Graphical Statics Problems, with Diagrams. By W. M. Baker, M.A. Pp. 60. (London: Edward Arnold, n.d.) Price 2*s.* 6*d.*

THIS is a compilation of sixty problems in graphical statics, many of them taken, by permission, from the army entrance examination papers. Each problem is accompanied by a diagram, and has a separate page allotted to it. This leaves plenty of room for the problem to be worked graphically on the page itself, without requiring the diagram to be transferred to drawing paper. The pages are perforated, and are easily removed if desired.

There is, perhaps, some unnecessary repetition and not enough diversity in the problems. We would suggest for a future edition that problems be included involving a direct appeal to experiment in verification of the principles of the polygon and the lever; and the scope of the subject might well be extended by the introduction of position, displacement, velocity, and momentum vectors, including vector differences, thus helping very materially to an adequate understanding of Newton's great law. Students should always measure their graphical results, and an appendix containing numerical answers would have been found very useful in this connection.

But the design of the book and the arrangement of the problems greatly facilitates the work of the teacher, and the volume can be strongly recommended to all who wish to include this very important branch of geometry in their curriculum.

LETTER TO THE EDITOR.

[*The Editor does not hold himself responsible for opinions expressed by his correspondents. Neither can he undertake to return, or to correspond with the writers of, rejected manuscripts intended for this or any other part of* NATURE. *No notice is taken of anonymous communications.*]

A Mite whose Eggs survive the Boiling Point.

IN several preparations of boiled flax seeds for fungus-culture it was observed that numbers of mites (*Tyroglyphus histiostoma*) made their appearance. A petri dish containing mites was boiled, and in about three weeks there were again large numbers of them present, though the cover had never been removed since boiling.

On June 6 a decoction of flax seeds containing mites in a test tube was boiled for five minutes, and the neck plugged with cotton wool. On June 15 a similar preparation was made, but the test tube was covered with an indiarubber cap in addition to the plug of cotton wool. On August 24 both test tubes contained living mites. So the inference seems justified that the eggs, though saturated with water, must have survived the boiling point.

The mite is about 2/5mm. in length. The bean-shaped eggs ($108\cdot5\mu \times 66\cdot5\mu$) are enclosed in two transparent valves like watch glasses.

I am much indebted to Mr. G. H. Carpenter for identifying the species.

J. ADAMS.

Royal College of Science, Dublin, September 2.

THE BERLIN CONFERENCE ON WIRELESS TELEGRAPHY.

WE have on two or three occasions referred in these columns to the International Conference on Wireless Telegraphy which was held last month at Berlin. The conclusions at which the conference arrived have now been published in the *Cologne Gazette,* and were summarised in the *Times* last week. In considering these conclusions it is as well to bear in mind that the conference was only preliminary; though representatives of nearly all the important States were present, it was not intended that the recommendations should be final, but rather that they should serve as a basis for discussion at a future conference with more definite powers. Still, the decisions are of interest as they indicate more or less clearly the general state of opinion on the present position of wireless telegraphy.

We have frequently pointed out in NATURE that for the present at any rate it should be the aim of those directly interested in the development of wireless telegraphy to perfect it as far as possible as a means of communication between ships at sea and between ship and shore. This is really an infinitely more important object than the more ambitious and more striking attainment of Transatlantic communication, and such seems to have been the opinion of the conference. Within the last few days it has been announced that Mr. Marconi is now practically in a position to reopen Transatlantic communication on a commercial basis, but even if the attempt proves successful on this occasion less will have been gained than seems to be the case at first sight. We have already means of communicating telegraphically across the Atlantic, and though wireless telegraphy may add another, and possibly a cheaper, method, the gain will be trifling compared with the advantage of perfecting it in a direction in which we have no other resources, whereas should the working of the high power long-distance stations in any way interfere with or hinder the development of the less pretentious short-distance signalling, the loss to the community generally will be very great. Unfortunately, the actual condition of affairs at the present time is difficult to determine; important facts are kept quiet for what are doubtless sound commercial reasons, and assertions and counter assertions are rife. On the one hand we are assured that the big stations do not interfere with the small ones, and on the other we have undeniable evidence that these monstrous etheric disturbances may affect all apparatus in their neighbourhood. It may be possible to avoid this interference by suitable adjustment, but it ought not to be permissible to make this necessary any more than it should be permissible for a factory to belch forth smoke from its chimneys on the ground that those who wish for cleanliness and health can move their firesides to the country.

Wireless telegraphy, indeed, presents a somewhat peculiar and difficult problem; in the first place its medium of communication is one to which all people have an equal right, and which, therefore, one person or set of persons must not be allowed to use to the detriment of others; secondly, its utility depends directly on its availability under all conditions, and at all places, so that to be most useful there must be either a world monopoly or else a perfectly free interchange between competing systems. The second consideration is a strong argument in favour of State monopoly of any means of communication, whilst the first is an additional reason for international control of wireless communication. At the same time it is naturally unjust that those who have spent time and money and energy in pioneering development should be deprived of the legitimate reward of their labours. It is obvious that a solution to the difficulties is only to be found by a fair compromise between conflicting interests, that of the public at large on the one hand and those of the various wireless telegraphy companies on the other. The resolutions of the Berlin conference indicate the only way we can see in which such a compromise can be arranged. Two of these, which are concerned with rates and the method of charging, are not of particular importance; the others propose that coast stations shall be obliged to receive and forward all telegrams from vessels at sea by whatever system transmitted, that telegrams referring to wrecks or calling for assistance shall have precedence, that stations shall be arranged to give the minimum of interference, and that any necessary technical details of the working of apparatus shall be published. The first of these is naturally the most important, and at the same time is the one which it will be most difficult to ratify. It is, of course, well known that the Marconi Company has refused to acquiesce in such an arrangement, by which, as far the largest and most powerful wireless telegraphy company, they have least to gain and most to lose; their position as undeniably the pioneers of practical wireless telegraphy entitles them to special consideration. For this reason the delegates of Italy and Great Britain did not sign this recommendation. The Italian Government is bound by a fourteen years' agreement with the Marconi Co., so that all the delegates could do was to undertake to suggest to the company the amendment of the agreement in the desired direction. The British Government is in an almost equally difficult position, for the Marconi Co. is a British company, and holds already a practical monopoly in this country. Still, it is to be hoped that these difficulties will not stand in the way of an ultimate settlement. There is not unnaturally a suspicion that so far as other countries are concerned there is a desire to benefit, if possible, by the organisation which the Marconi Co. has built up, and to enable home-bred systems to reap some of the reward of the enterprise of others. To a certain extent this is unavoidable, but it should be possible to arrange matters so that little or no injustice is done to the Marconi Co. whilst securing to the public the very fullest benefit that wireless telegraphy can confer, and it must not be forgotten that the interests of the British public, especially where shipping is concerned, extend all over the world.

MAURICE SOLOMON.

THE SOUTHPORT MEETING OF THE BRITISH ASSOCIATION.

THE seventy-third meeting of the British Association was opened yesterday, when the President, Sir Norman Lockyer, K.C.B., F.R.S., delivered his address in the Opera House.

Everything points to a highly successful meeting, though the number attending will probably fall short of that of the previous Southport meeting twenty years ago. In other respects, however, this year's meeting will probably surpass in interest that of 1883. The second edition of the local programme shows some additional arrangements made since our last article.

The list of excursions is given in greater detail, and a dredging excursion has been added on Thursday, September 17. A good deal of interest is being manifested in the motor car excursion on Saturday afternoon to Hoole and Rufford. A number of Southport gentlemen have placed their cars at the disposal of the local committee, and the show of automobiles will in itself attract attention. The excursion has a further interest, as Hoole is being visited, so that an opportunity may be given of seeing the place where Jeremiah Horrocks, the astronomer, lived at the time of his observation of the transit of Venus. A proposal has recently been mooted in Liverpool and Southport to erect a memorial to Horrocks, and a good deal of attention has been given to the Lancashire astronomer in the local Press. The Liverpool Corporation has kindly lent Mr. Eyre Crowe's picture of Horrocks at Hoole to the Southport committee, and it will be exhibited in one of the reception rooms during the meeting. The accuracy of Mr. Crowe's delineation of Horrocks's astronomical apparatus having been disputed, a Southport gentleman who has made a special study of Horrocks and his works has had painted by a local artist a picture representing the same subject depicted by Mr. Eyre Crowe, and the two pictures will hang in the same room.

The dredging excursion arranged for Thursday, September 17, is being organised by Prof. Herdman, and has been made possible through the courtesy of Mr. R. Dawson, the superintendent of the Lancashire and Western Sea Fisheries, who has kindly put the Sea Fisheries steamer, *John Fell*, at the disposal of the local committee for that purpose.

It is yet uncertain whether the kite-flying experiments for investigating the upper atmosphere can be successfully carried out at Southport. As mentioned in our issue of August 13, the Admiralty vessel put at the disposal of the kite-flying committee is no longer available, and it has been found impossible to bring the *Renown* (the boat from which the experiments are being conducted by Mr. W. H. Dines at Crinan) to Southport. The local committee has been offered the use of the *John Fell* by the Lancashire and Western Sea Fisheries Board for three days (Monday, Tuesday, and Wednesday, September 14, 15, and 16), but it is feared that the deck space will be insufficient for the proper conducting of the experiments. It is, therefore, possible that Mr. Dines will merely exhibit the apparatus at Southport, though every endeavour will be made to make use of the boat.

Prof. Pernter, of Vienna, has had forwarded to Southport one of the cannons used on the Continent for firing on clouds so as to arrest hailstorms. Test experiments in horizontal firing of vortex rings will be carried out on the Southport shore by permission of the Corporation.

A lecture has been arranged for Wednesday night, September 16, on "Garden Cities," by Mr. Ebenezer Howard, the founder of the Garden Cities Association, following an excursion on the same day to Port Sunlight, Cheshire, the model village erected by Messrs. Lever Brothers.

The local loan exhibition which is situated in the corridor near the reception room is in the hands of a small committee drawn from the Southport Literary and Philosophical Society, Society of Natural Science, and Photographic Society, and comprises local botanical and geological exhibits, photographs and drawings illustrating the antiquities of the district, and various exhibits of general scientific interest. The canoe which was dug out of the bed of Martin Mere in 1899 is being exhibited during the time of the meeting in the lecture room of Section H (Anthropology) in the Town Hall. The canoe is seventeen feet long and four feet wide.

The reception and writing rooms in the Art Gallery are rendered specially attractive by the presence on the walls of a portion of the Southport Corporation permanent collection of pictures.

The Mayor of Southport (Mr. T. T. L. Scarisbrick) is extending an almost lavish hospitality at his residence, Greaves Hall, Banks, and the local committee and the Southport Corporation are doing their utmost to make the meeting a memorable one so far as social entertainment is concerned. The Mayor has invited members of the Association to attend Emmanuel Church on Sunday morning, when the preacher will be the Bishop of Ripon. Other special preachers in Southport the same day include the Bishop of Liverpool, the Dean of Peterborough, the Rev. J. D. Bevan, the Rev. A. L. Cortie, S.J., the Rev. T. J. Walshe, the Rev. J. H. Moulton and the Rev. Frank Ballard (Wesleyan), the Rev. Dr. John Hunter (Congregational), the Rev. Dr. S. R. Macphail, Moderator of the Presbyterian Church of England, and the Rev. R. A. Armstrong (Unitarian).

In connection with the Mayor's and the committee's receptions to-night and on Tuesday next, a portion of the municipal gardens in front of the Cambridge Hall will be enclosed. These gardens are illuminated by electricity at night, more than 4000 glow-lamps being installed among the foliage of the trees. The installation is quite unique in this country. Special fittings had to be designed, as, being an outdoor installation, the electrical conditions are very severe. More than sixteen miles of underground and overhead cable are used.

The Mayor's dinner at Greaves Hall on Wednesday, September 16, promises to be a very brilliant function, and the lecture by Prof. Forsyth before the Literary and Philosophical Society on the following night on "Universities" will be largely attended by members of the British Association, a large number of whom have accepted the invitation to be present.

Inaugural Address by Sir Norman Lockyer, K.C.B., LL.D., F.R.S., Correspondant de l'Institut de France, President of the Association.

The Influence of Brain-power on History.

MY first duty to-night is a sad one. I have to refer to a great loss which this Nation and this Association have sustained. By the death of the great Englishman and great statesman who has just passed away, we members of the British Association are deprived of one of the most illustrious of our confrères. We have to mourn the loss of an enthusiastic student of science who conferred honour on our body by becoming its President. We recognise that as Prime Minister he was mindful of the interests of science, and that to him we owe a more general recognition on the part of the State of the value to the nation of the work of scientific men. On all these grounds you will join in the expression of respectful sympathy with Lord Salisbury's family in their great personal loss which your council has embodied this morning in a resolution of condolence.

Last year, when this friend of science ceased to be Prime Minister, he was succeeded by another statesman who also has given many proofs of his devotion to philosophical studies, and has shown in many utterances that he has a clear understanding of the real place of science in modern civilisation. We then have good grounds for hoping that the improvement in the position of science in this country which we owe to the one will also be the care of his successor, who has honoured the Association by accepting the unanimous nomination of your council to be your President next year, an acceptance which adds a new lustre to this chair.

On this we may congratulate ourselves all the more because I think, although it is not generally recognised, that the century into which we have now well entered may be more momentous than any which has preceded it, and that the present history of the world is being so largely moulded by the influence of brain-power, which in these modern days has to do with natural as well as human forces and laws, that statesmen and politicians will have in the future to pay more regard to education and science, as empire-builders and empire-guarders, than they have paid in the past.

The nineteenth century will ever be known as the one in which the influences of science were first fully realised in civilised communities; the scientific progress was so gigantic that it seems rash to predict that any of its successors can be more important in the life of any nation.

Disraeli, in 1873, referring to the progress up to that year, spoke as follows:—"How much has happened in these fifty years—a period more remarkable than any, I will venture to say, in the annals of mankind. I am not thinking of the rise and fall of Empires, the change of dynasties, the establishment of Governments. I am thinking of those revolutions of science which have had much more effect than any political causes, which have changed the position and prospects of mankind more than all the conquests and all the codes and all the legislators that ever lived."[1]

The progress of science, indeed, brings in many considerations which are momentous in relation to the life of any limited community—any one nation. One of these considerations to which attention is now being greatly drawn is that a relative decline in national wealth derived from industries must follow a relative neglect of scientific education.

It was the late Prince Consort who first emphasised this when he came here fresh from the University of Bonn. Hence the "Prince Consort's Committee," which led to the foundation of the College of Chemistry and afterwards of the Science and Art Department. From that time to this the warnings of our men of science have become louder and more urgent in each succeeding year. But this is not all; the commercial output of one country in one century as compared with another is not alone in question; the acquirement of the scientific spirit and a knowledge and utilisation of the forces of Nature are very much further reaching in their effects on the progress and decline of nations than is generally imagined.

Britain in the middle of the last century was certainly the country which gained most by the advent of science, for she was then in full possession of those material gifts of Nature, coal and iron, the combined winning and utilisation of which, in the production of machinery and in other ways, soon made her the richest country in the world, the seat and throne of invention and manufacture, as Mr. Carnegie has called her. Being the great producers and exporters of all kinds of manufactured goods, we became eventually, with our iron ships, the great carriers, and hence the supremacy of our mercantile marine and our present command of the sea.

The most fundamental change wrought by the early applications of science was in relation to producing and carrying power. With the winning of mineral wealth and the production of machinery in other countries, and cheap and rapid transit between nations, our superiority as depending upon our first use of vast material resources was reduced. Science, which is above all things cosmopolitan—planetary, not national—internationalises such resources at once. In every market of the world

> "things of beauty, things of use,
> Which one fair planet can produce,
> Brought from under every star,"

were soon to be found.

Hence the first great effect of the general progress of science was relatively to diminish the initial supremacy of Britain due to the first use of *material* resources, which indeed was the real source of our national wealth and place among the nations.

The unfortunate thing was that, while the foundations of our superiority depending upon our *material resources* were being thus sapped by a cause *which was beyond our control*, our statesmen and our universities were blind leaders of the blind, and our other asset, our mental resources, which was within our control, was culpably neglected.

So little did the bulk of our statesmen know of the part science was playing in the modern world and of the real basis of the nation's activities, that they imagined political and fiscal problems to be the only matters of importance. Nor, indeed, are we very much better off to-day. In the important discussions recently raised by Mr. Chamberlain, next to nothing has been said of the effect of the progress of science on prices. The whole course of the modern world is attributed to the presence or absence of taxes on certain commodities in certain countries. The fact that the great fall in the price of food-stuffs in England did not come till some thirty or forty years after the removal of the corn duty between 1847 and 1849 gives them no pause; for them new inventions, railways and steamships are negligible quantities; the vast increase in the world's wealth in free trade and protected countries alike comes merely according to them in response to some *political* shibboleth.

We now know, from what has occurred in other States, that if our Ministers had been more wise and our universities more numerous and efficient, our *mental resources* would have been developed by improvements in educational method, by the introduction of science into schools, and, more important than all the rest, by the teaching of science by experiment, observation and research, and not from books. It is because this was not done that we have fallen behind other nations in properly applying science to industry, so that our applications of science to industry are relatively less important than they were. But this is by no means all; we have lacked the strengthening of the national life produced by fostering the scientific spirit among all classes, and along all lines of the nation's activity; many of the responsible authorities know little and care less about science; we have not learned that it is the duty of a State to organise its forces as carefully for peace as for war; that universities and other teaching centres are as important as battleships or big battalions; are, in fact, essential parts of a modern State's machinery, and as such to be equally aided and as efficiently organised to secure its future well being.

Now the objects of the British Association as laid down by its founders seventy-two years ago are "To give a stronger impulse and a more systematic direction to scientific inquiry—to promote the intercourse of those who cultivate science in different parts of the British Empire with one another and with foreign philosophers—to obtain a more general attention to the objects of science and a removal of any disadvantages of a public kind which impede its progress."

In the main, my predecessors in this chair, to which you have done me the honour to call me, have dealt, and with great benefit to science, with the objects first named.

But at a critical time like the present I find it imperative to depart from the course so generally followed by my predecessors and to deal with the last object named, for unless by some means or other we "obtain a more general attention to the objects of science and a removal of any disadvantages of a

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[1] NATURE, November 27, 1873, vol. ix. p. 71.

public kind which impede its progress," we shall suffer in competition with other communities in which science is more generally utilised for the purposes of the national life.

The Struggle for Existence in Modern Communities.

Some years ago, in discussing the relations of scientific instruction to our industries, Huxley pointed out that we were in presence of a new "struggle for existence," a struggle which, once commenced, must go on until only the fittest survives.

It is a struggle between organised species—nations—not between individuals or any class of individuals. It is, moreover, a struggle in which science and brains take the place of swords and sinews, on which depended the result of those conflicts which, up to the present, have determined the history and fate of nations. The school, the university, the laboratory and the workshop are the battlefields of this new warfare.

But it is evident that if this, or anything like it, be true, our industries cannot be involved alone; the scientific spirit, brain-power, must not be limited to the workshop if other nations utilise it in all branches of their administration and executive.

It is a question of an important change of front. It is a question of finding a new basis of stability for the Empire in face of new conditions. I am certain that those familiar with the present state of things will acknowledge that the Prince of Wales's call, "Wake up," applies quite as much to the members of the Government as it does to the leaders of industry.

What is wanted is a complete organisation of the resources of the nation, so as to enable it best to face all the new problems which the progress of science, combined with the ebb and flow of population and other factors in international competition, are ever bringing before us. Every Minister, every public department, is involved, and this being so, it is the duty of the whole nation—King, Lords, and Commons—to do what is necessary to place our scientific institutions on a proper footing in order to enable us to "face the music" whatever the future may bring. The idea that science is useful only to our industries comes from want of thought. If anyone is under the impression that Britain is only suffering at present from the want of the scientific spirit among our industrial classes, and that those employed in the State service possess adequate brain-power and grip of the conditions of the modern world into which science so largely enters, let him read the report of the Royal Commission on the War in South Africa. There he will see how the whole "system" employed was, in Sir Henry Brackenbury's words applied to a part of it, "*unsuited to the requirements of an Army which is maintained to enable us to make war.*" Let him read also, in the address of the president of the Society of Chemical Industry what drastic steps had to be taken by Chambers of Commerce and "a quarter of a million of working men" to get the Patent Law Amendment Act into proper shape, in spite of all the advisers and officials of the Board of Trade. Very few people realise the immense number of scientific problems the solution of which is required for the State service. The nation itself is a gigantic workshop, and the more our rulers and legislators, administrators and executive officers possess the scientific spirit, the more the rule of thumb is replaced in the State service by scientific methods, the more able shall we be, thus armed at all points, to compete successfully with other countries along all lines of national as well as of commercial activity.

It is obvious that the power of a nation for war, in men and arms and ships, is one thing; its power in the peace struggles to which I have referred is another; in the latter, the source and standard of national efficiency are entirely changed. To meet war conditions, there must be equality or superiority in battleships and army corps. To meet the new peace conditions, there must be equality or superiority in universities, scientific organisation and everything which conduces to greater brain power.

Our Industries are suffering in the Present International Competition.

The present condition of the nation, so far as its industries are concerned, is as well known, not only to the Prime Minister, but to other political leaders in and out of the Cabinet, as it is to you and to me. Let me refer to two speeches delivered by Lord Rosebery and Mr. Chamberlain on two successive days in January, 1901.

Lord Rosebery spoke as follows:—

". . . The war I regard with apprehension is the war of trade which is unmistakably upon us. . . . When I look round me I cannot blind my eyes to the fact that so far as we can predict anything of the twentieth century on which we have now entered, it is that it will be one of acutest international conflict in point of trade. We were the first nation of the modern world to discover that trade was an absolute necessity. For that we were nicknamed a nation of shopkeepers; but now every nation wishes to be a nation of shopkeepers too, and I am bound to say that when we look at the character of some of these nations, and when we look at the intelligence of their preparations, we may well feel that it behoves us not to fear, but to gird up our loins in preparation for what is before us."

