THURSDAY, SEPTEMBER 17, 1908.

## SEWAGE WORKS.

*The Design, Construction, and Maintenance of Sewage Disposal Works.* By Hugh P. Raikes. Pp. xv+414. (London: Archibald Constable and Co., Ltd., 1908.) Price 16*s.* net.

THOSE entrusted with the design and construction of sewage works should have at their disposal the latest results of contemporary science to guide them, and the author's contention that no other book has recently been published from which equally full and trustworthy information can be obtained by the engineer is substantially correct, with the reservation that the information alluded to has reference to recent developments. Judged from this standpoint, the volume is likely to appeal to the engineer, since it summarises a considerable amount of recently acquired knowledge relating to sewage disposal, and contains the advice and experience of one who has had to face the practical problems involved.

From the circumstance that the work contains much elementary matter, more especially in the opening parts, it appears that it is not designed exclusively for advanced students; and that being so, this matter should be extended so as to meet the needs of those who approach the subject with comparatively little knowledge; for some of the bacteriological and chemical references in this volume are insufficient for the student's comprehension as they stand at present, and in some cases they demand revision in a subsequent edition.

To give instances, on p. 162 it is stated that "the best results have been obtained with a solution of bleaching powder containing hypochlorite of calcium having 36·35 available chlorine." On p. 143 the value of copperas as a chemical precipitant is discussed in a way which infers that its main virtue depends upon its acidity and the fact that its use in conjunction with lime prevents an excessively alkaline effluent. On p. 31 the author states that "the difference in the composition of sewage in different places may be as great as that between milk and writing ink." While conceding that great differences exist, the comparison is, to say the least, an unhappy one. There is no chemical or physical justification for it.

On p. 35 the author remarks, with reference to sewage effluents, that "the presence of a few disease germs cannot be considered of vital importance so far as water supplies are concerned when the water is again filtered before use." On p. 52 he states that "the danger of disease cannot be indicated by the mere numbers of any particular disease-producing micro-organisms that may happen to exist in samples"—of polluted water or shell-fish—"so that for the present, at any rate, topographical observations must be regarded as the only reliable means of detecting objectionable contamination."

The following statement on p. 71 is not very clear:—

"It would therefore seem to be a very much simpler matter to sterilise the shell-fish or water supplies than to deal with sewage effluents in this way, as no such system could be relied upon to remove all danger of contamination, and the consumers would still have to rely for protection on those who supply them with water or shell-fish as the persons directly responsible for their freedom from contamination."

The author very justly directs attention to the circumstance that local authorities all too frequently appoint as managers of sewage works individuals who have neither an adequate understanding nor appreciation of the duties appertaining to such a post, nor the qualifications which are necessary to enable them to fulfil those duties satisfactorily. He then proceeds to lay down some of the qualifications which a good manager should possess; and one is astonished to find the following paragraph on p. 367:—

"The increasing attention now being devoted to the study of bacteriology in connection with sewage disposal also renders it highly desirable that a manager should understand the methods of cultivating, counting, and distinguishing the different kinds of bacteria to be found in sewage, so that he may be able to observe the conditions that are favourable or unfavourable to their growth, and thus ascertain the best means of developing the growth of those which are useful for decomposing the sewage while at the same time destroying the pathogenic or disease-breeding bacteria, which may sometimes constitute an even greater source of danger in the final effluent than chemical impurity."

Placing the broadest construction upon the above sentence, how many expert bacteriologists in this country possess the knowledge held to be highly desirable in a manager of sewage works?

Chapters vii., viii., and ix., dealing with contact beds and percolating filters, may be singled out as the best in a volume which, from the engineering standpoint, justifies its appearance. It cannot fail to prove useful to those engineers who do not possess a first-hand knowledge and experience of sewage disposal, for the practical engineering facts are sound and up-to-date, and the requirements of the Local Government Board, the reports of the Royal Commissions, &c., are usefully summarised within the volume.

## MATHEMATICAL INSTRUCTION.

*A Study of Mathematical Education, including the Teaching of Arithmetic.* By B. Branford. Pp. xii+392. (Oxford: Clarendon Press, 1908.) Price 4*s.* 6*d.*

BY far the most valuable part of this book consists of the examples which it gives of the curiously limited powers of generalisation and abstraction possessed by young pupils. For example (p. 44), a class, after experimentally adding angles together, agreed that four angles could be added, but not five. A still more remarkable case is described on pp. 304–9. A little girl was given three congruent paper triangles A, B, C; after fitting A to B and A to C, she not only failed to draw the conclusion that B could be fitted to C, but refused to admit the force of arguments to that effect. This result was confirmed by experiment

with another little girl, and shows plainly enough that premature formal teaching must be injurious by destroying independence of thought. Unfortunately, the ages of the girls are not stated.

The volume is very miscellaneous, and, indeed, suffers from the fact that addresses, lectures, notes, &c., have been gathered together without much attention to revision or general effect. There are notes on lessons in geometry (often good), a long extract from an address by Bidder to the Institution of Civil Engineers, scraps of mathematical history, and a certain amount of that twaddling "psychology," so-called, and puerile classification, in which pædagogists take such unaccountable delight. For instance, we are solemnly told that "Geometry is the resultant of *Sense-Perception* and *Abstract Thought*," a statement equally true of all the sciences and most of the arts. Then we have a strobic disc, supposed to indicate the different proportions, at different ages, of perception to abstraction, and a so-called chart, something like a toy-trumpet or a church spire, to indicate the stages of mathematical progress in the race and the individual. This last is distinctly misleading, because it makes the advance linear, and it has been nothing of the kind, so far as the race is concerned.

The bibliography is neither discriminating nor up to date. Montucla and Marie are mentioned without a hint that, as works of reference, they have been made obsolete by M. Cantor's history; and the latter is described (without date) as in three volumes, whereas five complete volumes have appeared, and vols. ii. and iii. are in a second and revised edition. No mention is made of Merz's "History of European Thought," which has some very good sections on mathematics, or of Heath's studies of the Greek geometers.

But in spite of these defects the book is worth reading, and the author's views appear to be sound. Thus he realises that one great practical problem is to find out, if we can, how far the education of the race should be imitated in that of the individual; he has a reasonable idea of the proportion of experiment to theory in teaching geometry to boys and girls of different ages; and he very properly recommends the study of algebra, in its early stages, as a generalised arithmetic. Few will dispute that mechanical algebra does more than anything else to blunt a boy's mathematical faculties.

On pp. 352–6 there are samples of old algebraic notation, on pp. 356–60 a good collection of fallacies, and there is an index of twelve pages. G. B. M.

## THE ORIGIN OF THE SOLAR SYSTEM.

*Das Problem der Entwicklung unseres Planetensystems, Aufstellung einer neuen Theorie.* By Dr. Friedrich Nölke. Pp. xii+216. (Berlin: Julius Springer, 1908.) Price 6 marks.

THOUGH it is perfectly true, as the author reminds us, that the problem of the origin of the solar system has attracted the attention and exercised the ingenuity of the foremost minds in all ages, it is easy to recognise decisive steps in the gradual development, rendered possible by the acquisition of new and epoch-marking facts. Such were the discovery of the theory of gravitation, the modern views concerning the conservation of forces, and it is not impossible but that in theories yet to be broached, the recent conceptions as to the nature of matter may considerably modify the views that have hitherto been regarded as orthodox. Our theory of the cosmos is progressive, and continued adjustment is necessary to accommodate our conceptions to observed facts. Dr. Nölke reopens the graves of a long succession of these theories which have undergone amendment, and naturally finds them inadequate to explain phenomena with which their authors were unacquainted. But in any case, since Dr. Nölke is the author of a rival theory, he could not be satisfied with the work of his predecessors. To destroy is easier than to build, and he has little difficulty in pointing to many shortcomings; but though he confidently believes that he has removed all the objections that disfigure the efforts of earlier physicists, and is in possession of an absolutely flawless conception, it is not impossible but that his views will also pass into the limbo of discredited statements when reviewed by critics as severe as he has proved himself.

As in the theory of Moulton, the author starts with a spiral nebula resembling that in Canes, but with more delicate convolutions and a smaller mass. In that nebula an outlying portion is seen apparently detaching itself, and Dr. Nölke regards the formation of Neptune to have been accomplished in a similar manner. He next supposes the connecting link that holds the newly-formed Neptune to the original nebula to separate itself from the parent nebulous mass and the detached Neptune to make a Uranus. Saturn and Jupiter are formed by analogous processes. Within the internal folds of the spiral there apparently exists a mass of greater density, with four other regions of condensation surrounded by flocculent matter. This latter incoherent material formed the asteroids, while the condensations towards the centre gave rise to the four internal planets. Then, by the action of molecular forces and the "resistance of the æther," the slowly rotating sphere of gas forming the innermost nebula contracted, and the sun was produced. To bring about the necessary contractions and separations, the author has to introduce within the nebulous mass the action of other forces than those of gravitation, and to give to the æther a resistance which we fail to understand. But it is permitted to hold very varied views of the constitution of the æther, and possibly we have failed to grasp exactly the author's contention. We are willing to give him every latitude in this undecided question, but when he goes on to explain the occurrence of the Ice age on the earth as due to the passage of the sun through a nebulous mass, and selects the Orion nebula as the most probable, we feel that our guide becomes untrustworthy. Moreover, to use such a hypothesis as affording the means of determining the density of the Orion nebula must be regarded as unwarranted and calculated to bring into disrepute any points of merit the theory may possess.

## OUR BOOK SHELF.

*The Influence of Alcohol and other Drugs on Fatigue.* The Croonian Lectures delivered at the Royal College of Physicians in 1906. By Dr. W. H. R. Rivers. Pp. viii+136. (London: Edward Arnold, 1908.) Price 6*s.* net.

In these the Croonian lectures delivered before the Royal College of Physicians, London, in 1906, the author details the results obtained in an experimental research on the influence of certain drugs—caffeine, alcohol, cocaine, strychnine, and tobacco—on muscular and mental fatigue. The method employed for estimating muscular fatigue was by means of an ergograph, the latest form of Kraepelin's modification of Mosso's instrument, the records being obtained graphically in the form of an ergogram, and representing the movements of one joint. Mental fatigue, or more precisely the fatigue of attention, was studied by McDougall's method, in which the subject has to hit a succession of dots which pass before him across a slit. Many factors which may influence the results were recognised and allowed for, such as the effects of attention, interest in the work, conversation, the habitual use of the substances experimented with, *e.g.* caffeine in tea and coffee, alcoholic drinks and smoking, &c. The disturbing influence of such factors was very well shown, for example, in the case of tea and coffee—withholding these beverages before commencing the experiments with caffeine was found to be followed by a loss of energy, so that the earlier ergographic records became untrustworthy as indicating the effects of caffeine when administered. The flavour of the drugs also had to be disguised, so that the subject was unaware when he was or was not taking them.

The general results obtained may be summarised as follows:—caffeine in moderate doses (about 0·3 gram of the citrate) increases the capacity for both muscular and mental work, the stimulating action persisting for some time, and not being followed by any depressant action. Excessive doses, however, after a transitory stimulant action, are followed by a depressant action so marked that the drug in such circumstances becomes an accelerator of fatigue; in fact, caffeine may be a dangerous remedy in cases of prolonged fatigue.

Alcohol in small doses (5–10 c.c.) seemed to produce little effect, in larger doses (20–40 c.c.) the action was variable; in a subject not used to alcohol, sweating, giddiness, and other symptoms often ensued; the muscular work was at first increased, afterwards diminished, but there was a good deal of irregularity in the results, and this portion of the research is being continued, and the problem is one of great complexity. The capacity for mental work on the whole seemed to be lowered.

The researches carried out by Dr. Rivers are of great interest and importance, and it is to be hoped that they will be continued and extended to the other drugs mentioned.

*The Moral Ideal; a Historic Study.* By Julia Wedgwood. New and revised edition. Pp. xi+504. (London: Kegan Paul, Trench, Trübner and Co., Ltd., 1907.) Price 10*s.* 6*d.* net.

The first edition of this book was published twenty years ago. It is indicative of the soundness of the original work as well as of the completeness of the revision that the numerous interpolated references to recent events and contemporary thought seem never to have an adventitious but always a natural and integral connection with the context in which they appear. The book is intended to be a contribution to the "history of human aspiration," which the author regards as "the clue to all history," believing that "a partial and incomplete revelation of what men have sought to be tells us more of their true nature than does the most exhaustive record of what they have accomplished." From this point of view she gives a number of studies of the moral ideals which may be taken as characteristic of the races whose life has at different times formed part of the main stream of human progress. The spiritual histories of Egypt, India, Persia, Greece, and Rome are reviewed in succession, and an attempt is made to signalise the elements of cardinal importance which each has contributed to the moral development of Europe. Chapters follow dealing with the evolution of the moral consciousness of Christianity out of the mingled elements of eastern and western origin, while in a final study the author seeks to determine the relation of these earlier aspirations to the moral life of the present day, and considers, in particular, the relations between morality and modern science.

In her earlier chapters Miss Wedgwood appears to have followed the recognised authorities upon oriental history and religion, but from the point where she reaches the study of Greek ideals she depends largely upon her own reading and observation, and displays a fund of erudition as striking in profundity as it is engaging in quality. The variety and beauty of her illustrations from many literatures would alone suffice to make her pages interesting and impressive even if they were not decorated by the writer's own eloquence, sweetened by her catholic sympathy, and illuminated by her splendid moral enthusiasm.

*Electricity: What is it?* By W. Denham Verschoyle. Pp. xii+259. (London: Swan Sonnenschein and Co., Ltd., 1908.) Price 2*s.* 6*d.* net.

The main object of this book is to sustain the contention that something more than the usually accepted electrical idea is needed if we would aim at solving the many problems which exist around us.

To solve these problems on the modern electrical theory, it is generally recognised that we still require as postulates:—(1) Positive electricity, (2) negative electricity, (3) an attractive force between them, (4) æther, (5) gravity, (6) life. "There seems at present no possibility of further consolidation in these premises; they remain, as between themselves, isolated facts, having no relation to one another. We cannot express life in terms of positive electricity, for instance; or gravity, in terms of positive and negative electricity" (p. 232).

The author of this book, however, starting merely with three postulates, (1) absolute energy, (2) æther, (3) some form of interaction between them, develops a theory which claims to admit of the main facts of natural phenomena being arranged "in a homogeneous and inter-related series." The fundamental (though by no means new) conception of the theory is that of the *gyron*. The author supposes all matter to be made up of little planetary systems composed in their last analysis of gyrons which are themselves simply æther in an extremely energetic state of motion. The gyrons and systems of gyrons are supposed to resemble small discs in rapid rotation about a central axis, and in consequence capable of giving rise to three entirely distinct types of æther motion or *force*. These are called (1) the Alpha force, (2) the Beta force, (3) the Gamma force. Gravity and cohesion are different forms of the Alpha force; X-rays, light and heat are forms of the Beta force; electric and magnetic forces come in the category of the Gamma force.

It is not very clear how the author arrives at the existence of these forces emanating from the gyron,

but by means of them he is able to discuss the evolution of the atom, the relations of the elements, heat, light, electricity, dissociation. The "mystery of life" even is not excluded from the discussion.

The treatise, as the author himself frankly acknowledges, is a purely imaginative one, and we do not agree with him in thinking that the diverse and tentative views held just now by our leading investigators as to the ultimate constitution of matter afford a sufficient justification for the present attempt to explain matter and electricity by an effort of the imagination. Views and theories based on mathematical and experimental investigations are to us certainly more convincing.

*The Fossil Fishes of the Hawkesbury Series at St. Peter's.* By A. Smith Woodward, Mem. Geol. Surv. N. South Wales. (Sydney, 1908.)

Dr. Smith Woodward describes a series of Permo-Carboniferous fishes from St. Peter's, one of the Illawara suburbs of Sydney. The greater number of the specimens, including genera new to the Hawkesbury formation, were obtained from a dark indurated shale. The discovery of Sagenodus is interesting in connection with recent discoveries of dipnoan fishes in Australia, from the fact that we have evidence of the forerunners of the surviving Ceratodus in various formations from the Devonian to the Jurassic, and it is suggested that Ceratodus may have evolved in the Australian region. A new palæoniscid genus, Elpisopholis, allied to Phanerosteon and Sceletophorus, is described, in addition to several new species of fishes. A few specimens, somewhat newer in age, were obtained from a soft grey shale resembling that at Gosford. The work is well illustrated by four plates and a restoration of the new genus.

## LETTERS 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.*]

### Lamarck's "Système des Animaux sans Vertèbres."

This work, as is well known, was first published in the ninth year of the Republic, or 1801 A.D. (*i.e.* the last nine months thereof). But, to judge from the usual bibliographies and library catalogues, it does not appear to be generally known that the original sheets were re-issued with a fresh title-page in the following year. The differences between the two title-pages are quite unimportant until the imprint is reached. This in the first issue reads as follows:—

A PARIS

Chez { L'AUTEUR, au Muséum d'Hist. Naturelle;
DETERVILLE, Libraire, rue du Battoir, nº 16, quartier de l'Odéon.

AN IX—1801.

In the second issue the imprint is:—

A PARIS

Chez { Maillard, Libraire, rue du Pont de Lodi, Nº 1.
Deterville, Libraire, rue du Battoir, Nº 16, quartier de l'Odéon.
Moulardier, Imprimeur-Libraire, quai des Augustins, Nº 28.

AN X—1802.

That this was a re-issue and not a new edition is proved by a copy in the possession of my friend Mr. Victor W. Lyon, city engineer of Jeffersonville, Indiana. The text and tables present absolutely no difference from those of the first issue, and the new title-page, instead of forming a part of the first section, has been printed on a wide fly-leaf, the inner margin of which is folded round the adjoining leaves of the first section.

This new title-page has some interest as suggesting that the work was taken up by the booksellers more warmly than had been anticipated, and that it was no longer necessary for the author to be at the trouble of selling his own copies.

Since the writings of many naturalists show that a confusion already exists in their minds between the "Système," 1801, and the "Histoire," 1815–22, it has seemed advisable to help them out of any fresh difficulty that might be presented by the existence of two dates for the "Système." Just now, when Lamarck is being specially commemorated, it may be thought worth while to publish this detail, which otherwise might be overlooked.

F. A. Bather.

September 5.

### The Hong Kong Typhoon of July 27–28.

This typhoon appears to have been very similar in size, direction, and intensity to that which caused such destruction in Hong Kong on September 18, 1906.

It was notified by both the Hong Kong and Manila observatories on July 26. It was then said to be in the Balintang Channel, which runs between Luzon, the northern island of the Philippines, and Formosa, and is about 500 (nautical) miles E.S.E. of Hong Kong; the observations available at that date showed it to be moving westwards, but were not sufficient to indicate that it was a storm of any great intensity. From the Balintang Channel it crossed some 500 miles of open sea without an observing station, and it was not until 6 p.m. on July 27 that the local indications were such as to cause the observatory officials in Hong Kong to hoist the signals indicating a typhoon within 300 miles of the colony. At 9.30 p.m. it was notified that the typhoon was moving towards the coast in the neighbourhood of Hong Kong. At 11.15 p.m. the signal was hoisted indicating that a typhoon was imminent. The barometer commenced to fall sharply at 10 p.m., and reached its minimum at 1 a.m. on July 28; the fall varied from half an inch to an inch in these three hours in different parts of the colony, the variation in the fall indicating that the typhoon centre passed close to the south of the island. The speed would seem to have been about normal. The typhoon was in the Balintang Channel on the morning of July 26, and the centre passed Hong Kong at 1 a.m. on July 28—500 miles in forty hours, or 12½ miles an hour.

Owing to the timely warning, and to the gale coming from the east, in which direction the harbour is well sheltered, the damage to the shipping in it was comparatively small; four large steamers were driven ashore, a steel four-masted barque lost two of her masts, and many of the smaller craft suffered, with some loss of life, but the majority had acted on the warning given, and sought such shelter as was available. Outside the harbour the most serious disaster was the loss of a river steamer bound from Canton to Hong Kong, and with it some 400 lives. H.M. destroyer *Whiting* was also driven ashore and badly damaged. On shore the damage far exceeded that done by the typhoon of 1906. The damage to trees, most of which are evergreens, such as banyans, was such as almost entirely to deprive the roads and gardens on the lower levels of much needed shade. The roads were covered with broken branches, which will take weeks to remove. Even such hard-leaved plants as bamboos are, in exposed situations, now nothing but masses of stalks and withered yellow leaves.

The houses suffered mainly in their roofs and windows; the roofing used consists of the pantiles and mortar rolls common to China and the East, and is very liable to slip with the vibration caused by a hurricane. Several of the lower-class houses were demolished, with some loss of life. The gale commenced about 10 p.m. on July 27, and ended about 4 a.m. on July 28. Unfortunately, both the Kowloon Observatory anemometer and that at Victoria Peak, 1800 feet above sea-level, were damaged during the gale, and records are not available. It is thought that the force of the wind far exceeded that of the typhoon of 1906, and was very near to, if it did not exceed, the highest previous record of 108 miles per hour, in 1896.

Hong Kong, August 11. L. Gibbs.

## THE GERMAN MUSEUM OF SCIENCE AND TECHNOLOGY.

THE guide[1] to the collections in the new German Museum at Munich shows that the examples of the Conservatoire des Arts et Métiers in Paris, and of the Machinery and Inventions Museum at South Kensington, have been successfully followed, and even improved upon, in the Bavarian capital. In the old National Museum in the Maximilianstrasse a remarkable collection of "Meisterwerken" of science and technology has been brought together in a few months, a collection which is well worthy to rank with those which are the results in Paris of a hundred years, and at South Kensington of fifty years, of strenuous work.

In Germany the scheme for such a museum was suggested on May 3, 1903, by Oscar von Miller. The idea was adopted with enthusiasm; and George Krauss, the eminent authority on the locomotive, was the first to show practical interest in the scheme by presenting the sum of 5000*l*. A site for the museum was granted by the municipality of Munich, and a temporary home was found in the old National Museum and in the Isar barracks. The aim of the museum is to illustrate the gradual historical development of scientific research and of technology by means of original apparatus and machines, and by means of a library of ancient and modern works. On September 20, 1906, thirty-one competitive designs for the new museum were received from German architects, and on October 20 the first prize was awarded to Gabriel von Seidl for his design for a building, the cost of which was estimated at 375,000*l*. For meeting this cost, the city of Munich voted 50,000*l*., the Bavarian Government 100,000*l*., and the German Imperial Government 100,000*l*. The greater part of the remainder has been subscribed by scientific and technical corporations and individuals. On November 13, the day of the opening of the temporary museum, the foundation-stone of the new building was laid by the Prince Regent of Bavaria in the presence of the German Emperor, and in a few years' time the collections will have a stately permanent home.

In the meantime the collections are admirably displayed in the temporary museum, and a mere enumeration of the classification of the contents of the fifty-six rooms will suffice to show the vast field covered. The classification (Fig. 1) is as follows:—1, geology; 2, mining; 3–6, metallurgy; 7, hydraulic motors; 8–9, steam engines; 10, land transport; 11–12, roads; 13–14, motors; 15, astronomy; 16, geodesy; 17, mathematics; 18, mechanics; 19–20, optics; 21, heat; 22–23, acoustics; 24–26, electricity; 27, telegraphy; 28, telephony; 29, drawing and painting; 30, writing and printing; 31, photography; 32, horology; 33–35, textile industries; 36–37, agriculture; 38, dairy work; 39, brewing and distilling; 40–45, chemistry; 46, hydraulic engineering; 47, inland navigation; 48, canals; 49–51, naval architecture; 53–55, library and plan collection; and 56, court of honour.

It is impossible in the space available even to enumerate the many objects of interest shown. Walking through the rooms in the order indicated, one notices the first geological map of Bavaria by Michel in 1768, Siemens's first electric mine locomotive (1881), a model showing the Ilgner system of electric winding in shafts (Fig. 2); a huge model, on a scale of one-twelfth the natural size, of Krupp's steelworks, with the 50-ton steam hammer, and near it an original village smithy of the nineteenth century, and the first cast-steel bell made by Jacob Mayer in 1854. Among the hydraulic motors there are an old Roumanian water-wheel, such as that described by Leonardo da Vinci, the prototype of the modern turbine; the first Fourneyron turbine; and the Reichenbach hydraulic engine, built in 1817, and used until 1904 for pumping brine from Berchtesgaden.

