THURSDAY, AUGUST 16, 1894.

THE BRITISH ASSOCIATION.

OXFORD, AUGUST 15.

THE meeting which is now ending is in many ways a memorable one. To those who are engaged chiefly in the serious work of the Sections it will be memorable because of the unusual fulness of the sectional meetings and the exceptionally high standard of the communications which have been brought before them. To the popular mind the great feature of the meeting is the Presidential address. Apart from the accessory advantages derived from the eminence of the speaker, his position as Chancellor of the University, his command of the English language, his oratorical powers, and the unusual splendour of the University ceremonial, the address must be considered as one of the most remarkable that has been given from the Presidential chair for many years past. Its effects are likely to be considerable, because, unlike the majority of scientific addresses, it was thoroughly comprehended by the whole audience, and was written in such clear, vigorous, and easy English that there is no educated person who cannot understand every word of it. Whether the effect will be for good or for evil, time will show. Lord Salisbury passed in review the weaknesses of all branches of science, but his exposure of the incompleteness of the ethereal and atomic theories are not likely to prejudice the general belief in them. These are impersonal questions which the average layman is content to leave in the hands of specialists. It is otherwise with Evolution, which came in for a large share of criticism, much of which, it must be said, was criticism of a somewhat unfair kind. Evolution and the Darwinian hypothesis have been accepted of late by the people in a somewhat reluctant and hesitating fashion; there has been no great champion of the opposite view, and the "lay" mind has been overwhelmed with masses of technical argument until it has relapsed into sullen acquiescence. For the first time for some years past a voice has spoken from a seat of authority, and has raised the hope that the bondage under which unwilling minds were lying may be broken, that the doctrine of Evolution may be overthrown, and that of design resuscitated in place of it. One has only to read the articles which have appeared in all the leading newspapers to understand how real this hope is, and how gladly a large number of educated people would undo the labours which were begun by Treviranus and Lamarck, carried on to success by Charles Darwin and by Wallace, and elaborated by Huxley, Haeckel, Weismann, and many others. The biologist knows well the answer to most of Lord Salisbury's criticisms, and can show that most of them have often been raised before, and have been completely answered. They were partly answered by Prof. Huxley in the admirable speech in which he seconded the vote of thanks, and it is to be hoped that he has not said his last word in response to the challenge thrown down. A perusal of the newspaper articles of last week betrays a weakness in the armour of scientific debate, a weakness from which Prof. Huxley alone, or almost alone, is exempt. Since the "Origin of Species" was first published, much has been spoken and written on the subject, and an enormous mass of evidence has been accumulated, much of which is of the nature of verification, and carries, or should carry, as much weight in support of the theory of descent with modification as did the discovery of new elements in support of the theory of Mendeléef. But the subject is a large and intricate one, and the writings of many of the staunchest adherents of Evolution have failed to influence those who are not professed biologists because they have been couched in such technical, and, at times, in such uncouth language that they could not possibly be understood except by those who have had a long training in the special subject. Lord Salisbury has taught us that a skilled debater and a master of epigram may, by a sudden and brilliant attack, make a breach of some considerable extent in what we have come to consider as an almost impregnable stronghold. That the breach will be rapidly repaired, there can be no doubt, and in repairing it biologists will feel the advantage of having to improve the range and penetration of their weapons of offence and defence. It is not enough that a scientific truth should be the possession of a privileged few; those who value the truth should try to spread it and make it common intellectual property, and this can only be done when they realise that simplicity of language, a correct style, and a good arrangement are essential to its propagation. It is unnecessary to remind readers of NATURE that the questions in dispute among biologists are not as to whether evolution has taken place, but as to the manner in which it has taken place; that the selection of favourable variations is not denied, but that the operations of natural selection are still imperfectly understood, and that arguments drawn from artificial selection, if they are applicable at all, are applicable only to a very limited extent. Nobody supposes that the methods of artificial selection, the mating of the favourably varying bridegroom with the favourably varying bride, find their exact parallel in nature. The argument from artificial selection was originally brought in to prove that under certain conditions species were capable of transformation, and the different conditions under which transformation may be effected, and the extent of transformation under known conditions, are now the most promising subjects of biological study. This fact was very well exemplified in the discussion which followed Prof. D'Arcy Thompson's paper "On some Difficulties of Darwinism," on Monday last. It might appear that the debating of such a question in Section D was proof of the truth of Lord Salisbury's contention, that there is a reaction against Darwinism; but it is to be observed that none of the eminent authorities who took part in the debate doubted the fact of progressive modification; the question at issue was whether the direct effect of external conditions is or is not a factor of importance in causing and perpetuating variations. The sum and substance of Lord Salisbury's address was that science is not infallible, and still far from having attained an exact knowledge even of fundamental problems. This science knows very well, and the proceedings of Sections show how very much is still to be learnt.

It is impossible to review the work of each Section in detail, but it may be said that never in recent years has so much matter of novel or remarkable character been communicated in every department of Science. Section A has been particularly active. When it has not been occupied in holding joint discussions with Section G, on Flight and on Integrators, or with Section I, on the Theory of Vision, it has divided itself into three departments—two for Physics, and one for pure Mathematics—and in each the number and the quality of the communications have been of the highest order, one of the most remarkable being that of Prof. G. Quincke, on the formation of soap-bubbles by the contact of alkaline oleates with water.

But, so far as the scientific importance of the communications made to the present meeting is concerned, it is conceded on all hands that a verbal and really an informal announcement made by Lord Rayleigh to Section B, on Monday, on behalf of himself and Prof. Ramsay,

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takes the first place. It is known that Lord Rayleigh has been for many years engaged upon the determination of the densities of various gases. We have learnt that he found in the case of nitrogen different densities amounting to about one half per cent. according as the gas was obtained from chemical compounds and the so-called nitrogen of the atmosphere. This and other points have recently occupied the attention of both Lord Rayleigh and Prof. Ramsay, and they have succeeded in isolating from this so-called atmospheric nitrogen, and by two distinct processes, a second inert ingredient denser than true nitrogen. The first method employed was that used by Cavendish in his demonstration of the composition of nitric acid. Air mixed with oxygen is submitted to electric sparks in presence of alkali until no further contraction takes place. The excess of oxygen is then absorbed by pyrogallol. That the residual gas is not nitrogen is inferred from the manner of preparation, and from the appearance of its spectrum. A second method giving much larger quantities of the new gas depends upon the removal of nitrogen from deoxygenated air by passing it over heated magnesium. When this process was allowed to continue, the density gradually rose to 14·88, 16·1, and finally to 19·09. At this stage the absorption appeared to have reached its limit, indicating that the new gas amounts to about 1 per cent. of the nitrogen of the atmosphere. When the gas thus prepared was sparked with oxygen there was little or no contraction. Lord Rayleigh and Prof. Ramsay have already found that no liquefaction occurs when the gas is compressed at atmospheric temperatures.

Sir Henry Roscoe said that the communication was one of the greatest possible interest and importance, and the Section as well as the distinguished authors were greatly to be congratulated on the announcement of the discovery of what would in all probability turn out to be a new elementary body existing in the atmosphere. The discovery appeared to him to be of special significance, as being one brought about by the application of exact quantitative experiment to the elucidation of the problem of the chemical constitution of our planet.

There were many other communications of a most interesting nature, including a discussion on the action of moisture in promoting chemical changes, a problem which has occupied the attention of several Oxford chemists of late years. Mr. Miers read a paper of great interest to crystallographers in Section C, and Mr. Culverwell's criticism of Croll's views on the Ice Age excited much interest.

It was thought by many that the division of Section D into two very distinct departments of Zoology and Botany, and into a third and completely separate department of Physiology, might weaken the proceedings of each; but the fear has proved to be entirely groundless, for there has been almost a superfluity of interesting material, and the attendance in each Section or department has been as good as was usually the case in the undivided Section. One is glad to note, however, that the division is permissive, and that the three subjects may reunite under the common denomination of Biology in any meetings at which such a galaxy of talent as has been brought together on this occasion is not to be expected. Section E (Geography) has had one of the most successful years in its experience, and has been attended daily by large audiences, which were very well accommodated in the great North Writing School. Economic Science has been hardly less successful, and G and H have at various times been densely crowded, the accommodation in the Anatomical Department having proved sometimes to be altogether inadequate for the large audiences which assembled to hear Mr. Arthur Evans, Prof. Macalister, M. Emile Cartailhac, and Dr. Louis Robinson.

A further feature of the Oxford meeting may be mentioned. Several of the colleges dispensed a magnificent hospitality, and the reunions of foreign and English men of science in Magdalen and Merton will long be remembered by those who were fortunate enough to take a part in them. New College was not behindhand, since it entertained the Sectional Secretaries during their stay in Oxford; whilst Brasenose, Merton, Corpus Christi, Lincoln, Jesus, and Balliol vied with one another in hospitable efforts. Pembroke College was prepared to have done as much, but its intentions were frustrated by a sad event which happened just before the meeting. During the month of August Oxford is usually depleted (most of the University residents are away on their holidays), but for this occasion many returned and showed that the old traditions of University hospitality have not been forgotten since the Universities Acts came into force. The sixty-fourth meeting has altogether been a magnificent one, and well worthy of the town in which it was held.

The following is a synopsis of grants appropriated to scientific purposes by the General Committee:—

	£
Electrical Standards	25
Photographs of Meteorological Phenomena	10
Earth Tremors	75
Abstracts of Physical Papers	100
Reduction of Magnetic Observations made at Falmouth Observatory	50
Comparison of Magnetic Standards	25
Calculation of certain Integrals...	15
Meteorological Observations on Ben Nevis	50
Uniformity of Size of Pages of Transactions, &c. ...	5
Wave-length Tables of the Spectra of the Elements...	10
Action of Light upon Dyed Colours	5
Formation of Haloids from Pure Materials	20
Isomeric Naphthalene Derivatives	30
Electrolytic Quantitative Analysis	40
Erratic Blocks	10
Palæozoic Phyllopoda	5
Photographs of Geological Interest (renewed) ...	10
Shell-bearing Deposits at Clava, &c.	10
Eurypterids of the Pentland Hills	3
New Sections of Stonesfield Slate	50
Exploration of Calf Hole Cave	10
Investigation of a Coral Reef by Boring and Sounding	10
Nature and Probable Age of High-level Flint-drifts...	10
Examination of the Locality where the Cetiosaurus in the Oxford Museum was found	20
Table at the Zoological Station, Naples	100
Table at the Biological Laboratory, Plymouth (renewed)	20
Zoology, Botany, and Geology of the Irish Sea (partly renewed)	40
Zoology and Botany of the West India Islands ...	50
Index of Genera and Species of Animals	50
Climatology of Tropical Africa	5
Exploration of Hadramout	50
Calibration and Comparison of Measuring Instruments	50
Anthropometric Measurements in Schools	5
Lake Village at Glastonbury	30
Exploration of a Kitchen-midden at Hastings ...	10
Ethnographical Survey	30
Physiological Applications of the Phonograph ...	25
Corresponding Societies	30
Mathematical Tables (unexpended balance)	
	£1093

SECTION D.

BIOLOGY.

OPENING ADDRESS BY PROF. I. BAYLEY BALFOUR, M.A., M.D., F.R.S., PRESIDENT OF THE SECTION.

THE prospect of visiting Oxford to-day has, I am sure, been to all of us a pleasant one, and we who are specially interested in biology have looked forward to our meeting at this time with the distinguished members of the Oxford Biological School. But as we gather here there will, I think, be present to the minds of all of us a thought of one member of that school, whom we had hoped to meet, who is recently gone from it in the prime of his intellectual life. By the death of George John Romanes biological science is bereft of one of its foremost expositors, Oxford is deprived too soon of one whose mental power was yet in its zenith, and each one of us who knew him cannot but feel a deep sense of personal loss; and we shall in our meeting here sadly miss the man brimming with a geniality which robbed differences of their difficulty and charmed away bitterness from those controversies in which he revelled. This is not the occasion upon which to dwell on his character, his merits, or his work. We must all, I think, have appreciated the graceful accuracy with which these were sketched in the pages of NATURE by one of his colleagues; but under the shadow, as we are here, of his recent death, I believe I give utterance to feelings every one of you would wish expressed in paying this passing tribute to his memory from the chair of the Section of the Association devoted to the subject of his life-work.

I cannot open the business of the Section without referring to the fact that its organisation appears to be variable, like the objects of its study. It has changed its constitution more than any other Section of the Association, under influences partly from within in the strength of its elements, partly from without in the local circumstances of its meetings. At its origin it was the Section of botany, zoology, anatomy, and physiology; in the following year anatomy and physiology became a new Section, E, only after some years to merge again in the original one. Then a partition was tried—a physiology department and an anthropology department were formed within Section D; but the Montreal meeting saw anthropology as Section H of the Association, and physiology again an integral portion of Section D. This year, as you are aware, physiology—I must be careful to say animal physiology—has again become a definite Section —I. Whether or no the habit thus acquired through the environment of Oxford will be so permanent as to be transmitted and appear at future meetings of the Association is a problem upon which I refrain from speculating; my reason for mentioning this matter at all is to point out that, as in previous devolutions of subjects from Section D, animal physiology is the only physiology which is concerned. It was part of the original proposal that plant physiology should form a portion of the province of Section I. To this the botanical members of Section D are unable to assent. We all readily admit that the development within recent years of our knowledge of plant-life is entirely in the direction of bringing to light fundamental similarities between the vital processes in plants and in animals. To no one do we owe more in this sphere of investigation than to two of the distinguished botanists from Germany whom we are glad to welcome at this meeting—Profs. Pfeffer and Strasburger. And we fully reciprocate the desire for mutual comment and criticism implied in the suggestion of combination. But allowing these as grounds for the conjoint treatment of the physiology of plants and animals in one section, what we botanists feel is that we are a compact body of workers in a science the boundaries of which it is at present not difficult to define, and that to divorce physiology from morphology and other branches of botany would tend to loosen our cohesion, would be to go against the current of our progress, and would take all the vitality from our discussions. To have papers on plant physiology dealt with in Section I, whilst those on other botanical subjects were dealt with in Section D, would be not merely an extremely inconvenient arrangement, from causes inherent in the subjects themselves, but would strike at that fraternity and spirit of camaraderie amongst those treading the same path of science, the promotion of which is the chief, if not the only, function the British Association now fulfils. At the outset, therefore, of our meetings, I wish to make it known that papers and discussions on all botanical subjects will take place in Section D.

And now I pass to the special topic upon which I am to address you. In selecting it I have followed the lead of those of my predecessors in this chair who have used the opportunity to discuss a practical subject. Forestry, about which I purpose to speak, is a branch of applied science to which, in this country, but little attention has been given by any class of the community. By scientific men it has been practically ignored. Yet it is a division of Rural Economy which ought to be the basis of a large national industry.

There are no intrinsic circumstances in the country to prevent our growing trees as a profitable crop for timber as well as our neighbours. On the contrary, Great Britain is specially well adapted for tree-growing. We have woodlands of fine trees, grown after traditional rule-of-thumb methods, abundant in many districts. The beauty of an English landscape lies in its trees and its pastures. Nowhere in the world, probably, are to be found finer specimens of tree-growth. As arboriculturists we are unrivalled. But the growing of trees for effect and in plantations is a very different matter from their cultivation on scientific principles, for the purpose of yielding profitable crops. This is sylviculture. The guiding lines of the two methods of culture are by no means the same—nay, they may be opposed; and it is the sylvicultural aspect of the science of forestry which has hitherto been neglected in this country. The recognition of this is no new thing. But within recent years it has attracted considerable public attention, as the importance of wood cultivation in our national life has been more realised; and although various proposals have been put forward, and some little effort made for the purpose of remedying the admittedly unsatisfactory state of forestry practice, there has been so far no great result. I attribute this in great measure to the apathy of scientific men, especially botanists, and I am convinced that until they devote attention to forestry the great issues involved in it will not be rightly appreciated in the country.

It is not the first time the subject has been before this Section. I find that in 1885, at the Aberdeen meeting, a committee was appointed by it to consider "whether the condition of our forests and woodlands might not be improved by the establishment of a forest-school." The good intention of the promoters was not fulfilled, however. The committee did not meet.

In the first instance, let me briefly refer to the national economic features of forests as they affect us.

There are two aspects from which forests are of importance to a country—firstly, as a source of timber and fuel; secondly, on account of their hygienic and climatic influences.

With regard to the latter, it is a popular notion that trees exercise considerable influence upon atmospheric conditions, but it is only within recent years, and as the result of long experimental research in Switzerland, France, Austria, Germany, and other areas where forestry is practised at a high level of excellence, and also in the United States, that any sufficient data have been forthcoming to form a basis of scientific conclusion upon so important a matter. Although many points are still far from clear, the evidence goes to show that the direct influence of tree-growth upon climate is no mere superstition. Stated in the most general terms, it is proved that forests improve the soil drainage, and thereby modify miasmatic conditions; whilst, like all green plants, trees exercise, through the process of carbon-assimilation, a purifying effect upon the air, the existence of the increased quantity of ozone often claimed for the vicinity of forests is not yet established; by opposing obstacles to air currents, forests prevent the dissemination of dust particles with their contingent germs; they reduce the extremes of temperature of the air; they increase the relative humidity of the air and the precipitation in rainfall, and they protect and control the waterflow from the soil.

To us these effects do not appeal with the same force that they do in continental areas. Our insular and geographical position renders us in a measure independent of them. The data for these continental results, it must be remembered, are derived from large forest areas such as do not exist here. For this country I know of no experimental evidence on the subject. As, however, the effects of forest influence are felt mainly in local modifications of climatic conditions, we are not justified in regarding the conclusions that have been reached as inapplicable to Britain. No little interest attaches, therefore, to a statement based upon these continental observations to which Dr. Nisbet has recently done well to call attention—that, "where the rainfall is over forty inches it is undesirable to increase the forest area." The significance of this dictum, if it be established, to Britain, dependent so largely upon her agriculture, is evident. Wet years, unfavourable to farm crops, are, under existing conditions, more numerous than favourable dry ones, and any extensive tree-planting in agricultural areas might therefore prove disastrous. But I may here emphasise the point that, whilst for the growing of specimen trees we may agree with Evelyn when he says, "If I were to make choice of the place or the tree, it should be such as grows in the best cow-pasture, or upland meadow, where the mould is rich and sweet," yet the harvest which scientific sylviculture reaps comes from land unsuited to agriculture, which would otherwise lie barren and waste, and therefore schemes for the afforestation of such areas in non-agricultural districts need not be prejudiced by the prospect of an increased local rainfall. At the same time we must not fail to learn the obvious lesson that afforestation is not, as some suppose, a simple matter of employment of labour, but that it involves the consideration of weighty scientific problems.

Forests, as a source of fuel, have not the direct importance to this country, rich as it is in coal-supply, that they have in States less favoured, but their economic importance to us as a source of timber needs no comment. There are no means available through which to estimate the annual output of timber from our plantations, but indirectly we can gauge the insufficiency of our woodlands to supply the timber necessities of the country by reference to the returns showing the amount and value of forest produce annually imported. This has been steadily increasing until in 1893 its value exceeded eighteen million pounds. Of course a considerable proportion of the materials thus imported could not in any circumstances be produced in Britain. But, after allowing a liberal discount for these, there remains a large bill which we pay for produce, no small portion of which could be furnished at home. No one would suggest that in the limited and densely populated area of Great Britain timber-trees of kinds suiting our climate could be grown sufficient to supply all our demands; that would be impossible. But few would venture to deny that we could do very much better for ourselves than we do, and that our labour payments abroad might be materially reduced. It is admitted that well-grown home timber is, of its kind, equal to, if not superior in quality to, that which is imported; it is surely, then, legitimate to expect that a large supply of well-grown timber would enable us to hold the market to a much larger extent than is presently the case, and that we might be very much less dependent than we are upon the surplus timber of other nations.

The importance of this to the country is increased by the consideration of the continued appreciation of timber. There is abundant evidence forthcoming to indicate that the present rate of timber consumption of the world is in excess of the present reproduction in the forests of the great timber supplying countries, and with the persistence of existing conditions we would appear to be within measurable distance of timber famine. Experience, too, teaches that we may expect not a diminution but rather an increase in consumption. No doubt as civilisation advances the discoveries of science will, as they have done in the past, enable us to substitute in many ways for the naturally produced wood other substances prepared by manufacture; but this saving in some directions has been, and will probably continue to be, counterbalanced by greater utilisation in others —witness, for example, the enormous development within recent years of the wood-pulp industry abroad, and consider the prospect opened up by the manufacture of wood silk which is now being begun in Britain.

That the possibility of forest exhaustion is no chimera should be evident to anyone conversant with current timber literature. Taking North Europe, for instance:—In Norway, "raw timber is yearly becoming more expensive and more difficult to obtain." To Sweden, "pitch pine long beams are taken from America, suitable ones of sufficient size and quality being unobtainable now in Sweden." In Scandinavia, the virgin forests, "excepting such as are specially reserved by the Government in the districts where mills are situated, are almost exhausted." In Russia, the Riga "supply of oak is exhausted." These sentences, culled within the past few weeks from trade journals, show that this is a more pertinent question than some would suppose. In Sweden, which, it is remarkable, is actually importing logs from America, the situation is regarded as so serious that proposals are on foot for the imposition of a tax upon exported timber for the purpose of raising a fund for replanting denuded areas. But it is not only in North European countries that there are signs of the giving out of timber forests. As they fail the demand upon Canadian and American stocks increases, and when we look at these Canada "shows signs of beginning to find it hard to continue her voluminous exports to Europe, and at the same time send sufficient supplies to the United States." But the most striking evidence is that furnished by the chief of the United States department of forestry, in his official report for the year 1892, in which he says: "While there are still enormous quantities of virgin timber standing, the supply is not inexhaustible. Even were we to assume on every acre a stand of 10,000 feet B.M. of saw timber—a most extravagant average—we would, with our present consumption, have hardly one hundred years of supply in sight, the time it takes to grow a tree to a satisfactory log size. Certain kinds of supplies are beginning to give out. Even the white pine resources, which a few years ago seemed so great that to attempt an accurate estimate of them was deemed too difficult an undertaking, have, since then, become reduced to such small proportions that the end of the whole supply in both Canada and the United States is now plainly in view."

It must be owned that there are those who do not regard the suggestion of forest exhaustion as a serious one. They argue that the prophecy is no new one, and yet we are none the worse off than we have been; that failing supply from one source it has always been possible to tap another, and so it will probably continue; and then the period when exhaustion is likely to take place is so far off, there is ample time for the growth of new forests to replace those being cut. No doubt there is time. But this is just the kernel of the whole forestry question. With proper conservancy of forest areas, the application of scientific principles to the recuperation of areas recklessly denuded, and the afforestation of barren and waste lands, timber sufficient to meet a greater demand than is now made could be produced. This is the aim of scientific forestry, and it is to secure this that those who have given attention to the subject are working, conceiving it to be a duty of this generation to hand down to its successors a heritage no less valuable than that which it received.