Mr. Chamberlain's views were stated in the following words:—

"I do not think it is necessary for me to say anything as to the urgency and necessity of scientific training. . . . It is not too much to say that the existence of this country, as the great commercial nation, depends upon it. . . . It depends very much upon what we are doing now, at the beginning of the twentieth century, whether at its end we shall continue to maintain our supremacy or even equality with our great commercial and manufacturing rivals."

All this refers to our industries. We are suffering because trade no longer follows the flag as in the old days, but because trade follows the brains, and our manufacturers are too apt to be careless in securing them. In one chemical establishment in Germany, 400 doctors of science, the best the universities there can turn out, have been employed at different times in late years. In the United States the most successful students in the higher teaching centres are snapped up the moment they have finished their course of training, and put into charge of large concerns, so that the idea has got abroad that youth is the password of success in American industry. It has been forgotten that the latest product of the highest scientific education must necessarily be young, and that it is the training and not the age which determines his employment. In Britain, on the other hand, apprentices who can pay high premiums are too often preferred to those who are well educated, and the old rule-of-thumb processes are preferred to new developments—a conservatism too often depending upon the master's own want of knowledge.

I should not be doing my duty if I did not point out that the defeat of our industries one after another, concerning which both Lord Rosebery and Mr. Chamberlain express their anxiety, is by no means the only thing we have to consider. The matter is not one which concerns our industrial classes only, for knowledge must be pursued for its own sake, and since the full life of a nation with a constantly increasing complexity, not only of industrial, but of high national aims, depends upon the universal presence of the scientific spirit—in other words, brain-power—our whole national life is involved.

The Necessity for a Body dealing with the Organisation of Science.

The present awakening in relation to the nation's real needs is largely due to the warnings of men of science. But Mr. Balfour's terrible Manchester picture of our present educational condition[1] shows that the warning which has been going on now for more than fifty years has not been forcible enough; but if my contention that other reorganisations besides that of our education are needed is well founded, and if men of science are to act the part of good citizens in taking their share in endeavouring to bring about a better state of things, the question arises, has the neglect of their warnings so far been due to the way in which these have been given?

Lord Rosebery, in the address to a Chamber of Commerce from which I have already quoted, expressed his opinion that such bodies do not exercise so much influence as might be expected of them. But if commercial men do not use all the power their organisation provides, do they not by having built up such an organisation put us students of science to shame, who are still the most disorganised members of the community?

Here, in my opinion, we have the real reason why the scientific needs of the nation fail to command the attention either of the public or of successive Governments. At present, appeals on

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[1] "The existing educational system of this country is chaotic, is ineffectual, is utterly behind the age, makes us the laughing-stock of every advanced nation in Europe and America, puts us behind, not only our American cousins, but the German and the Frenchman and the Italian."—*Times*, October 15, 1902.

this or on that behalf are the appeals of individuals; science has no collective voice on the larger national questions; there is no organised body which formulates her demands.

During many years it has been part of my duty to consider such matters, and I have been driven to the conclusion that our great crying need is to bring about an organisation of men of science and all interested in science, similar to those which prove so effective in other branches of human activity. For the last few years I have dreamt of a Chamber, Guild, League, call it what you will, with a wide and large membership, which should give us what, in my opinion, is so urgently needed. Quite recently I sketched out such an organisation, but what was my astonishment to find that I had been forestalled, and by the founders of the British Association!

The British Association such a Body.

At the commencement of this address I pointed out that one of the objects of the Association, as stated by its founders, was "to obtain a more general attention to the objects of science and a removal of any disadvantages of a public kind which impede its progress."

Everyone connected with the British Association from its beginning may be congratulated upon the magnificent way in which the other objects of the Association have been carried out, but as one familiar with the Association for the last forty years, I cannot but think that the object to which I have specially referred has been too much overshadowed by the work done in connection with the others.

A careful study of the early history of the Association leads me to the belief that the function I am now dwelling on was strongly in the minds of the founders; but be this as it may, let me point out how admirably the organisation is framed to enable men of science to influence public opinion and so to bring pressure to bear upon Governments which follow public opinion. (1) Unlike all the other chief metropolitan societies, its outlook is not limited to any branch or branches of science. (2) We have a wide and numerous fellowship, including both the leaders and the lovers of science, in which all branches of science are and always have been included with the utmost catholicity—a condition which renders strong committees possible on any subject. (3) An annual meeting at a time when people can pay attention to the deliberations, and when the newspapers can print reports. (4) The possibility of beating up recruits and establishing local committees in different localities, even in the King's dominions beyond the seas, since the place of meeting changes from year to year, and is not limited to these islands.

We not only, then, have a scientific parliament competent to deal with all matters, including those of national importance, relating to science, but machinery for influencing all new councils and committees dealing with local matters, the functions of which are daily becoming more important.

The machinery might consist of our corresponding societies. We already have affiliated to us seventy societies with a membership of 25,000; were this number increased so as to include every scientific society in the Empire, metropolitan and provincial, we might eventually hope for a membership of half a million.

I am glad to know that the Council is fully alive to the importance of giving a greater impetus to the work of the corresponding societies. During this year a committee was appointed to deal with the question; and later still, after this committee had reported, a conference was held between this committee and the corresponding societies committee to consider the suggestions made, some of which will be gathered from the following extract:—

"In view of the increasing importance of science to the nation at large, your committee desire to call the attention of the Council to the fact that in the corresponding societies the British Association has gathered in the various centres represented by these societies practically all the scientific activity of the provinces. The number of members and associates at present on the list of the corresponding societies approaches 25,000, and no organisation is in existence anywhere in the country better adapted than the British Association for stimulating, encouraging and coordinating all the work being carried on by the seventy societies at present enrolled. Your committee are of opinion that further encouragement should be given to these societies and their individual working members by every means within the power of the association; and with the object of keeping the corresponding societies in more permanent touch with the Association they suggest that an official invitation on behalf of the Council be addressed to the societies through the corresponding societies committee asking them to appoint standing British Association sub-committees, to be elected by themselves with the object of dealing with all those subjects of investigation common to their societies and to the British Association committees, and to look after the general interests of science and scientific education throughout the provinces and provincial centres. . . .

"Your committee desire to lay special emphasis on the necessity for the extension of the scientific activity of the corresponding societies and the expert knowledge of many of their members in the direction of scientific education. They are of opinion that immense benefit would accrue to the country if the corresponding societies would keep this requirement especially in view with the object of securing adequate representation for scientific education on the Education Committees now being appointed under the new Act. The educational section of the Association having been but recently added, the corresponding societies have as yet not had much opportunity for taking part in this branch of the Association's work; and in view of the reorganisation in education now going on all over the country your committee are of opinion that no more opportune time is likely to occur for the influence of scientific organisations to make itself felt as a real factor in national education. . . ."

I believe that if these suggestions or anything like them—for some better way may be found on inquiry—are accepted, great good to science throughout the Empire will come. Rest assured that sooner or later such a guild will be formed because it is needed. It is for you to say whether it shall be, or form part of, the British Association. We in this Empire certainly need to organise science as much as in Germany they find the need to organise a navy. The German Navy League, which has branches even in our Colonies, already has a membership of 630,000, and its income is nearly 20,000*l.* a year. A British Science League of 500,000 with a sixpenny subscription would give us 12,000*l.* a year, quite enough to begin with.

I for one believe that the British Association would be a vast gainer by such an expansion of one of its existing functions. Increased authority and prestige would follow its increased utility. The meetings would possess a new interest; there would be new subjects for reports; missionary work less needed than formerly would be replaced by efforts much more suited to the real wants of the time. This magnificent, strong and complicated organisation would become a living force, working throughout the year, instead of practically lying idle, useless and rusting for 51 weeks out of the 52 so far as its close association with its members is concerned.

If this suggestion in any way commends itself to you, then when you begin your work in your sections or general committee see to it that a body is appointed to inquire how the thing can be done. Remember that the British Association will be as much weakened by the creation of a new body to do the work I have shown to have been in the minds of its founders as I believe it will be strengthened by becoming completely effective in every one of the directions they indicated, and for which effectiveness we their successors are indeed responsible. The time is appropriate for such a reinforcement of one of the wings of our organisation, for we have recently included Education among our sections.

There is another matter I should like to see referred to the committee I have spoken of, if it please you to appoint it. The British Association, which as I have already pointed out is now the chief body in the Empire which deals with the totality of science, is, I believe, the only organisation of any consequence which is without a charter, and which has not His Majesty the King as patron.

The First Work of such an Organisation.

I suppose it is my duty after I have suggested the need of organisation to tell you my personal opinion as to the matters where we suffer most in consequence of our lack of organisation at the present time.

Our position as a nation, our success as merchants, are in peril chiefly—dealing with preventable causes—because of our lack of completely efficient universities, and our neglect of research. This research has a double end. A professor who is not learning cannot teach properly or arouse enthusiasm in his students; while a student of anything who is unfamiliar with research methods, and without that training which research brings, will not be in the best position to apply his knowledge in after life. From neglect of research comes imperfect education and a small output of new applications and new knowledge to reinvigorate our industries. From imperfect education comes the unconcern touching scientific matters, and the too frequent absence of the scientific spirit, in the nation generally from the Court to the parish council.

I propose to deal as briefly as I can with each of these points.

Universities.

I have shown that so far as our industries are concerned, the cause of our failure has been run to earth; it is fully recognised that it arises from the insufficiency of our universities both in numbers and efficiency, so that not only our captains of industry, but those employed on the nation's work generally, do not secure a training similar to that afforded by other nations. No additional endowment of primary, secondary or technical instruction will mend matters. This is not merely the opinion of men of science; our great towns know it, our Ministers know it.

It is sufficient for me to quote Mr. Chamberlain:—

"It is not everyone who can, by any possibility, go forward into the higher spheres of education; but it is from those who do that we have to look for the men who, in the future, will carry high the flag of this country in commercial, scientific and economic competition with other nations. At the present moment, I believe there is nothing more important than to supply the deficiencies which separate us from those with whom we are in the closest competition. In Germany, in America, in our own colony of Canada and in Australia, the higher education of the people has more support from the Government, is carried further, than it is here in the old country; and the result is that in every profession, in every industry, you find the places taken by men and by women who have had a university education. And I would like to see the time in this country when no man should have a chance for any occupation of the better kind, either in our factories, our workshops or our counting-houses, who could not show proof that, in the course of his university career, he had deserved the position that was offered to him. What is it that makes a country? Of course you may say, and you would be quite right, 'The general qualities of the people, their resolution, their intelligence, their pertinacity, and many other good qualities.' Yes; but that is not all, and it is not the main creative feature of a great nation. The greatness of a nation is made by its greatest men. It is those we want to educate. It is to those who are able to go, it may be, from the very lowest steps in the ladder, to men who are able to devote their time to higher education, that we have to look to continue the position which we now occupy as, at all events, one of the greatest nations on the face of the earth. And, feeling as I do on these subjects, you will not be surprised if I say that I think the time is coming when Governments will give more attention to this matter, and perhaps find a little more money to forward its interests" (*Times*, November 6, 1902).

Our conception of a university has changed. University education is no longer regarded as the luxury of the rich which concerns only those who can afford to pay heavily for it. The Prime Minister in a recent speech, while properly pointing out that the collective effect of our public and secondary schools upon British character cannot be overrated, frankly acknowledged that the boys of seventeen or eighteen who have to be educated in them "do not care a farthing about the world they live in except in so far as it concerns the cricket-field or the football-field or the river." On this ground they are not to be taught science, and hence, when they proceed to the university, their curriculum is limited to subjects which were better taught before the modern world existed, or even Galileo was born. But the science which these young gentlemen neglect, with the full approval of their teachers, on their way through the school and the university to politics, the Civil Service, or the management of commercial concerns, is now one of the great necessities of a nation, and our universities must become as much the insurers of the future progress as battleships are the insurers of the present power of States. In other words, university competition between States is now as potent as competition in building battleships, and it is on this ground that our university conditions become of the highest national concern and therefore have to be referred to here, and all the more because our industries are not alone in question.

Why we have not more Universities.

Chief among the causes which have brought us to the terrible condition of inferiority as compared with other nations in which we find ourselves are our carelessness in the matter of education and our false notions of the limitations of State functions in relation to the conditions of modern civilisation.

Time was when the Navy was largely a matter of private and local effort. William the Conqueror gave privileges to the Cinque Ports on the condition that they furnished fifty-two ships when wanted. In the time of Edward III., of 730 sail engaged in the siege of Calais, 705 were "people's ships." All this has passed away; for our first line of defence we no longer depend on private and local effort.

Time was when not a penny was spent by the State on elementary education. Again, we no longer depend upon private and local effort. The Navy and primary education are now recognised as properly calling upon the public for the necessary financial support. But when we pass from primary to university education, instead of State endowment we find State neglect; we are in a region where it is nobody's business to see that anything is done.

We in Great Britain have thirteen universities competing with 134 State and privately endowed in the United States and twenty-two State endowed in Germany. I leave other countries out of consideration for lack of time, and I omit all reference to higher institutions for technical training, of which Germany alone possesses nine of university rank, because they are less important; they instruct rather than educate, and our want is education. The German State gives to one university more than the British Government allows to all the universities and university colleges in England, Ireland, Scotland, and Wales put together. These are the conditions which regulate the production of brain-power in the United States, Germany, and Britain respectively, and the excuse of the Government is that this is a matter for private effort. Do not our Ministers of State know that other civilised countries grant efficient State aid, and further, that private effort has provided in Great Britain less than 10 per cent. of the sum thus furnished in the United States in addition to State aid? Are they content that we should go under in the great struggle of the modern world because the Ministries of other States are wiser, and because the individual citizens of another country are more generous, than our own?

If we grant that there was some excuse for the State's neglect so long as the higher teaching dealt only with words, and books alone had to be provided (for the streets of London and Paris have been used as class rooms at a pinch), it must not be forgotten that during the last hundred years not only has knowledge been enormously increased, but things have replaced words, and fully equipped laboratories must take the place of books and class rooms if university training worthy of the name is to be provided. There is much more difference in size and kind between an old and new university than there is between the old caravel and a modern battleship, and the endowments must follow suit.

What are the facts relating to private endowment in this country? In spite of the munificence displayed by a small number of individuals in some localities, the truth must be spoken. In depending in our country upon this form of endowment, we are trusting to a broken reed. If we take the twelve English university colleges, the forerunners of universities unless we are to perish from lack of knowledge, we find that private effort during sixty years has found less than 4,000,000*l.*, that is, 2,000,000*l.* for buildings and 40,000*l.* a year income. This gives us an average of 166,000*l.* for buildings and 3300*l.* for yearly income.

What is the scale of private effort we have to compete with in regard to the American universities?

In the United States, during the last few years, universities and colleges have received more than 40,000,000*l.* from this source alone; private effort supplied nearly 7,000,000*l.* in the years 1898–1900.

Next consider the amount of State aid to universities afforded in Germany. The buildings of the new University of Strassburg have already cost nearly a million; that is, about as much as has yet been found by private effort for buildings in Manchester, Liverpool, Birmingham, Bristol, Newcastle and Sheffield. The Government annual endowment of the same German university is more than 49,000*l.*

This is what private endowment does for us in England, against State endowment in Germany.

But the State does really concede the principle; its present contribution to our Universities and colleges amounts to 155,600*l.* a year; no capital sum, however, is taken for buildings. The State endowment of the University of Berlin in 1891–2 amounted to 168,777*l.*

When, then, we consider the large endowments of university education both in the United States and Germany, it is obvious that State aid only can make any valid competition possible with either. The more we study the facts, the more statistics are gone into, the more do we find that we, to a large extent, lack both of the sources of endowment upon one or other or both of which other nations depend. We are between two stools, and the prospect is hopeless without some drastic changes. And first among these, if we intend to get out of the present slough of despond, must be the giving up of the idea of relying upon private effort.

That we lose most where the State does least is known to Mr. Chamberlain, for in his speech, to which I have referred, on the University of Birmingham, he said:—"As the importance of the aim we are pursuing becomes more and more impressed upon the minds of the people, we may find that we shall be more generously treated by the State."

Later still, on the occasion of a visit to University College School, Mr. Chamberlain spoke as follows:—

"When we are spending, as we are, many millions—I think it is 13,000,000*l.*—a year on primary education, it certainly seems as if we might add a little more, even a few tens of thousands, to what we give to University and secondary education" (*Times*, November 6, 1902).

To compete on equal grounds with other nations we must have more universities. But this is not all—we want a far better endowment of all the existing ones, not forgetting better opportunities for research on the part of both professors and students. Another crying need is that of more professors and better pay. Another is the reduction of fees; they should be reduced to the level in those countries which are competing with us, to, say, one-fifth of their present rates, so as to enable more students in the secondary and technical schools to complete their education.

In all these ways, facilities would be afforded for providing the highest instruction to a much greater number of students. At present there are almost as many *professors and instructors* in the universities and colleges of the United States as there are *day students* in the universities and colleges of the United Kingdom.

Men of science, our leaders of industry, and the chiefs of our political parties all agree that our present want of higher education—in other words, properly equipped universities—is heavily handicapping us in the present race for commercial supremacy, because it provides a relatively inferior brain-power which is leading to a relatively reduced national income.

The facts show that in this country we cannot depend upon private effort to put matters right. How about local effort?

Anyone who studies the statistics of modern municipalities will see that it is impossible for them to raise rates for the building and upkeep of universities.

The buildings of the most modern university in Germany have cost a million. For upkeep the yearly sums found, chiefly by the State, for German universities of different grades, taking the incomes of seven out of the twenty-two universities as examples, are:—

		£
1st Class ...	Berlin	130,000
2nd Class ...	Bonn Göttingen	56,000
3rd Class ...	Königsberg Strassburg	48,000
4th Class ...	Heidelberg Marburg	37,000

Thus if Leeds, which is to have a university, is content with the 4th class German standard, a rate must be levied of 7*d.* in the pound for yearly expenses, independent of all buildings. But the facts are that our towns are already at the breaking strain. During the last fifty years, in spite of enormous increases in rateable values, the rates have gone up from about 2*s.* to about 7*s.* in the pound for real *local* purposes. But no university can be a merely local institution.

How to get more Universities.

What, then, is to be done? Fortunately, we have a precedent admirably in point, the consideration of which may help us to answer this question.

I have pointed out that in old days our Navy was chiefly provided by local and private effort. Fortunately for us, those days have passed away; but some twenty years ago, in spite of a large expenditure, it began to be felt by those who knew, that in consequence of the increase of foreign navies, our sea-power was threatened, as now, in consequence of the increase of foreign universities, our brain-power is threatened.

The nation slowly woke up to find that its enormous commerce was no longer insured at sea, that in relation to foreign navies our own had been suffered to dwindle to such an extent that it was no longer capable of doing the duty which the nation expected of it even in times of peace. At first, this revelation was received with a shrug of incredulity, and the peace-at-any-price party denied that anything was needed; but a great teacher arose;[1] as the facts were inquired into the suspicion changed into an alarm; men of all parties saw that something must be done. Later, the nation was thoroughly aroused, and with an universal agreement the principle was laid down that, cost what it might to enforce our sea-power, our Navy must be made and maintained of a strength greater than those of any two possibly contending Powers. After establishing this principle, the next thing to do was to give effect to it. What did the nation do after full discussion and inquiry? A Bill was brought in in 1888, and a sum of 21,500,000*l.* was voted in order, during the next five years, to inaugurate a large ship-building programme, so that Britain and Britain's commerce might be guarded on the high seas in any event.

Since then we have spent 120,000,000*l.* on new ships, and this year we spend still more millions on still more new ships. If these prove insufficient to safeguard our sea-power, there is no doubt that the nation will increase them, and I have not heard that anybody has suggested an appeal to private effort.

How, then, do we stand with regard to universities, recognising them as the chief producers of brain-power and therefore the equivalents of battleships in relation to sea-power? Do their numbers come up to the standard established by the Admiralty principle to which I have referred? Let us attempt to get a rough-and-ready estimate of our educational position by counting universities as the Admiralty counts battleships. I say rough and ready because we have other helps to greater brain-power to consider besides universities, as the Admiralty has other ships to consider besides ironclads.

In the first place, let us inquire if they are equal in number to those of any two nations commercially competing with us.

In the United Kingdom, we had until quite recently thirteen.[2] Of these, one is only three years old as a teaching university and another is still merely an examining board.

In Germany there are twenty-two universities; in France, under recent legislation, fifteen; in Italy twenty-one. It is difficult to give the number in the United States, because it is clear, from the tables given in the Report of the Commissioner of Education, that some colleges are more important than some universities, and both give the degree of Ph.D. But of universities in title we have 134. Among these, there are forty-six with more than fifty professors and instructors, and thirteen with more than 150. I will take that figure.

Suppose we consider the United States and Germany, our chief commercial competitors, and apply the Admiralty principle. We should require, allowing for population, eight additional universities at the very lowest estimate.

We see, then, that instead of having universities equalling in number those of two of our chief competitors together, they are by no means equal to those of either of them singly.

After this statement of the facts, anyone who has belief in the importance of higher education will have no difficulty in understanding the origin of the present condition of British industry and its constant decline, first in one direction and then in another, since the tremendous efforts made in the United States and Germany began to take effect.

If, indeed, there be anything wrong about the comparison, the error can only arise from one of two sources; either the Admiralty is thoughtlessly and wastefully spending money, or there is no connection whatever between the higher intelligence and the prosperity of a nation. I have already

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[1] Captain Mahan, of the U.S. Navy, whose book, "On the Influence of Sea-power on History," has suggested the title of my address.

[2] These are Oxford, Cambridge, Durham, Victoria, Wales, Birmingham, London, St. Andrews, Glasgow, Aberdeen, Edinburgh, Dublin, and Royal University.

referred to the views of Mr. Chamberlain and Lord Rosebery on this point; we know what Mr. Chamberlain has done at Birmingham; we know the strenuous efforts made by the commercial leaders of Manchester and Liverpool; we know, also, the opinion of men of science.

If while we spend so freely to maintain our sea-power our export of manufactured articles is relatively reduced because our competitors beat us in the markets of the world, what is the end of the vista thus opened up to us? A Navy growing stronger every year and requiring larger votes to guard our commerce and communications, and a vanishing quantity of commerce to guard—a reduced national income to meet an increasing taxation!

