THURSDAY, AUGUST 8, 1907.

RESEARCH IN CHINA.

Research in China. In three volumes and Atlas: vol. i. in 2 parts. Part i. *Descriptive Topography and Geology.* By Bailey Willis, Eliot Blackwelder, and R. H. Sargent. Pp. xiv. + 354 + xvi. (Washington, D.C.; Published by the Carnegie Institution, 1907.)

THE title of this volume recalls the great pioneer work of the illustrious Baron von Richthofen, to whom science is indebted for the first broad and masterly sketch of the physiography and geology of the Celestial Empire. His volumes, unfortunately left still incomplete at the time of his lamented death, form the basis on which all later explorers will build. He indicated some of the great problems which remain to be solved by a more prolonged and minute survey than it was in his own power to achieve. But even where he left questions in doubt, his trained powers of observation sometimes enabled him to see so far into them, and to leave so many pregnant suggestions concerning them, that the paths for subsequent exploration have been indicated by him to his successors.

One of these paths lay in the further investigation of the great series of ancient sedimentary deposits, to which Richthofen gave the name of "Sinisches" (Sinesian or Sinian) system. He collected from what he regarded as the higher parts of this system a number of fossils, which proved the strata containing them to be of Cambrian age. As these sedimentary accumulations appeared to be thousands of feet in thickness, they seemed to offer at least a possibility that, in their lower members, traces might be found of a still older or pre-Cambrian fauna. The great interest which would attach to the discovery of any recognisable remains of that primæval biological period had long drawn the attention of geologists to the desirability of following up the suggestive observations of the German explorer. The opportunity of undertaking this investigation came at last when the Carnegie Institution of Washington was founded in 1902, with ample funds for the purposes of scientific research of every kind in all quarters of the globe. Mr. C. D. Walcott, then the energetic Director of the United States Geological Survey, whose contributions to Cambrian palæontology have given him a worldwide reputation, suggested the sending out of an expedition to China, one of the objects of which should be the further elucidation of the fossil contents of the oldest Palæozoic rocks of the country. He succeeded in planning and organising a scientific mission for the purpose of investigating the stratigraphy, palæontology, structure, and physiography of the regions to be visited. The first grant was made by the Carnegie Institution in the autumn of the year 1902, but it was not until July of the following year that the mission sailed for Europe. The party consisted of two geologists, Mr. Bailey Willis, an active member of the staff of the United States Geological Survey, to whom the chief charge of the expedition was assigned, and Mr. Eliot Blackwelder, of the University of Chicago. They were subsequently joined in China by Mr. R. Harvey Sargent, of the United States Geological Survey, who acted as topographer, and produced the series of maps which forms the Atlas.

The observers reached Pekin late in September, 1903, and spent about two months of the autumn of that year in the geological investigation of certain parts of the province of Shan-tung. The first five and a half months of 1904 were devoted to the exploration of Central China, and the journey of investigation came to an end at I-chang, on the Yang-tzi-kiang, on June 9. The time occupied by the research was thus little more than seven months in all. During this brief period the party must have worked hard. Their topographical surveys by graphic plane-table triangulation went on at an average rate of nearly fifty square miles a day, and an area of 2,900 square miles was mapped in fifty-eight days and a half. While the topographer was thus active, the geologists were simultaneously busy with their observations and collections. The results of this combined labour are intended to fill three massive volumes and an atlas of maps. The first part of the first volume which, with the Atlas, has just been issued, forms a bulky quarto of more than 350 pages, with upwards of fifty plates, consisting of photographic views of landscapes, maps, and geological sections. The second part is to include systematic petrography, zoological notes, and a syllabary of Chinese sounds. The second volume is intended "to summarize the detailed presentation of our results, and to combine them with the work of others in a systematic discussion of the geology of south-eastern Asia." The third volume is to be devoted to Palæontology. The Atlas contains some forty sheets of maps, sections, and photographic views, most of the maps being on the scale of 1/125,000, or two miles to the inch, engraved and coloured in the excellent style to which the United States Geological Survey has now accustomed us.

We willingly record our appreciation of the energy, skill, and success with which this expedition has been conducted. But we feel sure that the question will be asked by many not unsympathetic onlookers—were the few months of rapid and necessarily imperfect and incomplete observation sufficient to justify the addition of all these volumes to the ever-growing mass of geological literature? It has long been a characteristic of American geological explorers that they cannot simply describe what they have seen, but must launch out into theoretical disquisitions and systematic discussions, for which there has often been but slender basis in their own work. The various pioneering and other surveys have thus built up a pile of huge quartos, in which the really valuable original observations are often practically buried out of sight. The books are heavy alike for the hand and the head. They take up a large amount of space on library shelves, where they are now, we fear, comparatively seldom consulted.

The volume now before us is a conspicuous illustration of the American habit here referred to. We venture to think that all that was new and important among the results of the expedition might easily have been comprised within the limits of this first single volume. Not content, however, with the space the observers have contrived to fill with the amplification of their notes and discussions of the physiography of the regions which they rapidly traversed, and of which they can have acquired only the most superficial knowledge, Mr. Bailey Willis is yet to inflict upon us another volume of his "detailed presentation of results," besides the other reports that are promised.

If it is asked what have been the chief fruits of this skilfully-planned foray into the Chinese empire, two conspicuous features may be pointed to, on which the explorers deserve to be congratulated. They have materially increased our knowledge of the earliest Palæozoic fauna of China, and they have brought to light a remarkable band of boulder-clay, full of striated stones, lying apparently at the base of the Cambrian system.

The large increase which has thus been made to the known Cambrian fossils of China has been provisionally discussed by Mr. Walcott in a paper published in 1905, in the Proceedings of the United States National Museum, and will be more fully treated in the third volume of the Reports of the Expedition. It appears that at least forty-eight genera and 172 species of organisms are now known to occur in Chinese Cambrian formations, the greater number being assigned by Mr. Walcott to the middle division of the system. The lower division has yielded comparatively few forms, and it does not appear that any trace has been recovered of a fauna older than Cambrian. The trilobitic representation is especially abundant, comprising 118 species, belonging to twenty-five genera. The full details respecting this primæval fauna will be awaited with much interest.

It would appear from the observations of Messrs. Bailey Willis, and Blackwelder that Richthofen perhaps over-estimated the thickness of his "Sinisches System," and that the chances of the recovery of a pre-Cambrian fauna were less than had been hoped for. In Shan-tung the total thickness seems to be little more than 4000 feet, of which only some 1500 or 1600 feet are relegated to the Cambrian system, the overlying strata being referred to the next member of the Geological Record. The lower Cambrian division, consisting of 500 or 600 feet of shales and thin limestones, rests unconformably on a set of gneisses, schists, and granite, with other eruptive rocks. Mr. Blackwelder made a reconnaissance, in the Liau-tung peninsula, nearly along Richthofen's route; but he was unable to add anything of importance to what was noted by the German explorer regarding the Cambrian rocks of that district.

In threading the gorges of the Yang-tzi, the expedition at Nan-t'ou found at the base of the Palæozoic series a remarkable group of sediments resting unconformably on granite-gneiss, and having a total thickness of about 370 feet. Above a conglomerate and a series of red and white sandstones lies a mass of hard green boulder-clay or till, some 200 feet thick, which can be seen to dip under the Ki-sin-ling limestone. No fossils were obtained by the travellers from this boulder-clay, nor after a search for two hours were any found by them in the overlying bands of limestone. But as they disinterred Lower and Middle Cambrian organisms from what they regarded as the same limestone within less than 100 miles from Nan-t'ou, they regard it as highly probable that this ancient boulder-clay is of early Cambrian age.

The stones are subangular, with rounded edges and well-polished and well-striated surfaces. They are of various kinds of rock, and of all sizes up to two feet and a half in length, and they are huddled together without order, as in ordinary boulder-clay. The specimens represented in plate xxxviii. might have been selected as typical examples from any Pleistocene boulder-clay of Europe or America. It is hardly possible to resist the evidence that here is a true glacial deposit which, whether or not intercalated at the very base of the Cambrian system of China, must almost certainly be of early Palæozoic date.

The physiographical discussions in the volume are most unsatisfactory. When one reflects how difficult are the problems of physiographical development, how much patient research is needed into the geological history of a region, how much detailed local topographical knowledge is absolutely essential, and how little, after all, dogmatism on the subject is permissible, one is amazed at the confidence with which the physiography of vast territories is here disposed of. It is not by surveys of fifty square miles a day that these problems are to be solved, and it is matter for regret that such jejune attempts should be made, and should find a place in what ought to be a serious contribution to science.

THE EXPLORATION OF TIBET.

Tibet, the Mysterious. By Sir Thomas Holdich, K.C.M.G., K.C.I.E. Pp. ix+356; illustrated. (London: Alston Rivers, Ltd., 1906.) Price 7*s*. 6*d*. net.

"THE public which concerns itself about Tibet is a very small public indeed," says Sir Thomas Holdich in the volume he has compiled for "The Story of Exploration" series, and to this we may add that public interest in that country is not likely to be increased by such unsympathetic treatment as the subject receives in this book. The story of geographical achievement in Tibet, and especially of the attempts to reach the jealously guarded capital of the then closed land, was for many years one of the most fascinating interest, and now in the light of the more precise information that has recently been made available it could well afford re-telling as an instructive record of great daring and tenacity of purpose. In professing to supply such a summary, however, the present account is disappointing in that its information is neither very trustworthy nor up-to-date. The author does not appear to have any personal knowledge of the country, nor has he made himself sufficiently acquainted with what has been written on the subject, with the result that his book betrays frequent inaccuracies, and a lack of clear perspective that is rather bewildering to the reader. The narrative is made up for the most part of quotations from the reports of the more or less illiterate native surveyors, whose accounts, we are here told, although "the best and most important of all the stirring records of that remarkable country, have never yet seen the light"; whereas, as is well known, all those reports which were possessed of sufficient interest, including the best of them, namely, that by A-K, were published many years ago.

The geographical theme is frequently lost sight of altogether under the heaps of irrelevant topics that are dragged in. Indeed, fully one-fifth of the whole book is made up of generous extracts from the pages of Huc, the Lazarist missionary (not "Jesuit"), notwithstanding that our author admits "we do not gain much in the way of geographical information from it"! Relying on such antiquated sources of information, without being careful to check the stories by comparison with the more precise facts of later scientific research, Sir Thomas repeats many of the erroneous statements of the native surveyors as well as the mistaken notions of the older European writers. Thus, to take some instances at random, one would imagine that the author had never heard of the trustworthy work achieved by the British Survey officers of the Lhasa Mission, so generally is it neglected in preference to the less accurate data of the pioneer native surveyors. In this way we have here repeated the gross mistakes of U. G. and Sarat Das in respect to the route from Gyantse onwards to Lhasa. Amongst others, the Yamdok Lake is stated (p. 114) to be 13,900 feet above the sea-level, and at p. 252 to be 13,800 feet instead of the 14,350 feet as given by Major Ryder, while the adjoining Dumo Lake is made to be 500 feet higher than the Yamdok, whereas it is only some three feet higher. Even the elevation of Lhasa is given at 11,600 feet instead of 11,830 feet. So, too, with the map of Lhasa; we are told that A-K's old sketch-map is still "the best map we possess of it"—this is very hard on Major Ryder, who spent several days in the streets of Lhasa surveying and measuring, and plotting out the city in a large detailed map which was published more than two years ago.

The province of Nari, which stands in the extreme north-western corner of Tibet, is strangely enough stated to be in the "*southern* zone" of that country. Darchendo, the great mart for Chinese tea on the eastern border of Tibet, is, he says, "more correctly called 'Ta-chien-lu' in the newer" maps—the fact, however, is rather the other way, as the latter is merely a Chinese corruption of the former, which is the original and current Tibetan name of this important place. In alluding to the Chinese invasion of Nepal, our author goes beyond his authority when he credits Sir Clements Markham with the statement that the Chinese general "Sand Fo" (properly Sund Fô) sacked Kathmandu (which he spells Khatmandu); for Markham does not say that the victorious Chinese even entered the Nepalese capital, from which the battle was fought a day's march distant. So, too, we are informed that Moorcroft (who was really a veterinary surgeon temporarily employed by the East India Company on mule-breeding questions) was "a civilian of the Indian Civil Service."

Elementary facts even as to the position of Lamaism have not been grasped. We read (p. 51) that "Lhasa is the holy of holies, the ark of the covenant to over one-third of the human race." This amusing statement perhaps Sir Thomas did not mean to be taken seriously. For, as pointed out years ago, the Lhasa hierarchy has never been acknowledged by Buddhists outside Tibet, beyond Mongolia and a few of the sparsely populated Himalayan districts. The Buddhists of China, Japan and Corea, Siam, Burma and Ceylon would be astonished were they told that Lhasa, of which few of them have ever heard, was their "holy of holies." That place is sacred only to some five or six million votaries, and not the "400 millions" as here asserted. There are no distinctive page headings, and misspelling is frequent.

It would be pleasant to be able to congratulate the author on the illustrations, but nearly all of these we have seen elsewhere before. They are not very closely connected with the letterpress, nor are the landscapes very characteristic, whilst some of them are not what they profess to be; for out of the ten, at least two are from the Sikkim side of the Himalayas, and not in Tibet at all.

L. A. W.

OUR BOOK SHELF.

An Outline of the Natural History of our Shores. By J. Sinel. Pp. xvi+347; illustrated. (London: Swan Sonnenschein and Co., Ltd., 1906.) Price 7s. 6d.

THIS book has been written "to help to open some of the volumes of this part of Nature's library" by one who, having spent nearly forty years by the sea-shore, has had excellent opportunities of gaining the necessary knowledge at first hand.

Chapters i.–xiii. are devoted to descriptions, more or less short, of the animals which are to be found between tidemarks and in the maritime zone of Jersey, their habits and where to look for them; some account is also given of the chief characters of the various groups, together with descriptions of the anatomy of a few species, and something about the development of others. The author then deals with the various reasons for colour in marine animals, of which he gives instances, together with examples of "mimetic artifices" among the crabs (others are given in the chapter on Crustacea). In the following chapters we are given lists of apparatus, &c., necessary for shore collecting and tow-netting, with the method of use. A number of useful hints are also given on anæsthetising, preserving, and mounting specimens for the museum and other purposes, and also for imbedding, cutting, and staining sections for the microscope. In the last chapter, dealing with the marine aquarium, the beginner is initiated into the, to most inland people at least, difficult art of keeping and feeding the various marine animals which flourish in captivity, and also of hatching and rearing marine larvæ.

Although on the whole good, the book is marred by several inaccurate statements; among others we may mention the following:—Echinoderms have a heart; *Loligo media* is the young of *L. forbesii*; *Galeomma* is the only bivalve which crawls, whilst the author's explanation of the way in which starfish open oysters is certainly not the correct one. Moreover, we cannot agree that the author has followed the nomenclature most generally in use, especially in Pisces and Echinoderms.

In the outfit of the shore collector, the absence of a crowbar is rather surprising, especially on a rocky coast; whilst half an hour for tow netting, in view of the fact that two or three collections are apparently put into the same bottle, is certainly too long.

The illustrations, 123 in number, are mainly derived from photographs, the majority of which show a considerable lack of skill on the part of the photographer. One or two appear to be out of focus, many are too much of the soot and sawdust type; while in others the background chosen is not calculated to show up the "sitter" to the best advantage. Typographical errors, of which there are a fair number, are almost invariably confined to scientific names, such as *Nephtys* for *Nephthys*, Maidæ for Maiadæ, Spangus for *Spatangus*.

In spite of the above faults, we can, however, recommend the book to all beginners in the fascinating art of shore collecting, although, of course, it does not obviate the necessity of access to monographs on the various groups. R. A. T.

Field Operations of the Bureau of Soils, 1904. (Sixth Report.) Pp. 1151 + a case of 53 maps. (Washington: United States Department of Agriculture, 1905.)

THE United States Survey of Soils continues from year to year its enormous task, under the direction of its chief, Mr. Milton Whitney, and the present sixth report differs in no essential respect from its predecessors. The soil divisions are mapped upon a basis of physical texture, the same name being used right across the continent for soils which are judged to be of the same type, however different the origin or however remote the locality from that of the type originally credited with the name. It is just this classification which has been called in question by the critics of the survey in the United States, who discredit both the methods of identification and analysis which are adopted, and also the rapidity with which the work is pushed along. Certainly when the cost of the survey amounts to less than 10*s*. per square mile, as in the present case, the distribution of soils in the United States must be very different from what we are familiar with in the Old World, or else the maps can be little more than very sketchy first approximations. However, we are too far away to have any means of forming a judgment in this domestic discussion, but what the English reader will always find of value in this survey are the preliminary general accounts of the physiography and agricultural development of each area. There we get sketches of the style of farming and the local conditions which compare, though in a more scientific fashion, with the reports on the counties of England initiated by Arthur Young a little more than a hundred years ago. Doubtless in time these reports will have the same permanent value for America as a detailed picture of the state of the country and the position of its chief industry.

Hypnotism and Spiritism—A Critical and Medical Study. By Dr. Joseph Lapponi; translated by Mrs. Philip Gibbs. Pp. xiv + 268. (London: Chapman and Hall, Ltd., 1906.) Price 5*s*. net.

THE opening chapter deals with the historical data connected with hypnotism and spiritism, and the author points out how spiritism passed through the various stages of spirit rapping up to definite materialisation. Dr. Lapponi then describes what is understood by hypnosis, and it is clear that his views are not in accord with those held by most authorities at the present time. When the reader reaches the chapter on "Details about Spiritism," he will find a most vivid description of a *séance*, as given by "some of the best and most esteemed mediums." The author honestly states that he has not had personal experience of the "truth and reality of the marvellous phenomena" which he describes; nevertheless, he is evidently convinced of its actual existence. Dr. Lapponi gives some interesting accounts of the mystic performances of the Indian fakirs, and also records some instances of telepathy.

In discussing the relationship of hypnotism and spiritism, he endeavours to prove that there is little or no relationship between them, a fact which few would dispute; on the other hand, we do not think that the arguments which he adduces would go far towards convincing the sceptic. The author admits that "illusions and hallucinations explain some isolated cases of spiritism"; he also allows that mediums may have largely had recourse to frauds in order to enhance their reputations, and he is generous enough further to concede that "to the spiritistic frauds done voluntarily may be added others, not only involuntary but unconscious"; but even after allowing all these, he considers that there are phenomena which are well authenticated, and for which neither deception, art, nor science can render an account. This may be true, but because a matter is too subtle to unravel does not justify us in assuming that it is the result of spiritism. The author's attempt to account for the valuelessness of spirit revelation is very feeble, but it is left to the closing chapter to reveal the worthlessness of spiritism, for here we read that "spiritism is always dangerous, harmful, immoral, reprehensive, to be condemned and most severely prohibited without reserve, in all its grades, forms, and possible manifestations," except, maybe, in some rare exceptions. Surely, if there are spirits with whom we can confer, some of them should be able to raise us to higher planes of thought, for the spirit world should belong to a hierarchy which is nearer to the perfect.

LETTERS TO THE EDITOR.

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Festival of St. Alban.

WITH regard to what is said concerning the date of this festival in the review of the "Life of St. Patrick" in NATURE of July 25 (p. 296), it is to be noted that there is really only one date for the festival. In the time of Bede (H. E., i., 7), as in the pre-Reformation calendars of the English Church, as well as in the Latin Prayer Book of Queen Elizabeth, 1560, the date is June 22. But when the festival reappeared in the English Prayer Book of 1662 it was placed on June 17, an obvious error which is supposed to have arisen from wrongly writing xvii. for xxii. In the Roman calendar the date is, of course, June 22. C. S. TAYLOR.

Banwell Vicarage, July 26.

THE information supplied by the Rev. C. S. Taylor is most welcome. The evidence for regarding the 22nd as an arrested solstitial day, in connection with St. Alban, is now fairly conclusive.

(1) The 22nd was one of the three solstitial days about 303 A.D., the supposed date of Alban's martyrdom.

(2) If closely studied with that fact in view, the legend of his martyrdom, like those of the death of Patrick and Dewi, may reveal a clear midsummer festival setting. That much may be gathered from the statement that Alban was summoned to do sacrifice to the pagan gods. We know from other sources that people were penalised for non-attendance at the great pagan festivals.

(3) There is evidence that St. Alban's festival covered the three solstitial days.

(*a*) One old Welsh calendar fixes the festival on the 23rd.

(*b*) Though our modern bards call each of the solstitial quarter days an Alban, there is very little authority for such a use of the name. What appears likely is that Alban became a name of the midsummer festival, and that a bardic scribe at first wrongly applied the name to the other quarter days. The Alban of the bards covered three days, and each day is specially named. The first is the Vigil of the Alban, the second is the Alban itself, and the third is the Banquet of the Alban.

(4) Why have the Welsh made so much of the name Alban? The reason may be found in the association of the name with Caerleon-upon-Usk.

(*a*) There are some ruins near that ancient city still called Mount St. Alban's.

(*b*) Mr. Wade-Evans has made out a good case for localising Alban's martyrdom at that spot (in "Archæologia Cambrensis," about two years ago).

(*c*) Geoffrey of Monmouth tells us of a great observatory or school of astronomers in or near that city.

St. Alban's Day being the chief day of the year, and an observatory bearing his name, probably, at Caerleon being apparently the Greenwich of Wales at one time, it is no wonder that the Welsh bards have adopted the name as a solstitial epithet without ever a mention of Alban's martyrdom.