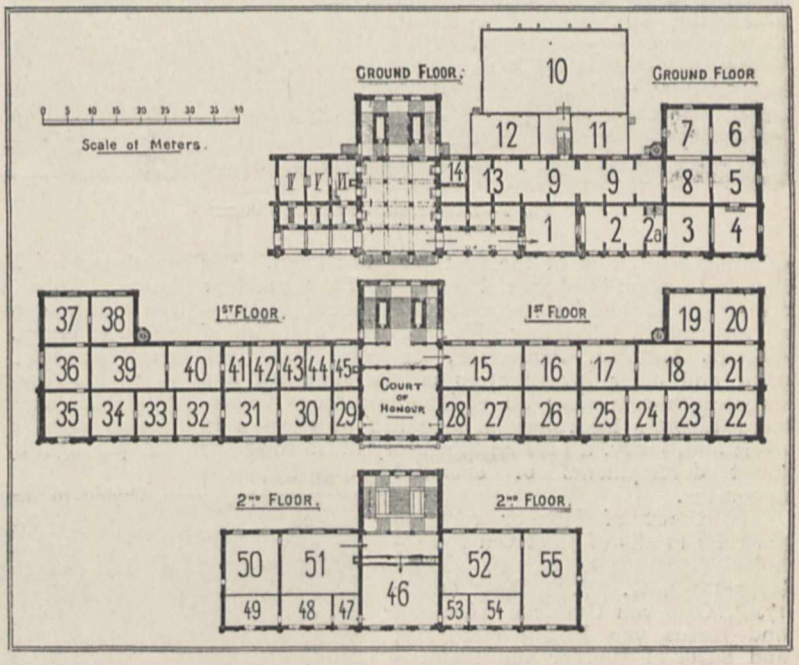



Fig. 1. Plan of the German Museum.

Among the steam engines one notices a model of the oldest German steam engine built for mine-drainage at Eisleben in 1813; the original water-tube boiler made by Alban in 1859; the original forms of Parsons' and De Laval's steam-turbines; and the first German portable engine built by Wolf in 1862. In Room 10 the development of land transport is shown. There are reproductions of the first bicycle and of the first motor-car, and an exact copy of Hedley's locomotive, "Puffing Billy," at South Kensington; a modern Bavarian express locomotive cut to show the internal construction, and, suspended above it, Lilienthal's flying machine.

On the first floor the physics division begins. A remarkable series of original instruments and models illustrates the development of astronomical work, and in succeeding rooms there are the original apparatus of Fraunhofer, Helmholtz, Kirchhoff and Bunsen, Ohm, Ampère and Röntgen, the originals of the first electric telegraph of Sömmerring (1809) and Reis's first telephone (1863), side by side with reproductions

[1] "Deutsches Museum von Meisterwerken der Naturwissenschaft und Technik." Führer durch die Sammlungen. Pp. 158; with 55 illustrations. (Leipzig: B. G. Teubner, 1908.) Price 1*s*.

of the apparatus of Otto von Guericke, Galileo and Volta. Passing on to the technological group, one notices the original lithographic press invented by Senefelder in 1797, and reproductions of Hargreaves's spinning jenny and of the first Jacquard loom. The chemical section is of special interest. There are four completely equipped laboratories of different epochs—an alchemist's laboratory (Fig. 3), with portraits of Albertus Magnus, Paracelsus, Agricola, Van Helmont and other investigators of the sixteenth and seventeenth centuries; an eighteenth-century laboratory; Liebig's laboratory as installed at Giessen in 1839; and, lastly, a modern laboratory illustrating the latest developments of chemical apparatus.

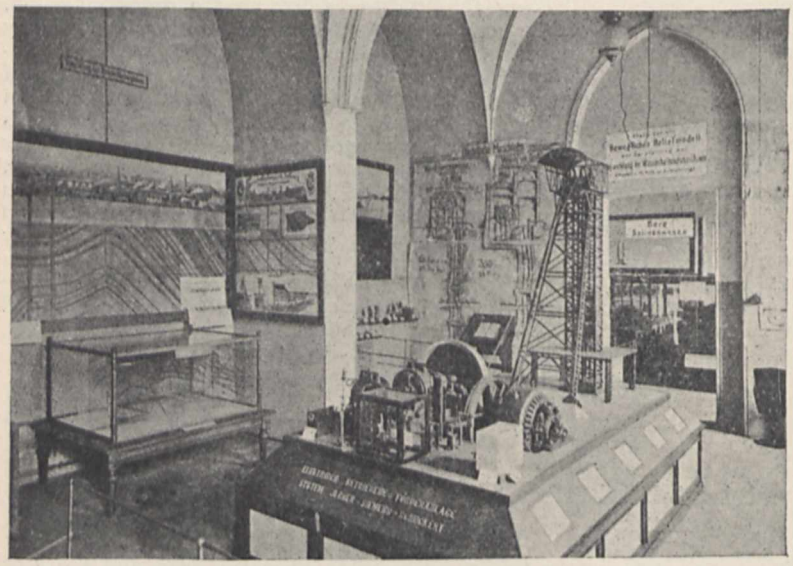


FIG. 2.—Model of electric winding plant.

The Court of Honour contains portraits in oils of Josef von Fraunhofer (1787–1826), K. F. Gauss (1777–1855), G. W. Leibniz (1646–1716), Otto von Guericke (1602–86), and Justus von Liebig (1803–75); and busts of Werner von Siemens (1816–92), Alfred Krupp (1812–87), Robert Mayer (1814–78), Hermann von Helmholtz (1821–94), Robert Bunsen (1811–99), and Henne Gensfleisch, known as Gutenberg (died 1468). There is also a collection of medals of scientific interest, including the Bessemer Gold Medal of the Iron and Steel Institute, and other medals awarded by British societies. Framed on the walls is a collection of historical documents, letters of Ampère, Berzelius, Faraday, Ohm and others. There is also a volume recording in chronological order the gifts received by the museum from all parts of the world.

The museum is keenly appreciated. The number of visitors averages 3000 on Sundays and 1000 on week-days. The detailed information given on the labels describing the objects has been compiled with scrupulous care, and adds greatly to the educational value of the collections. Huxley's definition of a museum was that it is a consultative library of objects. The German Museum is a consultative library for the engineer and the man of science, and it is something more. It is an effective agency for the enlightenment and education of the masses.

BENNETT H. BROUGH.

FIG. 3.—An alchemist's laboratory of the sixteenth century.

## THE NORTH-WEST PASSAGE.[1]

STRICTLY speaking, the north-west passage was accomplished in 1847, when Franklin and his men, retreating from their abandoned ships to the north-west of King William Land, passed through Simpson Strait to the mouth of the Great Fish River, and so crossed the tracks of Dease and Simpson, who in 1839 had reached Castor and Pollux Bay from the west. The existence of channels at least continuous, and possibly navigable, from east to west was thus proved. Later, in 1853, McClure and his men, abandoning the *Investigator* in Mercy Bay, Banks Land, which point she had reached from the Pacific, retreated to the ships of Belcher's squadron, then wintering on the south-east of Melville Island, and ultimately reached home. This was the first party to complete the traverse of the American Arctic regions from ocean to ocean. Technically, McClure did the north-west passage, but he proved at the same time that his route was quite impracticable. The *Enterprise* under Collinson, the *Investigator's* companion ship, did more towards the discovery of the passage by reaching Cambridge Bay from the west. Consequently, the only part untraversed by a ship was from the north of King William Land to

[1] "The North-West Passage." Being a Record of a Voyage of Exploration of the Ship *Gjöa*, 1903–7. By Roald Amundsen; with a Supplement by Lieut. Hansen. 2 vols. Pp. xiii+335 and pp. ix+397; illustrated. (London: A. Constable and Co., Ltd., 1908.) Price 31*s.* 6*d.* net.

the south of Victoria Land. A link of only some 200 miles (by the most direct channels) was all that remained to be forged when Amundsen planned and equipped his expedition in the *Gjöa*. But these facts cannot detract from the interest of the two volumes before us; the length of the *Gjöa's* voyage, no less than its historical importance, justifies the many pages.

There is no doubt that Amundsen's expedition will live in the annals of polar exploration in virtue of the accomplishment of the north-west passage; but that was only its secondary aim. "Our first and foremost task was to obtain exact data as to the Magnetic Pole," says Amundsen, and he repeats it several times. It had long been his ambition to navigate the north-west passage, but with a praiseworthy self-denial he compelled himself to keep the fulfilment of this feat of navigation subordinate to his scientific researches in magnetism. And yet in perusing the pages of the book one feels that the adventurous spirit of the Norseman was kept in check with difficulty; the desire to accomplish the passage was uppermost in his mind, and when once the greater part of the magnetic work was behind him his hearty enthusiasm seems to have been redoubled. However, in spite of this, Amundsen retained the *Gjöa* for nineteen months in winter quarters on the south-east of King William Land so that he could fulfil his programme of magnetic work, and this notwithstanding the fact that he saw open water ahead, and in all probability no obstacle in his road to the Pacific. That was an exhibition of devotion to scientific work in face of the greater fascination of an adventurous voyage which is most commendable and by no means common in polar exploration.

The *Gjöa*—a vessel of only forty-seven tons—left Christiania in 1903, and traversing Lancaster Sound and Barrow Strait reached Peel Sound. Amundsen was fortunate in finding Peel Sound open, as Franklin did in 1846 (but not so M'Clintock in 1858), and encountering no difficulties he sailed down Franklin Strait and entered Ross Strait to the east of King William Land. Here he was in virgin waters, for although M'Clintock had sledged down this strait in 1858, the *Erebus* and the *Terror* had passed to the west of King William Land in ignorance that there was a passage to the east. It was Rae who discovered the insularity of that land, and he held the opinion—afterwards shared by M'Clintock—that the only navigable passage was along its eastern and southern coasts. The ice pressing southward through Victoria Strait, narrow and encumbered with islands as it is, must always prove as insuperable an obstacle as it did to the *Erebus* and the *Terror*. Amundsen had reason to congratulate himself on following Rae's advice in this matter. Passing along Rae Strait the *Gjöa* went into winter quarters in September in a snug little harbour on the south-east of King William Land, since christened Gjöa Haven. The situation admirably suited the requirements of the work, which, the author explains, demanded such a distance from the magnetic pole that the inclination would be about 89°. From this base frequent excursions were made in all directions, Amundsen himself sledging on one occasion northward as far as the locality of the magnetic pole in Boothia Felix. By his observations he proved the truth of the theory that the magnetic pole has not a stationary position, but, on the contrary, is in continual movement within certain limits.

During April, May, and June, 1905, Lieutenant Hansen, accompanied by Ristvedt, made a sledge journey to Victoria Land, and succeeded in charting, as far as 72° N., the western shores of M'Clintock Channel, the supposed breadth of which he found had been much exaggerated. The new coast was named King Haakon VII. Coast. In addition, the "land seen by Rae" in Victoria Strait, which proved to be a group of many islands, was charted, though the work seems to have been done somewhat roughly. These surveys included all the topographical work of the expedition; nowhere else did the explorers touch quite new land. In August, 1905, the westward journey was resumed, and after some tortuous navigation through an island group in the north of Queen Maud Sea, Cambridge Bay was reached—the "farthest east" of Collinson's *Enterprise*. Thence onwards until King Point was made navigation was relatively simple, but at that point the *Gjöa* was stopped by ice, and compelled to pass a third winter. In the summer following she reached Nome City, and ultimately San Francisco, where she now lies, waiting, we understand, for the completion of the Panama Canal to return to Europe.

FIG. 1.—King Point. Shore strewn with Driftwood. From "The North-West Passage."

Amundsen thus accomplished the north-west passage, and, moreover, found a route that would probably be practicable for a small ship in any year if only Franklin Strait could once be reached from the east. The greatest difficulty in the whole passage lies in entering Franklin Strait, for Peel Sound and Bellot Strait, both of which Amundsen found open, may just as likely be blocked with pack-ice, as M'Clintock found them. Neither Ross nor Rae Straits appear to give much trouble, though in thick weather navigation in the vicinity of the magnetic pole must be, as the *Gjöa* found it, somewhat hazardous. The Esquimaux insist that Simpson Strait breaks up every year, and while Queen Maud

Sea probably is seldom navigable, the passage through Palander or Markham Straits, though intricate, is possible; three fathoms was the shoalest water found.

Except for the work in Victoria Strait and M'Clintock Channel, the voyage can scarcely be called one of exploration. The greater part of the route was relatively well known and charted. The expedition was never absolutely out of touch with the civilised world. Even at King William Land they got a mail by Esquimaux from Cape Fullerton, Hudson Bay, while at King Point they were in the company of whalers, missionaries, and policemen. During that winter Amundsen made a journey to Eagle City to get into cable communication with Europe. The main scientific work, magnetism, was successfully carried out, and a good series of meteorological observations were taken, at least in winter quarters.

Amundsen tells his story in a lucid, interesting style, and, though the book would not lose by condensation in places, it is singularly free from the trivialities with which such volumes are often loaded. But an appendix of scientific results would have given more permanent value to these volumes.

One rather serious error on p. 59 should be mentioned. The author speaks of passing through Bellot Strait when he evidently only passed by the end of it.

A very full and accurate index is provided.

## *THE REPORT OF THE ROYAL COMMISSION ON THE CARE AND CONTROL OF THE FEEBLE-MINDED.*

TO whatever criticisms this report may be subjected it cannot truthfully be characterised as either pusillanimous or incomplete. It is to the credit

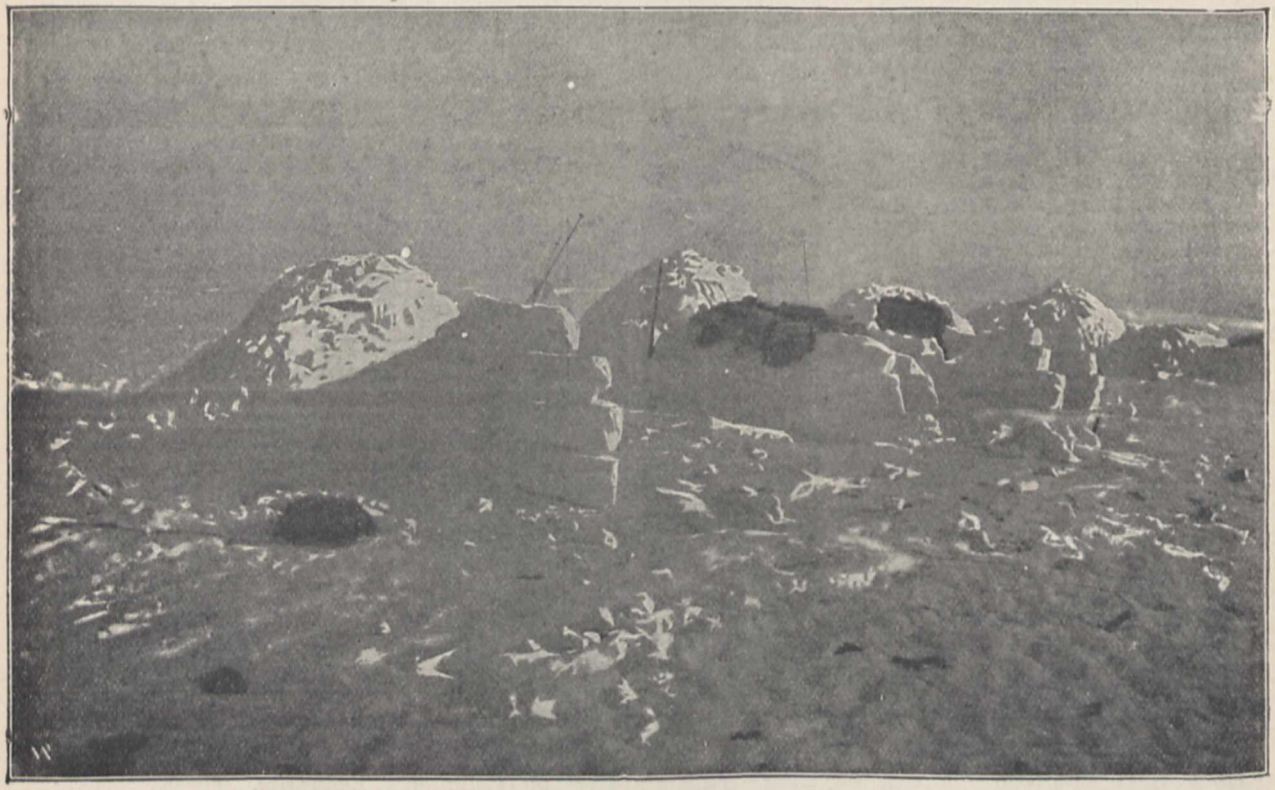


FIG. 2.—A Eskimo Camp in Winter Time. (Photograph taken at midnight.) From "The North-West Passage.

Lindström, the cook, was an enthusiastic collector of plants and animals, but, though one of the party was a geologist, we do not gather that geological observations and collections were made, except a few fossils at Boothia Felix and King William Land. That is a pity in view of the many opportunities that must have occurred during a voyage practically always within touch of land. Nor do we gather that any soundings were taken other than those essential for the navigation of the *Gjöa*; certainly none are indicated on the outline maps which accompany the volume. However, with regard to the Esquimaux encountered, very full information is given. The first two winters were passed in the company of the little-known Nechilli tribe. They appear to be one of the few tribes of Esquimaux who fortunately have had little or no contact with white men, though it was from members of this tribe that Rae got the news of Franklin's fate.

of the members of the commission that they have searched so thoroughly for their data and so fearlessly faced the numerous difficulties which the evidence presented to them. As a whole the report is broad-minded, eminently practical in its adjustment to the necessities of the situation, and conceived at once in a humanitarian and utilitarian spirit. Whether it is in advance of national ideas remains to be seen by the manner in which the legislature is prepared to deal with it.

The report necessarily opens up matter of great scientific interest; but the commissioners, perhaps wisely, have contented themselves with deducing from a mass of scientific evidence only such conclusions as bear upon the practical issues under their consideration. On the momentous question of the origin of mental defect, they remark somewhat plaintively (vol. viii., p. 179), "we found it practically impossible, and deemed it undesirable, to exclude from considera-

tion the great mass of evidence which was tendered to us in reference to the conditions and antecedents of mental defect, especially in the very large class of cases in which the evil dated from birth or from early life." The great majority of the witnesses who spoke specially on this question (among whom were Sir T. Clifford Allbutt, Sir E. Ray Lankester, Dr. Archdall Reid, and Dr. Bevan Lewis) regarded feeble-mindedness (where not accidental) as a germinal variation, a reversion to a more primitive type of brain, and a condition which is necessarily inherited. The trend of the evidence of these witnesses was distinctly opposed to the notion that causes such as faulty nutrition, wasting diseases, or alcoholism are of importance in the production of feeble-mindedness. Considerable evidence of a contrary kind was offered, but neither the authority of the witnesses nor the data upon which they relied was sufficient to shake what is at present the accepted teaching of biology. As might have been expected, an attempt was made by certain witnesses to put forward the opinion that the existence of mental defect in a community might be checked either by surgical or other artificial measures, or by placing obstacles in the way of the marriage of persons ascertained to be mentally defective. The commissioners repudiate these suggestions, but they nevertheless somewhat hesitatingly come to the conclusion upon the evidence submitted (vol. viii., p. 185), "(2) that especially in view of the evidence concerning fertility, the prevention of mentally defective persons from becoming parents would tend largely to diminish the number of such persons in the population." This is an opinion on which there is much room both for doubt and discussion. Many of the feeble-minded are the children of parents of average physical and mental health; a still larger number are children of neurotic parents, who are, however, of such mental integrity that no State would venture to prohibit their unions. The number of the feeble-minded who are descendants of obviously imbecile parents, while probably not inconsiderable, does not by any means form such a proportion of the class that the prevention of their existence would "largely" diminish the number. If mental unsoundness were a foreign strain introduced into a community, then it might possibly be extirpated in one of the several ways suggested; but as it is a germinal variation which, so long as individuals are not at a dead-level of mental endowment, must always arise anew, it is useless to propose means, adaptable to civilised societies, for checking its production. The alleged fertility of the feeble-minded referred to in the above quotation is contrary to general experience, which has hitherto rather pointed to an increasing sterility in direct ratio to the degree of the existing mental degeneracy. The existence of a special degree of fecundity on the part of the parents of the feeble-minded would require much fuller and more accurate statistical proof than has been produced by the promoters of the statement. The generally accepted view is that the more pronounced the feeble-mindedness the less fertile is the individual, and conversely, that the less feeble-minded the individual the more fertile he is likely to be. But feeble-mindedness is a term including a variety of mental conditions; on the one hand it embraces the absolute idiot, and on the other merges insensibly into the average mental level of the community. The attempt to prevent the union of the higher grades of the feeble-minded, who are also the most fertile, would thus be manifestly futile. The commissioners are, however, on safer ground when they suggest that some prevention in this respect is likely to be effected from the seclusion of the numbers of the feeble-minded with which their far-reaching recommendations propose to deal, for they say (*loc. cit.*) "(3) that the evidence strongly supports measures, which on other grounds are of pressing importance, for placing mentally defective persons, men and women, who are living at large and uncontrolled, in institutions where they will be employed and detained; and in this, and in other ways, kept under effectual supervision so long as may be necessary."

At p. 193 (vol. viii.) of the report a tabulated estimate of mentally defective persons (excluding certified lunatics) in England and Wales is given. From it may be seen that out of 149,628 such persons 66,509, or 44·4 per cent. of the whole, are practically unprovided for. The following abstract from the table is of interest:—

| | Number | Feeble-minded | "Needing provision." |
|---|---|---|---|
| School children ... ... | 6,044,394 | ... 47,515 | ... 35,804 |
| Paupers— | | | |
| (1) Indoor ... ... ... | 229,804 | ... 41,793 | ... 6,990 |
| (2) Outdoor ... ... | 532,778 | ... 12,308 | ... 4,790 |
| Prisoners ... ... ... | 21,221 | ... 1,942 | ... 1,608 |
| Inebriates in reformatories | 970 | ... 582 | ... — |
| Persons mostly under no public authority... ... | 25,576,697 | ... 45,488 | ... 17,317 |
| | 32,405,864[1] | ... 149,628 | ... 66,509 |

These figures amply justify the grave statement in the introduction to the report (p. 9), "there are numbers of mentally defective persons whose training is neglected, over whom no sufficient control is exercised, and whose wayward and irresponsible lives are productive of crime and misery, of much injury and mischief to themselves and to others, and of much continuous expenditure wasteful to the community and to individual families."

It is evident that the crux of the situation lies in the education and after care of feeble-minded children, 75 per cent. of whom are not only neglected in youth, but are more or less lost sight of in adult life. As means towards remedying these defects the recommendations of the commissioners appear sufficiently comprehensive. County councils or burgh county councils, as the case may be, are to be under statutory obligation to provide for the manual, industrial, or other training of mentally defective children who are not otherwise properly provided for; specially qualified medical officers of these bodies are to examine and report upon all such children, and, in case of doubt as to whether a child is mentally defective or merely "backward," the child may be placed upon a special probationary list and retained for such a period as may be considered necessary in a special class, school, institution or home for the mentally defective. Further, in the case of feeble-minded persons under twenty-one years of age who are not receiving suitable training, or are being cruelly treated or otherwise neglected, the local authority may, on the recommendation of their medical officer, assume all the rights of a parent or guardian until the child ceases to be a minor, subject to an appeal by the parents or guardians to a court of law. In the case of a person of feeble mind more than twenty-one years who is not suitably provided for, the local authority may, if it considers it necessary, present a petition as next friend of the mentally defective person with a view to his detention, control, or proper care.

