section of coal, and he also exhibited various pieces of coal, one of which he held in the position it occupied in the coal bed. Another diagram, he said, represented a quantity of black coaly matter arranged in layers, and embedded in this matter were some small bodies which had been flattened by the pressure of the coal, and by the superimposed beds between the coal.]

Prof. Huxley spoke of these bodies under the name of sporangia, or spore cases. Now, he (Prof. Williamson) had come to the conclusion that they were all spores of two classes—the larger ones called macro-spores, and the smaller ones micro-spores. A large number of the plants, if not all, found in the coal-measures belonged to the cryptogamic plants, in which was found no trace of seeds or flowers. The reproductive bodies that took the place of seeds were little bud-like structures, to which the name of spores was given. In a certain class of those plants, the club-mosses, for instance, were two kinds of these spores. The sporangia of club mosses and similar plants never became detached from their parent stem. They burst and liberated multitudes of contained spores, which were objects like those so abundant in many coals. But these spores did not play so important a part in the formation of coal as Prof. Huxley supposed. On examining these objects it was found that each of the little rounded discs exhibited three ridges that radiated in a triangular manner from a common centre. These discs were originally masses of protoplasm, lodged within a mother-cell. By-and-by each of these masses broke up into three or four parts; and it was found that to accommodate one another in the interior of their circular chamber, they mutually pressed one another. To illustrate the mutual compression, Prof. Williamson produced a turnip, which he had cut into four parts, that corresponded exactly, he said, in their arrangement with the arrangement of the four spores in the interior of the mother cell.

Then Prof. Huxley held that coal consisted of two elements. Prof. Williamson, exhibiting again a piece of coal said the dirty blackening surface was a thin layer of little fragments of woody structures, vegetable tissues of various kinds, known by the name of mineral charcoal. These layers of mineral charcoal were exceedingly numerous. Prof. Huxley, recognising the abundance and significance of these little spore-like bodies, thought that mineral charcoal formed only a portion, and a limited portion, while the great bulk of black coaly matter was really a mass of carbon derived from chemically altered spores. He thought that on this point they would be obliged somewhat to differ from Prof. Huxley.

The bed which had been most widely quoted as containing most beautiful spores was found in the district of Bradford. If everything decayed, and Bradford was by an exceedingly improbable combination of circumstances to pass out of memory, it would be remembered in scientific history as the locality in which the "better bed" was found. The fragment he held in his hand was a fragment of the better bed. On examining it for a moment through a magnifying glass he saw that it was a solid mass of mineral charcoal, yet the microscope revealed in it no trace whatever of organic structure. Therefore, while Prof. Huxley divided coal into two elements—mineral charcoal and coal proper, including in the latter term altered spores—he would say that coal consisted of three elements—mineral charcoal, black coal derived from mineral charcoal, and spores.

This outline of the history of coal led them to the independent conclusion that two elements were mingled in coal; the vegetable *débris*, or broken up fragments of the plants of the carboniferous age were intermingled with the peculiar spores to which Prof. Huxley had so properly called attention. In proceeding to deal further with the plants of which coal was formed, the lecturer took occasion to acknowledge with thanks the loan of certain valuable specimens to illustrate his discourse from the Bradford Museum. One of these specimens was a most rare and valuable specimen which he would be glad to take away with him to Owens College, if he had the chance; but he was afraid the Bradford people were too Conservative to stand that.

After giving a number of botanical and other details with regard to the plants of which coal was formed, he said our knowledge of this subject resolved itself into two divisions, viz., that of the outward forms of plants and that of their inward organisation. These two lines of inquiry did not always run parallel, and the one great object of recent research had been to make them do so. Specimens throwing light on the subject had been found at Arran, Burntisland, Oldham, Halifax, Autun in France, and elsewhere, and upon these a host of observers had been and still were working. It had long been known that most, if not all, the coal plants belonged to two classes, known as the Cryptogamia, or flowerless plants, and the gymnospermous exogens, represented by the pines and firs. All recent inquiries added fresh strength to this conclusion. One of the most important of these groups was that of the Equisetа or horse tails, and which were represented in the coal by the Calamites. The long cylindrical stems, with their transverse joints and longitudinal grooves, were shown to be casts of mud or sand, occupying the hollows in the piths of the living plants. Each of these piths was surrounded by a thick zone of wood, which again was invested by an equally thick layer of bark. Specimens were shown in which, though the pith was only an inch in diameter, the wood and bark combined formed a cylinder 4 inches thick, giving a circumference of at least 27 inches to the living stem. But there exist examples of the pith casts alone, which are between 2 and 3 feet in diameter. It was evident, therefore, he concluded, that the Calamites became true forest trees, very different from their living representatives—the horse tails of our ponds and marshes.

After describing the organisation of these plants, the Professor proceeded to describe the Lycopods of the coal measures as represented by the Lepidodendra, Sigillariæ, and a host of other well-known plants. The living Lycopods, whether seen at home or in tropical forests, are dwarf herbaceous plants, but in the carboniferous age they became lofty forest trees, 100 feet high, and ten or twelve feet in circumference. To enable such lofty stems, with their dense mass of serial branches and foliage, to obtain nutrition, an organisation was given to them approaching more nearly to that of our living forest trees than to that of any recent cryptogams. A succession of woody layers was added to the exterior of those previously existing; so that as the plant rose into the air the stem became strengthened by these successive additions to the vascular tissue. As this process advanced it was accompanied by other changes, producing a large central pith, and two independent vascular rings immediately surrounding the pith, and the relations of these various parts to the roots, and leaves, as well as to the nutrition of the plants, was pointed out. The fruits of these Lycopods were then examined. The existence of two classes of spores corresponding in functions to the stamens and pistils of flowering plants, was dwelt upon, and one of these classes (the macrospores) was shown to be so similar to the small objects found in coal, as to leave no doubt that those objects were derived from the lepidodendroid and sigillarian trees which constituted the large portion of the forest vegetation.

Certain plants known as Asterophyllites were next examined. The ferns were also reviewed, and shown to be as remarkable for the absence of exogenous growth from their stems as the Calamites and Lycopods were for its conspicuous presence. The structure of some stems supposed to represent palms was shown to be that of a fern, there being no true evidence that palms existed in that age. The plants known as coniferous plants, allied to pines and firs, were described, and their peculiar fruits, so common at Peel, in Lancashire, were explained, and some plants of unknown affinities, but beautiful organisation, were referred to. The physiological differences between these extinct ferns, and other plants especially in their marvellous *quasi*-exogenous organisation, was pointed out, and the lecturer concluded by showing how unvarying must have been the green hue of the carboniferous forests, owing to the entire absence from them of all the gay colours of the flowering plants which form so conspicuous a feature in the modern landscape, especially in the temperate and colder regions. The antiquity of the mummy, he added, was as nothing compared with the countless ages that had rolled by since these plants lived, and yet they must not forget that every one of those plants, living in ages so incalculably remote, had a history, an individuality as distinct and definite as our own. They would probably be inclined to ask the question, When did all these things take place? Echo answered, When?

THE BRITISH ASSOCIATION

THE Bradford Meeting has been on the whole a good one; though there have been no salient discussions, the papers read have been all up to a good useful average. Mr. Ferrier's paper on the brain was a surprise to many, we believe, and the only approach to a genuine sensation was the appearance of Captain Markham, R.N., in the Geographical Section on Saturday, he having arrived only the previous day at Dundee in the *Arctic*, along with the *Polaris* men.

The private hospitality of the Bradfordians has been magnificent, but the hotel charges, every one admits, have been simply monstrous. We quite agree with the remarks made in the last number of the *Pharmaceutical Journal* on this subject, and do not think that hotel-keepers by so recklessly increasing their ordinary charges do themselves or their town any good. We hope that in future the authorities of towns visited by the British Association will devise some means of counteracting such proceedings, as they no doubt tend to diminish the number of visitors. The number of tickets of all classes issued this year is not much above 1,800, being several hundreds under that of last year; no doubt the relative attractions of Brighton and Bradford will partly account for this.

The *soirée* in St. George's Hall last Thursday was a great success; indeed all the arrangements for the meeting have been satisfactory. The public lectures, by Profs. W. C. Williamson, Clerk-Maxwell, and Dr. Siemens were well attended, but the proportion of the working-classes present at the lecture on Fuel, which was specially intended for their benefit, was very small. Indeed, many are of opinion that this lecture should be abolished, seeing that so few workpeople take advantage of it, and that a lecture should be given every night, or three or four times during the meeting, to working-men who are registered, as at the School of Mines, in order to secure that the right sort of people gain admission.

This year the Association gave another lesson to Government. Last year, it may be remembered, the question of the Tides was given up by the Association; this year they have done the same to the Rainfall question, as being a work which it is the interest of the nation to see done. We hope the nation will see that it is attended to in the proper quarter.

On Monday Prof. Smith proposed Dr. Tyndall as president of next year's meeting; and it was somewhat of a surprise to most present when the Mayor of Belfast patriotically proposed that Prof. Andrews of that city should preside over a meeting to be held in Ireland. Prof. Andrews had been first suggested by the Council, and his friends were consulted, but it was found that the state of his health rendered it unadvisable to press the honour upon him.

Belfast is the place of meeting next year, and Bristol, it has been settled, will be visited by the Association in 1875; there is a tacit understanding that Glasgow will be the rendezvous for 1876, the Lord Provost and a strong deputation being present on Monday to earnestly urge the claims of that important place.

The Report of the Council for the year 1872-3 was presented to the General Committee at Bradford, on Wednesday, 17th September. The Council have had under their consideration the three Resolutions which were referred to them by the General Committee at Brighton. The first Resolution was—"That the Council be requested to take such steps as they deem desirable to induce the Colonial Office to afford sufficient aid to the Observatory at Mauritius to enable an investigation of the cyclones in the Indian Ocean to be carried on there."

In accordance with this Resolution, a correspondence took place between Dr. Carpenter, the President of the Association, and the Right Honourable the Earl of Kimberley, Secretary of State for the Colonies.

In consequence of this correspondence, the Council requested the President to urge upon the Lords Commissioners of Her Majesty's Treasury the desirability of affording such pecuniary aid to the Mauritius Observatory as would enable the Director to continue his observations on the periodicity of the cyclones; and an intimation has been received from Her Majesty's Government that an inquiry into the condition, size, and cost of the establishment of the Mauritius is now being conducted by a Special Commission from England, pending which inquiry no increase of expenditure upon the Observatory can be sanctioned; but that when the results of this inquiry shall be made known, the Secretary of State for the Colonies will direct the attention of the Governor to the subject.

The second Resolution referred to the Botanical establishment at Kew, but happily the Council have not deemed it necessary to take any action upon this Resolution.

Third Resolution:—"That the Council be requested to take such steps as they may deem desirable to urge upon the Indian Government the preparation of a Photoheliograph and other instruments for solar observation, with the view of assisting in the observation of the Transit of Venus in 1874, and for the continuation of solar observations in India."

The Council communicated with his Grace the Duke of Argyll, the Secretary of State for India, upon the subject, with the result explained in the following letter:—

"India Office, February 28, 1873.

"Sir,—With reference to my letter of the 13th of December last, relative to an observation in India of the Transit of the planet Venus in December 1874, I am directed to state, for the information of the Council of the British Association for the Advancement of Science, that the Secretary of State for India in Council, having reconsidered this matter, and looking to the number of existing burdens on the revenues of India, and to the fact that the selection of any station in that country was not originally contemplated for 'eye-observations' of the transit, has determined to sanction only the expenditure (356*l*. 7*s*. 6*d*.) necessary for the purchase and packing of a Photoheliograph, and any further outlay that may be requisite for the adaptation of such instruments as may be now in India available for the purpose of the proposed observation.

"The Duke of Argyll in Council has been led to sanction thus much of the scheme proposed by Lieut. Colonel Tennant, in consequence of the recommendation submitted by the Astronomer Royal in favour of the use of photography for an observation of the transit at some place in Northern India.

"I am, Sir, Your obedient Servant,

(Signed) "Herman Merivale."

"William B. Carpenter, Esq., British Association."