We have in Wales a very modern instance of the same process. In some districts June 22 is observed as Gwyl Barna, the Vigil of Barnabas. St. Barnabas's Day is the 11th, and in the seventeenth century it coincided with the solstice; but since 1752 it has been in those parts associated with the 22nd, and Gwyl Barna is now a name of the solstice. In the neighbourhood of Llandeilo Talybont, Glam., it is the custom of the farm labourers to get together the hay-making implements on the morning of Gwyl Barna, before going to a solstitial fair in the neighbourhood. JOHN GRIFFITH.

Llangynwyd, Glam.

The Sun's Motion with respect to the Æther.

So far as I know, it has not been pointed out that the velocity of light, as deduced from the observed times of occultation of Jupiter's satellites, is affected to the first order by the motion of the earth and Jupiter with respect to the æther. Taking the times best suited to such observations, when the distance between the two planets is very nearly a maximum or a minimum, there will be no appreciable relative velocity in the line of centres, and, to a first approximation, the velocity with which light from Jupiter approaches us is then made up of the true propagation-velocity increased by the common velocity-component of the two planets in the direction earth to Jupiter.

In order to determine the sun's motion with respect to the æther, the values for the apparent velocity of light deducible from the observed times of occultation might be analysed, so as to discover any systematic differences depending on the direction of the line of centres. Only very small corrections would be needed on account of the motion of the planets in their line of centres relatively to the sun. The probable absolute error in the finally deduced velocity of the sun (relatively to the æther) would be of the same order as that affecting the finally deduced velocity of light. The quantity to be determined might perhaps be swamped by the errors of observation, but even so a superior limit could be assigned to the sun's velocity through the æther. Two of the three rectangular components of that velocity being measured in the plane of the ecliptic, the determination of the third component would unfortunately be very badly conditioned. It may be some consolation, however, to reflect that a knowledge of our motion with respect to the æther is not theoretically unattainable.

Again, if the mean æthereal density is either less or greater where atomic matter is present than in free æther, it appears from some results which I have lately obtained in connection with a modified theory of gravitation that motional forces would be experienced (for example) by two bodies moving with uniform translational velocity through the æther. These forces would be proportional to the product of the masses of the two bodies, to the square of the velocity of translation, and inversely to the fourth power of the distance between the bodies. They would be equal in magnitude and opposite in direction, but would not in general act in the same line, so that an elongated body, partaking of the earth's diurnal and orbital motion, would in general be acted on by a couple. This couple would vary as the diurnal motion changed the orientation of the body, and if the variations were measurably great, we should have the means of determining, save for a constant factor and an ambiguity of sign, the velocity of the earth with respect to the æther at any point of its orbit. Observations at three or more points of the orbit would enable us to evaluate the constant factor and to remove the ambiguity of sign, thus determining the velocity of the sun with respect to the æther.

The effects referred to might or might not be detectable, but by means of quite simple apparatus they could be tested for with great delicacy. I hope shortly to publish a fuller account of the analysis on which the above conclusions are based. C. V. BURTON.

Cambridge, July 29.

The Dog's Sense of Direction of Sound.

OUR dog, Spot, of the intelligence of which an instance has been recorded in NATURE, is peculiarly sensitive to sound. The following instance may be worth recording. On Sunday, July 21, a heavy storm of thunder and lightning with rain broke over Wick. I sat in the porch of our house watching—Spot with me. The lightning was frequent, and the thunder played round in all directions—over Bath six miles to the east and Bristol six miles to the south-west.

Spot barked at each clap or rumble and rushed forward, always *towards the direction* from which the thunder appeared to come; the lightning affected him in no way. It was laughable when the thunder appeared to come from no definite direction, but to play round us. For then he ran, barking, over the lawn and round the trees as if angered by a sound he could not locate. I observed carefully what he did for perhaps half an hour, and I think Spot located the directions of sound at least as quickly as I did myself. F. C. CONSTABLE.

THE INTERNATIONAL CONGRESS ON SCHOOL HYGIENE.

THE second International Congress on School Hygiene was opened on Monday last at the University of London by Lord Crewe, in the presence of a large gathering, which included delegates from all the countries of Europe, the Colonies, and North and South America, in addition to representatives of administrative bodies in Great Britain. We shall publish at a later date an account of the proceedings of the Congress, but are pleased meanwhile to direct attention to the warm interest taken by the King in the objects for the consideration of which the congress was convened; indeed, but for the King's intervention, the congress would probably have been anything but a success, as will be seen by the opening remarks of the president, Sir Lauder Brunton, F.R.S.

Lord Crewe, Lord President of the Council, in opening the congress, said the first duty he had to perform in connection with the opening ceremony was a very agreeable one. He had a gracious command from the King to express to them the interest with which His Majesty regarded the subjects with which that congress was concerned and his hopes that its discussions might be a great success. His Majesty had further commanded him to express his regret that, owing to his enforced absence from London, he was unable to receive those who were to attend the congress. He was also privileged as a member of the Government to express the same desire on their part that the proceedings of the congress might be crowned with success, and on behalf of the Government to offer them all a hearty welcome. It was not in a strict sense an official conference. It was not subject to official control, it was not run on official lines, and it was not subsidised by official money. That, from many points of view, he took to be a distinct advantage. It lent freedom to the discussions which would take place; but, on the other hand, it must not be supposed that the Government of this country did anything else but take a keen interest in the proceedings of the congress, and they were well aware that the public departments concerned with the subjects for discussion hoped to learn much in the course of the next few days. He hoped that the result of their meeting might have the best possible effects. It must be a good thing for those belonging to different nations and used to different systems to interchange ideas and to engage in a most honourable and friendly rivalry as to which nation and which system could best carry out the objects they all had in view. He hoped, therefore, that their meetings might leave some permanent mark on the subjects, and that their deliberations would do much to advance the knowledge of school hygiene, and to remove what they must all regard as having been a serious blot on the civilisation of the world.

After speeches by Lord Londonderry and Lord Fitzmaurice, Sir Lauder Brunton delivered his presidential address, from which we print the following extracts:—

After welcoming the delegates, he said that he was sure that the first duty which they would wish him to perform as their president was to voice their thanks to the King, patron of the congress, for the gracious welcome which they had received from him through his representative, Lord Crewe. But it was not for words of welcome alone that the congress owed a debt of gratitude to His Majesty. It had also to thank him for most substantial help at a critical time. A fortnight ago things seemed to be going all wrong with the congress; it threatened to be more or less of a failure. At this juncture, through the kind intervention of Mr. Alfred de Rothschild, His Majesty graciously granted him (Sir Lauder Brunton) a personal interview, and asked him to explain the circumstances. He did so, and in a few minutes the King had put everything right, and things, which had been going all wrong before, from that moment went right, and the congress which threatened to be more or less of a fiasco now bid fair to be a brilliant success. Its success would not be due only to the numbers attending it nor to the enthusiasm of its members, but to the work which they trusted it would accomplish, not only during the time of its sitting, but after it was over, for they hoped that arrangements would be made by which its work would become permanent, and would be carried on in the intervals between successive congresses. For his services to the congress the King not only deserved the gratitude of the congress itself, but also of all school children, born and yet unborn, who might owe to its labours health, strength, and happiness.

They were met from every part of the civilised world, throwing aside every subject of disagreement, and were intent only on one common object—the health of the children. Parental affection was one of the strongest and most fundamental instincts, not only in man, but even in the lower animals. They all desired that their children should grow up healthy, strong, and happy; and they were all anxious to take the best means at their disposal to obtain such a desirable end. Amongst these, one of the chief was education. In savage communities, where the chief objects of life were war and hunting, education was comparatively simple, and was thoroughly well adapted to the end in view. But in civilised communities the complexity of conditions sometimes led, and indeed had led, to mistakes in education, and the very meaning of the word had been forgotten, so that, instead of drawing out and developing in every child all its possible powers of body and of mind—so that in its life it should do the very best of which its nature was capable—education had degenerated into a system of cramming and cultivating one or two faculties of the mind, and especially that of memory, to the injury of others, while the condition of the body as the servant of the mind had, to a certain extent, been lost sight of in this country. They were now awakening to the necessity of attending to the body if the mind was to be developed, and many efforts were being made in various countries to secure a system of mental and physical training which would ensure the best development of children. The great advantage of a congress like this was that the systems employed in various places were brought together and compared, so that each country might learn from the others the useful plans they ought to adopt and the errors they ought to avoid.

One of the most important subjects of all in this respect was that of medical inspection in schools, because this was the keystone of physical education. Without it, the defects of eyes, ears, nose, and teeth which affected individual scholars could not be ascertained, and so those children remained backward in their learning, suffering in their bodies and so much damaged in physique that they were unfitted for many occupations, could not enter the Army, and went to swell the numbers of the criminal classes.

The physical training of children during the period of growth was one of the best means of ensuring proper development. In some countries this was carried out more especially by systematic exercise, which developed the muscles, while in this country we depended more upon games. Both of these systems left something to be desired, and the ideal system was to be looked for in a proper combination of both. One of the most difficult, and yet one of the most important, questions of school hygiene was how to combine educational work with physical training, so that both should be productive of benefit, and not of injury, to the child. Proper alternation of mental and physical exercise was one means of preventing this, but attention must also be paid to the nature of the physical exercise.

But all attempts to develop a healthy race would be ineffectual if they took care only of the children who were at school now. They must look a generation ahead, and consider that the children who were at school now fifteen or twenty years hence would be the fathers and mothers of a fresh set of school children whose physique would depend very much upon the way they had been treated and fed in their infancy and childhood. It was, therefore, of the utmost importance that boys and girls should be instructed in the laws of health, the need of cleanliness, the dangers of impure food or water, and the evils of alcoholic abuse. Such instruction should not be given by lectures, which were likely to be misunderstood or forgotten, but by actual demonstration.

In conclusion, the president said that he felt sure that by cooperation they would obtain the object they had in view—namely, the health of the children.

At the conclusion of the meeting the following telegram was sent to the King:—

To His Majesty the King, Royal yacht *Victoria and Albert*, Cowes.—Your Majesty's most gracious message at the opening of the International Congress of School Hygiene by Lord Crewe this afternoon was received with the most humble and most respectful thanks of the delegates from foreign Governments and public authorities and the members of the meeting assembled. Signed, LAUDER BRUNTON, president, JAMES KERR and E. WHITE WALLIS, honorary general secretaries.

And in the evening, at the first general meeting and reception of delegates and members, the following reply from His Majesty was read:—

To Sir Lauder Brunton, 10 Stratford Place, London, W.

The King desires me to thank you and the honorary general secretaries for the telegram he has received from you and to express his hope that the ceremony to-day went off well. (Signed) KNOLLYS. Cowes.

THE BRITISH ASSOCIATION AT LEICESTER.

AS anticipated, the British Association has been fortunate in its choice of Leicester for this year's annual meeting, and we congratulate the association because of the high character of its proceedings, initiated by the presidential address, and maintained in the special discourses of Mr. Duddell, Prof. Miers, and Dr. Dixey, and the sectional papers, and the town itself because of its genuine and hearty welcome to its many visitors, and the carefully considered arrangements made for the convenience and comfort of all. Many important papers have received consideration at the sectional meetings, and the attendances have shown the interest taken in the subjects covered.

Visitors on arrival found quite artistic street direction cards attached to the lamp-posts and tramway standards, and these, with the capital maps provided on the official ticket and bound with the local programme, gave clear and definite directions for all.

The social side of the meeting has not by any means been neglected, but this has been kept quite subordinate to the real work—the advancement of science. The Mayor's reception and evening *fête*, held at the Abbey Park on the Thursday evening, and attended by nearly 3000 persons, was followed by the garden-party given by Sir Samuel and Lady Faire at Glenfield Frith on the Friday afternoon; both were largely attended and complete successes. Bands have played each afternoon and evening in the pretty loggia erected adjoining the Town Museum, and this central spot has formed a most pleasant rendezvous. A reception by the Leicester Literary and Philosophical Society was held here on Tuesday last.

Saturday, as usual, was given up to excursions. The weather in the morning was anything but propitious, and no doubt deterred many from attending; the day, however, proved bright and clear. Charnwood Forest, Belvoir Castle, Chatsworth, Peterborough, and a trip over the old Swannington Railway proved happy hunting-grounds for scientific pleasure.

The local executive and its chairman, Mr. Colson, must be congratulated on the efforts made by them for the comfort of the members of the association, and the success which attended their endeavours.

The report of the council for the year 1906–7 was adopted at the meeting of the general committee on July 31. The following matters are referred to in the report:—

The council has acted upon the resolution from Section A:—"That, in the opinion of the committee of Section A, it is highly desirable that Sir William Hamilton's memoirs on dynamics, on systems of rays, and other memoirs on pure and applied mathematics, should be republished in accessible form; and that this resolution, if approved by the council, be communicated to the Royal Irish Academy." A subcommittee of Section A is making inquiries for the purpose of promoting the object in view. A resolution from Section H in regard to the appointment of an inspector of ancient monuments has been considered by the council:—"That the council of the British Association be asked to impress upon His Majesty's Government the desirability of appointing an inspector of ancient monuments, fully qualified to perform the duties of his office, with full powers under the Act, and with instructions to report periodically on his work with a view to publication." The council appointed a committee, consisting of Sir John Evans, K.C.B., Sir Edward Brabrook, Mr. Sidney Hartland, Sir Norman Lockyer, K.C.B., and Lord Balcarres, to report on the proposal; and the report of the committee, having been approved by the council, was sent with a covering letter to the Prime Minister on December 19, 1906. Furthermore, the president attached his signature to a memorial upon the same subject drawn up by the council of the Society of Antiquaries. It is understood that, whilst no immediate action will be taken by His Majesty's Government, the matter is receiving careful consideration by the Prime Minister, with the object of placing all ancient monuments in the United Kingdom under adequate protection and more effective supervision.

At the second meeting of the general committee on Friday, August 2, Mr. Francis Darwin, F.R.S., who was nominated by the council to fill the office of president for the year 1907–8, was elected. The Lord Lieutenant, as His Majesty's representative in Ireland, was elected to fill the office of vice-patron for the Dublin meeting next year. The following were elected vice-presidents of the association for the same meeting:—The Lord Mayor of Dublin; the Lord Chancellor of Ireland; H.M. Lieutenant for the County of Dublin (Earl of Meath); Chancellor of the University of Dublin (Earl of Rosse); Chancellor of the Royal University of Ireland (Lord Castletown); Provost of Trinity College, Dublin (Dr. Anthony Traill); president of University College, Dublin (Rev. W. Delany); Viscount Iveagh; president of the Royal Dublin Society; president of the Royal Irish Academy (Mr. F. A. Tarleton); Vice-Chancellor of the University of Dublin (Mr. Justice Madden); Vice-Chancellor of the Royal University of Ireland (Sir Christopher Nixon, Bart.); vice-president of the Department of Agriculture, &c. (Mr. T. W. Russell, M.P.).

The meeting will be held in the first week in September next year, that is, from Wednesday, September 2, to Wednesday, September 9, 1908.

The new members of council elected by the general committee are Dr. Tempest Anderson, Prof. A. R. Forsyth, F.R.S., Mr. D. G. Hogarth, Lieut.-Colonel Prain, F.R.S., and Prof. C. S. Sherrington, F.R.S.

Subjoined is a synopsis of grants of money appropriated for scientific purposes by the general committee at the Leicester meeting:—

	£	s.	d.
Section A.—Mathematical and Physical Science.			
Seismological Observations	40	0	0
Further Tabulation of Bessel Functions ...	15	0	0
Kites Committee	25	0	0
Geodetic Arc in Africa	200	0	0
Meteorological Observations on Ben Nevis ...	25	0	0
Section B.—Chemistry.			
Wave-length Tables of Spectra	10	0	0
Study of Hydro-aromatic Substances	30	0	0
Dynamic Isomerism	40	0	0
Transformation of Aromatic Nitramines ...	30	0	0
Section C.—Geology.			
Fossiliferous Drift Deposits	11	12	9
Fauna and Flora of British Trias	10	0	0
Crystalline Rocks of Anglesey	2	17	2
Faunal Succession in the Carboniferous Limestone in British Isles	10	0	0
Erratic Blocks	17	16	6
Predevonian Rocks	10	0	0
Exact Significance of Local Terms	10	0	0
Palæozoic Rocks	15	0	0
Composition of Charnwood Rocks	10	0	0
Section D.—Zoology.			
Index Animalium	75	0	0
Table at the Zoological Station at Naples ...	100	0	0
Heredity Experiments	10	0	0
Fauna of Lakes of Central Tasmania	40	0	0
Section E.—Geography.			
Rainfall and Lake and River Discharge ...	5	0	0
Investigations in the Indian Ocean	50	0	0
Exploration in Spitsbergen	30	0	0
Section F.—Economic Science and Statistics.			
Gold Coinage in Circulation in the United Kingdom	6	0	0
Section G.—Engineering.			
Electrical Standards	50	10	8
Section H.—Anthropology.			
Glastonbury Lake Village	30	0	0
Excavations on Roman Sites in Britain ...	15	0	0
Anthropometric Investigations	13	8	8
Age of Stone Circles	53	0	0
Anthropological Photographs	3	3	6
Anthropological Notes and Queries	40	0	0

Section I.—Physiology.

	£	s.	d.
Metabolism of Individual Tissues	40	0	0
The Ductless Glands	30	0	0
Effect of Climate upon Health and Disease ...	35	0	0
Body Metabolism in Cancer	30	0	0
Electrical Phenomena and Metabolism of Arum Spadices	10	0	0
Section K.—Botany.			
Structure of Fossil Plants	15	0	0
Marsh Vegetation	15	0	0
Succession of Plant Remains	45	0	0
Section L.—Educational Science.			
Studies suitable for Elementary Schools ...	10	0	0
Corresponding Societies Committee.			
For Preparation of Report...	25	0	0
Total	1288	9	3

SECTION B.

CHEMISTRY.

OPENING ADDRESS BY PROF. A. SMITHELLS, B.Sc., F.R.S., PRESIDENT OF THE SECTION.

THE year which has elapsed since the meeting of our Section at York has been eventful in the most melancholy of ways; the losses sustained by our science have been unparalleled. The passing bell seems to have tolled almost without intermission as one after another of our masters has been taken from us: in Russia, Mendeléeff, Menschutkin, and Beilstein; in France, Berthelot and Moissan; in Holland, Bakhuis-Roozeboom. Whilst in some of these cases we may find consolation in contemplating a length of life and sustained activity beyond what we might have dared to expect, in others our regret is increased by the sense of untimeliness and of vanished hopes. I am tempted to speak of the work of such mighty men as Berthelot and Mendeléeff, to dwell upon the discoveries by which they transformed the whole fabric of chemical science; but this is not the occasion on which to offer an estimate of the labours of those who have passed away. I can only say that in the bond of brotherhood which the pursuit of science establishes among the different nations of the earth we who are Englishmen feel and deplore these losses as our own.

I must not omit to allude also, as I do with deep regret, to the death in our own country of two such ardent and fruitful workers as Cornelius O'Sullivan and Robert Warington.

These words were already in print when again we were called to mourn the loss of one of our greatest men, one who but a year ago was the subject of our special rejoicings, and whose vigour of body and youthfulness of spirit seemed to promise the long continuance of a noble and an extraordinarily fruitful life. We can at least feel thankful that William Henry Perkin lived long enough to learn in what honour and esteem his name was held, not only among his countrymen, but by all the chemists of the world, and by the leaders of those great industries of which he was justly acclaimed the founder. For more than a generation Sir William Perkin had been one of the most familiar figures at the meetings of this Section, and greatly shall we miss his gentle presence, his wise counsel, and his valued contributions.

I can, perhaps, best occupy your time to-day by attempting to give some account of the present state of the scientific subject to which I have paid most attention. The topic of flame, after a long period of repose, has aroused much interest during late years, and I think we may say that some considerable progress has been made in its elucidation, although in this, as in all other subjects of scientific inquiry, the more closely we scrutinise it the more impressed must we be with what still remains unknown.

One of the first questions that meet us in the study of flame is that of the temperature at which in any given case the phenomenon becomes evident. Here, I think, a great clarification of view has taken place. The old idea that there existed a fixed temperature at which inflammation suddenly took place cannot now be maintained, and the term "ignition temperature" has acquired a different meaning. It is now known that in a very great number of cases a mixture of two flame-forming gases, when gradually raised in temperature, will develop luminosity quite gradually, *pari passu*, with the chemical combination that is being induced. This phenomenon is, of course, known universally in connection with phosphorus, but it is not so widely known in connection with other combustible substances. There are some simple facts that seem as if they never could gain admission to text-books, and I do not think I have known more than a single chemical book that is not likely to leave a student under the impression that the phosphorescence of phosphorus is an almost unique phenomenon. I do not know how many times the independent discovery has been made that sulphur, arsenic, carbon disulphide, alcohol, ether, paraffin, and a whole host of other compounds, inorganic and organic, will phosphoresce as truly as phosphorus itself; that, in fact, phosphorescent combustion is the normal phenomenon antecedent to what we ordinarily call flame.