Such, in brief, are the means suggested for the selection, registration, education, care, and, where necessary, the permanent control of the feeble-minded. Were these recommendations to become law there is good ground for believing that in course of time much social sordidness, petty delinquency, and domestic misery would be checked at its source. Under existing administrative conditions it is well known to be

[1] General population other than certified lunatics, &c.

initiated—and the testimony of many witnesses who gave evidence before this commission gives the fact publicity—that vagrancy, prostitution, petty delinquency, pauperism, and inebriety are the pitfalls into which numbers of the poorer and less protected feeble-minded ultimately stumble.

Mentally defective children do not, however, by any means exhaust the category of persons requiring to be dealt with in any scheme of reform aiming at comprehensiveness. In illustration let us take the question of delinquency. Among feeble-minded delinquents two classes may be distinguished :—(1) Intellectually feeble persons in whom the moral sense is either practically wanting or so imperfectly developed as to afford no guide for conduct. (2) Those in whom the intellectual faculties are of average development, but who are either morally perverted or who possess such feeble moral resistance when the mind is crossed by certain emotional currents as to be practically irresponsible. Now it is evident that persons of the second class may up to adult age evade all ordinary tests applied for the detection of feeble-mindedness and afterwards manifest by their conduct such persistent moral obliquity as to raise the question of their mental responsibility. Many such persons pass most of their time in gaol as short-sentence prisoners, repeatedly convicted week after week on account of drunkenness, breaches of the peace, pilfering, &c. It may be that most of them are inebriates, but they are, in addition, weak-minded, irritable, profligate, and lacking in self-control in other directions than indulgence in alcohol. The entire uselessness of these repeated convictions is apparent, and the expenditure of money upon police, judicial procedure, and maintenance in prison must necessarily be greater than if these individuals, in accordance with the recommendations of the commissioners, were committed to homes or colonies on indeterminate sentences, where they might, to a certain limited extent, at any rate, be partially self-supporting. The recommendations in the report would make it obligatory upon the police and prison authorities to report such cases to the local authority, and upon the medical officer of the latter to act upon such reports.

In order that such notification may be of practical utility, it is necessary to reform the procedure under the various criminal lunacy acts. To this end the commissioners recommend that when a court of summary jurisdiction is of opinion that a person charged is mentally defective the court may (1) remand the person charged to a receiving house or institution for observation, or (2) make out a summary order for the reception of such a person into an institution on the certificate of the medical officer, or (3) after conviction may hand him over to the care of an officer of the local authority who becomes surety for his conduct. Such a person would remain under the care of the local authority until it sees fit to discharge him. Similarly in assize and quarter sessions' cases the justices may hand a feeble-minded prisoner over to the local authority pending trial; or when brought to trial the court may direct that the accused be submitted to examination, and, if necessary, certification, notwithstanding that he has been acquitted of the offence charged, if it is considered desirable that provision should be made for his care.

The analysis of the various types of the mentally defective, with their peculiarities and special dangers and inconveniences to society, and the many suggestions in the report for dealing with them, might be indefinitely prolonged and criticised, but sufficient has been said to indicate the wide scope of the field traversed by the commissioners. It remains to examine cursorily the machinery which the commission proposes for carrying out its recommendations. With logical consistence it urges that one central authority in each of the three kingdoms should have the control of all the mentally afflicted, and that that authority should be the existing lunacy commissions, enlarged and suitably equipped for the purpose. The advantage of having one central authority to supervise the care of all classes of the insane is apparent, and the withdrawal of certain classes of the insane from the control of such departments as Education and Local Government, where official interests are necessarily directed into totally different channels, needs no apology. Moreover, experience amply shows that progress in scientific and administrative knowledge is best attained when those at the head of any such department have at any rate such interest in its welfare as to encourage scientific pursuit in connection with it. With equal wisdom it recommends the utilisation of existing local authorities—in England and Ireland a statutory committee of county councils or borough councils, as the case may be, and in Scotland the district lunacy board. These local authorities shall, subject to the supervision of the central authority, have the entire control of all insane, feeble-minded, or mentally affected persons within their jurisdiction who are not otherwise adequately cared for privately, and it shall be their duty to provide such accommodation as is suitable to the various classes, *e.g.* asylums for the insane, training schools for imbeciles, colonies or private homes for the mentally enfeebled, &c.

A question of great importance both in its bearing on the liberty of the subject and the proper inclusion of every class of the mentally afflicted within the scope of the proposed measure is the form of the medical certificate prescribed.

The commissioners recommend that the word "lunatic" in the ordinary medical certificate be deleted and replaced by the words "mentally defective person." So far as comprehensiveness goes this is admirable. Whether it is a sufficiently accurate term to merit universal acceptance is another matter. There will, however, be general agreement with the resolution that the word "lunatic" shall be henceforth discontinued as a descriptive term, that "asylums" shall be called "hospitals," that the Board of Commissioners in Lunacy shall be called "The Board of Control," and that the term "mentally defective" shall be defined in the proposed Act as comprising "persons of unsound mind," mentally infirm persons, idiots, imbeciles, feeble-minded persons, moral imbeciles, epileptics, and inebriates who are mentally affected, and deaf, dumb, or blind persons who are also mentally affected. It is only by such a radical change in nomenclature that the object of including all these classes in one legal category could be attained, though the definite term suggested may not, as has been hinted, be the most appropriate.

With regard to the financial aspect of the proposed scheme, it will probably be much more formidable than the estimate given by the commissioners on p. 295 of the eighth volume of the report. Against the danger of any excessive financial burden being laid upon the country as the result of an Act, based upon the report, becoming law, it must be borne in mind that the great majority of the mentally unsound in the country are already under care—more or less perfect, and more or less expensive. The transference of those already under care from one form of administrative control to another ought not to entail any great additional expenditure; but the cost of the more perfect provision for some 60,000 feeble-minded persons in England alone is an item which cannot be lightly entertained. If, however, the other side of the account—the social dilapidation and degradation, the useless penal measures, the illegiti-

macy, and the pauperism with which such persons already burden the ratepayer—is kept in view, it is doubtful if the expense of their maintenance in decent surroundings can much exceed the wastage resulting from their present condition of so-called freedom.

## NOTES.

AT the meeting of the Paris Academy of Sciences on Monday last a letter was read from M. Jean Becquerel stating that his father, the late M. Henri Becquerel, had left the sum of 100,000 francs to the academy in the following terms:—"I bequeath to the Academy of Sciences the sum of 100,000 francs (4000*l*.) in memory of my grandfather and father, who were, like myself, members of your academy. I leave to it the responsibility of determining the best use which it can make of the interest on this capital, whether by creating an endowment or prize, or by distributing this income in a manner calculated to encourage the progress of science."

COLONEL SIR DAVID BRUCE, C.B., F.R.S., accompanied by Captains H. R. Bateman and A. E. Hamerton, Sergeant A. Gibbons and Mr. James Wilson, is about to sail for Uganda to investigate further the pathology of sleeping sickness. On arriving at Mombasa, the commission will travel by the Uganda Railway to the terminus at Port Florence, whence the lake will be crossed to Kampala. The headquarters of the work will be selected two miles from the lake shore in a wild and depopulated region in the province of Chagwe. Here the Uganda Government has been preparing a laboratory and station for the purposes of the mission. It is expected that the work will occupy about nine months.

A REUTER telegram from Simla, dated September 14, states that Dr. Sven Hedin has arrived at Fagu, twelve miles from Simla, in excellent health. During his travels he has been quite isolated in the wilds, and saw no white face until he reached Poo, in September, 1907, where the Moravian Mission offered him hospitality. Dr. Sven Hedin has, it is stated, travelled more than 4000 miles, mainly in western Tibet, and has made some noteworthy discoveries, regarding which he is very reticent for the present. He made extensive geological maps during his journey, the cost of which he estimates at more than 5000*l*. Dr. Hedin intends halting at Simla for ten days, and will then proceed direct to Sweden, and thence to London, where he has been invited to lecture by the Royal Geographical Society.

SINCE the time of going to press with our last number several successful flights have been made in America by Mr. Orville Wright in his aëroplane, the records of M. Delagrange and other competitors being easily beaten. On the morning of September 9 he stayed in the air 57m. 31s., and later in the day he flew for 1h. 2m. 15s., while on September 10 and 11 respectively he made new "world's records" by flying for 1h. 5m. 52s. and for 1h. 10m. 24s. On September 12 he was accompanied by Major George Squier, the acting chief signal officer, as a passenger, and remained in the air for 9m. 6s., flying at a speed of thirty-eight miles per hour. Major Gross, in the German military airship, made a circular tour on September 11 from Tegel, by way of Rathenow and Stendal, to Magdeburg, and thence back to Berlin, the trip lasting 13h. 2m. The previous longest flight—that of the *Zeppelin IV.*—lasted, it will be remembered, 11h. 50m.

THE death is announced, at the age of sixty-eight years, of Mr. John T. Taylor, I.S.O., for many years assistant-secretary to the principal librarian of the British Museum. Mr. Taylor superintended the arrangements for the removal of the natural history collections to South Kensington, and was on special service at the Natural History Museum from 1880–4.

BY the death on September 2 of Dr. Theodor Peters, the Society of German Engineers has lost its director. During the greater part of his connection with the society, extending over a period of twenty-five years, Dr. Peters was identified with all the changes made in the important institute under his guidance, and notably with the improvement and augmentation of the journal, the *Zeitschrift des Vereines deutscher Ingenieure*, the prosecution of systematic researches on points of mechanical and engineering interest, and the publication of such reports, not only in the current numbers of the journal, but as independent pamphlets, making the results accessible at merely nominal cost.

THE Huxley lecture of the Charing Cross Hospital Medical College, on "Recent Advances in Science and their Bearing on Medicine and Surgery," will be delivered on October 1 by Sir Patrick Manson, K.C.M.G., F.R.S.

THE medals, prizes, &c., will be distributed to the successful students of the Imperial College of Science and Technology, South Kensington, on Wednesday, October 7, by Sir William H. White, K.C.B., F.R.S. The rector, Dr. Henry T. Bovey, F.R.S., will deliver an address.

THE third International Congress for the Care of the Insane will be held on October 7–11 at Vienna. The subjects to be brought under consideration will be divided up into nine sections as follow:—(1) collective descriptions of the present state of the care of the insane in different countries; (2) the medical treatment of the insane; (3) provision for the insane from the building or architectural point of view; (4) administration; (5) insanity and insurance; (6) comparative lunacy law; (7) the care of idiots, epileptics, and the feeble-minded; (8) report of the International Committee upon the proposed establishment of an international institution for the study of the causes of insanity; and (9) the insane in the army.

THE eighth Australian Medical Congress will meet in Melbourne on October 17–24 next.

THE third International Congress of School Hygiene is to be held in Paris from March 29 to April 2, 1910. In connection with it there is to be an exhibition of everything concerned with school hygiene. Information respecting the congress can be obtained from M. Dinet, 11 bis Rue Cernuschi, Paris, but inquiries concerning the exhibition should be addressed to M. Friedel, Musée Pedagogique, 41 Rue Gay-Lussac, Paris.

AN International Industrial Exhibition is to be held at Turin from April to October, 1911, and will be divided into the following sections:—education, mechanics, electricity, photography, colonisation, national defences, measuring instruments and apparatus, public works, transportation (railways and tramways), mercantile navigation (sea, river, and lake), aërial navigation, postal services, sporting industries, modern town (dwelling, decoration, furniture), agricultural and forest industries, food industries and products, wearing apparel and leather industries, jewellery, printing, &c.

IN addition to the papers announced for reading at the autumn meeting of the Iron and Steel Institute (see NATURE, August 27, p. 398), a paper will be read by Mr. William Hawdon on the progress in the Cleveland iron

and steel industries during the past quarter of a century, that is, since the previous visit of the institute to Middlesbrough in 1883. The paper promised by Messrs. J. E. Stead and T. Westgarth is to be held over until the next meeting.

PROF. VON LEYDEN, of Berlin, and Prof. Czerny, of Heidelberg, have been elected, respectively, honorary president and president of the International Association for the Investigation of Cancer, which was founded at Berlin in May last.

ACCORDING to the *Lancet*, Prof. Krämer, senior staff-surgeon in the German Navy, has been appointed to the charge of the scientific expedition now being fitted out for the Antarctic Ocean.

THE publication of a monthly bulletin intended for the information of local health authorities and others interested in public-health work, and to keep them in touch with what is going on at headquarters, and in Western Australia as a whole, has been begun by the Department of State Medicine and Public Health of Western Australia. The body immediately responsible for its publication is the Central Board of Health, the president of which is Dr. T. D. Lovegrove.

TO mark the completion of the fiftieth year of the existence of the Geologists' Association, it is proposed to issue a volume dealing with the geology of the districts of England and Wales visited by the association since its foundation. The work, which will be edited by Messrs. H. W. Monckton and R. S. Herries, will be illustrated by maps and sections, and be ready for publication, it is hoped, before the end of the present year. Orders for copies should be sent to the secretary of the association.

ACCORDING to information received from Copenhagen, experiments in high-speed wireless telegraphy have recently been carried out by Mr. Poulsen, the Danish engineer. The experiments, which were conducted between the stations at Lyngby, near Copenhagen, and Esbjerg, on the west coast of Jutland, are declared to have resulted in the transmission of about 100 words per minute, and the inventor calculates that he will soon succeed in telegraphing 150 words a minute. It is added that the trials will, in the immediate future, be continued between Lyngby and Tynemouth, and new stations are being erected on the west coast of Ireland and in Canada, between which the high-speed system is to be employed.

THE recently issued report of the chief sanitary officer of Cuba regarding the destruction of the mosquito in the island is most encouraging. The town of Palmira, where yellow fever occurred as lately as January of this year, has been so thoroughly cleaned that in a recent inspection not a single deposit of larvæ was found in 112 houses examined. Similar good results have been secured in other provinces. In zones once noted for the prevalence of yellow fever the Stegomyiæ have been reduced below the yellow-fever limit. In Havana mosquito breeding is practically at an end, as a breeding place was found in only one house in 450 inspected, and of these considerably less than one-half were found to be Stegomyiæ.

ACCORDING to the annual report for 1907, a radical change has been inaugurated in the administration of the Marine Biological Association for the West of Scotland, and financial matters have, it is hoped, been placed on a more satisfactory footing. The committee has also expressed its intention of running the institution on strictly scientific lines, the systematic survey of the Clyde area being one of the first subjects for investigation.

THE summer of 1908 will, we learn from the September number of the *Entomologists' Monthly Magazine*, stand as a good year for clouded yellows, this being the first season since 1904 that this erratic butterfly has made its appearance in considerable numbers in the Isle of Sheppey. Most of the specimens taken were males, and all were in fine condition and colour. Pale clouded yellows have not been seen in Sheppey since 1902.

IN the *Irish Naturalist* for September Prof. G. H. Carpenter records two species of spring-tails (Collembola) as new to the British fauna. One of these was observed on a crop of tobacco, the cultivation of which has probably led to a great increase in the numbers of these minute insects. In the same issue a small gephyrean worm (*Petalostoma minutum*), typically from the Normandy coast, has been added to the Irish fauna. In No. 15 of the first volume of Economic Proceedings of the Royal Dublin Society (may we venture to call this a distinctly Hibernian title?) Prof. Carpenter gives an account of the injurious insects, &c., observed in Ireland during 1907. The fact of the caterpillar of the common rustic moth (*Apamea didyma*) feeding within the sheath-leaves of oats and barley appears to constitute a new record. A saw-fly (*Nematus maculiger*), hitherto known as feeding—in the larval state—on willow, has been detected in Ireland on larch, but beyond this there is little in the way of novelty in the year's account.

THE *Museums Journal* for August contains an editorial article on recent correspondence in connection with the British Museum (Natural History), and the deputation to the Prime Minister on the same subject. The author of the article shares Mr. Asquith's inability to realise the shortcomings of the Museum referred to by the deputation, and adds that an inquiry into the working of that institution is not likely to be granted so long as criticism is based on purely theoretical considerations. It is suggested, however, that the trustees should include more men with a practical knowledge of museum work. "Eminence in certain branches of natural science," it is added, "does not necessarily fit a man to govern a great museum any more than does eminence in law or in theology."

CHRISTOPHER MERRETT (1614–1695) forms the subject of the third part of "Early British Ornithologists," which appears in the September number of *British Birds*. Merrett, it appears, was the author of a work entitled "Pinax [= a list, or index] Rerum . . . Britannicarum," published in London in 1666, which contains a list of the birds of the country. Although extremely meagre, this list was the first attempt of its kind published.

IN *Biologisches Centralblatt* of August 15 Mr. O. Lehmann brings to a conclusion his interesting account of "scheinbar lebende Kristalle," in which he claims to have observed representatives of pseudopodia, cilia, and muscles.

IT was reported by the Departmental Committee on Irish Forestry that the amount of land in Ireland available for forestry purposes is much less than is generally supposed. This is explained by Mr. A. C. Forbes in an article communicated to *Irish Gardening* (September). He advocates the establishment of nurseries by county councils to grow trees suitable for road-side planting, and for supply to farmers, who may be encouraged to help towards increasing the timber area in the country.

IT is more than ten years since the disease known as root disease of sugar-cane was referred to the basidiomycetous fungus *Marasmius sacchari*; the fungus has

been identified in the West Indies, Hawaii, and Java. Although various mycologists have had the subject under investigation, there is still a good deal to be learnt with regard to its growth and the best methods of prevention. Mr. F. E. Stockdale has rendered useful service in collecting available information in a paper published in the West Indian Bulletin (vol. ix., No. 2). He expresses the opinion that there is a reasonable possibility of checking the disease by the application of Bordeaux mixture and lime, and refers to the resistant property manifested by some of the West Indian seedling canes.

THE Circular (vol. iv., No. 9) prepared by Mr. H. F. Macmillan, and issued from the Royal Botanic Gardens, Ceylon, on the acclimatisation of plants, offers several points for reflection. It furnishes evidence that the inhabitants of tropical countries, as much as of countries in temperate latitudes, have derived the greater part of their edible and economic products from exotic plants. Tea, coffee, cacao, rubber of all kinds, pine-apples, mangoes, and oranges have all been introduced into Ceylon; even the cocoa-nut palm, although of uncertain origin, is not indigenous. The author also differentiates between naturalised and acclimatised plants, and makes the broad generalisation that plants in which the reproductive period is normally prolonged are more easily acclimatised. The circular contains lists of acclimatised plants in Ceylon, naturalised weeds, and naturalised plants that have not become pests.

A REMARKABLE form of copper-rod currency, known to the natives of the north-east Transvaal as Marali, is described in the August number of *Man* by Dr. A. C. Haddon and Mr. H. D. Hemsworth, of which only two specimens are believed to have reached this country. Each example consists of a straight rod of copper about 49 cm. in length, with an average diameter of 13 mm. One end is attached to the rounded apex of a flattened, oval, conical projection, the plane of which is set at a little more than a right angle to that of the rod. Peculiar markings on one specimen seem to indicate that the bore used for the casting was made by covering a reed with earth, and that in this case, the reed having split, the coppersmith had enveloped it with bands to keep it in its proper shape. This form of currency was used chiefly in the purchase of brides by the chiefs, and each rod seems at one time to have represented the value of ten cows, the ordinary exchange price of a wife. Similar rods, which Mr. G. W. Stow in his "Native Races of South Africa" (p. 518) was inclined to regard as Madulas or phallic charms, appear to be examples of this remarkable form of currency.

IN the *National Geographic Magazine* for August Mr. T. Balfour contributes an account of the natives of Humboldt Bay, in Dutch territory, on the northern coast of New Guinea. Ethnologists will be interested in his description of their sacred drums and flutes, the latter so long that when "two men each takes one of these instruments and stand opposite each other, they blow into the end of the bamboo, and the length runs out so far that each man straddles his partner's flute." Their temples are taboo to women, and Mrs. Balfour experienced much difficulty in securing entrance and a sight of the sacred objects. The architecture is peculiar, the building consisting, as it were, of three cones superimposed one upon another, that at the summit being the smallest. Their modes of disposal of the dead range from desiccation to inhumation. The pestilential climate and the unfriendliness of the people offer little encouragement to the explorer of this portion of the island.

THE August number of the Bulletin of the American Geographical Society contains an interesting article, by Mr. J. D. Hague, on the discoveries of Sir Francis Drake, accompanied by reproductions of the Drake commemoration medal recently issued by the American Numismatic Society—the third of the series, the two earlier ones being, respectively, one in honour of Americus Vespucius, issued in 1905, and one in memory of John Paul Jones, issued in 1906. The medal now referred to represents a bust portrait of Sir Francis, which Prof. Rudolph Marschall, of Vienna, with the aid of photographic copies taken specially for this work, by the courtesy of Lady Drake, has produced from an oil painting from life by Abraham Janssens, continuously in the possession of the family, and now at Buckland Abbey, Devon. The reverse of the medal is a reproduction, as a partial facsimile, of one side (the western or Pacific hemisphere) of the celebrated silver medal or "map of the world," which is generally believed to have been made shortly, or, at most, within a few years, after Drake's return from his "world-encompassing" expedition, and concerning which the late Sir John Evans wrote in terms of high praise when directing the attention of the Royal Numismatic Society to it.

AN interesting note on the history of the knowledge of steel has been published in the *Revue de Métallurgie* (vol. v., No. 1) by Dr. Carl Benedicks, of Upsala University, the recipient this year of the Iron and Steel Institute's Carnegie gold medal for research. The difference between wrought iron, steel and cast iron, the varying proportion of carbon, was first demonstrated by Torbern Bergman in 1781. Linnæus (Pluto svecicus, 1734) describes steel as iron without sulphur, and the views adopted at that epoch were (1) that steel contained less "sulphur" than iron (Rohault and Polhem, 1740), and (2) that steel contained more "sulphur" than iron (Cramer, Gellert, Macquer, von Justi, Spielmann). The term sulphur at that period included all inflammable matter, such as asphalt and coal. The author directs attention to a forgotten French work, published anonymously in 1737, under the title of "Traité sur l'Acier d'Alsace, on l'Art de convertir le Fer de Fonte en Acier" (Strassburg). The writer of this work was an elder brother of Gilles Augustin Bazin, a Strassburg physician. Like Réaumur, he rejects the view that steel is purer than ordinary iron, and realises that steel must be made by adding a certain quantity of extraneous matter to wrought iron, or by removing foreign matter from pig iron. He had an exceptional knowledge of steel and of its thermal treatment, and his book deserves a place beside the monumental works of Réaumur and Swedenborg (1753). A Swedish translation of Bazin's book was published at Stockholm in 1753.

A SHORT note on the study of sea-quakes in the Mediterranean, by Prof. G. Platania, of the R. Istituto Nautico, Catania, appears in the August number of the *Rivista Maritima*. Prof. Platania proposes to undertake an exhaustive study of this subject, and appeals for information and records.

THE *Rendiconti* of the Reale Istituto Lombardo, vol. xli., contain a paper by Dr. Gorini on lactic acid fermentations of milk (fasc. xiii.), and one by Prof. Bordoni-Uffreduzi on diphtheria (fasc. xiv.–xvi.). In this it is shown that since the introduction of antitoxin treatment the number of cases of diphtheria in Milan has fallen from 1053, with 330 deaths, in 1896, to 657 cases, with 85 deaths, in 1907, a diminution of mortality per 10,000 living from 7·3 to 1·5.

THE *Atti della Fondazione Scientifica Cagnola* (xxi.) contains the reports of committees appointed to consider the merits of various prize essays submitted. The remainder (and greater part) of the volume contains an elaborate essay, by Dr. Moschini, on the supra-renal capsules, accompanied with a bibliography of fifty-five pages, and illustrated with some excellent coloured plates and tracings.