With an acreage of wooded land amounting to only 4 per cent. of their total area, Great Britain and Ireland possess a smaller proportion so covered than any other European country. Denmark comes near with only about 5 per cent., in France the percentage rises to 15, in Norway and Germany to 25, in Austria-Hungary to 30, whilst in Sweden the amount is over 40 per cent. The United States is estimated to have about 25 per cent. These figures do not, however, give a fair basis of comparison of the amount of timber area in Great Britain with other countries, inasmuch as in the continental lands the bulk of the woodlands is true forest, whilst a large part of the area included in the British return is merely pleasure ground, and another large portion is only plantation; of real forest the area is extremely limited. It is not surprising, then, that we are not able to furnish ourselves with an adequate supply of timber. But although there is so little land under wood, there are thousands of acres unsuited for any other crop, and these for reasons I have already indicated, it is desirable to have planted. How to have this accomplished, and how to secure that woodlands already existing shall be tended so as to produce a maximum result, giving a profitable return, are the problems we wish to see solved.

It will conduce to appreciation of the question if I briefly discuss the causes which have been active in developing the present condition of woodlands in Britain, and in bringing about the disparity between it and other countries in respect of woodland area.

State ownership of continental forests will probably occur to most people as the reason for the difference in area just pointed out. This is true with, however, some qualification. In consequence of the circumstances of their situation continental States have been compelled to recognise the national economic importance of forests. This they have done, not so much by the creation of State ownership in vast forests as by the organisation of a State department of forestry and a State system of forestry education. It is altogether a mistake to suppose, as is often the case, that the whole or even a large part of the forests on the continent belong to the respective States. The amount of State-owned forest is surprisingly small. Fernow gives it in Germany as about 33 per cent. of the whole forest area; in Scandinavia 15 to 20 per cent., in France some 10 per cent., in Switzerland 4 per cent., whilst in Italy it is not 2 per cent. The bulk of the forest is in the hands of private owners or corporate bodies, subject, though apparently not always, to some control or limitation by the State. But the example of the States in the management of their own woods, their readiness to give advice through their officials, and the education which is carefully provided for those concerned in forestry work, have resulted in those privately-owned forests being as well managed as those of the State. It is important to make clear this distinction, because it shows that a State system of conservancy and supervision of forestry is quite compatible with large private ownership in forests, and that efficient sylviculture upon a large scale is not inseparable from State ownership.

But someone may say, "We, too, have State forests!" Yes, but it is almost absurd to mention them in the same sentence with those of the continent for any part they play at present in connection with forestry in Britain. The nine thousand acres at Windsor are mainly covered with specimen trees. Of the twenty-five thousand acres in the Forest of Dean, a portion is supposed to be cultivated for a profitable crop, but appears to result in an annual deficit. The New Forest, with its sixty-three thousand acres of soil-area, affords us one of the most interesting object-lessons, showing the triumph of sentiment over common-sense, that the country affords. Its history is well enough known, and I need only remind you that Parliament has decreed the major part of it to persist as a barren waste, whilst in the remainder, which is covered with trees, the practice of forestry is prohibited, so that slowly the whole is going to wreck and ruin. This illustrates the value to us of State forests! In the days of the "wooden walls" the dockyards obtained valuable timber from them, but now their large area is, one may say, of no State service whatever as forest, if one excepts a small portion of Windsor Forest recently attached for instruction purposes to Coopers Hill College. There can be no question that if the State had set an example of scientific forestry in even a portion of these areas, the practice of sylviculture now throughout the country would have been very different.

I need not dwell on the fact that the conditions of land tenure in the country have exercised an important influence upon the extent of wood-planting in the country; and they must always do so. "The oak scorns to grow except on free land" is a saw that sums up pithily the relationship between land-laws and woodlands in England. Copyholders could hardly be expected to plant much timber when the lord of the manor claimed the crop; and I believe it is possible in some counties to trace the boundaries of copyholds by the entire absence of trees on one side of a line and the luxuriant growth on the opposite side. The intricacies of entail and the fact that life-renters had themselves to bear the expense of planting, except where necessary for shelter, without prospect of seeing a return for the outlay, must have operated prejudicially to an increase in woodlands. Happily since 1882 in England, and by an Act of last year for Scotland, the last-mentioned restriction upon tree-planting is removed.

Nor shall I pause over the question of game, which has been at once the origin and the destruction of forests in Britain. Not that it is an unimportant element. But the instinctive love of sport in the British race is proof against all argument of utility, and the needs of sport will always be a barrier, as they have been in the past, to the planting of large areas well adapted for timber-growing. It cannot well be otherwise. Landowners can hardly be expected to forego large and immediate game-rents for what appear the long-delayed, even though possibly greater, profits of timber cultivation. In this case the inevitable must be accepted. Nevertheless, there are large areas, the game-rent of which is infinitesimal for their acreage, which might be planted.

The most potent factors in bringing about the present condition of our woodlands are probably to be looked for in the nature of the crop itself and in the want of appreciation of its character manifested by landowners; in a word, in a want of knowledge of the principles of scientific forestry. Forestry is handicapped as compared with agriculture by the fact that the crop cannot be reaped within the year. The owner who plants and incurs the initial expense of stock, fencing, and perhaps draining, may after some years secure intermediate return from thinnings, but it will rarely happen that he reaps the final yield at maturity of the crop he has sown; it will fall to his successor. It is this planting for posterity that makes demands upon the landowner to which he is unequal. Hence it comes about that woodlands, beyond what may be requisite in the way of cover plantation and for shelter, are often regarded as expensive luxuries, and, in the time of high agricultural values, landowners have even grubbed out trees to make way for annual crops yielding an immediate return. But scientific tree-growing for profit does not consist in the covering of soil-area indiscriminately with trees, without definite system and relation of its part one to the other. Just as the farmer has to plan his rotations on a definite system with reference to his total acreage, so in properly managed timber-growing must areas be arranged in such a way that some part of the forest will be yielding annually its final return of mature crop, and cleared areas will by a natural process of regeneration replenish themselves without recourse to the expensive operation of planting being necessary. Scientifically worked a forest area of suitable land, of which there is such abundance in Britain, should be capable of yielding an annual net revenue as regular as that obtainable by any other form of soil cultivation.

It is nevertheless frequently urged as a reason for not growing timber that wood will not pay in Britain. A landowner will tell you he has acres of land which do not return him more than half-a-crown, and if it would pay better he would be glad to put them under timber, but he does not believe it would; and he will point to rates on woodlands which must be paid although no crop is being reaped. He will demonstrate that there is no market for home timber, which seldom fetches its value, and that there is a prejudice against it which increases the difficulty of any attempt to compete with the foreigner.

There is some reason in the latter part of this contention. The wood-grower in Britain has I think just cause for complaint when he finds his produce not only handicapped by preferential transport rates to foreign timber, as has been the case in the past, but that it is also disparaged by exclusion from, or admission only under conditions to, competition with foreign timber by the terms of building specifications. It is said to be the common practice of architects and others to bar home timber in this way, and the Government itself has not been guiltless in the matter. The Post Office form of tender a couple of years ago for telegraph poles entirely cut out native produce from competition, and the conditions of contract framed by the Board of Agriculture under the Land Improvements Act were until recently almost prohibitive to home timber. These latter are now modified, but whether or not the Post Office still boycotts home produce I cannot say.

However it is come about—and there are no doubt various effective causes—this undervaluing of home-grown timber is quite unreasonable, and the slur cast upon it is undeserved, so far as its quality is concerned. At the same time, there is ground for saying that the difficulties, occasioned in this and other ways, of disposing of home timber at renumerative prices are due to causes not altogether beyond the control of landowners who grow timber.

It is generally admitted that with a more regular and certain supply, as well as a larger amount in different districts, home timber would have a better chance of holding its own in the market. This is just what scientific forestry would bring about. Given a systematic cultivation of forest on scientific principles of rotation, and the conditions are prepared for a steady output of timber by annual cut, as well as for a supply of raw material for utilisation in the manufacture of the many subsidiary products derivable from forest growth. If landowners would only provide such supplies, they would alter altogether, and to their own advantage, the conditions under which they dispose of so much of their home wood. The timber merchant who now travels hither and thither over the country picking up small lots where they may occur for transport to his, probably distant, mills, at a cost which eats a big hole in the value of the trees to the landowner, would find it worth his while—and for that matter, it would be worth while for the landowner himself—to erect in the vicinity of the forest, mills for the purpose of converting and preparing the timber, and to put up machinery for the extraction of useful products from the waste wood. In such conditions a steady market could be created in which the advantage would lie altogether on the side of the home-grown article, and materials, the débris of the forest, now thrown aside as useless, would be turned to account to the greater benefit of the landowner. Encouragement, too, would be given to the establishment of local industries dependent upon forest growth, through which fresh outlets for forest produce would be provided.

The amount of profit returnable from timber cultivation must of course vary with the circumstances of the area in each case, but in comparing values it must always be borne in mind that timber land is land which can yield no agricultural rent. The official statistics relating to continental State forests show us the result of forestry on a large scale, and it is interesting to note how, under what we must believe to be an equally efficient system of forestry management, the net revenue from the several areas differs greatly. Thus from its two million acres of forest area Bavaria draws a little over five shillings per acre per annum; Wurtemburg, with nearly half a million acres, gets a return of about eleven shillings; and Saxony, with a somewhat less area, receives over seventeen shillings per acre per annum. For this country we have no such figures. Our State forests result in a loss. It is unfortunate, too, that no returns are available from private forests and woodlands, either in Britain or abroad. Estimates of possible profits in this country we have abundantly, but solid figures of expenditure and receipt in relation to timber growing there are none. By the favour of Mr. Munro-Ferguson, M.P., who, as a landowner, exhibits a most enlightened spirit in regard to forestry, I am, however, able to cite the case of a pine and larch wood at Novar, in Ross-shire, twenty-four acres in extent, which was clean cut in 1883, and gives instructive figures. After sixty-one years' growth on land similar to that which in the neighbourhood yields a grazing rent of from one to two shillings per acre, it is found to have yielded a net sum equal to a revenue to the landlord during the whole period of its growth of over nine shillings per acre per annum, or an increased value of quite seven shillings per acre per annum. Although it refers to only a single wood of limited extent, this return shows how profitable waste land may become under timber. No doubt from the estates of other of our landlords who own extensive woodlands, where, if there is not the highest scientific forestry, there is certainly good wood management, results of an equally instructive kind could be obtained—many would be better; and it is much to be desired in the interest of forestry that they should be made known as an object-lesson to those who doubt the profit of tree-growing.

But in the return I quote from there is another interesting point which I must not fail to note. During the period of growth of the wood, the outlay upon labour in connection with it amounted to a sum equal to an expenditure of over thirty-one shillings per acre per annum. That is to say, this sum was distributed in wages to the people of the neighbourhood. This exhibits the benefits brought in the train of forestry, which are no less important to the community at large than is the profit of the crop to the landowner. The scientific treatment of woodlands and cultivation of forests for profit on a proper scale involve the employment of a considerable amount of labour, much of it at a time when there is little else doing in country districts, not only in the actual tending of the forest area, but in the manipulation and subsequent preparation of the timber, and in the manufacture of the numerous by-products obtainable from it. In these days of congestion in cities the importance of the development of such an industry which can provide occupation in the country, and thus may aid in restraining migration to the towns, has not escaped notice, and it cannot be too often or too greatly emphasised.

The influences, to which we have just given attention, that have prevailed in bringing about the present limited area of woodland in Britain are, it will be seen, not wholly irremovable, nor are the obstacles to betterment insurmountable. And the question we have now to discuss is—How are these to be counteracted and overcome? By what means is it possible to bring forestry in Britain more in line with that of other nations? At the outset I would say that if forestry is to be established on a sound commercial basis, the only one on which it should rest, if we are to have a national home-timber industry, it can only be when the issues involved are more fully realised than they are nowadays. As in agricultural practice failure can only be obviated by the application of scientific methods in farm cultivation, so is it with forestry. To become a profitable industry it must be practised as an applied science, and not as an empirical routine.

We live beyond the days when it would be possible to apply the autocratic remedy for want of woodlands introduced in Scotland by the Jacobean statute, which compelled the landlords not only to plant wood and forest and make hedges, but also enjoined them under penalties to see that each of the tenants planted one tree for every marke of land. Nor, indeed, can much be said of the success of the compulsion. And I do not imagine anything could be gained nowadays by the method adopted in Scotland in the middle of last century by the "Select Society," as it was called, of offering a premium to farmers who planted the most trees within a specified time. That such processes were deemed necessary is interesting as showing how old standing has been the recognition of the want of sufficient woodland area in the country. At the present time there are those who would reverse, as it were, the process of the old statute, and who look to the acquisition by the State of large areas of waste land, and their afforestation by it, for the solution of this forestry question. It is, no doubt, a wise policy which encourages private enterprise to deal with the details of industries, and only invokes State aid as a directive and controlling force when its need can be clearly shown. That there is need for State aid in the case of forestry I do not deny, but it is not required to the extent just mentioned.

I unhesitatingly say that the State ought to treat the forest areas now in its possession in a reasonable and scientific manner, instead of leaving them as objects for the finger of scientific scorn. They might be made, in part at least, models of the best forestry practice. It is no use to dispute with the sentiment and taste which have prevailed in making the New Forest what it now is, and it is hopeless to expect an unanimous verdict as to the destiny of State woods and upon the method of treatment to which they should be subject. We have had recently, in the lively discussion regarding the management of Epping Forest, an illustration of how large is the number of people who have views upon the subject of the management of woodlands, and how the majority of them, if they had their way, would, through ignorance, defeat the very object they desire to accomplish. We must be prepared in any proposal for utilisation of State forests to incur the opposition of those who regard all scientific handling of woods as vandalism, although I do not know that forestry in itself involves a want of recognition of the beautiful, or dulls the feelings which a sylvan landscape invokes in the minds of those in touch with nature. It is allowed there are areas in our State forests sacred by many memories, possessing a grandeur and picturesqueness with which no hand, whether of forester or landscapist, would venture to meddle. But, on the other hand, there are tracts which without damage to the natural beauty, and without depriving in any sensible degree the people of their privileges of recreation they prize so much, might be and should be dealt with as forest cultivated on scientific principles. These might serve as instruction areas, showing all that is best for the information of foresters. The creation of some such experimental teaching stations in State forests is one of the essentials for forestry in Britain. I would go further and say that the area of State ownership should be increased to the extent of the establishment of forest stations, of an acreage sufficient to allow of a satisfactory rotation, in other parts of the country as centres of instruction. There have been, as you are aware, proposals for the afforestation of some of the three million and more acres of waste land in the Highlands of Scotland capable of growing timber, and we await with some interest the report of the Deer Forest Commission, which has taken evidence on the subject. If, as has been suggested may be possible, afforestation is attempted through any system of State-aided planting, an opportunity would be afforded for securing what would be of so much advantage to the country. Beyond this system of model experimental stations, the State ownership of forest in Britain does not seem to me to be necessary in the cause of forestry.

Replying recently to Sir John Lubbock in the House of Commons, the President of the Board of Agriculture, after recounting what his Board is now doing for forestry in Britain, added: "I shall always be glad to receive and to consider any suggestion for the increase of sound technical knowledge on this subject." Well, now, I have a suggestion to make. In a practical science like forestry "an increase of sound technical knowledge" can only be possible when facilities for practical instruction are provided. I would, therefore, ask the President to consider what I have just said with regard to State forest experimental areas. These cannot, of course, be created by a stroke of the pen, but the initiative for their formation would naturally come from the Board of Agriculture. It is possible that, with betterment in forestry practice, landowners might be found who would be willing to devote portions of their land for the purposes of instruction, following for forestry the noble example of Sir John Lawes in his work for agriculture; and everyone interested in forestry must hope this may be so. But when the State has already in its hands the means through which a large national industry can be fostered, it is surely incumbent on it to utilise them for the purpose. And mark you, in asking for this, one does not make a large demand upon the Treasury. The whole could be done at no ultimate cost, for the profits from the areas could unquestionably more than repay any outlay incurred upon them.

The true solution of the forestry question in Britain is to be found in the diffusion of accurate knowledge of forest science. The landowner has to be convinced that through scientific forestry a sound and profitable investment for his capital is to be found in woodlands; the factor or land agent must be instructed in the scientific principles of tree-growing for profit to enable him to secure a steady income to the landowner from his invested capital; and the working forester has to be taught methods of cultivation based upon science, by which his faith in traditional practice, when it is, as is so often the case, unscientific, may be dispelled. It is through education alone that we can arrive at improved forestry.

This was recognised by the Select Committee upon Forestry of the House of Commons in its report in 1887, which performed a very valuable service by its exposure of the prevalent ignorance of scientific forestry and of well-known facts of tree-cultivation amongst those professedly engaged in its practice and study—an ignorance the continued existence of which manifests itself in some of the writings in current periodicals. The remedy it suggested of a State Forest Board, including representatives of science and of bodies interested in forestry, charged with the superintendence of the formation of forest schools and the preparation of forest literature, was superseded by the later institution of the Board of Agriculture, in which were absorbed such functions in regard to forestry as the Government of the day accepted. We are so accustomed to anomalies in our administrative system that the discovery of an additional one hardly surprises us. Yet it is difficult to understand why it is that a Board which deals with subjects so essentially based on science as does the Board of Agriculture should not have on its staff scientific men representative of the fields of science within its purview. But I do not know that either agriculture or forestry is so represented. It seems odd that this Board should be dependent for scientific advice upon outsiders, and now that it proposes to undertake the responsibility of the publication of a journal which, I take it, will be a means for the circulation of accurate information upon scientific questions, I do not see how its functions can be adequately performed without scientific help from within. No one of us would expect to see, either to-day or to-morrow, in this country a Board of Agriculture with an organisation like that of the similar department in the United States, which excites our admiration by the excellence of the practical information it circulates. But there is a wide interval between the completeness of the American department and the incompleteness of ours; and if I may make another suggestion to the President of the Board of Agriculture, I would ask him to consider whether it would not strengthen the Board in the discharge of its rapidly growing functions if it had competent scientific advisers upon its staff. Such a man for forestry would, I believe, do much for "the increase of sound technical knowledge" in Britain, and promote to no little extent its interests.

Since 1887 we have made some advances along the lines of improved literature and of teaching pointed out by the Select Committee as those by which reform could be accomplished.

If one looks at the literature available up to a recent period to anyone desirous of learning something about forestry, one need feel little surprise at the ignorance which prevailed. It was alike meagre in amount and deficient in quality, consisting chiefly of the records of empirical practice of men who had had no scientific training. It is satisfactory to note that these are now being replaced by works having some pretension to scientific method and accuracy. From Coopers Hill there is issuing, more slowly than could be wished, Prof. Schlich's excellent "Manual of Forestry," and from his colleague Prof. Fisher we may, I believe, soon expect an important forestry book. You all know Prof. Marshall Ward's lucid little books on timber and plant-diseases, and we are promised immediately, under his editorship, a translation of Hartig's "Diseases of Trees," by Prof. Somerville. A most valuable and interesting contribution to forestry literature is the book by Dr. Nisbet, recently issued from the Clarendon Press, containing the lectures he delivered in the University of Oxford during the past year; and to his marvellous energy we shall owe the new edition of "Brown's Forester," which is shortly to appear, and an English version of Hartig's "Text-Book" for foresters. All this activity shows an increasing interest in forestry, but it is only the beginning of a movement to make up for the preceding dearth. Botanists are greatly indebted to the Delegates of the Clarendon Press—and it is fitting I should here acknowledge the obligation—for the splendid series of standard foreign works on botany they have brought within the reach of English-speaking students, and which have done so much for the progress of botany in Britain. If we have now got beyond the stage of dependence in pure botany, we are far from it in scientific forestry, and I would hope that the Clarendon Press will add to its botanical series some of the standard foreign forestry books, and thus aid in the dissemination of the knowledge so essential to progress in the subject.

I must not omit to refer here to the excellent opportunity that is afforded for the circulation of scientific information by the new journal of the Board of Agriculture, of which intimation has recently been made, and it is to be hoped that forestry will find a place in it side by side with agriculture.

The attention paid to the teaching and study of forestry by continental States, their many schools and copious literature of forestry, make it remarkable that, apart altogether from the economic side, forestry as a subject of study and investigation has not been long ago introduced in some of our teaching centres. I think the Sibthorpian Chair of Rural Economy of the University of Oxford was for long the only one through which forestry was recognised as within the sphere of University education. So far the limited tenure of this chair, in its new dress, has been held by agriculturists—in their line the most distinguished men; but I should like to think that one may look forward to a time when forestry shall have its turn, if by that time it has not come about that it is otherwise provided for.

It was, however, only the necessities of India which, at a comparatively recent date, led to the first starting of forestry teaching in Britain, and then only at the cost of India, and for those destined to serve there as foresters. Coopers Hill College, the outcome of these, with its excellent equipment—including now, I believe, a slice of Windsor Forest for purposes of practical work—possesses the elements of a successful forestry school, and it has within recent years opened its doors to outsiders who may wish to learn forestry. But, so far as I am aware, it does not draw the young landowners of the country as it should do. Possibly the expense of the special education, which equals that of the universities without offering the advantages in other directions they afford, may be deterrent; but I am inclined to think that if the authorities made the fact better known that men other than foresters for India are admitted to the college, more would avail themselves of the opportunity.

Beyond this and some slight notice of forestry at agricultural colleges, there have been no facilities for forestry-teaching in Britain until within the last half-dozen years. I leave out of reckoning mere examining boards. Can we wonder, then, that there is a general want of intelligent appreciation of scientific forestry? Even now all that has resulted from the agitation in favour of more attention being given to this subject is—a lectureship on forestry in the University of Edinburgh, supported partly by the Board of Agriculture and partly by an endowment from subscriptions among landowners and others (and, I may mention here, forestry is now included as an optional subject in the university curriculum for an agricultural degree); a chair, or part of one, in the Royal College of Science at Newcastle, founded conjointly by the Board of Agriculture and the County Council; a course of instruction in science for practical foresters in the Royal Botanic Garden at Edinburgh, maintained by the Board of Agriculture; and a lecture course on forestry in the Glasgow and West of Scotland Technical Institute, similarly provided for. I must not omit to mention, too, the beginning, just made, by the Surveyors' Institute of the formation of a forestry museum in London, which should have an important educative influence. Little though it is, I think there is occasion for congratulation that even so much has been done to provide instruction, and I would have you note that in this education the different classes concerned with forestry are all recognised. Valuable as the teaching so being given is, it must have an effect in showing the need there is for more. In one way the teaching of all these bodies is incomplete, and must be imperfect, inasmuch as they have not the means for practical forestry work. Until this is provided, as I have indicated already, the teaching of forestry cannot be thoroughly carried out.

But, after all, what has been done in the way of supplying our wants in the way of teaching is nothing to what is required if forestry is to be adequately taught in Britain. Dr. Nisbet, who in his book already mentioned, has had the last say on this question, boldly states the requirements at six forestry chairs in universities, and four schools of practical sylviculture in the vicinity of forests. I do not think he puts the needs one whit too high. I should be even disposed to add to them, because I note he has omitted to take into account the claim of Wales, whence there has recently been a request for the establishment of forestry teaching.

But there are two questions strictly pertinent to this demand, which need answering if the proposals are to be brought within the sphere of practicability—firstly, whence are the funds to be obtained for this organisation; and, secondly, where are we to get the teachers?