The pity is that our Government has considered sea-power alone; that while so completely guarding our commerce, it has given no thought to one of the main conditions on which its production and increase depend: a glance could have shown that other countries were building universities even faster than they were building battleships; were, in fact, considering brain-power first and sea-power afterwards.

Surely it is my duty as your President to point out the danger ahead if such ignoring of the true situation should be allowed to continue. May I express a hope that at last, in Mr. Chamberlain's words, "the time is coming when Governments will give more attention to this matter"?

What will they cost?

The comparison shows that we want eight new universities, some of which, of course, will be colleges promoted to university rank and fitted to carry on university work. Three of them are already named: Manchester, Liverpool, Leeds.

Let us take this number and deal with it on the battleship condition, although a modern university on American or German models will cost more to build than a battleship.

If our present university shortage be dealt with on battleship conditions, to correct it we should expend *at least* 8,000,000*l.* for new construction, and for the pay-sheet we should have to provide (8 × 50,000*l.*) 400,000*l.* yearly for personnel and upkeep, for it is of no use to build either ships or universities without manning them. Let us say, roughly, capitalising the yearly payment at 2½ per cent., 24,000,000*l.*

At this stage, it is important to inquire whether this sum, arrived at by analogy merely, has any relation to our real university needs.

I have spent a year in making inquiries, as full as I could make them, of friends conversant with the real present needs of each of the universities old and new, I have obtained statistics which would fill a volume, and personally I believe that this sum at least is required to bring our university system up to anything like the level which is insisted upon both in the United States and in Germany. Even Oxford, our oldest university, will still continue to be a mere bundle of colleges, unless three millions are provided to enable the university properly so-called to take her place among her sisters of the modern world; and Sir Oliver Lodge, the principal of our very youngest university, Birmingham, has shown in detail how five millions can be usefully and properly applied in that one locality, to utilise for the good of the nation the enthusiasm and scientific capacity which are only waiting for adequate opportunity of development.

How is this money to be raised? I reply without hesitation, *duplicate the Navy Bill of* 1888–9; do at once for brain-power what we so successfully did then for sea-power.

Let 24,000,000*l.* be set apart from one asset, our national wealth, to increase the other, brain-power. Let it be assigned and borrowed as it is wanted; there will be a capital sum for new buildings to be erected in the next five or ten years, the interest of the remainder to go towards increased annual endowments.

There need be no difficulty about allocating money to the various institutions. Let each university make up its mind as to which rank of the German universities it wishes to emulate. When this claim has been agreed to, the sums necessary to provide the buildings and teaching staff of that class of university should be granted without demur.

It is the case of battleships over again, and money need not be spent more freely in one case than in the other.

Let me at once say that this sum is not to be regarded as practically gone when spent, as in the case of a short-lived ironclad. *It is a loan* which will bear a high rate of interest. This is not my opinion merely; it is the opinion of those concerned in great industrial enterprises and fully alive to the origin and effects of the present condition of things.

I have been careful to point out that the statement that our industries are suffering from our relative neglect of science does not rest on my authority. But if this be true, then if our annual production is less by only two millions than it might have been, having two millions less to divide would be equivalent to our having forty or fifty millions less capital than we should have had if we had been more scientific.

Sir John Brunner, in a speech connected with the Liverpool School of Tropical Medicine, stated recently that if we as a nation were now to borrow ten millions of money in order to help science by putting up buildings and endowing professors, we should get the money back in the course of a generation a hundredfold. He added that there was no better investment for a business man than the encouragement of science, and that every penny he possessed had come from the application of science to commerce.

According to Sir Robert Giffen, the United Kingdom as a going concern was in 1901 worth 16,000,000,000*l.*

Were we to put aside 24,000,000*l.* for gradually organising, building and endowing new universities, and making the existing ones more efficient, we should still be worth 15,976,000,000*l.*, a property well worth defending by all the means, and chief among these brain-power, we can command.

If it be held that this, or anything like it, is too great a price to pay for correcting past carelessness or stupidity, the reply is that the 120,000,000*l.* recently spent on the Navy, a sum five times greater, has been spent to correct a sleepy blunder, not one whit more inimical to the future welfare of our country than that which has brought about our present educational position. We had not sufficiently recognised what other nations had done in the way of ship building, just as until now we have not recognised what they have been doing in university building.

Further, I am told that the sum of 24,000,000*l.* is less than half the amount by which Germany is yearly enriched by having improved upon our chemical industries, owing to our lack of scientific training. Many other industries have been attacked in the same way since, but taking this one instance alone, if we had spent this money fifty years ago, when the Prince Consort first called attention to our backwardness, the nation would now be much richer than it is, and would have much less to fear from competition.

Suppose we were to set about putting our educational house in order, so as to secure a higher quality and greater quantity of brain-power, it would not be the first time in history that this has been done. Both Prussia after Jena and France after Sedan acted on the view:—

> "When land is gone and money spent,
> Then learning is most excellent."

After Jena, which left Prussia a "bleeding and lacerated mass," the King and his wise counsellors, among them men who had gained knowledge from Kant, determined, as they put it, "to supply the loss of territory by intellectual effort."

What did they do? In spite of universal poverty, three universities, to say nothing of observatories and other institutions, were at once founded, secondary education was developed, and in a few years the mental resources were so well looked after that Lord Palmerston defined the kingdom in question as "a country of damned professors."

After Sedan, a battle, as Moltke told us, "won by the schoolmaster," France made even more strenuous efforts. The old University of France, with its "academies" in various places, was replaced by fifteen independent universities, in all of which are faculties of letters, sciences, law and medicine.

The development of the University of Paris has been truly marvellous. In 1897–8, there were 12,000 students, and the cost was 200,000*l.* a year.

But even more wonderful than these examples is the "intellectual effort" made by Japan, not after a war, but to prepare for one.

The question is, shall we wait for a disaster and then imitate Prussia and France? or shall we follow Japan, and thoroughly prepare by "intellectual effort" for the industrial struggle which lies before us?

Such an effort seems to me to be the first thing any national or imperial scientific organisation should endeavour to bring about.

Research.

When dealing with our universities, I referred to the importance of research, as it is now generally acknowledged to be the most powerful engine of education that we possess. But education after all is but a means to the end which, from the national point of view, is the application of old and the production of new knowledge.

Its national importance apart from education is now so generally recognised that in all civilised nations except our own means of research are being daily more amply provided for all students after they have passed through their university career, and more than this, for all who can increase the country's renown or prosperity by the making of new knowledge upon which not only commercial progress, but all intellectual advance must depend.

I am so anxious that my statement of our pressing, and indeed imperative, needs in this direction should not be considered as resting upon the possibly interested opinion of a student of science merely, that I must trouble you with still more quotations.

Listen to Mr. Balfour:—

"I do not believe that any man who looks round the equipment of our universities or medical schools, or other places of education, can honestly say in his heart that we have done enough to equip research with all the costly armoury which research must have in these modern days. We, the richest country in the world, lag behind Germany, France, Switzerland and Italy. Is it not disgraceful? Are we too poor or are we too stupid?"[1]

It is imagined by many who have given no thought to the matter that this research should be closely allied with some application of science being utilised at the time. Nothing could be further from the truth; nothing could be more unwise than such a limitation.

Surely all the laws of Nature will be ultimately of service, and therefore there is much more future help to be got from a study of the unknown and the unused than we can hope to obtain by continuing the study of that which is pretty well known and utilised already. It was a King of France, Louis XIV., who first commended the study of the *même inutile.* The history of modern science shows us more and more as the years roll on the necessity and advantage of such studies, and therefore the importance of properly endowing them, for the production of new knowledge is a costly and unremunerative pursuit.

Years ago we had Faraday apparently wasting his energies and time in playing with needles; electricity now fills the world. To-day men of science in all lands are studying the emanations of radium; no research could be more abstract; but who knows what advance in human thought may follow or what gigantic world-transforming superstructure may eventually be raised on the minute foundation they are laying?

If we so organise our teaching forces that we can use them at all stages from the gutter to the university to sift out for us potential Faradays—to utilise the mental products which otherwise would be wasted—it is only by enabling such men to continue their learning after their teaching is over that we shall be able to secure the greatest advantage which any educational system can afford.

It is now more than thirty years ago that my attention was specially drawn to this question of the endowment of research, first by conversations with M. Dumas, the permanent secretary of the Academy of Sciences, who honoured me by his friendship, and secondly by my association with Sir Benjamin Brodie and Dr. Appleton in their endeavours to call attention to the matter in this country. At that time a general scheme of endowment suggested by Dumas was being carried out by Duruy. This took the form of the "École spéciale des Hautes Études"; it was what our fellowship system was meant to be—an endowment of the research of post-graduate students in each seat of learning. The French effort did not begin then.

I may here tell, as it was told me by Dumas, the story of Léon Foucault, whose many discoveries shed a glory on France, and revived French industry in many directions.[2] In 1851, when Prince Napoleon was President of the Republic, he sent for Dumas and some of his colleagues and told them that during his stay in England, and afterwards in his study of the Great Exhibition of that year, he had found there a greater industrial development than in France, and more applications of science, adding that he wished to know how such a state of things could be at once remedied. The answer was that new applications depended upon new knowledge, and that therefore the most direct and immediate way was to find and encourage men who were likely by research in pure science to produce this new knowledge. The Prince President at once asked for names; that of Léon Foucault was the only one mentioned during the first interview.

Some time afterwards, to be exact at about 11 in the morning of December 2, Dumas's servant informed him that there was a gentleman in the hall named Foucault who wished to see him, and he added that he appeared to be very ill. When shown into the study, Foucault was too agitated to speak, and was blind with tears. His reply to Dumas's soothing questions was to take from his pockets two rolls of bank notes amounting to 200,000 francs and place them on the table. Finally, he was able to say that he had been with the Prince President since 8 o'clock that morning discussing the possible improvement of French science and industry, and that Napoleon had finally given him the money requesting him to do all in his power to aid the State. Foucault ended by saying that on realising the greatness of the task thus imposed upon him, his fears and feelings had got the better of him, for the responsibility seemed more than he could bear.[1]

The movement in England to which I have referred began in 1872, when a society for the organisation of academical study was formed in connection with the inquiry into the revenues of Oxford and Cambridge, and there was a famous meeting at the Freemasons' Tavern, Mark Pattison being in the chair. Brodie, Rolleston, Carpenter, Burdon-Sanderson, were among the speakers, and the first resolution carried was, "That to have a class of men whose lives are devoted to research is a national object." The movement died in consequence of the want of sympathy of the university authorities.[2]

In the year 1874 the subject was inquired into by the late Duke of Devonshire's Commission, and after taking much remarkable evidence, including that of Lord Salisbury, the Commission recommended to the Government that the then grant of 1000*l.* which was expended, by a committee appointed by the Royal Society, on instruments needed in researches carried on by private individuals should be increased, so that personal grants should be made. This recommendation was accepted and acted on; the grant was increased to 4000*l.*, and finally other societies were associated with the Royal Society in its administration. The committee, however, was timorous, possibly owing to the apathy of the universities and the general carelessness on such matters, and only one personal grant was made; the whole conception fell through.

Meantime, however, opinion has become more educated and alive to the extreme importance of research to the nation, and in 1891 a suggestion was made to the Royal Commission which administers the proceeds of the 1851 Exhibition that a sum of about 6000*l.* a year available for scholarships should be employed in encouraging post-graduate research throughout the whole Empire. As what happened is told in the Memoirs of Lord Playfair, it is not indiscreet in me to state that when I proposed this new form of the endowment of research, it would not have surprised me if the suggestion had been declined. It was carried through by Lord Playfair's enthusiastic support. This system has been at work ever since, and the good that has been done by it is now generally conceded.

It is a supreme satisfaction to me to know that in this present year of grace the national importance of the study of the *même inutile* is more generally recognised than it was during the times to which I have referred in my brief survey, and, indeed, we students are fortunate in having on our side in this matter two members of His Majesty's Government, who two years ago spoke with no uncertain sound upon this matter.

"Do we lack the imagination required to show what these apparently remote and abstract studies do for the happiness of mankind? We can appreciate that which obviously and directly ministers to human advancement and felicity, but seem,

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[1] NATURE, May 30, 1901.

[2] See *Proc. R.S.* vol. xvii., p. lxxxiii.

[1] In order to show how history is written, what actually happened on a fateful morning may be compared with the account given by Kinglake:—"Prince Louis rode home and went in out of sight. Then for the most part he remained close shut up in the Elysée. There, in an inner room, still decked in red trousers, but with his back to the daylight, they say he sat bent over a fireplace for hours and hours together, resting his elbows on his knees, and burying his face in his hands" ("Crimean War," i. p. 245).

[2] See NATURE, November and December, 1872.

somehow or another, to be deficient in that higher form of imagination, in that longer sight, which sees in studies which have no obvious, necessary, or immediate result the foundation of the knowledge which shall give far greater happiness to mankind than any immediate, material, industrial advancement can possibly do; and I fear, and greatly fear, that, lacking that imagination, we have allowed ourselves to lag in the glorious race run now by civilised countries in pursuit of knowledge, and we have permitted ourselves so far to too large an extent to depend upon others for those additions to our knowledge which surely we might have made for ourselves."—*Mr. Balfour*, NATURE, May 30, 1901.

"I would remind you that all history shows that progress—national progress of every kind—depends upon certain individuals rather than upon the mass. Whether you take religion, or literature, or political government, or art, or commerce, the new ideas, the great steps, have been made by individuals of superior quality and genius who have, as it were, dragged the mass of the nation up one step to a higher level. So it must be in regard to material progress. The position of the nation to-day is due to the efforts of men like Watt and Arkwright, or, in our own time, to the Armstrongs, the Whitworths, the Kelvins, and the Siemenses. These are the men who, by their discoveries, by their remarkable genius, have produced the ideas upon which others have acted and which have permeated the whole mass of the nation and affected the whole of its proceedings. Therefore what we have to do, and this is our special task and object, is to produce more of these great men." —*Mr. Chamberlain*, TIMES, January 18, 1901.

I finally come to the political importance of research. A country's research is as important in the long run as its battleships. The most eloquent teaching as to its national value we owe to Mr. Carnegie, for he has given the sum of 2,000,000*l.* to found a system of endowments, his chief purpose being, in his own words, "to secure if possible for the United States of America leadership in the domain of discovery and the utilisation of new forces for the benefit of man."

Here is a distinct challenge to Britain. Judging by experience in this country, in spite of the magnificent endowment of research by Mond and Lord Iveagh, the only sources of possible competition in the British interest is the State, which certainly could not put the 1/8000 part of the accumulated wealth of the country to better use, for without such help both our universities and our battleships will become of rapidly dwindling importance.

It is on this ground that I have included the importance of endowing research among the chief points to which I have been anxious to draw your attention.

The Need of a Scientific National Council.

In referring to the new struggle for existence among civilised communities, I pointed out that the solution of a large number of scientific problems is now daily required for the State service, and that in this and other ways the source and standard of national efficiency have been greatly changed.

Much evidence bearing upon the amount of scientific knowledge required for the proper administration of the public departments and the amount of scientific work done by and for the nation was brought before the Royal Commission on Science presided over by the late Duke of Devonshire now more than a quarter of a century ago.

The Commission unanimously recommended that the State should be aided by a scientific council in facing the new problems constantly arising.

But while the home Government has apparently made up its mind to neglect the advice so seriously given, it should be a source of gratification to us all to know that the application of the resources of modern science to the economic, industrial and agricultural development of India has for many years engaged the earnest attention of the Government of that country. The Famine Commissioners of 1878 laid much stress on the institution of scientific inquiry and experiment designed to lead to the gradual increase of the food-supply and to the greater stability of agricultural outturn, while the experience of recent years has indicated the increasing importance of the study of the economic products and mineral-bearing tracts.

Lord Curzon has recently ordered the heads of the various scientific departments to form a board, which shall meet twice annually, to begin with, to formulate a programme and to review past work. The board is also to act as an advisory committee to the Government,[1] providing among other matters for the proper coordination of all matters of scientific inquiry affecting India's welfare.

Lord Curzon is to be warmly congratulated upon the step he has taken, which is certain to bring benefit to our great dependency.

The importance of such a board is many times greater at home, with so many external as well as internal interests to look after, problems common to peace and war, problems requiring the help of the economic as well as of the physical sciences.

It may be asked, What is done in Germany, where science is fostered and utilised far more than here?

The answer is, there is such a council. I fancy very much like what our Privy Council once was. It consists of representatives of the Ministry, the universities, the industries, and agriculture. It is small, consisting of about a dozen members, consultative, and it reports direct to the Emperor. It does for industrial war what military and so-called defence councils do for national armaments: it considers everything relating to the use of brain-power in peace, from alterations in school regulations and the organisation of the universities, to railway rates and fiscal schemes, including the adjustment of duties. I am informed that what this council advises generally becomes law.

It should be pretty obvious that a nation so provided must have enormous chances in its favour. It is a question of drilled battalions against an undisciplined army, of the use of the scientific spirit as opposed to the hope of "muddling through."

Mr. Haldane has recently reminded us that "the weapons which science places in the hands of those who engage in great rivalries of commerce leave those who are without them, however brave, as badly off as were the dervishes of Omdurman against the Maxims of Lord Kitchener."

Without such a machinery as this, how can our Ministers and our rulers be kept completely informed on a thousand things of vital importance? Why should our position and requirements as an industrial and thinking nation receive less attention from the authorities than the headdress of the Guards? How, in the words of Lord Curzon,[2] can "the life and vigour of a nation be summed up before the world in the person of its sovereign" if the national organisation is so defective that it has no means of keeping the head of the State informed on things touching the most vital and lasting interests of the country? We seem to be still in the Palæolithic age in such matters, the chief difference being that the sword has replaced the flint implement.

Some may say that it is contrary to our habit to expect the Government to interest itself too much or to spend money on matters relating to peace; that war dangers are the only ones to be met or to be studied.

But this view leaves science and the progress of science out of the question. Every scientific advance is now, and will in the future be more and more, applied to war. It is no longer a question of an armed force with scientific corps, it is a question of an armed force scientific from top to bottom. Thank God the Navy has already found this out. Science will ultimately rule all the operations both of peace and war, and therefore the industrial and the fighting population must both have a large common ground of education. Already it is not looking too far ahead to see that in a perfect State there will be a double use of each citizen, a peace use and a war use, and the more science advances the more the old difference between the peaceful citizen and the man at arms will disappear; the barrack, if it still exists, and the workshop will be assimilated, the land unit, like the battleship, will become a school of applied science, self-contained, in which the officers will be the efficient teachers.

I do not think it is yet recognised how much the problem of national defence has thus become associated with that with which we are now chiefly concerned.

These, then, are some of the reasons which compel me to point out that a scientific council, which might be a scientific committee of the Privy Council, in dealing primarily with the national needs in times of peace, would be a source of strength to the nation.

To sum up, then. My earnest appeal to you is to gird up your loins and see to it that the science of the British Empire

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[1] NATURE, September 4, 1902.
[2] *Times*, September 30, 1902.

shall no longer remain unorganised. I have endeavoured to point out to you how the nation at present suffers from the absence of a powerful, continuous, reasoned expression of scientific opinion, urging in season and out of season that we shall be armed as other nations are with efficient universities and facilities for research to uphold the flag of Britain in the domain of learning and discovery, and what they alone can bring.

I have also endeavoured to show how, when this is done, the nation will still be less strong than it need be if there be not added to our many existing councils another, to secure that, even during peace, the benefits which a proper coordination of scientific effort in the nation's interest can bring shall not be neglected as they are at present.

Lest some of you may think that the scientific organisation which I trust you will determine to found would risk success in working on such large lines, let me remind you that in 1859, when the late Prince Consort occupied this chair, he referred to "impediments" to scientific progress, and said, "they are often such as can only be successfully dealt with by the powerful arm of the State or the long purse of the nation."

If the Prince Consort had lived to continue his advocacy of science, our position to-day would have been very different. His early death was as bad for Britain as the loss of a great campaign. If we cannot regain what we have lost, matters cannot mend.

I have done what I feel to be my duty in bringing the present condition of things before you. It is now your duty, if you agree with me, to see that it be put right. You can if you will.

SECTION A.

MATHEMATICS AND PHYSICS.

Opening Address by Charles Vernon Boys, F.R.S., President of the Section.

The first duty of every occupant of this Chair is a sad one. Year by year the record grows of those who have devoted their lives to the development of mathematical and physical science, of those who have completed their work. The past year has added many names to the record—more, it seems, than its fair share. The names include some of the most brilliant and active of our race, of those to whom this Association is deeply indebted, and also of our fellow workmen in other countries whose loss is no less to be deplored.

Lord Salisbury's devotion to the empire, of which this is not the occasion to speak, left him but little time for those scientific pursuits in which he took so keen an interest. Once, however, as President of this Association, he showed our members that, unlike the majority of our statesmen, science was not to him a phantom. His Address at Oxford will remain in the memories of all who heard it. The eloquence, the humour, the satire, the subtlety provided an intellectual treat of the rarest kind.

Of Sir George Gabriel Stokes and his work it is not possible for me to speak. Any attempt on my part to appreciate or gauge the value of the work of such a giant would be an impertinence. This can only fitly be done by one of our leaders, and Lord Kelvin has paid a fitting tribute in the pages of Nature. I can only record the fact that Stokes was for seven years Secretary, and twice President of this Section, and in 1869 was President of the Association.

Dr. Gladstone, for fifty-three years a member of this Association, was not only an unfailing attendant at our meetings, but an active member whose steady stream of original communications on subjects connecting physics and chemistry earned for him the designation of Creator of Physical Chemistry. His investigations on spectroscopy, refractivity and electrolytics are known to every student of physics. His researches upon early metallurgical history, while of less importance to the progress of science, are none the less interesting. An ardent apostle of education, he was for twenty-one years a member of the London School Board, and three years vice-chairman. Dr. Gladstone was the first President of the Physical Society. He has been President of the Chemical Society, and at the last meeting of the British Association at Southport—as also in 1872—he was President of the Chemical Section. So long ago, he said, in urging the importance of science as a factor in education, that the so-called educated classes were not only ignorant of science, but had not arrived at the knowledge of their own ignorance.