## OUR ASTRONOMICAL COLUMN.

COMET 1908*c*.—A set of elements and an ephemeris for comet 1908*c* have been computed by Herr H. Kobold, from observations made at Rome on September 3 and at Copenhagen on September 4 and 5, and are published in a supplement to No. 4272 of the *Astronomische Nachrichten* (September 4). The following are taken therefrom :—

*Elements.*

T = 1908 December 24·3175 M.T. Berlin.
$\Omega$ = 174° 13′·13
$\omega$ = 105° 3′·31 } 1908·0
$i$ = 140° 36′·58
log $q$ = 9·96412

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

| 1908 | α app. h. m. | δ app. ° ′ | log $r$ | log Δ | Brightness |
|---|---|---|---|---|---|
| Sept. 18 | 1 16·1 | +75 39·9 | 0·2651 | 0·1325 | 2·1 |
| ,, 20 | 0 40·7 | +76 17·2 | | | |
| ,, 22 | 0 0·4 | +76 31·9 | 0·2530 | 0·1039 | 2·5 |
| ,, 24 | 23 17·2 | +76 18·0 | | | |
| ,, 26 | 22 34·6 | +75 31·5 | 0·2405 | 0·0767 | 3·0 |
| ,, 28 | 21 55·5 | +74 12·1 | | | |
| ,, 30 | 21 21·8 | +72 22·2 | 0·2277 | 0·0520 | 3·6 |

The hazy, moonlit skies of the past week have militated against the observation of the comet in London, but, as will be seen from the ephemeris, the comet is becoming brighter, and will remain visible throughout the night during the present month, so that observations of it are very probable. The accompanying chart shows the

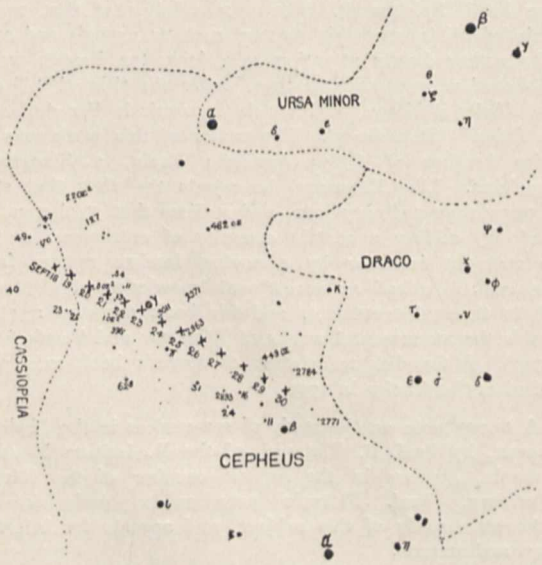



Chart showing apparent path of Comet 1908*c*, September 18–30.

apparent path of the comet, through the constellation Cepheus, for the remainder of September. It may be noted that at midnight on September 23 the comet will be about 4m. E. and 36′ S. of the 3·5 magnitude star γ Cephei.

Observations made by M. Giacobini at Nice on September 3, 4, and 5, and published in No. 10 of the *Comptes rendus* (September 7, p. 474), showed that the comet then appeared as a round nebulosity, of some 15″ to 20″ diameter, having an ill-defined nucleus and a feeble condensation. A small tail, in position-angle 250°, was suspected. When the field was illuminated gradually, the comet disappeared with stars of the eleventh magnitude.

OBSERVATIONS OF JUPITER.—In No. 4272 of the *Astronomische Nachrichten* (p. 389, September 4) Prof. Barnard briefly discusses some of his observations of the Great Red Spot, and directs particular attention to the peculiar repellent action of this spot, acting on the material of the south equatorial belt to form the Red Spot Bay. In the earlier observations of 1879, and again in 1885 and 1886, the bay was strongly marked, the material north and following the spot on the southern edge of the equatorial belt being apparently repelled, and leaving a clear, symmetrical interval between the main body of the belt and the spot itself. Since then the spot has, to a great extent, lost its red colour, and has, apparently, become greatly enfeebled, yet this repellent action has apparently persisted as strongly as ever; at the present time the matter of the equatorial belt has advanced so far southwards as to enclose completely the spot, yet a clear, narrow space, symmetrical in figure with the spot, isolates the latter object entirely from the surrounding material of the belt.

In the same journal Father Chevalier, of the Zô-sè Observatory, places on record the results of his observations of an occultation by Jupiter of the star BD + 19°.2095 on May 21.

THE FRANKLIN-ADAMS PHOTOGRAPHIC CHART.—In a letter to the *Observatory* (p. 354, No. 400, September) Mr. Franklin-Adams states that, with propitious weather conditions, he hopes to finish his chart photographs of the northern hemisphere early in October. Those already completed have proved so successful that he fears that some of the plates for the southern hemisphere will have to be repeated in order to compare favourably with the northern plates. The counting and classification of the star images is to commence at once, experimentally and tentatively, and Mr. Franklin-Adams intends to lay his proposed method before an early meeting of the Royal Astronomical Society in order that he may receive the general advice of those experienced in such work.

ANOMALOUS FORMS OF THE CALCIUM LINE, K, IN PROMINENCES.—In No. 24, vol. ii., of the *Mitteilungen der Nikolai-Hauptsternwarte zu Pulkowo*, Prof. Belopolsky discusses the results obtained during 1906–7 in a photographic research on the anomalous forms of the "K" line of calcium in prominences photographed at the sun's limb.

The object of the observations was to study the motions of material at the sun's surface, and to provide data for the discussion of the question of anomalous dispersion. Prof. Belopolsky gives three plates of reproductions of some of the forms recorded, together with full details of the measurements and a brief discussion of the results.

THE HYPOTHETICAL PARALLAXES OF DOUBLE STARS.—From a study of fifty-four binary stars of which the proper motions are generally known, and for which he has calculated the hypothetical parallaxes, Dr. Doberck has obtained some interesting results, which he states briefly in No. 4271 of the *Astronomische Nachrichten*.

On the assumption that the annual parallax is, on the average, one-fifteenth of the proper motion, the masses of the two components should average thirty-six times that of the sun, but in the few cases where the parallax has been determined it is indicated that each single star is, on the average, only some 1·3 times the mass of the sun. It is also shown, in these results, that the hypothetical parallax amounts to about one-seventh of the proper motion where the latter is large, is equal where it is small, and is about 0″·03 where the proper motion is too small to be determined.

From the figures given it appears that the hypothetical parallax is not a function of the magnitude; even in the case of stars of the sixth magnitude, at which rapidly revolving double stars are most common, the individual results differ greatly *inter se*, whereas hypothetical parallax and proper motion are very closely related.

## METEOROLOGY OF THE INDIAN OCEAN.[1]

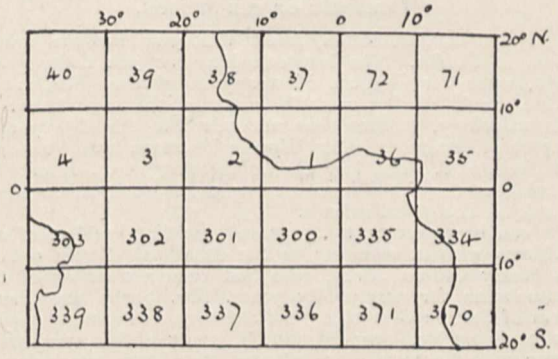
THE present volumes form a noteworthy contribution to the systematic knowledge of the meteorology of the sea on the lines laid down by the International Congress held in London in 1874. According to that plan the surface of the earth is divided by parallels of latitude and meridians, each 10° from the next, into sections numbered consecutively, starting from the square 0–10° N. and 0–10° W. of Greenwich, and proceeding west as indicated in the accompanying figure.

The observations from the meteorological log-books are then sorted according to the squares in which they are taken, and after a sufficient number has been obtained a definite scientific record of the meteorology of the region is made possible. If we look at it from another point of view, we might say that a knowledge of the "climate" of the different parts of the ocean may be obtained by this method.

The publications give the result of fifty years' observations, and some idea of the magnitude of the labour involved in reducing them to a form in which they are available for the sailor and the meteorologist may be gained from the fact that for each month about half a million observations had to be treated.

The tables give the values of the various elements for a large number of single degree squares in the following groups of 10° squares:—Nos. 63–69, 24–32, 323–332, 359–368, 396–406, 430–442, 466–478. These squares cover the whole of the Indian Ocean from Africa to Australia down to 50° S. lat.

The charts are not merely diagrammatic representations of the information contained in the tables. The guiding




principle in their construction has been to exhibit such information as a sailor will find useful, without overloading the map with unnecessary details or results of doubtful utility. On this account, also, the charts of cloud distribution, of rain and of fog, have been omitted from the present issue. The charts show the ocean current, the wind, the general circulation of sea and air, the mean pressure distribution, and the isotherms for the surface of the sea and for the atmosphere for each of the months September, October, and November. There are, in addition, three charts giving for each month the best routes for steam and sailing ships, at the same time showing the trajectories of cyclones and the northern limits of fog and floating ice.

An interesting result immediately seen on comparison of the wind and current charts is the fact that in regions where the wind is fairly steady in direction the ocean current flows to the left of the direction of the prevailing wind. Thus in the region of the trade winds, which blow from the south-east during these months, the ocean current flows steadily due west at an angle of 45° with the wind, while further south, where the prevailing wind is W. to W.N.W., the prevailing current comes from W. to W.S.W., although the regularity of the deviation is not so marked. This may be compared with Nansen's observations during the drifting of the *Fram* in northern latitudes. He found the direction of drift deviated 20°–40° to the right of the wind direction. The theory has been developed by Ekman (*Arkiv för Matematik*, vol. ii., No. 11), who found that in the open ocean, while the depth of the wind-produced current varied with the latitude, the deviation, an effect of the earth's rotation, was independent of the latitude and equal to 45°, except in the immediate neighbourhood of the equator. The current caused by the trade winds, on reaching the African coast, is deflected towards the south, and produces a marked effect on the temperature of the sea off the coast of Natal, where it is fully 5° C. warmer than in the same latitude in the open ocean or on the Australian coast.

A point especially worthy of commendation is the insertion in the tables of the number of observations on which each result is based. In the charts, too, the number of observations utilised for each 5° square is given. It is thus easy to see at a glance if an apparently anomalous result is doubtful owing to insufficiency of observations or really represents a feature worthy of investigation. In the pressure charts not only are the mean isobars drawn, but the mean pressure for each 2° square is inserted, one of the principal reasons for this being that small departures from the normal value in the barometric height are frequently in tropical regions a valuable indication of approaching cyclonic disturbances.

An important feature in the tables is the representation of the stability of the ocean currents and the wind. The value of this is taken to be the ratio of the resultant velocity to the mean velocity taken without regard to direction. It furnishes the sailor with an estimate of the probability of his meeting with the current or wind indicated by the resultant. It is an attempt at scientific statistical forecasting which will probably be further developed.

The number of observations of rain is given as a percentage of the total number of observations for each square, but no information is given regarding the amount of rain. No observations of humidity are published, an omission to be regretted in view of the importance of water-vapour both climatologically and in the thermodynamics of the atmosphere. E. G.

[1] Koninklijk Nederlandsch Meteorologisch Instituut, No. 104. Oceanographische en Meteorologische Waarnemingen in den Indischen Oceaan, September, October, November, 1856–1904. Tabellen en Kaarten. (Utrecht: Kemink & Zoon, 1908.) Prijs (met atlas) 5.50 fl.

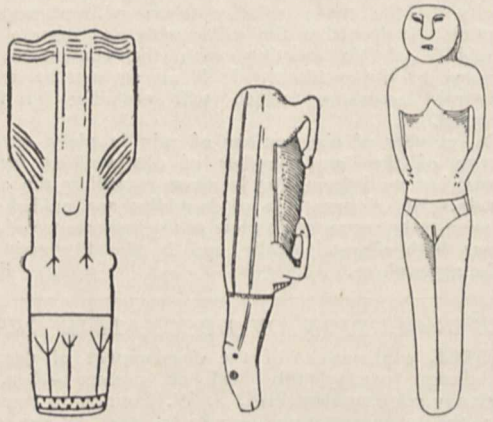
## THE EVOLUTION OF DECORATIVE DESIGN.

THREE explanations of the development of decorative design occupy the field at present:—first, that originally suggested by Prof. F. W. Putnam in connection with the ornamentation found on the pottery of the Chiriqui Indians, and independently advocated in this country by Mr. H. Balfour and Dr. A. C. Haddon, that conventional designs are developed from attempts at realistic representations, which gradually degenerate into a purely conventional representation, in which, at its later stages, the realistic origin can hardly be recognised; secondly, that of Semper, which emphasises the influence of material upon the development of the design; thirdly, the theory that the explanations of conventional motives are essentially secondary in character, and are due to the later association of the existing decorative forms with realistic designs. This last, the view propounded by Mr. A. L. Kroeber, Clark Wissler, and Dr. Franz Boaz, has now been re-stated and supplemented by fresh arguments and material by the last of these writers in a paper on the "Decorative Designs of Alaskan Needle-cases," published in vol. xxxiv. of the Proceedings of the United States National Museum.

This group of objects in their most generalised type displays the following features:—a tube slightly bulging in the middle; flanges at the upper end; small knobs under the flanges; a long concave face at the upper end of the tube; long parallel lines with small forks at their lower ends setting off the concave face; border designs consisting of lines at the upper and lower ends of the flanges and on the concave face; and an alternate-spur band at the lower end of the tube. The case itself is formed out of a strip of skin pulled into a tube, which protects the needle against breakage; and its most peculiar feature is a pair of wings or flanges at the upper end, below which are two small knobs on opposite sides of the tube.

This form of ornamentation is believed to be peculiar to Eskimo work, and does not occur in those parts of America or Asia which are beyond the sphere of Eskimo influence. The controversy, as now stated, turns mainly upon the diminutive knobs found in the Eskimo needle-case group, which appear to serve no practical end, and are, it is believed, purely conventional. This type of conventional ornament, according to the view of Dr. Boaz, is found to develop gradually into an animal design, such as that of a crouching beast, the knobs in the assumed later forms becoming heads, such as those of a seal, or even a partially or fully draped human figure, curiously reminiscent of the growth of the aniconic Greek pillar into an anthropomorphic image.

Dr. Boaz argues that it is impossible to believe that in this group the animal form was primitive; in other words, he attempts to prove that the seal-headed and similar more advanced designs could not have been developed by a degradation of a type which was originally more highly specialised. The process, it is contended, was the reverse of this, and the crude knob preceded the animalistic and later developments. "If we were to apply," he urges, "to the present series the theory of the origin of the conventional form from realistic motives, it would be exceedingly difficult to account for the general uniformity of fundamental type. It seems to me that on the basis of this theory we could not account for the diversity of realistic forms and the uniformity of the general type.



Characteristic forms of needle-cases, to show the evolution of type.

Neither does it seem possible to account for the series of types by the assumption of any influence of technic; and my impression is that the only satisfactory explanation lies in the assumption that the multifarious forms are due to the play of imagination with a fixed old conventional form, the origin of which remains entirely obscure. This I freely acknowledge. If, however, we are to form an acceptable theory of the origin of decorative designs, it seems a safer method to form our judgment based on examples the history of which can be traced with a fair degree of certainty, rather than on speculations in regard to the origin of remote forms for the development of which no data are available." Hence he explains decorative forms as "the results of the play of imagination under the restricting influence of a fixed conventional style." This influence of imagination is illustrated in the case of necklaces and leggings made by the American Indians, in which the tendency to use rhythmic repetitions of varying forms is specially apparent. Dr. Boaz sums up the discussion by remarking that "the development of decorative designs cannot be simply interpreted by the assumption of a general tendency towards conventionalism, or by the theory of an evolution of technical motives into realistic motives by a process of reading in; but that a considerable number of other psychic processes must be taken into consideration if we desire to obtain a clear insight into the history of art."

It is impossible to discuss in detail the views of Dr. Boaz in this important contribution. The weak points in the argument seem to be:—first, that the ultimate origin of the flanges and knobs in this group of objects remains unexplained; secondly, that it seems rash to assume that the historical development of the Eskimo form of design can be definitely established; thirdly, it may be urged that the objects themselves are of too special a type and found in a too limited area to supply a safe basis for such a wide induction as that which is here applied to the evolution of primitive art in general. It seems clearly necessary that a fuller comparison of this group with the types produced by other neighbouring tribes should be a preliminary to any further discussion of their origin and meaning.

It seems not impossible that this Eskimo form of decoration may be due to special influences of environment, technique, and general culture with which we are as yet imperfectly acquainted. This paper, however, with its abundant illustrations and ingenious interpretations of the evolution of decorative forms, must be taken into account by all future writers on the subject. In any case, it illustrates the danger, in the present imperfect state of our knowledge on this and other subjects connected with the thought and culture of so-called "primitive" man, of the dogmatic assumption that any one theory will account for the workings of the artistic faculty when exposed to the varying influences of imagination, culture, and environment.

## THE BRITISH ASSOCIATION.

### SECTION D.

#### ZOOLOGY.

OPENING ADDRESS BY SIDNEY F. HARMER, Sc.D., F.R.S., PRESIDENT OF THE SECTION.

THE British Association meets this year for the fourth time in Dublin. The last occasion was just thirty years ago, when Sir William Flower presided over Section D, while Prof. Huxley was Chairman of the Department of Anthropology, at that time not raised to the dignity of a separate Section, and Sir Wyville Thomson was President of Section E. The last Dublin meeting was fortunate in having among its officers men who have left an enduring mark on Zoological science.

I can hardly come to the more immediate subject of my Address without referring to the death, on March 9 last, of Henry Clifton Sorby, who had been a member of the Association for nearly fifty years. Dr. Sorby was President of Section C in 1880; but although he does not appear to have presided over Section D, many of his sympathies were with Zoology. He belonged to a type which is becoming almost extinct with the increasing specialisation of science, having done pioneer work in more than one branch. His interest in Chemistry was no doubt responsible for his having taken up the subject of the pigmentation of animals, by his researches on which he is probably best known to Zoologists. During recent years he had devoted particular attention to the study of the marine fauna of East Anglia.

According to the popular estimate, Zoology is regarded as the branch of science that has perhaps the least reference to the details of practical life. The importance of the applications of Chemistry, Physics, Geology, Botany, and Physiology to questions which involve the welfare of the human race is obvious and universally admitted. But pure Zoology is often supposed to be a study of merely academic interest, and its relation to the practical concerns of mankind is not always apparent. It is no doubt true that many of the investigations undertaken by Zoologists are of a highly special nature; and yet when the sum total of the results achieved by workers in this science is estimated it will be found that the contributions of Zoology to the common stock of human knowledge are by no means of restricted application.

There is no conception which has more profoundly influenced thought in all branches of knowledge than the idea of organic evolution, in the development of which Zoology has shared the honours with its sister-subject, Botany. The present summer has seen a memorable event in the celebration by the Linnean Society, on July 1, of the fiftieth anniversary of the communication to that

society of Papers, by Darwin and Wallace, which revolutionised the whole of Biology. There can surely have been few occasions when the commemoration of the jubilee of an epoch-making discovery has been attended by the man whose work was thus recognised. I am sure that I am expressing a unanimous feeling in saying that the award of the first Darwin-Wallace medal on that occasion to Mr. Wallace in person was a source of deep gratification to all men of science, and that the presence at the same meeting of others whom all Biologists must regard with peculiar respect gave the occasion a perfectly unique character.

The present century has seen a remarkable development of the study of the problems of heredity and variation, largely as the result of the interest awakened in the resuscitation of Mendel's experimental work from the oblivion in which it had remained for so many years, though the general problem is being attacked concurrently by investigators who attach more importance to the statistical method of study. Prof. Bateson, who has given the name "Genetics" to the experimental study of heredity, chose the advances made in that branch of Biology up to 1904 as the subject of his able address to Section D in that year. Some of the more recent conclusions of the workers in Genetics are to be discussed by this Section during the present meeting. It cannot be doubted that an accurate knowledge of the principles of heredity is destined to exert a marked influence on the practical concerns of humanity.

The study of diseases which are due to parasitic Protozoa has made striking progress during the last few years. Protozoology has become a distinct branch of Zoology, represented by its own journals and its own professors and lecturers, while it can command the resources of the schools of tropical medicine where researches are being carried on from which great benefits to humanity may be anticipated. Malaria, sleeping sickness, yellow fever, and the numerous diseases of domestic animals due to parasitic Protozoa such as Trypanosoma, Spirochæta, and Piroplasma, are some of the complaints which are now recognised as the objects of Zoological study. Most of these diseases are transmitted by blood-sucking Insects and Arachnids, an accurate knowledge of which has become a matter of pressing practical importance.

The history of Protozoology affords a complete vindication of the importance, even from a utilitarian standpoint, of conducting scientific investigations for their own sake, even though the likelihood that they will ever have any practical bearing may not at first be apparent. Some years ago it would have been generally supposed that the study of Ticks was a case of this kind, and that it could at most be of interest to the special students of the Arachnida. How far such a view would have been from the truth is well known, but we are suffering now from the comparative neglect of this group of animals in the past. There is still no satisfactory monograph by the aid of which the species of Ticks can be discriminated, and there are few Zoologists who would be prepared to express an opinion with regard to the determination of even those species that are the commonest and the most injurious. While it is clear that the investigation of the Arthropod carriers of parasitic Protozoa is essentially a Zoological question, it is equally true that the elucidation of the parasites themselves is largely dependent on the results that have been achieved by Zoological investigators who have worked without any thought of a practical outcome. The late Prof. Schaudinn, to whom we owe so many brilliant results in the study of the Protozoa, commenced his investigations from the Zoological side, and continued them in their applications to preventive medicine. It is generally admitted that the study of many of the tropical diseases can only be carried on by means of a due co-ordination between Zoological and Medical methods of inquiry.

As a further instance of the manner in which Biological science may react on other studies, I may mention the interesting theory which has recently been developed by Mr. W. H. S. Jones,[1] to the effect that the decay of the ancient civilisations of Greece and Rome was largely due to the introduction of malaria into those countries.

I can do no more than allude to Economic Entomology, a subject which has at present received but little official support in our own country, although its importance is fully recognised abroad, particularly in the United States of America, where large organisations are devoted to the combat with the Insect enemies of agriculture. We are fortunately spared some of the worst of the foes of vegetation which devastate other lands. But many of our cultivated plants suffer severely from the ravages of Insects and Arachnids; and it is perhaps not too much to hope that more systematic measures will some day be taken in this country to disseminate the knowledge by which this injury to agriculture may be minimised.

As a last illustration of the way in which Zoology comes into relation with practical matters, I may allude to the question of fishery investigation. Although much remains to be done in this connection, the importance of purely scientific work has been to some extent officially recognised. The Board of Agriculture and Fisheries in England, the Scottish Fishery Board, the Fisheries Branch of the Department of Agriculture and Technical Instruction for Ireland, and other organisations which are mainly or entirely supported by private funds, are in part devoted to the interests of the fishing industry. The Government has latterly participated in an international investigation of the North Sea, as the result of which many interesting facts have been recorded with regard to the life-histories of food-fishes, their migrations at various periods of life, the age at which they become sexually mature, and the nature of their food. These are questions that demand study by experienced Zoologists; and the interrelations of food-fishes and the organisms on which they subsist or with which they come into competition are so complex that a full study of the entire marine fauna appears to be a necessary preliminary to the elucidation of the questions of immediate practical utility.

I have tried to indicate that Zoology is a subject that has important relations with the practical concerns of mankind. But in Zoology, as in other branches of science, the principal advances have been made by investigators who have studied it for its own sake, without thought of the practical outcome. It would undoubtedly be a misfortune should an entirely utilitarian spirit become dominant in the pursuit of science. In the full conviction of the truth of this statement I venture to invite your attention to certain questions connected with the Polyzoa —a somewhat neglected group of animals which I do not profess to be able to connect in any direct way with practical matters. In choosing this subject I have been influenced by the belief that it is well for the President of a Section to speak on matters of which he has had practical experience.

During the course of my studies on the Polyzoa I have been conscious of the existence of many unsolved problems and difficulties, some of which are connected with the functions, distribution, and variations of certain remarkable appendages known as "avicularia" and "vibracula." Although the facts bearing on the significance of these organs are familiar to specialists only, they appear to me capable of throwing light on questions of general Biological interest, particularly in connection with variation in animals that increase by budding.

The statement has often been made, as the result of a theoretical conception of the physical basis of heredity, that the asexual method of reproduction gives rise to little or no variability. Although there are many reasons for doubting the validity of this conclusion, it may be well to state at the outset that the Polyzoa, which are without exception characterised by increasing in an asexual manner, show a high degree of variability in the individuals thus produced. So much is this the case that the want of fixity of type which results from the tendency to vary renders the definition of species particularly difficult in this group of animals.