Dr. Nisbet puts his hand in the Treasury pocket for the money—some five thousand pounds per annum—required by his scheme. I do not think many of us will be so sanguine as to expect the whole financial aid could be directly obtained in this way. But it may be, I think, of significance in regard to this to consider the sources from which money has been forthcoming for what has already been done. The Government, through the Board of Agriculture, has given most, the remainder has come from the County Councils and from private contributions.

There is no reason to suppose that the Board of Agriculture will be less willing in the future than it has been to aid in the establishing of forestry teaching in suitable centres; but its support from the limited funds—eight thousand pounds—at its disposal for educational purposes, is always given as a grant in aid, and is contingent upon evidence of local effort towards the end desired, which we must therefore look to in the first instance.

It is of no use to speculate upon the prospects of private munificence providing equipment in any centre. We may hope for it, but I do not think times are such as to lead us to expect large pecuniary aid from landowners. After vigorous effort amongst them, extending over some years, to secure an endowment for a chair of forestry in Edinburgh, a sum a little over two thousand pounds is all that has been raised.

But forestry is one of those subjects to the teaching of which we may be more sanguine of support from County Councils. It will always be a matter of regret to scientific men, and those interested in the industrial progress of the country, that the grand opportunity furnished by the fund dealt with under the Local Taxation Act (1890) was not taken more advantage of by the Government of the day. Distributed, even in part, through representative educational institutions, it could have provided equipment for technical education of the highest kind beyond our dreams. Thrown at the heads of the County Councils, before these bodies had had time to settle to their prescribed work, there has been, in the opinion of those well qualified to judge, no little waste. You could not create all at once the machinery requisite for the most efficacious expenditure of half a million of money on technical teaching. Much of the work done by these bodies is admirable. It is indeed surprising in the whole circumstances how efficiently technical instruction has been carried out, and no doubt it will improve. But it had a most extravagant start. It is difficult to trace, in the general returns of the technical education undertaken by the County Councils, the details of their work, and I have not been able to discover how far forestry has been treated as a subject of instruction. It has not, I think, been often included. But the example of Northumberland and Durham in respect of the Newcastle chair is one that gives encouragement for thinking that if the due importance of forestry to the community were made clear, County Councils, in districts favourable for forestry and its concomitant industries, might come forward with some of the financial support needed for the provision of the educational equipment.

It appears to me that whilst we must obtain from the Government the institution of sylvicultural areas for practical instruction, our best chance of success in acquiring the necessary endowment for the rest of the teaching lies in the line of combination between the Board of Agriculture and the County Councils, with, it may be, aid from private benefactors. But if we were to draw financial support from County Councils, or from private sources, we must as a first step towards this make known, more thoroughly than it is, the nature of the national interests involved. We must disabuse landowners, land agents, and practical foresters of the notion that forestry consists in the random sticking in of trees, which anyone, no matter how unskilled, may accomplish. We must bring home to the people's minds that in science is to be found the only sure guide to proper timber-growing, and that scientifically managed forests are alike a profit to the prodncer, a benefit to the community of the region in which they are reared, and a source of national wealth. Once we have got so far as to create this opinion, the funds for as extended a scheme of forestry education as may be necessary will, I venture to think, be forthcoming.

There is still the other question to answer—Whence are the teachers to come? This is, I think, fundamental. For, given a competent teacher, he will soon find opportunity for teaching. If to-morrow the whole or even a half of the chairs suggested by Dr. Nisbet as essential were founded, how should we meet the demand for men to fill them? We might, of course, draw upon the Indian Forest Service, but I do not know where you would find teachers in Britain. But if there is no prospect of such immediate requirement of teachers, that does not make the fact of their deficiency of any less moment. There is surely something wrong when men capable of giving scientific instruction in so important a practical subject are so scarce.

This is how it touches us botanists, and upon our shoulders I am disposed to throw the blame for the present outlook. We do not seem to have realised, except in relation to medicine, that modern botany has an outlet. Perhaps it has been the influence of medicine that has engendered this. We find chemists and physicists devoting their science to the furtherance of practical aims. Zoologists have applied theirs to the elucidation of problems bearing on the fishery industry, and we see in that monument to the ability and energy of Prof. Ray Lankester, the marine biological laboratory at Plymouth, an experimental station which, while it contributes to the nation's prosperity, serves at the same time as a home of pure research. But where is the practical outcome of modern botany? I must not overlook such brilliant work as that of Marshall Ward, full of purpose, and significant as it is to many large industries, nor that of Oliver in its bearings on horticulture. But it does seem to me that the general trend of botanical work in Britain is not utilitarian. Perhaps as good an illustration as could be given of the slight practical importance attached by the lay mind nowadays to botany is the fact that the Scottish Universities Commissioners have made it—though I must add it is bracketed with zoology—optional with mathematics for the degree in agriculture!

It is matter of history that its utilitarian side gave the first impetus to the scientific study of botany. The plant-world, as the source of products of economic value and drugs, attracted attention, and out of this grew, by natural development, the systematic study of plants. The whole teaching of botany was at the first, and continued for long to be, systematic and economic, and it was from this point of view that, the herbalist having become the physician, botany became so essential a branch of medical study. It is noteworthy that as an early practical outcome of the study came the establishment of botanic gardens, which, at their institution, were essentially what we would now style experimental stations, and contributed materially to the introduction and distribution of medicinal and economic plants, and to the trial of their products. If they are now in many instances simply appendages of teaching establishments, or mere pleasure-grounds, we at least in Britain are fortunate in possessing an unrivalled institution in the Royal Gardens at Kew, which still maintains, and under its present able Director has enormously developed, the old tradition of botanic gardens as a centre in our vast empire, through which botany renders scientific service to our national progress.

In Britain, consequent perhaps on our colonial and over-sea possessions, the systematic side of botany continued predominant long after morphological and physiological work had absorbed the attention of the majority of workers and made progress on the continent. Not that we were wanting in a share of such works, only it was overshadowed by the prevalent taxonomy, which in the hands of many no longer bore that relation to its useful applications which had in the first instance given it birth, and had become little more than a dry system of nomenclature.

The reaction of a quarter of a century ago, which we owe to the direct teaching of Sachs and De Bary and the influence of Darwin, many of us can remember; in it some who are here to-day had a share. Seldom I think is a revolution in method and ideas of teaching and study so rapidly brought about as it was in this instance. The morphological and physiological aspect of the subject infused a vitality into the botanical work which it much needed. The biological features of the plant-world replaced technical diagnosis and description as the aim of teachers and workers in this field of science. No weightier illustration of the timeliness of this change could be found than in the attitude of medicine. But a few years ago he would have been rash who would predict that botany would for long continue to be recognised as a part of university training essential to medical students. Its utility as ancillary to materia medica had lost point through the removal of pharmacy from the functions of the physician. But what do we see now? Not the exclusion of botany from the university curriculum of medical study, but the recognition to such an extent of the fundamental character of the problems of plant-life, that it is now introduced into the requirements of the colleges.

But if the old taxonomic teaching was stifled by its nomenclature, there is, it seems to me, a similar element of danger in our modern teaching, lest it be strangled by its terminology. The same causes are operative as of old. The same tendency to narrowing of the field of vision, which eventuates in mistaking the name for the thing, is apparent. With the ousting of taxonomy, and as the laboratory replaced the garden and museum, the compound microscope succeeded the hand-lens, and for the paraphernalia of the systematist came the stains, reagents, and apparatus of microscopical and experimental work as the equipment necessary for the study of plants, the inwards rather than the outwards of plants have come to form the bulk of the subject matter of our teaching, and we are concerned now more with the stone and mortar than with the general architecture and plan of the fabric; we are inclined to elaborate the minute details of a part at the expense of its relation to the whole organism, and discuss the technique of a function more in the light of an illustration of certain chemical and physical changes than as a vital phenomenon of importance to the plant and its surroundings. This mechanical attitude is quite a natural growth. It is a consequence of specialisation, and it is reflected in our research. But it must be counteracted if botany is in the future to be aught else than an academic study, as it was of old an elegant accomplishment. It has come about very much because of that want of recognition by botanists, to which I have already referred, of the natural outlets of their study—of their failure so far to see the lines through which the subject touches the national life. Modern botany has not yet found in this country its full application. It has not yet rendered the State service as it ought, and as was done by the taxonomic teaching it supplanted.

It is from this point of view that I wish to point out to you to-day that through forestry—and although I have particularly dealt with this branch of Rural Economy, what I say is equally true of horticulture and agriculture—modern botanical study should find a sphere of application by which it may contribute to our national well-being, and which would have a directive influence upon its teaching, taking it out of the groove in which it tends to run. What we botanists need to do in this connection is to teach and to study our subject from a wider platform than that of the mere details of individual form, and to encourage our pupils to study plant-life not merely in water-cultures in the laboratory, but in the broader aspects exhibited in the competitive field of nature.

If forestry is ever to thrive in Britain, botanists must lay the foundation for it in this way. We cannot expect to make our pupils foresters, nor can they yet get the practical instruction they require in Britain. In this we must depend yet a while on continental schools; the stream of continental migration, which needs no longer to flow in morphological and physiological channels, must now turn in the direction of forest schools. But we can so mould their studies and give bias to their work as will put them on the track of this practical subject. If we had only a few men so trained as competent foresters, and capable of teaching forestry, there would be an efficient corps with which to carry on the crusade against ignorance and indifference, the overcoming of which will be the prelude to the organisation of forestry schools and scientific sylviculture in Britain. The influence of the individual counts for much in a case like this. The advent of a capable man started forestry teaching in Scotland, which years of talk had not succeeded in doing. And so it will be elsewhere

I have endeavoured, thus briefly, to sketch the position, the needs, and the prospects of forestry in Britain. Its vast importance as a national question must sooner or later be recognised. It is a subject of growing interest. Its elements are complex, and it touches large social problems; but the whole question ultimately resolves itself into one of the application of science. To botanists we must look in the first instance for the propagation of the scientific knowledge upon which this large industry must rest. They must be the apostles of forestry. And forestry in turn will react upon their treatment of botany. Botany cannot thrive in a purely introspective atmosphere It can only live by keeping in touch with the national life, and the path by which it may at the present time best do this is that offered by forestry.

SECTION E.

GEOGRAPHY.

OPENING ADDRESS BY CAPTAIN W. J. L. WHARTON, R.N., F.R.S., PRESIDENT OF THE SECTION.

YOU will not be surprised if, having called upon an hydrographer to preside over this Section, he takes for the subject of his review the Sea. Less apparently interesting, by reason of the uniformity of its surface, than the land which raises itself above the level of the waters, and with which the term geography is more generally associated, the ocean has, nevertheless, received much attention of later years. In Great Britain, especially, which has so long rested its position among the nations upon the wealth which our merchant fleets bring to its shores, and upon the facilities which the sea affords for communication with our numerous possessions all over the globe, investigation into the mysteries, whether of its ever moving surface or of its more hidden depths, has been particularly fascinating. I purpose, therefore, to attempt a brief survey of our present knowledge of its physical condition.

The very bulk of the ocean, as compared with that of the visible land, gives it an importance which is possessed by no other feature on the surface of our planet. Mr. John Murray, after a laborious computation, has shown that its cubical extent is probably about fourteen times that of the dry land. This statement appeals strongly to the imagination, and forms, perhaps, the most powerful argument in favour of the view, steadily gaining ground, that the great oceans have in the main existed in the form in which we now see them since the constituents of the earth settled down into their present condition.

When it is considered that the whole of the dry land would only fill up one-third of the Atlantic Ocean, the enormous disproportion of the two great divisions of land and sea becomes very apparent.

The most obvious phenomenon of the ocean is the constant horizontal movement of its surface waters, which in many parts take well-defined directions. These great ocean currents have now been studied for many years, and our knowledge of them is approaching a point beyond which it is doubtful whether we shall ever much advance, except in small details. For though, while indisputably the waters continually move in each great area in generally the same direction, the velocities vary, the limits of the different streams and drifts vary, mainly from the ever-varying force and direction of the winds.

After long hesitation and much argument, I think it may be now safely held that the prime motor of the surface currents is the wind. Not, by any means, the wind that may blow, and even persistently blow, over the portion of water that is moving, more or less rapidly, in any direction, but the great winds which blow generally from the same general quarter over vast areas. These, combined with deflection from the land, settle the main surface circulation.

I do not know if any of my hearers may have seen a very remarkable model, devised by Mr. Clayden, in which water disposed over an area shaped like the Atlantic, and sprinkled over with lycopodium dust to make movement apparent, was subjected to air impelled from various nozzles, representing the

? this is rather indefinite - probably then read in connection with what [illegible] mean directions of the permanent winds. It dispelled the last doubt I held on the subject, as not only were the main currents reproduced, but the smaller effects and peculiarities of the Atlantic drifts were produced with surprising accuracy.

There is a small current, long shown on our charts, but which I had always regarded with suspicion. I refer to the stream which, after travelling from the Arctic Ocean southward along the east coast of Greenland, turns sharply round Cape Farewell to the northward into Davis Straits, where it again doubles sharply on itself to the southward. This is exhibited, in the model, in all its details, and is evidently caused by the pressure of the water forced by the mimic Gulf Stream into the Arctic region, where it has no escape except by this route, and is pressed against the land, round which it turns as soon as it can. This is, no doubt, the explanation of the real current.

The very remarkable winter equatorial current, which runs in a narrow belt eastwards, just north of the main stream travelling west, was also reproduced with extraordinary fidelity.

The winds, however, that are ordinarily considered permanent vary greatly, while in the monsoon areas the reversal of the currents caused by the opposite winds exercise a great influence on the movements of the water far beyond their own limits, and anything like a prediction of the precise direction and rate of an oceanic stream can never be expected.

The main facts, however, of the great currents can be most certainly and simply explained in this manner.

The trade winds are the prime motors. They cause a surface drift of no great velocity over large areas in the same general direction as that in which they blow. These drifts after meeting and combining their forces eventually impinge on the land.

They are diverted and concentrated and increase in speed. They either pour through passages between islands, as into the Caribbean Sea, are pressed up by the land, and escape by the only outlets possible—as, for example, the Strait of Florida, and form a great ocean current like the Gulf Stream—or, as in the case of the Agulhas current and the powerful stream which runs north along the Zanzibar coast, they are simply pressed up against and diverted by the land, and run along it with increased rapidity.

These rapid currents are eventually apparently lost in the oceans, but they in their turn originate movements of a slower character, which on again passing over shallow water or on meeting land develop once more into well-defined currents.

We find an analogous state of things on the western side of the Pacific, where the Japan current is produced in a similar manner.

The fact that on all western shores of the great oceans towards which the trade winds blow we find the strongest currents running along the coast, is almost enough of itself to prove the connection between them.

The westerly winds that prevail in higher northern and southern latitudes are next in order in producing great currents. From the shape of the land they in some cases take up and continue the circulation commenced by the trade winds; in others they themselves originate great movements of the water.

Compared to the great circulation from this source the effect of differences of temperature or of specific gravity is insignificant, though no doubt they play their part, especially in causing slow under-circulation, and in a greater degree the vertical mixing of the lower waters.

No drop of the ocean, even at its greatest depth, is ever for one moment at rest.

Dealing with minor points, the American officers of the Coast and Goedetic Survey have found after long and patient investigation that the velocity of the Gulf Stream in its initial and most marked part, the Strait of Florida, is greatly affected by the tide, varying as much as one-half its maximum rate during the twenty-four hours.

These American investigations are of greatest interest. They have extended over the whole area of the Caribbean Sea and its approaches, the Gulf of Mexico, and the Gulf Stream proper and its vicinity. In no other part of the ocean has observation of this detailed character been carried out, and they throw a great light on oceanic circulation. The *Blake*, the vessel specially fitted for the purpose, has during the several years in which she was employed on this work anchored in over 2000 fathoms water, or a depth of considerably more than two miles; a feat which would a short time ago have been deemed impossible.

One great point that has come out very strongly is the continual variation in the strength and direction of the currents, and the varying depths to which the surface current extend.

Eastward of the chain of the Windward Islands the general depth of the surface movement may be said to be about 100 fathoms, below which tidal influence is very distinct.

There is also a very plain backward flow of water, at depths which vary, caused by the submarine ridge which connects the Windward Chain of the West Indian Islands. These observations also generally support what I have already mentioned; that the velocity of a current depends on the strength of winds, possibly thousands of miles distant, which have given the original impetus to the water, and this, combined with tidal action when the current approaches or runs along a coast, will always cause uncertainty on the resultant velocity.

Dealing for yet another moment with the Gulf Stream, there are two points which have not been much dwelt upon, but which have a great effect on its power of bringing the modifying influence of its warm water as far as our shores.

The first is the prevention of its spreading, as it leaves the Strait of Florida, by the pressure of the portion of the equatorial current which, unable to get through the passages betweeen the Windward Islands, is diverted to the north of the Bahamas, and bears down on the eastward side of the Gulf Stream proper, compressing it between itself and the cold water flowing southward along the American coast, and at the same time adding to its forces and maintaining its high temperature.

The second is that by the time the Gulf Stream has lost its velocity as a current, in about the vicinity of the Bank of Newfoundland, it has arrived in the region of the westerly winds, that is of winds whose average direction is from west; whose influence, causing a surface drift somewhat comparable to that of the trade winds, bears the water onward to the British Islands and Norway. Without tnese prevailing westerly winds the warm water of the Gulf Stream would never reach these shores.

The depth to which the surface currents extend in other parts is little known. Direct observations on under-currents have been rare.

In the first place, it is not an easy observation to make. Apparatus has generally to be improvised. This has usually consisted of some form of flat surface lowered to the required depth, and suspended in the water by a buoy, which presents to the resistance of the upper stratum a very much smaller area than that of the surface below.

More perfect machines have been devised, notably, that used by the Americans in their West Indian experiments.

These, however, are delicate, and require so much care and experience in working, and so much time is wanted for such observations, that under the pressure of the more urgent requirements on surface movements in the interests of navigation very little has been done.

The *Challenger* made some observations on the depth of the equatorial current in mid-Atlantic, but they were not very conclusive for lack of suitable appliances. They, however, tended to show that below 100 fathoms there was but little current.

It has been calculated theoretically that winds blowing steadily in one direction with the ordinary force of the trade winds would in 100,000 years by friction between the particles put the whole of a mass of water 2000 fathoms deep, not otherwise influenced, into motion in that direction; but the direction and force of the trade winds are ever changing, and the actual strong currents of the ocean are not in the trade wind areas, but are the result of these drifts meeting one another and being compressed by the conformation of the land. We cannot, therefore, expect this theoretical effect to be realised.

One instance of the underrunning of one current by another is brought very plainly to our notice in the North Atlantic, to the east of the Great Banks of Newfoundland, where the icebergs borne by the Arctic current from Baffin Bay pursue their course to the southward across the Gulf Stream running eastward.

These great masses of ice, floating with seven-eighths of their volume under the surface, draw so much water that they are all but wholly influenced by the under-current. A large berg will have its bottom as much as six or seven hundred feet below the surface. The only reason that these bergs continue their ourney southward is the action of the cold under-current.

It was my good fortune to be ordered in 1872 to undertake a series of experiments of the currents and under-currents of the Dardanelles and Bosporus. They proved most interesting.

It was well known that a surface stream is almost continuously passing out of the Black Sea through the Bosporus into the Sea of Marmara, and again through the Dardanelles into the Mediterranean. Certain physicists, of whom Dr. W. Carpenter was one, were, however, of opinion that a return current would be found under the surface running in the opposite direction, and this I was enabled to demonstrate.

Though from the imperfection of our apparatus, which we had to devise on the spot, we were unable to exactly proportionate the quantities of water moving in the two directions, we found, whenever the surface current was rushing south-westward through these straits, that for a certain distance, from the bottom upwards, the water was in rapid motion in the opposite direction. It was an astonishing sight to behold the buoys which supported a wooden framework of 36 square feet area, lowered to depths from 100 to 240 feet tearing up the straits against a strong surface current of as much as three and four miles an hour. It was as perfect an ocular demonstration of a counter under-current as could be wished, and the Turks, who watched our proceedings with much suspicion, were strongly of opinion that the devil had a hand in it, and only the exhibition of the Sultan's firman saved us from interruption. In the investigation of these currents we found, as usual, that the wind was the most potent agent. Though the surface water from the Black Sea is almost fresh, and the bottom water of the heavy Mediterranean density of 1·027, it was found that when calm had prevailed the surface current slackened, and at times became nil, whilst the under-current responded by a similar slackening.

The ordinary condition of wind in the regions of the Black Sea and Sea of Marmara is that of a prevalent north-east wind. This causes a heaping up of the water on the south-west shores of those seas, precisely where the straits open, and the surface water therefore rapidly escapes.

These straits no doubt present abnormal characters, but, so far as surface currents are concerned, the long series of observations then made convinced me of the inadequacy of differences of specific gravity, which were here at a maximum, to cause any perceptible horizontal flow of water.

I have said that we were unable to define by direct observation the exact position of the dividing line between the opposing currents, but the rapid change in the specific gravity at a certain depth, which varied on different days, gave a strong indication that the currents changed at this point.

A Russian officer, Captain Makaroff, afterwards made similar experiments in the Bosporus, but with more perfect appliances, and he found that at the point where the specific gravity changed the currents also changed.

I have been anxious to obtain similar observations at the Straits of Babel Mandeb, the southern outlet of the Red Sea, where somewhat similar conditions prevail. Here the winds are governed by the monsoons. For half the year the wind blows from the north down the whole length of the sea, causing a surface flow outwards into the Gulf of Aden, and a general lowering of the whole level of the sea of about two feet. For the other half of the year the wind at the southern end of the sea is strong from the south-east, causing a surface set into the Red Sea, over which the general level of the water rises, while the northerly wind continues to blow throughout the northern half.

At either of these times I think it is highly probable that there is an under-current in the opposite direction to that at the surface, but unfortunately the sea disturbance is great and observations are very difficult.

Observations were, however, made by Captain W. U. Moore in H.M.S. *Penguin* in 1890, but at a time when the change of monsoon was taking place.

The result was peculiar, for it appeared that at a depth of about 360 feet the movement of the water was tidal, while the surface water was moving slowly in one direction—a result generally similar to that obtained by the Americans in the West Indies—but the direction of the tidal flow was directly opposite to what might have been expected, viz. the water ran in while the tide fell, and *vice versâ*.

More observations are, however, needed here before any certain conclusions can be formed.

The depth of the ocean is the next great feature which demands attention.

On this our knowledge is steadily, though slowly, increasing. The whole of it has been gained during the last fifty years.

Commenced by Sir James Ross, whose means were very small, but who nevertheless demonstrated that the so-called unfathomable ocean was certainly fathomable everywhere, the sounding of the ocean has continuously proceeded. The needs of submarine cables have constantly demanded knowledge in this particular, and the different cable companies have had a large share in ascertaining the facts.

Expeditions, whose main object has been to obtain soundings, have been sent out, Great Britain and the United States taking the first place; but most maritime nations have aided.

In the immediate past the additions have mainly been from the soundings which H.M. surveying ships continually take whenever on passage from one place to another, from the work of our cable companies, and from United States vessels.