This is, after all, only in harmony with the general truth that chemical combination between two gases does not set in suddenly, but comes into evidence quite gradually as the temperature is raised from a point at which the action, if it occurs at all, is so slow as to be negligible. The increase in the rate of combination is, of course, very rapid as compared with the increase of temperature, a difference of about 10° C. serving to double it. The interval between the beginning of phosphorescence and the production of vigorous flames may therefore be very short. In the case of phosphorus this interval, being from 7° to 60° C., includes ordinary atmospheric temperatures; hence the phosphorescence of phosphorus is a phenomenon that could not well be overlooked. If the prevailing terrestrial temperature were below 7° C., at which, under normal air-pressure, the phosphorescence of phosphorus ceases, it is possible that this element might never have acquired its peculiar reputation; it would not have shone in the dark, and in lighting it with a taper the phosphorescent interval would have been passed over as quickly as is ordinarily the case in the ignition of sulphur, paraffin, and other common combustibles. To make phosphorescence apparent in these last cases it is necessary to take special care to heat up a mixture of the combustible gas and air gently, and to maintain it at a temperature approaching, but not quite reaching, that of ignition. There is no simpler way than that used by Sir William Perkin, who brought the combustible substance near to, or in contact with, a massive metal ball previously heated to the suitable temperature.

The change from phosphorescence to ordinary flame is not sudden, but the appearance of ordinary flame is the end point of a continuous, though rapid, development. This end point is the temperature of ignition. What, then, determines the temperature of ignition? The answer to this question has been given with characteristic conciseness by van 't Hoff as "the temperature at which the initial loss of heat due to conduction, &c., is equal to the heat evolved in the same time by the chemical reaction."

We may obtain a clear idea of the meaning of temperature of ignition by supposing a combustible mixture of gases such as that of air and the vapour of carbon disulphide to issue through an orifice into an indifferent atmosphere. If we surround the orifice by a ring of platinum wire, which is gradually heated up by a current of electricity, a flame will gradually make its appearance. If, as soon as this is observed, the heating of the wire by the current be discontinued, the flame will disappear; it is, in fact, not self-supporting, but depends on the accessory supply of heat through the electrically heated wire. If now we raise the ring to a higher temperature we shall get a brighter flame, owing to an increased rate of chemical action, and at last we shall reach a point where it is possible to cut off the electric current without causing at the same time the extinction of the flame. This is the true temperature of ignition, the temperature at which the reaction proceeds at a rate just sufficient to overbalance the loss of heat by radiation, conduction, and convection from the burning layer of gases, so that the next layer is put in the same state, and steady combustion proceeds.

Phosphorescence has been spoken of as degraded combustion, and, though literally the appellation is correct, I think it is liable to be misunderstood. Again, it is often supposed that phosphorescence is necessarily associated with the formation of incompletely oxidised products. This may be the case in a chemical system which is capable of affording different products at different temperatures, but it is not an essential feature; the phosphorescent combustion of sulphur, for example, affords nothing but sulphur dioxide.

Temperature of ignition is, then, neither a temperature at which combination suddenly begins nor one dependent solely on the nature of the combining gases. It will vary with the proportion in which the gases are mixed and with their pressure and other circumstances. Notwithstanding the simplicity of this conception, it must be admitted that there are many obscure facts connected with the ignition of gases. The inflammability of gaseous mixtures is not necessarily greatest when they are mixed in the proportions theoretically required for complete combination; the influence of foreign gases does not appear to follow any simple law; the presence of a very small quantity of a foreign gas may exercise a profound influence on the ignition temperature as in the case of the addition of ethylene to hydrogen. When a mixture of methane and air is raised to its ignition temperature, a sensible interval (about ten seconds) elapses before inflammation occurs. These facts are cognate to others which have increased upon us so abundantly in connection with the influence of moisture on chemical change. The study of the oxidation of phosphorus in particular brings us among rocks and shoals. Apart from the influence of moisture on the combination we have the limitation of the process by a certain tension of oxygen and by minute quantities of a vast number of chemical substances, among which, in spite of much labour, no other common bond can be found. We do not know what oxide is initially formed in the oxidation, and the existence of the oxides P_4O and P_2O is as confidently disputed as it is affirmed. There is some reason for believing that the phosphorescence connected with phosphorus succeeds the formation of one oxide and accompanies the formation of another. The state of the oxygen, whether atomic, ionic, or molecular, which acts on phosphorus, the induced oxidation of other substances, the ionisation of air accompanying the oxidation—these are all matters concerning which there exists a bewildering literature that hangs over us like a cloud. The whole of my Address would, in fact, not suffice for a summary of the state of our ignorance about the oxidation of phosphorus. The subject, simple as it appears at first sight, is really involved with a vast number of unsolved chemical problems the elucidation of which would throw much light on chemical action in general. I may, perhaps, bequeath the topic to some successor in this Chair as one which may serve to illustrate the advance of knowledge since these present days of darkness.

The structure of flames has always been regarded as dependent upon the chemical changes taking place in the differentiated regions, but until recent times little attention has been given to any question beyond the cause of the bright luminosity of hydrocarbon flames. In a flame such as that of hydrogen or carbon monoxide, where we have some reason to suppose that the same kind of chemical transaction is taking place throughout the region of combustion we should not expect to find a differentiation of structure, and, as a matter of fact, we do not find any. Erroneous ideas have gained currency from the use of impure gases, and hydrogen is still described as burning with a pale blue flame, although Stas long ago stated that if the gas is highly purified, and the air freed from dust, the flame even in a dark-room can only be discovered by feeling for it: a fact consistent with the line spectrum of water lying wholly in the ultra-violet. The presence of a very small quantity of free oxygen in carbon monoxide destroys the perfect simplicity of the single shell of blue flame with which the purified gas burns, and in other flames small quantities of gaseous impurities or of atmospheric dust give rise to features of structure and halos which have been frequently supposed to pertain to the flame of the combining gases. The fringe of a flame in air may be often tinged by the presence of oxides of nitrogen.

No flame better illustrates the relation of structure to chemical processes than that of cyanogen, where the two steps in the oxidation of the carbon are clearly marked out in colour. Apart from hydrocarbon flames, very few others have been carefully explored from this point of view. There is, unfortunately, no gas composed of two combustible gaseous elements; and, though such gases as the hydrides of phosphorus and sulphur do not fall far short of this, the experimental difficulties of an exact exploration of their flames are very great. We are thus prevented from studying the flame of a composite combustible in its simplest form.

The flames of hydrocarbons have naturally been the subject of most frequent investigation. The use of single hydrocarbons instead of the mixtures present in coal-gas and other common combustibles has simplified the study considerably. Two problems stand out prominently: one is to trace the steps in the oxidation of the hydrocarbon, the other to account for the bright patch of yellow luminosity. With regard to the question of the luminosity, I do not think there is any longer doubt about its being due essentially to the separation within the flame of minute solid particles of what is practically carbon. The separation seems to be adequately explained by the high temperature of the blue burning walls of the flame, which decomposes the unburned hydrocarbon within. In a similar way arsenic and sulphur and phosphorus are liberated within flames of their hydrides; but these elements, being volatile, do not appear as solids unless a cold object be placed within the flame. In the case of the hydride of silicon the liberated element at once oxidises to form the solid non-volatile oxide, which gives a bright glow.

The mode in which a hydrocarbon yields carbon by the application of a high temperature has been the subject of experiment and of hypothesis; but neither the view of Berthelot, that the carbon results from a continuous coalescence of hydrocarbon molecules with elimination of hydrogen, nor that of Lewes, according to which the formation and sudden decomposition of acetylene is the essence of the phenomenon, appears to me to be in harmony with the experimental facts; and I am not aware that either view has secured any support from other workers in this field. It is certainly not easy to ascertain experimentally the changes undergone by a single hydrocarbon as its temperature is raised, and at the last it may be objected that the course of events in contact with the solid walls of a containing vessel is not necessarily the same as that within the gaseous envelope of a flame. I am glad to think that there is promise of further light on this subject from the work of Prof. Bone.

The course of oxidation of hydrocarbons has been the subject of very careful and fruitful study. The old view that a selective or preferential oxidation of the hydrogen always took place, that with a restricted supply of oxygen the hydrogen was oxidised and the carbon set free, is, I think, no longer maintained by anyone who has studied the question. The explosion of ethylene with its own volume of oxygen, which leaves us with practically all the carbon oxidised and all the hydrogen free, is fatal to this view. Again, when hydrocarbons are burned in a flame with a restricted supply of air, as is the case in the inner cone of the flame of a well-aërated Bunsen burner, there is clearly no separation of solid carbon, and the products of combustion when withdrawn and analysed disclose the presence of much free hydrogen and no unoxidised carbon. In describing this experimental fact I have spoken of it as the preferential oxidation of carbon. I have always thought it pedantic to quarrel with that expression; for, in speaking of a chemical transaction, we usually include only a description of the initial and final states of combination. I should be sorry, however, to detach the expression from the facts it describes and to exalt it into a general doctrine. That would be quite inadmissible, and, if there is any danger of misunderstanding, it would be better to avoid using the expression.

The admirable researches carried out in the University of Manchester by Prof. Bone and his collaborators have afforded most valuable information as to the oxidation of hydrocarbons at temperatures extending from those of incipient oxidation up to the highest ones that prevail in a flame. According to Prof. Bone, the oxidation of a hydrocarbon involves nothing in the nature of a selective or preferential oxidation of the carbon or the hydrogen; but it occurs in several well-defined stages, during which oxygen enters into and is incorporated with the hydrocarbon molecule, forming oxygenated intermediate products, among which are alcohols and aldehydes. The reaction, just referred to, between ethylene and an equal volume of oxygen is, according to Prof. Bone, to be represented by the scheme:

$$\begin{array}{c} CH_2 \\ \because \\ CH_2 \end{array} \rightarrow \begin{array}{c} CH.OH \\ \because \\ CH_2 \end{array} \rightarrow \begin{array}{c} CH.OH \\ \because \\ CH.OH \end{array} \rightarrow \begin{array}{c} H_2C:O \\ \\ H_2C:O \end{array} \rightarrow \begin{array}{c} H_2+CO \\ \\ H_2+CO \end{array}.$$

There can be no question about the facts on which this scheme is based, and they are a new and important addition to knowledge.

It is a great aid to the study of chemical changes, when we can resolve them into stages, whether or not these stages be realisable under certain experimental conditions. In this way we can get a clear view of the relationship between the action in one set of circumstances to the action in another set; and in this way also we can often establish rational links between reactions which at first sight seem quite disconnected. Intermediate reactions are much used to elucidate cases of contact action, and in the processes of organic chemistry they are almost universally assumed.

I am far from wishing to disparage these practices, but I think it important that we should realise how far we are dealing with convenient devices and how far with ascertained facts. The isolation of an intermediate product in one set of circumstances is in itself no proof that this product is transitorily formed when the reaction is proceeding in another set of circumstances; and if we were to assume generally that because we can represent a chemical transaction as if it were due to a successive construction and destruction of a series of molecular edifices it actually does take such a course, we should, I think, be making the same kind of mistake as to suppose that in the application of two differently directed forces to a body at rest, the body will move successively in the direction of each force instead of moving immediately in the direction of their resultant. I know that I may be considered hypercritical, and perhaps obstinate, in this matter; but I wished to state the reasons that prevent me from accepting entirely the interpretation which Prof. Bone has given to his experimental results, and to direct attention to a question of general importance that has not, I think, received the attention it deserves.

The mode of burning of carbon, whether in the free state or as a constituent of a compound, is not at all easy to determine; and notwithstanding many investigations, among which must be specially mentioned those of Prof. H. B. Dixon and his collaborators, so simple-looking a question as whether carbon forms carbon monoxide by directly uniting with oxygen, or only by reducing carbon dioxide, is still a matter of uncertainty.

Our knowledge concerning the question of flame temperatures has been much improved in recent times, thanks mainly to the admirable work of M. Le Chatelier. The well-known memoir of Mallard and Le Chatelier on the explosion of gases supplied the data which first permitted of a moderately exact calculation of flame temperatures, and the perfection of the thermo-couple by M. Le Chatelier gave us the first instrument that could be used directly for making a satisfactory measurement. The uncertainty connected with this subject may be well illustrated by quoting the temperatures that have at different times been ascribed to the flame of coal-gas when burnt in a Bunsen burner, where we have had values varying from 1230° to 2350° C.

The question of calculating the temperature attained during combustion by reference to calorimetric values, specific heat, dissociation, and other considerations is to form the subject of a joint discussion with Section G during the present meeting, so that I shall not here enlarge upon it.

With regard to the use of thermo-couples, I may remark that the practical difficulties have been successfully met. The chief difficulty is, of course, to secure that the thermo-junction attains as nearly as possible the temperature of the region in which it is immersed. As ordinary flames consist of thin shells of burning gases, on either side of which there is a very rapid fall of temperature, it is necessary to use thin wires, and to dispose them so that there is no appreciable drain of heat from the junction. By using wires of different gauge for the couples it is possible by extrapolation to arrive at a temperature for a couple of infinitely small cross-section, and it is also possible to make a correction for the superior radiating power of the couple as compared with the flame-gases. Without this last correction a maximum temperature of 1770° was obtained for the Bunsen flame by Waggener in Germany, and 1780° by White and Traver in America. Correcting for radiation, Berkenbusch found 1830° as the maximum temperature.

M. Féry, by an ingenious application of his beautiful optical pyrometer to a flame containing sodium, gives 1871° as the highest temperature of the flame of a Bunsen burner burning coal-gas.

The consideration of flame-temperatures has become of increasing importance in the arts owing to the use of the Welsbach mantle as a means of deriving light from coal-gas. The great improvements which have been made in the efficiency of atmospheric burners depend primarily on the fact that the smaller the external surface we can give to a flame consuming gas at a fixed rate the higher must be the average temperature; and since the emission of light from a mantle is proportional to a high power of the absolute temperature, a small increase of temperature is of great effect on luminosity.

The acetylene-oxygen flame in which a temperature of about 3500° prevails, not very different from that of the electric arc, is the hottest of the hydrocarbon flames, and finds some important practical uses.

I have already said something about the luminosity of flames so far as relates to the separation and glow of solid carbon. But there remains the more general question of the luminosity of flames containing nothing but gases. The older explanation of the emission of light from combining gases said no more than that the energy liberated during the reaction and appearing as heat raised the product to incandescence—that is to say, so increased the velocity of its molecules and the violence of their collisions that vibrations were set up the wave-lengths of which lay within the limits of visible radiation. This explanation has long been questioned, and there is now, I think, a very general agreement that it will not suffice. The average temperature, in fact, prevailing in a flame, if attained in the product of combustion by the supply of heat from outside, does not suffice to make that substance luminous. We are therefore thrown back upon the conclusion that the generation of light in a flame is not a consequence, though it is an accompaniment, of the elevation of temperature. The question now is, Can we go any further? To do this we are led to consider individual molecular transactions instead of statistical averages, and the view presents itself that the combining atoms may, in losing their chemical energy, form directly systems of independent vibration where the radiation is such as to fall within the limits of visibility. If we picture such vibrating systems momentarily formed, it is easy to see that by their collision one with another they may acquire in a secondary way increased translational motion, and so lead to a state of things where the greater part of their energy is degraded in the form of heat. The high temperature of a flame would then be a consequence rather than a cause of its light.

This subject of the mechanism of luminosity, however, like so many others, has now become involved with the theory of electrons, and a chemist may be excused if he hesitates to pursue the subject further. Some years ago I called attention to the scantiness of our knowledge of the chemical changes that take place when metallic salts are used in flames for the production of spectra. Though there was general agreement that, for example, the yellow flame produced by common salt was due to the liberation and glow of metallic sodium, there was no agreement as to how the sodium was set free.

Arrhenius, pursuing the analogy which exists between the laws governing matter in the gaseous state and in the state of dilute solution, had previously been led to the view that the electrical conductivity of flames containing salt-vapours was due to ionisation of the salt throughout the volume of the flame. It appeared possible therefore that the luminosity might be ascribed likewise to the metal separated in the ionic state. Experimental investigation undertaken with a view to elicit information on this subject seemed to favour the view that the metal was reduced by chemical processes, and that it glowed in the un-ionised condition. Evidence seemed to point to the conclusion that, for example, when common salt is introduced into the flame of coal-gas the sodium chloride yields sodium by the conjoint action of steam and reducing gases; when liberation of the metal was prevented by adding a large quantity of hydrochloric acid to the flame the glow disappeared, but the conductivity was not always diminished. The fact that sodium salts, including the chloride, impart their characteristic glow to the flame of cyanogen and to other flames in which water is absent leads to some difficulty in finding a chemical explanation, and it must be admitted that a direct thermal dissociation of an alkaline halide or oxide is not out of the question. The interval of detachment of the metallic atom may be exceedingly brief, but it must be remembered that even so short a time as the interval between the molecular encounters in a gas at a high temperature is still sufficient for the emission of thousands of undisturbed characteristic vibrations. The experiments to which I have alluded have been followed up with great industry and success by Prof. H. A. Wilson, who has added much to our knowledge of the electrical condition of the flames containing vaporised salts; but the question of the condition of the luminous gas is still far from being settled. Very interesting and important investigations have been carried out by Lenard, who has shown that the stream of luminous vapour produced from a sodium salt in a Bunsen flame is deflected in an electric field in such a way as to indicate that the vapour is positively charged; but he gives reason for believing that the charged condition is intermittent with the neutral condition. The lines in the spectrum of an alkali metal are divisible, as is well known, into distinct groups or series, in each of which the oscillation frequencies corresponding with the lines are in a definite mathematical relationship. The principal series, which include the lines seen individually as such in ordinary flame spectra, are, according to Lenard, due to the electrically neutral atoms. In a salted spirit flame, and in other flames of low temperature where only lines of the principal series are represented, the stream of luminous gas does not behave in an electric field as if it were charged. In the flame of coal-gas burnt in a Bunsen burner the salt-vapour gives, in addition to the distinct lines of the principal series, diffuse bands of luminosity on the dark background, which, according to Lenard, represent the undeveloped subordinate series; and it is the atoms emitting these series that are deflected in the electric field. It is inferred, therefore, that the light in a salted Bunsen flame comes from different groups of centres of emission—the principal series from the neutral atom, and the lines of the first, second, and third subordinate series from atoms which have lost respectively one, two, and three electrons. Lenard goes further, and shows that the salt-vapour in a Bunsen flame, as in the flame of the electric arc, emits these different kinds of radiation from different structural regions; thus the vapour at the edge of the flame is electrically neutral and gives only the lines of a principal series.

The negative electricity in a salted flame would, according to Lenard, be disembodied, and recent experiments by Gold confirm the view that the negative carrier in flames is a free electron. In connection with this subject I ought to allude to an investigation by Tufts, which seems to throw some doubt on the conclusions which were drawn from the experiments made by Prof. Wilson, Dr. Dawson, and myself; and I must also mention an important contribution to the subject recently made by Prof. Hartley, in which considerable light is thrown upon the chemical changes undergone by compounds of the alkaline earth metals when they are introduced into flames, and upon the relation of these changes to the various spectral features. I am afraid, however, that it would be wearisome if I were to prolong this summary, and I must be content to leave it without doing justice to those who are engaged upon the work. The subject is obviously one of fundamental importance in relation to spectrum analysis, and my own slight connection with it has only strengthened my opinion that there is still a great deal connected with the genesis of spectra that requires the attention of the chemist even more than that of the physicist. Spectrum analysis arose under the joint influence of Bunsen and Kirchhoff, and I think its problems still call for more combined work on the part of chemist and physicist than has latterly been the custom.

Having given a short summary of the present state of knowledge on one particular chemical topic, I may perhaps be permitted to conclude my Address with a few general observations relating to the science as a whole.

The contemplation of such a life as that of Berthelot makes us realise in a vivid way the progress of chemical science. He was a chemist without limitation, his activity extending over the whole range of the science, physical, inorganic, and organic. Whilst we must not forget his exceptional powers, we cannot help feeling how different in its extent was our science when he entered upon his labours from what it was when they ceased, and we cannot help feeling how vain it now is for anyone to hope for so imperial a sway.

Yet it is difficult to believe that the state of chemistry can ever have been more interesting than it is at the present moment, or that anyone who sighs for the good old times can do so from anything but the love of a quieter life. We need not go back more than twenty years to find a sharp contrast. At that time there was indeed no want of activity, but it was that of a band of travellers who had left their frontier adventures far behind, and were marching steadily over a wide and almost uninterrupted plain. To-day we are among the mountains, with new peaks and prospects appearing on every side. Truly a steady head is required; and well may we ask, Whither are we going and where is the path of progress and of safety? I rejoice to live in such times; but I feel no competence to describe them, still less can I pretend to have vision keen and comprehensive enough to let me figure as a guide.

One of the penalties of devotion to a progressive science is the constant feeling of being left behind, and the knowledge that, while we are attending to our personal task, things are happening, near or far, that may, for all we know, be affecting the simplest facts and the most elementary principles on which we have been accustomed to rely. This is a feeling that may well prevail at the present day. At the same time I do not think there is any occasion for panic, and I cannot help regretting the somewhat sensational language that has been used, even within our own circles, in regard to recent discoveries. The revelations attendant upon the investigation of radioactivity do indeed mark a distinct epoch in the history of chemical discovery, but that they entail anything like an unsettlement of our scientific articles of faith is not to be admitted for a moment. They make us realise in perhaps a not unprofitable way that scientific knowledge and scientific theories are necessarily proximate, never ultimate, and that ideas which may have been entertained for a long time without modification, and so have begun to seem perpetual, are, after all, only provisional.

There is certainly some embarrassment on finding that a substance like radium, which according to the conventions would be called a chemical element, breaks up so as to give substances which, according to the same conventions, are likewise called elements. But the confusion is one of terminology and not of ideas. I think it likely that few chemists of my own generation have been in the habit of regarding the conventional elements as the ultimate compositional units of matter. We know that in our own country distinguished men of science like Sir William Crookes and Sir Norman Lockyer have always insisted on the complex nature of the elements, and I suspect there are many among us who might own to having made sober, if unsuccessful, attempts at the resolution of elements before the days of radium.