Meeting as we do at Dublin, there is a special appropriateness in discussing the Polyzoa, as a tribute to the memory of a distinguished Irish naturalist, J. V. Thompson, to whom we owe not only the name Polyzoa, but also the first clear conception of what these animals really are.

[1] "Malaria: A Neglected Factor in the History of Greece and Rome." (Cambridge: Bowes and Bowes, 1907.)

In the fifth memoir, published at Cork in 1830, of a short but brilliant series of Papers,[1] Thompson was the first to demonstrate the essential nature of the differences between the Polyzoa and the other "Zoophytes" with which they had previously been classified. G. J. Allman, who at a later period did so much to throw light on the structure and natural history of these animals, particularly by his classical monograph on the Fresh-water Polyzoa,[2] was also an Irishman, who was born at Cork, and for some years held the professorship of Botany in the University of Dublin. Thomas Hincks, another worker who was pre-eminent for his knowledge of the Polyzoa and for the importance of his researches in this field, held professional appointments both at Cork and at Dublin for several years.

The Polyzoa are a group which is quite unknown to most persons who are not Zoologists. Before coming to my special subject, the variations of the avicularia, I may for this reason, perhaps, be excused for attempting to explain what the Polyzoa are like, and, in particular, what are the nature and functions of the structures we have to discuss.

The Polyzoa are a Class of aquatic organisms of world-wide distribution, and including a large number of species. They occur both in fresh water and in the sea, and the marine forms are found from between tide-marks to the deepest abysses of the ocean. Some of the species are among the commonest objects of the sea-shore, and others may be obtained in numbers by the use of the dredge or trawl. They often occur as delicate encrustations, usually calcareous, on plants, stones, or shells; or they may assume the appearance of sea-weeds, corals, or Hydroids. Although most of them are of comparatively small size, they are usually large enough to be recognised by the naked eye, while the largest of them reach a diameter of a foot or two.

The Polyzoa are always colonial animals, the colony consisting of a number of individuals which are in organic connection with one another, though they may appear at first sight as a series of isolated units. Each of these units consists of a body-wall, which is usually calcified and is termed the "zoœcium," since it was at one time supposed to constitute a sort of house for a zooid known as the "polypide." The idea of a dimorphism of individuals expressed by this nomenclature is no longer accepted, but the terms themselves are still conveniently employed for descriptive purposes. The polypide consists in reality of the visceral mass of the zoœcium, together with the series of ciliated tentacles which are used for the capture of food. The tentacles are protrusible, but are commonly found retracted into the interior of the zoœcium, in which condition they lie in a thin-walled introvert or "tentacle-sheath," which opens to the exterior by an "orifice" in the wall of the zoœcium. In the suborder Cheilostomata, to which my remarks will principally refer, the orifice is closed, during the retracted condition of the polypide, by a chitinous lid or "operculum."

In the great majority of cases the colony is inaugurated by the fixation of a free-swimming larva, which has been produced from an egg by the ordinary sexual method. On the completion of its metamorphosis the larva becomes the first zoœcium of the colony, and is then known as the "ancestrula," a term introduced by Jullien to signify that it is the ancestor of the future colony. In a large number of species belonging to the most diverse genera of Cheilostomes the ancestrula has a certain definite character which appears to have no relation to that of the individuals to which it gives rise by budding. The type of ancestrula in question has a striking resemblance to a single zoœcium of many of the species of the existing genus Membranipora, and is characterised by having a series of marginal spines which surround a region closed by a chitinous membrane, at one end of which is situated the operculum. That this form of ancestrula has a definite significance is indicated by its wide occurrence among Cheilostomes and by the fact that the same cannot be said of any other form of ancestrula, and is confirmed by the palæontological occurrence of Membranipora as one of the earliest genera of Cheilostomata.

[1] "Zoological Researches and Illustrations."
[2] Ray Society, 1856.

The ancestrula gives rise by budding to daughter-zoœcia, which usually assume from the first the characters proper to their species. In the growing colony the formation of new zoœcia takes place at the expense of a marginal zone, which contains the tissues concerned in the bud-development. Omitting the consideration of special regenerative processes which may take place, a zoœcium which has once been constituted at the growing margin of the colony does not, as a rule, possess the power of giving rise to new zoœcia, although it commonly has the faculty of producing sexual cells from which free larvæ may develop.

In the majority of the species of Cheilostomata many of the individuals of the colony have the form of the so-called avicularia. An avicularium is characterised by possessing a chitinous "mandible," which can be closed with great force by strong occlusor muscles, the organ being thus essentially of a prehensile nature. There can be little doubt that the mandible is a modification of the chitinous operculum which closes the orifice of the tentacle-sheath in Cheilostomata. It thus follows that avicularia are restricted to this particular division[1] of the Polyzoa. In the avicularium the operculum has become relatively and often absolutely enlarged, and its muscles have become more powerful than those of the unmodified zoœcia. The internal viscera have, as a rule, disappeared, and there are thus neither tentacles nor alimentary canal. The body-wall, or zoœcium, has become a case which contains the muscles, while part of it has been prolonged into a beak-like structure or "rostrum," which, with the chitinous mandible, constitutes the prehensile mechanism.

In Bugula and its allies the avicularium has the form to which its name refers, and has a striking resemblance to the head of a bird like an eagle or vulture. This resemblance is due, not only to the general form of the structure, but also to the hooked and beak-like shape of its rostrum and to the narrow neck by which it is connected with the zoœcium on which it is borne. The avicularia of Bugula have considerable powers of movement, and in the living condition they may be seen to bend backwards and forwards on their flexible neck, their range of action being thus considerably enlarged. The mandible is ordinarily held wide open, but it closes with great force when some foreign object is placed between the jaws. An avicularium which has in this way seized a small worm, for instance, is known to be able to retain its capture for many hours, in some cases for more than an entire day.

In the majority of Cheilostomata the avicularia are, however, not stalked. They occur scattered over the colony in a considerable variety of positions, and usually appear as appendages rigidly connected with the walls of the zoœcia.

More than one attempt has been made to explain the functions of the avicularia. The distribution of these organs indicates, I think, that the simplest and most obvious explanation is the correct one—namely, that, like the pedicellariæ of Echinoderms, they are defensive organs. The ordinary unmodified opercula probably have the same function in many cases; and if account be taken of the fact that the avicularium is morphologically a modified zoœcium it becomes easy to understand that the defensive office of the opercula has been made more efficient in specially modified zoœcia which concentrate their energies on this one function alone.

A casual inspection of a number of Cheilostomes taken almost at random reveals the fact that the avicularia are specially common in the immediate neighbourhood of the orifice of the tentacle-sheath and of that of the "compensation-sac."

This is a thin-walled cavity which in a considerable proportion of the Cheilostomes opens to the exterior at the proximal border of the operculum. Its principal function is to permit protrusion and retraction of the polypide to take place, since in a zoœcium with completely rigid walls the act of protrusion could not occur if the temporary removal of structures of considerable size were not compensated for by the admission of water into the space included by the rigid body-wall. At each movement of

[1] It may be noted that Palæontologists have described structures which they have regarded as avicularia in Polyzoa which do not belong to the Cheilostomata.

protrusion, therefore, a volume of water corresponding with that of the protruded organs is admitted into the compensation-sac, the dilatation of which, by means of radiating muscle-fibres, is the cause of the protrusion, and is again evacuated when the polypide is retracted. These alternate actions of filling and emptying the compensation-sac with water from the outside are probably of importance in the respiration of the animal. The advantages of having avicularia in such a position that they can guard the orifice from which the tentacles are protruded and that of the compensation-sac are too obvious to require detailed discussion.

The avicularia probably afford little if any protection against the attacks of the larger foes, such as Fishes, Echinids, and Nudibranch Molluscs, which are said to browse on Polyzoa. But there is one group of enemies against which the opercula and the mandibles are probably particularly effective. These are encrusting organisms, including other species of Polyzoa; and indeed the enemies against which a Polyzoon has to provide are probably in a special degree the members of its own class.

In many Polyzoa which afford large surfaces suitable for the growth of encrusting organisms the older parts of the colony, where the opercula and mandibles are no longer in working order, do actually harbour large numbers of encrusting Polyzoa, Sponges, Ascidians, and other organisms. These are usually absent in the active parts of the colony nearer the growing margins. In these positions the only animals which obtain a footing are such forms as the Infusorian Folliculina, adapted by its minuteness to find a place between the defensive appendages, or such organisms as are attached by means of delicate creeping stolons or rootlets that can find their way between the opercula and mandibles without being damaged by them. A branching species fixed by a narrow base may do little harm to a Polyzoon on which it is growing. But the effects of an encrusting species would be different, since the orifices of the colony which is being overgrown would be occluded, and the polypides entirely cut off from the outer world. Although experimental evidence is at present wanting to prove this view, I have little doubt that the avicularia are specially important in preventing the fixation of the larvæ of encrusting species. The larva is of course very vulnerable, and it cannot become the founder of an adult colony unless it can find a secluded spot in which it is safe from undue disturbance during the critical time of its metamorphosis. The avicularia are well adapted by their form for warding off larvæ. Those that have the so-called "duck-billed" or "spatulate" form are in many cases large enough to catch or crush a larva without difficulty, while those which have a mandible terminated by a spike-like projection must be even more destructive to the life of any minute organism which is so imprudent as to stray within their reach. In some of the avicularia belonging to this latter type the mandible is strongly compressed along the greater part of its length, and may then assume the shape of a knife-blade, with a sharp cutting edge and a thicker back. The blade shuts down into the calcareous rostrum of the avicularium in such a way that its action may be compared to that of a pair of scissors. It cannot be doubted that this form of avicularium has a high protective value.

In some cases the mandibles or the opercula are toothed. The teeth are specially strong in certain species of the genus Steganoporella, where the opercula become most formidable weapons. The large development of the occlusor muscles proves that the closure of these opercula must take place with much force.

The protective value of the avicularia may be illustrated by the distribution of these organs in Retepora, the species of which usually grow in the form of a calcareous network, with oval meshes or "fenestræ" between the branches. These are furnished with an elaborate armature of avicularia, which usually occur in large numbers and in considerable variety of form and size. Some of them are scattered over the front surface, on which alone the zoœcia open, while others occur on the more unprotected backs of the branches, where there are no zoœcial orifices. To guard against an attack from the rear the margins of the fenestræ are frequently furnished with avicularia, among which some are usually of a specially large size, and are well situated to intercept any larva or adult animal that might attempt to pass through a fenestra.

A healthy Retepore is usually completely free from encrusting organisms in regions where the avicularia are functional. One of the few exceptions I have noticed to this rule is specially instructive. In this case a small encrusting Cheilostome colony is growing near the edge of the Retepora frond. The primary individual or ancestrula of the encrusting colony is readily distinguishable, and its position shows that the larva from which it was formed must have attached itself to the growing margin of the Retepore, a region in which the avicularia were not fully formed. Having thus established itself, the colony has succeeded in invading a small region of the adjacent parts where the zoœcia are still vigorous and healthy. A dead Retepora, on the contrary, forms a substratum which is well adapted for the growth of various organisms, such as other Polyzoa, Sponges, Hydroids, Compound Ascidians, and Foraminifera.

Although the avicularia are thus effective in preventing the overgrowth of the colony by most of the organisms that might otherwise settle there, there are one or two animals of suitable habit which have succeeded in establishing themselves in the very midst of the defensive works. In species of Retepora from the Malay Archipelago [1] I find that a considerable proportion of the colonies are infested by a Gymnoblastic Hydroid of Syncoryne-like appearance. The association of this with its host is so intimate that the hydrorhiza becomes completely included in tunnels formed in the calcareous mass of the Polyzoon, where it is, of course, safe from the avicularia. These tunnels, the walls of which are secreted by the Polyzoon, open to the exterior by tubular apertures situated on the margins of the fenestræ and on other parts; and they are so definite in their appearance, and often so regularly arranged, that it might be difficult to believe that they were not a normal feature of the Retepora were it not possible to demonstrate their relation to the Hydroid.[2]

There is one other organism which has a definite relation to colonies of Retepora in Malay waters. This is Loxosoma, a stalked Polyzoon which leads a practically solitary life owing to the fact that its buds break off as soon as they have reached maturity. The Loxosoma no doubt succeeds in enjoying a secure existence, even though it is surrounded by avicularia, owing partly to its stalked form and partly to its minute size. It is commonly found in considerable numbers, and often attaches itself in such a way that it projects into one of the fenestræ, where it is as far as possible removed from the dangerous neighbourhood of the avicularia.

We have thus seen that, while the species of Retepora are adequately protected against many encrusting or epizoic organisms, there are one or two animals that have succeeded in evading the attacks of the avicularia, which, it must be remembered, are rigidly attached to the colony, and cannot go in search of any enemy that keeps out of their way. The efficient avicularian protection may well be responsible for the fact that Retepora is a common and widely distributed genus, flourishing in both shallow and deep water. Not only is it found in large numbers in the most diverse localities, but it has differentiated itself into a large number of species, among which avicularia occur in great profusion and in a great variety of forms. But so soon as the avicularia cease to be active we find that numerous organisms settle on the unprotected branches; and a dead colony of Retepora is accordingly usually found to be invaded by numbers of other animals.

One other familiar case may be mentioned illustrative of the means by which a Polyzoon may be protected from

[1] The greater number of the facts referred to in this Address have been observed during my study of the Polyzoa collected during the *Siboga* expedition.

[2] It may be noted, as has already been done by Alcock ("Ann. Mag. Nat. Hist.," ser 6, x., 1802, p. 207), that many other cases are known in which there is an association between a Gymnoblastic Hydroid and some other animal. The interesting case of the association of a Gymnoblastic Hydroid (Stylactis) with a fish (Minous) described by Alcock has also been described, more recently, by Franz and Stechow (*Zool. Anzeiger*, xxxii., 1908, p. 752). Another case of the association of a Cœlenterate with a Polyzoon has been recorded by Haswell and by Kirkpatrick, who have called attention to the occurrence of a small "Actinid" which forms definite cavities in a massive calcareous Cheilostome from Australian waters. There is in this case no satisfactory evidence to show what the Cœlenterate really is.

encrusting organisms, and at the same time of the success with which certain animals have ignored the defensive works that are effective against ordinary foes. This is the common *Flustra foliacea* of our own shores, in which, although avicularia are present, the defence is provided largely by the numerous stiff spines which make its surface irregular, and thus unsuitable for the growth of an encrusting organism. But certain delicate Polyzoa, such as Crisia and Scrupocellaria, which are attached by fine rootlets, flourish on this species, their rooting processes being able to adapt themselves to the irregularities of the surface, and to escape the closure of the opercula and mandibles. A Gymnoblastic Hydroid (*Hydranthea margarica*) of a similar mode of growth is also known to occur on healthy colonies of *Flustra foliacea*.

In a large number of erect Polyzoa the colony, or zoarium, assumes the form of a small branching tree-like growth in which, as in Retepora, the zoœcia open on one surface only of the branches. The opposite surface is often devoid of any armature of avicularia or vibracula, a fact which at first sight seems opposed to the view that these structures are protective. But I think that in some of these cases the form of the zoarium affords an answer to this objection, since the branches are so crowded that the avicularia of the front surface of one branch are probably quite capable of affording protection to the backs of the nearest branches. It may be noted that Scrupocellaria and Caberea, in which vibracula occur on the backs of the branches, usually have a much laxer mode of growth than Bugula, in which the back is unprotected.

In some other erect species there are no avicularia at all. But here we often find, as in Euthyris, that the whole of the frond is covered by an organic membrane, the "epitheca," which invests the calcareous parts; and it seems to me probable that this epithecal layer is itself protective. Schiemenz has shown that it is an advantage to certain Molluscs to have an internal shell, since Starfishes can devour Molluscs to the shells of which they can attach their tube-feet, while they can obtain no hold on the slimy surface of a Mollusc which has covered its shell by part of its soft tissues. Although the enemies to be guarded against are not the same in the Polyzoa, there may, none the less, be an advantage in having the calcareous parts covered with an organic membrane. The species which are especially liable to the attacks of Folliculina appear to be those in which the calcareous parts are but little protected, as in Cyclostomes such as Lichenopora; while this Infusorian readily establishes itself on dead parts of Cheilostomes which have lost the epitheca that covers their active regions. The encrusting species of Polyzoa doubtless prefer a hard, calcareous surface on which to grow to a soft, yielding membranous surface.

As a further factor with which the absence of avicularia may be correlated may be mentioned the shape of the individual zoœcia. There are many cases, such as *Schizoporella Cecilii*, *Mucronella ventricosa*, and a number of others, in which the zoœcia of a species devoid of avicularia are very convex in their external shape. The conjunction of a succession of convex zoœcia is probably important in preventing the encroachments of encrusting species, which more easily adapt themselves to a level surface than to one which is strikingly uneven or irregular. This is analogous to the case of *Flustra foliacea*, which we have already noticed, where the protection appears to depend largely on the development of spines. The irregular surface of many Cyclostomes, which is due to the projection of the free ends of the zoœcia, is probably similarly effective in preventing overgrowth by foreign organisms.

In the vibraculum the part that corresponds with the mandible of the avicularium has been prolonged into a thread-like structure, the "seta," which is moved by muscles corresponding with those of the avicularium.

The setæ of Caberea are very large, and they close into oblique grooves which run along the back of the branch. The protective value of these setæ is well shown in a specimen I have observed from Torres Straits, in which a minute encrusting Cheilostome has formed a single row of zoœcia along the region between two of the vibracular grooves, but has not extended into any part where it would be subject to injury by the movements of the setæ.

The vibracula are, however, probably used for other purposes besides the protection against living foes. They no doubt serve to brush away foreign particles which might otherwise settle on the surface of the colony and block up the orifices. This function has been suggested for the vibracula of the so-called Selenariidæ, a group of forms which agree in having a zoarium of a discoidal or inverted saucer-like shape. The colony is believed to rest freely on the bottom, on the edge of its concave base, though I have some evidence that it may be attached to the ooze by means of very delicate, flexible, rooting processes. Some at least of these Selenariiform species occur in situations where the ground is covered by Globigerina ooze, the settlement of which on the convex surface bearing the orifices is probably prevented by the vibracula. It is now generally admitted that his type of colony has been independently acquired in several cases, the so-called family being, in fact, an entirely unnatural assemblage of genera. It may be worth while to point out in passing that I have noticed in several cases that the Selenariiform colony commences its existence on a Foraminiferan shell or other minute object, in the absence of larger surfaces on which fixation can be effected, and that the characteristic discoidal form is due to the growth of the circular edge of the colony beyond this initial supporting base.

But my object in introducing this group of Cheilostomes at the present point is to direct attention to the relatively enormous size which is reached by the setæ of the vibracula of some of the species, a size which is so great that it has even been supposed that these appendages are used as oar-like organs of locomotion. In a specimen of *Selenaria hexagonalis*, from South Australia, in the Museum of Zoology at Cambridge, the setæ have been colonised by a minute Cheilostome belonging to the genus Eucratea. It might be said that in this case the setæ have almost over-reached themselves, since they have become so large and powerful that another species is minute enough to find a home on the protective mechanism itself.

Having thus dealt with the probable functions of the avicularia and vibracula, we may now return to the consideration of the forms assumed by these appendages and of their distribution in the colony. The protective function which they appear to possess prepares us for finding, as is actually the case, that they are modified in an extraordinary number of directions. But although they occur, in one form or another, in the majority of Cheilostomes, they may be completely absent in an entire genus, in certain species of a genus, in certain varieties of a species, or in individual colonies of species which normally possess them. They are often wanting on some of the zoœcia, though present on most of the zoœcia, of a colony; and they may vary to a considerable extent in the position they assume on the zoœcium. Not only are they thus variable in their occurrence, but they show equally striking differences in their individual characters. They may be all of one kind in a single species, or two or more kinds may occur distinguished by size, by the shape of the rostrum and mandible, or in other ways. We thus come to the consideration of the question how far these appendages can be used in the discrimination of species.

The characters on which species are founded in a group of colonial animals like the Polyzoa obviously differ in certain respects from those which are used in distinguishing species in organisms that lead a solitary existence. In the colonial forms we are concerned partly with the mode of association of the individual units, partly with the manifestations of dimorphism or polymorphism shown by those units and partly by the features of the individuals themselves. Among the Cheilostomatous Polyzoa the dimorphism or even polymorphism of the individual, due to the presence in the colony of avicularia and vibracula, is of special importance.

While the characters of the avicularia have accordingly long been used by systematists for distinguishing species, no one—so far as I am aware—has hitherto suggested any hypothesis which helps us to form a reasonable conception of the significance of the innumerable modifications undergone by these organs; nor do I think that the problem has ever been fairly stated.

The difficulty of understanding the evolutionary significance of the avicularia arises in part from the fact that the occurrence and distribution of these structures appear

in many cases to give but slight indications of affinities. It cannot, for instance, be assumed, without further evidence, that two species possessing an identical type of avicularium are nearly related. The complete absence of avicularia in a particular species is no sufficient reason for removing that species from an assemblage of forms in which avicularia are always present. And, lastly, there may be good grounds for believing that two forms with entirely different types of avicularia are closely related, and in some cases may even belong to the same species.

The result of a comparative study of the Cheilostomata leads, in fact, to the conclusion that although certain genera or species are characterised by the possession of one or more definite types of avicularium or vibraculum, other genera or species show no such constancy in this respect. The occurrence of the same type of avicularian appendage in the species of widely separated genera and the diversity of type of avicularium within the limits of a single genus or species render it most difficult to frame any theory that will account for the facts. Are we to assume that a given type of avicularium has been evolved independently in a number of cases, or must we suppose that species with that type have inherited it from a common ancestor? If the latter hypothesis be the correct one, we seem to be led to the conclusion that the ancestral Cheilostomes were provided with most of the types of avicularia that actually occur in existing species, many of which have lost one or more of those types.

In trying to arrive at some conclusion with regard to these points we may notice, in the first instance, one fact which stands out with great distinctness—namely, that, whatever the modifications of the avicularium may be, the mandible is usually either acutely pointed at its free end or rounded and spatulate at its termination. The difference may at first sight appear unimportant, but I am inclined to believe that it is an indication which may lead us to results of great significance.

Though it may be going too far to assert that all avicularia belong to one of these two types, there is usually no difficulty in recognising either the pointed or the rounded character in every avicularium present on a colony. The distinction may be observed by inspecting the form of the rostrum in a dry preparation of a part of the zoarium, but it is seen with more certainty when the mandibles have been isolated and are examined in Canada balsam. So striking is the difference that the inquiry naturally suggests itself whether there is any indication of the evolutionary meaning of the two kinds of avicularium. It appears to me probable that a condition which is characteristic of the existing genus Steganoporella may furnish the answer to this question. In this genus avicularia are typically absent, but in each species the zoœcia are of two kinds, distinguished by differences in the shape and structure of the opercula and orifices. The anatomy of the zoœcia is known in but few cases, but in those that have been observed both kinds of zoœcia possess polypides. In one division of Steganoporella the more differentiated zoœcia show some resemblances to the pointed type of avicularium, while in a second division they more nearly resemble rounded avicularia. I am inclined to believe that these conditions correspond respectively with the two kinds of differentiated avicularia of other Cheilostomes.

The avicularia most commonly met with occur as appendages of the ordinary zoœcia, which alone constitute the main framework of the colony. But in addition to these, the "adventitious" avicularia of Busk, we find, although less commonly, another kind known as the "vicarious" avicularium, from the fact that it occupies the place of an ordinary zoœcium, with which it agrees more or less closely in point of size. Its mandible is usually of the rounded type, appropriately referred to as "duckbill-like," and is readily seen to represent the operculum of an ordinary zoœcium. Compared with this the mandible and the orifice which it closes are greatly enlarged, while the occlusor muscles have become correspondingly increased in size. The polypide is generally absent in the vicarious avicularium.