We have, as a result, a very fair general knowledge of the prevailing depths in the Atlantic, but of the Indian and Pacific Oceans it is very fragmentary. We have enough to give us a general idea, but our requirements increase as years roll on. It is a vast task, and, it may be safely said, will never be completed; for we shall never be satisfied until we know the variations of level under the water as well as we know those on the dry land.

It is hopeless to do more than to briefly sketch the amount of our knowledge.

First, as to the greatest depths known. It is very remarkable, and from a geological point of view significant, that the very deepest parts of the ocean are not in or near their centres, but in all cases are very near land.

One hundred and ten miles outside the Kurile Islands, which stretch from the northern point of Japan to the north-east, the deepest sounding has been obtained of 4655 fathoms, or 27,930 feet. This appears to be in a deep depression, which runs parallel to the Kurile Islands and Japan; but its extent is unknown, and may be very large.

Seventy miles north of Porto Rico, in the West Indies, is the next deepest cast known, viz. 4561 fathoms, or 27,366 feet; not far inferior to the Pacific depth, but here the deep area must be comparatively small, as shallower soundings have been made at distances sixty miles north and east of it.

A similar depression has been sounded during the last few years west of the great range of the Andes, at a distance of fifty miles from the coast of Peru, where the greatest depth is 4175 fathoms.

Other isolated depths of over 4000 fathoms have been sounded in the Pacific. One between the Tonga or Friendly Islands of 4500 fathoms, one of 4478 fathoms near the Ladrones, and another of 4428 fathoms near Pylstaart Island, all in the Western Pacific. They all require further investigation to determine their extent.

With these few exceptions, the depth of the oceans, so far as yet known, nowhere comes up to 4000 fathoms, or four sea miles; but there can be little doubt that other similar hollows are yet to be found.

The sea with the greatest mean depth appears to be the vast Pacific, which covers 67 millions of the 188 millions of square miles composing the earth's surface.

Of these 188 millions, 137 millions are sea, so that the Pacific comprises just one-half of the water of the globe, and more than one-third of its whole area.

The Northern Pacific has been estimated by Mr. John Murray to have a mean depth of over 2500 fathoms, while the Southern Pacific is credited with a little under 2400 fathoms. These figures are based on a number of soundings which cannot be designated otherwise than very sparse.

To give an idea of what remains to be done, I will mention that in the eastern part of the Central Pacific there is an area of 10,500,000 square miles in which there are only seven soundings, whilst in a long strip crossing the whole North Pacific, which has an area of 2,800,000 square miles, there is no sounding at all. Nevertheless, while the approximate mean depth I am mentioning may be considerably altered as knowledge increases, we know enough to say that the Pacific is generally deeper than the other oceans. The immensity, both in bulk and area, of this great mass of water, is difficult to realise; but it may assist us when we realise that the whole of the land on the globe above water level, if shovelled into the Pacific, would only fill one-seventh of it.

The Indian Ocean, with an area of 25,000,000 square miles, has a mean depth, according to Mr. Murray, of a little over

2000 fathoms. This also is estimated from a very insufficient number of soundings.

The Atlantic, by far the best sounded ocean, has an area of 31,000,000 square miles, with a mean depth of about 2200 fathoms.

The temperature of this huge mass of water is an interesting point.

The temperature of the surface is most important to us, as it is largely on it that the climates of the different parts of the world depend. This is comparatively easy to ascertain. We know so much about it that we are not likely to improve on it for many years. We are quite able to understand why countries in the same latitude differ so widely in their respective mean temperatures; why fogs prevail in certain localities more than others; and how it comes about that others are subject to tempestuous storms.

On the latter point nothing has come out plainer from recent discussion than the fact that areas where great differences of surface temperature of the sea prevail are those in which storms are generated.

It is a matter of observation that in the region south of Nova Scotia and Newfoundland many of the storms which travel over the Atlantic to this country have their rise.

An examination of surface temperature shows that in this region the variations are excessive, not only from the juxtaposition of the warm water of the Gulf Stream and the cold water of the Arctic current flowing southward inside of it, but in the Gulf Stream itself, which is composed of streaks of warm and colder water, between which differences of as much as 20° F. exist.

The same conditions exist south of the Cape of Good Hope, another well-known birthplace of storms. Here the Agulhas current of about 70° F. diverted by the land pours into the mass of water to the southward, colder by some 25°, and the meeting-place is well known as most tempestuous.

South-east of the Rio de la Plata is another stormy area, and here we find the same abnormal variations in surface temperature.

Yet another is found off the north-east coast of Japan with the same conditions.

These differences are brought about by the mingling of water carried either by the flowing of a powerful current turned by the land into a mass of water of different temperature, as is the case off the Cape of Good Hope, or by the uprising of lower strata of cooler water through a shallow surface stream, as appears to be the case in the Gulf Stream.

A remarkable point recently brought to light by the researches of Mr. John Murray in Scotch lochs is the effect of wind on the surface temperature. It has been observed that wind driving off a shore drifts the surface water before it. This water is replaced by the readiest means, that is to say, by water from below the surface rising to take its place. As the lower strata are in all cases cooler than the surface a lowering of the temperature results, and we find, in fact, that near all sea-shores off which a steady wind blows the water is cooler than further to seaward.

This has an important bearing on coral growth, and explains why on all western coasts of the great continents off which the trade winds blow we find an almost absolute dearth of coral, while on the eastern coasts, on which warm currents impinge, reefs abound, the coral animal flourishing only in water above a certain temperature.

Observations of the temperature of the strata of water between the surface and bottom have been of late years obtained in many parts. Compared with the area of the oceans they are but few, but our knowledge steadily increases every year.

The subject of the vertical distribution of temperature has not yet been thoroughly investigated in the light of the whole of the information which we now possess, but Dr. Alex. Buchan has been for some time devoting his spare time to the task, and it is a heavy labour, for the data obtained here and there over the world by different ships of all maritime nations are very difficult to collect and to appraise, but I understand that before long we shall have the result, which will prove very interesting, in the last volume of the *Challenger* series.

It will readily be understood that observations on temperatures at great depths require great care. In the first place the thermometers must be most carefully manufactured. They must be subjected to rigorous tests, and they must be carefully handled during the operation. All observations are not of the same value, and the discussion, therefore, presents considerable difficulty and demands much discretion.

In the meantime we can state certain known facts.

We have learnt that the depth of the warm surface water is small.

In the equatorial current between Africa and South America, where the surface is of a temperature of 78°, at 100 fathoms it is only 55°, a difference of 23°, and a temperature of 40° is reached at 400 fathoms. In this region, so far as knowledge goes, the fall in temperature as we descend is most rapid, but generally speaking the same variations prevail everywhere.

In the tropical Pacific the temperature falls 32° from the surface, where it stands at 82°, to a depth of 200 fathoms, 40° being reached at from 500 to 600 fathoms below the surface.

Below the general depth of from 400 to 600 fathoms, the temperature decreases very slowly, but there is considerable variation in the absolute amount of it when we get to great depths in different parts of the ocean.

One of the most interesting facts that has been recognised is that in enclosed hollows of the ocean the bottom temperature is apparently much less than that of the stratum of water at a corresponding depth in the waters outside the submarine ridge that forms the enclosing walls, separating them from deeper areas beyond, and is, in all cases that have been observed, equal to that on the ridge. From this fact we are enabled to supplement our imperfect knowledge of depths, because if in a certain part of an ocean we find that the temperature at great depths is higher than we know exists at similar depths in waters apparently connected, we can feel certain that there is a submarine ridge which cuts off the bottom waters from moving along, and that the depth on this ridge is that at which is found the corresponding temperature in the outer waters. As a corollary we also assume that the movement of water at great depths is confined to an almost imperceptible movement, for if there was a motion that we could term, in the ordinary acceptation of the word, a current, it would infallibly surmount a ridge and pour over the other side, carrying its lower temperature with it.

A notable instance is the bottom temperature of the North Atlantic. This is nowhere below 35° F., although the depths are very great. But in the South Atlantic at a depth of only 2800 fathoms the bottom temperature is but a little above 32° F., and we are therefore convinced that somewhere between Africa and South America, though soundings do not yet show it, there must be a ridge at a depth of about 2000 fathoms.

We also come to the same conclusion with regard to the eastern and western portions of the South Atlantic, where similar differences prevail.

Again, the few temperatures that have been obtained in the eastern South Pacific show a considerable difference from those in the South Atlantic, and we are compelled to assume a ridge from the Falkland Islands to the Antarctic continent.

It is interesting that the investigation into the translation of the great seismic wave caused by the eruption of Krakatoa in 1883 led to a similar and entirely independent conclusion. The wave caused by the explosion in the Straits of Sunda reached Cape Horn, where by good chance a French meteorological expedition had erected an automatic tide gauge, but instead of one series of waves being marked on the paper there were two. A little consideration showed that the South Pole having directly interposed between Sunda Straits and Cape Horn, the waves diverted by the land about the pole would arrive from both sides.

One wave, however, made its appearance seven hours before the other.

Study showed that the earliest wave coincided in time with a wave travelling on the Pacific side of the pole, with a velocity due to the known depth, while the later wave must have been retarded in its journey *viâ* the South Atlantic. The only possible explanation is that the wave had been impeded by comparatively shallow water.

The evidence from bottom temperature was then unknown, and thus does one branch of investigation aid another.

In the Western Pacific the water is colder, a few bottom temperatures of a little over 33° F. having been found in the deep trough east of the Tonga Islands; but the North Pacific, though the deeper ocean—of enormous area and volume—is apparently again cut off by a submarine ridge. The north-western part of the Indian Ocean is for similar reasons assumed to be divided from the main body, the shallower water probably running from the Seychelles to the Maldive Islands.

Mr. Buchanan has pointed out why some parts of oceans, deep and vast though they be, are when cut off from communication with others warmer at the bottom.

Water can only sink through lower layers when it is the heavier, and though a warm surface current becomes from evaporation denser, its heat makes it specifically lighter than the strata below.

It is only when such a current parts gradually with its heat, as in travelling from tropical to temperate regions, that it sinks and slowly but surely carries its temperature with it, modifying the extreme natural cold of the bottom layers.

In the North Atlantic and Pacific we have such a condition. The great currents of the Gulf Stream and Japan current as they flow to the north sink, and in the course of ages have succeeded in raising the bottom temperature three or four degrees.

In the southern seas this influence is not at work, and, directly connected with the more open water round the South Pole, there is nothing to carry to the abysmal depths any heat to raise them from their normal low temperatures, due to the absence of any heating influence.

The ice masses round the South Pole have probably little or no effect on bottom temperature, as the fresher, though colder, water will not sink; and, as a matter of fact, warmer water is found at a few hundred fathoms than at the surface.

The lowest temperature ever obtained was by Sir John Ross in the Arctic Ocean in Davis Straits at a depth of 680 fathoms, when he recorded a reading of 25° F. This probably requires confirmation, as thermometers of those days were somewhat imperfect.

In the great oceans the greatest cold is found on the western side of the South Atlantic, where the thermometer stands at 32°·3 F., but temperatures of 29° F. have been obtained of recent years east of the Færoe Islands, north of the ridge which cuts off the deeper waters of the Arctic from the Atlantic.

Though scarcely within the limits of my subject, which is the sea itself, I must say a few words on the sea floor.

The researches carried on in the *Challenger* revealed that while for a certain distance from the continents the bottom is composed of terrestrial detritus, everywhere in deep water it is mainly composed of the skeletons or remains of skeletons of the minute animals that have lived in the water.

In comparatively small depths we find remains of many shells. As the depth increases to 500 fathoms or so we get mainly the calcareous shells of the globigerinæ which may be said to form by far the greater part of the oceanic floor.

In deeper water still, where pressure, combined with the action of the carbonic acid, has dissolved all calcareous matter, we find an impalpable mud with skeletons of the silicious radiolaria of countless forms of the greatest beauty and complexity. Deeper still, *i.e.* in water of—speaking generally—over 3000 fathoms, we find a reddish-coloured clayey mud, in which the only traces of recognisable organic remains are teeth of sharks and cetacea, many belonging to extinct species.

What the depths of these deposits may be is a subject of speculation. It may be that some day, as mechanical appliances are improved, we shall find means of boring, but up to the present no such operation has been attempted.

On the specific gravity of the water of the sea I can say but little except that it varies considerably.

It is not yet known for certainty how far the specific gravities observed at various points and depths remain appreciably constant.

In localities where evaporation is great, and other influences do not interfere, it is evident that the specific gravity of the surface will be high; a consideration which observations confirm, but there are many complications which require more observation before they can be resolved.

In some few places repeated observations permit deductions, but taking the sea as a whole we are yet very ignorant of the facts bearing on this point.

The waves which for ever disturb the surface of the sea demand much study.

The greatest of these, and the most regular, is the tidal wave. On this many powerful intellects have been brought to bear, but it still presents many unsolved anomalies.

Lord Kelvin and Prof. Darwin have demonstrated that the tidal movement is made up of many waves depending upon different functions of the moon and sun, some being semidiurnal, some diurnal. The time of transit over the meridian, the declination of both bodies, create great variations; the changing distance and position of the moon and the position of her node, also have great effect, while the ever-varying direction and force of the winds, and the different pressure of the atmosphere play their part, and sometimes a very large part, on what is somewhat loosely known as the meteorological tide.

The amplitude of the oscillation of the water depending upon each of the astronomical functions varying for every point on the earth, the effect is that, each having a different period, the resulting mean movement of the water has most astonishing variations.

In some places there is but one apparent tide in the day; in others this phenomenon only occurs at particular periods of each lunation, while in the majority of cases it is the movements of each alternate tide only that appear to have much to do with one another.

Though after long observation made of the times and ranges of tides at any one spot, they can now be predicted with great accuracy, for that particular place, the meteorological tide excepted, by the method of harmonic analysis, perfected by Prof. G. Darwin, no one can yet say what the tide will be at any spot where observations have not been made.

Observations all over the world have now shown that there is no part where the tidal movement is so regular and simple as around the British Islands. This is more remarkable when it is found that the tides on the other side of the Atlantic—at Nova Scotia, for instance—are very complicated.

The minor tides, which in most parts of the world, when combined in one direction, amount to a very considerable fraction of the principal lunar and solar tides, and consequently greatly increase or diminish their effects, are in Great Britain so insignificant that their influence is trifling; but why this should be, I have never yet found anyone to explain.

Nevertheless there are many very curious points about our tides which are plainly caused by interference, or, in other words, by the meeting of two tidal waves arriving from opposite directions, or from the rebound of the tidal waves from other coasts.

This effect, also, it has been so far found impossible to predict without observation. On our southern coasts, for instance; in the western part the tide rises about 15 feet, but as it travels eastward the range becomes less and less until, about Poole, it reaches a minimum of 6 feet. Farther east again it increases to Hastings, where the range is 24 feet. Yet farther east it again gradually diminishes. This is due to the reflection from the French coast, which brings another wave which either superposes itself upon, or reduces the effect of, the main tide advancing up the English Channel; but the details of such reflection are so complex that no one could forecast them without more knowledge than we possess.

There can be little doubt that to this cause, reflection, is mainly due the variations in the amount of mean range of tide which are found on many coasts at different parts; and as these reflected waves may arrive from great distances, and be many in number, we may cease to wonder at the extraordinary differences in range of tide which prevail, though it will be understood that this is wholly separate from the varying heights of each successive tide, or of the tide at different parts of each lunation, or at different times of the year, which depend upon the astronomical influences.

The actual height of the tide in deep water is small, but on passing into shallow water when approaching a shore, and especially when rolling up a gulf of more or less funnel shape, it becomes increased by the retardation caused by friction, and by compression laterally, and hence the height of the tide on a coast affected by other causes is greater than in the open sea.

The oceanic tide wave is supposed to be from 2 to 3 feet in height, but as this has been assumed from observations made at small oceanic islands, where, although the magnifying influences mentioned are at a minimum, they still exist, we wait for precise information until some means of actually measuring the tide in deep water is devised.

The waves due to wind, though not so far-reaching in their effects as the majestic march of the tide wave, are phenomena which are more apparent to the traveller on the ocean.

The deep sea in a heavy gale presents, perhaps, the most impressive manifestation of the powers of nature which man can behold, and doubtless many of us have experienced feelings that may vary from awe and wonder to sheer delight, according to the temperament of each individual, at for the first time finding himself face to face with this magnificent sight, though I rather fear that discomfort is the prevailing feeling that many carry away.

The height to which storm waves may rise has never been very satisfactorily determined. Apart from the difficulty of the task and the small number of people who will address themselves to it when they have the chance, it is but rarely that any individual sees really abnormal waves, even though he may be at sea all his life.

Different heights for what are called maximum waves have been recorded, and they vary from 40 to 90 feet from crest to hollow.

All we can say is that the most probable figure is about 50 or 60 feet.

These great storm waves travel very far. In some cases they convey a warning, as their velocity always far exceeds that at which the storm is travelling. In others they intimate that a gale of which no more is seen has occurred somewhere—it may be many miles distant.

When they have travelled beyond the limits of the wind which raised them, they lose the steepness of slope which characterises them when under its influence, and become an undulation which is scarcely noticed when in deep water.

On approaching shallow water, however, they are again apparent, and the "rollers" that occur unperiodically at various places in latitudes where gales never occur would seem to be caused by such waves, originating in areas many thousands of miles distant. Such appears to be the origin of the well-known rollers at Ascension and St. Helena, where the rocky and exposed nature of the landing has caused this phenomenon to be especially noticed.

Other rollers are, however, undoubtedly due to earthquakes or volcanic eruptions occurring in the bed of the sea.

Many of the great and sudden waves which have caused devastation and great loss of life on the shores of western South America are referable to this cause.

Observations to enable the focus of such a disturbance to be traced have generally been lacking, but it is probable that where the wave has been large the point of origin has not been far distant.

In one notable instance the conditions were reversed. The point of origin was known, and the distance to which the resulting wave travelled could be fairly satisfactorily traced.

This was the great eruption in the Straits of Sunda, in August 1883, which locally resulted in the disappearance of the major part of the island of Krakatoa, and the loss of nearly 40,000 lives, on the neighbouring shores of Java and Sumatra, by the huge wave which devastated them.

The records of automatic tide gauges and the observations of individuals enabled the waves emanating from this disturbance to be followed to great distances. These waves were of great length, the crests arriving at intervals of about an hour, and moving with a velocity of about 350 miles an hour, were about that distance apart.

The waves recorded at Cape Horn were apparently undoubtedly due to the eruption, and travelled distances of 7500 miles and 7800 miles in their course on either side of the south polar land.

They were only five inches in height above mean level of the sea, while the waves recorded at places on the southern part of Africa, at a distance of about 5000 miles from the scene of the eruption, were from one to two feet high, the original long waves being of an unknown height, but probably did not exceed ten or fifteen feet.

No other such opportunity of testing the distances to which great waves may travel has ever occurred, and as such a catastrophe as gave rise to them could scarcely be repeated without similar loss of life, it may be hoped we shall not live to see another, interesting though the discussion of the numerous phenomena were.

The movement of the particles of water due to the tide wave extends to the bottom of the deepest water, and doubtless plays an important part in keeping up a constant motion in the abysses, but the depth to which the action of the surface waves originating in wind reach is still but little known by observation.

If, however, we study the contour of the bottom off the shores of land exposed to the full influence of the great oceans, we are struck by the very general rapid increase of slope after a depth of about 80 to 100 fathoms (500 to 600 feet) has been reached.

It appears probable that this is connected with the depth to which wave action may extend, the fine particles brought down by rivers or washed from the land by the attrition of the breakers being distributed and gradually moved down the slope.

When we examine banks in the open sea we find, however, that there are a great many with a general depth of from 30 to 40 fathoms, and the question arises whether this may not be the general limit of the power of oceanic waves to cut down the mass acted upon when it is fairly friable.

The question has an interesting bearing on the subject of the ever-debated origin of coral atolls, for this is the general depth of many large lagoons; and granted that the sea can cut down land to this depth, we have at once an approach to the solution of the problem of the formation of bases of a suitable depth and material upon which the coral animal can commence operations.

This question also awaits more light, and I merely offer this remark as a suggestion.

It is, however, somewhat remarkable that in recent cases of volcanic islands piled up by submarine eruptions, they have all been more or less rapidly washed away, and are in process of further diminution under the surface.

Observations on the mean level of the sea show that it constantly varies, in some places more than others.

This subject has not yet been worked out.

In some localities it is plainly due to wind, as in the Red Sea, where the summer level is some two feet below that of winter, owing to the fact that in summer the wind blows down the whole length of the sea, and drives the water out.

In many places, as in the great estuary of the Rio de la Plata, the level is constantly varying with the direction of the winds, and the fluctuation due to this cause is greatly in excess of the tidal action.

In others the cause is not so clear.

At Sydney, New South Wales, Mr. Russell found that during eleven years the level was constantly falling at about an inch a year, but by the last accounts received it was again stationary.

The variations in the pressure of the atmosphere play an important part in changes of sea level.

A difference of one inch in the barometer has been shown to be followed by a difference of a foot in the mean level of the sea, and in parts of the world where the mean height of the barometer varies much with the seasons, and the tidal range is small, this effect is very marked.

Of any secular change in the level of the sea little is known. This can only be measured by comparison with the land, and it is a question which is the more unstable, the land or the water—probably the land, as it has been shown that the mass of the land is so trifling, compared with that of the ocean, that it would take a great deal to alter the general mean level of the latter.

All the points connected with the sea that I have had the honour of bringing before you form part of the daily observation of the marine surveyor when he has the chance, but I cannot refrain from also mentioning other duties, which are indeed in the present state of our knowledge and of the practical requirements of navigation the principal points to which he has to pay attention, as it may explain why our knowledge on so many interesting details still remains very imperfect.

Working as we do in the interests of the vast marine of Great Britain, the paramount necessity of good navigational charts requires that the production of such charts should be our principal aim.

It is difficult for a landsman and difficult even for a sailor who has never done such work to realise the time that is necessary to make a really complete marine survey. The most important part, the ascertainment of the depth, is done, so to speak, in the dark—that is to say, it is by touch and not by sight that we have to find the different elevations and depressions of the bottom of the sea.

In making a map of the land, an isolated rock or hill stands up like a beacon above the surrounding land, and is at once localised and marked, but a similar object under the sea can only be found by patient and long-continued sounding, and may very easily be missed.

When it is considered that marine surveying has only been seriously undertaken for about 100 years, with a very limited number of vessels, we shall, I think, understand how in the vast area of the waters, taking only those bordering the shores, many unsuspected dangers are yearly discovered.

Very, very few coasts have been minutely surveyed, and setting aside for a moment the great changes that take place off shores where sandbanks prevail, I should be sorry to say that even on our own coasts charts are perfect.

Yearly around Great Britain previously unknown rocks come to light, and if this is the case at home, what are we to think of the condition of charts of less known localities!

Our main efforts, therefore, are directed to the improvement of charts for safe navigation, and the time that can be spared to the elucidation of purely scientific problems is limited.

Nevertheless, the daily work of the surveyor is so intimately connected with these scientific problems that year by year, slowly but surely, we add to the accumulation of our knowledge of the sea.