A Committee was appointed at Exeter in 1869, on the Laws Regulating the Flow and Action of Water holding Solid Matter in Suspension, with authority to represent to the Government the desirability of undertaking Experiments bearing on the subject. The Committee presented a Memorial to the Indian Government, who have recently intimated their intention of advancing a sum of 2,000*l*. to enable Mr. Login to carry on experiments.

The Council have added the following list of names of gentlemen present at the last meeting of the Association to the list of Corresponding Members: M. C. Bergeron, Lausanne; Prof. E. Croullebois, Paris; Prof. G. Devalque, Liège; M. W. De Fonvielle, Paris; Prof. Paul Gervais, Paris; Prof. James Hall, Albany, New York; Mr. J. E. Hilgard, Coast Survey, Washington; M. George Lemoine, Paris; Prof. Victor von Richter, St. Petersburg; Prof. Carl Semper, Wurtzburg; Prof. A. Wurtz, Paris.

We now pass on at once to the Sectional work, delaying a reference to the Scientific grants made this year, and the concluding business till next week.

SECTION A.

Opening Address by the President, Prof. Henry J. S. Smith, M.A., LL.D., F.R.S.

For several years past it has been the custom for the president of this section, as of the other sections of the Association, to open its proceedings with a brief address. I am not willing upon this occasion to deviate from the precedent set by my predecessors, although I feel that the task presents peculiar difficulties to one who is by profession a pure mathematician, and who, in other branches of science, can only aspire to be regarded as an amateur.

But, although I thus confess myself a specialist, and a specialist it may be said of a narrow kind, I shall not venture, in the few remarks which I now propose to make, to indulge my own speciality too far.

I am well aware that we are certain, in this section, to have a sufficient number of communications, which of necessity assume a special and even an abstruse character, and which, whatever pains may be taken to give them clearness, and however valuable may be the results to which they lead, are nevertheless extremely difficult to follow, not only for a popular audience, but even for men of science whose attention has not been specially, and recently, directed to the subject under discussion. I should think it, therefore, almost unfair to the section, if at the very commencement of its proceedings I were to attempt to direct its attention in any exclusive manner to the subject which, I confess, if I were left to myself, I should most naturally have chosen—the history of the advances that have been made during the last ten or twenty years in mathematical science. Instead, therefore, of adventuring myself on this difficult course, which, however, I strongly recommend to some successor of mine less scrupulous than myself, I propose, though at the risk of repeating what has been better said by others before me, to offer some general considerations which may have a more equal interest for all those who take part in the proceedings of this section, and which appear to me at the present time to be more than usually deserving of the notice of those who desire to promote the growth of the scientific spirit in this country. I intend, therefore, while confining myself as strictly as I can to the range of subjects belonging to this section, to point out one or two, among many, of the ways in which sectional meetings, such as ours, may contribute to the advancement of science.

We all know that Section A of the British Association is the section of mathematics and physics; and I dare say that many of us have often thought how astonishingly vast is the range of subjects which we slur over, rather than sum up, in this brief designation. We include the most abstract speculations of pure mathematics, and we come down to the most concrete of all phenomena—the most every-day of all experiences. I think I have heard in this section a discussion on spaces of five dimensions, and we know that one of our committees, a committee which is of long-standing, and which has done much useful work, reports to us annually on the Rainfall of the British Isles. Thus our wide range covers the mathematics of number and quantity in their most abstract forms, the mathematics of space, of time, of matter, of motion, and of force, the many sciences which we comprehend under the name of astronomy, the theories of sound, of light, heat, electricity; and besides the whole physics of our earth, sea, and atmosphere, the theory of earthquakes, the theory of tides, the theory of all the movements of the air, from the lightest ripple that affects the barometer up to a cyclone. As I have already said, it is impossible that communications on all these subjects should be interesting, or indeed intelligible, to all our members; and, notwithstanding the pains taken by the committee and by the secretaries to classify the communications offered to us, and to place upon the same days those of which the subjects are cognate to one another, we cannot doubt that the disparateness of the material which comes before us in this section is a source of serious inconvenience to many members of the Association. Occasionally, too, the pressure upon our time is very great, and we are obliged to hurry over the discussions on communications of great importance, the number of papers submitted to us being, of course, in a direct proportion to the number of the subjects included in our programme. It has again and again been proposed to remedy these admitted evils by dividing the section, or at least by resolving it into one or more sub-sections. But I confess that I am one of those who have never regretted that this proposal has not commended itself to the Association, or indeed to the section itself. I have always felt that by so sub-dividing ourselves we should run the risk of losing one or two great advantages which we at present possess; and I will briefly state what, in my judgment, these advantages are.

I do not wish to undervalue the use to a scientific man of listening to and taking part in discussions on subjects which lie wholly in the direction in which his own mind has been working. But I think, nevertheless, that most men who have attended a meeting of this Association, if asked what they have chiefly gained by it, would answer in the first place that they have had opportunities of forming or of renewing those acquaintances or intimacies with other scientific men which, to most men engaged in scientific pursuits, are an indispensable condition of successful work; and in the second place, that while they may have heard but little relating to their own immediate line of inquiry which they might not as easily have found in Journals or Transactions elsewhere, they have learned much which might otherwise have never come to their knowledge of what is going on in other directions of scientific inquiry, and that they have carried away many new conceptions, many fruitful germs of thought, caught perhaps from a discussion turning upon questions apparently very remote from their own pursuits. An object just perceptible on a distant horizon is sometimes better descried by a careless sideward glance than by straining the sight directly at it; and so capricious a gift is the inventive faculty of the human mind that the clue to the mystery hid beneath some complicated system of facts will sometimes elude the most patient and systematically conducted search, and yet will reveal itself all of a sudden upon some casual suggestion arising in connection with an apparently remote subject. I believe that the mixed character and wide range of our discussions has been most favourable to such happy accidents. But even apart from these, if the fusion in this section of so many various branches of human knowledge tends in some degree to keep before our minds the essential oneness of science, it does us a good service. There can be no question that the increasing specialisation of the sciences, which appears to be inevitable at the present time, does nevertheless constitute one great source of danger for the future progress of human knowledge. This specialisation is inevitable, because the further the boundaries of knowledge are extended in any direction, the more laborious and time-absorbing a process does it become to travel to the frontier; and thus the mind has neither time nor energy to spare for the purpose of acquainting itself with regions that lie far away from the track over which it is forced to travel. And yet the disadvantages of excessive specialisation are no less evident, because in natural philosophy, as indeed in all things on which the mind of man can be employed, a certain wideness of view is essential to the achievement of any great result, or to the discovery of anything really new. The twofold caution so often given by Lord Bacon against over-generalisation on the one hand, and against over-specialisation on the other, is still as deserving as ever of the attention of mankind. But in our time, when vague generalities and empty metaphysics have been beaten once, and we may hope for ever, out of the domain of exact science, there can be but little doubt on which side the danger of the natural philosopher at present lies. And perhaps in our section, as at present constituted, there is a freer and fresher air—we are, perhaps, a less inadequate representation of "that greater and common world" of which Lord Bacon speaks, than if we were subdivided into as many parts as we include—I will not say sciences—but groups of sciences. Perhaps there is something in the very diversity and multiplicity of the subjects which come before us which may serve to remind us of the complexity of the problems of science, of the diversity and multiplicity of nature.

On the other hand it is not, as it seems to me, difficult to assign the nature of the unity which underlies the diversity of our subjects, and which justifies, to a very great extent, the juxtaposition of them in our section. That unity consists not so much in the nature of the subjects themselves, as in the nature of the methods by which they are treated. A mathematician, at least—and it is as a mathematician I have the privilege of addressing you—may be excused for contending that the bond of union among the physical sciences is the mathematical spirit and the mathematical method which pervades them. As has been said with profound truth by one of my predecessors in this chair, our knowledge of nature, as it advances, continuously resolves differences of quality into differences of quantity. All exact reasoning—indeed all reasoning—about quantity is mathematical reasoning; and thus as our knowledge increases, that portion of it which becomes mathematical increases at a still more rapid rate. Of all the great subjects which belong to the province of this section, take that which at first sight is the least within the domain of mathematics—I mean meteorology. Yet the part which mathematics bears in meteorology increases every year, and seems destined to increase. Not only is the theory of the simplest instruments of meteorology essentially mathematical, but the discussion of the observations—upon which, be it remembered, depend the hopes which are already entertained with increasing confidence, of reducing the most variable and complex of all known phenomena to exact laws—is a problem which not only belongs wholly to mathematics, but which taxes to the utmost the resources of the mathematics which we now possess. So intimate is the union between mathematics and physics that probably by far the larger part of the accessions to our mathematical knowledge have been obtained by the efforts of mathematicians to solve the problems set to them by experiment, and to create "for each successive class of phenomena, a new calculus or a new geometry, as the case might be, which might prove not wholly inadequate to the subtlety of nature." Sometimes, indeed, the mathematician has been before the physicist, and it has happened that when some great and new question has occurred to the experimentalist or the observer, he has found in the armoury of the mathematician the weapons which he has needed ready made to his hand. But, much oftener, the questions proposed by the physicist have transcended the utmost powers of the mathematics of the time, and a fresh mathematical creation has been needed to supply the logical instrument requisite to interpret the new enigma. Perhaps I may be allowed to mention an example of each of these two ways in which mathematical and physical discovery have acted and re-acted on each other. I purposely choose examples which are well known and belong, the one to the oldest, the other to the latest times of scientific history.

The early Greek geometers, considerably before the time of Euclid, applied themselves to the study of the various curve lines, in which a conical figure may be cut by a plane—curve lines to which they gave the name, never since forgotten, of conic sections. It is difficult to imagine that any problem ever had more completely the character of a "problem of mere curiosity," than this problem of the conic sections must have had in those earlier times. Not a single natural phenomenon which in the state of science at that time could have been intelligently observed was likely to require for its explanation a knowledge of the nature of these curves. Still less can any application to the arts have seemed possible; a nation which did not even use the arch were not likely to use the ellipse in any work of construction. The difficulties of the inquiry, the pleasure of grappling with the unknown, the love of abstract truth, can alone have furnished the charm which attracted some of the most powerful minds in antiquity to this research. If Euclid and Apollonius had been told by any of their contemporaries that they were giving a wholly wrong direction to their energies, and that instead of dealing with the problems presented to them by nature were applying their minds to inquiries which not only were of no use, but which never could come to be of any use, I do not know what answer they could have given which might not now be given with equal, or even with greater justice, to the similar reproaches which it is not uncommon to address to those mathematicians of our own day who study quantics of n-indeterminates, curves of the nth order, and (it may be) spaces of n-dimensions. And not only so, but for pretty nearly two thousand years, the experience of mankind would have justified the objection: for there is no record that during that long period which intervened between the first invention of the conic sections and the time of Galileo and Kepler, the knowledge of these curves possessed by geometers was of the slightest use to natural science. And yet, when the fulness of time was come, these seeds of knowledge, that had waited so long, bore splendid fruit in the discoveries of Kepler. If we may use the great names of Kepler and Newton to signify stages in the progress of human discovery, it is not too much to say that without the treatises of the Greek geometers on the conic sections there could have been no Kepler, without Kepler no Newton, and without Newton no science in our modern sense of the term, or at least no such conception of nature as now lies at the basis of all our science, of nature as subject in its smallest as well as in its greatest phenomena, to exact quantitative relations, and to definite numerical laws.

This is an old story; but it has always seemed to me to convey a lesson, occasionally needed even in our own time, against a species of scientific utilitarianism which urges the scientific man to devote himself to the less abstract parts of science, as being more likely to bear immediate fruit in the augmentation of our knowledge of the world without. I admit, however, that the ultimate good fortune of the Greek geometers can hardly be expected by all the abstract speculations which, in the form of mathematical memoirs, crowd the Transactions of the learned societies; and I would venture to add that, on the part of the mathematician there is room for the exercise of good sense, and, I would almost say, of a kind of tact, in the selection of those branches of mathematical inquiry which are likely to be conducive to the advancement of his own or any other science.