Pointed avicularia of the vicarious type occur normally in the species of Onychocella, which, alike by their structure and by their early palæontological appearance, may be regarded as representing a primitive type of the Cheilostomata. Vicarious avicularia with a rounded mandible occur in certain species which I refer provisionally to Siphonoporella, as well as in a small proportion of the species of Membranipora and Flustra. All these may fairly be regarded as belonging to a comparatively undifferentiated type of Cheilostomata, and their vicarious avicularia are usually the only ones present. It is thus not improbable that the avicularium in these cases really represents an early stage of evolution. But we must notice that precisely similar rounded vicarious avicularia make their appearance occasionally in species of a much more differentiated type, as in the well-known *Schizoporella Cecilii*[1] and in certain other species which may for the present be referred to the same genus. In the majority of the very numerous species of Schizoporella vicarious avicularia are not known to occur, and it is thus impossible to regard them as a typical attribute of the genus.

The vicarious avicularia, which by their position and general structure are so easily comparable with the ordinary zoœcia, are usually supposed to represent an initial stage in the evolution of the avicularium. But if this view be correct, how are we to account for the sporadic way in which these structures occur in a series of genera such as Membranipora, Flustra, Schizoporella, and Cellepora, the last two of which, at any rate, are highly specialised in other respects? What conclusion can we draw from the association, in one and the same colony, of this type of avicularium with adventitious avicularia of the most specialised description? How can we explain the fact that each kind of avicularium occurs in certain species, but not in all the species, of many distinct and not specially related genera? And, lastly, what is the significance of the fact that certain species of a genus which is normally provided with avicularia may be totally destitute of these organs? These are some of the problems of which no satisfactory solution has at present been given. On the ordinary view of the way in which the species of a genus are interrelated we should perhaps not expect to find that two species which are closely similar in other respects may be distinguished by possessing entirely different types of avicularia.

I am aware of the fact that it is perhaps premature to indulge in speculations which are unsupported by experimental evidence. But it appears to me worth while to suggest that some of our difficulties might be removed by appealing to the results obtained by workers on Mendelian inheritance. An essential part of the theory here involved is that in the formation of the gametes of an organism there is a segregation of certain paired or "allelomorphic" characters whereby some of the gametes are endowed with qualities by virtue of which they transmit one of the characters, while the rest of the gametes become capable of transmitting the characters of the other member of the allelomorphic pair. It has recently been made probable by Prof. Bateson, whose views have been confirmed by others, that the actual appearance of a particular character may be dependent on a coupling of two allelomorphs belonging to distinct pairs. If only one of them is present the character will not show itself. The phenomenon of reversion on crossing is thus explained as due to the combination of allelomorphs present in the isolated condition in two parental forms.

Is it not possible that the perplexing occurrence of vicarious avicularia in some of, but not by any means in all, the colonies of certain species may be interpreted as a reversion due to the combination of two or more allelomorphs that may not have occurred together in the parental forms? We have seen that there is some reason to believe that these avicularia are really of an archaic character, from their occurrence in certain genera of a primitive type, known in some cases by palæontological evidence to have appeared early in the evolution of the Cheilostomata. We may further remember that we have distinct evidence that Cheilostomes of a differentiated type may retain certain primitive characters, in the occurrence of a Membranipora-like form of ancestrula in so many of them. If, then, we may suppose that the appearance of vicarious avicularia is due to a combination of more than one allelomorph we may recognise the possibility that the

[1] Kirkpatrick, "Ann. Mag. Nat. Hist." (6), v., 1890, p. 21.

ancestrulæ of a given species still carry the determinants representing those allelomorphs. In species in which the vicarious avicularia are of normal occurrence there is no difficulty in this hypothesis. In others, of which examples may be found in Schizoporella, the vicarious avicularia make their appearance rarely, in a very small proportion of colonies. In these cases the facts might be accounted for on the hypothesis of the chance recombination of allelomorphs which are ordinarily separated, unless, indeed, it should prove to be the case that the vicarious avicularia represent a recessive character which is usually prevented from making its appearance by some dominant factor.

A single series of cases of this kind will not carry conviction, but there are many facts with regard to the distribution of adventitious avicularia that may point in the same direction. We may recur to the fact that the form of these appendages may be eminently characteristic of a whole series of species which from their similarity in other respects are naturally associated in a single genus or family. The most striking instance of this is, perhaps, the genus Bugula, in which we find the avicularium *par excellence*. The variations of this type of avicularium are comparatively slight, and for the most part depend on differences in position with regard to the zoœcia and on minor modifications of size, shape, and length of stalk. Both in Bugula and in the allied genus Bicellaria the avicularian characters may be described as relatively constant; and since they belong to a type that is rarely met with in other genera, they seem to confirm the evidence afforded by other structural features that the species which possess them are related to one another. But even in Bugula, where the avicularia reach the summit of their development, we meet with species or varieties in which these appendages are invariably absent throughout the colony. This may be illustrated by *Bugula neritina*, a widely distributed species which in the Mediterranean and certain other districts is remarkable for the complete absence of avicularia, although in other structural features it shows a close affinity to other species of Bugula. In Australian and Oriental waters, however, there occur forms which can hardly be distinguished from *B. neritina* except by the fact that they always possess numerous avicularia of the specialised character that is so distinctive of the genus. It does not matter for our present purpose whether these are to be regarded as a variety of *B. neritina* or not. If the appearance of avicularia may be regarded, on Mendelian principles, as due to the presence of one or more allelomorphs, it is possible to understand that these may be omitted in certain cases, and that there may thus be a close affinity between two forms, one of which differs from the other in what appears at first sight so essential a respect as the complete absence of the avicularia, which we are justified in regarding as the most important feature of the genus.

A second case of the same general nature may also be noticed. In the family Cellulariidæ are included a number of delicate erect species which are commonly placed in the genera Caberea, Scrupocellaria, Menipea, and Cellularia. The first two of these are distinguished by possessing vibracula as well as avicularia. Menipea is defined as possessing avicularia, but no vibracula; while *Cellularia peachii* does not possess either kind of appendage. A species known as *Amastigia nuda* has been placed in a separate genus because of the absence of vibracula and their replacement by avicularia, while in other respects it agrees with Caberea, in which the vibracula reach a development not exceeded by those of any other Cheilostome. Before considering the bearing of these facts we may appropriately consider another instance taken from the same family, although by doing so we are for the moment leaving the question of the avicularia. In the genera Caberea, Scrupocellaria, and Menipea certain species are distinguished by having the free surface of the zoœcium protected by a peculiar spine known as the "scutum," which is usually flattened and much expanded at its free end, where it overarches the membranous frontal surface in such a way as to cover and presumably to protect it. But in each genus other species are characterised by the complete absence of the scutum, while in others it occurs in varying degrees of reduction.

We have thus several cases in which certain species differ from their near allies in the complete absence of a structure which is, as a rule, one of the most distinctive features of the genera to which they are respectively assigned. Should it be possible to prove that the appearance of the organ in question, whether avicularium, vibraculum, or scutum,[1] was of the nature of an allelomorphic character, its disappearance would be readily intelligible.

The facts which I have indicated with regard to the so-called Cellulariidæ have not hitherto been sufficiently discussed; but I imagine that most systematists who have considered the question have assumed that the scutum, for instance, has undergone parallel evolution in Caberea, Scrupocellaria, and Menipea, either having been independently evolved in each of the three cases (a most improbable supposition), or having independently undergone a series of regressive changes of precisely similar character in the three genera.

But it is perhaps in the mode of occurrence of adventitious avicularia that we find the strongest reason for believing in the existence of some form of alternative inheritance. We may indeed go so far as to assert that alternative development does actually take place, whether the explanation of the facts is given by the Mendelian theory or not. The difference between the pointed and the round avicularia is a very definite one, which—it is no exaggeration to say—may be observed in hundreds of species. When these species are arranged under genera according to the result of a study of the whole of the evidence derived from all the characters that have proved valuable in classification, we find that many genera include some species with one type of avicularium and others with the other type. It should perhaps be pointed out that the validity of many of these genera is a matter on which differences of opinion exist. The subject is undoubtedly a difficult one, and we are far from having arrived at any certainty with regard to the classification of the Cheilostomata. But it is perfectly certain that we could not utilise the two kinds of avicularia in dividing these Polyzoa into two main series, since there are innumerable cases in which both kinds occur in a single colony. This is a fact to which I shall return later.

We may accordingly maintain that, although much is probably faulty in our present system, we have clear evidence that the same genus may include species which differ in the type of avicularium; and, moreover, that these are not exceptional, but, on the contrary, are of common occurrence. A few instances will make these points clear.

In the encrusting species and in certain others the avicularia commonly occur, as we have already seen, in a position near the orifice of the zoœcium, where they are usually either lateral or suboral. In one of the species with lateral avicularia these appendages may be of the pointed type, while in another they may be rounded; and the same statement may be made with regard to the suboral avicularia. Within the limits of the same genus we may further notice that certain species have lateral avicularia, while others have suboral avicularia. Here, again, we find the same indifference as to the shape of the rostrum and mandible.

If we might provisionally suppose that the two kinds of avicularia constituted an allelomorphic pair, represented by Aa, and that the lateral and suboral positions indicated a second allelomorphic pair, Bb, the four combinations, AB, Ab, aB, ab, would be theoretically possible. We might, in other words, have pointed or rounded lateral avicularia, and pointed or rounded suboral avicularia. All these conditions actually occur in such genera as Lepralia and Schizoporella; and in some cases two species which agree in the form of the avicularia but differ in their position, or agree in the position but differ in their form, appear on other grounds to be nearly related one to the other.

Other cases may be taken from Retepora, an instance where we may feel ourselves on comparatively secure ground, since there are strong reasons for believing the genus to be a natural one. The genus as a whole possesses an almost bewildering variety in the form, position, and

[1] The case of the scutum is less striking than that of the other structures under consideration, since conditions intermediate between full development and complete absence are not uncommon.

size of the avicularia, among which, however, we may distinguish the following kinds:—(i) The suboral avicularium, closely related to the orifice and usually termed "labial," because it occurs on what may be described as the lower lip; (ii) frontal avicularia, on some part of that surface of the zoœcium which bears the orifice; (iii) basal or dorsal avicularia, on the backs of the branches; (iv) fenestral avicularia, which guard the edges of the fenestræ or meshes of the colony.

In many of the species of this large genus the suboral avicularia are of the small rounded type. In other species they are small and pointed, with an acute mandible; while others are distinguished by possessing suboral avicularia that may be described as gigantic.

Among the frontal avicularia similar differences exist. In one case that has come under my observation a remarkable variation of this kind is found within the limits of a single species. Remembering the great difficulty there often is in arriving at certainty with regard to the limits of the species in the genus under consideration, I wish to emphasise the fact that this instance is taken from *Retepora phoenicea*, a form that not only has well-marked specific characters of the ordinary kind, but is remarkable in having a beautiful carmine-red or violet colour, a respect in which it differs from most of its nearest allies. The frontal avicularia of this species are usually of the pointed type, but in the variety in question —a colony from Torres Straits—they are, so far as I have been able to ascertain,[1] all of the rounded kind.

The fenestral avicularia show a similar behaviour. In South Australian waters there are a number of forms which are regarded as varieties of *Retepora monilifera*. In the form known as var. *munita* there is usually a suprafenestral avicularium of large size, distinguished by having a rounded mandible, which is a good deal broader than it is long.[2] In another form of the same species, distinguished by MacGillivray as var. *acutirostris*, the *munita*-avicularium may either occur as such in some of the fenestræ, or be replaced in others by a large avicularium of the typical pointed form.

In other species a gigantic infrafenestral avicularium commonly occurs, but while these structures are found in a considerable proportion of the fenestræ of some colonies they appear to be completely absent in other colonies. In this series of cases, which is well illustrated by *Retepora phoenicea*, I think there is clear evidence that different colonies, from the same locality and belonging to the same species, may show the two conditions of presence and absence respectively of fenestral avicularia. According to the ordinary criteria by which species of Polyzoa are discriminated, it might be necessary to place these in different species—a result which is not supported by other evidence. I think we must conclude that a species may have the faculty of entirely dropping out some complete series of organs, like certain kinds of avicularia. The Mendelian principle may here come to our aid by showing the theoretical possibility of having the two conditions represented in a series of colonies of identical parentage. If this should really be the explanation of the facts, it should occasion no surprise if some members of the immediate progeny of a colony in which a certain type of avicularium is absent should be found to be provided with a complete armature of these appendages.

The cases so far considered may conceivably be explained on ordinary Mendelian lines by assuming that an entire colony is homozygous or heterozygous with regard to particular characters. Remembering that the so-called ancestrula, or primary individual, does not show all the characteristics of the mature colony, we must, however, assume that the determinants present in it do not find their full expression until the budding process has commenced.

But we are by no means at the end of our difficulties, even in considering the distribution of the appendages we have so far discussed. The instances already given have for the most part been cases in which an entire colony differs in certain respects from other colonies. We have still to notice the common case in which there are differences in different parts of one and the same colony. No theory can be considered complete unless it is able to account for these differences.

I approach this part of the subject with great trepidation, conscious as I am of the absence of experimental evidence for the suggestion I wish to make. This suggestion is, briefly, that if a segregation of characters normally takes place in the formation of the gametes of an organism, it is conceivable that an analogous segregation may occur in the blastogenic processes, or, in other words, in the formation of a bud. It may be asserted positively that there is a very definite differentiation of individuals at this time, not only in the Polyzoa, but also in other animals which increase by budding. The fact that some of these differentiations appear to be alternative suggests the possibility that they are due to a process which resembles the Mendelian segregation of determinants in the gametes.

One of the instances which appears to me specially suggestive in this connection is the genus Steganoporella, the species of which are remarkable for the dimorphism of their zoœcia. This dimorphism is expressed, as we have already seen, by differences in the opercula and in their muscles, and in the form of the orifices which are closed by the opercula. It is not too much to say that every individual in a Steganoporella colony belongs to one of the two types in question; and, so far as I am aware, intermediate forms of zoœcium do not occur. It is thus a positive fact that the blastogenic tissues undergo some sort of differentiation of an alternative character, and there is at present no reason for believing that the differentiation is in any way correlated with the production of sexual cells by either of the two kinds of zoœcia.

Another case which seems to me specially suggestive is that of the simultaneous occurrence in the same colony of two different kinds of avicularia. These instances are not confined to a few species, but may be found in a number of genera which do not constitute a single assemblage of related forms. The pointed and rounded adventitious avicularia may be scattered about promiscuously in the same colony, or even on the same zoœcium. Sometimes avicularia of one of the two types normally occur in a particular position, but are occasionally replaced by avicularia of the other kind, an example of a general phenomenon to which Prof. Bateson has given the name of "homœosis."

Excellent illustrations of this substitution may be taken from the genus Retepora. In the *R. monilifera* series already considered, the *munita* and *acutirostris* types of avicularia may occur in different fenestræ of the same colony. *R. granulata* usually possesses a labial avicularium and a frontal avicularium, both of the small rounded kind. In one of the colonies of this species dredged by the *Siboga* most of the labial avicularia are of this type, but a certain proportion of the zoœcia have a pointed labial avicularium. In another colony most of the *frontal* avicularia are small and round, but in some of the zoœcia they are large and pointed. In both instances the examination of the mandibles proved the reality of the distinction inferred from the shape of the calcareous parts.

Instances of a similar substitution could easily be multiplied, while the cases of the simultaneous occurrence of the two kinds of adventitious avicularia are innumerable. Without going so far as to say that intermediate conditions do not occur—a generalisation that could only be established by very prolonged study—it may certainly be maintained that it is the general rule for an avicularium to assume one of the two types. In a suitable preparation it is usually quite easy to sort all the mandibles into their proper group at first sight, and without having to pause to consider doubtful cases. This fact is surely significant, and it can at least be argued that in the blastogenic processes by which the avicularia have been developed some differentiation or segregation must occur by which the two kinds are constituted. If this differentiation should prove to be analogous to the segregation which occurs during the formation of gametes we should be able to account for much that is at present perplexing in the polymorphism of the Cheilostomata. We should in par

[1] It may be noted that it is extremely difficult and often impossible to make a study of every part of a large and irregular Retepore sufficiently exhaustive to justify one in asserting positively that all parts are identical in respect of their avicularia.

[2] This characteristic *munita*-avicularium is probably merely an enlarged f rm of the small circular type of avicularium met with as labial avicularia and in other positions in many species.

ticular not be precluded from regarding a colony with avicularia of one type as nearly related to other colonies which possess avicularia of the other type; and we should have some explanation of the fact that many of the genera possess all the different forms of avicularia which are variously distributed among their constituent species.

I have so far spoken as if the adventitious avicularia belonged to two types only. This statement requires some further qualification, although it may nevertheless be true that all the forms can be referred to one or other of the two principal kinds. As a matter of fact, a single Cheilostome colony may bear more than two sorts of avicularia; as, for instance, appendages with large pointed mandibles, in addition to two kinds of those with small rounded mandibles.[1] This introduces a further complication, about which it is unnecessary to speculate at present.

It may naturally be asked whether there are any numerical facts which support the suggestions I have made with regard to the significance of the different forms of avicularian appendages. I must admit that the numerical relations are so complicated and apparently so variable that I have not been able to draw any definite conclusion from them.

Experimental evidence is at present wanting, nor would it be easy to devise crucial tests. Even if it were possible to experiment with two colonies of the same species which differ in their avicularian appendages, the result might be negative, since it is not possible to say definitely whether the eggs of a given colony are normally fertilised by the spermatozoa of the same colony or by those of a different colony. Some light may conceivably be obtained from observations on the regenerative processes which may occur in Polyzoa. A recent Paper by Levinsen[2] gives some information with regard to this point, and there are a few other observations on the same subject scattered through the literature of the Polyzoa.

It is thus obvious that the speculations in which I have permitted myself to indulge cannot be regarded as more than a guess as to the significance of the causes which underlie the facts observed; but, whether the view I have outlined has anything to recommend it or not, the observations on which I have depended are, I think, correct. If this be the case, some explanation of the facts is urgently required. The decision of the principles on which the Polyzoa should be classified may not be a matter of immediate practical importance, but our theories of species cannot be regarded as established until they have shown themselves capable of explaining all the cases. Some modification of the Mendelian theory seems to me to be capable of elucidating the apparently haphazard way in which the several forms of avicularia are distributed in the species of Cheilostomata, and it may perhaps be allowed to afford a working hypothesis that can be used in systematic study. The results of such a hypothesis would, I think, be far-reaching. Whether we are justified in accepting it provisionally or not, I am convinced that we require some hypothesis by which we may regard two specimens as belonging to the same species, even though they may differ in what might at first sight seem to be fundamental respects. And, *vice versâ*, we require the liberty to regard two species as widely separated from each other in the system, even though they possess identical types of avicularia.

There are other questions which might have been considered in the Cheilostomata, and, in particular, the presence or absence of oral or marginal spines and the forms and distribution of the ovicells. The occurrence of the latter is, however, probably connected with the presence in the young zoœcium of tissue which will give rise to an ovary; and this implies the consideration of another factor which is very difficult to estimate.

[1] In the species of Retepora, for instance, there may occur the following types of avicularia, in addition to others that need not be mentioned: Conspicuously large avicularia, some of which are usually fenestral, either pointed (*a*) or rounded (*b*); small avicularia, either pointed (*c*) or rounded, these latter occurring as two well-marked types in which the mandible is respectively longer than broad (*d*) or broader than long (*e*). The following combinations may occur in individual species or colonies: *a*+*c*+*d*, *a*+*d*+*e*, *a* alone, *b*+*c*, *b*+*d*, and others. Examples of some of these combinations may be seen in Busk's Report on the Polyzoa collected by H.M.S. *Challenger* (Part XXX., 1884).

[2] "Sur la Régénération totale des Bryozoaires," Acad. Roy. des Sci. de Danemark, Bull. de l'Année 1907, No. 4.

I must not conclude without at any rate referring to the fact that the Polyzoa are by no means the only animals in which dimorphism or polymorphism occurs as the result of blastogenic processes. But among the Cœlenterates, for instance, the occurrence of medusoid individuals cannot be considered apart from the question of the sexual cells. There is, however, one series of cases among Hydroids to which allusion may perhaps be made. I refer to the existence of pairs of genera such as Corymorpha and Tubularia, Syncoryne and Coryne, Podocoryne and Hydractinia, in each of which pairs the two genera are distinguished by the fact that one produces free medusæ while the other has sessile gonophores. There is already some evidence that the validity of these generic distinctions is open to question; and the free medusoid individual and the sessile gonophore might conceivably be related in such a way as to form members of an allelomorphic pair. The same phylum contains another striking example of dimorphism in the distinction between gastrozooids and dactylozooids in many Hydroids; while in the Siphonophora the differentiation of various forms of individual has advanced much further.

But I have already gone much beyond my evidence, and I must bring my remarks to a conclusion by expressing the view that the causes which regulate the differentiation of the individuals during the blastogenic development of the Polyzoa are well worthy of further study, and that our knowledge of the unity of the vital processes throughout the animal kingdom gives us reason to believe that they are part of some general Biological law.

## SECTION E.

### GEOGRAPHY.

### Opening Address by Major E. H. Hills, C.M.G., R.E., President of the Section.

The thirty years that have elapsed since the British Association last met in this city of Dublin have seen an obvious and rapid progress in the science of geography, and a steady though perhaps not quite so apparent change in the character of that science.

In 1878 large parts of the earth's surface still remained untrodden by the feet of a white man; large areas were open to the enterprise and intrepidity of the explorer; large spaces were blank paper upon our maps. Now there is but little of the earth's surface absolutely unknown.

It is not my intention to detain you by any recapitulation of the work of these years to show you how and by whom these areas have been traversed and the gaps in our maps filled in. I intend rather to speak of the present and of the future work of the geographer, and to do this to any advantage we must at the outset recognise the change that has taken place in the nature of his task, and the fact that the days of individual exploration are over, never to return. We must recognise that sporadic, unorganised effort must be and is being replaced by organised, systematic work, and that the scientific traveller of the last century, with his rough map-making equipment, his compass, watch, and sextant has yielded his place to the scientifically equipped survey-party with their steel tapes, theodolites, and plane tables.

The theme is not a new one to this Section. I find on referring to the transactions of past years that in 1902, at the Belfast meeting, Sir Thomas Holdich, the President of Section E, said: "We find those spaces within which pioneer exploration can be usefully carried out to be so rapidly contracting year by year as to force upon our attention the necessity for adapting our methods for a progressive system of worldwide map-making, not only to the requirements of abstract science but to the utilitarian demands of commercial and political enterprise."

These words express succinctly the ideas that I wish to take as the text of my address to-day. I am, however, not ambitious enough to attempt to cover the whole surface of the earth in the brief review that I intend to put before you of the progress of scientific survey. Rather I wish to restrict our outlook to that section of the work in which we may all be considered as having a direct personal interest—namely, the survey of the British empire, especially those lands under the more immediate tutelage of the

Government of this country. Let it not be thought, however, that while we for the moment pay little attention to the regions lying outside this definition, we are supporting the fallacious idea that the survey of any part of the earth can be considered apart from the survey of the surrounding country. With the possible exception of the case of an oceanic island such an assumption would be an erroneous one. Our British empire is so widespread and our possessions are so often in close and intricate juxtaposition with those of other nations that there is in this work large scope, and indeed necessity, for international co-operation. Examples of this will occur to us in the course of our review. We shall thus see that in addition to the obvious connection which the geography of our empire has with that of other countries there is an even closer connection in the methods of manufacture of that geography, which methods we summarise under the general term of survey. One of the root ambitions of the scientific surveyor is to determine the exact figure of the earth, an operation for which observations spreading over a large area of the earth's surface are demanded. In fact, we may truly say that the problem of the earth's shape will not be completely solved until the whole surface is known to the surveyor. That is, therefore, pre-eminently a problem for international solution.