SECTION G.

MECHANICAL SCIENCE.

OPENING ADDRESS BY PROF. A. B. W. KENNEDY, LL.D., F.R.S., M.INST.C.E., PRESIDENT OF THE SECTION.

The Critical Side of Mechanical Training.

WHILE there is no place in the kingdom more suitable for a meeting of the British Association than Oxford, and certainly no place in which it is more delightful for the members to meet, it is yet to be admitted that there are few places which have much less in common with the special work of Section G. Nominally devoted to "Mechanical Science," the Section has for many years specially dealt with those branches of applied mechanical science which constitute the business of the engineer—to quote the well-known words of the Royal Charter, "the art of directing the great sources of power in nature for the use and convenience of man." The association of this ancient and learned city with boilers and chimneys, with the noise and racket of ordinary mechanical work, seems an incongruity. Even the harmless necessary railway-station is kept as far away as possible, and the very river flows with a quiet dignity which seems to shut out the thought of anything more mechanical than the most ancient and futile of water-wheels.

Naturally enough these considerations did not tend to make more easy the choice of a subject for this address, and I have come very near to agreement with a recent critic in the opinion that presidential addresses are, in fact, almost immoral in the nature of things and fit only to be abolished. Finally I decided upon taking up my present subject, as being one in which the academic rather than the technical side of our work comes to the front, while at the same time it does not lead me out of lines in which I have been able, in past years, to work myself. It is now twenty years since I first took any active part in the scientific training of engineers, and five since I ceased to do so. I have often wished that I may have been at all as successful in teaching others at University College as I was, at the same time, in teaching myself. And since I have ceased to teach I seem to have been spending my time in finding out how much better I could now do it than was possible when I was actually engaged in it. This may be pure imagination on my part; there is nothing more easy, as we all know, than to suppose that we know best how to do the things that other people do, and not the things we have to do ourselves. Indeed, I understand that this is the recognised attitude of the really superior critic. If, however, in anything which I have to say, it should seem that I am finding fault with what is now being done, I may at least point out that most of all I am finding fault with myself for not having done right when I had the opportunity—an opportunity which can now never recur. Indeed, instead of the decorous and unobtrusive heading which I have given to this address, I might have indicated its general lines almost as truly if I had entitled it "The Regrets of an Emeritus Professor"—a name which, on a suitable binding, might even have secured it a sale at the railway bookstalls.

I know well—too well—that in the present congested state of the engineering profession there are many of us who do not like to hear the word "training" mentioned at all. It seems to mean merely the preparation of more lads to struggle for a share of work that is even now insufficient to go round. There is no doubt much to be said for this point of view. But against it one must remember that all other professions are equally full, and that, after all, lads must do something. The fault is surely that there are too many lads! If our population is really to go on increasing as rapidly as at present—the benefits of which Sections D, E, and F might have a joint meeting to discuss, if not to discover—it is inevitable that demands should come for more and more complete professional preparation. The man of exceptional parts will come to the front under any conditions, training or no training, in the future as in the past. But for ordinary men—that is for 99 per cent. of us—it is essential that no advantage should be given to a rival in the fierce competition of life, and for them therefore it is of an importance hardly to be exaggerated to obtain the most complete and perfect training possible. At the same time, and on purely general grounds, it can hardly be denied that to raise the standard of our profession is indirectly to confer a benefit on the whole community. I hope, therefore, that in making certain suggestions about the training of engineers, it will not be thought that I am desirous of increasing their number, which is really an end as far as possible from my own wishes. Whether the number increases or stands still or falls off, it is of importance from every point of view that those who come forward should be as well prepared as possible. And even the most conservative of us are compelled to recognise that the standard required in engineers' offices now is enormously higher than it was thirty years ago. This may truly be either the cause or the effects of improved training, but in either case it has made the training itself a necessity.

The particular aspect of mechanical training of which I wish to speak is its critical side. I do not know how a man should be trained to be an inventor. I would not tell anyone if I did! To be a creator in mechanical matters—which, however, is a quite different thing,—is a faculty given only to a very few, and with them it is "born, not made." Many of us, however, without being either inventors or creators, have sufficient natural aptitude or inclination towards things mechanical to form a basis for the trainer or educator to work on, with some hope that he may be of service. About the sciences which should be taught to such men, or the methods of teaching them, about the extent and nature of their experience in shops or on works, I do not intend to speak. I shall confine myself to one aspect of the training only, an aspect which is perhaps not always sufficiently clearly kept in view—the aspect which I have just called the critical side of mechanical training.

An engineer is a man who is continually being called upon to make up his mind. It may be only as to the size of a bolt; it may be as to the type of a Forth Bridge; it may be as to the method of lighting a city; or only as to the details of a fire-grate. But, whatever it is, once it is settled it is decided irrevocably—it is translated into steel and iron and copper, and cannot be revoked by an Act passed in another session. The time given him in which to decide may be a day, or a month, or a year, but in any and every case (so far as my own experience goes) it is about one-tenth part of the time which he would like to have. It is only in rare cases that the decision is obvious—most often there are more courses open than even the most facile politician ever dreamt of. The matters are too complex to be dealt with mathematically or even physically; even if they were not, there are few engineers who would have the special capacity to handle them. Moreover, their solutions are seldom "unique." From this point of view, the whole use of college training, of workshop practice, of practical experience, is to provide the engineer later on with the means of critically examining each question as it comes up, of reviewing systematically the *pros* and *cons* of each method of dealing with it, of coming finally, rapidly and positively to some defensible decision, which may then be irrevocably carried out.

In the case of a problem in pure mathematics or physics, where only one right solution can exist, that solution is arrived at by the help of a thorough knowledge of the science in question—there is little room for the critical faculty except as to method—the result is either right or wrong. With our work, on the other hand, solutions of all problems except the very simplest—in other words, decisions on all points which present themselves—can be arrived at only by a process of criticism applied to the problems, to their statement, to their condition, to all their many possible solutions. The development of the necessary critical faculty should be one of the chief aims of every teacher and every student.

A scientific training cannot make a man an engineer. Perhaps it is impossible for anything to make a man an engineer unless he has grown that way from the beginning! But a scientific training may make him, or at least give him the possibility of making himself, a critic.

In the vigorous attempts which have been made to specialise the education of engineers very early, I am afraid that the idea of teaching *subjects* is sometimes too prominent, to the neglect of matters less obviously useful. It is, of course, one thing to know a subject from the examination point of view, and quite another to be able to think about it, and still another to be able to write about it. In particular, I have often regretted to find how little attention has been given to a matter which perhaps may be called literary rather than scientific, but which is all-important in criticism, I mean to the power of expression. It is not easy to overrate the importance to the engineer, as to other folk, of the power of saying clearly what he means, and of saying just what he means. I do not mean only of doing this for its own sake, but because if a man cannot say or write clearly what he means it is improbable that he can *think* clearly. By the power of expression I do not mean, of course, the mere power of speaking fluently in public, a thing which appears physically impossible to some people; I mean rather the power of expression in writing, which carries with it clearness and consecutiveness of thought. It is difficult to know how this matter can be taught, but at least it can be insisted upon probably to a much greater extent than is commonly the case. A man requires to see clearly not only the exact thing which he wants to say, but the whole environment of that thing as it appears to him. Not only this, but he must see the whole environment of the same thing as it appears to the persons for whom he is writing, or to whom he is speaking. He has to see what they know about the matter, what they think, and what they think they know, and if he wishes to be really understood has got to do much more than merely write the thing he means. He has carefully to unwrite, if I may use the expression, the various things that other people will be certain to think that he means. For after all the great majority of people are very careless listeners and readers, and it is not for the small minority who are really exact in these matters that one has to write. Moreover, it is a great help to clearness of thought and expression to keep before one always an ideal audience of people who will certainly misunderstand every single sentence about which any misunderstanding is in any way possible, and some others as well.

In attempting to think out or to discuss any question, whether it be technical or non-technical—in fact as long only as it is non-political—the first necessity is probably a knowledge of the question itself; and not only this, but also a proper understanding of its whole environment. This knowledge must be of such a kind as to distinguish what parts of it are important, what parts of it are unimportant, what parts can be described in two sentences, and what others may require as many paragraphs; what parts affect the result but little, however large they seem; and which ones must be considered vital, although their very existence is difficult to discover. The faculty which enables a man to handle his knowledge in this fashion may be summed up in the single expression, "sense of proportion." Moreover, the knowledge, to be of real value, must be as totally free from prejudices and prepossessions as in the most rigorous branch of pure science, and as thoroughly imbued with a healthy spirit of scepticism.

One is accustomed to think of engineering work as mainly constructive. But after all it is quite as much critical. In almost every department of mechanical work there are half a dozen ways of solving any particular problem. In some fashion or other the engineer must be able to judge between these various methods, methods which are often very much alike, but each of which may possess certain particular advantages and certain particular drawbacks. The arithmetical criticism which merely counts the advantages and the drawbacks, and puts an equal number of the one against an equal number of the other, is common enough, but obviously useless. The very first necessity to the critic is that he should have what I have just called the sense of proportion, a sense which will enable him to distinguish mere academical objections from serious practical difficulties, which shall enable him to balance twenty advantages which can be enumerated on paper by one serious drawback which will exist in fact, which will enable him in fact to place molehills of experience against mountains of talk. It is perhaps a doubtful point how far this sense of proportion can be taught at all. No doubt it can only be built up upon some natural basis. I am sure that in engineering we all know men whose judgment as to whether it was advisable to take a particular course we would accept implicitly, because we know that it is based on large general criticism, in spite of the most elaborate and specious arguments against it set down on paper. Any third-year student—not to go still further back—can criticise perfectly along certain very narrow lines, just as anyone can learn the rules of harmony and can write something in accordance with them which purports to be music. But after all the music may be music only in name, and the criticism may not be worth the paper it is written upon, however formal it may appear to be, unless the writer is thoroughly imbued with a sense of the proportionate value of the different points which he makes. To take the commonest possible case, I dare say we have all of us heard certain methods, mechanical, chemical, or other, stigmatised as totally wrong and absolutely useless because they contain certain easily provable errors. I am sure, too, that most of us could give illustrations of cases in which this has has been said with the very greatest dogmatism when the errors of the impugned method are not one-tenth part as great as the equally unavoidable errors of observation in the most perfect method.

Probably the best special education in proportion which a man can have is a course of quantitative experimental work. I say *quantitative* with emphasis, as meaning something much more than mere qualitative work. Here, I think, comes in the usefulness of the engineering laboratory. We require that the training should be not only in absolute measurement, but in relative measurement, the latter being quite as important as the former. Many kinds of measurements stand more or less upon a level as a training of the faculties of observation in themselves, but no single kind of measurement is sufficient as a training in proportion. A year spent in calibrating thermometers or galvanometers might make an exceedingly accurate observer in a perticular line, but it would not give the observer a knowledge of what even constituted accuracy in other directions; for accuracy is a relative and not an absolute term. In most engineering matters the conditions are, unfortunately, of a most complex kind; so complex that our problems are incapable of any solution sufficiently exact to satisfy the mathematician or physicist. The temptation to treat these problems as the mathematician treats those with which he deals—namely, to alter the assumed conditions in order to get an exact solution—is a very strong one. I am afraid it is most strong often in those engineers who are the best mathematicians. It is a temptation, however, steadily to be resisted. We must assume our conditions to be what they actually are, and not what we should like them to be; and if we cannot obtain an exact solution of our problem with its actual conditions, so much the worse for us, not so much the worse for the conditions. Our first duty is generally to find out the conditions; if they are disadvantageous (in fact I mean, and not merely in the problem) to alter them if they can be altered, but not to ignore them because they are inconvenient. We have then to find out the extent to which the known conditions permit any exactness of solution at all, and, finally, we have to keep this in view as a measurement of the highest accuracy which is attainable. To work out certain branches of the problem with such minuteness as to give us apparently very much greater accuracy than this is not only useless, but is apt to be positively misleading, as giving an impression of an accuracy which has no real existence.

The relative value of accuracy in different sets of observations is in itself a matter in which a sense of proportion is wanted, and often very badly wanted. Where one has to measure half a dozen things of which two are very easily measured and the remaining four are only measurable with great difficulty, it is only human nature that we should spend our energies on getting extremely accurate results with the first two and roughly do our best with the others. It is very difficult under such circumstances to remember that the accuracy of the whole is not the accuracy of the best part of our work, but of the worst.

The extraordinary effect of a want of sense of proportion is nowhere better shown than in the absurd statements which are constantly made as to technical matters in public prospectuses, and the still more absurd statements made in those very numercus documents of a similar kind of which some of us see a great many, but which do not finally emerge into public view. Fortunes are apparently to be made by inventions which, although doubtless ingenious, yet only concern one way of doing a thing which could be done equally well in half a dozen other ways. Every one is expected to run after a piece of apparatus which is to save 50 per cent. of something, the total cost of that something, however, being so very small that nobody cares to save in it at all. I need hardly mention the all too common case where a contemplated saving of 10 per cent in the cost of a material works out yearly to an amount much more than equal to the whole cost of the original article.

I believe that experimental work in an engineering laboratory can educate this critical sense of proportion very admirably in a number of ways. In the first place, it directs quantitative work into very varied channels, and not along one particular line. Secondly, it compels the observer to combine a number of measurements in such a way that the relative importance of accuracy in each can be seen. In the case of an engine trial, for instance, the combined results are affected by the accuracy of measurements of the dimensions of the machine, by the apparatus and methods used for measuring the water, by the indicator, and by its springs, by the speed counter, by the thermometers, and so on. An error of 1 per cent. in counting the revolutions is just as important as an error of 1 per cent. in measuring the water, or in measuring the mean pressure. I am afraid that one could point to a good many cases in which this has been more or less forgotten. Then, by making a series of measurements all in absolute quantities, the relative importance of each quantity to the desired total result can be seen. Thus it will be found that changes in certain quantities affect the total result to a very small extent, while changes in others affect it very largely, so that not only is the accuracy with which different quantities can be determined very different, but also the same degree of accuracy is of very different importance according to the particular quantity to which it refers. Once it is found that a final result is exceedingly little affected by a particular set of changes, it ceases to be of importance to measure or observe those changes in any extremely minute way, and of course the reverse holds equally good. Finally, and this perhaps is the most important matter of all, measurements in such a laboratory are made to a great extent under the complicated conditions under which the actual final result has to be obtained in practical work. They are not made under the conditions which insure the greatest individual accuracy of each result.

It will be seen that throughout, but particularly in the two last points which I have mentioned, the work of an engineering laboratory is in intention and in essence different from that of a physical laboratory. The aim of the latter is to make its problems as simple as possible, to eliminate all disturbing elements or influences, and to obtain finally a result which possesses the highest degree of absolute accuracy. In most physical investigations the result aimed at is one in which practically absolute accuracy is attainable, although attainable only if infinite pains be taken to get it. It is the business of the physicist to control and modify his conditions, and to use only those which permit of the desired degree of accuracy being reached. In such investigations it sometimes becomes almost immoral to think of one condition as less important than another. Every disturbing condition must be either eliminated or completely allowed for. That method of making the experiment is the best which ensures the greatest possible accuracy in every part of the result. The business of the engineer, on the other hand, is to deal with physical problems under conditions which he can only very partially control, and the conditions are a part of his problem. He does not, for instance, experiment with a steam engine so made that it can work with a Carnot cycle. It is in the nature of the case that he must experiment with a much less perfect machine. In burning fuel he does not use apparatus especially made to absorb the whole heat of combustion, but in the nature of the case has to investigate the behaviour of apparatus in which a very large part of that heat is unavoidably wasted. So one might go on through an immense number of instances. Perhaps the whole matter may best be summed up by saying that in a physical laboratory the conditions of each experiment are under the control of the experimenter, and are subservient to the experiment itself. In an engineering laboratory the conditions form part of the experiment. However much more difficult or complicated they render it, they still unavoidably form part of it—an experiment under any other conditions, or with those conditions removed, would *ipso facto* be irrelevant.

A critical training in matters mechanical is, however, only too similar to the celebrated training of the Mississippi pilot which so nearly broke the heart of Mr. Mark Twain. Whenever the whole matter seems to be completely mastered from one point of view, it is only to find, with a little more experience, that from another point of view everything looks different, and the whole critique has to be started afresh. Machines cannot be finally criticised—that is to say, they cannot be pronounced good or bad—simply from results measurable in a laboratory. One wishes to use steam plant, for instance, by which as little coal shall be burnt as possible. But clearly it would be worth while to waste a certain amount of coal if a less economical machine would allow a larger saving in the cost of repairs. Or it might be worth while to use a machine in which a certain amount of extra power was obviously employed, if only by means of such a machine the cost of attendance could be measurably reduced. In fact, what may be summed up in the phrase the "worth-whileness" of economies, is in itself a matter upon which a whole paper might be written. Unfortunately, the latter points which I have mentioned are just such as cannot easily be measured in laboratory work, or, indeed, in any other way whatever, except by actually using the apparatus in question. All that can be said is that a careful training in the critical measurement of comparatively simple points fits a man more than anything else to gauge accurately the importance of such other matters as I have mentioned. No doubt there are many men in whom the critical faculty is insufficiently developed to allow them ever to be of use in these matters, but to those who are intellectually capable of the "higher criticism" it must be, I think, of inestimable benefit to have had a systematic training in the lower.

Is there, then, any general standpoint from which mechanical criticism can be directed? Certain points are obvious, but probably the whole matter cannot easily be generalised. A city has to be supplied with water; there are three requisites: that the water should be of proper quality, of sufficient quantity, and that it should be brought in at a reasonable cost. But in such a case the first two are so enormously more important than the third, that the ideal is comparatively simple (of course, this is quite a different thing from being simply reached). A city has to be supplied with electric light: the essential conditions are similar. But in this case there are so many qualities which are equally proper, and there are so many different ways of bringing it in in sufficient quantity, that the third point—namely, the cost—becomes especially important. A factory has to be driven by steam power: the amount of power that is wanted can be produced by so many different types of engine and boiler—all capable of approximately equal economy, and all claiming equal freedom from breakdowns—that the choice is a peculiarly difficult one from the critical point of view.

It seems almost impossible that a criticism on any one basis could meet all the three cases which I have supposed unless that basis were that the thing supplied should be the absolutely fittest, having regard to all the conditions of each case and the relative importance of each condition. Possibly in all cases we could get at some generalisation which would show us which was the absolutely fittest, if only the necessary data were in any way complete, which they very seldom are. Perhaps in one sentence we may say that that scheme, or system, or machine, will be the absolutely best in any particular case which will the longest survive and maintain its place in its particular environment. I cannot doubt that this development of Darwinian ideas in the world of the inorganic is a legitimate one. Of course the problem would be comparatively easy in each particular case if only the environment would stand still. It would even be comparatively easy if we knew how the environment was going to alter, but this we are unable to do. We only know that it certainly *will* change and will go on changing, and that therefore the things which we make now have not got to survive in the conditions in which we make them, but have got to survive through some new sets of conditions of which we know nothing. I do not think the difficulty is in any way met by the popular method of guessing at what will be wanted fifty years hence, which generally means simply guessing at something very big. It is of no use making our ships or our engines of a type which we choose to imagine will be that of fifty years hence. If we do they will be of no use to-day, and for that very reason they will not even be in existence, useful or other, at the end of the fifty years. Sufficiently sad illustrations of this will occur to everyone in very different directions. I hope I shall not be considered churlish in saying that I do not think that the men who have worked on this principle have really been far-seeing, or have really brought us much forward. They have been men often of genius, often of great personal fascination, always of immense imagination. But they have proceeded by methods essentially opposed to anything like the gradual evolution which must occur in technical as it does in natural matters, and in too many cases the results of their labours have not even been giants, but only monsters.

As to what causes one thing to survive rather than another we can only speak very generally. Mere survival may come about by the accident of a peculiarly tough constitution. A few engines built in the time of James Watt are still to be found at work in our own day, but can no more be taken as the fittest type than some solitary megatherium would be who, having outlived all his contemporaries, was able in after ages to look down upon his pigmy and short-lived successors. Mere length of life in such a case may be a mere accident, and is not itself a proof of fitness. We have it thrown at us every now and then that our engines nowadays do not last like the old ones, as if the mere existence of a very old machine were a proof of its virtues. It is certainly a proof of the excellence of its construction—or, as one may say, of its constitution—and perhaps also of the very small amount of work it has done in proportion to its life and its dimensions.

It is sometimes, I am afraid, rather humiliating to have to remember that, to a very great extent, the question of the fittest, so far as it affects us, is a financial one. In manufacturing processes efficiency and economy tend to survival because they lead to decreased cost of production. In structures or other large permanent works those types tend to perpetuate themselves which require the least material—that is, in which the material used is disposed to the best advantage—and in which the outlay on labour is also smallest, assuming, of course, equal fitness in other respects. There is, no doubt, at present a tendency to dispute this altogether, and to treat all reductions in cost of labour as disadvantageous, unless, indeed, the labour be very highly skilled, in which case its remuneration must necessarily be brought down for the sake of equality! I imagine this tendency will last exactly as long as the faithful can get some other people to pay the increased cost, and will thereafter determine itself somewhat suddenly. It can no more stand in the way of natural progress in engineering matters than could the somewhat similar outcry against the introduction of machinery into manufactures two generations ago. It would be as wise to paint a generation of cats green, in the hope of compelling natural selection to work along new lines.

I think we may fairly assume, therefore, that efficiency and economy are both legitimate criteria as to ultimate fitness, and will remain so. Moreover, they are both matters in which measurements can be made, and as to which judgment can be guided by such measurements. But there are other characteristics, not directly measurable, by which we can in some degree form an opinion as to the ultimate fitness of things or processes.

One set of considerations which has great critical importance is summed up in the word *simplicity*. This does not mean fewness of parts. Reuleaux showed long ago that with machines there was in every case a practical minimum number of parts, any reduction below which was accompanied by serious practical drawbacks. Nor is real simplicity incompatible with considerable apparent complexity. The purpose of machines is becoming continually more complex, and simplicity must not be looked at as absolute, but only in its relation to a particular purpose. There are many very complex-looking pieces of apparatus in existence which work actually so directly along each of their many branch lines as to be in reality simple. I believe it almost always happens that the first attempt to carry out by a machine a new purpose is a very complicated one. It is only by the closest possible examination of the problem, the getting at its very essence, that the machine can be simplified, and this is a late and not an early stage of design. If a mechanical problem is really only soluble by exceedingly complicated apparatus, it generally becomes a question whether the solution is worth having. There is no impossibility in making a machine that will do anything. But the very simplest possible form of apparatus which would wash our hands for us in a suitable manner is probably so very complicated that for many years to come at least that operation will be performed by manual labour.

Very closely allied to simplicity is what I may call directness. In nearly all mechanical processes certain transformations are unavoidable. In many mechanical processes, as I have recently had occasion to mention, a very large number of transformations is at present practically unavoidable. I myself cannot help thinking that probably one of the most distinct signs of fitness is a reduced number of transformations, the bringing of the final and the initial stages as close together as possible, and cutting out altogether the apparently worthless middle processes. But any generalisation of this kind must be very cautiously handled; these apparently useless processes are no doubt in certain cases as indispensable as is the much abused middle-man in matters economic.