It is not possible to pass on without paying a tribute, in which all who knew Dr. Gladstone will share, to his character no less than to his genius.

Sir William Roberts-Austen was probably one of the most active members that this Association has known. Not only had he for many years made the subject of metals and alloys his own, but he worked for the Association in many ways. At three meetings have audiences been charmed by his fascinating and brilliant evening lectures, all relating to metals. He was President of the Chemical Section at the Cardiff meeting in 1891, and not only did he perform these duties, but he accepted the more laborious and more thankless task, for which his unfailing courtesy and tact so well fitted him, of acting as our General Secretary for four years. His labours in the important field of research which he tilled were appreciated by numerous technical societies and institutions of which he was an honorary member, or had been president or vice-president. Many branches of the public service had the advantage of his skill and experience, which received the official reward in 1899.

Dr. Common's skill as a designer and constructor of instruments was well known. His instinct or judgment in producing planes and figured concave mirrors of great dimensions was rare, for this is an art almost unknown in the laboratory. His generosity and his valuable advice have been appreciated by many besides myself.

Rev. H. W. Watson, Second Wrangler and Smith's Prizeman in 1850, was a Vice-President of the British Association in 1886. Mathematical physicists are familiar with the joint work of himself and Burbury on "Generalised Co-ordinates," and with his mathematical articles.

In Otto Hilger, the brother of the late Adam Hilger, who between them brought to this country German thoroughness and French skill in instrument manufacture, we have lost one of our first and most valuable constructors. Noted for the high class of all the optical work turned out by the firm, Otto Hilger was not afraid of attacking the problem of manufacturing the Michelson echelon grating. This little bundle of glass plates requires for its success perfection and precision commensurable only with the genius of the inventor. This Otto Hilger supplied.

Dean Farrar, a life member of the British Association, whose activity lay in another direction, showed his appreciation of the value of science in education by appointing the first science master at Marlborough when he became headmaster in the year 1870. As I was a boy at the school at that time, I can speak of the incredulity with which such an announcement was at first received and of the general feeling that such an action was akin to a joke. I was, however, by no means the only boy who hailed the news with delight. We devoured the feast of chemistry and physics put before us by Rodwell and the books which at once became available. Out of gratitude to the late Dean of Canterbury I recall this episode.

James Wimshurst, the inventor of the influence machine which has carried his name into every corner of the scientific world, was not a member of this Association, but he fostered and encouraged the scientific spirit in young men who, by good fortune, came to know him. I do not think I have heard anyone spoken of with such gratitude and appreciation as Wimshurst, by men who in their younger days were allowed the run of his well-equipped workshop.

James Glaisher, best known as a balloonist in the sixties, has died at the great age of ninety-three. The balloon ascent with Coxwell on September 5, 1862, when they attained the altitude of 37,000 feet, will long remain in the popular imagination, not on account simply of the great altitude, but by reason of the sensational account of their having been paralysed with cold, and of their being able to stop the ever-increasing ascent only by the presence of mind of Coxwell, who, with his limbs frozen, seized the valve rope with his teeth, and so let out the gas.

While this event remains in everyone's mind, the more prosaic work of Glaisher in astronomy, meteorology, and photography, when most of us were children, and many yet unborn, led to his being elected president of various learned societies.

He gave one of the evening lectures of the British Association in 1863, the subject being balloon ascents.

A. F. Osler, the inventor of the self-recording direction and pressure anemometer and rain gauge, whose active meteorological work was carried out in the first half of the last century, when he contributed papers to the British Association and the Literary and Philosophical Society of Birmingham, has died at the still greater age of ninety-five. He was Vice-President of the British Association in 1865.

Of other countries, America has lost Prof. J. Willard Gibbs, a mathematical physicist whose very learned and original contributions to the knowledge of the world on the thermodynamical properties of bodies, on vectors, the kinetic theory of gases, and other abstruse subjects, have received the highest recognition that the learned societies of this country can bestow. Prof. Harkness, the astronomer, and Prof. Rood, the skilled experimental physicist of Troy, have also maintained the high standard that we now look for in American science.

Germany has lost Prof. Deichmüller, Professor of Astronomy at Bonn, at an early age. Sweden has lost Prof. Bjerknes, whose hydrodynamical experiments showing attraction and repulsion were so much admired when he performed them at a meeting of the Physical Society some twenty-five years ago. Switzerland has lost Prof. C. Dufour, the astronomer; and Italy has lost Prof. Luigi Cremona, a foreign member of this Association, Principal of the Engineering School in Rome, whose contributions to pure geometry and to its applications have made him famous.

Of the events of the last year, one stands out beyond all others, not only for its intrinsic importance and revolutionary possibilities, but for the excitement that it has raised among the general public. The discovery by Prof. and Madame Curie of what seems to be the everlasting production of heat in easily measurable quantity by a minute amount of a radium compound is so amazing that, even now that many of us have had the opportunity of seeing with our own eyes the heated thermometer, we hardly are able to believe what we see. This, which can barely be distinguished from the discovery of perpetual motion, which it is an axiom of science to call impossible, has left every chemist and physicist in a state of bewilderment. Added to this, Sir William Crookes has devised an experiment, characteristic of him, if I may say so, in which a particle of radium keeps a screen bombarded for ever, so it seems, each collision producing a microscopic flash of light, the dancing and multitude of which forcibly compel the imagination to follow the reasoning faculties, and realise the existence of atomic tumult. Thanks to the industry and genius of J. J. Thomson, Rutherford and Soddy, Sir William and Lady Huggins, Dewar and Ramsay, and others in this country, besides Prof. and Madame Curie and a host of others abroad, this mystery is being attacked, and theories are being invented to account for the marvellous results of observation; but the theories themselves would a few years ago have seemed more wonderful and incredible than the facts, as we believe them to be, do to-day. An atom of radium can constantly produce an emanation, that is something like a gas, which escapes and carries with it wonderful properties; but the atom, the thing which cannot be divided, remains, and retains its weight. The emanation is truly wonderful. It is self-luminous, it is condensed by extreme cold and vaporises again; it can be watched as it oozes through stopcocks or hurries through tubes, but in amount it is so small that it has not yet been weighed. Sir William Ramsay has treated it with a chemical cruelty that would well-nigh have annihilated the most refractory or permanent known element; but this evanescent emanation comes out of the ordeal undimmed and undiminished.

Not content with manufacturing so remarkable a substance, the radium atom sends out three kinds of rays, one kind being much the same as Röntgen rays, but wholly different in ionising power, according to the experiments of Strutt. Each of these consists of particles which are shot out, but they have different penetrative power; they are differently deflected by magnets and also by electricity, and the quantity of electricity in relation to the weight is different, and yet the atom, the same atom, remains unchanged and unchangeable. Not only this, but radium or its emanations or its rays must gradually create other bodies different from radium, and thus, so we are told, one at least of those new gases which but yesterday were discovered has its origin.

Then, again, just as these gases have no chemical properties, so the radium which produces them in some respects behaves in a manner contrary to that of all proper chemicals. It does not lose its power of creating heat even at the extreme cold of liquid air, while at the greater degree of cold of liquid hydrogen its activity is found by Prof. Dewar to be actually greater.

Unlike old-fashioned chemicals which, when they are formed, have all their properties properly developed, radium and its salts take a month before they have acquired their full power (so Dewar tells us), and then, for anything we know to the contrary, proceed to manufacture heat emanations, three kinds of rays, electricity, and gases for ever. For ever; well, perhaps not for ever, but for so long a time that the loss of weight in a year, calculated, I suppose, rather than observed, is next to nothing. Prof. Rutherford believes that thorium or uranium, which act in the same kind of way, but with far less vigour, would last a million years before there was nothing left, or at least before they were worn out; while the radium, preferring a short life and a merry one, could not expect to exist for more than a few thousand years.

In this time one gramme of radium would evolve one thousand million heat units, sufficient, if converted into work, to raise five hundred tons a mile high; whereas a gramme of hydrogen, our best fuel, burned in oxygen, only yields thirty-four thousand heat-units, or one thirty-thousandth part of the output of radium. I believe that this is no exaggeration of what we are told and of what is believed to be experimentally proved with regard to radium; but if the half of it is true the term "the mystery of radium" is inadequate: the miracle of radium is the only expression that can be employed.

With all this mystery before us, which I must confess myself wholly unable to follow, I feel sure that members of the Association who are interested in the work of this Section will welcome the discussion, for which our secretaries have been able to arrange, and hear from the lips of Prof. Rutherford the conclusions to which his researches have at present brought him. No one is more fitted than Prof. Rutherford to open such a discussion, for no one has attacked the theoretical side with such originality and daring, or with such ingenuity of experiment.

As an example of the activity of mind and of research to which the activity of radium has given rise, I may mention the fact that the last number of the *Proceedings* of the Royal Society is wholly concerned with radium, there being four papers, all of the first importance, dealing with entirely different phenomena.

It is not my purpose to review these or the subject of radium generally; I am in no way fitted to do so. But I cannot well let the present opportunity pass of referring to another mystery of which a conspicuous example is now leaving us. I refer to the mystery of the comet and its tails. What is a comet? of what does its tail consist? Gravitational astronomy has told us for many years past that compared with the planets or their satellites a comet does not weigh anything. It weighs pounds or perhaps hundreds, thousands, or millions of tons; but in comparison with inconspicuous satellites it weighs nothing. Yet some of them as they approach the sun from remote regions begin to shoot out streamers which pour away as though repelled by the sun, not being left as a trail behind the comet, as is so often supposed. These streamers, ejected towards the sun, bend round and pour away at speeds which are enormous compared with that of the comet itself, thus producing the tail. Now these streams separate very often, and give rise to comets with two or three tails. Let me read one paragraph from "The History of Astronomy," by Miss Clerke:—

"The amount of tail curvature, he [Olbers] pointed out, depends in each case upon the proportion borne by the velocity of the ascending particles to that of the comet in its orbit; the swifter the outrush the straighter the approaching tail. But the velocity of the ascending particles varies with the energy of their repulsion by the sun, and this again, it may be presumed, by their quality. Thus multiple tails are developed when the same comet throws off, as it approaches perihelion, specifically distinct substances. The long straight ray which proceeded from the comet of 1807, for example, was doubtless made up of particles subject to a much more vigorous solar repulsion than those formed into the shorter curved emanation issuing from it nearly in the same direction. In the comet of 1811 he calculated that the particles expelled from the head travelled to the remote extremity of the tail in eleven minutes, indicating by this enormous rapidity of movement (comparable to that of the transmission of light) the action of a force much more powerful than the opposing one of gravity. The not uncommon phenomena of multiple envelopes, on the other hand, he explained, are due to the varying amounts of repulsion exercised by the nucleus itself on the different kinds of matter developed from it."

It is impossible not to be struck by the similarity both of phenomenon described and of language used in this paragraph and in almost any of the papers on radium. I know this mere superficial similarity is worth very little, if anything; but for centuries the sky has shown us a phenomenon still not entirely understood, and the inability to remove all difficulty by the aid of radium or similar material is no reason for dismissing the idea of connection without further thought.

The comet's tail is still a mystery. Let me take the most recent explanation, which was set forth only three months ago in the *Astrophysical Journal* in the United States. Those admirable experimentalists Nichols and Hull have for some years been investigating the back pressure exerted by the action of light upon bodies on which it falls. In this they have followed the Russian physicist Lebedew, but in minuteness and delicacy of measurement, and in their successful elimination of disturbances, their results are unequalled. It is sufficient to say that, difficult and minute as the experiment is, their success is such that the discrepancy between the calculated force and that which they have found is under 1 per cent. Perhaps I may express some satisfaction that in this measurement use was made of the quartz fibre.

Having now definite and accurate confirmation of the existence of the force produced by the action of light, or rather radiation, Nichols and Hull proceed to examine the question as to how far such repulsion may be competent to overcome the gravitative attraction of the sun and drive away the matter which pours out from the comet. It is interesting to note here that Kepler put forward this very idea, and that Newton, the inventor of the corpuscular theory of light, looked upon the suggestion with some favour.

Coming now to this recent paper of Nichols and Hull, we find first the consideration of the relation of the attraction by gravitation, and the repulsion by light upon particles of different sizes and densities. Density has no influence on the action of light, while it is favourable to gravitation, and therefore unfavourable to tail formation. Size is favourable to both, but more to gravitation than to light, for if the diameter of a particle be doubled, one is increased eightfold and the other only four. So size favours gravitational attraction. Conversely, of course, smallness favours repulsion by light, which relatively should get greater and greater as the particles diminish in size. At last, then, a degree of smallness may be reached in which the repulsion by light will actually be equal to the attraction by gravitation, and such a particle would remain in space, its motion unaffected by our sun. Let the diminution of size continue, and then the repulsion will be in excess, and if the law were to continue it would with sufficient diminution become relatively as large as we please.

The law, however, does not continue. Schwarzschild has shown that when the particles are small enough, light does not act upon them in the same way. Owing to diffraction, the effect of light is unduly great for a certain very small size of particle, while it fails almost entirely when the particle is made much smaller. Thus it is that the indefinite increase in the repulsion by light as compared with the attraction by gravitation with diminution of size of particle is checked, and when, according to theory, with a particular density of particle, the light pressure is about twenty times as great as gravitational attraction, further diminution of size ceases to favour the action of light, and it begins to fall off again. The distance of the particle from the sun has no influence upon the relation between the two kinds of forces, for they rise and fall together. Nichols and Hull, therefore, while not denying that other causes may operate, believe that light pressure is adequate to account for the phenomena, and that where the material coming from the head or comet proper is of two or three kinds, whether of density or of size of particle, the separation of the two or three tails should naturally follow.

This theory presupposes that the nucleus of a comet will be able, owing to the evolution of gas under the sun's heat, to send out enormous quantities of dust, the finer and lighter the better, so long as it is not unduly small with respect to a wave-length of light. Such dust would account for any reflected solar light that the spectroscope may show, but it is not easy to see how the spectrum of hydrocarbons, of sodium, and of other metal, should be produced for lack of temperature. It is not easy to see why fortuitous dust should be graded of such sizes as to give well separated and defined tails; it is not easy to see how the dust could be produced in sufficient quantity to provide visible illumination to millions of millions of cubic miles of space through which it may be passing at ultra-planetary velocity, even though in looking through a million miles or so one grain of dust in a hundred miles might suffice to supply the light.

Other theories of the comet's tail require an electrified sun, the existence of which is explained by Arrhenius as being caused by the emission by the sun of negatively charged electrons which, picking up condensing gases as Aitken's dust picks up moisture from the atmosphere, are driven away by the light pressure. Arrhenius believes that these acting on the matter in the tail would give rise to the bright line spectra which have been observed. The result of all this escape of negative electricity is a positively charged sun, but what limits the charge in the sun it is as difficult to see, as it is, why the electrostatic attraction helped by gravitation does not ultimately stop the action. I may be displaying my ignorance, of which I am sufficiently sensible, but I am not aware of any evidence for the existence of the stream of electrified grains or drops imagined by Arrhenius.

Nichols and Hull, while calling to their aid the researches of Schwarzschild to give them a repulsive force some twenty times as great as gravitative attraction, do not seem to have given due weight to the extremely small range of size of particle for which this high effect is available. The maximum effect for any wave-length according to Schwarzschild is produced, when the size is such that a wave-length will just reach round it; that is, with ordinary light when the diameter is between one hundred thousandth and one hundred and fifty thousandth of an inch. If the diameter is two-and-a-half times the wave-length the action of light is only equal to gravity with a material of the density of water; or again, if it is reduced to one-eighth of a wave-length it again becomes equal, and in these two cases there is no resultant action. With either larger or smaller particles gravity rapidly gets the better of light, while the high advantage of light over gravity is confined to very narrow limits.

What the sifting process can be that will give rise to such a quantity of this microscopic dust we can hardly expect to be told, nor why even if the material should in some mysterious way be graded, the ungraded wave-lengths of the solar spectrum should allow of the marked separation in some instances of comets' tails.

One thing, however, they do assert, and that is that the light pressure can have no action on a gas, so that if what we see is considered to be gaseous the light pressure theory must be thrown over for some other.

I cannot leave this excursion of Nichols and Hull into a speculative domain of science without expressing my admiration of the experimental work which they have accomplished, and my appreciation of the ingenuity and daring with which they have attempted the hitherto unheard-of feat of making a comet.

While the theory just referred to may be the most recent it must not on that account be supposed to displace all that has gone before; the authors themselves do not suggest this; it is the last thing that would occur to them. They have referred to the researches of Bredechin that occupy so large a proportion of the annals of the Observatory of Moscow.

It is impossible to read even a tithe of these without feeling that the subject of comets and their tails is one which

Bredechin, by his amazing industry, has made his own property, and that any stranger casually passing by and taking a random shot should receive the severe penalty awarded to poachers in this country. Bredechin has dealt unmercifully—I do not say unjustly—with the author of at least one such random theory.

It is therefore with the greater diffidence and more urgent plea for forbearance that I venture to draw certain parallels and hazard certain suggestions which I admit freely have not reached a stage at which detailed comparisons with known comets are possible.

It does not seem possible now to contemplate the phenomena of the comet, of the divided tails, of their tenuity and transparency, of the pale luminosity, partly reflected solar light, partly light as from a glowing gas; of the gradual wearing out and disappearance of those comets which constantly pay visits to solar regions, with all the mysteries of radium now so much in evidence without tracing the features in which they resemble one another. By radium, of course, I mean any material with the remarkable radio-active properties that radium exhibits with such pre-eminent splendour, whether known in the laboratory or not.

How many physicists have been peering at comets through radium spectacles, or how many astronomers detect the sparkle of radium in the fairy tresses of their hirsute stars I know not. One writer, however, T. C. Chamberlin, so long ago as July, 1901, looked upon a connection between radio-active materials such as were then known and comets as at least worth considering. Chamberlin's paper in the *Astrophysical Journal* was mainly on the tidal disruption of gravitating bodies and the possible evolution of comets, nebulæ and meteorites, and he did not pursue this consideration in any detail; indeed, the enormous accumulation of new properties of radium was not then available.

Whatever may be imagined as to the constitution of a comet, difficulties still remain. All I suggest now is that the curious properties of radium and of similar bodies should be kept in mind. Radium at least supplies the means by which, if the increasing warmth or the tidal action of the sun should awaken its activity, Rutherford's α-rays should be shot out at the speed that he has measured of a thousand million inches a second, *i.e.* one-twelfth the velocity of light. These α-rays, according to Rutherford, consist of helium; they weigh each twice as much as a hydrogen atom, and so the same weight of comet matter that would make one of Nichols and Hull's best particles, *i.e.* one that would be just visible with a microscope, would be sufficient for about 400 millions of Rutherford's α-ray particles, an advantage surely where diffuseness seems so miraculous.

These particles, shot out at a velocity one-twelfth that of light, go so fast that, if they were to start horizontally on the surface of the earth, the gravitative attraction of the earth would curve their path to the infinitesimal extent of a curve with a radius of forty thousand million miles. Yet so great is the electric charge they carry that a visible curvature can be imposed upon them in a practicable electrostatic field.

Now imagine these transferred into space at a distance from the sun, for instance, equal to that of Venus. Gravity there due to the sun is only one-thousandth of what it is here, so gravity there would be, to the same extent, less able to impose visible curvature on their paths. But their electric charges are still available, and unless I have made an arithmetical blunder of a considerable order, it would require no very heavy electrification of the sun to bend these rays round in a curve with a radius of 1000 miles. An electrostatic field of under two ten-thousandths of a unit should be sufficient, a field which would be produced if the sun were only charged with a surface density of one electrostatic unit on every three square centimetres.

Whether these figures are correct or not—and I know the risk of getting just thirty thousand million times too large or too small a result—does not much matter. An electrified sun, which after all others besides Arrhenius have postulated, would be sufficient to turn the rays and send them away at rapidly increasing speed so as to form the tail. The speed would in a short time reach the velocity of light if it were not for the change in properties of matter which supervenes when any such velocity is nearly reached. Thus, according to the ratio of charge to mass, particles such as Rutherford's α-rays would be sent away each with its limiting velocity, giving rise to streaks more or less well defined, and double, triple, or multiple according to the number of kinds of ray which the various radio-active materials were able to generate.

Not only should streaks pointing away from the sun be formed, but any negatively charged rays such as radium is said to give out should form a tail directed towards the sun. Perhaps this might be expected to be general, but while not common one was described by Hind in the comet of 1823–24, and three or four more have been observed.

The head or coma would be the envelope of all the independent orbits, leaving the nucleus in all directions—orbits which while their velocities are still of the Rutherford order would be hyperbolas convex to the sun.

If this should not appear to be absolute nonsense it would seem as if another difficulty should become less than it has been. I refer to the visibility, luminosity, and spectral character.

Lodge, as an interpreter of Larmor, tells us that an electrified ion subject to acceleration, whether transverse or in the line of motion, radiates energy. The streamers from the nucleus subject to the greatest acceleration may be bright almost as the nucleus itself; then, as they have become dissipated into regions where far less acceleration becomes possible, the radiation falls off and the tail is lost in space.

The observations made last month by Sir William and Lady Huggins of the spectrum given by a piece of radium in the air may have some bearing upon the luminosity of the comet. It is possible that the internal motions set up by the separate parts, each pursuing its individual orbit, may produce collisions numerous and violent enough to account for all the light that is seen, and for temperature sufficient to bring out the spectral lines that have been identified. Whether this is so or not, radio-active bodies and their emanations can produce light independently of such action; and now these observers have found that in the case of radium in air this light gives the spectrum, line by line, of nitrogen. Is it possible that the enveloping nitrogen has had its atoms so harried by the activity of the radium as to give a response hitherto only awakened by electric discharge? The ability to obtain such a response opens up a new possible interpretation of these spectra, which hitherto have been assumed, with our laboratory experience only to guide us, to have required for their production temperature above a red heat. If further observation should confirm this, the hydrogen, the hydrocarbon, and possibly even the sodium or iron spectrum that has been observed, may have come from cold atoms; and it is not even quite beyond the limits of imagination to picture, not from the comet matter itself, but from loose residual and highly attenuated matter through which the comet is passing.