I pass to my second example, of which I may treat very briefly. In the course of the present year a treatise on electricity has been published by Prof. Maxwell, giving a complete account of the mathematical theory of that science, as we owe it to the labours of a long series of distinguished men, beginning with Coulomb and ending with contemporaries of our own, including Prof. Maxwell himself. No mathematician can turn over the pages of these volumes without very speedily convincing himself that they contain the first outlines (and something more than the first outlines) of a theory which has already added largely to the methods and resources of pure mathematics, and which may one day render to that abstract science services no less than those which it owes to astronomy. For electricity now, like astronomy of old, has placed before the mathematician an entirely new set of questions, requiring the creation of entirely new methods for their solution, while the great practical importance of telegraphy has enabled the methods of electrical measurement to be rapidly perfected to an extent which renders their accuracy comparable to that of astronomical observations, and thus makes it possible to bring the most abstract deductions of theory at every moment to the test of fact. It must be considered fortunate for the mathematicians that such a vast field of research in the application of mathematics to physical inquiries should be thrown open to them, at the very time when the scientific interest in the old mathematical astronomy has for the moment flagged, and when the very name of physical astronomy, so long appropriated to the mathematical development of the theory of gravitation, appears likely to be handed over to that wonderful series of discoveries which have already taught us so much concerning the physical constitution of the heavenly bodies themselves.

Having now stated, from the point of view of a mathematician, the reasons which appear to me to justify the existence of so composite an institution as Section A, and the advantages which that very compositeness sometimes brings to those who attend its meetings, I wish to refer very briefly to certain definite services which this section has rendered and may yet render to Science. The improvement and extension of scientific education is to many of us one of the most urgent questions of the day; and the British Association has already exerted itself more than once to press the question on the public attention. Perhaps the time has arrived when some further efforts of the same kind may be desirable. Without a rightly organised scientific education we cannot hope to maintain our supply of scientific men; since the increasing complexity and difficulty of science renders it more and more difficult for untaught men, by mere power of genius, to force their way to the front. Every improvement, therefore, which tends to render scientific knowledge more accessible to the learner, is a real step towards the advancement of science, because it tends to increase the number of well qualified workers in science.

For some years past this section has appointed a committee to aid in the improvement of geometrical teaching in this country. The report of this committee will be laid before the section in due course; and without anticipating any discussion that may arise on that report, I think I may say that it will show that we have advanced at least one step in the direction of an important and long-needed reform. The action of this section led to the formation of an Association for the improvement of geometrical teaching, and the members of that Association have now completed the first part of their work. They seem to me, and to other judges much more competent than myself, to have been guided by a sound judgment in the execution of their difficult task, and to have held, not unsuccessfully, a middle course between the views of the conservatives who would uphold the absolute monarchy of Euclid, or, more properly, of Euclid as edited by Simson, and the radicals who would dethrone him altogether. One thing at least they have not forgotten, that geometry is nothing if it be not rigorous, and that the whole educational value of the study is lost, if strictness of demonstration be trifled with. The methods of Euclid are, by almost universal consent, unexceptionable in point of rigour. Of this perfect rigorousness his doctrine of parallels, and his doctrine of proportion, are perhaps the most striking examples. That Euclid's treatment of the doctrine of parallels is an example of perfect rigorousness, is an assertion which sounds almost paradoxical, but which I, nevertheless, believe to be true. Euclid has based his theory on an axiom (in the Greek text it is one of the postulates, but the difference for our purpose is immaterial) which, it may be safely said, no unprejudiced mind has ever accepted as self-evident. And this unaxiomatic axiom Euclid has chosen to state, without wrapping it up or disguising it,—not, for example, in the plausible form in which it has been stated by Playfair, but in its crudest shape, as if to warn his reader that a great assumption was being made. This perfect honesty of logic, this refusal to varnish over a weak point, has had its reward; for it is one of the triumphs of modern geometry to have shown that the eleventh axiom is so far from being an axiom, in the sense which we usually attach to the word, that we cannot at this moment be sure whether it is absolutely and rigorously true, or whether it is only a very close approximation to the truth. Two of those whose labours have thrown much light on this difficult theory are at present at this meeting—Prof. Cayley, and a distinguished German mathematician, Dr. Felix Klein; and I am sure of their adherence when I say that the sagacity and insight of the old geometer are only put in a clearer light, by the success which has attended the attempt to construct a system of geometry, consistent with itself, and not contradicted by experience, upon the assumption of the falsehood of Euclid's eleventh axiom.

Again, the doctrine of proportion, as laid down in the fifth book of Euclid, is, probably, still unsurpassed as a masterpiece of exact reasoning; although the cumbrousness of the forms of expression which were adopted in the old geometry has led to the total exclusion of this part of the elements from the ordinary course of geometrical education. A zealous defender of Euclid might add with truth that the gap thus created in the elementary teaching of mathematics has never been adequately supplied.

But after all has been said that can be said in praise of Euclid, the fact remains that the form in which the work is composed renders it unsuitable for the earlier stages of education. Euclid wrote for men; whereas his work has been used for children, and it is surely no disparagement to the great geometer to suppose that after more than 2,000 years the experience of generations of teachers can suggest changes which may make his Elements, I will not say more perfect as a piece of geometry, but more easy for very young minds to follow. The difficulty of a book or subject is indeed not in itself a fatal objection to its use in education, for to learn how to overcome difficulties is one great part of education: Geometry is hard, just as Greek is hard, and one reason why Geometry and Greek are such excellent educational subjects is precisely that they are hard. But in a world in which there is so much to learn, we must learn everything in the easiest way in which it can be learnt; and after we have smoothed the way to the utmost of our power, there is sure to be enough of difficulty left. I regard the question of some reform in the teaching of elementary geometry as so completely settled by a great concurrence of opinion on the part of the most competent judges, that I should hardly have thought it necessary to direct the attention of the section to it, if it were not for the following reasons:—

First, that the old system of geometrical instruction still remains (with but few exceptions) paramount in our schools, colleges, and universities, and must remain so until a very great consensus of opinion is obtained in favour of some one definite text-book. It appears to me, therefore, that the duty will eventually devolve upon this section of the British Association, of reporting on the attempts that have been made to frame an improved system of geometrical education; and if it should be found that these attempts have been at last successful, I think that the British Association should lend the whole weight of its authority to the proposed change. I am far from suggesting that any such decision should be made immediately. The work undertaken by the Association for the improvement of geometrical teaching is still far from complete; and even when it is complete it must be left to hold its own against the criticism of all comers before it can acquire such an amount of public confidence as would justify us in recommending its adoption by the great teaching and examining bodies of the country.

Secondly, I have thought it right to remind the section of the part it has taken with reference to the reform of geometrical teaching, because it appears to me that a task, at once of less difficulty and of more immediate importance, might now be undertaken by it with great advantage. There is at the present moment a very general agreement that a certain amount of natural science ought to be introduced into school education; and many schools of the country have already made most laudable efforts in this direction. As far as I can judge, there is further a general agreement that a good school course of natural science ought to include some part or parts of physics, of chemistry, and of biology; but I think it will be found that while the courses of chemistry given at our best schools are in the main identical, there is great diversity of opinion as to the parts of physics and of biology which should be selected as suitable for a school education, and a still greater diversity of opinion as to the methods which should be pursued in teaching them. Under these circumstances it is not surprising to find that the masters of those schools into which natural science has hardly yet found its way (and some of the largest and most important schools in the country are in this class), are doubtful as to the course which they should take; and from not knowing precisely what they should do, have not as yet made up their minds to do anything of importance. There can be no doubt that the masters of such schools would be glad on these points to be guided by the opinion of scientific men; and I cannot help thinking that this opinion would be more unanimous than is commonly supposed, and further, that no public body would be so likely to elicit an expression of it, as a Committee appointed by the British Association. I believe that if such an expression of the opinion of scientific men were once obtained, it would not only tend to give a right direction to the study of natural science in schools, but might also have the effect of inducing the public generally to take a higher and more truthful view of the objects which it is sought to attain by introducing natural science as an essential element into all courses of education. All knowledge of natural science that is imparted to a boy, is, or may be, useful to him in the business of his after life; but the claim of natural science to a place in education cannot be rested upon its practical usefulness only. The great object of education is to expand and to train the mental faculties, and it is because we believe that the study of natural science is eminently fitted to further these two objects, that we urge its introduction into school studies. Science expands the minds of the young, because it puts before them great and ennobling objects of contemplation; many of its truths are such as a child can understand, and yet such that, while in a measure he understands them, he is made to feel something of the greatness, something of the sublime regularity, and of the impenetrable mystery, of the world in which he is placed. But science also trains the growing faculties, for science proposes to itself truth as its only object, and it presents the most varied, and at the same time the most splendid examples, of the different mental processes which lead to the attainment of truth, and which make up what we call reasoning. In science, error is always possible, often close at hand; and the constant necessity for being on our guard against it is one important part of the education which science supplies. But in science, sophistry is impossible; science knows no love of paradox; science has no skill to make the worse appear the better reason; science visits with a not long deferred exposure all our fondness for preconceived opinions, all our partiality for views that we have ourselves maintained, and thus teaches the two best lessons that can well be taught—on the one hand the love of truth, and on the other, sobriety and watchfulness in the use of the understanding.

In accordance with these views I am disposed to insist very strongly on the importance of assigning to physics, that is to say to those subjects which we discuss in this section, a very prominent place in education. From the great sciences of observation, such as botany, or zoology, or geology, the young student learns to observe, or more simply, to use his eyes; he gets that education of the senses which is after all so important, and which a purely grammatical and literary education so wholly fails to give. From chemistry he learns, above all other things, the art of experimenting, and of experimenting for himself. But from physics, better as it seems to me than from any other part of science, he may learn to reason with consecutiveness and precision, from the data supplied by the immediate observation of natural phenomena. I hope we shall see the time when each successive portion of mathematical knowledge acquired by the pupil will be made immediately available for his instruction in physics; and when everything that he learns in the physical laboratory will be made the subject of mathematical reasoning and calculation. In some few schools I believe that this is already the case, and I think we may hope well for the future, both of mathematics and physics in this country, when the practice becomes universal. In one respect the time is favourable for such a revolution in the mode of teaching physical science. During the past few years a number of text-books have been made available to the learner, which far surpass anything that was at the disposal of former generations of pupils, and which are probably as completely satisfactory as the present state of science will admit. It is pleasant to record that these text-books are the work of distinguished men who have always taken a prominent part in the proceedings of this section. We have Deschanel's Physics, edited, or rather re-written, by Prof. Everett, a book remarkable alike for the clearness of its explanations and for the beauty of the engravings with which it is illustrated; and passing to works intended for students somewhat further advanced, we have the treatises of Prof. Balfour Stewart on Heat, of Prof. Clerk Maxwell on the Theory of Heat, of Prof. Fleeming Jenkin on Electricity, and we expect a similar treatise on Light from another of our most distinguished members.

These works breathe the very spirit of the method which should guide both research and education in physics. They express the most profound and far-reaching generalisations of science in the simplest language, and yet with the utmost precision. With the most sparing use of mathematical technicalities, they are a perfect storehouse of mathematical ideas and mathematical reasonings. An old French geometer used to say that a mathematical theory was never to be considered complete till you had made it so clear that you could explain it to the first man you met in the street. This is of course a brilliant exaggeration, but it is no exaggeration to say that the eminent writers to whom I have referred have given something of this clearness and completeness to such abstract mathematical theories as those of the electrical potential, the action of capillary forces, and the definition of absolute temperature. A great object will have been attained when an education in physical science on the basis laid down in these treatises has become generally accepted in our schools.

I do not wish to close this address without adverting, though only for one moment, to a question which occupies the minds of many of the friends of science at the present time, the question what should be the functions of the State in supporting, or in organising, scientific inquiry. I do not mean to touch on any of the difficulties which attend this question, or to express any opinion as to the controversies to which it has given rise. But I do not think it can be out of place for the President of this section to call your attention to the inequality with which, as between different branches of science, the aid of Government is afforded. National observatories for astronomical purposes are maintained by this, as by every civilised country. Large sums of money are yearly expended, and most rightly expended, by the Government for the maintenance of museums, and collections of mineralogy, botany, and zoology; at a very recent period an extensive chemical laboratory with abundant appliances for research as well as for instruction has been opened at South Kensington. But for the physical sciences—such sciences as those of heat, light, and electricity—nothing has been done; and I confess I do not think that any new principle would be introduced, or any great burden incurred, capable of causing alarm to the most sensitive Chancellor of the Exchequer, if it should be determined to establish, at the national cost, institutions for the prosecution of these branches of knowledge, so vitally important to the progress of science as a whole. Perhaps also, upon this general ground of fairness, even the pure mathematicians might prefer a modest claim to be assisted in the calculation and printing of a certain number of Tables, of which even the physical applications of their science are beginning to feel the pressing need.