In a critical view of any case where similar results are aimed at by hand-work and by mechanical means, it is important to recognise that the similarity of result should very seldom become identity. In the first machine to do anything mechanically which has before been done by hand, the error is often made of trying to imitate the hand-work rigorously. The first sewing machines were, I believe, made to stitch in the same way as a seamstress. It was not until a form of stitch suitable for a machine, although unsuitable for hand, was devised that the sewing machine proved successful as a practical matter. In another but analogous line too you may remember that the first railway carriages were practically stage coaches put upon trucks, from which the present carriages have only very slowly been evolved.

The critic has also to remember that very often the attainment of some very unimportant point, or point of which the importance has been greatly exaggerated, is made the reason mechanically for very great complication. The question of proportion comes in here again, and it has to be considered in any particular case whether the academically perfect machine, which is also extremely complicated, is not inferior to the *almost* equally good machine which has been constructed in a practicable shape,—it almost always is so.

I have endeavoured in my remarks to indicate what appears to me to be the attitude of the engineer towards a very large portion of the work which comes into his hands. In order to deal with the work it is necessary for him first of all to have a certain definite knowledge of "things," that is to say, both of the various subjects which form part of the curricula of all technical schools, and of the further matters which form as it were his professional alphabet. These last he learns not from books or lectures as a student, but by example and attempt, as does an artist. Of this part of his training I have said nothing; it has been perhaps sufficiently talked about of late years, and there is little to say which I could have made interesting to a general gathering like this. I cannot leave it altogether, however, without dealing with one matter. Exceptional men are all-round mathematicians or physicists, still more exceptional men are both; but for ordinary folk the study of one side of mathematics or of a single branch of physics is the work of a lifetime. The engineer is bound to know his own profession, by hypothesis, and it is in itself no small matter. Yet in addition he must know some mathematics, some physics, some chemistry, even also some geology, if he is to take any high rank in it. It is, therefore, surely in the very nature of things impossible that he should be a great mathematician or a great physicist, or should devote as much study to those most fascinating sciences as if they themselves were the work of his life. Therefore I beseech my friends of Section A to do what they can to modify their natural attitude of superiority—even of contempt—towards us, especially when we are students. The young engineer—I speak as a member of the great majority of the ordinary kind—would probably never have chosen his profession if he had had special aptitude for mathematical work. Having chosen it, he has to look at mathematics simply as a tool, a means to an end, not an end in itself. I cannot myself see that this point of view is one disrespectful to the parent of all the sciences, and I am confirmed by the knowledge that one or two of the greatest mathematicians in the country are of the same opinion and have the courage to act on it—with infinitely beneficial results to the young men they have to deal with. But I know that to mathematicians in general—the physicists are not so bad—the very name of engineering student is odious, indicating only a man who wilfully refuses to make mathematics his "first subject," and who therefore deserves neither consideration nor quarter, to whom it is privilege sufficient that he should be allowed to pick up such crumbs as he can digest from a table prepared for his betters. I humbly protest that we deserve better treatment. It is no doubt a great misfortune to us that we cannot afford to spend our training-time preparing for examinations, and that we have been compelled to choose for our future a career in which mathematics plays only a secondary part. It is our further misfortune that we have to solve twenty real live problems, each demanding a real live answer, for every single one which otherwise we would have worked out on paper. Perhaps it is also our misfortune—or it may be only our thickheadedness—to believe that in consequence of this we are quite able to judge for ourselves what units it is most convenient for us to work in, what nomenclature satisfies our requirements, and that we are as capable of getting our "*g*'s" in their right places as even some of our distinguished critics. But this is the end of the nineteenth century; philanthropy fills our breasts. May not our misfortunes call out some pity and not alone contempt? In spite of solemn warnings which I have lately received in the press against the monstrous idea that a presidential address should contain any individual opinions, I venture to repeat here what I had lately an opportunity of saying before a Royal Commission, that in cases where a University or University College takes in hand the preparation of engineers (and I hope that such cases will grow in number) they should provide for them special training in mathematics, and probably also in physics, distinct from the general training in these subjects most suitable for Degrees. I say this with the full knowledge that I may be accused of wishing to degrade the purity of scientific work, and, at the same time, with the full knowledge that I have no such wish. On the contrary, this special training is the only means by which the rank and file of us will ever know any mathematics at all. And I can say from my own knowledge that, if only we can be made what I may call mathematically articulate beings, we shall be able to repay the kindness by placing before the man of pure science problem after problem of transcendent difficulty, of immense interest, and having no single drawback whatever except that its solution may really be "useful"; and, after all, this need not be brought too prominently under his notice.

This digression has turned out a long one. I have only further to say that my main object in this address has been to indicate, as well as I could, the general attitude which the engineer must of necessity take up towards much of his work,—the point of view from which he must look at it. I shall be extremely glad if anything which I have said should cause this attitude, this,—this point of view,—to be more clearly kept in mind in the period of training than probably has been hitherto the case.

SECTION H.

ANTHROPOLOGY.

Opening Address by Sir W. H. Flower, K.C.B., LL.D., Sc.D., F.R.S., President of the Section.

It is not usual for the President of a Section of this Association to think it necessary to give any explanation of the nature of the subjects brought under its cognisance, or to emphasise their importance among other branches of study; but so general is the ignorance, or at all events vagueness of information, among otherwise well-instructed persons, that I will ask your permission to devote the short time accorded to me before the actual work of the Section begins to giving some account of the history and present position of the study of Anthropology in this country, and especially to indicate what this Association has done in the past, and is still doing, to promote it.

It is only ten years since the Section in which we are now taking part acquired a definite and assured position in the organisation of the Association. The subject, of course, existed long before that time, and was also recognised by the Association, though with singular vicissitudes of fortune and position. It first appeared officially in 1846, when the "Ethnological sub-Section of Section D" (then called "Zoology and Botany") was constituted. This lasted till 1851, when Geography parted company from Geology, with which it had been previously associated in Section C, and became Section E, under the title of "Geography and Ethnology." In 1866 Section D changed its name to "Biology," with Physiology and Anthropology (the first occurrence of this word in our official proceedings) as separate "Departments"; but the latter does not seem to have regained its definite footing as a branch of Biological Science until three years later (1869), when Section E, dropping Ethnology from its title, henceforward became Geography alone. The Department for the first two years (1869 and 1870) was conducted under the title of Ethnology, but in 1871 it resumed the name of Anthropology, given it in 1866, and it flourished to such an extent, attracting so many papers and such large audiences, that it was finally constituted into a distinct Section, to which the letter H was assigned, and which had its first session at the memorable meeting at Montreal, exactly ten years ago, under the fitting and auspicious presidency of Dr. E. B. Tylor.

The history of the gradual recognition of Anthropology as a distinct subject by this Association is an epitome of the history of its gradual growth, and the gradual recognition of its position among other sciences in the world at large, a process still in operation and still far from complete. Although the word Anthropology had certainly existed, but used in a different sense, it was not till well into the middle of the present century that it, or any other word, had been thought of to designate collectively the scattered fragments of various kinds of knowledge bearing upon the natural history of man, which were beginning to be collected from so many diverse sources. Indeed, as I have once before upon a similar occasion remarked, one of the great difficulties with regard to making Anthropology a special subject of study, and devoting a special organisation to its promotion, is the multifarious nature of the knowledge comprehended under the title. This very ambition, which endeavours to include such an extensive range of subjects, ramifying in all directions, illustrating and receiving light from so many other sciences, appears often to overleap itself, and give a looseness and indefiniteness to the aims of the individual or the institution proposing to cultivate it. The old term Ethnology, or the study of peoples or races, has a limited and definite meaning. It treats of the resemblances and modifications of the different groups of the human species in their relations to each other, but Anthropology, as now understood, has a far wider scope. It treats of mankind as a whole. It investigates his origin and his relations to the rest of the universe. It invokes the aid of the sciences of zoology, comparative anatomy and physiology, in its attempts to estimate the distinctions and resemblances between man and his nearest allies, and in fixing his place in the scale of living beings. In endeavouring to investigate the origin and antiquity of man, geology must lend its assistance to determine the comparative ages of the strata in which the evidences of his existence are found, and researches into his early history soon trench upon totally different branches of knowledge. In tracing the progress of the race from its most primitive condition, the characteristics of its physical structure and relations with the lower animals are soon left behind, and it is upon evidence of a kind peculiar to the human species, and by which man is so pre-eminently distinguished from all other living beings, that our conclusions mainly rest. The study of the works of our earliest known forefathers—"prehistoric archæology" as it is commonly called—is now almost a science by itself. It investigates the origin of all human culture, endeavours to trace to their common beginning the sources of our arts, customs, and history. The difficulty is, what to include and where to stop; as, though the term prehistoric may roughly indicate an artificial line between the province of the anthropologist and that which more legitimately belongs to the archæologist, the antiquary and the historian, it is perfectly evident that the studies of the one pass insensibly into those of the others. Knowledge of the origin and development of particular existing customs throws immense light upon their real nature and importance; and conversely, it is often only from a profound acquaintance with the present or comparatively modern manifestations of culture that we are able to interpret the slight indications afforded us by the scanty remains of primitive civilisation.

It is considerations such as these that have caused the gradual introduction of the term Anthropology as a substitute for Ethnology—a change which I have traced in the history of this Association, and which is seen in other organisations for the cultivation of our science.

The first general association for the study of man in this country was founded in 1843, under the name of the "Ethnological Society" (three years therefore, before the Ethnological sub-Section of Section D of this Association). It did excellent work for many years under that title, but partly from personal considerations, and partly from a desire to undertake a wider and somewhat different field of research another and in some senses a rival society, which adopted the name of "Anthropological," was founded in 1863. For some years these existed side by side, each representing in its most active supporters different schools of the science. This arrangement naturally involved a waste of strength, and it was felt that the interests of the subject would be promoted by an amalgamation of the two societies. Many difficulties, chiefly, as is usual in such cases, of a personal nature, had to be overcome, one of the principal being the selection of a name for the united society. It was generally felt that "Anthropological" would be most appropriate, but the members of the old Ethnological Society could not bring themselves absolutely to sink the fact of their priority of existence, and all that they had done for science for so many years, by merging their society into that of their younger and active rivals; so after much discussion a compromise was effected, and the new organisation which arose from the coalescence of the two societies adopted the rather cumbrous title of "Anthropological Institute of Great Britain and Ireland." This was in 1871, and since that period, the *Society*, as it is to all intents and purposes both in structure and function, has pursued a peaceful and useful course of existence, holding meetings at stated periods throughout the session, at which papers are read and subjects of interest to anthropologists exhibited and discussed. It has also published a quarterly journal, which has been the principal means in this country of communicating new information upon such subjects. The Institute has for twenty-three years performed this duty in a business-like and unostentatious manner, the only remarkable circumstance connected with its history being the singular want of interest taken by the outside world in its proceedings, considering their intrinsic importance to society, especially in an empire like ours, which more than any other affords a field for the study of man, under almost every aspect of diversity of race, climate, and culture. At the present time it numbers only 305 ordinary members, whose subscriptions afford barely sufficient means to maintain the library and journal in a state of efficiency. The kindred Geographical and Zoological Societies have respectively 3775 and 2985 fellows, so far greater is the interest taken in the surface of the earth itself, and in the animals which dwell upon it, than in its human inhabitants!

Societies similar in their object to that the history of which I have just sketched have sprung up, and are now in a more or less flourishing condition, in every civilised country of the world. But confining our retrospect to our own country, we may take a glance at what has been done in recent years to promote the organised study of Anthropology otherwise than by means of this Association (to which I shall refer again later) or the Society of which I have just spoken.

One of the most potent means of registering facts, and making them available for future study and reference, is to be found in actual collections of tangible objects. To very considerable branches of anthropological science this method of fixing the evidence upon which our knowledge of the subject is based is particularly applicable. These branches are mainly two, very distinct from each other, and each representing one of the principal sides in which Anthropology presents itself.

I. Collections illustrating the physical structure of man, and its variations in the different races.

II. Collections showing his characteristic customs and methods of living, his arts, arms and costumes, as developed under different circumstances and also modified by different racial conditions.

It is very rarely that these two are combined in one general arrangement, and they are almost always studied apart, the characteristics of mind, the general education and special training which are required for the successful cultivation of either being rarely combined in a single individual; and yet the complete history of any race of mankind, especially with regard to its relation to other races, must be based upon a knowledge both of its physical and psychical characteristics, and customs, habits, language, and tradition largely help, when anatomical characters fail to separate and define.

The anthropological museums of this country, as well as elsewhere, are all of recent growth, and they are making progress everywhere with steadily accelerating speed. This cannot be better illustrated than in the place where we are at the present time. Many of those who are now in this room can remember when the materials for the study of either branch of the subject in Oxford were absolutely non-existent. I can myself recall the time when the site of the handsome building which now houses the scientific treasures of the University was a bare field. All who know the modern history of Oxford must be aware that it was mainly owing to the enthusiastic zeal and steady perseverance in the cause of scientific education of one who is happily still among us, the veteran Regius Professor of Medicine, Sir Henry Acland, that that building was erected. The possession of a well-selected and representative collection illustrating the anatomical characters of the human species is chiefly owing to the energetic labours of Prof. Rolleston, one of the brightest and noblest of Oxford's sons, a man of whom I cannot speak without feelings of the strongest affection and most profound regret for his untimely loss to the University and the world.

The collection illustrating the arts and customs of primitive people the University owes to the ingenuity and munificence of General Pitt-Rivers, who not only provided the material on which it is based, but also the original and unique scheme of arrangement, which adds so greatly to its value as a means of education, and is so admirably calculated to awaken an interest in the subject, even in the minds of the most superficial visitor. In speaking thus of the method of displaying the Pitt-Rivers collection, I must not be supposed to imply any disparagement of others arranged on different plans. Provided there is a definite and consistent arrangement of some sort, it is well that there should be a diversity in the treatment of different collections, and for such a vast and exhaustive collection as that under the care of Sir Wollaston Franks, at the British Museum, the geographical system which has been adopted is certainly the best. In it every specimen of whatever nature at once finds a place, in which it can at any time be discovered and recognised.

In referring to our great national collection, I cannot refrain from saying that there seemed till lately to be only one element wanting to make it all that could be desired, and that was space, not only for the proper preservation and exhibition of what it already contains, but also for its inevitable future expansion. The provision in this respect was totally inadequate to do justice to the importance of the subject. Happily this consideration will be no longer a bar to the development of the collection. The provident action of the authorities of the Museum, aided by the liberality of the Duke of Bedford, and the wisdom of Her Majesty's Government, has secured for many years to come the necessary room for the expansion of the grandest of our national institutions.

More modern even than museums has been the introduction of any systematic teaching of Anthropology into this country. This is certainly most remarkable, considering that there is no nation to which the subject is of such great importance. Its importance to those who have to rule—and there are few of us now who are not called upon to bear our share of the responsibilities of government—can scarcely be over-estimated in an Empire like this, the population of which, as I have just said, is composed of examples of almost every diversity under which the human body and mind can manifest itself. The physical characteristics of race, so strongly marked in many cases, are probably always associated with equally or more diverse characteristics of temper and intellect. In fact, even when the physical divergences are weakly shown, as in the different races which contribute to make up the home portion of the Empire, the mental and moral characteristics are still most strongly marked. As the wise physician will not only study the particular kind of disease under which his patient is suffering before administering the approved remedies for such disease, but will also take into careful account the peculiar idiosyncrasy and inherited tendencies of the individual, which so greatly modify both the course of the disease and the action of remedies, so it is absolutely necessary for the statesman who would govern successfully, not to look upon human nature in the abstract and endeavour to apply universal rules, but to consider the special moral, intellectual, and social capabilities, wants, and aspirations of each particular race with which he has to deal. A form of government under which one race would live happily and prosperously may to another be the cause of unendurable misery. All these questions then should be carefully studied by those who have any share in the government of people belonging to races alien to themselves. A knowledge of their special characters and relations to one another has a more practical object than the mere satisfaction of scientific curiosity; it is a knowledge upon which the happiness and prosperity or the reverse of millions of our fellow-creatures may depend. The ignorance often shown upon these subjects, even in so select an assembly as the House of Commons, would be ludicrous if it were not liable to lead to disastrous results.

Now let us consider what, amid all the complex, diverse, and costly machinery of education in this country, is being done to satisfy the demands for such knowledge. We may say at once, as regards all institutions for primary and secondary education, absolutely nothing. The inhabitants of the various regions of our own earth are treated with no more consideration and interest in all such institutions than if they lived on the moon or the planets. We must turn straight to the higher intellectual centres in the hope of finding any anthropological teaching. Here at Oxford, if anywhere, we may expect to find it, and here, first among the British Universities, have we seen, since the year 1883, among the list of the subjects taught the word "Anthropology," but the teacher, though one of the most learned of men in the subject the country has produced, still only bears the modest title of "Reader." A professorship of Anthropology does not exist at present in the British Isles, and even here the subject, though recognised as a "special," offers little field for distinction in the examinations for degrees, and has therefore never been taken up in a thorough manner by students. Dr. Tylor's lectures must, however, have done much to have spread an intelligent interest in some branches of Anthropology, and have proved a valuable complement to the Pitt-Rivers collection, as have also the courses which have been given by Mr. Henry Balfour upon the arts of mankind and their evolution, one of which I am glad to see is announced among the advantages offered to the University Extension students at present with us. Physical Anthropology has also been taken up by Prof. A. Thomson, who, I understand, gives instructive lectures upon it, open to the members of his class of human anatomy. At the opposite end almost of the subject must be mentioned the extension and organisation of the Ashmolean Museum under the care of Mr. Arthur Evans, which has a bearing upon some branches of Anthropology, and the foundation of the Indian Institute under the auspices of Sir Monier Monier-Williams, which must give an impetus to the study of the characteristics of the races of our great Empire in the East. Last, but by no means least in its bearing upon the origin, divisions, and diffusion of races, is the world-famous linguistic work of Prof. Max Müller and Prof. Sayce, both of whom have presided over this Section at former meetings of the Association.

Of the sister University I wrote thus in 1884: "In Cambridge there are many hopeful signs. The recently appointed Professor of Anatomy, Dr. Macalister, is known to have paid much attention to Anatomical Anthropology, and has already intimated that he proposes to give instruction in it during the summer term. An Ethnological and Archæological Museum is also in progress of formation, which, if not destined to rival that of Oxford, already contains many objects of great value, and a guarantee of its good preservation and arrangement may be looked for in the appointment of Baron Anatole von Hügel as its first curator."

Ten years have passed, and it is satisfactory to know that the teaching of Anthropology has not only been fairly established, but the subject has also found a place in the scheme of University examination. The learned Professor of Human Anatomy continues to take a wide view of its functions, giving a course during the Easter term on the methods of Physical Anthropology, and also museum demonstrations on craniometry and osteometry, by the aid of a greatly increased and continually augmenting collection of specimens. Those students who take anatomy as their subject for the second part of the Natural Science Tripos have both paper work and practical examination in Anthropology, each man having a skull placed in his hands of which he is expected to make a complete diagnostic description. For the first part of the tripos each candidate has one or more questions on the broad general principles of the subject. Prof. Macalister informs me that he has always at least six men who go through a very thorough practical course with their own hands. There has also lately been established a course of lectures on the Natural History of the Races of Man, delivered during the Michaelmas and Lent terms by Dr. Hickson, of Downing College, and Baron von Hügel gives a course of museum demonstrations on the weapons, ornaments, and other objects in the Ethnological Museum, which is open to all students, and of which many take advantage.

In London, owing to the chaotic condition of all forms of higher instruction, which has been brought so prominently into notice by the universal demand for a teaching University (an aspiration which the labours of the late Gresham Commission certainly seem to have brought nearer to realisation than ever appeared possible before), all systematic anthropological teaching has been entirely neglected. The great collections to which I have already alluded, that of arts and customs at the British Museum, and that of osteological specimens at the Royal College of Surgeons, have by their steady augmentation done valuable service in preserving a vast quantity of material for future investigation and instruction, and students have at present all reasonable facilities for pursuing their own researches in them. Lectures have never formed any part of the official programme of the British Museum, but at the College of Surgeons it is otherwise, and though the contents of the collections are specially indicated as the subject on which they should be delivered, for the last ten years at least, Anthropology, notwithstanding the magnificent material at hand for its illustration, has had no place in the annual syllabus. It is also entirely ignored in the examination scheme of the University of London, an institution which prides itself as being on a level with modern educational requirements; and the managers of the new Imperial Institute, casting about in all directions for some worthy object to occupy their energies and their spacious buildings, do not appear to have taken into serious consideration the value to the world and the appropriateness to their original design of a great central school of Anthropology, from which might emanate a full and satisfying knowledge of the characteristics of all the various races of which the Empire is composed.

In Scotland the recent Universities Commission has recognised Physical Anthropology as a branch of human anatomy in their scheme for graduation in pure science, the examination on this subject embracing a knowledge of race characters as found in the skull and other parts of the skeleton, in the skin, eyes, hair, features, and the external configuration of the body generally; the methods of anthropometrical measurement, both of the living body and the skeleton; the possible influence of use and of external surroundings in producing modifications in the physical characters of man, and an acquaintance with the "types" of mankind and the structural relations of man to the higher mammals. These regulations came into operation in the University of Edinburgh in 1892, and in accordance with them Prof. Sir William Turner delivers a special course of twenty-five lectures on Physical Anthropology, and in addition ten practical demonstrations on osteometry. The museum under his charge has greatly increased of late in number and value of the specimens. But "Human Anatomy, including Anthropology," being only one of a series of nine subjects in any three or more of which a final science examination on a higher standard has to be passed, there is not at present any considerable number of students who take it up, and the other Scotch Universities have not yet thought it necessary to establish distinct courses of Physical Anthropology, although it is becoming more and more a regular part of the anatomical teaching to advanced students.

For the following account of what is being done to further the knowledge of our subject in the sister isle I am indebted to Prof. D. J. Cunningham. The only place in Ireland where anthropological work is done is Trinity College. For many years those in charge of the museum have been collecting skulls, and they were fortunate in obtaining the greater part of Sir William Wilde's collection. To these great additions have been recently made, principally in the form of Irish crania from different districts. All the anthropological specimens are lodged in one large room, which is also used as an anthropometric laboratory. Though there has never been any systematic teaching of Anthropology in Trinity College, Dr. C. R. Browne (Prof. Cunningham's able assistant), who takes charge of the laboratory, attends for two hours on three days a week, and gives demonstrations in anthropological methods to any students who are interested in the subject. The laboratory was opened in June 1891, the instruments being provided by a grant from the Royal Irish Academy, and about 500 individuals have already been measured, the greater number of them students of the College. This is, however, only part of the work carried out by the laboratory. Every year the instruments are taken to some selected district in Ireland, and a systematic study of the inhabitants is made. The Aran Islands, and also the islands of Inishboffin and Inishshark, have been already worked out, and this year excursions are organised to Kerry, to a district in Wicklow, and to another in the west of Ireland. The Academy makes yearly grants to the Committee for carrying on this work, the results of which have been published in admirable memoirs by Prof. A. C. Haddon and Dr. C. R.