The perplexities of chemists at the present day do not come, I think, from the novelty of the ideas that are being presented to them, but from the great rapidity with which the whole science is growing, from the invasion of chemistry by mathematics and, in particular, from the sudden appearance of the subject of radio-activity with its new methods, new instruments, and especially with its accompaniment of speculative philosophy. There is an uneasy feeling that developments of great importance to the chemist are being made by experiments on quantities of matter of almost inconceivable minuteness. Spectrum analysis of course took chemistry beyond the limits of the balance, but the new materials which it disclosed could at least be accumulated in palpable quantity. With radio-activity we seem, in relation to the ponderable, almost to be creating a chemistry of phantoms, and this reduction in the amount of experimental materials, associated as it is with an exuberance of mathematical speculation of the most bewildering kind concerning the nature, or perhaps I should say the want of nature, of matter, is calculated to perturb a stolid and earthy philosopher whose business has been hitherto confined to comparatively gross quantities of materials and to a restricted number of crude mechanical ideas. He is tempted to think of Falstaff's reckoning and to exclaim with Prince Henry, "Oh, monstrous! but one halfpennyworth of bread to this intolerable deal of sack!" Experimental science has latterly been spun to greater and greater fineness, until in the region of the *n* rays the objective element seems to have disappeared altogether.

I should, however, gravely abuse the position in which I am allowed to speak for the moment as a representative of chemists if I failed to express profound admiration for the masterly work which has been accomplished by the pioneers of the science of radio-activity. All that I wish to say beyond that, is in explanation of a certain awe or trepidation which chemists of the older school may feel in the presence of such bold explorers; and I am the more tempted to say something on the subject, because in recent times, before the advent of radium, a good deal has happened which has given chemists occasion to ask themselves whether chemistry was not beginning, as it were, to drift away from them.

The most conspicuous development of the science during the past twenty years has been, of course, on the physical side, and abundant have been its fruits; but it has seemed to demand from chemists habits and endowments which they did not normally possess, and which they could not easily acquire. I was much struck by a remark made to me a few years ago by a distinguished chemist, who is, I think, the most perfect manipulator I have ever seen at work, to the effect that he felt himself submerged and perishing in the great tide of physical chemistry which was rolling up into our laboratories. Now, it is precisely such men that must be preserved to chemistry. Though chemistry and physics meet and blend, there is, I believe, an essential difference between the genius of the chemist and the genius of the physicist, and I venture to think that some insistence on the primary functions of a chemist is not untimely. The chemist's first qualification is that he shall be master of a peculiar craft; his greatest merit that he is a consummate workman; his distinctive power a nicety of discrimination in questions affecting the composition and quantity of materials. He is not given to elaborate theories and is usually averse to speculation; nor has he usually an aptitude for mathematics. Such the normal chemist is, or was, and such I hope he always may be—naked perhaps in some respects, but unashamed.

There seems to be a solicitude in some quarters to make a chemist something more than a chemist, a solicitude which, if gratified, will, I believe, make him something less than one. We are told, for example, that a chemist should be a mathematician. I do not admit it for a moment. Some mathematics he must of necessity have—that has always been admitted—but in proportion as chemistry develops on the mathematical side does it become important, not that our chemists should be trained in mathematics, but that they should be more than ever carefully trained in the art of exact experiment; that their methods of work, their powers of observation, and, if possible, their experimental conscience, if I may use the expression, should acquire a finer edge. There is never more cause for anxiety than when we see a mathematical theory awaiting the delivery of the confirmatory facts, and there is nothing more important for chemistry than the continual recruiting of that old guard which will be ever ready to stand to arms on the appearance of an eager theorist.

I do not for a moment wish to disparage the adventurous spirits within or outside our science, still less do I wish to range myself with those who meet new ideas with mere objurgation or raillery. We must be content to see new alliances and new activities on the frontiers that separate us from other sciences; content to see many new kinds of chemistry arise in which we cannot all effectually participate. Chemistry is becoming bewildering in its extent, and it would be a great misfortune if this led to the notion that every chemist must try to enlarge his ambit to its confines and fit himself for every variety of work. Those of us who have responsibilities as teachers cannot, I think, be too careful, lest in the attempt to secure breadth we may encourage shallowness and fail to give our students that peculiar and time-honoured discipline in exactitude of work in chemistry proper, which has characterised the chemists of the past, and which is infinitely more important than superficial dealings with a great variety of processes and appliances. I confess that I have frequent misgivings as to whether our modern courses of instruction may not tend to turn out chemists more learned in the science and less perfect in the art than was the case under the ancient *régime*. There was, after all, great virtue in the system which often detained a student day after day, or perhaps week after week, on a single problem of chemical composition such as is involved in the exact analysis of fahl-ore. It is not easy to meet all requirements, but I think we shall all agree that, whatever is left undone, we must make a chemist a good craftsman. It is of the utmost importance that those whom we send out to work in the newer fields shall take with them the resources that have proved most serviceable in the old, and I think it is by supplying such men for special service, rather than by attempting to shift the centre of gravity of the whole system of chemical education, that we can best serve the newer interests.

Another perturbation within the chemical camp in recent times has come from the region of philosophy. Even before the days of radium we have been accused of clinging too fondly to our atomic theory and of stating our knowledge too exclusively in terms of that theory. We are said to have drifted into a dogmatism as real as any we ourselves have had to attack, and to shut our eyes to the light which will enable us to orient ourselves truly in the wide realm of thought. The answer that most of us would give would be, that we value our hypotheses according to their productiveness in new knowledge, and that it is, on the whole, perhaps better to over-exalt an hypothesis that is fertile than from high considerations of philosophy to allow our ideas to become so fluid that they can afford no rigid framework for thought. I think that the attempts to view chemical phenomena apart from the atomic hypothesis, interesting as they undoubtedly are, have not made us feel that this hypothesis has either misled us in any matter of fact or obscured any pathway that we might have followed with greater profit. The value of the thermo-dynamical treatment of chemical problems is attested by its fruitfulness in promoting fresh discoveries; and here we may welcome a valuable adjunct to the atomic hypothesis. But I do not think we are called upon to acclaim a new method of treating old questions unless it promises some more tangible result than an alleged improvement of our intellectual morals.

If, as I have ventured to hint, mathematics brings with it an element of danger into chemistry, I think that the intrusion of metaphysics would give far greater cause for apprehension. Philosophy always stands with open arms desiring a closer embrace of all the sciences, of which she declares herself to be the fond mother, whilst Science, as we understand the term, has stood reluctant, suggesting, as someone has wittily remarked, that she regards Philosophy rather as a mother-in-law. It may perhaps be desirable, especially in the present state of things, that scientific men should allow themselves to become a little more interested in deep questions affecting all knowledge, and should at least examine with some care the gifts that Philosophy is so anxious to bestow upon us. I have a fear that otherwise in the elaboration of scientific theory we may find ourselves embroiled in an unequal contest with what I cannot but regard as the traditional enemy—I mean the unmitigated metaphysician—and the suggestion that I make is, to tell the truth, not so much from the hope of gain as from the desire for self-defence and the safe preservation of the methods that have served us so well in the past.

I think the accusation that we delude ourselves into the belief that our hypotheses are final truth is not true of any thoughtful chemist; the great men of science have surely possessed that quality of mind which philosophy would most approve. If, as has often been remarked, Faraday was mathematically-minded, though untrained in mathematics, it seems not less true that he stood in the same relation to philosophy. When, for example, he was asked to express his opinions on the atomic theory, he wrote as follows:—

"I do not know that I am unorthodox as respects the atomic hypothesis. I believe in matter and its atoms as freely as most people—at least I think so. As to the little solid particles, which are by some supposed to exist independent of the forces of matter, and which in different substances are imagined to have different amounts of these forces associated with, or conferred upon, them (and which even in the same substance, when in the solid, liquid, and gaseous state, are supposed to have like different proportions of these powers), as I cannot form any idea of them apart from the forces, so I neither admit nor deny them. They do not afford me the least help in my endeavour to form an idea of a particle of matter. On the contrary, they greatly embarrass me; for after taking account of all the properties of matter, and allowing in my consideration for them, then these nuclei remain on the mind, and I cannot tell what to do with them. The notion of a solid nucleus without properties is a natural figure or stepping-stone to the mind at its first entrance on the consideration of natural phenomena; but when it has become instructed, the like notion of a solid nucleus, apart from the repulsion, which gives our only notion of solidity, or the gravity, which gives our notion of weight, is to me too difficult for comprehension; and so the notion becomes to me hypothetical, and, what is more, a very clumsy hypothesis. At that point, then, I reserve my mind as I feel bound to do in hundreds of other cases in natural knowledge."

This is the attitude of mind, I think, of all thoughtful chemists; if they do not exhibit it ostentatiously it is only because it is as disturbing to the proper work of a chemist for him to be constantly dwelling on the inward nature of his hypotheses as it is distracting in ordinary life to have men always talking about their emotions.

Few, I think, will deny that the atomic theory stands to-day as an indispensable instrument for productive chemical work; it has neither had its day nor ceased to be. Physicists have never been quite satisfied with the hard indivisible ball of specific substance and definite mass which has served chemistry so well. They have given it bells, have made a vortex ring of it, and have indeed done much that few chemists can understand to make it meet the exacting requirements of their science. But to us it has always been the same; what we have done to it has been external; we have given it, vaguely perhaps, a charge of electricity, a store of energy; we have attached the hooks or rods of valency, but we have not meddled with its interior. We are now called upon by chemical considerations of change of composition, as well as by other considerations more recondite, to subdivide our atom, to credit it with an unsuspected store of energy, to consider it a congeries of unsubstantial electrons. We should wish, of course, to know that the evidence is good enough, but otherwise there can be no possible objection from our side; it will undo nothing that has been done, and we may have good hopes that it will lead to the doing of many new things in chemistry. The newer theories are in consonance with the old in one most vital point: they afford those mental pictures of phenomena which most of us find indispensable for fruitful work. They do not belong to what Prof. Schuster has characterised as "the evasive school of philosophy." "Those," he says, "who believe in the possibility of a mechanical conception of the universe, and are not willing to abandon the methods which from the time of Galileo and Newton have uniformly and exclusively led to success, must look with the gravest concern on a growing school of scientific thought which rests content with equations correctly representing numerical relationships between different phenomena, even though no precise meaning can be attached to the symbols used." Most of us, I think, will take comfort in this pronouncement and rejoice that if our conception of the atom is to be transformed, it may still be represented as having some kinship with what Sir Henry Roscoe's famous examinee described as the "square blocks of wood invented by Dr. Dalton."

SECTION C.

GEOLOGY.

OPENING ADDRESS BY PROF. J. W. GREGORY, D.Sc., F.R.S., PRESIDENT OF THE SECTION.

I. *The Geological Society of London.*

1907! This is the centenary year of the Geological Society of London; next month the British geologists will celebrate the event, and their pleasure will be enhanced by the sympathetic presence of a distinguished company of foreign geologists.

With a just feeling of satisfaction may we celebrate this event; for to the Geological Society of London is due the conversion of Geology from a fanciful speculation to an ordered science. Yet so quietly has this society done its work that the debt due to it is inadequately realised. When we consider what the world owes to Geology in respect of its economic guidance—the intellectual stimulus of its conceptions—the reverence it inspires for the venerable and majestic universe—its liberating influence from dogma—we may rightly regard the work of the Geological Society as one of the most valuable British contributions to intellectual progress during the nineteenth century.

A hundred years ago the spirit of the eighteenth century still controlled much of the then orthodox Geology. Jameson's "Elements of Geognosy," of which the preface is dated January 15, 1808, taught, as the certain conclusions of Geology, doctrines that had been reached by applying prejudiced speculation to imaginary facts. It was a manual of pure, *a priori*, Wernerian Geology. The author claimed that to Werner "we owe almost everything that is truly valuable in this important branch of knowledge"; and that it was Werner "who had discovered the general structure of the crust of the globe and pointed out the true mode of examining and ascertaining those great relations which it is one of the principal objects of geognosy to investigate."

But Jameson's book was the death-song of Wernerian Geology in British science. A new Geology was developing; and the Geological Society of London ushered in its birth. No more should observations be made through the distorting medium of preconceived fancies! No more should Geology be inspired by that heedless spirit, which cares not to distinguish between fancy and fact! With youthful vigour the new Geology would have nothing to do with the search for cosmogonies and such like fancy foods; and the Geological Society of London should be nourished on unadulterated facts.

The time was ripe for the change. No less a person than Goethe, once an enthusiastic votary of Geology, was now, in his play of "Faust," holding up its teachers to ridicule. The theories "evolved from the inner consciousness" of Continental Neptunists and Plutonists were to Goethe excellent subjects for caricature. It was then the Englishman, Greenough, founded a society to turn Geology from the pursuit of fleeting fancies and lead her to the study of sober but enduring facts. The members of this society were to abandon the quest of scientific chimæras; they were to leave to later generations the attempt to solve the universe as a whole.

The Geological Society has owed its influence to its bold, original purpose. It was not founded as a drifting social union of men, with a common interest in a single science. Its object was to apply to Geology one particular mode of research. It adopted as its motto this fine passage from Bacon:—

"If any man makes it his delight and care—not so much to cling to and use past discoveries, as to penetrate to what is beyond them—not to conquer Nature by talk, but by toil—in short, not to have elegant and plausible theories, but to gain sure and demonstrable knowledge; let such men (if it shall seem to them right), as true children of knowledge, unite themselves with us."

The methods of the society were as practical as its ideals. London, with characteristic unconventionality and originality, has used its scientific societies as its university for post-graduate teaching. Informally the Geological Society enrolled every British master of Geology on its staff of unpaid professors, then set each of them to teach the branch of Geology which he knew best. And these professors were no carpet knights; they were knights errant who derived their knowledge, not from books alone, but from their wanderings over hills and dales, in mines and quarries, by ice-polished rocks and water-worn valleys. At its meetings the leaders of the society announced what they had discovered, gave sure and demonstrable proofs of their discoveries, and showed in what direction the geological forces should be directed for the conquest of Nature. The goodly fellowship of the Geological Society has always encamped on the ever-advancing frontier of geological knowledge, where the well-surveyed tracks pass out into the bright, alluring realms of the unknown.

The actual founders of the Geological Society were apparently men of less showy intellect than the great Werner, whose teaching had intoxicated many of the most gifted of his enthusiastic pupils. They were men, like Horner and Greenough, who had a practical insight that enabled them to give a permanent help to the progress of science. They had that supreme gift, the power to see things as they are. It would not be fair to claim for them that they were the originators of accurate methods in Geology; such methods had been used before their day—by William Smith in England, by Lehman in Germany, and by Desmarest in France. But these men, acting singly, had not been able to save Geology from the eighteenth-century spirit of adventurous speculation, nor had they lifted from Geology the burden of those quaint theories, that made this science the butt of Voltaire's luminous ridicule.

The great achievement of the Geological Society has been this: as a corporate body it has been able to spread its influence very widely; its clear-sighted pursuit of a practical ideal has been adopted in other countries; its resolute rejection of the temptation to wander in dreamland has affected geological students all over the world. In this way has been laid a broad foundation of positive knowledge upon which modern Geology has been built.

The fine self-restraint, which induced the founders of the Geological Society to restrict its work for a while to observing the surface of the earth, has had its reward. The methods this society was founded to employ have been so widely used, that we now have geological maps of a wider area than was known to geographers of a century ago. The general distribution of all the rocks on the earth's surface has been discovered; most settled countries have been surveyed in some detail; the main outlines of the history of life on the earth have been written and carried back almost as far as palæontologists are likely to go. There are doubtless fossiliferous areas still undiscovered in the "back blocks" of the world; but, though negative predictions are proverbially reckless, it seems probable that Palæontology will not carry geological history materially farther back. Fossils have been discovered in the præ-Cambrian rocks; the best known is the fauna described by Walcot from Montana; but his Beltina, the oldest well-characterised fossil, is still of Palæozoic type. It may be that the poverty of carbonate of lime, which is so characteristic a feature of most Cambrian and præ-Cambrian sediments, indicates that the bulk of the contemporary organisms had chitinous shells or were soft-bodied. Palæontology begins with the appearance of hard-bodied organisms; it can only reveal to us the dawn of skeletons, not the dawn of life. We are dependent for knowledge of the climate and geography of Eozoic time to the evidence of the sediments, of which there are great thicknesses beneath the fossiliferous rocks in most parts of the world.[1]

II. *The Geology of the Inner Earth.*

Now that this geological survey of the earth is in rapid progress; while the history of life has been written at least in outline; the chief fossils, minerals, and rocks have been described and generously endowed with names; and the manifold activity of water and air in moulding the surface is duly appreciated, it is not surprising to find that the centre of geological interest is shifting to the deeper regions of the earth's crust and to the problems of applied Geology. The secrets of these deeper regions are both of scientific and economic interest. They are of scientific importance, for it is now generally recognised that the main plan of the earth's geography and the essential characters of the successive geological systems are the result of internal movements. The relative importance of those restless external agents that we can watch, denuding here and depositing there, has been exaggerated; probably they do little more than soften the outlines due to the silent heavings produced by the colossal energies of the inner earth.

The study of the deeper layers of the crust is of economic interest, for, with keener competition between increasing populations and with the exhaustion of the most easily used resources of field and mine, there is growing need for the better utilisation of soils and waters, and for the pursuit of deeper deposits of ore.

If a shaft be sunk at any point on the earth's surface, a formation of Archæan schists and gneisses would probably always be reached; and, working backward, geological methods always fail at last—in primæval, Archæan darkness. The Archæan rocks still hide from us the earlier period of the earth's history, including that of all rocks which now lie beneath them. But already there are indications that the mystery of the "beyond" is not so impenetrable as it seemed.

(1) *The Nebular and Meteoritic Hypotheses.*—The eighteenth century explained the history of the earth by the nebular hypothesis of Laplace. Geologists respectfully adopted this idea from the astronomers; they accepted it as one of those essential facts of the universe with which geological philosophy must harmonise. The resulting theory represented the earth as originally a glowing cloud of incandescent gas, which slowly cooled, until an irregular crust of rock formed around a gaseous or molten core; as the surface grew cooler, the depressions in the crust were filled with water from the condensing vapour, forming oceans which became habitable as the temperature further fell. The whole earth was thought to have had a long period with a universal tropical climate, under which coral reefs grew where flow our polar seas, and palms flourished on what are now the Arctic shores. Still further cooling had established our climatic zones; and it was predicted that in time the polar cold would creep outward, driving all living beings toward the equator, until at length the whole earth, like the moon, would become lifeless through cold, as it had once been uninhabitable through heat. This theory has permanently impressed itself on geological terminology; and its corollaries, secular refrigeration and the contortion of the shrinking crust, once dominated discussions concerning climatic history and the formation of mountain chains. This nebular hypothesis, however, we are now told, is mathematically improbable, or even impossible; and it is only consistent with the facts of Geology on the assumption that, in proportion to the age of the world, the whole of geological time is so insignificant that the secular refrigeration during it is quite inappreciable; hence Geology can no more confirm or correct the theory than a stockbreeder could refute evolution by failing to breed kangaroos into cows in a single lifetime.

The theory of the gaseous nebula has been probably of

[1] Such are the Algonkian sediments represented by the Huronian and Algonkians of America, the Algonkians of Scandinavia, the Karelian of Finland, the Briovarian of North-West France, the Heathcotian of Australia, the Transvaal and Swaziland systems of South Africa, the Dharwar and Bijawar systems of India, the Itacolumnite series of Brazil, &c.

more hindrance than help to geologists; its successors, the meteoritic hypothesis of Lockyer and the planetismal theory of Chamberlin, are of far more practical use to us, and they give a history of the world consistent with the actual records of Geology. According to Sir Norman Lockyer's meteoritic hypothesis, nebulæ, comets, and many so-called stars consist of swarms of meteorites which, though normally cold and dark, are heated by repeated collisions, and so become luminous. They may even be volatilised into glowing meteoric vapour; but in time this heat is dissipated, and the force of gravity condenses a meteoritic swarm into a single globe. Some of the swarms are, says Lockyer, "truly members of the solar system," and some of them travel around the sun in nearly circular orbits, like planets. They may be regarded as infinitesimal planets, and so Chamberlin calls them planetismals.

The planetismal theory is a development of the meteoritic theory, and presents it in an especially attractive guise. It regards meteorites as very sparsely distributed through space, and gravity as powerless to collect them into dense groups. So it assigns the parentage of the solar system to a spiral nebula composed of planetismals, and the planets as formed from knots in the nebula, where many planetismals had been concentrated near the intersections of their orbits. These groups of meteorites, already as solid as a swarm of bees, were then packed closer by the influence of gravity, and the contracting mass was heated by the pressure, even above the normal melting-point of the material, which was kept rigid by the weight of the overlying layers.

This theory has the recommendation of being consistent with the history of the earth as interpreted by Geology. For whereas the nebular hypothesis represents the earth as having been originally intensely hot, and having persistently cooled, yet geological records show that an extensive low-level glaciation occurred in Cambrian times in low latitudes in South Australia;[1] indeed, it seems probable that, in spite of many great local variations, the average climate of the whole world has remained fairly constant throughout geological time. Whereas it has often been represented, in accordance with the nebular theory, that volcanic action has steadily waned, owing to the lowering of the earth's internal fires and the constant thickening of its crust, yet epochs of intense volcanic action have recurred throughout the world's history, separated by periods of comparative quiescence. Whereas it has been assumed, as a corollary to the nebular theory, that the force which uplifted mountain chains was the crumpling of the crust owing to the contraction of the internal mass, yet observation reveals that the crust has been corrugated, and fold mountains formed by contraction to an extent far greater than secular cooling can explain.