One word further on this subject of State assistance to Science, and I have done. It is no doubt true that for a great, perhaps an increasing, number of purposes, Science requires the assistance of the State, but is it not nearer to truth to say that the State requires the assistance of Science? It is my conviction that if the true relations between Science and the State are not recognised, it is the State, rather than Science, that will be the great loser. Without Science the State may build a ship that cannot swim, and may waste a million or two on experiments, the futile result of which Science could have foreseen. But without the State, Science has done very well in the past, and may do very well in time to come. I am not sure that we should know more of pure mathematics, or of heat, of light, or electricity than we do at this moment if we had had the best help of the State all the time. There are, however, certain things which the State might do and ought to do for Science. It, or corporations created by it, ought to undertake the responsibility of carrying on those great systems of observation which, having a secular character, cannot be completed within the life-time of a single generation, and cannot therefore be safely left to individual energy. One other thing the State ought to do for Science. It ought to pay scientific men properly for the services which they render directly to the State, instead of relying, as at present, on their love for their work as a means of obtaining their services on lower terms. If anyone doubts the justice of this remark, I would ask him to compare the salaries of the officers in the British Museum with those which are paid in other departments of the Civil Service.

But what the State cannot do for Science is to create the scientific spirit, or to control it. The spirit of scientific discovery is essentially voluntary; voluntary, and even mutinous, it will remain: it will refuse to be bound with red tape, or ridden by officials, whether well-meaning or perverse. You cannot have an Established Church in Science, and, if you had, I am afraid there are many scientific men who would turn scientific nonconformists.

I venture upon these remarks because I cannot help feeling that the great desire which is now manifesting itself on the part of some scientific men to obtain for Science the powerful aid of the State may perhaps lead some of us to forget that it is self-reliance and self-help which have made Science what it is, and that these are qualities the place of which no Government help can ever supply.

Report of the Committee appointed to consider the possibility of improving the methods of instruction in Elementary Geometry.

Until recently the instruction in elementary geometry given in this country was exclusively based upon Simson's modification of the text of Euclid. Of late years, however, attempts have been made to introduce other text-books agreeing with the ancient *Elements* in general plan, but differing from it in some important details of treatment. And in particular, the Association for the Improvement of Geometrical Teaching, having considered the whole question with great labour and deliberation, is engaged in the construction of a Syllabus, part of which is already completed. The Committee had thus to consider, *first*, the question of the plurality of text-books; *secondly*, certain general principles on which deviation from the ancient standard has been recommended; and, *thirdly*, the Syllabus of the Geometrical Association.

1. *On the Plurality of Text-Books.*

It has already been found that the practical difficulty of examination stands in the way of allowing to the geometrical teacher complete freedom in the methods of demonstration, and in the order of the propositions. The difficulty of demonstrating a proposition depends upon the number of assumptions which it is allowable to start from; and this depends upon the order in which the subject has been presented. When different text-books have been used, it thus becomes virtually impossible to set the same paper to all the candidates. And in this country at present teaching is guided so largely by the requirements of examinations, that this circumstance opposes a serious barrier to individual attempts at improvement. On the other hand, the Committee think that no single text-book which has yet been produced is fit to succeed Euclid in the position of authority; and it does not seem probable that a good book could be written by the joint action of selected individuals. It therefore seems advisable that the requisite uniformity, and no more, should be obtained by the publication of an authorised Syllabus, indicating the order of the propositions, and in some cases the general character of the demonstrations, but leaving the choice of the text-book perfectly free to the teacher. And the Committee believe that the authorisation of such a Syllabus might properly come from the British Association.

2. *On some Principles of Improvement.*

The Committee recommend that the teaching of Practical Geometry should precede that of Theoretical Geometry, in order that the mind of the learner may first be familiarised with the facts of the science, and afterwards led to see their connection. With this end the instruction in practical geometry should be directed as much to the verification of theorems as to the solution of problems.

It has been proposed to introduce what are called redundant axioms; that is to say, assumptions whose truth is apparently obvious, but which are not independent of one another. Such, for example, as the two assumptions that two straight lines cannot enclose a space, and that a straight line is the shortest distance between any two of its points. It appears to the Committee that it is not advisable to introduce redundant axioms; but that all the assumptions made should be necessary for demonstration of the propositions, and independent of one another.

It appears that the Principle of Superposition might advantageously be employed with greater frequency in the demonstrations, and that an explicit recognition of it as an axiom of fundamental assumption should be made at the commencement,

The Committee think also that it would be advisable to introduce explicitly certain definitions and principles of general logic, in order that the processes of simple conversion may not be confounded with geometrical methods.

3. *The Syllabus of the Geometrical Association.*

The Association for the Improvement of Geometrical Teaching has issued (privately) a Syllabus covering the ground of the first four books of Euclid. The Committee are of opinion that the Syllabus is decidedly good, so far as it goes, but they do not wish to make a detailed report upon it in its present incomplete state. When it is finished, however, they will be prepared to report fully upon the merit of its several parts, to make such suggestions for revision as may appear necessary, and to discuss the advisability of giving to it the authority of the British Association. For this purpose the Committee request that they may be reappointed.

SECTION B.—Chemistry

A report on *Essential Oils*, prepared by Dr. Wright and Dr. Gladstone, was read by the former.

On Black Deposits of Metals, by Dr. Gladstone, F.R.S.

If one metal be thrown down from solution by means of another metal, it does not always present itself of the same colour as it exhibits when in mass; in fact, most metals that are capable of being precipitated by substitution may be obtained in a black condition. The allied metals, platinum, palladium, and iridium, are generally if not always black when thus precipitated, and bismuth and antimony form black fringes and little else. Similar fringes are also formed by gold, but it also yields green, yellow, or lilac metal according to circumstances. Copper, when first precipitated on zinc, whether from a weak or a strong solution, is black; but in the latter case it becomes chocolate-coloured as it advances, or red if the action be more rapid. Lead, in like manner, is always deposited black in the first instance, though the growing crystals soon become of the well-known dull grey. Silver and thallium appear as little bushes of black metal on the decomposing plate, if the solution be very weak; otherwise they grow of their proper colour. Zinc and cadmium give a black coating, quickly passing into grey when their weak solutions are decomposed by magnesium. The general result may be stated thus: If a piece of metal be immersed in the solution of another metal which it can displace, the latter metal immediately makes its appearance at myriads of points in a condition that does not reflect light; but as the most favourably circumstanced crystals grow, they acquire the optical properties of the massive metal, the period at which the change takes place depending partly on the nature of the metal and partly on the rapidity of its growth. In the production of the black deposit of the copper-zinc couple lately employed by the author and Mr. Tribe to break up various compound bodies, there are several stages that may be noticed. At first an outgrowth of copper forms on the zinc; then, while this action is still proceeding, the couple itself acts upon the water or the sulphate of zinc in solution, the metallic zinc being oxidised, and hydrogen gas or black zinc being formed against the copper branches. This deposit of zinc was originally observed by Dr. Russell. The arrangement of the particles between the two metals in connection is supposed to be somewhat thus:—

$$Cu \mid Zn\,SO_4 \mid Zn\,SO_4 \mid H_2O \mid H_2O \mid Zn$$

which, by the conjoint power and chemical force, becomes—

$$Cu \mid Zn \mid Zn\,SO_4 \mid H_2\,SO_4 \mid H_2O \mid Zn$$

If there is still copper sulphate in the solution, this deposited zinc may in its turn become coated with copper, but if it remains exposed to water it is sure to become oxidised. The black deposit often assumes a brownish colour when this is the case. The copper on which zinc has been deposited gives a brassy streak when rubbed in a mortar; but the presence of oxide tends to prevent the sticking together of the detached pieces of metal, and thus the formation of a streak on pressure. If, however, the oxide be removed by acetic acid, the clean ramifications of metal, whether black or otherwise, conglomerate of their own accord in a remarkable way, and little pressure is required to obtain a yellowish metallic streak; while if hydrochloric acid be used, the zinc itself also dissolves with effervescence, and the conglomerating pieces of metal, when rubbed, give a coppery streak.

The Secretary read a paper communicated by Mr. Tribe, *On an Improved Specific Gravity Bottle.* The apparatus was originally designed for taking the specific gravity of inflammable liquids, but, as the President explained, it might be used for any other class of liquids.

Mr. W. H. Pike read a paper on *Several Homologues of Oxaluric Acid.*

The anhydrides of dibasic acids combine with urea and sulpho-urea to form bodies which have the general formula.

$$R\left\langle\begin{matrix}CO—NH—CO—NH_2\\COOH\end{matrix}\right.$$

. The acids in this series which have been obtained are—

Succino-carbaminic acid, $\begin{matrix}CH_2—CO—NH—CONH_2\\|\\CH_2—COOH.\end{matrix}$

Succino-sulpho-carbaminic acid, $\begin{matrix}CH_2—CO—NH—CSNH_2\\|\\CH_2—COOH.\end{matrix}$

Citracon sulpho-carbaminic acid, $C_3H_4\left\langle\begin{matrix}CO.NH.CS.NH_2\\COOH.\end{matrix}\right.$

Dr. Wright read a paper on *New Derivatives of Codeine and Morphine.*

It was a *résumé* of the results obtained in the previous year in continuation of those brought before the Association on former occasions. Morphine gave rise by treatment with sulphuric acid to polymerides precisely analogous to those obtained from codeine under similar conditions. Trimorphine and tetramorphine had been isolated, but di-morphine had not yet been formed. Derivatives from these bodies by the action of hydrochloric acid had been obtained and extended. By the action of hydrochloric acid on morphine a chlorinated product had been formed. By further treatment this formed apomorphine, a new body. Under the same circumstances codeine gave rise to a chlorinated base homologous with that from morphine. But further action gave rise not to the apomorphine, but to a somewhat similar body containing more of the elements of water. The action of zinc chlorides on morphine had also been examined; the final products were apomorphine and an isomeric base of the tetra series, intermediate substances being formed. The physiological properties of most of these new derivatives had been stated, and some connection made out in certain cases between the composition and the physiological action.

Friday, September 19

The report of the Committee for superintending the Monthly Reports of the Progress of Chemistry was read. The report bore testimony to the great good which the publication of the abstracts of chemical papers by the Chemical Society had already effected, and in the discussion which ensued it was stated that amongst the purposes to which the Association applied its funds, there was none which had proved more useful than this grant.

The report of the Committee on Siemens's Pyrometer was read by Prof. G. C. Foster, F.R.S.

The experiment of which the results were communicated to the Chemical Section of the Association in the Report presented last year, having shown that the exposure of the Pyrometer to a red heat caused an alteration of the Zero-point of the instrument, which was attributed by Prof. Williamson, in consequence of experiments on the behaviour of platinum heated in contact with silica in an atmosphere of carbonic oxide, to the chemical alteration of the platinum of the pyrometer-coil due to the joint action of the silica of the porcelain core on which the wire was wound, and of the reducing atmosphere existing inside the protecting iron tube. Mr. Siemens supplied the Committee with two pyrometers, in which, in order to guard against the cause of change above-mentioned, the platinum coil was incased in a platinum tube placed inside the outer iron tube. The experiments of the Committee during the past year have been directed to testing the efficacy of this modification of the instrument. Owing to circumstances, these experiments have not been as numerous or complete as they were intended to be, but, as far as they go, they indicate that the addition of the platinum tube does not result in any perceptible improvement, since the two pyrometers supplied to the Committee were found to be as much changed, after being heated to a good red heat, as the instrument experimented upon last year.

Independent testimony, however, of considerable weight as to the value of Siemens's pyrometer, as an instrument for industrial use, has been borne by Prof. Adolf Weinhold, of Chemnitz (*Programm des königl. höherem Gewerbschule zu Chemnitz*, 1873), who after a careful, critical, and experimental review of various processes of pyrometry, arrives at the conclusion that this is the only ready-made pyrometer which can be recommended for use ("Von den fortig zu beziehenden Pyrometern ist nur das Siemens'sche brauchbar und empfehlenswerth," *loc. cit.* p. 42).