There is one other feature of this remarkable observation of equal interest. The lines of the spectrum were not exactly in their proper place, but were all shifted towards the red end of the spectrum about twice the distance between the D lines. If only one or two lines had been so observed a different origin might well have been suspected; but when the whole series are faithfully reproduced it is reasonable to look upon the spectrum as modified to that extent as though the works of the nitrogen atom had not only been set in movement, but had been loaded with the radium emanation.

Before dismissing these random speculations on the possible connection between radio-activity and comets I would ask your leave to refer once more to Bredechin's conclusions. He has found that it is merely necessary to postulate three kinds of matter, issuing from the nucleus with three initial velocities, and subject to repulsion from the sun with three sets of forces of repulsion—*i.e.* as compared with ordinary gravitative attraction—for the whole of the phenomena of all sorts of comets to be very completely accounted for. His highest initial velocity is only about five miles a second, and his lowest about a quarter of a mile a second. His highest repulsion, after deducting gravitative attraction, is only eleven times gravity, and his lowest only a fifth of gravity. If, then, with such velocities and forces the phenomena can be exactly accounted for, it would seem futile to consider the possibility of initial velocities from 4000 to 80,000 times as great and effective repulsions of a corresponding order being able to produce effects with anything in common. This is not necessarily the case, for with the comparatively slow separation of the atoms of Bredechin's matter from the nucleus, each one describing its own hyperbola convex to the sun, the tail at any moment represents the then position of any number of atoms which left the nucleus for some distance back, whereas with the enormous velocities and effective forces now discussed the comet moves so slowly in comparison that the tail would practically represent the path at the time.

It has taken me far longer to throw out this not very luminous ray than I had expected or than it is worth. I fear that it is a sort of ray in which the ratio of its dead weight to its vitalising charge is too small to enable it to penetrate the lightest screen of examination.

These are the days of rays, and now before we have quite become familiar with the rays of radio-active bodies Blondlot has presented us with N rays, which issuing from the mantle of an incandescent gas burner penetrate wood or aluminium, and then increase the light without increasing the heat of hot bodies on which they fall.

Passing now from the amusement of speculation to more serious duties, I find myself confronted with the difficulties that prevent us in this country from succeeding as we used to do in the international struggle—a struggle the issue of which is daily becoming more and more a question of brains, of education, of skill and enterprise in manufacture—and finally of that great virtue extolled by the President of the United States, strenuousness.

It is the duty of everyone who sees the way in which we are being outstripped in the race to do what in him lies to scrape off the rust which is clogging our educational machinery. I now refer to the defects which hamper the intellectual progress of the majority of our youth. I believe the public school mathematics in this country stands on a level of its own, well below that of any other. In England, owing to our complicated system of weights and measures, which our Ministers and our Parliament dare not abolish for our own good, the scanty hours allowed for mathematics are devoted to the learning of tables which should never have to be learned at all, to compound reductions designed merely to puzzle but not to lead to any new step; and, even if our present system were not futile enough, to learning lists of antique values which serve the useful purpose of giving the boys something to do. The result is that beyond having time to acquire a few elementary algebraical rules the boy is never introduced to algebra proper; he has no idea of algebraical reasoning; his trigonometry often does not exist, and the very sound or suggestion of coordinate geometry or of the differential calculus, which might be well within his reach, produces a shiver of dismay. Geometry is presented for the first time in the form of Euclid, a form as repulsive to most boys as it well could be. I must confess to having been attracted and not repelled by Euclid; but the boy does not care for time. Now that I look at Euclid again I have also to confess that any lingering regard for an old friend vanishes before the archaic language and the unnecessary circumlocution. If Euclid must be retained let it be translated into English, the English that any parent would use in explaining the ideas to his son; let it be illustrated by constant reference to real things so as to appeal to the boy who does not revel in the abstract. Let the ideas and the terms first be presented in the form of experiments and of measurements with instruments; let the schoolmaster dare to throw over the intolerable conservatism which prevents our doing anything ten times as well lest some item should prove to be a trifle worse; in fact, let us take some heed of the possibly extreme, but none the less genuine and valuable preaching of Prof. Perry. I have so far referred only to the miserable use that is made of the odd hours grudgingly given to what is called mathematics. Is it any use to repeat the long-standing complaint of the way in which the schoolmaster insists upon overdoing his Latin and Greek under the belief that they are at least essential to intellectual development if, indeed, they do not supply the only stimulus? As society is constituted they are essential to education as an extensive knowledge of Confucius is essential to an educated Chinaman, so that we may mix one with another, appreciate the works of our great authors, understand the same allusions, and have the same kind of knowledge of the development of our civilisation. Few men of science, perhaps none, wish to see all of this, some of which is essential to a general education, abolished; all that we ask is that the schoolmaster shall not continue to impose upon the community the unbalanced learning which corresponds to mathematics and science without letters. The time given to classics is exorbitant; more must be reserved for those pursuits which draw out the habit of independent thought, creation and originality. It would be well if every schoolmaster could read an admirable article by James Swinburne on the two types of mind fostered by the two complementary types of education, but this is buried away in an inaccessible number of the *Westminster Review*.

The classic is unfortunately still in possession, and where, as is still often the case, he is innocent of any appreciation of the educational value of post-Newtonian studies it is not surprising that he thrusts into odd moments the subjects he does not understand, and which he therefore despises, and that the boys committed to his charge and living in such an atmosphere are half ashamed of showing any interest in the scanty science which is within their reach. It is almost impossible to believe that such can be the case, but I have referred to the impression to which the appointment of the first science master at my own school gave rise. I now refer to the contribution to a discussion on education but a year or two ago by that experienced teacher, Principal Griffiths. Fortunately our public schools are not the only ones in the country. Smaller and less fashionable schools pay more attention to education and suffer less from what, in defiance of all rule, I can only call didactatorial method.

I am not aware that the result of this almost total exclusion of tabooed subjects in favour of Latin and Greek is producing a standard of classical attainment in our youth greatly in advance of that to be found in other countries, but it is certain that in history, modern languages, mathematics, and science the product of our public schools is sadly deficient.

There is another point related to our deficient general scientific training on which I wish to offer some remarks, and that is in relation to manufacture. It is the fashion among some of our scientific people to talk of our manufacturers as if they were a very ignorant lot and to suppose that one word from some professor who has never seen outside a laboratory would be sufficient to put them right. Now in my somewhat varied experience I have had occasion to become acquainted with corners of our great manufacturing areas, and while my experience is small and not enough to generalise upon, it is nevertheless several times as great as that of some who are ready to adopt the superior attitude, but have none.

The loss of one industry after another is only too patent. In so far as this may be due to want of enterprise in our men of business we are not concerned with the cause in this Section; in so far as it may be due to want of that little assistance which the fiscal arrangements in other countries make possible for our rivals again we are not concerned in this Section; in so far as our patent laws are unique among those of manufacturing nations in allowing the foreigner to manufacture in his own country under the protection of our patent law, so that the most valuable school we possess, the manufactory, as well as the manufacture, is conducted to the advantage of our rivals—a point which I suppose it is unnecessary to commend to the notice of Mr. Chamberlain—with this, too, we have no concern in this Section; but in so far as this, or the want of enterprise or of foresight that leads to it, is due to ignorance and to want of appreciation of scientific advance we are very much concerned with it. If I may refer to my own limited experience, there is a lamentable contrast in the manner in which a great number of our own countrymen look at any proposition put before them and that in which the alert American does. It is useless to explain that which would be self-evident to a man with a moderate knowledge of chemistry and physics such as our schools ought to supply, or for which they should at least lay the foundation, for the words have no meaning; they are merely words. He distrusts anything new; he has heard of a new process before that did not work out well; experience on the Continent to him is no experience at all, for he believes the inhabitants in such distant parts of the earth are not capable of knowing as well as the enlightened Englishman whether a thing is properly done or not, and so he goes on as he did before, perfectly content. This attitude would not be possible with the most elementary understanding of common principles.

But there is another side to this picture. Anyone who has discussed any scheme with the board of directors, the manager, the engineer, and the chemist of one of our great manufactories must have been struck with the concentrated ability there found in harness. It has often seemed to me that it is a great misfortune that our professors of mechanics, of physics, and of chemistry are in so many instances precluded from a better acquaintance with the working of these great machines—a misfortune not for the works, at least directly, but for the professors, and more especially for their pupils.

Nowhere are scientific problems of greater complexity constantly having to be solved than in a great manufactory; nowhere is such concentrated talent necessary as in a works organised and carried on in competition with all the world. I look upon these as our most valuable schools, and the closer the touch between them and those whose province it is to teach, the better for the teacher and the pupil.

It is, perhaps, hardly desirable to mention any one where there are so many. I am tempted to dwell upon the problem which has been at last successfully solved by Parsons, this being the joint product of the school and of the works; but there is one picture—a contrast, I will not say of light and shade, but of colour and colour—to which I must refer. I remember in my early days, in the surroundings of a classical atmosphere, the general feeling of contempt for the manufacturer, the intellectually inferior creature who only made money, but who knew nothing of τύπτω or τέτυμμαι. I am not sure that some such feeling does not still exist among those whose horizon is limited to the Latin and Greek that they have learned—or should I say limited *by* instead of *to*? This recollection came back to me when not long ago I was visiting one of the best organised and most skilfully conducted works in the country—I mean Willans and Robinson—when I remembered that another great manufactory, conducted on American lines, was near by, and when across the road I saw the walls of one of our most famous English schools. I pictured the old contrast: on the one hand the conviction impressed upon me when a boy that there is something intellectually superior in the struggle with a paragraph of Xenophon or a page of Homer, while manufacture is merely mechanical, sordid and base, with what I believe to be the reality on the other. I wondered in what spirit the erection of these works was viewed at the school and to what extent the high intellectual attainment there so essential and so evident is properly appreciated.

Of the last of the three headings, Strenuousness, we have plenty, but at school it is most apparent in cricket and football, and in after life in various expensive ways of murdering defenceless animals.

However, a change is already beginning to be felt. The public schools no longer withhold the elements of chemistry and physics, and those who have benefited, even in small degree, are taking responsible places vacated by those who had no such opportunity. The numerous polytechnics are providing more serious instruction to thousands of our young men, and it may be hoped that in time even the official—I mean the mere official whose only conception of activity is centred in obstructing progress and enlightenment—will have some appreciation of things as well as of words.

SECTION D.

ZOOLOGY.

OPENING ADDRESS BY PROF. SYDNEY J. HICKSON, M.A., D.SC., F.R.S., PRESIDENT OF THE SECTION.

AT the last meeting of the British Association which was held in Southport, the President of Section D, Prof. E. Ray Lankester, delivered an impressive address on the provision in this country for the advancement of Biological Science, in which he pointed out the very inadequate encouragement which existed at that time for those who, by education and inclination, were fitted to pursue original investigation in Zoology and Botany. Twenty years have passed since that Address was written, and yet we have to acknowledge that, notwithstanding the important part which our branch of Science has played in contributing to the sum of useful human knowledge during the last two decades, the progress made in the direction indicated by Prof. Lankester is far from satisfactory. I do not propose in this Address to make any detailed statement of the number of posts in this country that are now open to zoologists, or of the amount of the present-day endowments for the encouragement of Zoological Science as compared with those of twenty years ago; but I wish to point out that neither in the older Universities of Oxford and Cambridge, nor in the Colleges and National Institutions situated in London, nor in the newer Universities and Colleges of the provinces, have any new posts been created or adequately endowed which enable the holder to devote a reasonable amount of his time to the pursuit of biological knowledge. It is true that there are a few more posts now than there were, in which a small stipend or salary is offered to young trained zoologists for their services as teachers of Elementary Biological Science to medical students and others; but the emoluments of such posts are so small, depending as they do, almost entirely, upon a share of the fees paid by the students, and the duties so arduous and prolonged, that they really offer very little inducement to the pursuit of continuous and systematic original research.

In one respect, however, we may notice and acknowledge, with gratitude, an improvement in our position. In the laboratory accommodation, both in our Universities and on the sea coast, we are a good deal better off than we were. Twenty years ago there was no biological laboratory on the whole of the long line of the British Coast. Now, thanks to the efforts made by biologists and their friends, we have at Plymouth an institution for the study of the marine fauna and flora under favourable conditions, and similar institutions at Port Erin in the Isle of Man, at Piel, at Millport, and at St. Andrews, and a provisional laboratory for the study of fishery problems at Grimsby. New laboratories for the study of zoology have also been built at Oxford, at Cambridge, at the University of Manchester, at Edinburgh University, and elsewhere, and I may add that a fine new laboratory is now in course of construction for the department of Zoology in the University of Liverpool.

These new institutions, however, only emphasise, they certainly do not ameliorate, the weakness of our position in having so little encouragement to offer to competent and well-trained men who wish to devote their lives to the advancement of Zoological Science. Moreover, I would point out that these institutions have been built and are being maintained almost entirely by funds supplied by private benefactors, or out of the inadequate resources of the Universities.

The Treasury has made a provisional grant of 1000*l.* per annum towards the maintenance of the work done by the Marine Biological Association, and it may be supposed that a small share of the annual Government grant made to the University Colleges and Scotch Universities goes to the support of the zoological departments; but, apart from this, there has been no increase in the support given to us from public funds.

If we were to compare our progress in the matter of the public appreciation of our science during the past two years with that in other countries, we should find that our position is by no means satisfactory. In Germany, France, Belgium, Holland, and more particularly in the United States of America, progress has been rapid and continuous. The number of persons in these countries who by the aid of university or public endowments are able to devote themselves to original work in zoology has considerably increased of late years, and the number of magnificently equipped institutions that have been built for their accommodation and convenience makes our efforts in the same direction appear very small.

It would not be difficult for me to bring facts and figures before you in support of these general statements; but my object is not so much to lament over the past and to mourn for the present position of our science in this country, as to suggest directions in which we may work together for its development and progress.

Upon one matter, however, I think we may congratulate ourselves. If the research done by English zoologists has not been as great in amount as it might have been, I think it may be truly said that we have fully maintained its standard as regards quality.

The contributions that have been made to the Science of Zoology by our countrymen during the past twenty years in general interest and in theoretical importance are of such a nature that any civilised race might well be proud of them, and I venture to say they compare favourably with those of any other country. I may remind you that the discovery and description of the Okapi, Cænolestes, Nyctotherus Rhabdopleura, Cephalodiscus, Limnocodium, and Pelagohydra, the rediscovery of Lepidosiren and Ctenoplana, the most important features of the development of Balanoglossus, Lepidosiren, Amphioxus, Peripatus Hatteria, and some of the Marsupialia, and that the discovery of the important character of the fauna of the deep seas involving the discovery of many new genera and species, were the work of British zoologists. Moreover, that the prolonged and painstaking investigations carried on in our laboratories have thrown much light upon the character and relations of cœlomic cavities, the homologies of the nephridia and genital ducts, and many other important morphological problems.

In the field of evolutionary theories we have done much important work in the study of the facts of protective and aggressive mimicry in insects, in the statistical estimation of variations, and in the experimental inquiry into the value of current theories of heredity.

The list is far from complete; but with such a record of good work done with the scanty means at our disposal there is no reason to suppose that the science is on the decline in this country, or that our countrymen are not as capable as any others of grasping the importance of biological problems and ultimately wresting from Nature the secrets that are hidden.

Whilst we may thus congratulate ourselves upon the achievements of the past and upon our strength and ability to carry on good work in the future, I cannot help feeling that the time has come for us to make a united effort to place before the general public of this country, and more particularly the educated and influential part of it, the disadvantages under which we suffer, and our need for help in the further development of our subject.

We have all realised that in this country, more than in any other that is called civilised, there prevails among all classes an extraordinary ignorance of the first principles of biological science. It is this ignorance on the part of the general public, I believe, which prevents us from gaining that sympathy for our aims and that assistance for our efforts which we think is necessary not only for the reputation, but also for the welfare of our country. We must remember that the science of Natural History is as a closed book to most of those who after a public school and university education have attained to positions of trust and responsibility in the government of our country and our cities. Moreover, and this is perhaps the most serious aspect of the question, there are many who have gained a high position as men of science, and whose opinion is frequently quoted as authoritative on questions affecting science in general, who are more ignorant of the first principles of the science of biology than the Dutch schoolboy of fifteen years of age.

It appears to me, then, that it is of fundamental importance for the zoologists of this country to consider and report upon the necessity for the extension and improvement of the teaching of Natural History in our schools and colleges. We shall have to meet the objections that there is not time for Natural History in the school curricula, and that it is not a suitable subject for the instruction of boys and girls. These objections can be met, I believe, and overcome.

In many foreign countries Natural History is a compulsory school subject for all scholars. In Holland, for example, by the law of April 28, 1876, all scholars of the gymnasia during the first and second years devote two hours per week to the study of Natural History, and in the fifth and sixth years all students preparing for natural, mathematical, and medical sciences courses devote two hours per week to the science. In the superior middle-class schools one hour a week is devoted to the science in the first and second classes, and two hours per week in the remaining three years. If, therefore, time can be found in the middle and upper class schools for the study of Natural History in a country like Holland, where the general education is so excellent, surely time can be found for it here.

It is also a matter for general regret that some course of Elementary Biology is no longer compulsory for those who are proceeding to degrees in science in our universities, and I cannot help feeling that a very retrograde step was taken a few years ago by the authorities of the University of London, when Biology was made an optional subject in the Intermediate Examination for the degree of Bachelor of Science. We cannot expect to receive that sympathy in our pursuits and appreciation of our discoveries which we expect from our fellow-men of science if we tacitly admit that an elementary knowledge of the laws of living bodies is not a necessary part of the equipment of a man of scientific culture.

I think we must all admit that the time is ripe for a full discussion by biologists of the particular form of teaching and study which is most suitable for schools and elementary university examinations. It is a matter in which we are all interested; it is a matter affecting most intimately the interests of those who will be our pupils in the future, and we should be careful to see that no ill-considered or fantastic schemes of study are thrust upon the authorities by unauthorised persons at this very critical period in the educational history of our country.

There are other matters, however, which also demand our careful attention. The growth of our great cities and the improvement in our ideas of sanitation have brought forward as important problems for consideration the purity of the water-supply and the disposal of sewage. The municipal authorities at last realise that these problems can only be satisfactorily met by elaborate scientific investigation, and they have found that it is not only desirable for sanitary reasons, but also—and this has probably the greater weight—profitable to call in men of science for consultation and advice. At present, however, these problems are approached from only two points of view—the chemical and the bacteriological—the effect or effects of other organisms than bacteria upon the character of the sewage effluent and the purity of water for drinking purposes being, so far as I have observed, neglected. I was very much impressed with the fact that at the meeting of the Sanitary Institute last year in Manchester the speakers used the expression "bacteriological examination" and "biological examination" as if they were synonymous, and no mention was made either of the animals or plants which are invariably present, and materially assist if they are not actually necessary for the maintenance of the most suitable balance of life in these waters. The time has come when an inquiry should be made of the organisms other than bacteria that are normally present both in the waters at the sewage works and in the large reservoirs which supply cities with drinking-water.

I may be allowed here to quote two cases that have recently come under my notice which will show the kind of work that might be done and the nature of the results which may be expected to follow such an inquiry.

Some years ago complaints were made that the water supplied by the borough of Burnley had an offensive smell. This smell was of such a nature that it was impossible to use the water for the manufacture of soda-water.

The smell was traced to the Hecknest reservoir, where the common water snail, *Limnaea peregra*, was present in enormous numbers. The problem to be solved was how to destroy or reduce the numbers of the Limnæa without interfering in other respects with the purity of the water. The authorities of the corporation asked the advice of a trained zoologist, who made certain recommendations which were adopted, and at a minimum cost the nuisance was abated, and during the six years that have elapsed has not recurred. I will not detain you with a full description of the cause and the cure of this particular pest, but I may say that the recommendations that were made were based on the knowledge of the life habits and reproduction of the Limnæa, and were therefore of a purely zoological character.

Two years ago the Chairman of the Water Committee of the Corporation of Manchester reported that the mains had become partially choked by the growth of an organism which he called a "moss." No less than 700 tons of this "moss" were removed from the mains by a laborious and expensive process. It is not necessary for me to inform this Section that the organism was not a moss. It was probably not even a vegetable, but an animal belonging to one of the genera of fresh-water Polyzoa. In this case, however, so far as I am aware, not only were no steps taken to identify the organism, but no investigations were made to discover its origin or to prevent the return of the trouble in the future. I could give you several other examples which show that our ignorance of the general balance of animal and vegetable life in the large reservoirs is profound, and that a systematic inquiry conducted by competent persons would most certainly lead to knowledge which would be of great scientific importance, and in the long run remunerative to the community.

I do not think that we can expect that any one of the municipal authorities will feel justified in bearing the cost of such an investigation. The problems that one corporation has to face are very much the same as those that others have met; and each corporation hopes to profit by the successful and neglect the unsuccessful experiments of its neighbours. An investigation such as this, which is really for the benefit of the whole community, should be conducted by a central authority at the public expense.

The scientific investigation of the problems that are connected with the maintenance and extension of our sea fisheries is another matter that requires the very careful attention of the zoologists of the present day. The valuable work that has already been done by the officers of the British Marine Biological Association, the Lancashire Sea Fisheries Committee, the Scottish Fishery Board, and other bodies is of a nature sufficiently encouraging to justify us in asking for the necessary means and appliances for still further developments of the inquiry. There is, however, a great need for a free discussion by those who are competent to speak on the subject to determine and, if possible, to come to some conclusion upon the question of the best and most profitable lines that the inquiry should take in the immediate future, and the establishment of such co-operation as is necessary by the different authorities to prevent duplication where it is unnecessary, and simultaneous observations of similar phenomena on different parts of the coast when it is considered desirable. The report of the Committee on Ichthyological Research, 1902, has shown that there is already in this country a good deal of activity in various branches of investigation of the fisheries problems, but the authorities are not on all points in agreement as to the best plan or course to pursue in future. I cannot but hope that if some conference were held, at which those zoologists who have made a special study of these matters were present, the principal differences of opinion might be cleared up and a unanimous report presented to the authorities.