(2) *The Materials of the Inner Earth.*—This planetismal hypothesis is not only consistent with geological records, but also with the known facts as to the internal composition of the earth and the structure of extra-terrestrial bodies as revealed by meteorites. Meteorites are of two main kinds—the meteoric irons, which consist of nickel iron, and stony meteorites, which are composed of basic minerals. Some of the stony meteorites have been shattered into fault breccias, showing that they are fragments of larger bodies which were subject to internal movements, like those that have formed crush conglomerates in the crust of the earth. Those stony meteorites, therefore, both in composition and structure resemble the rocks in the comparatively shallow fracture zone of the earth's crust. The nickel-iron meteorites, on the other hand, represent the barysphere beneath the crust.

The earth appears to consist of material similar to that of the two types of meteorites; but whether the proportions of the two materials in the earth represent their proportions in other bodies and in meteoric swarms is problematical. There appear to be no satisfactory data for an estimate of the relative abundance in space of the iron and stony meteoric material. Stony meteorites have been seen to fall far more frequently than iron meteorites; but the largest known meteorites are of the nickel-iron group, although this material, in moist climates, very soon decays. The most trustworthy indication as to the relative amounts of the stony and nickel-iron meteorites is given by a comparison of the weight of the two types of material in meteorites of which the fall was seen. According to Mr. Fletcher's list of the meteorites in the British Museum up to 1904, the collection included 319 specimens of which the fall is recorded: of them 305 specimens were stony meteorites of an average weight of 2·63 lb., 9 were iron meteorites of an average weight of 2·31 lb., and 5 were siderolites (or meteorites containing a large proportion of both silicates and nickel iron) of an average weight of 54 lb.[1] Therefore, according to this test, the stony materials would appear to be the more abundant. But if all known meteorites are considered, the iron group far outweighs the other; for the iron meteorites in the British Museum collection weighed 11,873 lb., as against a total weight of only 865 lb. of stony meteorites. The available evidence suggests that the stony meteorites fall the more frequently on the earth, but the meteoric irons come in such large masses that they outbalance the showers of the smaller stones.

We might have expected help from another source in examining what lies below the Archæan rocks. Cannot the relative proportions of the stony and metallic constituents in the earth help us? Unfortunately, this proportion is as uncertain as that of stony and iron meteoritic material. The best-established fact about the interior of the earth is that its materials are much heavier than those of its crust. The specific gravity of the earth as a whole is about 5·67; the specific gravity of the materials of the crust may be taken as about 2·5, while that of the heavier basic rocks is only about 3·0. Hence the earth as a whole weighs about twice as much as it would do, if it were built of materials having the same density as those which form the crust.

Two explanations of the greater internal weight of the earth have been given. According to one, the earth is composed throughout of the same material, and the internal mass is only heavier because it is compressed by the weight of the overlying crust. Laplace estimated that the material would gradually increase in density from the surface to the centre, where its specific gravity would be 10·74, and the calculations of Schlichter show that condensation due to compression may be adequate to account for the greater internal weight.

According to the alternative or segregation theory, the difference in density is explained as due to a difference in composition; the interior of the earth is thought to be heavier owing to the concentration of metals within it. The probability of this metallic interior has been advanced from several lines of evidence; and the assumed metallic mass has received from Posepny the name of the "barysphere," or heavy sphere. According to this view the earth is essentially a huge ball of iron, which, like modern projectiles, is hardened with nickel; and it is covered by a stony crust, the materials of which were primarily separated from the metallic mass, like the slag formed on a ball of solidifying iron in a puddling furnace.

It has been objected that the weight of the earth is not great enough for much of it to be composed of metallic iron or of meteoritic material. The specific gravity of iron under the pressure at the earth's surface is about 7·7, and it would be even greater when compressed in the interior. But the barysphere is doubtless impregnated with much stony material that would lessen its weight. An estimate by Farrington (1897) of the average specific gravity of the meteorites of which the fall had been recorded is only 3·69. According to the Rev. E. Hill (1885) the mean specific gravity of all the meteorites in the British Museum was 4·5; and, though Mr. Hill duly considered the effect of compression, he concluded that "the density of the earth is perfectly consistent with its being an aggregation of meteoric materials." Moreover, within the metallic barysphere there may be a core of lighter material; for earthquake waves travel more slowly in the central core of the earth than in the intermediate zone, or are even suppressed altogether there; hence the centre of the earth may be occupied by matter less compact than that of the shell around it; and, according

[1] As shown by the work of Prof. Howchin, of Adelaide.

[1] The weights are given in pounds avoirdupois. For the calculation I am indebted to Mr. W. R. Wiseman, of the Geological Department of Glasgow University.

to Oldham's calculations, the light central core occupies two-fifths of the diameter of the earth.

The evidence of density alone, therefore, gives no convincing evidence of the nature of the earth's interior; and geologists have been left with no conclusive reason for choosing between the condensation and segregation theories. Radio-activity has, however, unexpectedly come to our aid, and has disclosed a further striking resemblance between the internal mass of the earth and the iron meteorites. It has supplied direct evidence about the constituents of the earth at depths which have hitherto been far beyond the range of observation. Mr. Strutt has shown that radium is probably limited within the earth to the depth of 45 miles; that the deeper-lying material is free from radium; and that this substance is not found in iron meteorites.

The agreement in radio-active properties between the iron meteorites and the interior of the earth is an additional and weighty argument in favour of the view that the earth is largely composed of nickel iron.

(3) *Physical Conditions and Temperatures.*—The physical condition in which the material exists is now of secondary interest. The old controversy as to whether the earth has a molten interior inclosed within a solid shell has lost its importance, because it has become a mere matter of definition of terms. The facts which led geologists to believe that the interior of the earth is fluid are consistent with those which prove that the earth is more rigid than a globe of steel. For under the immense pressure within the earth the materials can transmit vibrations and resist compression like a solid; but they can change their shape as easily as a fluid. They are fluid just as lead is when it is forced to flow from a hydraulic press. Not only are geologists now justified in their belief that the deeper layers of the earth's crust are in a state of fluxion, but, according to Arrhenius (1900), the earth is solid only to the depth of 25 miles, below which is a liquid zone extending to the depth of 190 miles; and below that level, he tells us, "the temperature must, without doubt, exceed the critical temperature of all known substances, and at this depth the liquid magma passes gradually to a gaseous magma." This distinguished physicist gives a description of the earth's interior which reminds us of the views of the early geologists. Arrhenius's theory rests, however, on the existence within the earth of exalted temperatures; and this assumption a geologist may now hesitate to accept with less risk of getting into disgrace than he would have run a few years ago. It is improbable that the rapid increase of heat with depth which is observed near the surface should continue below the lithosphere; for, if the earth consists in the main of iron, even although it be arranged as a mesh containing silicates in the interspaces, the heat conductivity might be sufficient to keep the whole metallic sphere at a nearly equal temperature. Here, again, Mr. Strutt's work on radio-activity is in full agreement with the requirements of geologists, for he estimates that below a crust 45 miles thick the earth has a uniform temperature of only 1500° C. Whether the further conclusion, that this heat is due to the action of the radium in the crust, be established or not, it is gratifying to hear a physicist arguing in favour of a moderate and uniform internal temperature.

All that the actual observations prove and that geological theories require is that the material within the earth be intensely hot, and that it lie under such overwhelming pressure that it would as readily change its form and as quickly fill up an accessible cavity as any liquid would do. Whether such a condition is to be described as solid, liquid, or gaseous is of little concern to geologists.

III. *The Deep-seated Control over the Earth's Surface.*

The modern view of the structure of the earth adds greatly to the interest of its study, for it recognises the world as an individual entity of which both the geological structure and the history have to be considered as a whole. Once the earth was regarded as a mere lifeless, inert mass which has been spun by the force of gravity, that hurls it on its course into the shape of a simple oblate spheroid. Corresponding with this astronomical teaching as to the shape of the world was the geological doctrine, that all its topography is the work of local geographical agents, the control of which over the surface of the earth is as absolute as that of the sculptor's chisel over a block of marble.

Both these conceptions are now only of historic interest. The irregular individual shape of the earth is expressed by its description as a geoid. The processes which have produced its varying shape have also controlled its geological history and evolution, for they cause disturbances of the crust, which affect the whole earth simultaneously; and so the geographical agents are given similar work and powers at the same time in different places.

Hence there is a remarkable world-wide uniformity in the general characters of the sedimentary deposits of each of the geological systems. The last præ-Cambrian system includes thick masses of felspathic sandstones alike in the Torridonian of Scotland, the sparagmite of Scandinavia, the Keweenawan Sandstones of the United States, and perhaps also the quartzites of the Rand. The Cambrian has its greywackes and coarse slates and its numerous phosphatic limestones; the Ordovician its prevalent shales and slates; the Silurian its episodal limestones and shales. The Devonian has its wide areas of Old Red Sandstones as a continental type, while its marine representatives show the prevalence of coarse grits and sandstones in the lower series, of limestones and slates in the middle series, and the recurrence of sandstones in the upper series; and this sequence occurs alike in North-Western Europe, in America, and Australia. The Carboniferous contains the first regional beds of thick limestone and the first important Coal Measures. The Trias is as characterised by rocks indicating arid continental conditions in America and Australia and South Africa, as Prof. Watts has shown then prevailed in the neighbourhood of Leicester. In the Mesozoic era we owe to Suess the demonstration of the world-wide influence of those marine encroachments or "transgressions" whereby the great continents of the Trias were gradually submerged by the rising sea.

Speaking generally, there is a remarkable lithological resemblance between contemporary formations in all parts of the world. This fact had been often remarked, but was usually dismissed as due to a number of local isolated coincidences of no special significance. But the coincidences are too numerous and too striking to be thus lightly dismissed. They are among the indications that the main earth-changes have been due to world-wide causes, which led to the predominance of the same types of sedimentary rocks during the same period in many regions of the world.

The conditions that govern the geological evolution and general geography of the earth are probably due to the interaction between the earth's crust and the contracting interior; they may take place as slow changes in the form of the earth, causing the slow rising or lowering of the sea surface, or the slow uplift or depression of regions of the earth's crust; or they may give rise to periods of violent volcanic action in many parts of the earth, between which may be long periods of quiescence. The geographical effects of changes in the earth's quivering mass affect distant regions at the same time. Therefore the landmarks of physical geology will probably be found to give more precise evidence as to geological synchronism than those of Palæontology, on which we have hitherto had to rely.

IV. *Plutonists and Ore-formation.*

Belief in the earth's internal fires was most faithfully held amongst geologists by the Plutonists of the eighteenth century, and repudiated with equal thoroughness by the Neptunists, who refused to concede that volcanic action was due to deep-seated cosmic causes. Thus Jameson in 1807 stoutly maintained that volcanoes were superficial phenomena due to the combustion of beds of coal beneath fusible rocks, such as basalt, and that the explosions were due to the sudden expansion of sea-water into steam by contact with the burning coal. Volcanoes, according to this view, were correctly described as burning mountains, giving forth fire, flame, and smoke. The extreme Neptunist and Plutonist schools have long since been extinct, but the controversy is not quite closed. The battlefield is now practically restricted to economic geology, and the issue is the origin of some important ores.

Ore deposits present so many perplexing features that deep-seated igneous agencies were naturally invoked to explain them, and some of the most thorough-going champions of the igneous origin of ores make claims that remind us of the eighteenth-century Plutonists. The question is to some extent a matter of terms. Many of the ores which Vogt, for example, describes as of igneous origin he attributes, not to the direct consolidation of material from a molten state, but to eruptive after-actions due to the hot solutions and heated gases given off from cooling igneous rocks. Igneous rocks probably play a notable part in the genesis of most primary ore deposits; for the entrance of the hot ore-bearing solutions is rendered possible by the heat of the igneous intrusions, as Prof. Kemp has well shown in his paper on "The *Rôle* of Igneous Rocks in the Formation of Metallic Veins." Prof. Kemp limits the term "igneous" to materials formed by the direct consolidation of molten material; and this decision seems to me to be most convenient. For example, the quartzite that is so often found beneath a bed of basalt is due to hot alkaline water from the lava cementing the loose grains of sand; the process is an eruptive after-action, but it would be unusual to call such a quartzite an igneous rock.

(1) *Igneous Ores.*—That there are ores which are the products of direct igneous origin is now almost universally admitted. The mineral magnetite is a most valuable source of iron, and it is a constituent of most basic igneous rocks. If iron were a high-priced metal, such as tin or copper, of which ores containing one or three per cent. are profitably worked, then basalt would be an ore of igneous origin. Under present commercial conditions, however, basalt cannot be regarded as an iron ore. But if the magnetite in a basic rock had been segregated into clots or masses large enough and pure enough to pay for mining, then they would be iron ores formed by igneous action. There are cases of such segregations large enough to be mined. The most famous is Taberg, a mountain in Småland, near the southern end of Lake Wetter, in Sweden. It is a locality of historic interest; a view of it, as a mountain of iron, was published by Peter Ascanius[1] in the Philosophical Transactions in 1755, and Sefström discovered the element vanadium in its ore in 1830.

Taberg consists of an intrusive mass of rock composed of magnetite, olivine, labradorite, and pyroxene. Many theories of its formation have been advanced. The view generally adopted is that of Törnebohm, who described the rock as a variety of hyperite in which there has been a central segregation of magnetite to such an extent that some of it contains 31 per cent. of iron. Törnebohm claims to have traced a gradual passage from normal hyperite to a variety poor in felspar, then to one without felspar, and finally to a granular intergrowth of magnetite and olivine. This Taberg ore was mined and smelted for iron in the eighteenth century, when transport was more costly and commercial competition less keen than it is to-day. The ore has been worked at intervals as late as 1870; and as the hill is estimated to contain 100 million tons of ore above the level of the adjacent railway, it is not surprising that efforts are being again made to utilise the deposit, in spite of its low grade and high percentage of titanium. The Taberg rock has almost reached the line which divides magnetite-bearing rocks from useful iron ores. Its igneous origin, however, has not been universally accepted. The theory has been rejected by so eminent an authority as Posepny, according to whom the ore occurs in solid veins as well as in grains; and he holds that, like other Scandinavian iron ores, it was due to secondary deposition. During a visit to the mountain, I failed to see any secondary veins, except of insignificant value. The microscopic sections of the ore show that it is a granular aggregate of olivine, generally with labradorite and pyroxene. Hence I have no hesitation in accepting the view of the Swedish geologists and regard Taberg as a magmatic segregation. Posepny[2] has in this case carried his Neptunist theory of the genesis of ores too far.

[1] vol. xlix. pp. 30–34, pl. ii.

[2] F. Posepny. "The Genesis of Ore Deposits," Trans. Amer. Inst. Min. Eng., 1893, p. 323.

At Routivaara, in Swedish Lapland, there is a still larger mass of magnetite, which is claimed, in accordance with the descriptions of Petersson and Sjögren, to be due to segregation from the magma of the surrounding gabbro. This mass of magnetite is of colossal size, but it is of no present economic value, owing to its high percentage of titanium and its remote position.

An igneous origin is claimed by Prof. Högbom for some small masses of titaniferous magnetite in the island of Alnö, opposite Sundsvall, on the eastern coast of Sweden. This case is of interest, as the surrounding rock is not basic: it is a nepheline syenite, containing only 2 per cent. of magnetite, which, however, has been concentrated in places, until some specimens (according to an analysis quoted by Prof. Högbom) contain as much as 64 per cent. of magnetite, 9 per cent. of ferrous oxide, and 12 per cent. of titanic oxide.

The Alnö magnetites, again, are of no practical value, as they are too low in grade and too refractory in nature. I understand that about 500 tons of the material have been smelted, but with unprofitable results, and the rest of the material quarried has been left on the shore. We may therefore accept the iron-bearing masses of Alnö and Routivaara, as well as that at Taberg, as due to magmatic segregation, without having conceded much as to the igneous formation of ores. The process in this case has formed rocks, rich in titaniferous magnetite, from which iron could be obtained, but rocks which no iron-master is at present willing to buy as iron ore. Whether a basic igneous rock is to be regarded as an iron ore, or as only useful for road metal, depends on cost of treatment. The definition of the term "ore" is very elastic. Petrographers speak of the minute grains of magnetite or chromite in a rock as its ores; but that is a special use of the term "ore." Usually ore means a material which can be profitably worked as a source of metals under existing or practicable industrial conditions.[1] According to this definition, the Swedish deposits of titaniferous magnetite are at present doubtfully within the category of iron ores.

The famous iron mines of Middle Sweden at Dannemorra, Norrberg, Grängesberg, and Persberg occur under different geological conditions; they work lenticles or bands of ores in metamorphic rocks, of which some are altered sediments; and the view has therefore been held by de Launay and Vogt that the ores also are altered sediments.

That ores are formed by igneous segregation of sufficient size and purity to be of economic importance is a theory which rests on two chief cases—the nickel ores of Sudbury in Canada and the iron ores of Swedish Lapland.

(2) *The Sudbury Nickel Ores.*—The nickel ores of Sudbury are the most important historically. They have been repeatedly claimed as of direct igneous origin by Bell (1891), von Foullon (1892), Vogt (1893), Barlow (1903), and by other geologists; and his view was advocated before the Association at the Johannesburg meeting by Prof. Coleman. The theory was stoutly opposed by Posepny in 1893, and Prof. Beck in 1901 described some of the brecciated ore, and showed that its metallic minerals are sharply separated from the barren rock. He held that such ore must have been formed, not only after the consolidation of the rock, but even after or during its subsequent metamorphism. The views of Posepny and Beck seem to have been established by additional microscopic study of the ores by C. W. Dickson (1903). He has shown that the sulphides are separated from the barren rock by sharp boundaries, and without any indication of a passage between them; that the fragments of ore in the rock have short corners, whereas, had they grown in a molten magma, the angles would have been rounded, and the faces corroded. Most of the ore, moreover, occurs as a cement filling interspaces between broken fragments of barren rock and along planes of shearing. The Sudbury ores, therefore, appear to have been deposited from solution during or after the brecciation of the rocks in which they occur, and long after their first consolidation.

[1] The Oxford Dictionary adopts a still more restricted definition: according to it an ore is "a native mineral containing a precious or useful metal in such quantity and in such chemical combination as to make its extraction profitable."

If Dickson's facts be right, the Sudbury ores are necessarily aqueous and not igneous in origin.

(3) *Scandinavian Iron Ores.*—The other important mining field of which the ores are claimed as of igneous origin is Swedish Lapland. Its ores are rich and the ore bodies colossal. One mine, Kirunavaara, yielded more than one and a half million tons of ore in 1906, and according to a recent agreement with the Swedish Government the annual output of ore from that mine may be raised to three million tons by 1913.

The chief mining fields of Lapland, although situated to the north of the Arctic Circle, have long been known; for some of them contain veins of copper which were worked, for example, at Svappavaara in the seventeenth century. The iron ores, however, could not be used until a railway had been laid through the swamps of Lapland to carry the ores cheaply to the coast. In 1862 an ill-fated English company began a railway to the Gellivara mines, and thirty years later this was completed across Scandinavia, from the head of the Gulf of Bothnia at Lulea to an ice-free port at Narvik, on the Norwegian coast.

This railway, the most northern in the world, passes the two great mining fields of Gellivara and Kiruna. The mining field of Kiruna is the larger and at present of the greater geological interest, as its structure is simpler and its rocks less altered.

The ore body at Kiruna outcrops along the crest of a ridge two miles long, and it is continued beneath Lake Luossajarvi to the smaller but still immense ore body of Luossavaara. At Kiruna the ore rises to the height of 816 feet above the surface of the lake, and it varies in thickness from 30 to 500 feet, with an average thickness of about 230 feet. According to the report by Prof. Walfrid Petersson,[1] submitted this year to the Swedish Parliament, Kirunavaara contains 200 million tons of ore above lake-level, and Luossavaara another 22½ million tons. The ore is high-grade. According to Lundbohm 60 per cent. of the trial pits showed a yield varying from 67 to 71 per cent. of iron, and 21 per cent. of them showed a yield of from 60 to 67 per cent. of iron. The average of nineteen analyses published in Prof. Petersson's recent report gives the contents of iron as 64·15 per cent. Unlike the Taberg and Routivaara ores, the percentage of titanium is very low; thus in nineteen analyses given by Petersson the average of titanic acid is only 0·23 per cent., and it varies in the specimens from 0·04 to 0·8 per cent.

The ore lies between two series of acid rocks, which have been very differently interpreted, but will no doubt be fully explained by the researches now in progress under the direction of Mr. Lundbohm. The rocks were first called halleflinta, as by Fredholm, and regarded as of sedimentary origin. They are now accepted as an igneous series, associated with some conglomerates, slates, and quartzites. The ore body itself is bounded on both sides by porphyrites, of which that on the lower or western side is more basic than that overlying the ore to the east. The basic western porphyrite is in contact with a soda-augite syenite of which the relations are still uncertain. Interbedded with the overlying eastern porphyrite are rocks that appear to be volcanic tuffs, and both in the tuffs and in the upper porphyrite are fragments of the Kiruna ore.

Three main theories of the genesis of the Kiruna ores have been proposed. Their sedimentary origin was urged on the ground that they occur regularly interstratified in a series of altered sediments, and that the ores, therefore, are also sedimentary. This view may be promptly dismissed, since the adjacent rocks are igneous.