Before proceeding to the consideration of our special subject, the survey of the British empire, it will be interesting to interpose a few remarks on the questions of the utility and origin of national surveys in general. We may first note the somewhat curious fact that the production of a map of a country, useful as such a work is for many purposes, has almost always been embarked upon because the imperative necessity of maps of the theatre of operations in war has been brought home to the people and Government of a nation. Thus the ordnance survey of England had its first beginning in a military map of the highlands of Scotland, commenced in 1747, intended to facilitate the operations of the troops under the command of the Duke of Cumberland. It was not until many years later that the systematic triangulation of the country was undertaken, a work which was initiated partly for map making and partly for astronomical purposes. There was a consensus of opinion among astronomers that it would be greatly to the advantage of that science if the observatories of Greenwich and Paris could be connected by triangulation, and the famous French astronomer Cassini, in October, 1783, drew up a memoir to this effect. The arguments brought forward convinced King George III., and he granted a sum of money sufficient to enable the work to be started. This act of royal generosity was recorded by the surveyors in the following grateful terms: "A generous and beneficent monarch, whose knowledge and love of the sciences are sufficiently evidenced by the protection which he constantly affords them and under whose auspices they are daily seen to flourish, soon supplied the funds that were judged necessary. What his Majesty has been pleased to give so liberally it is our duty to manage with frugality consistent with the best possible execution of the business to be done."

It is worthy of remark that the junction of the triangulation systems of Great Britain and France was not made until 1861, and that the trigonometrical connection of Greenwich and Paris observatories has not yet been completed to the final satisfaction of men of science, a point which we shall have occasion to recur to later.

In France, we may note in passing, the starting of the triangulation had a quite different and quite definite object, the determination of the length of the metre. This unscientific unit of length was fixed as a fraction (1/10,000,000) of the quadrant of the earth's surface between the Pole and the Equator, and to find this quantity it was necessary to measure on the earth's surface as long an arc of the meridian as could be obtained.

In the case of our other great national survey, that of India, its origin is to be found in circumstances somewhat analogous. The Madras Government, owing to the success of the British arms in the Mysore campaign, found itself with a great accession of totally unsurveyed country in the middle of the Peninsula, while at the same time there were only in existence the roughest sketch-maps of the older possessions. It was apparent that if any map, of even approximate accuracy, was to be made covering a country of such vast area, it was imperative that the work should be prosecuted upon the most rigorous and strictly scientific basis. The general lines upon which it should be undertaken were laid down in February, 1800, by Brigade-Major Lambton, who addressed a letter to the Madras Government advocating a mathematical and geographical survey of the peninsula.

In this letter he discussed the principles upon which such a survey should be based. He dismissed astronomical fixations as not providing the requisite degree of precision, observing that such determinations of position are liable to great inaccuracies, "three, four, perhaps ten minutes," and proposed a triangulation emanating from a measured base line checked by similar base lines at intervals. He recognised that the figure of the earth and lengths of the polar and equatorial radii were not then known with the precision necessary for fixing the spheroidal co-ordinates of the trigonometrical stations of a survey covering such a large area of the earth's surface, and that a geodetic survey was therefore necessary *pari passu* with the geographical survey. He had an impression, how derived it is not now possible to say, that there was a sudden abnormal diminution of the force of gravity at the latitude of 10° north, and consequently that "a degree on the meridian from that parallel to the Equator must be very short compared with a degree to the northward of 10°." He observed that it would be necessary to "attend to this circumstance," which he characterised as important both from the map-making and from the rigorously scientific point of view. He added: "I shall rejoice, indeed, if it should come within my province to make observations tending to elucidate so sublime a subject."

In a similar case, occurring in recent years, the outcome has not been so satisfactory. It will be within the recollection of all here how at the time of the South African war the public at home learnt with shocked surprise that there were no maps in existence of a colony which had been under the British flag for a long period of years. To those who knew the facts this was, naturally, no matter of surprise; but it was earnestly hoped by many that this grave deficiency thus revealed by the stress of war would be remedied by quiet work in the time of peace, and that, at the conclusion of the military operations, the foundation should be laid for a federal survey department of British South Africa comparable with, though on a more moderate scale than, the Survey Department of India. This hopeful scheme, which it may be recorded very nearly came to fruition, ultimately found political conditions too adverse, and had to be indefinitely postponed. An army engaged in field operations in the north of Natal now, or, in fact, at any time for an indefinite number of years in the future, would find the country nearly as mapless as it was found by Sir R. Buller in 1900.

In this short recital of the determining causes which have in the past led to the initiation of national surveys, it will have been noticed that no allusion has been made to what we should now perhaps consider the main utility of a map—namely, its value for all purposes connected with the ownership, development, and taxation of land. When the ordnance surveys of Great Britain and Ireland were originated there was little thought of this use, and it was not until long after that period, when the enormous deficiencies of the existing property plans were revealed by the Tithe Commutation Acts and by the railway boom, that the value of a national survey for preparing a cadastral or large-scale property map of the country was recognised and acted upon. Now this is often the ostensible object for embarking upon a regular survey. It is fully recognised that, especially in the case of a country undergoing rapid development, which is fortunately true of many of our oversea possessions, the provision of an accurate land map is of prime necessity both to the private or corporate landowner and to the State.

Neither were any of the early surveys undertaken for the purpose of mutual delimitation of international boundaries, a necessity which has in recent years been the stimulating cause for many pieces of valuable survey work, especially in Africa.

The other manifold uses of a map are familiar to all of you, and we need not pause to enumerate them. We

may admit the fact that the adequate mapping of its territories is recognised as one of the duties of a civilised State. Let me now turn to the main subject of this address—the inquiry as to how far this duty is performed by us, what shortcomings we can perceive, and what suggestions we can offer for the future.

Two years ago this task would have been a difficult and laborious one. Now it is greatly facilitated by the issue from the Colonial Office of those excellent little volumes, the reports of the Colonial Survey Committee.

This body has been in existence since August, 1905, and has published three annual reports. The Committee is therein defined as an advisory one formed at the instance of the Secretary of State for the Colonies to advise him in matters affecting the survey and exploration of British colonies and protectorates, more especially those in tropical Africa. It is not at present an executive body, that is to say, it has at its own disposal no grant of public money or other funds; whether it will ultimately develop into such is a question that the future alone can answer. Even thus limited in scope and powers it has, however, already worked a notable improvement—firstly, by laying down authoritatively some of the more salient conditions that ensure the efficient and economical expenditure of whatever funds may be available, and by pointing out the disastrous extravagance of unsystematic and unmethodical work; secondly, by insisting upon uniformity where uniformity is essential, such as in matters relating to the style, projection, scales, and sheet-lines of the maps produced, while leaving the utmost latitude as to methods, these being selected in each case to suit the very divergent nature of the country met with. It results from this that any two small portions of the map of Africa, say, for instance, one sheet of the dense forest region of the Gold Coast and another of highland country of East Africa, though 3000 miles apart and executed at different times by a different staff, will match each other in general character, and will ultimately be found to fit exactly into their places as constituent parts of a great map of the country. Thirdly, we may reckon the mere fact of publicity in these matters as of no mean advantage. Though, as in the case of many other Government publications, this report is not as widely read as its merits deserve, yet it is all to the good that the information is there ready and available for anybody who has the curiosity to consult it. I therefore welcome the opportunity of directing your attention to this volume.

In entering upon the discussion on the survey of British Africa, the first point that meets us is the geodetic basis of the whole work; upon what do the actual positions depend? In other words, to put the matter more familiarly, how are we to provide that every isolated piece of the map will exactly fit into its proper place? The only method for ensuring this is by basing all our surveys, ultimately, upon a skeleton or framework of geodetic or primary triangulation executed with the utmost attainable precision. Such a skeleton, or rather backbone, will eventually exist in Africa in the shape of the meridional arc, or chain of triangles, along the thirtieth meridian, running right through the country from north to south, and ultimately joining on to the great arc observed by the famous astronomer Struve. This originally extended from the mouth of the Danube to Hammerfest, in Norway, an amplitude of 25½° of latitude. To prolong it southward, passing up the Nile Valley, through the heart of tropical Africa, across the Zambezi River, and terminate it at the southernmost point of the continent, is a magnificent conception due to Sir David Gill, to whose energy and enterprise the actual execution of considerable sections of the undertaking must also be ascribed.

At the present time the chain has been completed from the south to within seventy miles of the southern end of Lake Tanganyika, a distance of about 1700 miles. At Lake Tanganyika it will enter into German territory. The German Government, fully recognising that the project is not only of great theoretical interest, but also of immediate practical value, are already taking steps to start work on their own section, from the south of Tanganyika up to the parallel of 1° south latitude. From 1° south, northward to about 1½° north, the arc lies near the boundary between the Congo Free State and the British Protectorate of Uganda. An International Commission is at present engaged in the survey of the boundary region, and Sir D. Gill, ever ready to seize an opportunity of forwarding the work he has at heart, succeeded in raising sufficient funds, partly from the Treasury and partly by grants from a few leading scientific societies, to enable an observer to be sent out with this Commision to carry the arc over this section. North of this point the line comes into the territory of the British Soudan, and traversing this eventually reaches Egypt proper. Here it comes into the charge of Captain H. G. Lyons, the director of the Survey Department of Egypt, under whose care its interests are safe.

It will thus be seen that while the actual completion of the whole chain is as yet somewhat remote, we are in the satisfactory position of being able to say that, so far as the section lying on the continent of Africa is concerned, there is no portion of which there is not a reasonable probability that it will be finished within a measurable period. With regard to the section joining Africa and Europe the position is not so happy. This will run through Palestine and Asia Minor, and therefore lies in Turkish territory. It is not likely that the Turkish authorities either will or could carry out such a work; in fact, seeing that even when completed it would be totally useless to them, it would be hardly reasonable to expect them to do so. It must, therefore, presumably be a matter for international cooperation. One point may be mentioned with regard to the exact route of this connecting section. Sir D. Gill, in his Report on Geodetic Survey of South Africa, 1896, said: "By an additional chain of triangles from Egypt along the coast of the Levant, and through the islands of Greece, the African arc might be connected by direct triangulation with the existing triangulation of Greece, and the latter is already connected with Struve's great arc of meridian which terminates at the North Cape in latitude 71° N. The whole arc would then have an amplitude of 105°." This, however, gives rather a poor connection with the European triangulation. The South Albanian series has a much higher average error than either Struve's original work or any part of the African series. This portion would consequently be a weak link in the geodetic chain, and it would be better to avoid it altogether by carrying the line along the coast of Asia Minor to Constantinople, and then up the east side of Turkey to the mouth of the Danube.

When we look back a few years and call to mind the prominent part that this country has taken in the survey of Palestine—I need only mention in this connection the names of Kitchener, Warren, and Conder—we cannot avoid a feeling of regret that we are not ourselves in a position to take the whole execution of this section of the line upon our shoulders. I am too well aware of the many urgent claims upon the Treasury to suggest that it is possible that they would be prepared to incur such a charge; but supposing, for the moment, that part of the necessary funds could be provided from other sources, I think we may fairly urge that it is our duty to contribute a substantial monetary grant towards the furtherance of an end so desirable and so practically useful.

The difficulty of obtaining money for geodetic work, the benefit of which is not immediately apparent to the man in the street, is notorious. Thus Sir T. Holdich, in 1902, said: "But this accurate framework, this rigorously exact line of precise values which ultimately becomes the backbone of an otherwise invertebrate survey anatomy, is painfully slow in its progress and is usually haunted by the bogey of finance. It does not appeal to the imagination like an Antarctic expedition, although it may lead to far more solid results, and it generally has to sue *in formâ pauperis* to Government for its support." To account for this regrettable, but undoubtedly true, fact two reasons may be adduced. There is, in the first place, the possible ignorance as to the ultimate value of the work; but, secondly, and perhaps not least, there is the fear, not entirely unjustified, that to satisfy the demands of the scientific man is something akin to the operation of filling a sieve with water. It has been so often seen that compliance with one demand only leads to another being made, that we may well sympathise with the holder of the public purse when he draws the strings tight and

refuses to pay for an arc along the thirtieth meridian in the fear that directly this is completed he will be asked to pay for one along the twentieth meridian, and then along the tenth, and so *ad infinitum*. It behoves us, therefore, as practical men to make sure that our demands are reasonable and limited to the actual requirements of the case, and where such limits cannot be set we should make this fact clear at the outset. When, however, it is possible to set such limits, we should not hesitate to do so; and in the case of the African arc this latter course is fortunately possible.

If we take the map of Africa we shall see that the arc along the thirtieth meridian passes through, or near, all the colonies of British South Africa, close to British Central Africa, or Nyasaland, through Uganda, and is thus connected with British East Africa, through the British Soudan and through Egypt. There remain absolutely untouched by it only the West Africa colonies—Nigeria, the Gold Coast, Sierra Leone, and the Gambia. These latter will eventually get their geodetic framework by an extension southwards of the French triangulation of Algeria, a work of a high order of precision. We are therefore entitled to say—and I take this opportunity of saying it with all due emphasis—that with the exception of some triangulation to join the West African colonies with the French triangulation, the arc along the thirtieth meridian is the only primary triangulation required for the adequate mapping of the whole of British Africa. The remainder of the geodetic framework can be supplied by ribs of secondary triangulation branching out from the main backbone, such as the line already completed along the boundary between British and German East Africa, passing to the north of the Victoria Nyanza and thence westward to the thirtieth meridian.

You will observe that I here speak only of the triangulation required for mapping purposes, not of that demanded by the geodesist for the study of the figure of the earth. The latter is satisfied only with a survey of the highest attainable precision covering as large an area of the earth's surface as possible, or at all events with arcs, both meridional and longitudinal at frequent intervals. It cannot be other than a very long period before the whole of Africa is surveyed upon this scale of accuracy, and in the meantime we must devote ourselves to the far more urgent duty of mapping the country, leaving the more remote and abstract task to our descendants, well satisfied if in our hands the foundations have been well and truly laid.

Furthermore, as we shall see presently, if we are prepared to recognise as a national duty the minutely precise survey of our own land and of all territories under our flag—and I do not see how any reasonable man can withhold this recognition—then there are duties of this nature lying closer to our hands than any to be found in Africa.

Having thus passed in brief review the ultimate geodetic basis of our African surveys, let us enter more into detail and glance at the actual survey work now in progress in the different regions of the continent.

In British South Africa, as we have already noted, the political conditions are at present unfavourable to any comprehensive scheme of operations. There is, however, in progress a first-class topographical survey of the Orange River Colony and a reconnaissance survey of Cape Colony. The former is an excellent example of the class of work that can be done by a small military party of the highest technical training working upon systematic lines, and I should like to devote a few minutes to a short description of the methods adopted and of the results obtained.

The survey party consists of two Royal Engineer officers and four non-commissioned officers, the former undertaking the triangulation and the general supervision of the field work, and the latter the plane tabling. The positions are primarily based upon the points of the geodetic survey broken up into a secondary triangulation with sides averaging ten miles. In 1907 the average triangular error of the secondary work was 2·9 seconds of arc, and the greatest linear errors of displacement, as tested by the geodetic triangulation at the end of a chain forty-five miles long, were three feet in latitude and two feet in longitude. The probable error of a trigonometrical height was under a foot. You will see, therefore, that the accuracy is ample for all mapping purposes, even upon large scales, and the degree of precision is in excess of that demanded for a topographical map on the scale of two miles to an inch. The rate of progress and the low cost of work are, however, no less notable than its accuracy. The actual rate of out-turn is about eight square miles per day per man, or for the whole party twenty-three square miles of detail survey per diem, and the number of trigonometrical points fixed about three hundred per annum. The cost works out to about eight shillings per square mile of the completed map, and the whole area of 47,000 square miles will be finished, printed and published, in five and a half years.

These remarkable results are due in a large measure to the energy and organising power of the officer in charge, Captain L. C. Jackson, R.E. The detail survey is done in sheets fifteen minutes square, each non-commissioned officer being given one complete sheet, which he works at until finished. Four such sheets are therefore in progress at any given time, and each sheet takes about six weeks. Seeing the rapid rate of progress maintained, it might perhaps be thought that the country is a particularly easy one for the topographer. Such is, however, by no means the case. It is true that there is an entire absence of the surveyor's greatest impediment, large areas of dense forest, but there is much broken and difficult country, rising in places to altitudes of above 7000 feet.

In Cape Colony the reconnaissance survey is of a somewhat similar character, but owing to the large area of the country and to the small amount of money available the work has perforce to be of a more rapid nature. In Natal, Bechuanaland, and Rhodesia no survey is at present in progress.

Passing northward through Africa, we come to the British Protectorate of Nyasaland, formerly called British Central Africa. Of this country a certain number of maps exist purporting to give topographical detail; but as they are not based upon any framework of triangulation, and as much of the detail only depends upon rough sketches, it is impossible to say how far they can be accepted as correct representations of the ground.

It is most unfortunate that financial considerations prevent the execution of any systematic trigonometrical survey. The absence of such, and the fact that maps are being made which must inevitably be withdrawn and replaced by others in the future, will undoubtedly be the cause of ultimate waste of money.

Passing northward again we come to the large and important protectorates of British East Africa and Uganda, in both of which systematic surveys are in hand. The geodetic framework is supplied by a triangulation along the Anglo-German boundary, connected with chains of triangles along the railway in the neighbourhood of Nairobi. In Uganda proper there is also a triangulation covering a substantial area. As already noted, all this work will eventually be tied into the thirtieth meridional arc, though it is not likely that the final adjustment of geodetic positions thus arrived at will necessitate any substantial alterations upon the maps.

In both protectorates topographical surveys are in hand, and maps on the scale of two miles to an inch will be issued. In British East Africa, under the able direction of Major G. E. Smith, R.E., rapid progress is being made. This topographical mapping is additional to the cadastral maps also in progress in both countries. These latter are required for property purposes, in Uganda for demarcating the estates given over to the native inhabitants of the country under the agreement of 1900, and in East Africa for attachment to title-deeds of lands alienated for farming or stock-raising.

In the Soudan the enormous area of the country—more than a million square miles—and the limited funds available have prevented any systematic survey being taken up. A large amount of reconnaissance mapping has been done, and a series of sheets on the scale of 1/250,000 (four miles to an inch) have been published. These are corrected and improved by officers and Government officials as opportunity offers. The energies of the Survey Department are almost entirely spent in meeting urgent local requirements in the shape of cadastral maps of the cultivated areas along the river.

Somaliland, a British protectorate which came into un-

fortunate prominence a few years ago, is a country of too small value to be worth the cost of any sort of survey, and the only maps that exist are based upon the route sketches of travellers and sportsmen and upon the work done by a small section of the Survey Department of India during the military operations five years ago.

Leaving the east side of Africa and turning our eyes westward, we may note that in the colony of the Gold Coast a rigorous survey was rendered imperative by the gold-mining boom of 1901. The work was entrusted to Lieut.-Colonel Watherston, C.M.G., R.E. Owing to the dense forest covering practically the whole country triangulation would have been prohibitive in price and very slow in execution. The initial positions were therefore fixed by a network of long traverses, executed with all possible refinements with steel tapes and theodolites. Astronomical latitudes were observed by Talcott's method at every fifty miles. The errors of misclosure of the traverses proved to vary from about 1 in 2000 in unfavourable cases to nearly 1 in 6000—results inferior to triangulation, but at the same time sufficiently accurate to form the basis of a map with no appreciable errors *on the paper*. One great defect of the traverse method of fixing points lies in the practical impossibility of carrying the heights through without occasional checking, either by lines of levels or by trigonometrical observations. Such work makes, therefore, an imperfect basis for topography, and would only be used when natural features compel its adoption.

Northern Nigeria is a country of enormous area, and, up to the present, of small revenue. It has therefore not been found possible to allocate the funds for any systematic mapping. The existing maps are compilations based upon sketches made by civil and military officers when travelling upon duty and upon the surveys made by the different Anglo-French and Anglo-German boundary commissions. In 1905–6 Captain R. Ommaney, R.E., fixed the astronomical longitudes of fifteen towns by exchange of telegraphic signals with Lagos. With the aid of these values, combined with a number of astronomical latitudes, it has been possible to combine the material into something like a complete map. It need, however, hardly be pointed out that astronomical fixations are liable to large and uncertain errors, due to the variation of local attraction, and cannot attain the precision of even a rapid triangulation. In Southern Nigeria the experience has been somewhat unfortunate. This colony has spent a very substantial sum upon its survey department, and if the work had been properly organised and systematically carried out we should by now be in possession of a complete map of a large portion of the country. Unluckily, the mistake has been made of detaching survey parties for non-geographical purposes, such as the erection of telegraph lines, work doubtless urgently required in the interests of the colony, but not lying within the sphere of a survey department. Thus systematic progress was rendered impossible, and, though isolated pieces of triangulation and long lengths of traverses have been done, no topographical map of any area yet exists.

Of the remaining West African colonies the Gambia river is a narrow piece of land with boundaries running parallel to the river banks, and, except for the actual trade along the river, is unimportant. In Sierra Leone the country in the immediate vicinity of Freetown was surveyed by the colonial survey section, a small party employed by the War office for the purpose of making surveys of places of special military importance. The map of the remainder of the colony is a compilation based on miscellaneous material.

In the course of this summary of the state of the mapping of British Africa mention has been made of the surveys made by joint commissions appointed for the delimitation of international frontiers. No small part of the existing map is due to work of this class. Thus joint Anglo-French commissions have marked out the frontiers of the Gambia, Sierra Leone, the Gold Coast, and Nigeria; Anglo-German commissions the eastern boundary of Nigeria, the boundaries between British and German East Africa, between German East Africa and North-East Rhodesia from Lake Nyasa to Tanganyika, and between Bechuanaland and German South-West Africa; Anglo-Portuguese commissions the frontiers between Portuguese East Africa and North-East Rhodesia and Nyasaland respectively. Useful surveys have also been made in the course of the mutual demarcation of the frontiers between Abyssinia and the Soudan on the west and British East Africa on the south; also of the frontier between the colony of Sierra Leone and the Republic of Liberia.

Important as the work done by these commissions has been, its value would be greatly enhanced if the reports of each commission were published in a succinct and easily accessible form. Such reports would naturally contain a record of the actual frontier as finally ratified, and also a technical account of the survey methods employed. They would thus be of permanent use both to the official or officer on the spot for the easy settlement of any disputes that may arise, and to the chief of any future boundary commission as an aid to the selection of the methods of survey most suitable to the particular country with which he is concerned.

Up to three years ago many of the African protectorates were under the tutelage of the Foreign Office, while the older colonies were under the Colonial Office. The reports of Boundary Commissions are therefore scattered through official documents in the two offices, and are drawn up upon no uniform model. Now that the superintendence of all these territories has been handed over to the Colonial Office, and that body has set itself such an excellent example in the appointment of the Colonial Survey Committee and the publication of its reports, it is greatly to be hoped that they will follow up the good work and systematise and publish all these Boundary Commission reports. If a model for such a publication is desired, I may refer to the account of the demarcation of the Turko-Egyptian frontier between Rabah on the Mediterranean to the Gulf of Akaba, lately issued by the Egyptian survey.

The account which I have endeavoured to give you, short and imperfect as it is, of the present state of the mapping of British Africa will have shown you clearly that there is a large amount of excellent work now in course of execution, and that there has been, especially during the last few years, very considerable progress made towards coordinating this work and towards maintaining certain fixed standards of accuracy, rapidity, and economy.

It will naturally occur to you to inquire whether this coordination could not advantageously be pressed a step further, and whether all the isolated survey departments, now working in the various colonies and protectorates, could not be amalgamated under one executive head; whether, in fact, a Survey Department of Africa, precisely analogous to the Survey Department of India, could not be formed. The advantages of such a step are obvious, but must not be allowed to blind us to the difficulties. We have, in the first place, the objection to be met that the South African colonies would, in present circumstances, almost certainly refuse to join in any general scheme, and would not consent to any arrangement whereby money raised in one colony would be spent outside its own geographical limits. If, however, we leave South Africa out of the question, the financial difficulty tends to disappear. Both our East and West African possessions are, in general, not yet in a position to maintain themselves, and are still, and will be for some time to come, partially supported by grants from the Imperial Treasury. To divert a portion of these grants to pay for the maintenance of a survey department would only be a matter of account, and could be adjusted so as to cause no hardship to any one colony. There remains the geographical difficulty of space. The fact that the heads of the department would have to keep in close personal touch with countries differing entirely in character, and perhaps three months' journey from each other, does not appear to offer any insuperable objections, and I cannot avoid expressing the hope that it may be found possible at a no very remote date to take some steps in the direction of a consummation which appears so desirable.