I have felt very strongly for some time past, and I know there are many of my colleagues who agree with me, that the zoologists of this country are under some disadvantage in not being provided with the necessary machinery for full discussion of matters which affect the welfare of the science as a whole. There are several societies which receive, discuss, and publish papers on various branches of zoological research, but they do not, and from the nature of their constitution cannot, give effective utterance to the general or unanimous opinion of professional zoologists on matters of their common interests. There is no society which all serious students and teachers of zoology feel is the one society which it is their duty and in their own interests to join. Some join the Zoological Society of London, others the Linnean Society, others, again, the Royal Microscopical, Entomological, or Malacological Societies, or some combination of two or more of them. There is no common ground on which we meet for the discussion of such subjects as those I have just mentioned in this Address. In the early days of the British Association this Section supplied the needs which we feel now. It was the Society, if I may call it such, which all the zoologists of the time made a special effort to attend. Important matters were fully discussed by the most competent authorities, and people felt that the prevalent opinion on any subject expressed by Section D was the prevalent opinion of men of science throughout the country.

In concluding this portion of my Address, I may express the hope that when the Association meets next year at Cambridge some steps may be taken to render the organisation which we already possess in connection with this Section more generally useful and more efficacious than it is at present.

In the opening sentences of my Address I used an expression which some of my hearers may have considered open to criticism. Let me take this opportunity of saying, then, that by using the expression "useful human knowledge" I did not intend to express an opinion that there is any knowledge of the character that is expounded and discussed in these sections of the Association which can be called useless knowledge.

A distinction, however, is frequently drawn between knowledge that can be directly applied to the arts and crafts and knowledge which, on the face of it, appears to us at present to be only of general scientific interest. For example, in the award of the Exhibition (1851) Scholarships and Bursaries, the candidates must still give evidence of capacity for advancing science or its application by original research in some branch of science, *the extension of which is especially important to our national industries.* We can rejoice most cordially in the successful developments of the technical institutions in the country, we can heartily join hands with our colleagues in other sciences in urging upon the authorities the encouragement of those branches of science which have a direct bearing upon our industries, but we have a no less important duty to perform in claiming for those branches of science that have apparently no such direct application the needful sympathy and encouragement. I venture to say that at the time the Association last met in Southport no one would have ventured to predict that the study of the anatomy and life-history of the Diptera, or the general biology of the minute sporozoa, would have any direct bearing upon the development of our industries. But to-day, by our knowledge of the mosquito Anopheles, and the sporozoan parasite it carries, we are in a position to destroy or ameliorate the malaria pest which has hindered the commercial development of so many of our colonies in tropical countries, and by encouraging the development of such countries we are assisting to a very material extent our home industries and the general trade of the country. In this, as in so many other cases, the benefit to industry and commerce has come from an unexpected quarter of the field of zoological research. Those who were working within the narrow limits of what is called applied science could never have discovered the facts which we now regard as of extreme importance, however well equipped they were with laboratories and appliances and endowments for research.

It will be of very little profit to this country to endow munificently the technical institutions and those branches of science to which the adjective "applied" is given, to build British "Charlottenburgs," and to attract by handsome salaries the most distinguished professors to the study of the application of science, if at the same time we starve and allow to sink into insignificance the fundamental sciences upon which the whole superstructure rests. It does not need a prophet to foretell that a great disaster will occur if we add story to story of our house of education without widening and broadening the basis upon which it rests.

Many of us, I am afraid, are too much inclined to believe that the intellectual portion of the community has at last awakened to the importance of the work in the fields of pure science, that the old prejudice against us who indulge what is called our harmless curiosity is dying out, and that our science is bound to receive a fair share of encouragement and attention in the progress of the modern developments of science and learning.

The distinction that is drawn between pure and applied science is, however, in danger of being broadened and deepened rather than diminished by the recent activity in the foundation of schools and colleges for technical instruction. There are, it is true, several eminent and distinguished persons who recognise the danger and do their best to avoid it, but this fact is not in itself sufficient to justify us in any relaxation of our efforts on behalf of the maintenance and development of those branches of the sciences which are usually supposed to have no direct or technical application.

In the wide field of zoological research there are many subjects now being investigated and discussed which, at present, seem to us to have but a remote bearing upon any practical problem of industry or medicine. Of all these subjects there are two which have excited during the past ten years extraordinary interest, and are from many points of view subjects of greatest possible importance. I refer to the subject of the natural variations of animals and plants, and the problem of the hereditary transmission of characters from generation to generation.

At present there appears to be some doubt whether the workers in these subjects are really agreed as to the general propositions of the problems, the definitions of the terms employed, and the standard of proof that is requisite in each step of progress. It is true that in most, if not in all, biological problems we are at the disadvantage of being unable to define or measure anything with the same mathematical accuracy that our friends, the chemists and physicists, are accustomed to. We cannot say for example that the chela of a particular species of crab is so many millimetres in length, in the manner the chemist determines the atomic weight of a new metal, as the length of the chela is found to vary within a certain range in all species that have been investigated; nor can we define such common expressions as a species, a variation, or even a cell with the same conciseness as a physicist defines the ohm, the volt, specific gravity, or the mechanical equivalent of heat. As a consequence it is not surprising that when our problems have been studied and a solution reached the resultant "laws" exhibit so many exceptions that they are really not worthy to be called "laws" at all. We may see the truth, but we see it as through a glass, darkly.

There is perhaps no word in the whole of our vocabulary which is used in so many different senses as the word "variation," and yet when it is used an attempt is only rarely made to define the sense in which it is employed.

When we study the adult progeny of a single pair of parents we notice that they differ from one another as regards any one particular character within a certain range. Thus the eight children of a single pair of human parents may vary in weight from, say, 130 lbs. to 200 lbs., and we may find that the average weight of the eight children is approximately the same as the average weight of the two parents. If parents and children were all of exactly the same weight—an impossible supposition—it would be said that they exhibited no variation in this respect, but, as they always do vary in weight, it is said that they exhibit "variations" in weight. Now, such variations may be due partly to differences in the muscular training, the nourishment, the general health, and other post-natal causes; but it is assumed, and there are doubtless good reasons for the assumption, that if all these post-natal influences had been equal throughout life there would still remain variations in weight of lesser amplitude than is usual, but nevertheless substantial.

The variation of the adult in weight, therefore, is a compound quantity, partly due to the influence of external conditions upon the growing body, and partly due to a quality or character present at birth and usually supposed to be inherited with the germ-plasm from one or both parents. The former may be called the artificial part of the variation, or for brevity the artificial variation, and the latter the natural or inherited variation. In the character of weight in human beings there can be no doubt that artificial variation is predominant, the character being a very fluctuating one and liable to profound modification in the varying vicissitudes of civilised human life.

In the character of stature the artificial variation is probably much less predominant. The children of tall parents grow into tall men and women, however handicapped in early life by ill-health or insufficient nourishment, and the children of short parents remain short in adult life, however healthy and well fed in their youth. Nevertheless, he would be a bold man who would assert that the character of stature is uninfluenced by the environment, and that the short people would not have been taller had the conditions of their life in childhood been more favourable, or the tall people shorter if the conditions in their early life had been less favourable.

Finally, we have, in the colour of the iris, the shape of the ear, and the size of the teeth, characters which are usually considered to be unmodified by post-natal conditions, or at least so slightly modified by them that the differences observed in them may be regarded as almost pure natural variations. Now, if we turn our attention to characters such as weight, which we feel certain are influenced very profoundly by the environment, we might be tempted to exaggerate the importance of the environment in moulding or forming the characteristic features of the adult organism, as, in the opinion of many authorities, Lamarck did, and many of his followers are still doing. If, on the other hand, we confine our attention to such characters as the colour of the iris or the shape of the ear, we might be tempted to under-estimate the influence of the environment.

This brings us to the important question whether the characters of the adult that are due to the influence of the environment, and that part or degree of any character which is more or less modified by the conditions of the earlier stages of life are or are not transmitted by parents to their offspring. Time will not permit me to discuss this difficult problem here. Rightly or wrongly, I agree with those who maintain that acquired characters are not inherited, and I intend to assume for the purpose of the argument that follows that they are not inherited. I will also assume, and I must say that the facts seem to be conclusive in favour of this assumption, that the characters which are usually supposed not to be influenced, or to be only slightly influenced, by the environment are capable of transmission by heredity.

We have, then, in most variations a part that can be transmitted and a part that cannot be transmitted by heredity from parents to offspring, and we find in every plant and animal an enormous difference in the proportions of these two parts in different organs. It is not difficult to see the general reasons for these differences. It is clearly important that some organs should be plastic—*i.e.* capable of changing in form and size to meet the varying changes in the environment, and that others should remain relatively constant in spite of changes in the environment. Thus the shape and size of the branches of an oak in a plantation will vary enormously, according to the light and space they have for their development, whereas the anthers, the pistils and fruit will be relatively constant in form and colour. It is clearly important for a chamæleon that the colour of its skin should vary according to the colour of its environment; but it is none the less important that the shape and muscular organisation of its tongue should remain relatively constant throughout life.

An essential point, however, for us to consider is whether there are any characters in animals or plants upon which the environment exercises no influence at all or exercises such a slight influence that it may be safely neglected. The method to adopt in order to settle this point would be to compare at a definite period of their lives the statistics of variation in a family or population which has been brought up under identical circumstances with those of a similar family or population at the same period of life which has been brought up under differing circumstances. If this were done we could determine with considerable accuracy the proportion of the variation of any character of the individuals that is due to the environment and that which is natural and inherited.

Unfortunately it is impossible to bring up a population under identical circumstances. If we take, for example, the individuals of a single hive of bees, which have the same parents, pass through the early stages of their development in cells which are almost identical in size and are regularly fed by the workers during the whole of their larval life, there is still a considerable probability that the individuals do not have a treatment which can, with any pretence to accuracy, be called identical. The food that is collected by the worker-bees frequently comes from varied sources or from flowers in different stages of their growth, and it is impossible to believe therefore that it has always identical nutritive properties; the larvæ are not of the same age, and seasonal changes may affect the larvæ differently, some being checked in the early stages of their development more than others.

But even if we could, with justice, assume that the conditions of life for the individual bees in a hive are identical from the time of hatching up to the time when the adult characters are assumed, there still remain two sets of variable conditions which must affect the development independently of the influences brought by the two parents in the germ-plasms.

In the egg of the bee there is a considerable quantity of yolk, and this yolk is the food material upon which the embryo is nourished throughout the earlier stages of its development. There is no evidence that the yolk in the eggs of this or of any other animal is constant either in quality or quantity. On the other hand, the extraordinary variations or abnormalities, as they are usually termed, which the embryologist meets with in the segmentation of the egg suggest that there are considerable differences in these respects between the eggs laid by a single parent in a single act of oviposition. Moreover, the manner in which the young eggs of the insects are nourished in the tubular oviduct before they are ready for fertilisation gives very little support to the view that the amount of yolk deposited in each egg is identical.

The second consideration under this heading is possibly of even greater importance. Vernon[1] has shown that the size and other characters of echinoderm larvæ vary very considerably according to the freshness or staleness of the conjugating ova and spermatozoa. For example, he found that when the fresh spermatozoa of Strongylocentrotus fertilised the eggs which had been kept eighteen hours of the same animal, the larvæ differed from the normal larvæ, −17·6 in body length and −15 per cent. in arm length, and when the fresh eggs were fertilised by spermatozoa which had been kept eighteen hours the resulting larvæ differed from the normal by +11 per cent. in body length and by −32·8 per cent. in arm length.

This consideration is practically eliminated in the case of the worker-bees by parthenogenesis, but it cannot be set aside in the case of the drones nor in the cases of the broods of other animals which do not exhibit the phenomenon of parthenogenesis. A comparison of the curve of variation of some character, common to both, in drones and worker-bees from one hive would perhaps throw some light on the general importance of this character.

Before leaving this part of the subject, I must call attention to two results bearing upon it, obtained by De Vries in his botanical investigations, and related by him in his very important work entitled "Die Mutationstheorie." This observer found that the younger the seedling is the greater is the influence of external circumstances upon its adult characters, and in the second place that an even greater influence is exerted upon the characters of a plant by the external circumstances affecting the mother-plant. If these results hold good for animals as they do for plants, we should expect to find, then, that the external circumstances affecting the mother at the time she is maturing the eggs in her ovaries and the external circumstances affecting the embryo before and during the larval period are of far greater importance in affecting the curve of variation of the adults than are the external circumstances affecting the young in their period of adolescence. We must come to the conclusion, from these considerations, that the general variability of a brood or progeny of a single pair of parents must be very largely the effect of the varying conditions affecting the gametes from the earliest stages of their genesis in the gonophore, the fertilised ovum, and the early stages of development. We find, however, as I have already pointed out, that some characters are much more influenced by external circumstances than others. Weight and stature in human beings, for example, are probably much more influenced than the colour of the iris or the shape of the fingers. We may, indeed, recognise two kinds of characters, connected, of course, by a complete series of intermediate links, which may be called, for convenience sake, plastic characters and rigid characters.

Now, in some animals, the characters that are rigid are much more numerous than they are in others. For example, adult salmon or perch are much more variable in size and weight than adult herrings or mackerel; some species of butterflies are much more variable in the colour and pattern of their wings than other species; some species of birds are much more variable in their plumage than others are. Several other examples could be chosen to illustrate this point from the higher groups of animals; but I wish particularly to call your attention to several instances found in the Cœlenterata, because it was the special study of this group of animals that led to the train of thought I have ventured to put before you.

In all the sedentary forms of Cœlenterates the mouth is surrounded by a circlet of tentacles. These organs are used for catching and paralysing the prey and passing it to the mouth to be swallowed. They are also very delicate, and indeed the only specialised organs of sense performing a function similar to that of the feelers or antennæ of Arthropoda. There can be no exaggeration in saying, therefore, that they are of the utmost importance to the animal. In some groups of Cœlenterata, however, we find that they are fixed in number, but in others that they are variable.

In the Alcyonaria, for example, the number of tentacles of the adult polyp is eight. I have examined many thousands of polyps belonging to the suborders Stolonifera, Alcyonacea, Gorgonacea, and Pennatulacea, and I have not found a single example of an adult polyp with either more or less than eight tentacles. This is a character, then, which is remarkably well fixed in the Alcyonaria. It does not fluctuate at all. The tentacles of the Hydrozoa, and of many of the Zoantharia, on the other hand, fluctuate considerably in number. In some forms, such as Tubularia among the Hydroids, and Actinia among the Zoantharia, the number of tentacles is considerable, and it is not, perhaps, surprising to find variations in their number. But in many cases, when the number of tentacles is small, there is also frequent variation. In *Hydra viridis*, for example, the number of the tentacles is 6, 7, or 8, and more rarely 5 or 9.

Again, in the Alcyonaria, the number of mesenteries of the adult polyp is always eight; never more and never less.

In the Zoantharia, on the other hand, the number varies not only in different suborders and families, but even in different individuals of the same species from a single locality. Parker found, for example, that the number of non-directive mesenteries in the sea-anemone *Metridium marginatum*, collected at Newport, R.I., varied from four to ten pairs in those forms with the normal number (2) of directive mesenteries, and that there were further variations in the number of non-directive mesenteries in those forms with an abnormal number of directive mesenteries. In fact, of the 131 adult specimens collected, only 40 or about 33 per cent. exhibited the arrangement of mesenteries which is regarded as normal for the species. On the other hand, Clubb found that of the specimens of another common sea-anemone, *Actinia equina*, only 4·24 per cent. showed variations from the normal mesenterial arrangement for the species. We have then, in these examples, a set of organs which are very variable in one genus (Metridium), much less variable in another (Actinia), and perfectly fixed or rigid in another series of genera (the Alcyonaria).

Passing on, now, to the character "shape." Not many years ago the systematic zoologists, who directed their attention to the sedentary Cœlenterates, based their specific diagnoses very largely on the shape of the colonies. Thus we have introduced such names as *Millepora alcicornis, M. ramosa, M. plicata, Madrepora cervicornis, M. prolifera, M. palmata, Alcyonium digitatum, A. palmatum*, &c. Zoologists are now agreed, however, that the shape of these colonies is so variable that in most genera it is of very little value for the separation of species. In fact, I have elsewhere given reasons for holding the view that the widely distributed and very variable genus Millepora is represented by only one true species. But what is true for most sedentary Cœlenterates is not true for all colonial Cœlenterates. In most of the genera and species of Pennatulida, for instance, the shape of any one individual of a species is almost identical with that of any other. A *Funiculina quadrangularis*, from the west coast of Scotland, is similar in shape to one of the same species from the coast of Norway. A *Pennatula murrayi*, from the reefs of Funafuti, is similar in shape to one from Ceram. In other words, the character "shape" is extremely plastic in Millepora and Madrepora, but very slightly plastic or almost rigid in Pennatula and Funiculina.

This difference in the plasticity of the character "shape" in Millepora and the Pennatulids must be associated with the fact that the young Millepora colony is unable to move from the spot where the larva settles, whereas the Pennatulid is capable of moving from place to place throughout life. The Millepora colony must either accommodate itself to the environment in which it begins life or perish, but the young Pennatulid can, within certain limits, travel to the environment that suits itself.

The shape of a growing coral or sedentary Alcyonarian on a reef must accommodate itself to the depth of water, the position of neighbouring zoophytes to itself, the direction of the tides, and other influences; and such a power of accommodation is essential for the species in the struggle

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[1] H. M. Vernon: "The Relations between the Hybrid and Parent-forms of Echinoid Larvæ." *Phil. Trans.* 1898, B. p. 465.

for existence on the coral reef. But in the case of the Pennatulid, the natural or normal shape is adapted to a less variable series of environmental conditions, and it has sufficient power of movement to shift itself into localities where the environment is suitable for it. In other words, the power of movement is associated with a loss of plasticity of the character "shape."

But the growth of corals may be affected in other ways. A great many of these forms of life harbour a small fauna of epizoic crustacea, mollusca, and worms, and the ramification or surface is often affected by these in a remarkable way. I have elsewhere pointed out that the character of certain specimens of Millepora, which is known as verrucose, is due to a modification of the growth round epizoic barnacles. Semper has shown that the curious cage-like growths seen on the branches of Seriatopora and Pocillopora are galls produced by the action of certain species of crabs. In a recent paper I have also given reasons for believing that the tubular character of the stem and some of the branches of the genus Solenocaulon is due to the action of certain crustacea belonging to the family Alpheidæ, and that when these Alpheids are not present the form with a solid stem hitherto known as the genus Leucoella is produced.

But whilst some genera of corals and Alcyonaria are plastic in this way, others are not. These coral galls may be found on the Milleporas and Madreporas of a certain portion of a reef and be absent from all the other genera of neighbouring corals. The crab-galls that are found so commonly and in such abundance upon Pocilloporas and Seriatoporas in certain parts of the Pacific and elsewhere are found only in cases of extreme rarity in other corals.

Many other cases could be given to show that in some genera the cœnenchym is remarkably plastic or accommodating to these epizoites, whereas in others it is resistent and rigid.

The size and shape of the spicules have been taken as characters for the determination of the species of Alcyonaria. It is true that in some species the spicules are remarkably constant in size and shape, but in others they are extremely variable. The remarkable torch-like spicules of the cœnenchym of *Eunicella papillosa*, the club-shaped spicules of Acrophytum, and the needle-shaped spicules of many species of Pennatulids are remarkably constant in size and shape, but in Sarcophytum, the new genus Sclerophytum, Siphonogorgia, Spongodes, and a great many others, the size and shape of the spicules are extraordinarily variable. In the matter of colour, too, we find the same thing. The genera Tubipora and Heliopora are widely distributed in the shallow waters of the tropical seas and are very variable in many of their characters, and yet there is not a single specimen of Tubipora known that is not red, nor a single specimen of Heliopora that is not blue. The same may be said for several other species. On the other hand, many species of Alcyonaria are extremely variable in colour. Thus, *Muricea chamaeleon* is, according to Von Koch, sometimes yellow, sometimes red, and in some cases specimens show both red and yellow branches. The specimens of *Melitodes dichotoma* in Cape waters are sometimes red and sometimes yellow. In a small species of Melitodes from the Maldive Archipelago there is a very remarkable degree of variation in colour both in the nodes and internodes, the details of which I have briefly described in vol. ii. of Mr. Gardiner's Results. In the genus Chironephthya, also from the same Archipelago, the variations in colour are very remarkable, the spicules of the general cœnenchym showing various shades of red, pink, yellow, and orange, and the crown and points purple, yellow, and orange colours which sometimes agree, but usually do not agree, with the general colour of the cœnenchym. The variability of the genus is particularly interesting, as in Siphonogorgia, the genus which comes nearest to it, and is, in fact, difficult to separate from it, the colour of the cœnenchym is almost invariably red.

To summarise this knowledge of variability in the Cœlenterata we may say that we find either extreme plasticity or remarkable rigidity in many of their most important characters. Such important and essential organs as the tentacles, stomodæum, mesenteries, &c., are in some groups very variable indeed, and in others as stationary or fixed; we find the same with organs such as the spicules of Alcyonaria, which are, so far as we can judge, of less essential importance, and in characters, such as colour, which must be, in the sedentary forms at least, of minor importance.

If we compare this with what we find in the higher groups of animals we observe a great contrast. In fishes, to take an example at random, we may find that in such characters as the size and weight of the adults, there may be great or considerable variability, but in the essential organs, such as the heart, brain, and stomach, there is almost complete rigidity. I do not mean by using the expression "rigidity" to imply that minor variations in size and shape do not occur, but that major variations, such as a doubling of the stomach, a bifurcation of the cerebral hemispheres or other variations, which it would be considered grotesque to suggest even, do not and cannot occur. But even in minor characters, such as colour, the possible range of variation in a fish is far less than in Cœlenterates. We may find in the mackerel, for example, that individuals differ in the shade and range of the green pigment, but we do not find in any species of fish that some individuals are red, some yellow, some purple, &c.