The second theory has been advanced independently by Prof. de Launay and Dr. Helge Bäckström: according to them the porphyrites above and below the iron ores are lava flows, and the ore was a superficial formation deposited in an interval between the volcanic eruptions. According to de Launay the iron was raised to the surface as emanations of iron chloride and iron sulphide; the iron was deposited as oxide, and most of it subsequently reduced to magnetite during the metamorphism of the district.

The third theory—that the ores are of direct igneous origin—has been maintained by Löfstrand, Högbom, and Stutzer; according to them the ores are segregations of magnetite from the acid igneous rocks in which they occur. The segregation theory has been opposed, amongst others, by de Launay and Vogt. Thus, de Launay maintains that the segregation would have been impossible in such fluid lavas as the Kiruna porphyrites, and is improbable, since there is no transition between the ore and the barren rock.

The segregation theory has serious difficulties, and is faced by several obvious improbabilities. The ore occurs as a band nearly forty times as long as it is broad. It has the aspect, therefore, of a bed or a lode. The ore has not the granular, crystalline structure of an igneous rock like the hyperite of Taberg, but the aspect of a material deposited from solution or formed metasomatically. It is almost free from titanium, the undesirable constituent so abundant in the ores of Taberg and Routivaara.

The igneous theory cannot, however, be lightly dismissed, as it is supported by the high authority of Prof. Högbom, and therefore demands careful consideration.

It has been advanced in two main forms, the one considering the ore to have been deposited at the time when the igneous rocks are consolidating, the other considering it was deposited at a later period. According to Prof. Högbom, the ore was syngenetic, being a true magmatic segregation from a syenite. But, according to Dr. Stutzer (1906), the segregation was later than the consolidation of the syenite. He describes the lode as an intrusive banded dyke, of which the chief constituents are magnetite and apatite; and the injection of this dyke pneumatolytically affected the rocks beside it, producing an intermediate zone, impregnated with ore, which he compares to contact deposits.[1]

In spite of the high authority of Prof. Högbom, I am bound to confess that the Kiruna ores do not impress me as of igneous formation. Their bed-like form, microscopic structure, and poverty in titanium are features in which they differ from those admittedly due to direct magmatic segregation. The microscopic sections that I have examined suggest that both the magnetite and apatite were deposited from solution and later than the consolidation of the underlying porphyrite, which the ore in part replaces. An examination of the field evidence supports the conclusions of de Launay and Bäckström as to the ore being a bedded deposit overlying a lava flow, but enlarged by secondary deposition.

V. *Future Supply of Iron Ores.*

This conclusion is perhaps economically disappointing. The possible existence of such vast segregations of iron in the acid igneous rocks has an important economic bearing. There is only too good reason to fear that the chief iron ores are comparatively limited in depth; for most of them have been formed by water containing oxygen and carbonic acid in solution, which has percolated downward from the surface. Ores thus formed are therefore restricted to the comparatively limited depths to which water can carry down these gases. On the theory, however, that these ores are primary segregations from deep-seated igneous rocks there need be no limit to their depth. They would rather tend to increase in size downward, while maintaining, or even improving, in the richness of their metallic contents. For these bodies may be regarded as fragments of the metallic barysphere which have broken away from it and revolve around it like satellites floating in the rocky crust. On this conception these ore bodies would be of as great interest to the student of the earth's structure, as their existence would be reassuring to the ironmaster, haunted as he is by constant predictions of an iron famine at no distant date. It is no doubt true that many of the richest, most accessible, most cheaply mined, and most easily smelted iron ores have been exhausted.

[1] *Bihang till Kikd. Prot.*, 1907, 1 Saml., 1 Afd., 84 Häft, No. 107, pp. 213, 217.

[1] In a later paper, of which only a short abstract has been issued, Dr. Stutzer, however, explains that "the intrusion of the ore dyke was at relatively the same time as the formation of the syenite, and that the ores were formed by magmatic separations *in situ*, or as peregrinating magmatic separations (magmatic veins and bedded streams)." He adds that "pneumatolysis plays no inconsiderable *rôle* in the formation of these veins." Dr. Stutzer's position may be summarised as regarding the ores as collected by segregation, but deposited in their present position by eruptive after-actions.

The black-band ironstone and the clay iron ores of the coalfields, which gave the British iron industry its early supremacy, now yield but a small proportion of the ores smelted in our furnaces. The Mesozoic beds of the English Midlands and of Yorkshire still supply large quantities of ore. Nevertheless the British iron industry is becoming increasingly dependent on foreign ores. So it would be pleasant to find that the Scandinavian iron mines are not subject to the usual limits in depth. I fear the typical iron deposits of Middle Sweden and of Gellivara will follow the general rule; but Kiruna may be an exception, and its ores may continue far downward along the surface of its sheet of porphyrite. The uncertainty in this case lies in the extent of the subsequent enrichment and enlargement of the bed; if most of the ore is due to secondary deposition, then it may be restricted to the comparatively shallow depths at which this process can act; and though that limit will be of no practical effect for a century or more to come, the ore deposit may be shallow as compared with gold mines.

The geological evidence may convince us that all the economically important iron ores are limited to shallower depths than lodes of gold, copper, and tin; but this conclusion shall not enroll me among the pessimists as to the future of the iron supply. Twenty years ago a paper on the gold supplies of the world was read to the Association at the request of the Section of Economics. About the time that the report was issued, there were sixty-eight mining companies with a nominal capital of 73,000,000*l*. at work upon the Rand. Nevertheless, the author, accepting the view that "the future of South African gold-mining depends upon quartz veins," concluded: "There is as yet no evidence that the yield will be sufficient in amount to materially influence the world's production. As regards India, the prospect is still less hopeful."

That quotation may be excused, as it is not only a warning of the danger of negative predictions, but of the unfortunate consequences that happen when geologists are unduly influenced in geological questions by the opinions of those who are not geologists. In economic Geology, as in theoretical Geology, we should have greater confidence in the value of geological evidence. Negative predictions are especially rash in regard to iron, it being the most abundant and widely distributed of all the metals. The geologist who knows the amount of iron in most basic rocks finds it difficult to realise the possibility of an iron famine; he can hardly picture to himself some future ironmaster complaining of "iron, iron everywhere, and not a ton to smelt." There are reserves of low grade and refractory materials which the fastidious ironmaster cannot now use, since competition restricts him to ores of exceptional richness and purity. When the latter fail, an unlimited quantity could be made available by concentration processes. The vast quantities of iron ores suitable for present methods of smelting in Australia, Africa, and India show that the practical question is that of supplies to existing iron-working localities, and not of the universal failure of iron ores.

VI. *Mining Geology and Education.*

The genesis of ores and the extent of future ore supplies are intimately connected questions, and the recognition of this fact has led to the remarkable growth of interest in economic Geology. This wider appreciation of the practical value of academic Geology should, I venture to urge, be recognised among teachers by giving a more honoured place to economic Geology.

It was inevitable that until the principles of Geology had been firmly established, the detailed study of their application should have been postponed. Now, however, last century's work on academic Geology enables the difficult problems connected with the genesis of metalliferous ores to be investigated with illuminating and practically useful results.

British interest in mining education has therefore been revived. Its history has been sadly fitful. Lyell,[1] in 1832, deplored the superiority of the Continent in this respect, as "the art of mining has long been taught in France, Germany, and Hungary in scientific institutions established for that purpose," whereas, he continues (quoting from the prospectus of a School of Mines in Cornwall, issued in 1825), "our miners have been left to themselves, almost without the assistance of scientific works in the English language, and without any 'School of Mines,' to blunder their own way into a certain degree of practical skill. The inconvenience of this want of system in a country where so much capital is expended, and often wasted, in mining adventures, has been well exposed by an eminent practical miner."

Though the chief British School of Mines made a late start, the brilliant originality of its professors soon carried it into the front rank; but in an evil day for the Mining School it was united with a Normal School for the Training of Teachers, now the Royal College of Science, and that school by its great success overwhelmed its older ally. Those interested in economic Geology therefore welcome the recent decision to separate the technical from the educational and other courses, while leaving the Schools of Mines and Science sufficiently connected for successful cooperation. This policy should give such opportunities for the teaching of mining research that we may not always have to confess, as at present, that British contributions to mining Geology do not rank as high as those made to other branches of our science.

Regrets are sometimes expressed, and perhaps still more often felt, at the tendency in scientific teaching to become more technical; but I, for one, do not fear evil from any such change. It is possible that the educational conflict of the future will be between academic science and technical science, on grounds in some respects analogous to those between classics and science during the last century. The advocates of the educational value of technical science are not inspired by mere impatience with the apparently useless, for they accept the principle that the essence of education is method, not matter. Therefore they claim that the methods and principles of science can be better taught by subjects which are being used on a large scale in modern industries than by subjects of which the interest is still purely theoretical. Those who fear that academic science will be neglected if technical science be used in education may be encouraged by the brilliant revival of classical research since classics lost its educational monopoly. Academic science is even less likely to be neglected. It will always have its fascination for those intellectual hermits—shall I not say those saints of science?—who prefer to work for love of knowledge, free from the worrying intrusion of the mixed problems and fickle conditions of the industrial world; and the greater the progress of applied science the more urgent will be its demands for help from pure science, and, as a necessary consequence, the wider will be the appreciation and the more generous the endowment of scientific research.

Technical education must be as rigorous as that in academic education, and its connection with the fundamental principles must be as intimate. When so taught, economic problems provide at least as good a mental training as those branches of science which are purely theoretical. If the new Imperial College of Science and Technology carry on the mission for which the Geological Society was founded a century ago, if it inspire its students to have their delight in using past discoveries on the open surface of the earth, so that they may penetrate to what is within, then they will gain that sure knowledge of the formation and distribution of ores, which is of ever-growing national importance.

[1] C. Lyell, "Principles of Geology," vol. i., ed. 2 (1832), p. 63.

SECTION E.

GEOGRAPHY.

Opening Address by George G. Chisholm, M.A., B.Sc., President of the Section.

Geography and Commerce.

The subject which I have chosen for this Address is one that is very apt to raise questions that might lead to keen and even warm controversy. For the raising of such questions no occasion could be less suitable, and it will therefore be my endeavour to handle the subject in such a manner that burning questions may be altogether avoided. For that reason I propose to consider the relations of geography and commerce from an historical point of view, which at least gives one the opportunity of confining oneself to less debatable ground than is entered on when one ventures on prophecy, that "most gratuitous form of error," as it is styled by George Eliot. That I shall be able to keep wholly free from debatable matter is more than I can hope, but it is my intention to try to avoid it as much as possible by illustrating my subject chiefly by reference to the broad, familiar facts of commerce considered in the light of geographical and other implications that may be described as obvious—obvious, and yet perhaps not unimportant and not unworthy of having attention specially called to them; for, after all, the obvious is obvious only to those who are looking in the right direction and with the proper focus, not to those who are looking another way or far beyond what is immediately before them.

As the first of these obvious considerations I may point out that unquestionably the foundation of commerce is the mutual advantage to be derived from the exchange of commodities produced in different places. Geographical relations are therefore of necessity implied in commerce. But those who carry on commerce have always aimed at the greatest possible advantage to themselves, and the commerce that has always attracted the greatest attention is that which has resulted in the greatest additions to their wealth. Peculiar importance therefore belongs to the geographical relations between regions which in any given circumstances lead to the most profitable exchanges.

But before applying this consideration there is another point which must detain us a little. In speaking of wealth as I have just done I am aware that I have made use of a term which economists recognise as one requiring a great deal of exposition to prevent misunderstanding, and there is not the slightest doubt that in the history of commerce it has led to great misunderstanding, and therefore it is necessary, without entering upon an economic disquisition on the subject, to consider the meaning of the term "wealth" sufficiently to indicate the way in which that misunderstanding has arisen. For this purpose it will be most convenient not to give one of the highly abstract definitions of wealth which a modern political economist will give us, but to go back to the more concrete considerations set forth by Adam Smith, who tells us that "the wealth of a country consists not in its gold and silver only, but in its lands, houses, and consumable goods of all different kinds."[1] Now no definition of wealth is given by economists which excludes this last form of wealth, but the misunderstanding to which I refer arises from the fact that this form of wealth is apt to be overlooked. It may happen that a country or region produces a great abundance of consumable goods in proportion to its population, and hence from this point of view be entitled to be regarded as wealthy, and yet may not be a country or region that attracts much attention by its wealth. What has always attracted attention to wealth, and what has caused wealth to have an important effect in directing the main streams of commerce, and commerce to have an important effect, direct or indirect, on history, has been the accumulation of much wealth in few hands, so that a comparatively small number of people in a community have enjoyed, directly or indirectly, the command of a great deal of labour, have had the means of providing themselves with commodious and luxurious houses, with a variety of other comforts, luxuries, and splendours, and over and above that the means of so directing labour as to add still further to their wealth. Such conditions may exist where the great bulk of the population are extremely poor.

Now, it happens that wherever a great abundance of consumable commodities is produced on a relatively small area there is always in that area a greater or smaller number of individuals in whose hands much wealth is concentrated. It is for economists to explain how this comes about, or has come about, but it is a fact of the utmost importance for geographers to bear in mind in considering the relations of commerce and geography.

The existence of a relatively dense population may be due to different causes, such as a great abundance of agricultural products, the carrying on of mining or manufacturing industries, the concentration of the administration of a great dominion, or the pursuit of commerce itself. Where it is due to any cause but the production of great quantities of the necessaries of life foodstuffs must be imported in large quantities, and where the pursuit of manufactures is the cause, or one of the chief causes, then the importing of raw materials is entailed. Where these are most advantageously found there also much wealth is likely to be accumulated in few hands.

Further it is to be noted that where a comparatively small number have the command of much wealth there is sure to be a demand for things of such value that they can be bought only by the wealthy, things that are more or less rare, such as precious metals, jewels, gems, ivory, fine woods, ornamental skins and feathers, manufactured goods of rare materials or of fine quality, as well as, in many places and in most periods of history, slaves. Such trade is necessarily limited in amount, but puts great profits in the hands of those who carry it on with success, and for that reason attracts attention.

With this class of goods may be associated certain others that may be regarded as intermediate in position between those which are bought only by the wealthy and those which are not merely generally consumed but also very widely produced. Amongst these may be mentioned salt, the consumption of which is universal, but the production of which, away from the seaboards of the warmer latitudes, though in a sense widespread, is strictly confined to scattered spots. A more interesting example is that of spices, one of which, pepper, has from a remote period been very generally consumed, but in still smaller quantity than salt, and for that reason has been able to bear still higher transport costs. For ages these costs were very high, for various reasons, amongst which were risks both numerous and great, but the profits of those who were successful in the trade were proportionately high.

Peculiar importance in commercial geography is thereby given to the relations between the regions that yield or yielded spices and those in which they were consumed at a great distance from the place of origin, and one of the most important facts in human history is that for many hundreds of years an extremely valuable trade in these commodities was carried on between India and the Mediterranean. Spices no doubt were less talked about, less prominent as symbols of wealth, than gems and jewels, fine woods and ivory, but they formed the basis of a larger trade, which was in the aggregate probably more profitable than that in the still more costly wares.

The geographical relations between India and the Mediterranean necessarily determined the routes followed by this traffic. These routes were singularly few. They were practically confined for the most part to minor variations in two main routes, one by way of the Red Sea, the other by the Persian Gulf. At more than one period of history, in very early times in the days of the splendour of Assyria and Babylonia, and again in the flourishing days of the Caliphs of Baghdad, the Persian Gulf route had a peculiar advantage in the existence of the large and rich populations that afforded an intermediate market; and another important fact in the relations of geography and commerce, one that has had vast effects on human history, is that the physical conditions of the area between the head of the Persian Gulf and the Mediterranean are and throughout human history have been such as to make the most convenient outlet of that route some point or points on that seaboard which in ancient times was known as Phœnicia. Between that seaboard and the Euphrates the desert is sufficiently narrowed to be most easily crossed. The most favoured outlets on this seaboard were not always the same. They varied in different circumstances, which gave a different geographical value now to one point, now to another. But on these variations, interesting and instructive as they are from a geographical point of view, there is no time to enter on this occasion, and it will be enough to call attention to a very interesting paper by the late Elisée Reclus entitled "La Phénicie et les Phéniciens," dealing with this and other matters connected with the geographical basis of Phœnician commerce and industry, a paper too that is apt to be overlooked, inasmuch as it was con-

[1] "Wealth of Nations," book iv., ch. i.

tributed by him with a generosity characteristic of one of the least self-seeking natures with which the world was ever blessed to a rather out-of-the-way publication, the *Bull. de la Soc. Neuchâteloise de Géol.* (vol. xii., 1900). But while I do not desire to enter into details regarding the Phœnicians it is necessary to point out how naturally and indeed inevitably this position of the Phœnician cities between the Mediterranean on the one hand and Mesopotamia and the Persian Gulf route to India on the other hand brought other sources of wealth in its train. Conveniences for the distribution of manufactured goods have always been one of the most important advantages for the development of manufacturing industry, and the wealthier the community forming the market for the products of such industry the more valuable are the manufactures likely to be. Hence the Phœnician manufactures of fine linens and woollens richly dyed, glass and metal wares, for which other parts of the Mediterranean and its seaboard furnished the raw materials, slaves to do the manual labour, and food for that population which the narrow strip of Phœnicia could not adequately supply. Food is indeed a bulky commodity, but even bulky commodities could be transported by sea at a relatively small cost, and in connection with this traffic we must note the indirect effect which the wealth of Phœnicia must have had in promoting the settlement of districts favourably situated for supplying food, and especially of such districts where the opportunities for producing food were great, but not fully turned to account, where the supply therefore could easily be made superabundant in proportion to the wants of the population. This shows that from the very nature of commerce its benefits are not confined to one side. Although the geographical conditions for a long period of time led to a special accumulation of the wealth due to commerce on Phœnicia, Phœnician trade promoted the growth of wealth and civilisation elsewhere. The Greeks of the Ægean distinctly recognised what they owed to the Phœnicians, and they in their turn derived much wealth from Eastern trade, even though not so directly as the Phœnicians, and they in their turn derived some of the food for a commercial population from the far west —from Syracuse, Sybaris, and even the distant Kume. But the far east had a peculiar fascination. As the articles from which much of the wealth of commerce was derived originally came from India, it was natural that the idea should arise that India was a wealthy country, a country well worth possessing. I am not aware whether India ever was in historical times a wealthy country in the sense of producing a great abundance of the necessaries and ordinary conveniences and comforts of life in proportion to the population, but if it was not rich itself it was at least the means of making others rich. There can hardly be a doubt that the desire of possessing this country of real or imagined wealth was prominent among the motives that led Alexander the Great to embark on that enterprise which had such surprisingly—one might almost say miraculously—widespread, profound, and lasting effects on the history of the Near East. If we may accept as historical the speech in which Quintus Curtius represents Alexander as having addressed his troops after his victory over Porus, in order to encourage them to advance further into India, that speech affords fairly strong evidence of what has just been stated. "What now remained for them," said Alexander, "was a noble spoil. The much-rumoured riches of the East abounded in those very regions to which their steps were now bent. The spoils accordingly which they had taken from the Persians had now become cheap and common. They were going to fill with pearls, precious stones, gold, and ivory not only their private abodes, but all Macedonia and Greece." Alexander was no merchant. Pepper was beneath his notice. His symbols of wealth are those which have always most powerfully affected the imagination. Later on, however, we shall meet with a king who was a merchant, and who understood perhaps better than Alexander wherein consisted the value of Indian trade.

At the outset of his career Alexander had destroyed Tyre, thinking, no doubt, that he had thereby wiped away the claims of one rival for a share of the wealth of the East; but it is a noteworthy fact that he did not thereby destroy the value of the site of Tyre under the conditions which then subsisted. Tyre revived and again obtained wealth from its trade with the East, as it did again and again in subsequent history. A heavier blow to Tyre than its mere destruction was the ultimate accomplishment of Alexander's idea for founding a great seat of commerce on the harbour which he saw could be created in the neighbourhood of the Nile delta. The foundation of Alexandria and the successful efforts of the successors of Alexander in Egypt to divert a large part of the trade in spices and other Oriental goods to the Red Sea route for the Mediterranean did more than a single act of war to deprive Tyre and other Phœnician cities of the peculiar preeminence which they had long enjoyed in the trade in those wealth-bringing commodities.

But perhaps the history of Venice shows even more clearly than that of Tyre the importance of this eastern trade in connection with certain inevitable geographical relations. The foundation of the future commercial glory of Venice may be said to have been laid when Rome planted her colonies north of the Po. The gradual clearing of forests gained for agriculture to a greater and greater extent one of the most favoured agricultural areas in Europe. There resulted a superfluity of agricultural products, which begot a trade by sea. The great outlet of this plain in Roman times was Aquileia, which in the beginning of the fifth century, when no one of discernment could imagine that there would ever be other than Roman times, was described by a Roman man of affairs and minor poet as one of the nine great cities of the world. But before that century was out Aquileia was destroyed, never to recover. The value of its site was replaced, and that in a strange way, which no man of discernment could ever have foreseen. The time that saw the destruction of Aquileia and the times that immediately followed were such as made safety a prime consideration, and especially for all who possessed or desired to possess wealth. Refugees from Aquileia, and afterwards from other Italian cities, thought at first of nothing but safety. Many of them found it on a few muddy and sandy islands near the muddy shores of the lagoon in which Venice now lies. But here they found the means of trade. The sea could be made to furnish both fish and salt, and the rivers that flowed into the lagoon enabled them to exchange these commodities for provisions of other kinds which the adjoining land could supply. Gradually this commerce grew, until in the eighth century we find the Venetians trading with Syria and Africa, Constantinople, and the ports of the Black Sea.