Browne. The Science and Art Museum in Dublin, under the direction of Dr. V. Ball, contains a small collection, arranged with a view to general instruction, showing by means of skulls and casts the physical characteristics of the different races of man, those of each race being explained by a short printed label, and its range shown on a map.

Though the development of anthropological science has thus not been greatly advanced, in this country at least, by means of endowments, or by aid of the State or, till very recently, by our great scholastic institutions, but has been mainly left to the unorganised efforts of amateurs of the subject, its progress in recent years has been undeniably great. I will give an instance of the strides that have been made in one of its most important branches.

Physical or Anatomical Anthropology, or the study of the modifications of the human body under its various aspects, the modifications dependent upon sex and age, the modifications dependent upon race, and those dependent upon individual variability, studied not many years ago in a vague and loose manner, has gradually submitted to a rigorous and, therefore, strictly scientific method of treatment. The generalities which were formerly used to express the differences that were recognised between the various subjects compared with each other have been replaced by terms conveyed in almost mathematical precision. No one acquainted with the history of the development of this branch of Anthropology can fail to recognise how much it was accelerated by the genius of Broca, and the school which he established in France, although all cultivated nations are now vying with each other in the practice of exactitude in anthropological research, and the time seems rapidly approaching when a common agreement will be arrived at, by which all the observations which may be made, under whatever diverse circumstances, and by whatever different individuals, will be available for comparison one with another.

This branch of our science has received the name of "Anthropometry." Although, as the name implies, measurement is one of its principal features, it includes such other methods of comparison as can be reduced to a definite standard, or to which definite tests can be applied, such as the colour of the hair, eyes, and complexion, the form of the ear and nose. The great desiderata that have been sought for, and gradually attained, in measuring either the skeleton or the living person have been two in number: (1) Exact definition of the points between which the measurements should be taken. (2) Exact methods and instruments of measurement. In both these cases the object looked for has been not only that the measurements taken by the same observer at different times and under different circumstances should coincide, but also that those taken by different observers should be comparable. These requirements seem so simple and natural at first sight that the majority of persons whom I am addressing will wonder that I should allude to them. Only those who are seriously occupied, or perhaps I should rather say, only those who were seriously occupied a few years ago, with the endeavour to solve these problems can have any idea of their difficulty. The amount of time and labour that has been spent upon them is enormous, but the result has, I think, been quite commensurate with it.

We have attained at last to methods of measurement and standards of comparison which, in the hands of persons of ordinary intelligence, and with a moderate amount of training, will give data which may be absolutely depended upon. From these we hope to be able to formulate accurate information as to the physical conformation of all the groups into which mankind is divided, and so gradually to arrive at a natural classification of those groups, and a knowledge of their affinities one to another.

But the exact methods of modern Anthropometry are not only important on account of the aid they give in studying the race characteristics of man. As has so often happened when scientific observation has been primarily carried out for its own sake, it ultimately leads to practical applications undreamt of by its earlier cultivators. The application of Anthropometry not to the comparison of races, but to elucidate various social problems —as the laws of growth, of heredity, of comparative capacities of individuals within a community, and the effects of different kinds of education and occupation, as worked out first by Quetelet in Belgium, and subsequently by Francis Galton, Roberts, and others in this country, and its still more concrete application as an aid in administering justice by methods perfected by Bertillon in France—are striking illustrations of the practical utility of labours originally undertaken under the influence of devotion to science pure and simple.

The importance of being able to determine the identity of an individual under whatever circumstances of disguise he may be presented for examination has, of course, long been apparent to all who have had anything to do with the administration of the criminal law, and rough and ready methods of recognition, depending mainly upon the more or less acute faculty of perception and recollection of differences and resemblances, possessed by the persons upon whom the duty of identification has devolved, have long been in operation. The general conformation, height, form of features, and colour of complexion, hair, and eyes, have also been noted. Much additional assistance has been obtained by the registration of definite physical characteristics, the results either of natural conformation, or of injury, such as mutilations, tattoo-marks, and scars, inflicted by accident or design. The application of one of the most important scientific discoveries of the age, photography, was eagerly seized upon as a remedy for the difficulties hitherto met with in tracing personal identity, and enormous numbers of photographs were taken of persons, the peculiarities of whose career led them to fall into the hands of the police, and who were likely to be wanted again on some future occasion. No doubt much help has been derived from this source, but also much embarrassment. Even among photographic portraits of one's own personal friends, taken under most favourable circumstances, and with no intention of deception, we cannot often help exclaiming how unlike they are to the person represented. With portraits of criminals, the varying expression of the face, changes in the mode of wearing the hair and beard, differences of costume, the effects of a long lapse of time, years perhaps passed in degradation and misery, may make such alterations that recognition becomes a matter at least of uncertainty. That photographs are extremely valuable as aids to identification, when their true position in the process is recognised, cannot be doubted, but as a primary method they have been found to be quite inapplicable, owing partly to the causes just indicated, but mainly to the difficulty, if not impossibility, of classifying them. The enormous expenditure of time and trouble that must be consumed in making the comparison between any suspected person and the various portraits of the stock which accumulates in prison bureaus may be judged of from the fact that, in Paris alone, upwards of 100,000 such portraits of persons interesting to the police have been taken in a period of ten years.

The primary desideratum in a system of identification is a ready means of classifying the data upon which it is based. To accomplish this is the aim of the Bertillon system. Exact measurements are taken between certain well-known and fixed points of the bony framework of the body, which are known not to change under different conditions of life. The length and breadth of the head, the length of the middle finger, the length of the foot, and the length of the forearm, are considered the best, though others are added for greater certainty, as the height, span of arms, length of ear, colour of eyes, &c. All these particulars of every individual examined are recorded upon a card, and by dividing each measurement into three classes, long, medium, and short, and by classifying the various combinations thus obtained, the whole mass of cards, kept arranged in drawers in the central bureau, is divided up into groups, each containing a comparatively small number, and therefore quite easily dealt with. When the card of a new prisoner is brought in, a few minutes suffice to eliminate the necessity of comparison with any but one small batch, which presents the special combination. Then photographs and other means of recognition, as distinctive marks and form of features, are brought into play, and identification becomes a matter of certainty. On the other hand, if the combination of measurements upon a new card does not coincide with any in the classed collection in the bureau, it is known with absolute certainty that the individual being dealt with has never been measured before.

One of the most striking results of the introduction of this system into France has been that, since it has been brought fully into operation, a large proportion of old offenders, knowing that concealment is hopeless, admit their identity at once, and save a world of trouble and expense to the police by ceasing to endeavour to conceal themselves under false names.

Various representations upon this subject have been addressed to the Home Secretary of our own Government during the last few years, and among others one from the Council of this Association, which originated in a resolution of this Section, adopted by the General Committee at the meeting at Edinburgh in 1892, to this effect:

"That the Council be requested to draw the attention of Her Majesty's Government to the Anthropometric Method for the measurement of criminals, which is successfully in operation in France, Austria, and other continental countries, and which has been found effective in the identification of habitual criminals, and consequently the prevention and repression of crime."

In consequence of these representations a Committee was appointed, on October 21, 1893, by Mr. Asquith, consisting of Mr. C. E. Troup, of the Home Office; Major Arthur Griffiths, Inspector of Prisons; and Mr. Melville Leslie Macnaghten, Chief Constable in the Metropolitan Police Force; with Mr. H. B. Simpson, of the Home Office, as Secretary, "to inquire (*a*) into the method of registering and identifying habitual criminals now in use in England; (*b*) into the 'Anthropometric' system of classified registration and identification in use in France and other countries; (*c*) into the suggested system of identification by means of a record of finger marks: to report whether the anthropometric system or the finger-mark system can with advantage be adopted in England either in substitution for or to supplement the existing methods; and, if so, what arrangements should be adopted for putting them into practice, and what rules should be made under Section 8 of the Penal Servitude Act, 1891, for the photographing and measuring of prisoners."

The Report of this Committee, with minutes of evidence and appendices, was issued as a Parliamentary Blue-book in March last, and not only contains a lucid and concise description of the methods of identification already in use in this country, but also most striking testimony from impartial but well-qualified persons to the value of a more scientific mode of dealing with the subject. No pains seem to have been spared to obtain, both by personal observation and by the examination of competent witnesses, a thorough knowledge of the advantages of the Bertillon system as practised in France, and the result has been the recommendation of that system, with certain modifications, for adoption in this country, with the addition of the remarkably simple, ingenious, and certain method of personal identification first used in India by Sir William Herschel, but fully elaborated in this country by Mr. Francis Galton, that called the "finger-mark system," about which I shall have a few more words to say presently.

With the concluding words of the Committee's Report I most fully concur: "We may confidently anticipate that, if fairly tried, it will show very satisfactory results within a few years in the metropolis; but the success of its application in the country generally will depend on the voluntary co-operation of the independent county and borough police forces. This, we feel sure, will not be withheld. When the principles of the system are understood and its usefulness appreciated we believe it will not only save much time and labour to the police in the performance of an important duty, but will give them material assistance in tracing and detecting the antecedents of the guilty, and will afford, so far as its scope extends, an absolute safeguard to the innocent."

It is very satisfactory to be able to add that in the House of Commons on June 26, in answer to a question from Colonel Howard Vincent, the Home Secretary announced that the recommendations of the Committee have been adopted; and that, in order to facilitate research into the judicial antecedents of international criminals, the registers of measurements would be kept on the same plan as that adopted with such success in France, and also in other continental countries.

I have just mentioned the "finger-mark system" and of all the various developments of Anthropology in recent times none appears to be more interesting than the work done by Mr. Galton upon this subject; for though, as indicated above, he is not quite the first who has looked into the question or shown its practical application in personal identification, he has carried his work upon it far beyond that of any of his predecessors, both in its practical application and into regions of speculation unthought of by anyone else. Simple and insignificant as in the eyes of all the world are the little ridges and furrows which mark the skin of the under-surface of our fingers, existing in every man, woman, and child born into the world, they have been practically unnoticed by everyone until Mr. Galton has shown, by a detailed and persevering study of their peculiarities, that they are full of significance, and amply repay the pains and time spent upon their study. It is not to be supposed that all the knowledge that may be obtained from a minute examination of them is yet by any means exhausted, but they have already given important data for the study of such subjects as variation unaffected by natural or any other known form of selection, and the difficult problems of heredity, in addition to their being one of the most valuable means hitherto discovered of fixing personal identity.

As an example of the importance of some ready method to prove identity, apart from its application to the detection, punishment, and prevention of crime, to which I have already referred, I may recall to your recollection that remarkable trial which agitated the length and breadth of the land rather more than twenty years ago; a trial which occupied so many months of the precious time of our most eminent judges and counsel, and cost the country, as well as several innocent persons—I am afraid to say how many—thousands of pounds, all upon an issue which might have been settled in two minutes if Roger Tichborne, before starting on his voyage, had but taken the trouble to imprint his thumb upon a piece of blackened paper. It is wonderful to me, on reading again the reports of the trial, to see how comparatively little attention was paid by counsel, judge or jury, to the extremely different physical characteristics of the two persons claimed to be identical, but which were so strongly marked that they ought to have disposed of the claim, without any hesitation, at the very opening of the case. It was not until the 102nd day of the first trial that the attention of the jury was pointedly called to the fact that it was known that Sir Roger Tichborne had been tattooed on the left arm with a cross, anchor, and a heart, and that the Claimant exhibited no such marks. When this was clearly brought out and proved, the case broke down at once. The second trial for perjury occupied the court 188 days, the Lord Chief Justice's charge alone lasting eight days. The issues were, however, more complex than in the first trial, as it was not only necessary to prove that the Claimant was not Tichborne, but also to show that he was someone else. I feel convinced that at the present time the greater confidence that is reposed in the methods of Anthropometry or close observance of physical characters, and in the persistence of such characters through life, would have greatly simplified the whole case; and I would strongly recommend all who have nothing about their lives they think it expedient to conceal to place themselves under the hands of Mr. Galton, or one of his now numerous disciples, and get an accurate and unimpeachable register of all those characteristics which will make loss of identity at any future period a sheer impossibility.

Partly with this object in view, the Association has, for several years past, during each of its meetings, opened, under the superintendence of Dr. Garson, an Anthropometric Laboratory, on the plan of the admirable institution of the same name which has been carried on in the South Kensington Museum since the beginning of the year 1888, under the direction and at the sole cost of Mr. Francis Galton, in which up to the present time more than 7000 complete sets of measurements have been made and recorded. The results obtained at the British Association meetings have been published in the Annual Reports of the Association, and though on a smaller scale than Mr. Galton's, the operations of the laboratory have been most useful in diffusing a knowledge of the value of anthropometric work, and of the methods by which it is carried on.

For many years an "Anthropometric" Committee of the Association, in which the late Dr. W. Farr, Mr. F. Galton, Mr. C. Roberts, Dr. Beddoe, Sir Rawson Rawson, and others, took an active part, was engaged in collecting statistical information relating to the physical characters, including stature, weight, chest-girth, colour of eyes and hair, strength of arms, &c., of the inhabitants of the British Isles; and their reports, illustrated by maps and diagrams, were published in the annual volume issued by the Association. This Committee terminated its labours in 1883, although, as was fully acknowledged in the concluding report, the subject was by no means completely exhausted.

A great and important work which the Association has now in hand, in some sense a continuation of that of the Anthropometric Committee, though with a more extended scope of operation, is the organisation of a complete ethnographical survey of the United Kingdom based upon scientific principles. In this work the Association has the co-operation of the Society of Antiquaries of London, the Folk-lore Society, the Dialect Society, and the Anthropological Institute. Representatives of these different bodies have been formed into a committee, of which Mr. E. W. Brabrook is now chairman. It is proposed to record in a systematic and uniform character for certain typical villages and the neighbouring districts (1) the physical types of the inhabitants, (2) their current traditions and beliefs, (3) peculiarities of dialect, (4) monumental and other remains of ancient culture, and (5) historical evidence as to continuity of race. The numerous corresponding societies of the Association scattered over various parts of the country have been invited to co-operate, and the greater number of them have cordially responded, and special local committees have been formed in many places to carry out the work.

The result of a preliminary inquiry as to the places in the United Kingdom which appeared especially to deserve ethnographic study, mainly on account of the stationary nature of the population for many generations back, was given in the first Report of the Committee presented at the Nottingham meeting of the Association last year, in which it was shown that in the British Isles there are more than 250 places which, in the opinion of competent authorities, would be suitable for ethnographic survey, and in which, notwithstanding the rapid changes which have taken place during the last fifty years in all parts of the country, much valuable material remains for the committee to work upon. Without doubt, as interest in the subject is aroused, this number will be greatly increased.

A most important step in securing the essential condition that the information obtained should be of the nature really required for the purpose, and that the records of different observers should be as far as possible of equal value and comparable one with another, has been the compilation of a very elaborate and carefully prepared schedule of questions and directions for distribution among those who have signified their willingness to assist, and as a guarantee that the answers obtained to the questions in the schedules will be utilised to the fullest extent, certain members of the committee specially qualified for each branch of the work have undertaken to examine and digest the reports when received.

It may be remarked in passing that the Anthropological Society of Paris has within the past year formed a Commission of its members to collect in a systematic manner the scattered data which, when united and digested, shall form "une anthropologie véritablement nationale de la France," and has issued a circular with schedules of the required observations. These are, however, at present limited to the physical characters of the population.

Among the many services rendered to the science of Anthropology by the British Association, not the least has been the aid it has afforded in the publication of that most useful little manual entitled "Notes and Queries on Anthropology," of which the first edition was brought out exactly twenty years ago (1874), under the supervision and partly at the expense of General Pitt-Rivers. Since that time the subject has made such great advances that a second edition, brought up to the requirements of the present time, was urgently called for. A Committee of the British Association, appointed to consider and report upon the best means of doing this, recommended that the work should be placed in the hands of the Anthropological Institute of Great Britain and Ireland. This recommendation was approved by the Association, and grants amounting to £70 were made to assist in defraying the cost of publication. The council of the Anthropological Institute appointed a committee of its members to undertake the revision of the different subjects, with Dr. J. G. Garson and Mr. C. H. Read as editors respectively of the two parts into which it is divided. The work was published at the end of the year 1892, and is invaluable to the traveller or investigator in pointing out the most important subjects of inquiry, and in directing the observations he may have the means of making into a methodical and systematic channel.

Besides those I have already mentioned, the Association has aided many other anthropological investigations by the appointment of committees to carry them out, and in some cases by the more substantial methods of giving grants from its funds, and by defraying the cost of publication of the results in its journal. Among these I may specially mention the series of very valuable reports upon the physical characters, languages, and industrial and social condition of the north-western tribes of the Dominion of Canada, drawn up by Mr. Horatio Hale, Dr. F. Boas, and others, the importance of which has been recognised by the Canadian Government in the form of a grant in aid of the expenses.

Another very interesting investigation into the habits, customs, physical characteristics, and religion of the natives of Northern India, initiated by Mr. H. H. Risley, and carried on under his supervision by the Indian Government, though it has received little more than moral support from the Association, may be mentioned here on account of the illustration it affords of the value of exact anthropometric methods in distinguishing groups of men. Although a practised eye can frequently tell at a glance the tribe or caste of a man brought before it for the first time, the special characters upon which the opinion is based have only lately been reduced to any definite and easily comparable method of description. In Mr. Risley's examination, the nose, for instance (which I have always held to be one of the most important of features for classificatory purposes), instead of being vaguely described as broad or narrow, is accurately measured, and the proportion of the greatest width to the length (from above downwards), or the "nasal index," as it is termed (though it must not be confounded with the nasal index as defined by Broca upon the skull), gives a figure by which the main elements of the composition of this feature in any individual may be accurately described. The average of mean nasal indices of a large number of individuals of any race, tribe, or caste offer means of comparison which bring out most interesting results. By this character alone the Dravidian tribes of India are easily separated from the Aryan. "Even more striking is the curiously close correspondence between the gradations of racial type indicated by the nasal index and certain of the social data ascertained by independent inquiry. If we take a series of castes in Bengal, Behar, or the North-Western Provinces, and arrange them in the order of the average nasal index, so that the caste with the finest nose shall be at the top, and that with the coarsest at the bottom of the list, it will be found that this order substantially corresponds with the accepted order of social precedence. The casteless tribes—Kols, Korwas, Mundas, and the like—who have not yet entered the Brahmanical system, occupy the lowest place in both series. Then come the vermin-eating Musuhars and the leather-dressing Chamárs. The fisher castes of Bauri, Bind, and Kewat are a trifle higher in the scale; the pastoral Goala, the cultivating Kurmi, and a group of cognate castes—from whose hands a Brahman may take water—follow in due order; and from them we pass to the trading Khatris, the landholding Bábhans, and the upper crust of Hindu society. Thus, it is scarcely a paradox to lay down as a law of the caste organisation in Eastern India that a man's social status varies in inverse ratio to the width of his nose." The results already obtained by this method of observation have been so important and interesting that it is greatly to be hoped that the inquiry may be extended throughout the remainder of our Indian Empire.

But for want of time I might here refer to the valuable work done in relation to the natives of the Andaman Islands, a race in many respects of most exceptional interest, first by Mr. E. H. Man, and more recently by Mr. M. V. Portman, and for the same reason can scarcely glance at the great progress that is being made in anthropological research in other countries than our own. The numerous workers on this subject in the United States of America are, with great assistance from the Government, very properly devoting themselves to exploring, collecting, and publishing, in a systematic and exhaustive manner, every fact that can still be discovered relating to the history, language, and characters of the aboriginal population of their own land. They have in this a clear duty set before them, and they are doing it in splendid style. I wish we could say that the same has been done with all the native populations in various parts of the world which have been, to use a current phrase, "disestablished and disendowed" by our own countrymen. We are, however, now, as I have shown, not altogether unmindful of what is our duty to posterity in this respect; a duty, perhaps, more urgent than that of any other branch of scientific investigation, as it will not wait. It must be done, if ever, before the rapid spread of civilised man all over the world, one of the most remarkable characteristics of the age in which we live, has obliterated what still remains of the original customs, arts, and beliefs of primitive races; if, indeed, it has not succeeded—as it too often does—in obliterating the races themselves.

NOTES.

THE death is announced of Prof. Rudolph Weber, Berlin, at the age of sixty-five, and of Prof. M. P. J. Rollet, of Lyons Observatory, a correspondent in the Médecine et Chirurgie Section of the Paris Academy of Sciences.

THE University of Halle, on the occasion of the recent bi-centenary celebrations, conferred the honorary degree of Ph.D. upon Prof. Victor Horsley, F.R.S.; Mr. F. G. Kenyon and Mr. H. L. D. Ward, both of the British Museum; Mr. G. A. Grierson, and Prof. W. W. Skeat.

A REUTER telegram reports that Mr. Aagaard, the United States Consular Agent at Tromsö, has despatched Captain Bottolfsen on board the fast-sailing cutter *Malygen* to Spitzbergen with a supply of provisions and clothing for the Wellman Expedition, for which the *Malygen* will search, and which, if possible, it will take back to Tromsö.

THE President of the Photographic Society of Great Britain has received a communication from the Secretary of State to the effect that the Queen has given her consent to the proposal to call the Society "The Royal Photographic Society of Great Britain."

HERR OTTO LILLENTHAL, whose aërial excursions were described in these columns a short time ago, recently met with a serious accident. The wings of his flying machine collapsed while he was at an altitude of about two hundred feet, causing him to fall to the ground. His fall was broken to some extent, but he was badly injured.

AN earthquake disturbance is reported to have occurred at Aci Reale, Sicily, shortly before six o'clock on the morning of August 8. Great damage was done at Zafarana, where six persons were killed and several injured. Both there and at Aci San Antonio, nearly all the houses have fallen in. Slight shocks were felt in Catania and several other communes in the neighbourhood of Mount Etna, but no damage was done.

THE *Times* correspondent at Calcutta, writing on August 12, reports that the Gohna Lake rose 24 ft. 6 in. last week, and is now within 57 ft. of the top of the dam. Its full length is now 4½ miles, the average width being half a mile. The greatest depth is 720 ft. The percolation is very heavy. This, combined with heavy rain, has washed away a large portion of the lower part of the dam, leaving an almost perpendicular drop of 400 ft. The section thus displayed shows a layer of boulders on the top, below which is pulverised rock. The lake is expected to overflow within fifteen days.

WE learn that the arrangements have now been completed for the fourteenth congress and exhibition of the Sanitary Institute, to be held in Liverpool near the end of next month. On Monday, September 24, the Lord Mayor of Liverpool will receive members at the Town-hall, and the President, Sir F. S. Powell, M.P., will deliver the inaugural address in the large theatre of University College; while in the evening the Lord Mayor will formally open the exhibition. Next day there will be conferences in University College on a variety of subjects. In the conference on "Domestic Hygiene," the Lady Mayoress will preside, and the ladies will afterwards hold a reception. At night Dr. G. B. Longstaff lectures at University College. On September 26, Section I., "Sanitary Science and Preventive Medicine," meet under the presidency of Dr. Klein, in the college, and the discussion will be continued next day. The Lord Mayor gives a reception in the Walker Art Gallery on Wednesday evening. Section II., "Engineering and Architecture," meets on Thursday, and the discussions will be continued on the following day, when also Section III., "Chemistry, Meteorology, and Geology," meet under the presidency of Dr. T. Stevenson. The closing general meeting of the congress takes place in the college on Friday evening, September 28, and later, Sir James Crichton Browne will address the working classes in the Picton Lecture-hall. The exhibition will remain open three weeks.