The contrast in this respect between the Cœlenterate and the fish must be associated with their different degree of complexity of structure. In a complicated organisation such as that of a fish, the brain, heart, and stomach must mutually work together; they must be co-ordinated in form and action. Any profound variation or abnormality of one would interfere with the action of the others and would therefore be incompatible with continued existence. In the Cœlenterate, however, the doubling of the siphonoglyph, the duplication or quadruplication of the mesenteries does not, in some cases, interfere materially with the action of the other organs of the body. If we were to alter the size or shape of some part of a simple machine it might be able still to do its work the better or the worse for the change, but if we were to alter the corresponding part of a complicated machine it would probably throw it out of gear and prevent any work being done at all.

From this consideration we gather that in the process of the evolution of the higher forms of life there has been a gradual diminution in the range of variation of the different characters of the body, a gradual diminution of the response of these characters to changes of the environment. Characters which, in the early stages of evolution, were probably plastic become rigid.

The gradual evolution of the power of co-ordinated movement has been undoubtedly accompanied by a loss in the variability of the shape of the body, the gradual evolution of a blood vascular system and nervous system has led to a loss of variability in the alimentary canal with which they are associated. In the majority of cases, however, we are much too ignorant of the facts of the co-ordination of the parts of the body or of the co-ordination of any one part to the environment to be able to frame an hypothesis as to why any one character has become rigid. It is difficult to see the reason why the number of the tentacles and mesenteries in Alcyonian polyps has become fixed at eight, while in other Cœlenterates these characters are so variable, or why the colour of Tubipora is always red, and of Melitodes variable.

The study of species, however, teaches us that, in all cases, except perhaps in some examples of degeneration, the plastic condition of the characters was antecedent to the rigid, that in the earlier stages of evolution the condition of extreme plasticity and ready response to changing external conditions were necessary for the survival of the species; and that in the later stages, when special adaptations to special circumstances were developed, a certain rigidity or indifference to changing external conditions was equally necessary for its survival.

Now, the study of the various orders of Cœlenterates conveys a very strong impression that the part played by the environment in the production of the variations of the adult is much greater in proportion than it is in the higher groups of animals. It is true that direct proof of this is wanting. Such a direct proof can only be obtained by experiments in rearing and breeding under varying conditions, and there are at present many serious difficulties to overcome before experiments of this nature can be satisfactorily made.

Nevertheless, the circumstantial evidence in favour of the truth of this impression is, to my mind, so strong that we are justified in considering its bearing upon the general question. It is quite impossible for me on this occasion to set before you at all adequately the general nature of this circumstantial evidence. To do so would involve statements concerning the actual variations of a large number of species already observed in one locality and in several widely distributed localities, with a discussion of the possible direct influence of the conditions of such localities, so far as they are known, upon each of the principal variations. Such statements would necessarily be of such a special and technical kind that, even if time permitted me to make them, they would not be suitable for an Address of this character. I may be permitted to say, however, that I am collecting and preparing the evidence for publication on this point at a later date. There can be no doubt, however, from the evidence I have already submitted to you in part, that some species are far more influenced by changes in the environment, or, to simplify the expression, are far more plastic than others; and we may conclude that in the evolution of other groups of animals the earlier forms were far more plastic than their modern descendants. In the earlier stages of evolution there must have been in the first instance a lessening of the power of change in structure according to change of environment. The fixity or rigidity of certain characters thus produced enabled a more elaborate coordination both in form and action to occur between one set of organs and another. It permitted a further localisation and specialisation of functions, or, in other words, further differentiation of the animal tissues.

Accompanying this differentiation there was a loss in the power of regeneration. As Trembley showed many years ago, a Hydra can be cut into many pieces, and each by the regeneration of the parts that are missing will give rise to a complete individual. The Earthworm can, when cut in half, regenerate a new tail but not a new head region. An Arthropod dies when cut in half, but has the power of regenerating new appendages in place of those that are lost. But in Vertebrates there is very little power of regenerating new appendages, and the general powers of regenerating new parts are reduced to a minimum.

Now, whether the loss in the plasticity of characters was the cause of the loss in the power of regeneration of lost parts, or the loss in the powers of regeneration was the cause of the loss of plasticity, is a problem upon which I do not feel we are competent to express a definite opinion; but that the two series of phenomena are intimately associated is, I believe, a generalisation that is worth a good deal of further thought and study.

In Vertebrates, however, although the power of regeneration of lost parts is at a minimum, it is not by any means entirely wanting. The muscles, nerves, epithelia, and other tissues, are able to repair injuries caused by accident and disease. And similarly, although the power of response of various organs to the changes of external conditions in Vertebrates is very much diminished as compared with that in the lower groups of the animal kingdom, it still remains in an appreciable degree. Whether the curves of variation of the so-called fluctuating characters of Vertebrates represent simply or solely the influence of the environment on the organism cannot at present be determined with any degree of certainty; but it appears to me that zoological evidence, confirmed as it is in such a remarkable way by the recent researches of the botanists, points very strongly to the conclusion that the major part of each such curve is, after all, but an expression of the influence of the environment.

In venturing to put before you these considerations, I am quite conscious of the vastness and complexity of the problems involved and of the many omissions and imperfections which a short Address of this kind must contain. Not the least of these omissions is that of any reference to the distinction that might be drawn between continuous and discontinuous variations in the simpler forms of life. This is a matter, however, which involves so many interesting and important questions that I have felt it to be beyond the scope of my Address to-day.

We are still in need of further systematic knowledge of the widely distributed species of Cœlenterates; we want to be able to form a more definite opinion than we can at present upon the value of specific distinctions, and we need still further observations and descriptions of the phenomena of irregular facies, abnormal growths, and meristic variations. But more important still is the need of further researches in the field of experimental morphology.

When we have accumulated further knowledge on these lines in a group of animals such as the Cœlenterata, of relatively simple organisation, we shall be in a better position than we are now to deal with the problems of heredity and variation in the far more complicated groups of Arthropoda and Vertebrates.

NOTES.

THE following committee has been appointed by the Lord President of the Council to make a preliminary inquiry into allegations that have been made concerning the physical deterioration of certain classes of the population:—Mr. Almeric W. FitzRoy, C.V.O. (chairman), Colonel G. M. Fox, C.B., Mr. J. G. Legge, Mr. H. M. Lindsell, Colonel George T. Onslow, C.B., Mr. John Struthers, C.B., Dr. J. F. W. Tatham.

WRITING to the *Times*, the honorary treasurer of the Cancer Research Fund states that Mr. William Waldorf Astor has just sent a cheque for 20,000*l*. to the fund, and that, as a result of the speech delivered on July 30 by Mr. Balfour, several other donations have also been received; he points out, however, that the fund is still more than 25,000*l*. short of the amount required, and appeals for further help. The address of the fund is the Examination Hall, Victoria Embankment, W.C.

THE Paris correspondent of the *Morning Post* states that particulars of a new anti-tuberculosis serum will shortly be communicated to the Academy of Medicine by the discoverer, Dr. Marmorek, of the Pasteur Institute. The new serum is said to have been tried in the Paris hospitals, and to have cured several comparatively advanced cases of tuberculosis.

COMMANDER PEARY has been granted three years' leave of absence by the U.S. Navy Department to enable him to make another attempt to reach the North Pole. According to Reuter he will start by about July 1 next year, in a new steamer, for the Whale Sound region, where he will embark a number of Eskimos and establish a permanent base at Cape Sabine; thence he will force his way to Grant Land, where he hopes to establish his winter quarters on the northern shore. In the following February, with the earliest light, a start will be made due north over the pack ice with a small, lightly equipped party, which will be followed by a larger party. Commander Peary hopes to reach the Pole and return to his winter quarters within little more than 100 days. The distinctive features of the plan are the use of sledges with comparatively light loads drawn by dogs, the adoption of Eskimo methods and customs, and the fullest possible utilisation of the Eskimos themselves.

REUTER'S Agency learns that Major Powell-Cotton, who has been exploring in Africa for the past year, arrived safely at Wadelai, on the Upper Nile, in the middle of July, from Mount Elgon, where he had been studying the cave-dwellers. Major Powell-Cotton had had satisfactory interviews with the Congo officials, and was then preparing to start on an expedition in search of okapi.

A TELEGRAM from Mombasa on Saturday last states that Lieut.-Col. Bruce, who, with Dr. Nabarro, was despatched from London in February last, on behalf of the Government and the Royal Society, to study the sleeping sickness in Uganda, has left for England on the conclusion of his mission. Lieut.-Col. Bruce is reported to have stated that the ravages of the disease are unabated.

ACCORDING to a telegram from New York, through Laffan's Agency, Mr. W. G. Tight, the president of the University of New Mexico, has made the ascent of Mount Orata, in Bolivia. This is the first time the peak has been scaled.

THE members of the Liverpool School of Tropical Medicine trypanosoma expedition to the Congo Free State (Drs. Dutton, Todd, and Christy) started on Friday last from Southampton.

THE next meeting of the International Congress of Hygiene will be held in Berlin in 1907. The congress has been invited to meet in Washington in 1909.

THE fourth general meeting of the American Electrochemical Society begins on Thursday next at Niagara Falls, New York, and will last for three days. The following is a list of the papers which are to be read and discussed:—"A New Type of Electrolytic Cell," P. G. Salom; "Manufacture of Ferro-alloys in the Electric Furnace," Dr. George P. Scholl; "Electrolytic Copper Refining," Dr. W. D. Bancroft; "Electro-metallurgy of Gold," Dr. W. H. Walker; "Some Theoretical Considerations of Resistance Furnaces," F. A. J. FitzGerald; "On the Supposed Electrolysis of Water Vapour," F. Austin Lidbury; "Efficiency of the Nickel Plating Tank," Prof. O. W. Brown; "Electrolysis of Sodium Hydroxide by Alternating Current," Carl Hambuechen; "A Practical Utilisation of the Passive State of Iron," Prof. C. F. Burgess; "The Present Status of the Theory of Electrolytic Dissociation," Dr. E. F. Roeber; "Berthelot's Law of Electrochemical Action," C. J. Reed. There will also be a discussion on the theory of electrolytic dissociation.

THE thirteenth annual convention of the American Electro-Therapeutic Association will take place at Atlantic City, New Jersey, from September 22 to 24. A lengthy programme of interesting papers which are to be read at the gathering has been published.

AN educational exhibition of edible fungi is to be held under the auspices of the Royal Horticultural Society in the Drill Hall, Buckingham Gate, on September 15. A lecture on the subject of the exhibition will be given in the afternoon by Dr. M. C. Cooke. All interested in extending or acquiring the knowledge of the edible species are invited to send specimens, but notice of an intention to exhibit should, if possible, be sent a few days before to the secretary of the Royal Horticultural Society.

AT the International Congress of Hygiene which has just been held in Brussels the following resolution was passed on the motion of Sir Patrick Manson:—"That this congress, recognising the practical importance of the mosquito malaria theory, would urge on all Governments in malarial countries (1) that officials, both civil and military, be required before taking service in such countries to show evidence of practical knowledge of the theory and its application; (2) that educational establishments, whether governmental, missionary, or other, in such countries be requested to include in their curriculum instruction of native students in the mosquito malaria theory and its practical application; (3) that officials ignorant of the theory or systematically ignoring its practical application be considered as unsuitable for service in malarial countries." In addition to the foregoing resolution the first and second sections of the congress sitting together passed the following resolution:—"That human tuberculosis is perfectly transmissible from one person to another. Nevertheless, in the present state of our knowledge, it is necessary to recommend hygienic measures for the prevention of the propagation of animal tuberculosis in the human species."

THE Scottish Sanitary Congress was opened at Stranraer on Thursday last, when the president, Prof. Glaister, of Glasgow University, delivered an address, and various papers dealing with sanitary matters were read and discussed. Prof. Glaister, in the course of his remarks, urged that men of science and local authorities should realise the detrimental effect of atmospheric pollution, and together grapple with the subject. The prejudicial effects of town living could not be better demonstrated than in the depreciated physique of the third and fourth generations of many of those who had proceeded from the country to the towns. One of the significant features of present-day statistics, and one calling for the serious consideration of sanitarians, was the high prevailing rate of infantile mortality in populous centres. If the state of the principal English towns for 1901 be considered, it will be found that the infantile death rate varied from 126 per thousand up to 226 per thousand. These figures exhibited a great wastage of infantile life. He affirmed that it was a preventable wastage, and, therefore, worthy the reflections of sanitarians. Such high rates of infantile mortality were bound in the future to become a serious national concern in view of the diminution of the birth rate which had been progressively taking place for the last few decades.

THE fourteenth annual meeting of the Institution of Mining Engineers was held last week in Nottingham under the presidency of Mr. J. C. Cadman. The Institution appears from the report to be in a satisfactory condition, the membership being at present more numerous than at any former period. The present total is 2601 as compared with 2554 of the previous year.

THE Municipal Exhibition at Dresden has been a great success. In all, 128 German communities, including practically the whole of the large cities, contributed officially to it. The exhibition was of a practical nature, and provided a more or less complete survey of municipal achievement, effort, and ideals. It was divided into eight sections, which again were subdivided. The regulation of traffic, lighting, the police and police-courts, ordinary and model dwelling houses, public art galleries, public health, school accommodation and buildings, public education, the care of the poor and the sick, benevolent institutions and charity schools, the financial administration of municipalities, infectious and common diseases and their prevention and cure, safeguards against fire, parks and open spaces, and the growth of towns were among the numerous features of municipal life illustrated.

SHORTLY before his death, the late Prof. Nocard, of Paris, strongly urged the authorities of the Liverpool School of Tropical Medicine to make the institution available for the instruction of veterinary surgeons. A committee has now been formed for the purpose of giving effect to this suggestion, and the veterinary branch is open for the reception and instruction of students. It is under the direction of Profs. Boyce and Sherrington, with adequate assistance, and a farm has been provided at Runcorn for its requirements.

THE Tramways and Light Railways Association offers an annual prize, consisting of a bronze medal and books, for the best essay on improved means of communication. No essay must exceed 4000 words in length, and the right is reserved by the council to publish the papers in the Association's official journal.

A GRANT of 70,000 r. (7000*l.*) has been made to the Moscow University by the Russian Government for the purpose of technical education; of this sum 30,000 r. is allocated to a physical institute, 15,000 r. to a chemical laboratory, and the balance to physico-geographical, zoological, and botanical teaching.

A NEW gem, lilac coloured and transparent, has recently been discovered in California by Dr. George F. Kunz, of New York. On the suggestion of Dr. C. Baskerville, of the University of North Carolina, who made an analysis of the mineral at the New York Museum of Natural History, the name of Kunzite has, it is stated, been given to the stone in honour of its discoverer. In the course of the tests made by Dr. Baskerville, the Kunzite crystals were subjected to the action of ultra-violet light without showing any evidence of fluorescence or phosphorescence, and it was not until Röntgen rays of very high penetration were brought to bear upon them that they became at all fluorescent. On their removal to a dark chamber they exhibited a persistent white luminosity never before observed in this class of minerals. A description of the gem, by Dr. Kunz, appears in *Science* of August 28.

THE *Pioneer Mail,* Allahabad, states that the Ceylon Government has given notice that, under the Insect Pest Ordinance, the importation of pepper plants into Ceylon from any part of India is prohibited. The dried seed of the pepper plant imported for commercial use is, however, exempt from the prohibition.

THE daily weather report issued by the Meteorological Office on Friday last, September 4, showed that a barometric depression had passed the Azores and was advancing on an easterly course; the mercury was lowest on the west coast of Ireland, with south-easterly winds, and the air becoming close and thundery. As occasionally happens, a secondary depression was developed to the southward of the primary system, and this subsidiary disturbance caused during the afternoon severe thunderstorms over the southern portion of England, which subsequently extended to the metropolis and eastern coast, accompanied by torrential rain, laying many districts under water. At Ventnor a fall of 1·65 inches was recorded the next morning, at Westbourne 2·4 inches, and at Brixton 1·2 inches. At some places the fall was probably greater, as at Dover the shipment of mails was delayed, and many houses in the low-lying districts of that town were flooded to the depth of several feet.

PROF. LANGLEY has addressed a statement to the American Press with reference to his mechanical flight experiments from which we abstract the following:—"These trials, with some already conducted with steam-driven flying machines, are believed to be the first in the history of invention where bodies far heavier than the air itself have been sustained in the air for more than a few seconds by purely mechanical means. In my previous trials success has only been reached after initial failures, which alone have taught the way to it, and I know no reason why prospective trials should be an exception. . . . The fullest publicity consistent with the national interest (since these recent experiments have for their object the development of a machine for war purposes) will be given to this work when it reaches a stage which warrants publication."

MR. EDISON is reported to have developed his alkaline storage battery into a form fit for commercial use, and already has works equipped capable of turning out per day one complete set of cells suitable for motor-car work; soon he will be able to turn out five sets a day. The results of tests of the practical working of the battery are said to be entirely satisfactory; four sizes are made, capable of running a car 25, 50, 75, and 100 miles respectively on one charge, at an even rate of 25 miles an hour. The possibility of working at more than normal discharge rates without injury to the cells gives cars equipped with this battery good hill-climbing powers. The results of general outside experience of the battery will be eagerly awaited.

MR. MARCONI, who recently went out to America on board the *Lucania,* had special apparatus fitted on the ship to enable him to carry out experiments during the voyage. The main object of the experiments was to determine the power necessary to transmit messages to and from a moving station, such as a ship, with varying distances.

IT is announced that the Metropolitan District Railway will be equipped with trains run on the multiple unit train control, which is in use on the Central London and several American railways. Each train will have three motor-cars all controlled by a single driver; if by any accident the driver is incapacitated, the train is automatically brought to a standstill as soon as he releases his hold on the driving lever. The motor equipment is separated from the public part of the car by a fireproof steel partition. The contract for the equipment (known as the Sprague-Thomson Houston system) has just been placed with the British Thomson Houston Company, of Rugby and London.

THE supervision of the Imperial Department of Agriculture for the West Indies extends to several islands, where the progress that is being made is not placed on record except in the yearly reports. Of these, the report which originates from St. Vincent refers to the eruptions of Mont Soufrière during the period included in the official year 1902–3. The botanic gardens escaped, but the Georgetown experimental plot was almost entirely destroyed; even this catastrophe was turned to account, as experiments were started in order to test the possibility of growing certain plants, such as sugar-canes, cotton, ground-nuts, &c., in the volcanic ash. The experiment station of the British Virginia Islands is situated at Tortola, and the yearly report is presented by Mr. Fishlock, who took up the position of agricultural instructor at the beginning of the year. The station lies low, and is not suited to the cultivation of cacao or coffee, but pines produce excellent crops, and there is every reason to expect that good results will attend the introduction of cotton cultivation.

A PAPER entitled "The Forward Movement in Plant-breeding" was read by Prof. L. H. Bailey before the American Philosophical Society, and is published in its *Proceedings.* The advice which is offered to the scientific breeder is to get thoroughly acquainted with the characteristics and qualities of the plant which it is desired to cultivate, to decide in what direction he can make practical improvements, and after choosing what appears to be a suitable strain, to get all the information possible from his results by means of a careful system of measurement and tabulation.

IN the September issue of the *Irish Naturalist* Messrs. Carpenter and Beresford publish the result of certain experiments as to the relations existing between the wasps respectively known as *Vespa austriaca* and *V. rufa.* The former, which is not uncommon in Ireland, is believed to produce no workers, but to breed as an "inquiline" in the nests of other species. In a nest with an *austriaca* queen kept under observation by the authors, all the workers hatched were of the *rufa* type, while of the drones some were *austriaca,* some *rufa,* and others intermediate between the two. As the two forms are sufficiently distinct to be regarded as species, it seems as if we had here an instance of the origin of species by discontinuous variation. "We think that we see here a new species arise by the production, through many generations, of an increasing number of individuals (*rufa* forms) among the offspring, that are markedly unlike the parents (*austriaca* forms). We believe that *austriaca* forms give rise to *rufa* forms, but we have no evidence of the reverse process."

At the conclusion of the second part of his memoir on the development of the molluscan lingual ribbon, or radula, Mr. H. Schnabel, in the *Zeitschrift für wissenschaftliche Zoologie*, vol. lxxiv. part iv., points out an important distinction in this between cephalopods and gastropods. In contrast to the cephalopods, the development of the radula in the gastropods commences, not with the appearance of the single unpaired median row of teeth, but with a number of paired lateral rows. The other contents of the issue include an article on gastrulation in Cucullanus, by E. Martini; an essay on the morphology of the male genital appendages of the Lepidoptera, by E. Zander; and an account of the structure of the bristles in certain chætopods and brachiopods, by A. Schepotieff.

The alleged occurrence of "aptosochromatism," that is, colour-change in feathers without moulting, in birds, has by no means met with universal acceptation, one at least of the late Mr. F. J. Birtwell's three papers on this subject having been adversely criticised. Shortly before his death Mr. Birtwell entered on a fresh series of observations in the hope of establishing his theory on a basis which would be beyond question. These observations, which were made on two species of buzzard, are now published in the *Bulletin* of the Hadley Laboratory of the University of New Mexico (vol. iii. No. 7).

An Irish specimen of Dopplerite has been described by Mr. Richard J. Moss (*Sci. Proc.* Royal Dublin Soc., vol. x. No. 6). It was found in peat in Sluggan bog, at Drumsue, near Cookstown Junction, in County Antrim. In its original moist condition it appeared like a stiff jelly of a velvety-black colour, but when dry it became very like jet, breaking with a conchoidal fracture, and exhibiting a vitreous lustre. Dopplerite was originally found in peat in Styria, and has not previously been recorded from Britain. It appears to have been formed from peat by a process of oxidation.

A handbook to Southport, which should prove of much service to those attending the meeting who are not well acquainted with the town, has been written for the members of the British Association. Southport is considered from a historical and descriptive point of view, and as a health resort. Other chapters are devoted to meteorology, geology, botany, zoology, Martin Mere, archæology, and the life and works of the Rev. Jeremiah Horrocks (spelt in the volume Horrox). The volume is published by Messrs. Fortune and Chant, of Southport, and appears to have been carefully prepared.

The current issue of the *Illustrated Scientific News* is a double one, and brings to a close our contemporary's first volume. The number contains many interesting articles, among which there are no fewer than three respecting the British Association; one is illustrated by portraits of the president and five of the presidents of sections for this year. Other contributions deal with "Charlottenburg," the "Solar Physics Observatory at Meudon," "Progress with Airships," &c.