Throughout the period of growth the policy of this trading republic, both by land and sea, is very significant. Venice early realised the force of Bacon's maxim "that he that commands the sea is at great liberty, and may take as much and as little of war as he will." Power at sea was necessary to provide security for her commerce. In early times she generally owned allegiance to the Eastern Roman Empire, a suzerainty which could do her little harm and could and did do her much good. To that allegiance she adhered until she was strong enough to turn against and reap advantage from the overthrow of her suzerain. At an earlier date, before the close of the tenth century, she had conquered Dalmatia, and thereby destroyed the hordes of pirates who had found refuge in the innumerable harbours of that coast and constantly harassed the commerce of the Adriatic. At every opportunity she secured establishments and acquired possessions in the Levant.

On the land side, however, dominion would have added more to her risks than her advantages, and that dominion was not sought. For more than eight hundred years after the first flight to the islands of the lagoon, more than six hundred after the election of the first Doge (697), Venice possessed no territory on the mainland beyond a mere narrow ribbon on the edge of the lagoon. The nature of the situation made her indispensable to the trade of the land immediately behind. An incident belonging to the close of the ninth century illustrates the force of this observation. A keen dispute had arisen between the Patriarch of Aquileia and the Patriarch of Grado. Venice supported the Patriarch of Grado, and war seemed to be threatened. But so necessary had the commerce of Venice become to the inhabitants of the territory acknowledging the authority of Aquileia that in order to bring about the submission of the Patriarch of Aquileia it was enough to close or blockade the port of Pilo, on the mainland opposite the *lidi*. The subjects of Aquileia then forced the patriarch to sue for peace.[1] On another occasion, in a dispute with the Bishops of Belluno and Treviso, the matter was again partly settled through the efficacy of the measures taken by the Doge Orseolo II., with the consent of the people, to stop commerce with the territory of the bishops, by which the inhabitants found themselves without supplies of salt, and without the means of exchanging their leather and meat for Venetian wares or selling the abundant timber of their forests for the building of Venetian ships.[2] In holding the outlets for maritime commerce Venice felt herself to be in the possession of "the keys of trade," to use the expression employed by Sir William Petty in speaking of the analogous position of Holland in later times at the mouths of the Rhine, Meuse, and Scheldt.

But while possession on the mainland was not necessary to Venice she always recognised and sought the advantage of good relations with the occupants of the plains behind her, whoever these occupants might be, and on every occasion endeavoured to turn to her own benefit the vicissitudes of those plains. In her early days she is found now in alliance with the Greeks, now with the Pope, now with the archbishops of Ravenna, and now with the Lombards, just as it happened to suit her interests, and in any case taking every opportunity of obtaining direct and indirect advantages from trade with the most profitable customers in the plains. When famine pursued the steps of the Lombard invaders of Italy in the sixth century "the Venetians in their pacific retreat," says Mutinelli,[3] "could send their ships to the ports of Apulia and elsewhere to obtain victuals and corn for the famished barbarians," and in consequence the Lombards took them under their protection and granted them security and favours throughout the Lombard kingdom. When Charlemagne, at the invitation of the Pope, invaded Italy to deliver the Church from its subjection to the Lombards, Venetian traders promptly appeared in the camp of the Franks at Pavia and sold to the Frankish chiefs all the riches of the East—Tyrian purples, the plumage of gay birds, silks, and other ornaments, pranked in which the purchasers stalked about in their pride, feeling, no doubt, that now at last they had conquered a land the wealth of which would reward all their labours and hardships.[4] Charlemagne, it is true, was inclined to look with little favour on the Venetians, whom he regarded as supporters of the Greeks, but an attack by his son Pepin in 809 on the islands of the lagoon only served to establish the strength and security of their position, at least on the inner islands of the lagoon. By closing the passages of the canals, removing the navigation beacons, and fortifying and barring the chief entrances to the land they succeeded in holding out during a siege of six months, until the heats of summer began to decimate the troops of Pepin, who, on hearing also of the approach of a Greek fleet, came to terms with the Venetians on conditions similar to those which had been maintained with the Lombards. The Venetians agreed to a tribute, but solely for the narrow strip of territory held on the mainland and in return for commercial privileges in the Frankish dominion, not for any recognition of the existence of the State. The tribute was afterwards paid or withheld according to the power which the Emperors showed of enforcing it; but one permanent result of this incident was that the Venetians, perceiving the smaller security belonging to the islands nearer the mainland, of their own choice made the Rialto the capital of their little State[5] (810).

As a last illustration of the nature of the relations of Venice to the North Italian plains we may refer to some of the points mentioned in a celebrated and often quoted address delivered to the principal senators of Venice by the Doge Mocenigo just before his death (1423), at the time at which Venetian trade was at the very height of its prosperity. At that time Venice was in possession of a considerable tract of adjacent territory on the mainland, and there was a party favourable to further action on the part of Venice against the growing power of Milan. The aged and sagacious Doge feared that this party was going to gain the upper hand and elect as his successor Francesco Foscari, who, he thought, would involve them in dangerous and disastrous as well as useless enterprises. The immediate occasion of the conflict of views in the Venetian Senate was a request of the Florentines for support against alleged designs of the Duke of Milan. Mocenigo, however, not only warned the senators in the most earnest and urgent language against Foscari personally, but also advised them against the particular enterprise, maintaining that it was of no consequence even if the Duke of Milan made himself master of Florence, since the artisans of Milan would continue to send their manufactures to Venice, and the Venetians would be enriched to the loss of the Florentines. He then went on to give particulars of the trade of Venice at that time, dwelling specially on the value of that with Lombardy. To Lombardy alone, it appears, Venice sold every year cloths to the value of 400,000 ducats, *tele* (? linens) to the value of 10,000 ducats: wools of France and Spain to the value of 240,000 ducats, cotton to the value of 250,000 ducats, wine to the value of 30,000 ducats, cloth of gold and silk to the value of 250,000 ducats, soap to the same value, spices and sugar to the value of 539,000 ducats, dye-woods to the value of 120,000 ducats, other articles 110,000 ducats: in all, goods to the value of more than 2,500,000 ducats, the profit amounting to quite half a million ducats. With the exaggeration that comes natural to a lover of his country Mocenigo goes on to say rather grandiloquently that to the Venetians alone land and sea were equally open; to them only belonged the carriage of all riches; they were the providers of the entire world.

All this trade, as well as that of Genoa and other Italian ports which shared with others in the spice trade must have had a remarkably fructifying effect in North Italy generally. Agriculture and manufactures would be alike promoted, and in consequence of that the growth of population; and when war, with its attendant scourges, led to a diminution both of industry and population, this commerce could not fail to assist in bringing about a speedy recovery. It has already been hinted that in manufactures both Milan and Florence took a prominent place in the time of Mocenigo. In truth, manufactures in both cities are of much older date, and it may be interesting to mention here that even in the thirteenth century English wool was a commodity sufficiently valuable to bear the cost of transport to Florence. A letter has come down to us,[1] dated London, January 6, 1284, from the representative of a Florentine house, giving particulars as to purchases that he had made, in many cases for several years in advance, of all or a portion of the wool of many English monasteries from Netley and Titchfield, in Hants, and Robertsbridge, in Sussex, to Grimsby, in Lincolnshire, and Sawley, on the Ribble, in the county of York (one of these monasteries, you may be interested to learn, as near Leicester as Monks Kirby, about midway between Rugby and Nuneaton); and from the work in which this letter is published we also get particulars[2] as to the cost of conveying wool from London by way of Libourne to the Mediterranean port of Aigues Mortes in the same or

1 Romanin, "Storia documentata di Venezia," vol. i., pp. 197–8.
2 *Ibid.*, pp. 270–1.
3 "Del Commercio dei Veneziani," p. 12.
4 "De rebus bellicis Caroli Magni," L. iii., quoted by Romanin, as above, vol. i., p. 130.
5 Romanin, as above, vol. i., pp. 144–9.

1 Published (1765) in a work having no author's name, but stated in the British Museum Catalogue to be by G. F. Pagnini della Ventura, and bearing the title "Della Decima e delle altre Gravezze della Moneta. e della Mercatura de' Fiorentini fino al secolo XVI," the third volume of which contains "La Pratica della Mercatura" of Balducci Pegolotti (ascribed to the first half of the fourteenth century), under whose name the work is entered in the British Museum Catalogue. The date of the letter is given on p. 94 of vol. ii., and the letter itself on pp. 324–7 of the same volume. For the identification of the names of monasteries in their much disguised Italian forms and spelling I am indebted to my friend Mr. A. B. Hinds, M.A., editor of the last issued volume of the "Calendar of State Papers (Venice)." Most of them, however, are entered and identified in the list given from Pegolotti on pp. 629–41 of Cunningham's "Growth of English Industry and Commerce, Early and Middle Ages," 4th edition (1905).
2 *Ibid.*, vol. iii., pp. 261–3.

the following century. Florence, indeed, depended on England, Spain, and Portugal for wools of fine quality, its own and other wools of Italy being of very inferior value, so that when four bales of English wool were worth in Florence 240 gold florins the same quantity of wool of Garfagna dell' Aquila was worth only 40 florins.[1] The author of this work adds that he has found no indication of the prices of the wools of Spain and Portugal in Florence. Besides manufacturing cloths from the raw material "Florence carried on a large trade in dressing and finishing woollens manufactured in Flanders and Brabant, and brought to Florence either by way of Paris and the Saône-Rhône valley or by way of Germany and across the Alps. In the time of Mocenigo many of these products of Florentine industry came to Venice for export. In the address already referred to Florence is said to have sent to Venice every year 16,000 pieces of cloth, which were sold to Aquila, Sicily, Syria, Candia, the Morea, and Istria.

It will be noticed that in the address above quoted Mocenigo lays no special stress on the spice trade, but there is not the slightest doubt that spices were amongst the most important commodities with which the Venetians provided a large part of the western world. Just as nowadays the large trade of Britain in bulky goods makes of this country a great entrepôt for the more valuable and less bulky, so in Venetian times the exceptionally large population behind Venice receiving and supplying the bulky goods thus fed the shipping which brought to Venice a much larger proportion of the more valuable goods of the East than was brought to other ports. But there is plenty of direct evidence of the importance of Indian trade to Italy in the Middle Ages. It is to be remembered that of necessity this trade enriched other countries before it reached Venice, and in proof of its importance in the Mediterranean generally one may call attention to the investigations of the Venetian Marin Sanuto Torcello about the end of the thirteenth century, who, we are told, saw with indignation that the defeats of the Christians in Palestine were specially due to the power of the Soldans of Egypt, and perceiving that their great power derived its nourishment from the commerce with the Indies, based on that observation the projects which he urged on Christendom for the overthrow of that power. It is further significant that a sea way to India should have been sought by Genoese as early as 1291,[2] and even more significant that a century later Venice should have found it worth while to maintain a consul in Siam.[3]

But the clearest evidence of the supreme importance of the Indian trade to the Italian cities is to be found in the results of the discovery which finally diverted from Venice and the Mediterranean the great bulk of the Indian trade until that trade had lost all the special significance which it had retained for thousands of years. It need hardly be said that I refer to the discovery of the sea way to India by the Portuguese in 1497–9. Of the feeling aroused in Venice by this discovery Romanin has reproduced,[4] from the "Diarii" of Priuli, an interesting contemporary record, written with reference to a despatch to the Doge probably from Pietro Pasqualigo, a Venetian envoy at Lisbon at the time of the return of the second Portuguese voyage to India under Cabral. The letter is stated to have reached Venice on July 24, 1501. After giving the letter, in which we are told, among other things, how the Portuguese had charged their ships at Cochin with spices at a price which the writer feared to mention, Priuli adds: "On the arrival of this news at Venice all the city was deeply moved and remained stupefied, and the wisest held it for the worst news that could reach them. For, it being recognised that Venice had risen to so high a degree of renown and wealth solely by the commerce of the sea and by navigation, by means of which every year a great quantity of spices was brought thither, which foreigners then flocked together to acquire, and that by their presence and the traffic they obtained immense advantages, now by this new voyage the spices would be brought from the Indies to Lisbon, where Hungarians, Germans, Flemings, and French[1] would seek to acquire them, being able to get them there cheaply; and that because the spices that came to Venice passed through the whole of Syria and the countries of the Soldan, paying in every place exorbitant duties, so that at their arrival at Venice they were so weighted that what at first was of the value of a single ducat was raised in the end to sixty and even a hundred ducats; from which vexations, the voyage by sea being exempt, it resulted that Portugal could give them at a much lower price." So said the wisest, but it is interesting also to note what was said by the less wise. Priuli goes on: "And while the wisest saw that, others refused to believe the story [these, I presume, were the least wise], and others again said that the King of Portugal would not be able to continue this navigation to Calicut, since of thirteen caravels only six had returned safe, the loss would be greater than the advantage, and that it would not be so easy to find men who would consent to risk their lives in so long and perilous a navigation; that the Sultan of Alexandria, seeing the loss of so fine a profit as that obtained by the passage of the spices through his lands, would see to that."

But in this case it happened that the wisest were right. The effects of this discovery were not long in making themselves felt in the notable diminution in the sales of spices at Venice. Under the date February, 1504, Priuli enters in his diary, "The galleys of Alexandria have entered into harbour empty: a thing never before seen." In the following month the same thing happened in the case of the galleys from Beirut.[2] Under August, 1506, it is stated that the Germans at the fair of the preceding month had bought very little. Various remedies for these evils were thought of, and among these it is interesting to note that in 1504 the Council of Ten seriously discussed a proposal to empower an envoy to the Sultan of Egypt to come to an agreement with him, if possible, for the cutting of a canal through the Isthmus of Suez.[3] But the proposal was not adopted. Other efforts to avert the results of the great achievement of the Portuguese were vain. Other disasters befell the republic about the same time. Not only was commerce taking another direction, but, says Romanin, "the wars of Italy were emptying the treasury, the Turkish power was despoiling the republic step by step of its possessions beyond the sea, and Venice was beginning to descend that incline which was to reduce it to a subordinate position among the powers of Europe."[4] North Italy generally suffered at the same time. The withdrawal of the greater part of the spice trade, by diminishing the growth of wealth among the inhabitants, made that part of the world a less important market for manufactured goods. Countries outside of Italy, where rival manufactures had already started, were increasing their wealth more rapidly, and thus imparting an increasing stimulus to their manufactures, and these increased while those of Italy declined. In 1338 the number of woollen factories in Florence is given at 200, making in all 70,000 to 80,000 pieces of cloth in the year; in 1472 the number of shops or factories had risen to 270, but no estimate is given of the quantity of the product; in 1529, however, the number of shops is said to have sunk to 150, and the quantity of cloth manufactured to 23,000 pieces per annum, and in the time of the editor of Balducci Pegolotti the quantity was only about 3000 pieces annually.[5]

Before going further, however, there is one point in the comments on the discovery of the sea way to India quoted above from the "Diarii" of Priuli which calls for notice. Hungarians, Germans, Flemings, and French, he observes, will in future go to Lisbon to get the spices of India more cheaply than at Venice. This remark illustrates the difficulty of shifting the geographical point of view according to circumstances, a difficulty of which at all times abundant illustrations can be offered. The

[1] *Ibid.*, vol. ii., p. 95.
[2] See the account of this attempt and its results so far as they are known in G. H. Pertz, "Der älteste Versuch zur Entdeckung des Seeweges nach Ostindien" (Berlin, 1859).
[3] Romanin, as above, vol. iii., p. 335, note (5).
[4] As above, vol. iv., p. 461.

[1] We must recognise, with due humility, that the English are of little account in Venetian eyes in 1501.
[2] G. Coen, "Le Grandi Strade del Commercio Internazionale proposte fino dal Sec. XVI" (Leghorn, 1888), p. 71.
[3] Coen, as above, pp. 82–3.
[4] As above, vol. iv., p. 466.
[5] "Della Decima," as above, vol. ii., pp. 64, 105.

purchasers of spices who come first into the mind of Priuli are Hungarians and Germans. It was inevitable that they should be among the leading customers of Venice. The Hungarians were supplied from the Dalmatian ports which belonged to Venice. The Germans came by way of the Rhine and the Elbe, and then across the Alps, to get supplies for central, north-western, and northern Europe. But it was neither Hungarians nor Germans who came in greatest numbers to Lisbon to buy the spices which Portuguese ships brought from the East. In any case Lisbon had no advantages like those of Venice for supplying by land a large and rich population immediately behind it. The valley of the Tagus was small and poor, and had not the capacity for expansion in wealth and population which the Lombard plains had when the commerce of Venice began to grow. The bulk of the spices brought to Lisbon had therefore to reach their final markets by routes that did not pass through Lisbon into the interior. To supply the most important of those markets it was the Dutch, the people who held "the keys of trade" for the important valleys of the Rhine, Meuse, and Scheldt, who came to Lisbon in greatest numbers to buy spices of the Portuguese. And here it has to be added that, in spite of the discovery of the sea way to India, the Venetians continued to retain great advantages in the spice trade with Hungary and parts of Germany, as well as, of course, the northern plains of Italy. Things did not remain always as bad as recorded in the years 1504 and 1506. The Portuguese, while maintaining successfully for a hundred years the monopoly of the trade in spices at the place of origin in the East, found their advantage in dividing the trade with Europe between the sea way and the Persian Gulf route, of which latter route they held the key since the final capture of Ormuz in 1515. The trade by way of the Tigris through Baghdad (the so-called Babylon of those days) and the Euphrates to the old Phœnician seaboard was again revived, and was maintained as long as Portugal held command of the trade. It was by this route that the first English commercial expedition to India, that of Newberie, Leedes, Story, and Fitch, went out in 1583, and by which Ralph Fitch, the sole survivor of that expedition, returned in 1591. By this route Venice got back some of her spice trade; not perhaps with the same profit to herself as formerly, but still a trade of no slight importance not only to Venice, but also to Augsburg, Nuremberg, and some of the other cities of South Germany.

But beyond doubt the bulk of the trade was now carried on by the sea route, and we are thereby enabled to get a better idea both of the amount and the nature of the trade. On both points we get information from the "Narrative" of the above-named Ralph Fitch, who tells us that "the Fleete which commeth every yeere from Portugal, which be foure, five, or sixe great shippes, commeth first hither [to Goa]. And they come for the most part in September, and remaine there fortie or fiftie dayes; and then go to Cochin, where they lade their Pepper for Portugall."[1] Now in 1583 a ship of 500 tons would certainly be called a great ship. In 1572 the largest vessel sailing from the port of London was of 240 tons,[2] and the largest of the first fleet of the East India Company was one of 600 tons. I could give more definite information as to the capacity of these fleets at that time if I knew exactly what a *salma* was, for in a report on Portuguese trade sent to the Grand Duke Ferdinand I. of Tuscany (1587–1608) we are told that the fleet consisted of four or five carracks of the capacity of 5000 or 6000 *salme*.[3] But a *salma* is a term for which one sometimes gets a very indefinite meaning, at other times definite but very diverse meanings, sometimes a weight of 25 lb., which is obviously too little, and again a weight of 1000 lb., which is probably too much. The large dictionary of Tommaseo gives this latter weight with an example stating the capacity of a ship: but if that were the meaning then the carracks would be of a burden of from 2250 to 2700 tons, a much heavier tonnage than is elsewhere indicated, so far as I am aware, for vessels of the period. Probably 3000 tons would be the outside limit of the aggregate cargoes annually brought to Portugal, for in any case much room in the ships was required for the large crews of those days with their armaments, for then the idea of carrying on commerce by sea without being in a position to defend your ship was out of the question.

1 Horton Ryley, "Ralph Fitch," p. 61.
2 *Ibid.*, p. 17.
3 Angelo de Gubernatis, "Memoria intorno di viaggiatori Italiani nelle Indie Orientali dal secolo XIII a tutto il XVI," p. 149.

Of the commodities sent home from India, Fitch mentions in this place only pepper, and the correspondence of Albuquerque with the King of Portugal soon after the discovery of the sea way to India clearly reveals how all-important the pepper trade was; but it may be worth while to give the complete list of the commodities which Ralph Fitch enumerates at the end of his "Narrative" as coming from India and the country further eastward. The list is not a long one. It comprises pepper, ginger, cloves, nutmegs and maces, camphora ("a precious thing among the Indians . . . solde dearer then golde"), lignum aloes, long pepper, muske, amber, rubies, saphires, and spinels, diamants, pearles, spodium, and many other kindes of drugs from Cambaia—all of them, it will be observed, having the character of being of high value in proportion to their bulk, so that a very great value of such goods might be carried in ships of small capacity.

Fitch does not tell us what was sent in return, but information as to that is to be had from other sources and presents one or two points of interest. In 1513 Albuquerque, after a long course of fighting, concluded a peace with the Zamorin of Calicut, in which it was agreed, among other things, that the Zamorin should supply the Portuguese with all the "spices and drugs" his land produced, and that "coral, silk stuffs, quicksilver, vermilion, copper, lead, saffron, alum, and all other merchandise from Portugal" should be sold at Calicut as heretofore.[1] Coral comes first in this enumeration. To us at the present day this does not seem a very important article of commerce, but it was otherwise then. One Mafio di Priuli, writing from India in 1537 to the Magnifico M. Constantino di Priuli, says, "At a great fair which is called that of Tremel I have seen buttons of coral sold for their weight in silver."[2] That is the point of view of a European in India, but a native of the East Indies in Europe at the same date would no doubt have spoken with astonishment of the amount of silver that could be got in Europe for a few grains of pepper. Our letter-writer says in his cheerful, hopeful, gossiping way, "The gains of these parts are other than those of Damascus, Aleppo, and Alexandria: for if one does not gain cent. per cent. from Portugal here, and from here back again, one thinks that one gains nothing. And three or four years would be quite enough."[3] But, while he indicates how these immense gains are made, he also indicates clearly enough how they continue to be made—that is, how they are so counterbalanced by losses that if these great gains were not made on occasion commerce would cease. It was all very well to exchange your coral for spices, but the great matter was to get your coral out and your spices home in safety. The writer of this letter had entrusted to a friend who had left on a ship for Ormuz jewels of the value of 4000 Venetian ducats, but the jewels were lost. He believed that his friend was murdered. "But such losses," he adds, "will occur." Another time he lost more than 6000 ducats gold in Portuguese vessels going to Ormuz, and on another occasion he suffered great loss when Pegu was sacked by the King of Burma.