The Committee, therefore, consider that the further examination of Siemens's Pyrometer is a matter of sufficient importance to justify them in the recommendation that the Committee be re-appointed, and that the original grant of 30*l.*—no part of which has yet been expended—be renewed.

SECTION D.—Biology

Department of Zoology and Botany

Report of the Committee for the Foundation of Stations in different parts of the Globe.

The Committee reports that since the last meeting the Zoological Station at Naples has been completed, a photograph of which accompanies this report.

Both the mechanical and scientific arrangements inside require perhaps two more months to be finished, and though the cost of the whole has exceeded in no small degree the estimates, Dr. Dohrn hopes nevertheless to balance them by finding new means of income for the establishment. He has succeeded in obtaining a subvention of 1,500*l.* from the German Empire, and his scheme of letting working-tables in the laboratories of the station has met with general approval. Two tables have been let to Prussia and to Italy, one to Bavaria, Baden, and the Universities of Strasburg and Cambridge. A letter from the Dutch Minister of the Interior informs Dr. Dohrn that Holland accepts the offer of one table for the stipulated annual payment of 75*l.* Applications have also been made to the Imperial Government of Russia, both on the part of Dr. Dohrn and by different Russian scientific authorities. A correspondence has taken place between Dr. Dohrn and Professors Lovin and Steenstrup about a possible participation of the Scandinavian kingdoms, but has as yet led to no definite result. The case with respect to Switzerland and Saxony has been similar, but hopes are entertained that these countries may join the others in their endeavour to support the Zoological Station, and afford every facility to their naturalists of profiting by this new and powerful instrument of investigation.

Dr. Dohrn thinks it desirable to explain once more the leading ideas that have induced him to request the assistance of all these Governments and Universities.

The Zoological Station has sprung up altogether in consequence of the desire to facilitate investigation in marine zoology, and to enable naturalists to pursue their studies in the most effective manner and with the greatest possible economy of money and energy. All those zoologists that have visited Naples during the last year—amongst whom have been Professors Gegenbaur, Claus, Oscar Schmidt, Pagenstacher—consider that this end will be fully attained by the organisation and arrangements made or intended in the station. They all agreed that it is in the highest degree desirable that nobody who cares at all for the progress of zoology should fail to join Dr. Dohrn's exertions in bringing about a universal participation in the expense of keeping up the new establishment; and thus it is due to Prof. Oscar Schmidt's influence that the Imperial Government at Berlin hired a table for the University of Strasburg, and to the initiation of Prof. Pagenstacher that the Grand Duchy of Baden has also taken one table, whilst Prof. Claus has promised his services to induce the Austrian Government to take a similar step.

As is, we believe, universally known, no money-speculation whatever is contemplated by the founder of the Naples Station, in so far as money-speculation means a high interest and the return of the capital invested into the pocket of the founder. Nevertheless every honest means will be used to procure as large an income as possible, for more than one reason. There is not only the necessity incumbent upon the establishment to repay some of the capital to those who have lent money to Dr. Dohrn in order that he might complete the building in its actual enlarged state, a task for which his own means would not have sufficed, in spite of the German Government's subvention. There is further reserve funds to be provided for the eventuality that the income of the aquarium might at any time not cover the outlay for the year's management. And last, not least, it is just the plan to have every year a certain sum to spend for scientific pursuits. If, for instance, Prof. Dubois-Reymond, as he has expressed to Dr. Dohrn his wish to do so, should proceed to Naples to carry on experiments on the electric torpedo, it needs would require not inconsiderable means to buy the necessary apparatus and physiological instruments, and to provide the famous physiologist every day with fresh materials to conduct his investigations on a scale large enough to yield a distinct result. Or to enable embryologists to carry on an investigation on comparative selection-embryology, it requires means to buy large quantities of female sharks and skates, which are by no means so cheap as a foreigner might think. And for conducting well and accurately faunistic researches, everybody in this section knows what an amount of money must be spent in dredging-expeditions; how much trouble, how much time and work is necessary to get at the animals and to determine their identity or non-identity with the known and described species. And this is one of the foremost duties which the Zoological Station will propose to itself, as it is too well known how great a confusion exists with regard to systematic and faunistic questions of the Mediterranean fauna. To bring this confusion to an end it will require more than one lustrum and more than 1,000*l.* There may perhaps have risen a prejudice among systematists against the new establishment as one which, in consequence of the partiality of its leader for Darwinian views, might dispense altogether with Systematics. Nothing could be more erroneous than such an opinion. The leader of the zoological station is as little opposed to systematics as the Darwinian theory itself. He is of opinion—and the reporter can state this on the most absolute authority—that zoological battles may be best won according to Count Moltke's principle, "to march separately and to fight conjunctively," thus leaving to systematists their own route as well as to anatomists, physiologists, and embryologists, on condition only that they will, when meeting the enemy—error and ignorance—fight together. And he desires the zoological station to become such a battle-field, where all the different zoological armies may meet and fight their common adversaries.

That such wars need much of the one element, which, according to Monternouli, best secures victory—money, money, money, will be illustrated by two letters which Dr. Dohrn has received from Prof. Louis Agassiz, and which he has been authorised to publish.

The celebrated American naturalist writes, under the date "Museum of Comparative Zoology, Cambridge, Mass., June 10, 1873," the following:—

"It is a great pleasure and satisfaction to me, that I can tell you how, in consequence of the munificence of a wealthy New York merchant, it has become my duty to erect an establishment whose main object will be similar to that of your Naples station, only that teaching is to be united with it. The thing came thus to pass. During last winter I applied to our state authorities to secure more means for the museum in Cambridge (Mass.) Among the reasons, I alluded to the necessity of having greater means for trading purposes. I addressed my speech to our deputies, and it was afterwards reported in the newspapers. By chance the report fell into the hands of a rich and magnanimous tobacco-manufacturer, Mr. John Anderson, of New York. He sent, on the same day, a telegram asking me whether I would be at home on the following day for two friends, which I answered by 'yes.' The two gentlemen came, by order of Mr. Anderson, offering me a pretty little island in Buzzard Bay, for the purpose of erecting a zoological school. I accepted this offer, of course, but added, that without further pecuniary means it would be difficult to teach there. After two days, a sum of 50,000 dollars was handed over to me, and now I am erecting there a school for natural history, which at the same time will be a zoological station in the immediate neighbourhood of the gulf-stream, of the greatest assistance to our zoologists, especially as splendid dredging ground. This certainly must greatly promote zoological study in the United States. Already forty teachers of our Normal and high schools have applied for this summer's lessons; besides, I will be accompanied thereto by my private students. Some of my special colleagues are ready to assist me, so that I may hope to obtain already some results before winter's approach."

The next letter is dated "Penikese, Aug. 13, 1873," and contains some more information:—

"The school has been opened on July 8. Some of my friends have assisted me as teachers, several other naturalists are occupied with special studies. The bottom of the sea is very rich, the general situation quite excellent. The solitude which prevails is a great help for our teaching purposes. As students, forty teachers of our public schools are present, besides ten younger gentlemen, who prepare for a scientific career.

"The buildings are very well constructed and adapted to their uses. The two chief houses have a length of 120 feet, and a breadth of 25 feet each. In the lower story are the laboratories each with 28 windows; every student occupies one window, and has for himself one aquarium. In the upper story of each house are 28 bed-rooms, for every student one. The professors and naturalists are lodged in another house of the shape of a Greek cross. The dining-room is in a third house, which contains also the kitchen and the servants' rooms. Besides we have an ice-house, a cellar for alcohol, stables for domestic animals; about one hundred sheep are feeding in the pasture grounds of the island; some smaller hutches contain rabbits, guinea-pigs, &c.

"Next year physical, chemical, and physiological, laboratories will be constructed. . . .

"I believe I did not tell you before, that my son presented me on my birthday with 100,000 dollars for the enlargement of the Museum. I intend to apply this sum chiefly to the augmentation of the collections, hoping the State will pay for the enlargement of the buildings. . . ."

These letters prove that the name of this committee has not been ill-chosen, for though the American Zoological Station has not been founded by its direct intervention, there can be little doubt that the foundation of the Zoological Station of Naples has been the signal for a new and powerful movement to assist zoological research.

Of course the American Station has met with such extraordinary advantages, that a competition between it and Naples Station as regards means and favourable circumstances would be all but hopeless for the latter. Nevertheless it may prove the most powerful instrument in carrying out strictly the self-supporting principle, by earning money through the Aquarium, and by letting tables in the laboratory. And though any act of munificence to the Naples Station is exceedingly desirable, and would be heartily welcomed (as the moment has not yet arrived, where any scientific establishment in this world had at its disposal more money than it knew how to spend) the greatest stress will always be laid upon these two elements.

The reporter is further glad to state that the library of the Zoological Station has recently been augmented. A magnificent gift has been made by the Zoological Society of London, which presented a complete set of its illustrated proceedings. The Royal Academies of Copenhagen, Naples, and Berlin, have also granted their biological publications, and promised to continue to do so in future. The Jenckenberg Institute in Frankfort-on-the-Main, as well as the Zoological Gardens of that city, have sent all their transactions; as has the Smithsonian Institution in Washington, with respect to its biological publications. Well-founded hopes are entertained that in a short time many other academies and scientific societies will follow the example of the above-mentioned.

German publishers have continued to send their biological publications gratis to the library of the station, and great quantities of books, pamphlets, and separata from publications in periodicals, have been forwarded from all parts of the scientific world through the kindness of the authors.

From the side of the Zoological Station, though still in an embryonic state, considerable activity has been displayed with regard to furnishing continental zoologists with collections of well-preserved marine animals. Thus Prof. Wilhelm Müller in Jena, has been supplied with Amphioxus and Tunicata, Prof. Greeff of Marburg with large quantities of Echinodermata; mixed collections of every kind of animals have been sent to Prof. Oscar Schmidt, Strasburg, Prof. Claus, Vienna, to the Jenckenberg Museum at Frankfort, the Natural History Society at Offenbach, and many others.

Several German zoologists have already announced their intention to come during next winter and work in the station; a similar announcement is made through an Italian zoologist and through Prof. Foster. I am informed that two young English biologists will arrive at the station in January.

The committee hopes this report will convince the section, that the year between the present and the last meeting of the British Association has been one of steady and considerable progress for the Zoological Station at Naples. The committee refrains from making any further proposition to the section, but expresses its wish, that every influence may be used to secure to the station at Naples such assistance, as will serve to promote the eminent scientific ends for which it has been erected.

DEPARTMENT OF ANATOMY AND PHYSIOLOGY

OPENING ADDRESS BY THE PRESIDENT, PROFESSOR RUTHERFORD

In addressing you upon the subjects of anatomy and physiology, I would invite your attention to some of the features which characterise these departments of biology at this present time, and to some recent advances in physiology, the consideration of which you will find to be possessed of deep interest and importance.