THE tenth meeting of the International Congress of Americanists was held at Stockholm, August 3–8, and was attended by the President, Dr. Rudolph Virchow, Baron Nordenskiöld, Mrs. Zelia Nuttall (of Dresden), M. Charnay, and Dr. Robert Munro, among others. Prof. Gustav Retzius, M. E. W. Dahlgren, and M. O. Montelius were some of the members of an influential executive committee, of which M. Carl Bovallius acted as general secretary. H.M. the King of Sweden, with S.A. the Crown Prince, attended the morning sitting on August 6, and heard the following communications read:—"Recent Finds from South American Tombs," by Dr. R. Virchow; "The Cliff Dwellers," by M. Charnay; and "Remarks on the Calendar System of the Ancient Mexicans," by Mrs. Zelia Nuttall. This lady paid a graceful tribute to the memory of that ardent "Americanist," the late Mrs. Hemmenway, of Boston, whose death was a sad loss to the cause of American archæology, and gave a summary in French of the chief results of her own investigations on the calendar system of the ancient Mexicans. Her paper on this subject was printed in English for distribution among the members of the Congress. The same evening the King gave a *fête* to the members of the Congress at the Palace of Drottningholm, and proposed the toast of "The Americanist Congress" at supper, to which Dr. Virchow suitably replied.

THE letter on a recent change in the character of April, which appeared in our issue of July 12, has led Dr. O. Z. Bianco to examine the meteorological statistics of Turin for evidence of a similar variation. By tabulating the values of the mean temperature in April at that place since 1865, and smoothing them in averages of five, he finds that, in the thirty years considered, the lowest average temperature occurred in 1889 at Turin as well as at Greenwich. The temperature appears to have gradually fallen to this minimum since 1865, and is now rising. If the results of observations are represented diagrammatically, a figure is obtained which agrees very closely with that accompanying the letter to which we have referred. Taking simply the monthly mean temperature in different years, the lowest values belong to 1879 and 1891, and are 10°·1 C. and 10°·2 C. respectively. For Greenwich the corresponding point was a temperature of 43·5° F. (6°·4 C.) in 1879 and 1888. In the latter year the mean temperature of April in Turin was 10°·8 C., which is nearly a degree below the normal value. Further inquiry may perhaps lead to an explanation of the change to which attention has been directed.

WE have received the first four numbers of a series of Electrical Engineering Leaflets by Prof. E. J. Houston and Mr. A. E. Kennelly, which are being issued in weekly parts. These leaflets are divided into three grades: elementary, which is suited for the use of electrical artisans, wiremen, and elementary students; intermediate, suited to students in technical schools; and advanced, suited to students taking a course in electrical engineering. Although, to judge from the four first numbers, these leaflets will be hardly suitable to form by themselves a complete text-book in this subject, since the points treated are of too wide a scope to admit of sufficient detail and explanation being given in the moderate size of the work (some 300 pages small octavo) to ensure a student, without some other source of information, being able to grasp the subject. They will, however, be found very useful as a book of reference, and for revising and keeping fresh information which has already been acquired, forming as they do a compact and clearly expressed synopsis of the subject. Another useful feature in the numbers under consideration are tables of physical quantities, such as the electromotive force of different cells, specific resistance of solids and liquids, the temperature coefficient being in most cases given as well as the temperature at which the value of the resistance given is measured, together with the observer's name. An elaborate scheme of prefixes used to denote multiples and submultiples of the different units is given, which, as long as the scheme is printed on the opposite page to the table in which these prefixes are used, saves a good deal of space, but will probably cause a great deal of unnecessary confusion if they are used in other parts of the work, unless the value is in every case also given in the index notation.

IN a short communication, made to the French Academy of Science, M. Moureaux says that on examining the magnetograph records of the Parc Saint-Maur Observatory for the night of July 11-12, he finds a disturbance which corresponds in time with the earthquake shock that caused so much destruction at Constantinople. As M. Moureaux has taken the precaution to have non-magnetic copper bars suspended alongside the magnetograph needles, and the records from these bars show no disturbance, it is evident that the effects observed were due to magnetic causes, and not to a mechanical shock. As the magnetic disturbance occurred sixteen minutes before the time at which the earthquake shock was felt at Constantinople, and since the two places are separated by a distance of 3000 kilometres, it would appear that the disturbance travelled at the rate of only three kilometres per second. This is certainly a very slow rate of propagation, and it would be of great interest if the observers at other observatories where a permanent magnetic record is kept, were to examine their curves, and see whether they show a similar disturbance, and if so, if the rate of propagation is about the same as the above. If the values obtained vary much, it is probable that the disturbance noted by M. Moureaux was of solar rather than of terrestrial origin, or at any rate was not connected with the earthquake at Constantinople.

ANYTHING respecting Corea is of special interest at the present time, and the short article on the "Cultivation of Cotton" in that little-known country, which a recent number of the *Journal of the Society of Arts* contains, is certain to have many readers. According to this article, which is based upon a report of the Commissioner of Corean Customs at Fusan, the total area under the cultivation of cotton in Corea is roughly computed to be 872,000 acres, the yield of seed cotton from which per annum is put at 1,200,000,000 lbs. The yearly consumption of "cleaned" or raw cotton is estimated at 300,000,000 lbs. The Corean fibre is reported to be superior to that produced in Japan. The method of cultivation is as follows:—The ground is usually ploughed up during the early winter, and allowed to remain in this condition until the frost is well out of it, when it is broken up with a hoe, and manure, mixed with wood ashes, spread over it. The fields are now ready for the reception of the seed, which is generally sown about April to May. The seed, of which there is but one kind, is not placed in drills, as is done in Japan, but is sown broadcast, and then trodden in and covered up with the feet, sesamum seed being very often sown in the same field with it. The young shoot shows above ground about the tenth day, and at maturity attains a height of from 2 feet to 2½ feet. The plant blossoms in August, and on an average bears forty pods, each containing four cells, as a rule within a double capsule. The gathering of the crop, which begins about October, continues until frosts sets in, some time in November. No attention is paid or skill displayed in the cultivation once the seed is in the ground; everything is then left to nature. No further manure is added, nor are they ever thinned out or given water in times of drought. The crops are principally gathered by women, who also are largely employed afterwards in separating the seed.

DURING the last few years, alloys of tin and lead have been employed in manufactures in which the constancy of melting points after successive meltings played an important part. Rudberg, one of the earliest workers in this field, noticed that the thermometer stopped at two points during the solidification of these alloys; the higher point varied with their composition, while the lower was constant, being about 187°, and was identical with the melting point of the "chemical alloy" represented by the formula $PbSn_3$. In the current number of *Wiedemann's Annalen*, Bernhard Wiesengrund gives the results of a complete series of experiments with tin-lead alloys ranging from $PbSn_{12}$ to $Pb_{12}Sn$. They were melted in a crucible of sheet iron covered with a lid provided with two brass tubes to admit and withdraw dry hydrogen during heating. An iron tube closed at the bottom was attached to the lid. It dipped into the alloy, and served to contain the thermometer, the bulb of which was surrounded by mercury. The thermometer was graduated from 0° to 360° C., and contained nitrogen above the mercury column. The crucible was surrounded by a sheet-iron water-jacket kept at 150° C., and the heating was done by means of a triple Bunsen burner. As regards the densities of the alloys, it was found that they were all lighter than might have been expected from the densities of their constituents. This increase of volume was greatest in the case of the "chemical alloy" $PbSn_3$, and decreased as one or the other constituent preponderated. The process of solidification showed Rudberg's two points distinctly. The higher one, called the melting point, was really a point at which the cooling became somewhat less rapid. The lower, called the point of solidification, was a truly stationary point, except in the alloys containing much lead. The most regular curve of cooling is shown by the alloy $PbSn_3$. At about 178° there is a dead stop lasting for seven minutes, not preceded by a perceptible stop at the melting point. The latter becomes more pronounced as the percentage of tin increases, and appears as a point of inflexion in the alloy $PbSn_{12}$. As the lead is increased, the melting point rises, the point of solidification falls slightly and becomes less pronounced, and all breaks in the curve of cooling tend to disappear. The author gives a plausible explanation of the phenomena analogous to the theory of saline solutions, tin being regarded as the solvent. After twenty-four successive remeltings a mechanical rearrangement was observed, producing a slight elevation of the fusing point and an approximation of the point of solidification to that of the "chemical alloy." This was due to the excess of the heavy lead, or the light tin gradually separating out from the alloy $PbSn_3$.

THE *Transactions and Proceedings* of the New Zealand Institute (vol. xxvi.), containing papers read before the Institute during 1893, has been published, and is obtainable from Messrs. Trübner and Co.

THE *Quarterly Journal* of the Geological Society (No. 199, August) has been issued. It contains five plates, illustrating papers by Mr. A. Harker, Mr. W. W. Watts, Mr. Frank Rutley, and Sir J. W. Dawson and Dr. W. Hind.

THE August number of the *Journal* of the Royal Microscopical Society is almost entirely taken up with summaries of current researches. The only two papers are by Mr. F. Chapman and Mr. T. Comber, the former dealing with the foraminifera of the gault of Folkestone, and the latter with the characters generally accepted for specific diagnosis in the Diatomaceæ.

THE Romanes Lecture on "The Effect of External Influences upon Development," delivered by Prof. Weismann, at Oxford, last May, and reported in these columns (vol. l. p. 31) has been published in English by the Clarendon Press. The translation has been done by Mr. Gregg Wilson. In the preface, Prof. Weismann adds his tribute to the many that have been paid to the memory of the late Dr. Romanes.

MESSRS. J. AND A. CHURCHILL will shortly publish a new edition of Dr. F. Kohlrausch's indispensable handbook to practical physics—"An Introduction to Physical Measurements." The edition has been translated from the seventh German edition, published in 1892, and it contains nearly four times the number of pages that the first one did in 1869. Mr. T. H. Waller and Mr. H. R. Procter are the translators.

GLACIAL action in Australasia has much attention devoted to it in the *Proceedings* of the Royal Society of Tasmania for 1893. Mr. R. M. Johnston contributes an elaborate review of the evidences of former glaciation in Australasia, with critical observations upon the principal hypotheses which have been advanced to account for glacial epochs generally, and there are several papers on the discovery of glacial action in Tasmania.

IN the current number of *Mind*, Mr. Francis Galton contributes an article on "Discontinuity in Evolution," which should be read by all who are interested in modern biological theory. It owes its origin to the publication of Mr. Bateson's recent work, and contains a summary of the views on discontinuous or "transilent" variation and on "organic stability," which Mr. Galton has published in "Natural Inheritance," in "Finger Prints," and in the preface to a reprint of "Hereditary Genius." The data on which these views are based lie somewhat off the beaten track of biological inquiry, and Mr. Galton's conclusions have not received the consideration due to results based on careful and prolonged observation.

THE Royal Meteorological Institute of the Netherlands has published a new edition of "The Tides on the Dutch Coast," containing, among other useful information, the results of tidal observations made at several stations during recent years. The tables show that on the North Hinder Bank, for instance, the temperature of the air from September to February is lower than that of the sea surface; but from March to August it is higher, and that the prevalence of thunderstorms increases with the latitude. Tide rips are most frequent in the month of April and during the first four days of full and new moon.

THE Meteorological Council have recently issued a second edition of a Barometer Manual for the use of seamen, in which many alterations and improvements have been made. The work contains carefully drawn charts showing the mean atmospheric pressure and prevailing winds for January and July, and also many valuable hints on the management of the barometer. The portions dealing with winds and storms, and especially with practical rules for seamen in tropical cyclones, are of especial value, and this small work of forty pages contains all the necessary information for the safe navigation of a vessel which may be in the vicinity of these storms.

WE have received the *Journal of the Anthropological Institute* for August, containing papers read at meetings of the Institute during the first quarter of this year. Among other papers, we notice one on flint implements of a primitive type from old (pre-glacial) hill-gravels in Berkshire, by Mr. P. A. Shrubsole, and a note on the poisoned arrows of the Akas, by Prof. L. A. Waddell. The Akas are one of the Lohitic tribes of the Asam Valley, occupying independent territory to the north of the Brahmaputra. They poison their arrows for use in warfare, the poison being derived, as has been found in other cases, from the roots of a species of *Aconitum*. A translation of the second part of "Shamanstoo," being Prof. Mikhailovskii's important account of Shamanism in Siberia and European Russia, is contributed by Mr. O. Wardrop.

A THIRD edition, enlarged and partly rewritten, of "Select Methods in Chemical Analysis," by Prof. W. Crookes, F.R.S., has been published by Messrs. Longmans, Green, and Co. During the eight years which elapsed between the publication of the second edition and the preparation of this, various new processes have been introduced, and old ones have either been displaced, or become so well known in ordinary laboratories that their retention in a "select" work, like that of Prof. Crookes', is unnecessary. For it will be remembered that the work is "not intended to provide the student with a complete text-book of analysis, but rather with a laboratory companion, containing information not usually found in ordinary works on analysis." In the present edition, volumetric operations have been almost entirely omitted, and also processes of technical importance. These omissions have made room for the addition of a series of electrical separations, and other processes from Dr. Classen's "Quantitative Chemical Analysis by Electrolysis." As Prof. Crookes only includes in the volume such methods as have been proved in his own laboratory, their practicability is assured. A disadvantage of this eclectic method, however, is that good methods of analysis are passed over because they do not happen to have been personally tested by the author.

THE additions to the Zoological Society's Gardens during the past week include a Black Ape (*Cynopithecus niger*, ♂) from the Celebes, presented by Mr. Gambier Bolton; a Slender Loris (*Loris gracilis*) from Ceylon, presented by Mr. Thos. E. Remington; a Common Chameleon (*Chamæleon vulgaris*) from North Africa, presented by Captain Philip Langdale; four Alpine Newts (*Triton alpestris*), European, presented by Mr. Malcolm O. Smith; four Land Crabs from Jamaica, presented by Mr. Percy Walter Jarvis; a Black-backed Jackal (*Canis mesomelas*) from South Africa, deposited; a Weka Rail (*Ocydromus australis*) from New Zealand, purchased; a Cayenne Lapwing (*Vanellus cayennensis*), bred in the Gardens.

OUR ASTRONOMICAL COLUMN.

RECENT OBSERVATIONS OF MARS.—Mars now rises shortly after nine p.m., and is on the meridian between four and five o'clock in the morning. He will be in opposition on October 20. Two important papers, containing the results of recent observations of the planet, are contributed to the August number of *Astronomy and Astro-Physics*. Mr. Percival Lowell, whose observatory was described in these columns on June 14, began to observe the planet at the end of May, and the observations recorded in his article were made between then and June 24. The clearness of the atmosphere at Flagstaff, Arizona, where the observatory is situated, is responsible for the early date at which it was possible to scrutinise the face of the earth's ruddy brother. And the success with which his features were made out may be judged from the fact that Mr. Lowell recognised a dozen of Schiaparelli's canals two and a half months before the summer solstice of the planet's southern hemisphere. At the beginning of the period of observation, the southern snow-cap was found to have a diameter of about forty-seven degrees; that is, it covered nearly the whole frigid zone. On June 19, the cap measured thirty-nine degrees. Throughout all the period, the outer edge appeared to be perfectly elliptical, indicating that the boundary line of the cap was really a circle. The snow was continuously bordered by a dark streak of nearly uniform width. Mr. Lowell thinks that this belt was water at the edge of the melting snow; in fact, a polar sea. His view finds support in the observation that the streak was widest where the dark markings on the planet's face—the markings intrepreted as seas—were greatest in extent. Several brilliant star-like points flashed out upon the snow-cap at different times and disappeared after being conspicuously visible for a few minutes. The imaginative mind may think that these flash lights represent signals from the Martians, but a more probable explanation is that they are produced by snow slopes being illuminated in such a manner that the sunlight after glancing across them is reflected at a particular angle to the Earth. The great rift in the snow-cap was observed and found to be about twelve hundred miles long, and rather more than two hundred miles wide. Mr. Lowell did not see any irregularities upon the terminator of Mars, so he concludes that there are few, if any, great mountains on the planet. The first canal, thought to be Cerberus, was observed on June 7, and two days later it was seen double for an instant. Other canals were glimpsed from time to time, and some were seen well enough to be sketched. Prof. W. H. Pickering has also observed Mars at the Lowell Observatory. He remarks: "What appears to me to be the most important conclusion deducible from our work is that Mars does not always present the same appearance at the corresponding time upon two successive Arean years. This remark does not apply merely to small details, but to large and prominent features. Moreover, this difference does not seem to be due simply to the fact that one season is a few weeks later than the other, but that the phenomena presented upon the two years are really different." Prof. Pickering has noticed slight notches in the terminator, but he thinks these are produced by variations in the inclination of the surface of the planet rather than by differences of level.

THE ROTATION OF THE TERRESTRIAL POLES.—Dr. S. C. Chandler has lately been investigating the question whether either component of the polar rotation deviates from a uniform circular motion (*Astr. Jour.* No. 323, July 27). The discussion furnishes clear proof that the figure described by the pole of rotation and pole of figure approximates to an ellipse with a major axis of about 0''·55 and a minor axis of about 0''·30. Dr. Chandler refers this departure from circular, or rather epicyclical motion, to the annual term alone. A computation based upon this assumption shows that the figure is "a very eccentric ellipse with a major axis of 0''·32, lying in the line 53°–233°, and a minor axis of about 0''·10; the period being manifestly about a year, and the motion being from west to east. The angular velocity seems to stand in some inverse relation to the radius."

SOCIETIES AND ACADEMIES.

PARIS.

Academy of Sciences, August 6.—M. Lœwy in the chair.—On the variations of *Spirifer Verneuili*, by M. Gosselet.—New anthropological and palæontological researches in the Dordogne. Abstract of a memoir by M. Émile Rivière. Certain details are given concerning palæolithic remains from the "Grottes des Combarelles," the "Grotte Rey," the "Grotte de Cro Magnon," and the "Grotte de la Fontaine," including bones from a numerous fauna and carved and sculptured fragments. Neolithic remains from Pageyral, Sireuil, and Pagenal will be described in a future communication.—The Secretary announced the deaths of the following correspondents: M. A. Hannover, July 7; M. Rollit, August 2.—On groups of substitutions isomorphous with symmetrical or alternate groups, by M. Maillet.—On the zeros of certain discontinuous functions. Principle of the method for finding the zeros of certain functions, by M. Desaint.—On the equations of dynamics, by M. R. Liouville. A claim for priority in reference to the subject-matter of two notes by M. W. Vladimir de Tannenberg, of dates July 30 and May 25 respectively.—On carbonic hydrate and the composition of hydrates of gases, by M. P. Villard. The author determines the composition of a hydrate of carbon dioxide formed by himself to be $CO_2.6H_2O$, and calls attention to the remarkable resemblance between this substance and the hydrate of nitrogen monoxide $N_2O.6H_2O$. They have apparently the same crystalline form, the same heat of formation, and are both optically inactive. The hypothesis is made that hydrates of gases should, in general, have a composition expressed by the formula $M.6H_2O$. This assumption is supported by the formulæ found by the author for the similar compounds of sulphur dioxide and methyl chloride. The hydracids are excepted from the rule. Doubt is thrown upon the formula $Cl_2.8H_2O$ for chlorine hydrate.—Basic salts of calcium, by M. Tassilly. The best method of preparation and thermal data concerning calcium oxybromide and calcium oxyiodide are given. These substances have an exactly similar composition to that of André's oxychloride, $CaCl_2.3CaO.16H_2O$. They have the same heat of solution and a heat of formation increasing with increasing atomic weight of the halogen present.—On the use of selected ferments, by M. Charles Fabre. The following conclusions are given—(1) The selected ferment cannot be employed with *any* must for the production of high-class wines. (2) The must in which the ferment is sown should have been obtained from grapes belonging to or vines long acclimatised in the region from which the selected ferment has been obtained.—Peripheric applications of alkaloids in the treatment of acute maladies with cutaneous determination, by MM. L. Guinard and Gustave Geley. The external application of sparteïne in cases where the skin is the active seat of disease has been found to give remarkable curative results, more particularly in cases of erysipelas.—On coprolitic bacteria of the Permian age, by MM. B. Renault and C. Eg. Bertrand. *Bacillus permiensis*, occurring in coprolites from the Permian at Autun, consists of rectilinear bacillus elements, isolated or in pairs, and having the dimensions 14 to 16μ by 2·5 to 3·3μ by 0·4μ. It sometimes occurs curved or twisted in spirals or chains.—On the nature of the great crevasse caused by the last earthquake at Locrides, by M. Socrate A. Papavasilion.—On the existence of *lentilles recifales* with Ammonites in the *Barrêmien* near Châtillon-en-Diois, by MM. G. Sayn and P. Lory.

BOOKS, PAMPHLETS, and SERIALS RECEIVED.

BOOKS.—The Aborigines of Western Australia: A. F. Calvert (Simpkin).—Theoretical Mechanics—Fluids: J. E. Taylor (Longmans).—A Treatise on Astronomical Spectroscopy: Prof. Dr. J. Scheiner, translated, &c., by E. B. Frost (Ginn).—Controversen in der Ethnologie, IV., Fragestellungen der Finalursachen: A. Bastian (Berlin, Weidmann).—Coal Dust an Explosive Agent: D. M. D. Stuart (Spon).—Geological Guide-Book for an Excursion to the Rocky Mountains: S. F. Emmons (K. Paul).—British Rainfall, 1893: G. J. Symons and H. S. Wallis (Stanford).—Systema Naturæ; Regnum Animale, editio decima 1758: C. Linnæi (Leipzig, Engelmann).—Le Centre de l'Afrique, Autour du Tchad: P. Brunache (Paris, Alcan).—Memoirs of the International Congress of Anthropology: edited by C. S. Wake (K. Paul).—The Water Supply of Towns and the Construction of Waterworks: Prof. W. K. Burton (Lockwood).

PAMPHLETS.—Supplement to 41st Report of the Department of Science and Art (Eyre and Spottiswoode).—Representation and Suffrage in Massachusetts, 1620-1691: Dr. G. H. Haynes (Baltimore).

SERIALS.—School Review, June (Hamilton, New York).—Proceedings of the Royal Physical Society, Session 1892-93 (Edinburgh).—American Journal of Science, August (New Haven).—Papers and Proceedings of the Royal Society of Tasmania for 1893 (Hobart).—Zeitschrift für Physikalische Chemie, xiv. Band, 4 Heft (Leipzig, Engelmann).—Engineering Magazine, August (Tucker).—Notes from the Leyden Museum, January to April (Leyden, Brill).—Astronomy and Astro-Physics, August (Wesley).—Journal of the Royal Microscopical Society, August (Williams and Norgate).—Sechzehnter Jahres-Bericht über die Thätigkeit der Deutschen Seewarte für das Jahr 1893, Beiheft i. (Hamburg).

CONTENTS.