The additions to the Zoological Society's Gardens during the past week include two Black Rats (*Mus rattus*), British, presented by Mr. J. E. Millais; a Ducorps's Cockatoo (*Cacatua ducorpsi*) from the Solomon Islands, presented by Mrs. J. Aarons; a Neumann's Baboon (*Papio neumanni*), a Doguera Baboon (*Papio doguera*) from Abyssinia, a Bell's Cinixys (*Cinixys belliana*) from Tropical Africa, an Adanson's Sternothere (*Sternothoerus adansoni*) from North-east Africa, deposited; three Fat-tailed Desert Mice (*Pachuromys dupresi*), born in the Gardens.

OUR ASTRONOMICAL COLUMN.

Search-ephemeris for Faye's Comet.—In No. 3896 of the *Astronomische Nachrichten*, Herr E. Strömgren gives a continuation of the search-ephemeris for Faye's comet which appeared in No. 3876 of the same periodical, and was reproduced in these columns. The following is an extract from the later portion:—

Ephemeris 12*h*. (*M.T. Berlin*).

1903	α h. m. s.	δ ° ′	log r	log Δ
Sept. 12	8 5 14	+12 13·4	0·2842	0.3864
,, 16	8 13 26	+11 34·8	—	—
,, 20	8 21 24	+10 55·5	0·2930	0·3821
,, 24	8 29 6	+10 15·5	—	—
,, 28	8 36 31	+ 9 35·1	0·3020	0·3771
Oct. 6	8 50 32	+ 8 13·4	0·3110	0·3712
,, 14	9 3 28	+ 6 51·6	0·3201	0·3645
,, 22	9 15 15	+ 5 30·7	0·3293	0·3569
,, 30	9 25 48	+ 4 11·8	0·3384	0·3484

The Canals on Mars.—In the fifth report of "The Section for the Observation of Mars" (British Astronomical Association *Memoirs*, vol. xi.), several charts of the planet's surface are reproduced, in one of which, Plate viii., the director of the section, M. E. M. Antoniadi, has omitted the reticulated canal systems so familiar to aërographers on the charts published during the last twenty-five years. These have been omitted because recent research has thrown grave doubts on their objective reality.

In the recent experiments carried out by Messrs. Maunder and Lane it was demonstrated that the regular "canaliform" markings may be consistently seen by numerous unbiased individuals on a surface which is free from any such markings, but which has drawn on it features similar to the other markings on Mars. It was also pointed out that, in general, the so-called canals on aërographical maps are drawn either from one projecting feature to another or where half-tone boundaries are seen on the planet, just where one would expect them to be drawn if they were really due to physiological suggestion.

Many so-called "canals" are retained on M. Antoniadi's chart, but these are not of the rigidly geometrical shape shown on the charts published during recent years, and are, probably, objective features of the Martian landscape (the *Observatory*, No. 335).

Radiation Pressure and Cometary Theory.—In No. 5, vol. xvii., of the *Astrophysical Journal*, Messrs. E. F. Nicholls and G. F. Hull describe and illustrate some laboratory experiments they have made at Dartmouth College, Hanover, U.S.A., in order to demonstrate the effect of the solar radiation pressure in the formation of comets' tails.

A glass tube shaped like an hour-glass was partially filled with sand and dried lycopodium powder, and then highly evacuated. On causing the sand and powder to fall from the upper to the lower part of the tube, and directing an intense beam of light against the stream, it was seen that, whilst the sand fell vertically, the powder was diverted in the direction of the beam against the side of the tube opposite to the light source. Unfortunately the light pressure, on particles of the size and density used, had been previously overestimated, and a subsequent calculation showed that the observed deviation may not have been wholly due to the light-pressure, although some of it was.

Another suggestion as to the cause of repulsion in cometary phenomena is that the particles heated from one side evolve gases, and are, therefore, driven in the opposite direction in a similar manner to the ordinary rocket, and in the experiments performed by Messrs. Nicholls and Hull this "reaction" pressure would be about ten times as great as the "radiation" pressure. This research has experimentally illustrated the repulsion, and has shown that a part of it at least is probably due to the "radiation" pressure; it now remains to determine more definitely the relative effect of each of the possible causes.

A CATALOGUE OF 1520 BRIGHT STARS.—As the "Revised Harvard Photometry," which will contain details of about nine thousand stars of magnitude 6·5 and brighter, is not yet ready, the Harvard College Observatory has published a smaller catalogue, which only contains 1520 stars, and does not give the detailed information which will be contained in the larger volume.

The catalogue gives, in tabular form, the H.P. number, the constellation name, the R.A. and declination, the magnitude and the type of spectrum for each star, and a comprehensive set of "remarks" describes the peculiarities appertaining to various stars included in the list.

A large edition of the catalogue has been prepared, and anyone interested may obtain a copy on applying to the director.

IRON AND STEEL INSTITUTE.

THE autumn meeting of the Iron and Steel Institute was held in the Town Hall, Barrow-in-Furness, on September 1, 2, and 3, with Mr. Andrew Carnegie, the president, in the chair, and was very largely attended. After an eloquent address of welcome from the Mayor, Mr. Carnegie delivered a short presidential address, in which he traced the progress made in the metallurgy of iron and steel since the Institute's last visit to Barrow twenty-nine years ago. After various business announcements had been made by the secretary, Mr. Bennett H. Brough, the reading and discussion of the thirteen papers on the programme began. The first read was that by Mr. R. A. Hadfield on the alloys of iron and tungsten. This formed a monograph of sixty-eight closely printed pages. It contains historical details regarding the ores of tungsten, the metal and its alloys, and a large amount of physical data. It concludes with a carefully compiled bibliography of the subject, showing that a large amount of attention has been devoted to studies of this interesting metal and its employment in the manufacture of steel. Osmond, by his cooling curves, has brought out several peculiar points in the thermal behaviour of this steel, and Barrett has discovered that tungsten affects the conductivity of iron less than any other added element. Though tungsten-iron alloys will have an important future, there is no doubt that their use is not likely to be on the same large scale as some of the other special steels now produced. In the discussion some interesting details were added by Mr. F. W. Harbord and by Mr. J. E. Stead.

This paper was followed by a series of memoirs dealing with the heat treatment of steel. These were discussed together.

The paper read by Mr. J. E. Stead and Mr. Arthur W. Richards on the restoration of dangerously crystalline steel by heat treatment established facts of far-reaching importance. The microscope shows that heating at high temperatures causes a great development in the size of the crystalline grains, and reheating to about 870° restores the original or a better structure. If all structural steels in their normal rolled or forged condition are good, they can be readily deteriorated in quality by heating to a temperature a little above that to which steel is most commonly heated previous to rolling or forging. Steel made brittle by such heating, and dangerously brittle by heating at considerably higher temperatures, can be completely restored to the best possible condition without forging down to a smaller size or by remelting. Not only are the original good qualities of normally rolled steel, after making brittle, restored by the exceedingly simple treatment of heating to about 900° C. for a very short time, but such steel is made considerably better than it was. That brittle "soft steel" can be restored by reheating is well known, but that carbon steels can be actually made much superior to the original properly forged metal by reheating to 870° and cooling in air is a discovery. It is urged that in every large forge and smith's shop Le Chatelier pyrometers should be introduced, together with suitable furnaces for reheating the forgings.

Mr. J. E. Stead and Mr. Arthur W. Richards next read a remarkable paper on sorbitic steel rails. The term sorbitic is used for a transition condition of the carbide intermediate between the states in which it exists in hardened and annealed steels. The chief point of interest in the authors' work is the simple method employed for producing sorbite in steel. The usual custom has been to reheat and oil-harden, or to quench completely in water and reheat to dull redness. They avoid reheating, and quench the heads of the rails, and allow the residual heat in the rails to do the tempering. The results of the later experiments show clearly enough that by partially quenching the heads and allowing the rails to temper themselves, although the elongation is decreased, the contraction of area remains practically the same. A normal rail of 37 tons tenacity when made sorbitic is increased in strength to 45 tons without diminution of the contraction of area. A normal rail with 36½ tons tenacity is increased to 49 tons with a slight increase in the contraction of area. In other cases the tenacity is increased from 43 to 50 tons with a slight diminution in the contraction of the area. Pieces of the rail cut from the area of maximum sorbite on being tested by repeated reversals of strain showed greater toughness and endurance than the normal material. The wear is very greatly in favour of the sorbitic material, as would naturally be expected, and it is believed that, by treating the rails in the simple manner described, their life will be increased from 25 to 50 per cent. The results obtained should lead metallurgists to aim at replacing pearlite by sorbite in all structural steels that have to be subjected to friction, percussion, or vibration when in use.

A paper on the heat treatment of steel rails high in manganese was contributed by Mr. J. S. Lloyd (South Russia). Steels containing more than 1 per cent. of manganese have not hitherto been fully studied, and a research carried out in Russia by the author shows that, at the ordinary normal heat suitable for rolling ingots, steel containing 0·46 per cent. of carbon and 1·33 per cent. of manganese is made exceedingly brittle if it is not further treated, but is allowed to cool on the mill floor. Slowly cooling in the furnace after heating for eighteen hours at 950° makes the material about twice as ductile as it was in the original rail, but the tenacity is considerably reduced. The heating to the rolling temperature causes an enormous development in the size of the crystals, but these are broken up and become about one-eighth of the dimensions by heating to 950° C. and slowly cooling afterwards, and the structure so obtained is twice as fine as it was in the normal rail.

Some further experiments on the diffusion of sulphides through steel were described by Prof. E. D. Campbell, of the University of Michigan. They appear to sustain the conclusions drawn from his work—that iron is permeable by sulphides when heated above 1200° C., and that the sulphur content of the iron is not necessarily increased by the passage of the sulphide through it. In fact, in a slightly oxidising atmosphere the sulphur content of the steel may be even less after the diffusion than it was before. The author is not prepared at present, from the experimental data at hand, to give a positive explanation of the manner in which sulphides permeate or diffuse through iron. The most plausible hypothesis would seem to be that the sulphides originally present in the iron fill more or less completely the interstitial spaces between the crystals of iron; that above 1200° these sulphides are very fluid, and may be drawn out of the steel by capillary action of some absorbent such as asbestos, and their place taken by some other sulphides, provided these latter are sufficiently mobile to find their way into the extremely minute spaces between the steel crystals. If the sulphide replacing the original sulphide contain less sulphur than the latter, or if absorption by the asbestos continued after the sulphides had ceased to enter the iron from within, the diminished percentage of sulphur in the steel at the hot end would be readily accounted for.

The paper by Prof. A. Stansfield on the overheating and burning of steel was a report on work carried out by him as Carnegie research scholar, its publication having been delayed by his appointment to the chair of metallurgy at Montreal. The memoir covers thirty-six pages. The burnt structure of very much overheated steel is shown to be largely due to the partial melting which results from heating the steel above a given temperature. This melting causes brittleness directly, and indirectly by the admission of oxygen to the steel. According to American metallurgists the latter stage would alone be called burning, but as the effect of partly melting the steel is quite distinct from that of overheating below the zone of partial fusion, the author would prefer to apply one word to the whole of the changes that take place in this zone. If the word burning is still employed, it should be remembered that it is essentially a partial melting of the steel, though often accompanied by oxidation. The following stages have been recognised:—(1) overheating (below the point of incipient fusion); (2) partial melting, called burning; (*a*) merely producing segregation of carbon in the joints; (*b*) accompanied with liquation and producing flaws; (*c*) further liquation and oxidation in the flaws. (1) Steel that has merely been overheated can be completely restored by heating just above its highest recalescence point and allowing to cool. (2) Steel in the stage (*a*) can be restored by suitable annealing; in the stage (*b*) forging would also be needed; and in stage (*c*) it would be restored with great difficulty, if at all.

The paper on the heat treatment of steel submitted by Dr. William Campbell (New York) is a report on research carried out by the author as Carnegie research scholar. It forms a pamphlet of ninety-three pages. The steel used contained 0·50 per cent. of carbon, 0·98 manganese, 0·094 silicon, 0·098 phosphorus, and 0·08 sulphur. The structure of the steel used was found to depend upon the two constituents present, namely, the ferrite and the pearlite. The pearlite will certainly show the finest structure when the steel has been heated to just above Ac_1, or when it has been transformed into martensite. Heating to temperatures above this point will cause a coarsening of the structure. The higher the temperature the coarser the structure. Above Ac_1 the ferrite begins to diminish in size, due to its being dissolved in the martensite. This will continue until the whole of it is dissolved, when the change Ac_{2-3} is complete. Then the finest structure of the whole will be found where these two changes balance. This point is apparently just below the point where Ac_{2-3} is complete. The best finishing temperature is such that the bars leave the rolls as near Ar_{2-3} as possible. The bars would necessarily have to be drawn from the furnace at a higher temperature, which is about 740° C. in this case, allowing for a cooling of, say, 40° C. or more during rolling. In comparing the results obtained with those of pure carbon steel, the effect of the manganese present must be taken into consideration.

An animated discussion followed the reading of these papers on heat treatment, in which Messrs. Westgarth, Ridsdale, Lange, Price-Williams, L. N. Ledingham, and Hadfield took part.

The probability of iron ore lying below the sands of the Duddon Estuary formed the subject of a paper by Mr. J. L. Shaw (Whitehaven). He adduces evidence to show that there is a limestone area probably carrying large bodies of ore, and advocates the putting down of exploratory boreholes. In the discussion Mr. G. J. Snelus gave further particulars of geological interest.

The paper by Mr. W. F. Pettigrew on coal as fuel at Barrow-in-Furness contained much of interest. In that district at the present time coal is obtained from Cumberland, Lancashire, and Yorkshire. As the prices at the pit, the cost of carriage, and the quality of the coal from these districts vary considerably, the author has carried out several experiments to find the relative value of coal obtained from the districts before mentioned, also from various parts of Scotland and South Wales. Experiments carried out with a locomotive showed that the sample of Yorkshire No. 1 gave the best results. This coal has excellent steaming qualities, is very clean, with an open clinker, and low percentage of ash. The Welsh coal was also good when tried, and equal in all respects to the Yorkshire coal, and would no doubt give even better results if properly fired, which was not the case during the trials, the men having had practically no experience with this kind of coal. The Cumberland coal was good, particularly one sample, but this was not found suitable for locomotive purposes. The other sample of Cumberland coal gave fairly good results, but it is a dirty coal, and necessitates the frequent cleaning of fires. The Lancashire samples were in some cases very good steaming coal, with a moderately low consumption, but several samples gave very bad results, and were quite unfit for locomotive purposes. The Scotch coals tested were fairly good, but in most cases a very heavy consumption was recorded. They are quick burning coal and dirty, but with an open clinker, which did not interfere in any way with the steaming. The consumption was from 20 to 40 per cent. higher than the Yorkshire coal.

Mr. C. H. Ridsdale (Middlesbrough) read a lengthy paper on the diseases of steel. In it he collated various types of defects, and traced them to their origin.

Mr. H. Ehrhardt, of Düsseldorf, contributed a paper describing a process for making weldless steel pipes and shells by which rings up to 8 feet in diameter and 10 feet in length are manufactured.

The regulation of the combustion and distribution of the temperature in coke oven practice was dealt with in a paper by Mr. D. A. Louis. Illustrations were given to show the design and character of the Brunck and v. Bauer coke ovens, two ovens of new design.

The influence of silicon on iron was dealt with in a paper by Mr. Thomas Baker. He prepared a series of alloys of silicon and iron with traces only of other elements, and studied the micro-structure and physical properties of each. Although the addition of silicon to iron increases the elastic limit and tenacity of iron, such increase is only obtained by loss of ductility, which loss, provided the material has been well annealed, is very small until the silicon reaches 3 per cent., after which it becomes very great, the ductility almost becoming zero with 4 per cent. silicon. The alloys gradually increase in hardness with the addition of silicon, and after exceeding 5 per cent. silicon require great skill and care in machining in order to avoid fracture of the bar. As the percentage of silicon increases the permeability for low magnetic fields increases, and the coercive force and hysteresis loss decrease. Prof. T. Turner (Birmingham) was the chief speaker in the discussion.

The proceedings concluded with the customary votes of thanks to the reception committee, and an invitation, tendered by Mr. Kirchhoff, of New York, on behalf of the American societies, that the Institute should meet in the United States next autumn was accepted.

In connection with the meeting an elaborate programme of visits and excursions was arranged, including the works of the Barrow Hæmatite Steel Co., the Askham blast furnaces, the Hodbarrow mines and sea-wall, the naval construction works of Vickers, Sons and Maxim, the Furness Railway locomotive works, the North Lonsdale iron works, and to Lake Windermere, Grasmere, and Blackpool. The social functions included a conversazione given by the Mayor, a ball by the reception committee, a garden party by Mr. Victor Cavendish at Holker Hall, and an illuminated *fête* at Furness Abbey.

UNIVERSITY AND EDUCATIONAL INTELLIGENCE.

SATURDAY, October 31, has been fixed for the holding of a convocation of the University of Oxford for the purpose of electing a Chancellor of the University in the place of the late Marquis of Salisbury.

ARRANGEMENTS for next term have been published in connection with the Oxford University School of Geography. Nine lectures a week by different members of the staff will be given in various branches of geographical science, and practical instruction to supplement several of the courses of lectures has been arranged. A geographical scholarship of the value of sixty pounds is to be competed for on October 14, and candidates must have taken honours in one of the final schools of the university. Courses of instruction are now given also in preparation for the university certificate in surveying, and to meet the requirements of students reading for the university diploma in education.

The report of the Board of Education for 1902–3 shows that during the session 1901–2 the total number of students receiving science and art instruction under the Board was 291,758. The total number of schools in which the teaching was given was 2061. The grants paid during the year amounted to 314,212*l.*, of which 143,671*l.* was paid upon attendances. From the same report we learn that great progress has been made with the new buildings for the Royal College of Science. It is hoped the work will be complete in two years' time.

The University College at Reading continues its useful work in the adjoining counties in connection with field trials and lectures at rural centres, and the work of the agricultural department is of a kind to secure the confidence of practical men. Instruction in dairy farming and dairying is given in cooperation with the British Dairy Institute; the College Poultry Farm at Theale is available for students who desire to obtain a practical acquaintance with poultry-keeping; and there is a college garden for horticultural practice and instruction.

At the forthcoming opening of the medical schools, the following will deliver addresses:—At the St. George's Hospital medical school on October 1, Dr. W. R. Dakin; at King's College, London, on October 1, Sir John Alexander Cockburn, K.C.M.G., on "Imperial Federation and its Physiological Parallels"; at Guy's Hospital Physical Society, on October 10, Dr. J. F. Goodhart; at the Middlesex Hospital on October 1, Mr. William Hern; at the Medical Faculty of University College, London, on October 5, Prof. E. H. Starling, F.R.S.; at the University of Liverpool on October 1, Sir Dyce Duckworth; and at the University College, Sheffield, on October 15, Sir Michael Foster, K.C.B., F.R.S.

The report on the work of the Sir John Cass Technical Institute for the session ending last July, and the recently published syllabus of the classes to be held during next winter together show that this young polytechnic is doing excellent work. Many of the students are engaged in technical pursuits during the day. For example, quite half of the students of chemistry are employed in some form of chemical technology, and an examination of the entries of last winter in the metallurgical department shows that one was the head of a firm of bullion refiners, three were managers in metal refining works, five were chemists engaged in metallurgical industries, three were foremen in metallurgical works, and others clerks or samplers in works or trades associated with metals. Among others of a thoroughly practical nature arranged for next session may be noticed a course of practical instruction in glass blowing suited to the requirements of chemists, physicists, teachers, and those engaged in the making of glass apparatus and instruments.

In his report for the year 1903 on secondary education in Scotland, Sir Henry Craik, K.C.B., says there has again been a gratifying increase in the number of schools presenting candidates in science at the leaving certificate examination, and also in the total number of candidates presented. The examiners report that there is need to repeat once more the warning to teachers against taking up practical work of which the theory is beyond the comprehension of their pupils, or has not been made clear to them. The methods of examination differ in some important points from those regulating the system in regard to other subjects. The examination is chiefly oral and practical, and it is shaped in the case of each school by the curriculum of that school. It is interesting to find that the most satisfactory work appears to be done in the schools the profession of which is comparatively modest. In practical science, as in all educational subjects, the special discipline given is better got from a thorough study of one branch than through a too ambitious attempt to cover a very wide field. The chief examiner is inclined to recommend that, unless the time available during the third year's course is more than four hours a week, the whole of it should be devoted to one subject instead of being divided between two. Another point to which he directs attention is the very limited extent to which "home-made" apparatus is employed in the laboratories.

SOCIETIES AND ACADEMIES.

Paris.

Academy of Sciences, August 31.—M. Bouquet de la Grye in the chair.—A fixing liquid isotonic with sea water, for objects in which it is desired to preserve lime formations, by M. M. C. **Dekhuyzen.** In a previous note a formula has been given for a liquid, isotonic with sea water, for fixing delicate marine organisms. This contains acid, and in fixing the larvæ of sea urchins, which contain extremely delicate chalk formations, it is necessary to employ a liquid free from acidity. The formula of a liquid possessing the required properties is given in the present paper, and in the hands of M. Delage has given perfect results in fixing very delicate larvæ.

Göttingen.

Royal Society of Sciences.—The *Nachrichten* (physico-mathematical section), part iii. for 1903, contains the following memoirs communicated to the society:—

February 21.—W. **Voigt**: Questions of crystalline physics, i. On the rotatory constants of heat-conduction in apatite and dolomite.

March 7.—W. **Kaufmann**: On the "electromagnetic mass" of the electrons. V. **Cuomo**: Measurements of the electric dispersion in the open air at Capri (October, 1902–February, 1903).

May 16.—W. **Voigt**: On the theory of total reflexion. K. **Schwarzschild**: Contributions to electrodynamics—(1) two forms of the principle of least action in the theory of electrons; (2) the elementary electrodynamic force.

June 13.—F. **Merkel**: Remarks on the fasciæ and veins of the human pelvis.

The "Business Communications," part i. for 1903, contain a report on the Samoa Observatory, and a highly appreciative obituary notice of the late Sir G. G. Stokes, by Prof. W. Voigt.

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