State of Anatomy

Anatomy, dealing as it does merely with the structure of living things, is a far simpler subject than physiology, whose province it is to ascertain and explain their actions. It was not a difficult thing to handle such instruments as a knife and forceps, and with their aid to ascertain the coarser structure of the body. Accordingly, the naked eye anatomy of man has been fully investigated, and although the same cannot be said of that of many of the lower animals, it is nevertheless, as far as this kind of inquiry is concerned, a mere question of time as regards its completion. But minute or microscopic anatomy is in a different position. Requiring, as it does, the microscope for its pursuit, it could not make satisfactory progress until this instrument had been brought to some degree of perfection. Doubtless much advantage is still to be derived from improvements in the construction of this instrument; but probably most of the future advances in our knowledge of the structure of the tissues and organs of the body may be expected to result from the application of new methods of preparing the tissues for examination with such microscopes as we now have at our disposal. This expectation naturally arises from what has been accomplished in this direction during the last fifteen years. For example, what valuable information has been gained regarding the structure of such soft tissues as the brain and spinal cord by hardening them with such an agent as chromic acid, in order that these tissues may be cut into thin slices for microscopical study. How greatly has the employment of such pigments as carmine and the aniline dyes facilitated the microscopical recognition of certain elements of the tissues. What a deal we have learned regarding the structure of the capillaries, and the origin of lymphatics, by the effect which nitrate of silver has of rendering distinctly visible the outlines of endothelial cells. What signal service chloride of gold has rendered in tracing the distribution of nerves by the property which it possesses of staining nerve fibrils, and thereby greatly facilitating their recognition amidst the textures. Moreover of what value osmic acid has been in enabling us to study the structure of the retina. In the hands of Lockhart Clarke, Beale, Recklinghausen, Cohnheim, Stultz, and others, these agents have furnished us with information of infinite value, and those who would advance microscopical anatomy may do so most rapidly by working in the directions indicated by these investigators. In human microscopical anatomy, indeed, there only remain for investigation things which are profoundly difficult, such as, for example, the structure of the brain, the peripheral terminations of nerves, the development of nerve tissue, and other subjects equally recondite But in the field of comparative anatomy there is far greater scope for the histological investigator. He has only to avail himself of those reagents and methods which have recently proved so useful in the microscopical anatomy of the vertebrates; he has only to apply those more fully than has yet been done to the invertebrates, and he will scarcely fail to make discoveries. For the lover of microscopical research, there is, moreover, a wide field of inquiry in the study of comparative embryology; that is to say in the study of the development of the lower animals. Since it has become clear that a knowledge of the precise relations of living things one to another can only be arrived at by watching the changes through which they pass in the course of their development, research has been vigorously turned in this direction, and although an immense mass of facts has long since been accumulated regarding this question, Parker's brilliant researches on the development of the skull give an indication of the great things we may yet anticipate from this kind of research. Speaking of microscopical study before this audience, I cannot but remember that in this country more than in any other we have a number of learned gentlemen who, as amateurs eagerly pursue investigations in this department. I confess that I am always sorry to witness the enthusiastic perseverance with which they apply themselves to the prolonged study of markings upon diatoms, seeing that they might direct their efforts to subjects which would repay them for their labours far more gratefully. I would venture to suggest to such workers that it is now more than ever necessary to abandon all aims at haphazard discoveries, and to approach microscopy by the only legitimate method, of undergoing a thorough preliminary training in the various methods of microscopical investigation by competent teachers, of whom there are now plenty throughout the country.

State of Physiology

With regard to physiology, the present standpoint is not so high as in the case of anatomy. Physiology, resting as it does upon a tripod consisting of anatomy, physics or mechanics, and chemistry, is many-sided. The most minute anatomy, the most recondite physics, and the most complex chemistry, have all to be taken into account in the study of the physiology of living things; so that it is not surprising that it should, in its development, lag behind the comparatively elementary subject—anatomy. Until not so very long ago anatomy and physiology were in most of our medical schools taught by the same professor, who, although professing to teach both subjects, was generally more an anatomist than a physiologist. This arrangement gave to physiology a bias which was eminently anatomical, and this bias continued in many quarters, notwithstanding the separation of the physiological from the anatomical tuition. I am aware that there are still some distinguished anatomists who intermingle physiological with anatomical teaching. I am not questioning the usefulness of the practice when carried to a moderate extent. I wish merely to point out what appears to me to have been a result of the practice, and I believe that the result was to give to physiology an anatomical tendency. It was natural for the anatomist who dealt with visible structure to constantly refer to this in explaining physiological action or function. The physiologist with the anatomical tendency always tried to explain a difference in the action or function of a part by a difference in its evident structure, and when his microscope failed to show any structural difference between the cells which form saliva and those which produce pancreatic fluid, between the egg of a rabbit and that of a dog, he, baffled on the side of anatomy, was too ready to adopt the conclusion that inasmuch as the microscope reveals no difference in the structure there is really no structural difference between them, and that the only way in which the difference in action can be explained is by having recourse to the old hypothesis that the metamorphoses of matter, and the actions of force are in the living world regulated by a metaphysical entity termed a vital principle, and that dissimilar actions by similarly constructed parts are only to be explained by referring them to the operations of this principle. After alluding further to the hypothesis of the vital principle and its supposed actions, and after stating that he did not follow the teaching of those who still adhere to this doctrine, the lecturer said that, viewed from the physical side, there appears to be no reason for supposing that two particles of protoplasm, which possess a similar microscopic structure, must act in the same way; for the physicist knows that molecular structure and action are beyond the ken of the microscopist, and that within apparently homogeneous jelly-like particles of protoplasm there may be differences of molecular constitution and arrangement which determine widely different properties.

A great change is now taking place in physiological tuition in this country—a superabundance of physiological anatomy, and an almost entire absence of experiment, are no longer the characteristic features of our tuition. The study of physics, too much neglected, is happily now being more and more regarded as important in the preliminary training of the physiologist, as the study of anatomy and of chemistry; and I trust that the day is not far distant when in our medical schools the thorough education of our students in mathematics and physics will be insisted upon as absolutely essential elements in their preliminary education. Until this is done physiology will not advance in this country so rapidly as we could wish. I would not in this place have alluded to a question concerning medical education, but for the fact that the progress of physiology will always greatly depend upon the education of medical men, for only those who are conversant with physics and chemistry, and who, in addition, are acquainted with the phenomena of disease—that is to say, with abnormal physiological conditions—can handle physiology in all its branches. Physiology owes not a little to a study of pathology—that is, of abnormal physiological states. The study of a diseased condition has, on several occasions, given a clue to the discovery of the function of an organ. Nothing was known regarding the function of the spleen until the pathologist observed that an increase in the number of white corpuscles in the blood is commonly associated with an enlargement of this organ. Hence arose the now accepted doctrine that the spleen is concerned in the growth of blood corpuscles. The key to our knowledge of the functions of certain parts of the brain has also been supplied by a study of the diseased conditions of that organ. The very singular fact that the right side of the body is governed by the left, and not by the right side of the brain, was ascertained by observing that palsy of the right side of the body is associated with certain diseased conditions of the left side of the brain. That the corpus striatum is concerned in motion, while the optic thalamus is concerned in sensation; that intellectual operations are manifested specially through the cerebral hemispheres, are conclusions which were indicated by the study of diseased conditions. Moreover, by the pursuit of the same line of inquiry the key has been given to the discovery of many other facts regarding the brain functions. Some years ago M. Broca made the remarkable observation that, when a certain portion in the front part of the left side of the brain becomes disorganised by disease, the person loses the power of expressing his thoughts by words, either spoken or written. He can comprehend what is said to him, his organs of articulate speech are not paralysed, and he retains his power of writing, for he can copy words when told to do so, but when he is asked to give expression to his thoughts by speaking or by writing, or even to tell his name, he is helpless. With a palsy of a portion of his brain, he has lost his power of finding words—he has lost his memory for words; and mark you, although he loses his power of finding words, his intelligent perception of what passes around him and of what is said to him is not lost. It is true that this condition of aphasia, as it is termed, has been found to exist when various parts of the brain have been diseased; for example, it has been found to coexist with a diseased state of the posterior instead of the anterior part of the cerebrum. This fact renders it very difficult as yet to assign a precise locality to the faculty of speech. It is not, however, my intention to discuss this question, for my object is merely to show how the study of disease has given a clue to the physiologist. Broca's observation led to the thought that, after all, the dreams of the phrenologists would be realised, in so far as they supposed that the various mental operations are made manifest through certain definite territories of the brain.

It has until lately been supposed that the convolutions of the cerebrum are entirely concerned in purely intellectual operations, but this idea is now at an end. It is now evident, from recent researches, that in the cerebral convolutions—that is, in the part of the brain which was believed to minister to intellectual manifestations—there are nerve-centres for the production of voluntary muscular movements in various parts of the body. It has always been taught that the convolutions of the brain, unlike nerves in general, cannot be stimulated by means of electricity. This, although true as regards the brains of pigeons, fowls, and perhaps other birds, has been shown by Fritsch and Hitzig to be untrue as regards mammals. These observers removed the upper portion of the skull in the dog, and stimulated small portions of the exposed surface of the cerebrum by means of weak galvanic currents, and they found that when they stimulated certain definite portions of the surface of the convolutions in the anterior part of the cerebrum, movements are produced in certain definite groups of muscles on the opposite side of the body. By this new method of exploring the functions of the convolutions of the brain, these investigators showed that in certain cerebral convolutions, there are centres for the nerves presiding over the muscles of the neck, the extensor and adductor muscles of the forearm, for the flexor and rotator muscles of the arm, the muscles of the foot, and those of the face. They, moreover, removed the portion of the convolution on the left side of the cerebrum, which they had ascertained to be the centre for the movements of the right forelimb, and they found that after the injury thus inflicted, the animal had only an imperfect control over the movements of the part of the limb in question. Recently, Dr. Hughlings Jackson, from the observation of various diseased conditions in which peculiar movements occur in distinct groups of muscles, has adduced evidence in support of the conclusion that in the cerebral convolutions are localised the centres for the production of various muscular movements. Within the last few months these observations have been greatly extended by the elaborate experiments of my able colleague in King's College, Prof. Ferrier.

Adopting the method of Fritsch and Hitzig—but instead of using galvanic he has employed Faradic electricity, with which, strange to say, the investigators just mentioned obtained no very definite results—he has explored the brain in the fish, frog, dog, cat, rabbit, and guinea-pig, and lately in the monkey. The results of this investigation are of great importance. He has explored the convolutions of the cerebrum far more fully than the German experimenters, and has investigated the cerebellum, corpora quadrigemina, and several other portions of the brain not touched upon by them. There is, perhaps, no part of the brain whose function has been more obscure than the cerebellum. Dr. Ferrier has discovered that this ganglion is a great centre for the movements of the muscles of the eyeballs. He has also very carefully mapped out in the dog, cat, &c., the various centres in the convolutions of the cerebrum, which are concerned in the production of movements in the muscles of the eyelids, face, mouth, tongue, ear, neck, fore and hind feet, and tail. He confirms the doctrine that the corpus striatum is concerned in motion, while the optic thalamus is probably concerned in sensation, as are also the hippocampus major and its neighbouring convolutions. He has also found that in the case of the higher brain of the monkey there is what is not found in the dog or cat—to wit, a portion in the front part of the brain, whose stimulation produces no muscular movement. What may be the function of this part, whether or not it specially ministers to intellectual operations, remains to be seen. These researches of Fritsch, Hitzig, Jackson, and Ferrier, mark the commencement of a new era in our knowledge of brain function. Of all the studies in comparative physiology there will be none more interesting, and few so important, as those in which the various centres will be mapped out in the brains throughout the vertebrate series. A new, but this time a true, system of phrenology will be founded upon them; by this, however, I do not mean that it will be possible to tell a man's faculties by the configuration of his skull, but that the various mental faculties will be assigned to definite territories of the brain, as Gall and Spurzheim long ago maintained, although their geography of the brain was erroneous.

I have alluded to this subject, not only because it affords an illustration of the service which a study of diseased conditions has rendered to physiology, but also because these investigations constitute the most important work which has been accomplished in physiology for a very considerable time past.

Revival of Physiology in England

We may, I think, term this the renaissance period of English physiology. It seems strange that the country of Harvey, John Hunter, Charles Bell, Marshall Hall, and John Reid, should not always have been in the front rank as regards physiology. The neglect of physics must be admitted as a cause of this; it is also to be attributed to the, until a few years ago, almost entire absence of experimental teaching; but it would be unjust not to attribute it in great measure to the limited appliances possessed by our physiologists. It is to be remembered that physiology could not be successfully cultivated without proper laboratories, with a supply of expensive apparatus. Without endowments from public or private resources, how can such institutions be properly fitted up and maintained by men who can, for the most part, only turn to physiological research in moments snatched from the busy toil of a profession so laborious as that of medicine. In defiance of these difficulties we are now striving to hold our place in the physiological world. A new system of physiological tuition is rapidly extending over the country. In the London schools, in Edinburgh, Cambridge, Manchester, and elsewhere, earnest efforts are being made to give a thoroughly practical aspect to the tuition of our science, and notwithstanding the imperfect results which must necessarily ensue in the absence of suitable endowment, we can nevertheless point to the fact that the effect of these efforts has been to awaken a love for physiological research in the mind of many a student, and the results of this awakening are already apparent in the archives of Royal Societies, in the "Journal of Anatomy and Physiology," and elsewhere. But physiological research is most expensive and laborious, and it is, moreover, unremunerative. The labours of the physiologist are entirely philanthropic; all his researches do nothing but contribute to the increase of human happiness by the prevention of disease, and the amelioration of suffering; and I would venture to suggest to those who are possessed of wealth and of a desire to apply it for the benefit of society, that in view of the wholly unselfish and philanthropic character of physiological labours, they could not do better than follow the admirable example set by Miss Brackenbury in endowing a physiological laboratory in connection with Owens College, in Manchester. The endowment of a dozen such laboratories throughout the country would immensely aid in the development of physiological research amongst us.