In giving my evidence before the Royal Commission on the War in South Africa, presided over by Lord Elgin, I outlined the general features of a scheme under which the Imperial Government would undertake the topographical mapping of all our oversea possessions, apart from self-

governing colonies. As on this occasion I was considering the whole question more exclusively from the military side, no reference was then made to the question of cadastral maps, and it was tacitly assumed that these would fall to be constructed by the land office or a land survey department belonging to each separate colony. On the present occasion we are not restricted to the military point of view, but are permitted a wider outlook. Our task is to consider the map in all its aspects, both as regards its method of construction and its ultimate use, whether for military, administrative, engineering, or purely scientific purposes. This enlargement of our scope does not, I think, modify our previous conclusions, and were I now called upon to devise a scheme for the mapping of British Africa, I should base it upon the principle of a central Imperial body for executing the triangulation and topography, leaving the land survey to local organisations.

The arguments in favour of this policy are manifold. As regards the triangulation they hardly require stating. It will be obvious to all that such work must be closely coordinated, and that some central, directing head is imperatively called for. The enormous waste of money that is ultimately involved by tolerating imperfect work, of which many examples could be cited, is alone a sufficient justification for holding this view. We may, however, pause to examine a little more closely into the advantages of centralisation as regards one particular operation in a survey. That is the measurement of the initial base line upon which the accuracy of the whole framework depends. This task used to be one of the most laborious and difficult with which the surveyor is confronted. The apparatus employed, some form of compensation bar, was cumbrous and difficult to use, the site selected had to be levelled, and the preparatory alignment carried out with the most scrupulous care. Thus the Loch Foyle base for the triangulation of Great Britain and Ireland was about six miles long, and the actual measurement, quite apart from the time spent on the preparation of the ground, took sixty days, an average rate of work of just more than 500 feet per working day.

A few years ago the discovery was made of the nickel steel alloy with a very small or zero coefficient of expansion, the so-called invar. This valuable metal, by abolishing the necessity for any temperature correction, has enormously simplified all physical measurements of length, and, *à fortiori*, those measurements, such as base lines, which are perforce done in the open air and over a large range of temperature. Survey bases are now measured with an invar wire stretched to carefully regulated tension, and either laid along a flat trough, or what appears to give equally good results, hung freely between supports. The gain in precision due to the avoidance of errors of expansion or contraction in the measuring apparatus is substantial, while the gain in rapidity is very great. Thus, as a contrast to the Loch Foyle base, let me give a short account of the measurement of a base in Spitsbergen by the Russian party of the joint Swedish and Russian missions in 1900, extracted from a review already written for the *Geographical Journal*.

The conditions for accurate work were very unfavourable: no site even approximately flat could be found, and the base was therefore irregular in contour and traversed rough and in some parts marshy ground. The weather conditions were far from ideal. The cycle of operations was as follows: An auxiliary base 175 metres long was measured with Struve's apparatus, twice before the main base measurement and twice afterwards. The two wires used for the main base were standardised on this subsidiary base four times, twice before and twice after use. The main base, 6·2 kilometres long, was measured twice in each direction by each of two wires, eight measures in all. The limit of error in the final value was 17 millimetres—say, one part in 360,000.

The whole of these operations, including the laying out of the standard and the comparison of the wires, were completed in a period of three weeks; Monsieur Backlund, who superintended the actual measurement, left the observatory at Pulkowa on June 11 and returned to it on July 24. It was therefore possible to standardise the wires not only by the check base upon the spot, but also by the permanent standards of the observatory within three weeks of their use for the actual measurement. It need hardly be pointed out that this was eminently favourable to the attainment of the highest exactitude, and we have here a marked example of the value of centralisation. The proposed trigonometrical survey department of Africa would probably find it advantageous to adopt similar procedure, and, instead of trusting a base measurement to a local staff unacquainted with the work, it would send out one or two men of highly trained technical skill equipped with the best apparatus. The money spent in journeys would be more than saved—firstly, by the unquestionable gain in accuracy and the consequent avoidance of the costly necessity for repeating bad work; and, secondly, by the gain in time, due to the fact that the local staff would not be called upon to learn the use of an unfamiliar set of instruments.

Similar advantages would arise from a partial specialisation of the angular measurements. Thus the first-class observer with a theodolite must possess certain qualities of eyesight, health, and judgment, rarely combined in one individual. When such a combination of qualities is found it should be made the best use of, and a good man should not be wasted on second-class work. At present, upon the system of regarding each colony as an isolated unit, it is not possible to employ every man to the highest advantage, and there are doubtless many examples at present in Africa of able men being set tasks much below the standard of their ability, and, *per contra*, men of no such qualifications being given work beyond their powers. It is only by working with an extended organisation, employing a large staff and responsible for a large area of country, that any approximation can be made towards that ideal wherein every member of the establishment is used to the best advantage according to his special qualifications.

To turn from the triangulation to the question of topography, we shall find analogous arguments in favour of entrusting this work to one central department. Whether we consider the necessity for a uniform system of training for the topographer, or whether, looking at the matter from the other side, we consider the desirability of a close degree of uniformity in the resulting map, we arrive at the same end. Nor need we confine ourselves to theoretical arguments; practical results are before us as examples. It is not possible at the present moment to point out a single case of a thoroughly satisfactory topographical map of any country whatever which has not been executed by men trained in a properly organised survey department or, what is equivalent, in the Corps of Royal Engineers. Examples of failure to accomplish this are numerous. Thus we have the cases of the British Colonies in South Africa before the war; of Canada, where no topographical map existed until two years ago, when the work was taken up by the military department; and of Ceylon, where, in spite of the vast sums spent on survey and the small size of the island, no topographical map of the slightest pretensions to completeness exists of any part of the country.

It may also be noted that, especially in the case of a developing country, it is of enormous advantage that the map shall be begun and finished within some reasonable time. If a long interval elapses between the commencement and the completion, the first sheets are out of date before the last are done, and the whole exhibits a most undesirable lack of uniformity.

With a central organisation the mapping of each protectorate can be taken up in turn and dealt with rapidly, thus producing a homogeneous map impossible to a small local body. Upon the converse point, the question as to whether our central department should or should not undertake cadastral survey, the arguments are perhaps not so one-sided. It is, however, quite clear towards which side the balance of advantage tends. Taking into account the intimate connection of the cadastral survey with the system of land holding and land taxation, the fact that these systems necessarily vary and that as a financial matter of account the receipts and expenditure of each colony are separate, it is not difficult to see that the land survey is better left to local control. This would not preclude any particular colony from arranging with the central body for the execution of any definite piece of

work of this class, upon terms agreeable to both sides, in a similar manner to that in which cadastral survey is executed by the Indian survey for provincial Governments, and it need hardly be pointed out that the geodetic points fixed by triangulation would in any case be available as a framework for the large-scale map.

The geographical survey of the British Empire, apart from Africa, will not on this occasion detain us long. I exclude from present consideration the great self-governing colonies—Canada, Australia, and New Zealand—and also the whole country lying within the sphere of the survey of India. Ceylon has an elaborate land survey system; and though, owing to past mistakes, the geographical mapping of the island is in a most lamentably backward condition, there are good grounds for hope that this state of affairs will be remedied in the near future. The Malay States, where, owing to the fertility of the soil and the ubiquity of rich tin ore, the land values are high, have the basis of an excellent survey system, and possess a backbone of triangulation which will eventually extend southward to Singapore, and possibly northward to join the Indian series in the south of Burma. Hong Kong, including the leased territory on the mainland, is of small area and of no appreciable geographical importance. It has been adequately mapped for military purposes. Of our insular possessions, Mauritius, St. Helena, and (in the Mediterranean) Cyprus and Malta are thoroughly surveyed. The other islands scattered throughout the ocean which fly the Union Jack, including the West Indies, while their coast lines have naturally been the subject of close attention by the Hydrographic Department of the Admiralty, are, as regards their internal geographical features, still quite imperfectly known. The large and important territory of British Guiana is entirely unsurveyed, and indeed in part almost unexplored.

You will thus realise that if we are prepared to admit the validity of the premiss that the mapping of its own territory is an imperative duty of a State which aspires to justify itself before the nations as the possessor of a world-wide Empire, there is still plenty of employment for the scientific geographer in the British dominions.

Having thus far spoken of our duties and obligations, for such they appear to me, which lie abroad in countries remote from our own shores, let us now turn our eyes inward and see if we cannot discern some similar duties lying close to our hands.

I take it that the great majority of us have been brought up in the idea that our own Ordnance Survey is of such a high order of accuracy that a proposal to undertake a revision of the fundamental triangulation of the British Isles must appear strange. Yet this idea will not be a new one to the British Association, for two years ago at the York meeting I brought the subject before this Section in a short note, which gave rise to a useful discussion.

What I shall say now will be in a large measure a repetition of my previous remarks, a repetition for which I need offer no apology, as it will be apparent to you that had any steps been taken to remove this standing reproach to British geodetical science no recurrence to the subject would be called for. As matters stand, however, I feel impelled to recur to it with increased emphasis, a position in which I am confident of being supported by all those who earnestly care for the scientific repute of our country. Some few years ago, at the request of the International Geodetic Conference, a volume was prepared by General Ferrero, the eminent Italian geodesist, giving a summarised account of all the geodetic surveys of the world. If we take this volume and examine the relative degree of precision of the different national surveys there enumerated we shall find that Great Britain stands lowest on the list.

The popular illusion, for it is really no other, as to the extreme accuracy of the triangulation of the British Isles rests in no small degree upon what must be considered a fortuitous circumstance—namely, the accidental smallness of the closing error. Have we not all been told how at the conclusion of the triangulation, when the observations had been carried from the primary base on the shore of Loch Foyle across part of Ireland and across Wales and England, terminating in two points on Salisbury Plain, the distance between these points was calculated, using as data the measured length of the Loch Foyle base and the observed angles of the triangles across the country? The distance between the same two points was then measured with every refinement of accuracy, and the measured length compared with the calculated length. The difference between them was found to be twenty inches. If in traversing a large portion of the kingdom the aggregate error only amounted to this minute quantity—minute, that is, compared with the distances involved, how can we either expect or demand a better result, even if the work be re-done with the most refined methods that the accumulated experience of the last fifty years can suggest?

To answer this question we must bear in mind that the closing error of a piece of work such as a triangulation is not the only, nor indeed the best, test of its precision. A small closing error may be due to accident; larger discrepancies may have occurred at intermediate stages which have chanced nearly to cancel themselves at the end. Such undoubtedly did happen in this case. The work was not as accurate as the smallness of the closing error would seem at first sight to imply. We have, however, in such a case an absolute measure of relative precision in the magnitude of the average triangular error, being the quantity by which the sum of the observed angles of a triangle exceeds or falls short of the true value of 180° + spherical excess.

From this we can readily deduce the "probable error" of a single observed angle, a form in which the measure of precision of a triangulation is often expressed.

In our British survey this quantity equals 1·20 second of arc, while in good modern work it does not in general exceed 0·25 second. Making due allowance for the fact that the network of triangles over our islands is a complicated one, and therefore that the ultimate precision is considerably greater than that of a chain of triangles of the same order of individual accuracy, we are probably justified in concluding that a re-survey would at least halve the final errors.

Such a re-survey is urgently demanded in the interests of international geodesy.

It will of course be clearly understood that this implies no adverse criticism upon the work of the men who originated and carried out the primary triangulation of the British Isles. For that great achievement we must all have the most sincere admiration. It was pioneer work of the highest order; it set a standard of accuracy never before attained, and was for long taken as the model for such work in other countries. It was, however, started at the end of the eighteenth century, and was completed in 1857. It is therefore hardly surprising that it falls somewhat short of the precision of modern observations of the same class. It will also be understood that this re-survey does not affect the question of the trustworthiness of our Ordnance Survey maps. Any errors which exist in our triangulations are important only for geodetic discussions, such as the determination of the exact figure of the earth, and are quite negligible for map-making purposes. There can be no appreciable error from this cause upon the maps of our own country, even those on the largest scales, and no question of reconstructing our maps can arise. This is fortunate from the financial point of view. Such a reconstruction would involve a very heavy expenditure, while the cost of the re-triangulation suggested would be quite trifling compared with the actual annual expense of our national surveys.

The result of this inferiority in accuracy of the British survey is that it is useless to coordinate it with the Continental series for geodetical purposes. This defect is all the more noticeable in that the necessary observations for joining up the two series were actually made. Three stations on the coast of Kent—St. Peter's Church, between Margate and Ramsgate; Coldham, a hill about two miles north of Folkestone; and Fairlight, a hill about four miles north-east of Hastings—were connected trigonometrically with three stations in France—Montlambert, near Boulogne; St. Inglevert, over the village of Wissant; and the Clock Tower at Gravelines. This was done in 1861–3. The observations were of a high order of precision. It would not be necessary to repeat them.

The importance of the coordination is apparent when we inspect a map of Europe with the neighbouring part

of Africa, upon which the triangulation lines are entered. We then see that the British part of the work is imperatively required to extend, and in fact to complete at one end in each case, two important geodetic arcs, viz., the meridional arc along the meridian of Greenwich and the longitudinal arc along the latitude of 52° north. Without the British portions these arcs extend from Ain Sefra in Algeria to Gravelines in France, an amplitude of 18°, and from Orsk in Russia to the same point in France, an amplitude of 57°. With the British section added they would be further extended to Saxavord, the northernmost point of the Shetland Islands, and to Valentia, on the West of Ireland, respectively. The added amplitudes would be 10° and 11½°, very material additions, which would undoubtedly prove of substantial scientific value.

It will thus be seen that it is by no means necessary, or even desirable, to re-observe the whole network of triangles covering our islands. All that is required is to connect geodetically the three extreme points—Saxavord, Valentia, and the stations on the Kent coast just mentioned.

A knowledge of the exact figure of the earth is of high scientific importance, especially so in reference to recent speculations as to its possible deviation from a spheroidal form. It cannot be other than a subject of national shame that so important a link in this research remains unfilled. We may note with gratification the forward position that our nation has in the past taken in the advancement of geodesy. We know the great work done in the triangulation of India, and we have alluded to the magnificent conception of the Cape to North Sea arc due to Sir David Gill. Surely it is not asking too much that we should take steps to set our own house in order, and to ensure that our own triangulation is at least as accurate as that covering the neighbouring portions of the continent of Europe. The subject is one upon which the powerful influence of the British Association might legitimately be brought to bear, and any representations from our body would come with a peculiar appropriateness from this the Dublin meeting, seeing that so large a section of the work, the importance of which we wish to urge upon the Government, lies upon Irish soil, the execution of which would therefore devolve naturally on the Ordnance Survey of Ireland.

In concluding this address I feel constrained to apologise for what may have appeared to some of you the dull and unromantic character of my theme. I am too well aware that to many the idea of geographical advance is confined to the perilous traversing of virgin lands, to the navigation of unknown waters, and to the penetration of forests or deserts never yet trod by white men's feet. I am conscious that the substitution of the surveyor for the explorer has necessarily destroyed much of the old romance, and that the feelings born when any fraction of the earth's surface was for the first time opened to our ken can never be revived. While, however, the romance has gone, the dangers remain, and there is as much call now for unflinching courage and for unselfish devotion to duty as there was in the days when the search for the sources of the Nile was an impelling cause sending adventurous men into the unknown. Whether occupied in cutting his way through the almost impenetrable forests of the Gold Coast or struggling with the papyrus swamps of the Nile basin, or whether, standing upon the top of some old volcanic hill, he is engaged in scanning the blue distances of the great Rift valley, the surveyor is not less worthy of your admiration than the earlier traveller whose name is perhaps honourably enshrined in that of river or mountain. Whether pushing his way through the jungles of the Malays or floating upon the muddy stream of an African river, whether he is braving the attacks of savage animals, of treacherous natives, or the far more insidious assaults of the germs of some deadly disease, he is equally deserving of your sympathy and your encouragement. He is in truth a shining example of the power of that spirit of adventure and thirst for information which has carried our race so far in the past, and which in the future is, we all trust, destined to lead us ever "upwards and on"; the spirit that esteems no sacrifice too great in the cause of duty, and recognises no duty so high as that of making some contribution towards the increase of natural knowledge.

## UNIVERSITY AND EDUCATIONAL INTELLIGENCE.

LONDON.—A course of nine post-graduate lectures on "The Scientific Principles of Radio-telegraphy and Radio-telephony" will be given by Prof. J. A. Fleming, F.R.S., at University College on Wednesdays, beginning October 14. The introductory lecture will be addressed to a general audience, and no charge for admission is to be made. Cards of admission must, however, be obtained beforehand by those attending. The succeeding lectures will be free to graduates of the University and to undergraduates in their third year who may be qualified to take advantage of them. A fee of two guineas for the course will be charged to all other persons. Those desirous of attending the course should apply to the secretary, University College, Gower Street, W.C.

THE Rev. W. Lower Carter has been appointed lecturer in geology at the East London College.

PROF. JOSEF MOELLER, of Graz, has been appointed to the chair of pharmacognosia at the University of Vienna.

THE foundation-stone of a new college for the training of teachers was laid at Dudley on Thursday last by the Countess of Dudley. The cost of the building (which will accommodate 100) is 19,000*l*.

CLASSES for the instruction of miners are being started at Hamstead by the Staffordshire County Council, which will, it is hoped, enable many miners who possess sufficient practical knowledge, but who lack the necessary scientific and other training, to fill higher positions in the mines.

THE new municipal college at Portsmouth was opened on Thursday last by the Mayor of the town. The building, which is the outcome of a scheme for higher education organised by the local education authority, is an adaptation of the best ideas of the principal technical institutes of the country to the requirements of Portsmouth, and is stated to be in its equipment one of the most modern in England.

THE following arrangements have been made for the opening of the winter session of certain of the medical schools. At Guy's Hospital (in connection with the Physical Society), Sir R. Douglas Powell will deliver an address on October 8 entitled "Just Procedure of Medicine"; Dr. Charles Slater is to speak on October 1 at St. George's Hospital on "The Laboratory in Medical Education and Practice"; on the same date an address will be delivered at the Middlesex Hospital by Dr. A. M. Kellas; at King's College Hospital Prof. Alexander MacAlister, F.R.S., will deliver an address on October 1; Sir Edward Fry, F.R.S., is to speak at University College Hospital on October 2. At St. Mary's Hospital, on October 1, an address is to be given by Sir John Broadbent; Dr. Harrington Sainsbury is to speak on the same day at the London School of Medicine for Women; at the West London Post-graduate College an address is to be given on October 13 by Sir R. Douglas Powell; Dr. R. Jones is to speak on "Insanity, Wit, and Humour" on October 1 at the Polyclinic; at the North-East London Post-graduate College Mr. Jonathan Hutchinson, F.R.S., is to speak on October 8; Sir T. Clifford Allbutt, K.C.B., F.R.S., is to give an address at the University of Manchester, on October 1, on "Hospitals, Medical Science, and Public Health"; and at University College, Bristol, on October 1, Sir Rubert Boyce, F.R.S., is to speak.

THE approaching winter session in our technical colleges and schools is being heralded by the publication of numerous attractive and carefully compiled year-books and prospectuses of the various institutions in London and the provinces. We have received a number of these helpful guides, and, without exception, they provide intending students with valuable assistance in the choice of classes and hints from experienced teachers as to how to plan courses of work likely to be of service in various industries. Among recent syllabuses published in connection with London institutions we notice those of the Northampton Polytechnic Institute, the Sir John Cass Technical Institute, and the East Ham Technical College. At the Northampton Institute there are provided

for next session day and evening courses in mechanical and electrical engineering, technical optics, horology, and artistic crafts, in addition to numerous other classes in a varied selection of subjects. The recent provision of increased accommodation obtained by the occupation of the British Horological Institute not having been found sufficient for the requirements of this institute, an additional building is being erected in the courtyard, and it is hoped that the greater part of it will be available immediately after Christmas. It is interesting to observe that in the technical optics department there will be classes for kinematograph operators in continuation of the pioneer classes last session. In these classes an attempt is to be made to safeguard the holding of kinematograph exhibitions by giving a practical training to the operators in charge of the apparatus. At the Sir John Cass Institute the instruction is devoted especially to technical training in experimental science and in the artistic crafts. Graded curricula of study, extending over several years, are provided in pure and applied chemistry, metallurgy, art metal work, jewellery, enamelling, bronze casting, and chasing. Full courses of study are also provided in drawing, design, and modelling in connection with these crafts, drawing and modelling from living animals being a special feature. In addition to the evening classes at the East Ham College, conducted in eight departments and intended to supply the particular educational needs of the district, there is a well-staffed secondary school for boys and girls.

## SOCIETIES AND ACADEMIES.

### LONDON.

**Royal Society**, June 25.—"The Spectrum of Scandium and its Relation to Solar Spectra." By Prof. A. **Fowler.** Communicated by Sir William Crookes, F.R.S.

(1) The arc spectrum of scandium consists of two distinct sets of lines, which behave very differently in solar spectra. Each set includes both strong and faint lines.

(2) Lines belonging to one set correspond with the enhanced lines of other elements, notwithstanding that they appear strongly in the ordinary arc spectrum:—(*a*) these lines are very feeble or missing from the arc-flame spectrum, and are strengthened in passing to the arc, the arc in hydrogen, or the spark; (*b*) they occur as relatively strong lines in the Fraunhofer spectrum; (*c*) they are weakened in the sun-spot spectrum; (*d*) they occur as high-level lines in the chromosphere.

(3) The remaining lines show a great contrast when compared with the first group:—(*a*) they are relatively strong lines in the arc-flame; (*b*) they are very feebly represented in the Fraunhofer spectrum; (*c*) the stronger lines are prominent in the sun-spot spectrum; (*d*) they have not been recorded in the spectrum of the chromosphere.

(4) The special development of the enhanced lines in the Fraunhofer spectrum, together with their presence in the upper chromosphere, indicates that the greater part of the scandium absorption in the solar spectrum originates at a higher level than that at which the greater part of the iron absorption is produced.

(5) The discussion of scandium lines indicates that while in the case of some elements solar identifications are to be based chiefly on arc lines, in others it is the enhanced lines which may be expected to show the most important coincidences.

(6) The flutings which occur in the arc and arc-flame do not appear when the arc is passed in an atmosphere of hydrogen. As suggested by Thalén, they are probably due to oxide of scandium.

Tables are given which show the lines of the arc spectrum from 3930 to 6580, the positions of the oxide flutings, and comparisons of the principal lines of the two classes with the sun, sun-spots, and chromosphere.

### PARIS.

**Academy of Sciences**, September 7.—M. Bouchard in the chair.—Vortices in the solar atmosphere: H. **Deslandres.** The filaments (the *long flocculi* of Hale) are considered to be vortices with horizontal axes, parallel to the surface, and traces of the effects of these are to be found right across the face of the sun. Six diagrams showing the alignment of these on the sun's surface at different dates are given. Similar effects may be expected on the earth, and the application of the theory here developed to the problems of terrestrial meteorology may give interesting results.—The new Marehouse comet: M. **Giacobini.** Observations were made on September 3, 4, and 5. The apparent positions of the comet are given on these dates, together with the mean positions of the comparison stars. The comet shows as a rounded nebulosity of about 15″ to 20″, with a badly defined nucleus. A small tail, with a position-angle of 250°, can be distinguished.—The law of Stokes and the Brownian motion: Jean **Perrin.** The force opposing the motion of a sphere in a viscous liquid has been calculated by Stokes as a function of the viscosity of the fluid, the radius of the sphere, and its velocity. From experiments with emulsions of gutta, the author shows that this law is verified for spheres having a radius of about a tenth of a micron. The assumption of the applicability of this law, made by the author in his previous work on this subject and criticised by J. Duclaux, is thus shown to be well founded.—The fixation of acetophenone on benzoylacrylic acid: J. **Bougault.** Von Pechmann has shown that boiling solutions of alkalies decompose benzoylacrylic acid into glyoxylic acid and acetophenone. In the cold the reaction is different, some diphenacylacetic acid being produced. The yield of the latter acid is increased if some acetophenone is added to the alkaline solution, and the author gives reason to suppose that a direct condensation between the acid and the ketone takes place under these conditions.—The ages of the basalts in the neighbourhood of Massiac, Cantal: P. **Marty.**—The existence of transported strata in the north-east of Algeria: L. **Joleaud.**

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