We anticipate great benefit to the community not only from an advance of physiology, but from a diffusion of a knowledge of its leading facts amongst the people. This is now being carried out in our schools on a scale which is annually increasing. Thanks to the efforts of Huxley, the principles of physiology are now presented in a singularly palatable form to the minds of the young. The instruction communicated does not consist of technical terms and numbers, but in the elucidation of the principal events which happen within our bodies, together with an explanation of the treatment which they must receive in order to be maintained in health. Considering how much may be accomplished by these bodies of ours if they be properly attended to and rightly used, it seems to be a most desirable thing that the possessor of the body should know something about its mechanism, not only because such knowledge affords him much material for suggestive thought—not only because it is excellent mental training to endeavour to understand the why and the wherefore of the bodily actions, but also because he may greatly profit from a knowledge of the conditions of health. A thorough adoption of hygienic measures—in other words, of measures which are necessary to preserve individuals in the highest state of health—cannot be hoped for until a knowledge of fundamental physiological principles finds its way into every family. This country has taken the lead in the attempt to diffuse a sound knowledge of physiological facts and principles among the people, and we may fairly anticipate that this will contribute not a little to enable her to maintain her high rank amongst nations; for every step which is calculated to improve the physiological state of the individual must inevitably contribute to make the nation successful in the general struggle for existence.

DEPARTMENT OF ANTHROPOLOGY

OPENING ADDRESS BY THE PRESIDENT, JOHN BEDDOE, F.R.S.

The position of Anthropology in the British Association, as a permanent department of the Section of Biology, being now fully assured, and its relations to the allied and contributory sciences beginning to be well understood and acknowledged, I have not thought it necessary, in opening the business of the department, to follow the examples of my predecessors, Prof. Turner and Colonel Lane Fox. The former of these gentlemen, at our Edinburgh Meeting, devoted his opening address to the definition, history, and boundaries of our science; the latter, at Brighton, in the elaborate essay which many of you must have listened to, not only discussed its relations to other sciences, but gave an illustrative survey of a great portion of its field and of several of its problems.

But while, on the one hand, I feel myself incompetent to follow these precedents with success, on the other hand I am encouraged to take a different line by the consideration that if, as we are fond of saying in this department, "the proper study of mankind is man"—if, that is, anthropology ought to interest everybody, then assuredly the anthropology of Yorkshire ought to interest a Yorkshire audience.

Large as the county is, and sharply marked off into districts by striking diversities of geological structure, of climate and of surface, there is an approach to unity in its political and ethnological history which could scarcely have been looked for.

Nevertheless we must bear in mind the threefold division of the shire—not that into ridings, but that pointed out by nature. We have, first, the western third, the region of carboniferous limestone and millstone-grit, of narrow valleys and cold rainy moorlands; secondly, the great plain of York, the region, roughly speaking, of the Trias, monotonously fertile, and having no natural defence except its numerous rivers, which indeed have sometimes served rather as a gateway to the invader than as a bulwark against him; to this plain Holderness and the Vale of Pickering may be regarded as eastern adjuncts. Thirdly, we have the elevated region of the east, in the two very dissimilar divisions of the moorlands and the wolds; these are the most important parts of Yorkshire to the prehistoric archæologist; but to the modern ethnologist they are comparatively of little interest.

The relics of the palæolithic period, so abundant in the south of England, are, I believe, almost wholly wanting in Yorkshire, where archæology begins with the neolithic age, and owes its foundations to Canon Greenwell of Durham, Mr. Mortimer of Driffield, Mr. Atkinson of Danby, and their predecessors in the exploration of the barrows of Cleveland and the Wolds, whose results figure largely in the "Crania Britannica" of Davis and Thurnam,—themselves, by the way, both natives of the city of York.

The earliest inhabitants we can distinctly recognise were the builders of certain long barrows, such as that of Scamridge in Cleveland. There is still, I believe, some difference of opinion among the anthropologists of East Yorkshire (where, by the way, in the town of Hull, the science flourishes under the auspices of a local Anthropological Society)—still, I say, some difference of opinion as to whether the long-barrow folk were racially diverse from those who succeeded them and who buried their dead in round barrows. But Canon Greenwell at least adheres to Thurnam's doctrine, and holds that Yorkshire, or part of it, was occupied at the period in question, perhaps 3,000 years ago, by a people of moderate or rather short stature, with remarkably long and narrow heads, who were ignorant of metallurgy, who buried their dead under long ovoid barrows, with sanguinary rites, and who labour under strongly-founded suspicions of cannibalism.

Of the subsequent period, generally known as the bronze age, the remains in Yorkshire, as elsewhere, are vastly more plentiful. The Wolds especially, and the Cleveland hills, abound with round barrows, in which either burnt or unburnt bodies have been interred, accompanied sometimes with weapons or ornaments of bronze, and still more often with flint arrowheads. Where bones are found, the skull presents what Barnard Davis considers the typical British form; *i.e.* it is generally rather short and broad, of considerable capacity and development, with features harsh and bony. The bodily frame is usually tall and stalwart, the stature often exceeding 6 ft., as in the well-known instance of the noble savage of Gristhorpe, whose skeleton is preserved in the Scarborough Museum.

Though certain facts, such as the known use of iron in Britain before Cæsar's time, and its extreme rarity in these barrows, and some little difference in proportion between the skulls just described and the type most common among our modern British Kelts, do certainly leave room for doubt, I have little hesitation in referring these round barrows to the Brigantes and Parisii,* the known occupants of Yorkshire before the Roman conquest.

Both what I will term provisionally the pure long-barrow and the pure round-barrow types of cranium are represented among our modern countrymen. But the former is extremely rare, while the latter is not uncommon. It is probable enough that the older type may, in amalgamating with the newer and more powerful one, have bequeathed to the Kelts of our own time the rather elongated form which prevails among them. Whether this same older type was really Iberian is a point of great interest, not yet ripe for determination.

Another moot point is the extent to which the population of modern England is derived from the colonists introduced under the Roman occupation. It is my own impression that the extent, or rather the intensity of such colonisation has been over-estimated by my friend Mr. Thomas Wright and his disciples. I take it that, in this respect, the Roman occupation of Britain was somewhere between our own occupations of India and of South Africa, or perhaps still more nearly like that of Algeria by the French, who have their roads, villas, and military establishments, and even considerable communities in some of the towns, but who constitute but a very small percentage of the population, and whose traces would almost disappear in a few generations, could the communication with the mother-country be cut off.

If, however, any traces of the blood of the lordly Romans themselves, or of that more numerous and heterogeneous mass of people whom they introduced as legionaries, auxillaries, or colonists, are yet recognisable anywhere in this county, it may probably be in the city of York, or in the neighbourhood of Catterick. The size and splendour of ancient Eburacum, its occupation at various times as a sort of military capital by the Emperor Severus and others, its continued existence through the Anglian and Anglo-Danish periods, and its subsequent comparative freedom from such great calamities * or vicissitudes as are apt to cause great and sudden changes of population, might almost induce us to expect to find such vestiges. If Greek and Gothic blood still assert themselves in the features and figures of the people of Arles, if Spanish characteristics are still recognisable in Bruges, why not Italian ones in York? It may be so; but I must confess that I have not seen them, or have failed to recognise them. Catterick, the site of ancient Cataractonium, I have not visited.

Of the Anglian conquest of Yorkshire we know very little, except that it was accomplished gradually by successive efforts, that the little district of Elmet, in the neighbourhood of Leeds, continued British for a while, and that Carnoban, which is almost certainly Craven, is spoken of by a Welsh writer as British after all the rest of the country had ceased to be so—a statement probable enough in itself, and apparently corroborated by the survival of a larger number of Keltic words in the dialect of Craven than in the speech of other parts of Yorkshire.

Certain regulations and expressions in the Northumbrian laws, among others the less value of a churl's life as compared with that of a thane, have been thought to indicate that the proportion of the British population that remained attached to the soil, under Anglian lords, was larger in the north than in some other parts of England. The premisses are, however, insufficient to support the conclusion; and, on the other hand, we are told positively by Bede that Ethelfrith Fleisawr drove out the British inhabitants of extensive districts. The singular discoveries of Boyd Dawkins and his coadjutors in the Settle Cave, where elaborate ornaments and enamels of Romano-British type are found in conjunction with indications of a squalid and miserable mode of life long endured, attest clearly the calamities of the natives about that period (the early part of the seventh century), and show that even the remote dales of Craven, the least Anglian part of Yorkshire, afforded no secure refuge to the Britons of the plains, the unfortunate heirs of Roman civilisation and Roman weakness. The evidence yielded by local names does not differ much from that of the same kind in other parts of England. It proves that enow of Welshmen survived to transmit their names of the principal natural features (as Ouse, Derwent, Wharfe, Dun, Roseberrry, Pen-y-gent), and of certain towns and villages (as York, Catterick, Beverley, and Ilkley), but not enow to hinder the speedy adoption of the new language, the re-naming of many settlements, and the formation of more new ones with Anglian names. The subsequent Danish invasion slightly complicated this matter; but I think it is safe to say that the changes in Yorkshire were more nearly universal than in counties like Devonshire, where we know that the descendants of the Welsh constitute the majority. If the names of the rivers Swale and Hull be really Teutonic, as Greta undoubtedly is, the fact is significant; for no stream of equal magnitude with the Swale, in the south of England, has lost its Keltic appellation.

We do not know much of the Anglian type, as distinguished from the Scandinavian one which ultimately overlaid it almost everywhere to a greater or less depth. The cranial form, if one may judge of it by the skulls found in the ancient cemetery of Lamel-Hill near York, was not remarkably fine, certainly not superior to the ancient British type as known to us, to which, moreover, it was rather inferior in capacity. There is some resemblance between these Lamel-Hill crania and the Belair or Burgundian type of Switzerland, while the Sion or Helvetian type of that country bears some likeness to our own Keltic form.

* It has been conjectured that the Parisii were Frisians; but I think it very unlikely.

* Unless indeed York was the "municipal town" occupied by Cadwalla and besieged by his Anglian adversaries.

The group of tumuli called the Danes' Graves, lying near Driffield, and described by Canon Greenwell in the *Archæological Journal*, have yielded contents which are a puzzle for anthropologists. Their date is subsequent to the introduction of the use of iron. Their tenants were evidently not Christians; but they belonged to a settled population. The mode of interment resembles nothing Scandinavian; and the form of the crania is narrower than is usual, at least in modern times, in Norway and Denmark. It is hazardous to conjecture anything about them; but I should be more disposed to refer them to an early Anglian or Frisian settlement than to a Danish one.

We come now to the Danish invasions and conquest, which, as well as the Norman one that followed, was of more ethnological importance in Yorkshire than in most other parts of England. The political history of Deira, from the ninth century to the eleventh, the great number of Scandinavian local names (not greater, however, in Yorkshire than in Lincolnshire), and the peculiarities of the local dialect, indicate that Danes and Norwegians arrived and settled, from time to time, in considerable numbers. But in estimating these numbers we must make allowance for their energy and audacity, as well as for the very near kinship between the Danes and the Northumbrian Angles, which, though it did not prevent sanguinary struggles between them at first and great destruction of life, must have made amalgamation easy, and led the natives readily to adopt some of the characteristics of the invaders.

Whatever the Danish element in Yorkshire was, it was common to Lincolnshire and Nottinghamshire, and to the north-eastern part of Norfolk; and it was comparatively weak in Northumberland and even in Durham. In Yorkshire itself, it was irregularly distributed, the local names in *by*, *toft*, and *thwaite*, and the like being scattered in a more or less patchy manner, as may be seen on Mr. Taylor's map. They are very prevalent in Cleveland, as has been shown by Mr. Atkinson. Again, the long list of the landowners of the county under Edward the Confessor, given in Domesday Book, contains a mixture of Anglian with Scandinavian names, the latter not everywhere preponderating. Here, again, Cleveland comes out very Danish. I am inclined to believe that the Anglian population was, in the first fury of the invasion, to some extent pushed westwards into the hill-country of the West Riding, though even here distinctly Danish names, such as Sowerby, are quite common. Beverley and Holderness perhaps remained mainly Anglian.

The Norman conquest fell upon Yorkshire, and parts of Lancashire and Durham, with unexampled severity. It would seem that the statement of William of Malmesbury that the land lay waste for many years through the length of sixty miles, was hardly, if at all exaggerated. The thoroughness and the fatal effects of this frightful devastation were due, no doubt, partly to the character of William, who, having once conceived the design, carrried it out with as much completeness and regularity as ferocity, and partly to the nature of the country, the most populous portion of which was level and devoid of natural fastnesses or refuge, but also, in some degree, to the fact that the Northumbrians had arrived at a stage of material civilisation at which such a mode of warfare would be much more formidable than while they were in a more barbarous condition, always prepared for fire and sword, and living, as it were, from hand to mouth. Long ages afterwards the Scots told Froissart's informants that they could afford to despise the incursions of the English, who could do them little harm beyond burning their houses, which they could soon build up again with sticks and turf; but the unhappy Northumbrians were already beyond that stage.

In all Yorkshire, including parts of Lancashire, Westmoreland, and Cumberland, Domesday numbers only about 500 freemen, and not 10,000 men altogether. This great destruction, or rather loss of population (for it was due in some measure to the free or forced emigration to Scotland of the vanquished), did not necessarily imply ethnological change. Let us examine the evidence of Domesday on this point. It agrees with that of William of Malmesbury, that the void created by devastation remained a void, either entirely or to a great extent. Whole parishes and districts are returned as "waste." In one instance 116 freemen (sockmanni) are recorded to have held land in King Edward's time, of whom not one remained; in another, of 108 sokemen only 7 remained. But foreigners *did* settle in the county to some extent, either as military retainers of the new Norman lords, as their tenants, or as burgesses in the city of York, where 145 francigenæ (Frenchmen) are recorded as inhabiting houses.

Of the number maintained by way of garrisons by the new nobility, one can form no estimate; but considering the impoverished and helpless condition of the surviving natives, such garrisons would probably not be large. But from the enumeration of mesne tenants, or middlemen, some inferences may perhaps be drawn. On six great estates, comprising the larger part of Eastern and Central Yorkshire, sixty-eight of these tenants are mentioned by name, besides 11 milites, or men-at-arms. Only 11 of the 68 bear names undoubtedly English; and none of them have large holdings, as is the case with some of those bearing Norman names. On the lands of Drogo de Bevrere, about Holderness, several of the new settlers were apparently Flemings.

The western part of the county, however, or the greater part of it, had been granted to two lords who pursued a more generous policy. Alan, count of Bretagne, the founder of Richmond, had twenty-three tenants, besides twelve milites, men-at-arms with very small holdings. Of the twenty-three, nine were Englishmen, in several instances holding as dependents the whole or part of what had been their own freeholds. The Breton ballads and traditions seem to favour the supposition that Count Alan's Breton followers mostly returned home; and Count Hersart de la Villemarquée, the well-known Breton archæologist, informed me that his ancestors returned to Bretagne from Yorkshire in the twelfth century. On the whole, I do not think it probable that the Breton colony was numerous enough to leave distinct and permanent vestiges; but if any such there are, they may be looked for in the modern inhabitants of Richmond and Gilling.

Ilbert de Lacy, again, had a great domain, including most part of the wapentakes of Morley, Agbrigg, Skyrack, and Staincross, extending, that is, far to the north and south of our present place of meeting. Bradford, by the way, was then hardly so important and wealthy as at the present day. A thane named Gamel had held it at the time of Edward the Confessor, when it was valued at 4*l*. yearly; but at the time of the survey it was waste, and worth nothing.

Sixty-seven mesne tenants under Ilbert de Lacy are mentioned, of whom no less than forty-one bore English names, and only twenty-six foreign ones. It is probable, therefore, that in this important part of the county the ethnological change wrought by the Conquest was not greater, if so great as in England generally, but that in the centre, east, and north-east it was of some moment, and that the Scandinavian element of population suffered and lost more than the Anglian.

It might be a matter of some interest to a minute ethnologist or antiquarian to trace out fully the local history after the Conquest from an ethnological point of view, investigating particularly the manner and source of the repeopling of the great plain of York.

After this had been completed, no further change of ethnological importance took place during several centuries. The Flemings and Frisians, who, in considerable numbers, settled at various times in Leeds, Halifax, and Wakefield, whether drawn hither by the course and opportunities of trade, or driven by the persecutions of Philip II. and the Roman Catholics, brought in no new element, and readily amalgamated with the kindred race they found here.

The more recent immigrations into the West Riding and Cleveland from all parts of Britain, and even from the Continent, have interest of other kinds. Vast as they have been, they have not yet obscured in any great degree the local types, physical or moral, which still predominate almost everywhere, though tending of course to assimilate themselves to those of the mixed population of England in general.

In describing these types I prefer to use the words of Prof. Phillips, who, in his "Rivers of Yorkshire," has drawn them in true and vivid colours. He speaks of three natural groups:—

"First. Tall, large-boned, muscular persons; visage long, angular; complexion fair or florid; eyes blue or grey; hair light, brown or reddish. Such persons in all parts of the county form a considerable part of the population. In the North Riding, from the eastern coast to the western mountains, they are plentiful.

Second. Person robust; visage oval, full and rounded; nose often slightly aquiline; complexion somewhat embrowned, florid; eyes brown or grey; hair brown or reddish. In the West Riding, especially in the elevated districts, very powerful men have these characters.

"Third. Person of lower stature and smaller proportions; visage short, rounded, complexion embrowned; eyes very dark, elongated; hair very dark. Individuals having these characters occur in the lower grounds of Yorkshire, as in the valley of the Aire below Leeds, in the vale of the Derwent, and the level regions south of York."

I have chosen to quote from Professor Phillips rather than to give descriptions of my own, both because his acquaintance with the facts is more extensive than mine, and because I desire to pay my small tribute to the genius and insight of the author of a work so unique and so admirable as his upon Yorkshire.

He ascribes the first and second of these types mainly to a Scandinavian, the last to a Romano-British, or possible Iberian origin; and appears to think that the first, the tall, fair, long-faced breed, resembles the Swedes, and that the second, the brown burly breed of the West Riding, is more Norwegian in character. He probably selects the Swedes as the purest or most typical of the Scandinavian nations. For my own part, I am disposed to treat the first as Norwegian more than Anglian, the second as Anglian rather than Norse, and Norse rather than British. The tall fair type engrosses most of the beauty of the north, having often an oval face, with a fine straight profile nearly approaching the Greek, as Knox and Barnard Davis, two close observers, have both remarked. And it is markworthy that it reappears in force almost everywhere in Britain where Norse blood abounds, *e.g.* in Shetland, Orkney, Caithness, in the upper class of the Hebrideans, in Cumberland, Westmoreland, and Lonsdale, about Lincoln (where Professor Phillips also noted it) and the Vale of Trent, and about the towns of Waterford and Wexford. The second type, on the other hand, much resembles a prevailing form in Staffordshire, a very Anglian county. A notable point about it is the frequency of eyes of a neutral, undecided tint, between light and dark, green, brown, and grey, the hair being comparatively light. The third is of more doubtful and of more manifold origin. Iberian, Britokeltic, Roman, Breton, Frenchman, may all, or any of them, have contributed to its prevalence. I am inclined to think, though on rather slender grounds, that it is common in some of the districts depopulated by the Conqueror. Professor Phillips speaks of its smaller proportions, but it includes many robust men. It is probably far from well representing the Brigantian type, which seems to me to have influenced the other types, but rarely to crop out all purely.

The breadth of the head is, on the average, somewhat greater in Yorkshire than in other parts of Britain; so we are informed by the hatters. In this the natives of Yorkshire agree with those of Denmark and Norway, who have rather broader heads than those of Sweden and of Friesland.

I have already spoken of the colours of the eyes and hair. The latter is, on the whole, lighter in Yorkshire than in most parts of England; but dull rather than bright shades prevail. In the east, at Whitby, Bridlington, and Beverley, in Teesdale and Middle Airedale, light hair is particularly abundant; in Craven, as might have been expected, it is less so. Other parts of the county are not so well known to me, and in this matter I have to trust to my own observations.

As to the stature and bulk of the people, however, I have much and accurate information, through the kindness of numerous observers, some of them of repute as naturalists. These are Mr. Atkinson of Danby, Mr. Tudor of Kirkdale, Dr. Wright of Melton, Dr. Christy of the North Riding Asylum, Drs. Kelburne King and Casson of Hull, Mr. Ellerton of Middlesborough, Mr. Wood of Richmond, Mr. Kaye of Bentham, Mr. Edy of Grassington, Dr. Paley of Ripon, Dr. Ingham of Haworth, Messrs. Armitage of Farnley, Dr. Wood of Kirkby Overblow, Dr. Aveling and Mr. Short of Sheffield, Mr. Miller, late of Wakefield Prison, and a clergyman on the Wolds, whom the prejudices or fears of his parishioners will not allow me to name. "A Yorkshireman," complained this last gentleman, "is a difficult animal to catch and weigh and measure;" but a very large number of them have been subjected to these processes by my obliging correspondents. The general result is that in the rural districts they are remarkably tall and stalwart, though not, except in parts of the west, so heavy as their apparent size would indicate—but that in the towns, and especially in Sheffield, they are rapidly degenerating; and I conclude from the Haworth report that the same is the case in the manufacturing villages. In many of the rural districts the average ranges between 5 ft. 8 in. and 5 ft. 9 in., and about Richmond and on the Bentham Fells is considerably higher: while at Sheffield and even at Haworth, it may hardly reach 5 feet 6 inches. The causes of this great degeneration are manifold: some of them may easily be traced; but either the will or the power to remedy the evil is wanting.

Of the moral and intellectual endowments of Yorkshiremen, it may perhaps appear presumptuous or invidious to speak; but the subject is too interesting to be passed by in silence, and I will endeavour to treat it without either "extenuating, or setting down aught in malice." In few parts of Britain does there exist a more clearly marked moral type. To that of the Irish it has hardly any affinity; but the Scotchman and the Southern Englishman alike recognise the differences which distinguish the Yorkshire character from their own, but are not so apt to appreciate the numerous respective points of resemblance. The character is essentially Teutonic, including the shrewdness, the truthfulness without candour, the perseverance, energy, and industry of the Scotch, but little of their frugality, or of the theological instinct common to the Welsh and Scotch, or of the imaginative genius, or the more brilliant qualities which sometimes light up the Scottish character.

The sound judgment, the spirit of fair-play, the love of comfort, order, and cleanliness, and the fondness for heavy feeding are shared with the Saxon Englishman; but some of them are still more strongly marked in the Yorkshireman, as is also the bluff independence—a very fine quality when it does not degenerate into selfish rudeness. The aptitude for music was remarked by Giraldus Cambrensis seven centuries ago; and the taste for horseflesh seems to have descended from the old Norsemen, though it may have been fostered by local circumstances. The mind like the body, is generally very vigorous and energetic, and extremely well adapted to commercial and industrial pursuits, as well as the cultivation of the exact sciences; but a certain defect in imaginative power must, I think, be admitted, and is probably one reason, though obviously not the only one, why Yorkshire, until quite modern times, was generally behindhand in politics and religion, and why the number of her sons who, since Cædmon, have attained to high eminence in literature is not above the average of England.

DIARY

WEDNESDAY, October 1.

Royal Microscopical Society, at 8.—A description of some new species of Diatomaceæ: F. Kitton.—On an Organism found in fresh pond water: Dr. Maddox.

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