These notes may serve to illustrate the conditions of trade in the glorious days for Portugal when fine fortunes were heaped up in Lisbon through trade, but the great bulk of humanity got very little at least directly through that trade: but we have not exhausted the interest connected with the nature of the outgoing commodities for India, and to that it will be well to return. Another of the stipulations of the treaty of 1513 above referred to was that while duties were to be paid in coin "the Portuguese were to pay for all the pepper and other

1 Danvers, "The Portuguese in India," vol. i., p. 283.
2 P. 34 of the letter referred to as published at Venice in 1824.
3 *Ibid.*, p. 29.

merchandise they might purchase in kind," and, as the peace led among other things to a dearth of prizes, Albuquerque "was constrained to send an urgent request home for large quantities of merchandise to be sent out to make up for this deficiency."[1] How long this stipulation remained in force I cannot say, but things were certainly different a hundred years later. In the report to the Grand Duke of Florence above cited we are told that what the Portuguese carry to India for exchange is above all "silver in reals, and besides silver wine, oil, and some other sort of merchandise, such as coral, glass, and the like, of little importance"; and as to the silver he adds that "the reals bring a gain of more than 50 per cent. as soon as they have reached India, for the real of eight, which in Lisbon is worth 320 reis, in India is sold and spent at the rate of 480 to 484 reis of that money, and with it one buys all sorts of spices and drugs which are sold there, except pepper, which is the monopoly of the King of Portugal and those to whom he gives a lease of that trade." The importance of silver among the outgoing commodities for India has continued from that time down to the present day, latterly, however, in diminishing proportion. For a long time after the date at which we have now arrived it was as predominant as a means of exchange with India as it was in the first century of the Christian era, when the drain of silver from the Roman Empire to the East was bewailed by the writers of that time. In the voyages of the English East India Company of the four years 1620–3 inclusive the value of the bullion (chiefly silver) sent out to India was 205,710*l*., as against only 58,806*l*. worth of merchandise.[2]

Now, what is the meaning of the change in the position of silver in Indian trade which seems to have taken place between 1513 and the end of the sixteenth century? No doubt we may see there the result of another change in geographical relations brought about by a discovery nearly contemporaneous with that of the sea way to India—namely, that of the New World. The first result of that discovery of importance to commerce was the pouring into Europe of large quantities of the precious metals, and the quantity was enormously enhanced after the silver mines of Potosi, in Upper Peru (as it was then called), were discovered in 1545. It was probably this discovery that brought it about that of all commodities of such small bulk in proportion to their value as to stand the costs of transport to the East this was the one which could be sent out for the most part with the greatest advantage. And this discovery no doubt also helps to explain why that of the sea way to India had so little effect for a very long time in lowering the prices of spices in Europe, why prices even rose. At the time of the return of Vasco da Gama from the first voyage to India the price of pepper at Lisbon is estimated by Danvers[3] to have been about 1*s*. 5*d*. per lb., and we all know that the immediate occasion of the foundation of the English East India Company about a hundred years later was that the Dutch suddenly raised the price of pepper against the English from 3*s*. to 6*s*. and 8*s*. per lb.

But the particular commodity which made up the principal portion of the outward trade to India is, after all, a matter of detail, though not unimportant detail. The main point on which I want to insist is that, whatever the commodities were, whether carried out or home, the nature of the trade with the East was little if at all altered by the discovery of the direct route to India by sea. The trade still continued to be one concerned in a moderate number of articles of small bulk but high value. It was merely a change of route that the Portuguese effected, and for more than a hundred years they remained in sole command of this route. After that, however, they were ousted from the greater part of this trade, and that the more valuable part, chiefly by the Dutch, and from a geographical point of view it is very interesting to note how the Dutch did it. They did not trouble themselves much about India proper. They left the Portuguese alone at Goa, and from that port as a base allowed them to pick up as much trade as they could at Calicut and Cochin, which, said Albuquerque, "were capable of supplying the Portuguese fleets until the Day of Judgment." But Malacca, on the straits of that name, gave command of the route to the further East, whence came in the end even larger quantities of pepper than could be got from India, whence came too ginger, cloves, and nutmegs, as well as the products of China. The importance of this place Albuquerque had accordingly recognised, and in 1511, the year after he took Goa, he took it also by the right that always belongs to the lion as against the jackal. This place was taken by the Dutch (1641), who had previously established themselves on Java and the Spice Islands, where they maintained an absolute monopoly. Ceylon, again, was (and is) almost the only place from which the true cinnamon was to be obtained, so the Dutch took that island also from the Portuguese (1656). As long as the Portuguese were the sole Europeans in the East, Calicut and Cochin not merely furnished the Portuguese with Indian wares, but were important entrepôts for the spices, perfumes, drugs, and jewels of the Further East as well as of Chinese silks and porcelains; but the trade in these commodities could be wholly or largely diverted to places in the possession of the Dutch. Even before the capture of Malacca and Ceylon a Portuguese viceroy had reported (1638) that the Dutch had a monopoly of trade from the Bay of Cochin China to the point of Sunda.

But this change also was little more than a change of route. The general character of the Eastern trade remained the same. The English East India Company, the operations of which, through the hostility of the Dutch, came to be restricted to India proper, there founded a trade that gave much more opportunity for expansion under modern conditions than that of the Dutch, but for a long time it retained the same character. All the commodities enumerated by Colquhoun as brought back by the voyages of 1620–3 in exchange for the bullion and merchandise sent out were pepper, cloves, mace, nutmegs, Chinese and Persian raw silk, besides calicoes, the sole manufactured article, and one of course that had relatively a much higher value than now, when the direction of the trade in that commodity is reversed.

A similar character for a long time belonged to the trans-Atlantic trade, even though the costs of transport in that case were less, and favoured the development of a trade in somewhat bulkier commodities. Furs from the Far North, tobacco from Virginia, sugar and afterwards coffee and cotton from the West Indies, were by far the most prominent imports. It was the tobacco trade of Virginia that first enabled Glasgow, which at the time of the union of the English and Scottish Parliaments was an insignificant town with less than 13,000 inhabitants, to convert itself into a seaport, and thus lay the foundations of its subsequent prosperity. Now tobacco makes up less than 1 per cent. of the value of the goods imported at Glasgow, and, though that may be partly due to a diminution in the actual quantity of tobacco imported at Glasgow, this result has chiefly been brought about by changes in relative values. A hundred years ago the value of the imports into Great Britain and Ireland from the British West Indies was about one-fourth of the total value of the imports from all parts; now it is less than 1 per cent. of that value.

What has brought about such changes, what makes the essential difference between recent and all previous commerce, is the series of enormous improvements in the means of communication which followed so closely on the invention of textile machinery and the improvement of the steam-engine in this country. These improvements have had two important effects on commerce. First, they have facilitated the maintenance of order and security both by land and sea, and thus enormously reduced the risks of commerce. Secondly, they have directly lowered the cost of transport for different goods in different degrees. Bulky goods of little value could now for the first time be profitably conveyed many hundreds of miles by land to a seaport, and there load ever larger ships for distant shores, thus opening up markets with vast undeveloped resources in the heart of great continents. Along with these bulkier goods the more valuable goods are carried at a cost far

[1] Danvers, vol. i., pp. 281, 286.

[2] I take these figures from p. 6 of the appendix to P. Colquhoun's "Treatise on the Wealth, Power, and Resources of the British Empire," 2nd ed., London, 1815.

[3] As above, vol. i., p. 64.

below that of former times, so that for such commodities as pepper the mere freight is almost a negligible item.

At the present day there can be no doubt that in point of quantity the spice trade is much larger than it ever was. If Venice could get the whole of that trade into her hands, a thing which she never had, notwithstanding the patriotic boast of Doge Mocenigo, the trade would not now bring her a tithe of the wealth which it brought in the days of her grandeur. Much has been said of the sudden "fall" of the Portuguese and Dutch in turn, and that fall has often been explained by mistakes in method. "The fall of the Dutch colonial empire resulted," says Sir William Hunter, "from its short-sighted commercial policy. It was deliberately based upon a monopoly of the trade in spices, and remained from first to last destitute of sound economical principles."[1] But one may well ask, Did the Dutch ever fail in a manner for which they were in any way responsible? It is true that the Dutch East India Company did not supply as many people as they could with the spices of which they held the monopoly. But that was not their aim. It is true that they did not build up a great empire like that of the English East India Company. But neither was that their aim. Their aim was to declare dividends, and dividends they declared. The profits of the company down to 1720 averaged 20 per cent. per annum, never sinking below 15 per cent., and sometimes rising to 50 per cent. If spices ceased to enable them to declare such dividends that was not their fault. It was James Watt, George Stephenson, William Symington, and Robert Fulton, who, without intending it, and without being able to foresee what in this respect they were destined to do, sucked the value out of pepper, and that in a manner which neither the strength of armies nor the subtlety of statesmen could have done anything to prevent.

Now the countries that offer the most attractive markets for the greatest quantities of goods of all kinds are no longer those which look to the spice trade or to trade in any specially valuable commodities for their enrichment, but those which abound in coal so placed as to develop a great amount of manufacturing industry, an industry engaged for the most part in working for the million, not merely in producing the luxuries of the rich. The commodities of very small bulk in proportion to their value now have a comparatively insignificant place in commerce. The precious metals and precious stones still indeed retain a good deal of their former importance. But very few vegetable or animal products can be put in the same category. Rubber, indeed, may be reckoned as one, and very handsome profits are reaped from some rubber estates. But everyone knows that such exceptional profits can be reaped only for a short time. Of animal products ornamental feathers are the most valuable in proportion to their bulk. Egrets' feathers, I believe, are seldom worth less and often worth a good deal more than twice their weight in gold, but ornamental feathers altogether make up less than a third of 1 per cent. of the total value of British imports.

Perhaps the greatest feature of modern commerce is the unparalleled manner in which it has promoted the increase of population nearly all the world over. Rendering it possible for manufacturing and commercial peoples to depend in a very large measure for their very means of subsistence on supplies brought from the ends of the earth, it is rapidly pushing the settlement of vacant land to the base of the mountains and the edge of the desert. Fifteen years ago Prof. Bryce said, "We may conjecture that within the lifetime of persons now living the outflow from Europe to North America will have practically stopped."[2] We are at least nearing the time when the "new lands" of this earth in the temperate zone will all have been allotted. The results of such a check to expansion after a long period of stimulation to expansion must be momentous, but what the nature of these results will be I for one confess that I am unable to foresee. I am, however, convinced that, if we are to be enabled to make any probable forecast as to the course of future development, one of the most important aids to that result must consist in the study of the relations of geography and history from the point of view which I have endeavoured to indicate. To study these relations merely with reference to the immediate causes and effects of wars and treaties gives little real insight into the working of geographical influences in history. As in the study of the human body medical men have recognised the necessity of ascertaining with the aid of the microscope the normal functions of the cells of which the body is composed, the pathological states that interfere with their normal working, and the effects on one part of the body of minute disturbances of function in another part, so in tracing the course of history it is becoming more and more recognised that the minute gradual silent changes must be inquired into and taken into account, not merely in relation to the regions in which they take place, but in relation, it may be, to regions far distant. Such studies, it is true, are not confined to the geographer. In them, indeed, the geographer must seek the aid of workers in other fields; but there can hardly be a doubt that it must help greatly towards arriving at a sound solution of the problems presented to keep steadily before one the geographical point of view. The field for such studies is of course immense, the material perhaps not all that could be wished; but I can imagine no task more delightful for those who have the opportunity to engage in it than that of seeking out and examining from that point of view such material as actually exists.

[1] "Imperial Gazetteer of India," 2nd ed., vol. vi., p. 362.

[2] "The Migrations of the Races of Men considered Historically," in the *Scottish Geographical Magazine*, 1892, p. 419.

NOTES.

THE death is announced, at the age of fifty-one years, of Prof. Emil Petersen, professor of chemistry in the University of Copenhagen. Prof. Petersen was a pupil of and collaborator with Prof. Jörgensen, and was well known for his researches in physical and analytical chemistry.

WE regret to see by the *Scientific American* that Prof. Angelo Heilprin died on July 17 at the age of fifty-four years.

THE sum of 960*l*. has been given by Mr. W. H. Crocker, of San Francisco, to the University of California for the purpose of defraying the expenses of an expedition to observe the total solar eclipse of January 3 next, which will be visible on the Pacific coast.

THE Board of Trade is about to constitute a special temporary branch (under the direction of Colonel Sir Herbert Jekyll, K.C.M.G.) for the purpose of dealing with matters relating to London traffic so far as they come within the scope of the Board.

MR. H. C. PLUMMER, assistant in the Oxford University Observatory, has been appointed to a fellowship at the University of California in connection with the Lick Observatory on Mount Hamilton.

IN reply to a question put to him in the House of Commons on Thursday last by Mr. McCrae, the member for Edinburgh, East, as to whether he was in a position to say if he was able to accede to the request of the Scottish members of Parliament for a grant to the Scottish Meteorological Society for the purpose of reopening and maintaining the Ben Nevis observatories, the Chancellor of the Exchequer said the only scheme which had up to the present been placed before him was one under which the whole cost of the re-equipment and maintenance of the observatories would be thrown upon public funds, and to this he did not feel justified in assenting. He was, however, quite prepared to consider the question of renewing the Government grant, which was for many years given to these institutions through the Meteorological Council, provided that an adequate contribution towards their re-establishment and maintenance were forthcoming from other sources.

A PARTY of observers, consisting of Dr. T. A. Jaggar, jun., head of the department of geology, Massachusetts Institute of Technology; Dr. H. S. Eakle, University of California; Prof. H. V. Gummery, professor of mathematics, Drexel Institute, Philadelphia, who will have charge of the magnetic observations; Dr. Van Dyke, who will study the botany and entomology of the islands; and Prof. F. T. Colby, who will investigate the natural history of the region, recently sailed from Seattle, Washington, to study the geological formation of the Aleutian group of islands and other scientific features of the archipelago. The investigators will, according to the *Scientific American*, pay particular attention to Perry Island, which suddenly rose from the sea more than a year ago. The party will begin working westward from Attu Island, and will devote several months to their researches.

DR. CHARCOT has furnished the *Geographical Journal* with further particulars of the plans for his new Antarctic expedition. The choice of the same field of exploration as on the former expedition was made, after due consideration of the plans of other expeditions now being organised or projected, for the following reasons:—(1) the importance of gaining further knowledge of the almost unknown Alexander I. Land; (2) the possibility of the existence in that region of an ice-barrier similar to that of Ross, over the surface of which an advance could be made; (3) the advantages of continuing the scientific work begun by the former expedition, and utilising the experience gained by it; (4) the support to be expected from the Argentine Republic in view of the excellent relations entered upon on the former occasion. The building of a special ship will, it is hoped, soon be begun. While large enough to permit the carrying out of scientific work under suitable conditions, the vessel will be small enough to enable it to navigate in safety along the coasts and to seek shelter in small coves. In addition to ordinary sledges, it is proposed to take motor-sledges for possible use on the surface of an ice barrier. Wandel Island is to be the final base of operations, and from this the coast of Alexander I. Land will be explored as far as possible, also the unknown area, scientific work being at the same time carried on at the base. During the second summer an attempt will be made to navigate westward as far as possible in the direction of King Edward VII. Land.

INFORMATION is given in the August number of the *Geographical Journal* respecting a new scientific expedition to the extreme south of South America which is being organised by Mr. Carl Skottsberg, one of the members of the recent Swedish Antarctic Expedition. The expedition, which will leave Gottenberg next month, will consist of Messrs. Skottsberg, P. Quesnel, and T. Halle. It will not sail in a ship of its own, but will make use of the ordinary mail steamers and coasting vessels for transport to the scene of operations, and will be equipped for botanical, geological, zoological, and meteorological work. Proceeding *via* Buenos Aires and Montevideo to the Falklands, the leader and Mr. Halle will there spend the summer of 1907–8 for the purpose of continuing the researches begun by the Swedish Antarctic Expedition, Quesnel meanwhile going to Punta Arenas, where he hopes to make an excursion to the Cerro Payne region. On re-uniting at Punta Arenas, the party will, if time permits, make an expedition to the northwards along the Cordillera and round Otway and Skyring waters, before winter sets in. This will be spent in the rainy region of the western channels, and in the spring an attempt will be made to reach Lago Fagnano, the party then moving its headquarters to the region of Beagle channel. It is proposed to conclude the summer's work with a trip to Tekeenika Bay, returning to Sweden in April or May, 1909.

MR. CHARLES HAWKSLEY has commemorated the centenary of the birth of his late father by offering the sum of 1000*l*. to the council of the Institution of Mechanical Engineers for the foundation of a scholarship or premium. The offer has been accepted by the institution, and the terms on which the gift is to be held are under consideration.

Two sums, each of 250*l*., have been received by the Institution of Mechanical Engineers from the Metropolitan Water Board and the chairman of the Court of Arbitration (under the Metropolitan Water Act, 1902), which the donors desire to be used for some engineering purpose connected with the institution. The council have invested the amount—500*l*.—in a trustee security, the income from which they have decided, after consultation with Sir Edward Fry, shall be offered biennially for a paper submitted in accordance with prescribed conditions. It has been further decided that the prize shall be known as the "Water Arbitration Prize," and shall be offered for a paper on an engineering subject to be announced by the council one year before the time for sending in the papers. The prize, which will have a value of approximately 30*l*., will take any form which the council may from time to time decide upon, and will be accompanied by a certificate bearing the seal of the institution. If, in the opinion of the council, no paper of sufficient merit be received in reply to any particular offer of the prize, the amount available for that award will be added to the capital of the fund. The conditions for the first award, to be made in 1908, are that:—(1) The award will be made to the author of the selected paper dealing with the filtration and purification of water for public supply. (2) Members, associate members, associates, and graduates of the institution may compete. (3) Papers must be sent in to the secretary of the Institution of Mechanical Engineers, and must reach him not later than January 3, 1908. (4) Each paper must be clearly written, or typewritten, on one side only of foolscap paper, with a margin, and must be accompanied by an outline or synopsis of its contents of not more than six hundred words; any illustrations submitted with the paper must be properly drawn to scale. (5) Papers submitted for competition will become the property of the institution, and, at the discretion of the council, may be either read and discussed at a general meeting or printed in the Proceedings without having been so read and discussed. Each paper must consist of original matter written by the competitor himself, and the council will require a written statement to that effect. Any paper not accepted for printing in the Proceedings will be returned to the author. No paper which has been previously published will be accepted for competition.

A SPECIAL committee, with M. V. V. Podvysotsk, director of the Institute of Experimental Medicine, as president, has been appointed by the Medical Council of the Russian Ministry of the Interior to study the question of establishing a committee for the investigation of cancer.

ACCORDING to the *Lancet*, the late Prof. Grancher, of Paris, has left to the society founded by himself, the object of which is the protection of children from tuberculosis, a sum sufficient to provide an annual income of 20,000 francs. Dr. Roux, director of the Pasteur Institute, has accepted the position of president of the society.

AT the first meeting of the medical section of the Royal Society of Medicine, which is to take place on October 22, Dr. Hector Mackenzie will open a discussion on the complications and sequelæ of pneumonia and the treatment of pneumococcal infections by serum or vaccine. The section is now fully constituted, and is open to receive papers for reading and discussion during the winter session.

THE fourteenth International Congress of Hygiene and Demography will meet in Berlin from September 23 to September 29. A strong international committee has been constituted for the organisation of the meeting, which promises to be a very successful and interesting one. Of the British section, Sir Shirley Murphy is the chairman, Prof. Nuttall, F.R.S., and Mr. Paul Moline are the secretaries, and Mr. Cutler is the treasurer. The congress is divided into eight sections, and a number of interesting subjects have been selected for discussion. Anyone engaged scientifically or practically in hygiene or demography is eligible as a member, the subscription being 1*l*., which entitles him to a copy of the transactions. Those not eligible for membership (*e.g.* the relatives of members) will be admitted to the sectional meetings, &c., on payment of a subscription of 10*s*. Some of the subjects selected for discussion are the ætiology of tuberculosis, pathogenic protozoa, alcoholism, care of infants, overwork in schools, caisson disease, uniform methods of testing disinfectants, preventive inoculation, housing of the working classes, artificial ventilation, sleeping sickness, and control of milk.

THE eighth session of the Australasian Medical Congress is to take place in Melbourne in October of next year. The president will be Prof. H. B. Allen, of the University of Melbourne. The eleven sections into which the congress is to be divided will be presided over respectively by Dr. G. E. Rennie, medicine; Dr. B. Poulton, surgery; Mr. E. T. Thring, obstetrics and gynæcology; Dr. J. T. Wilson, anatomy and physiology; Dr. F. Tidswell, pathology; Dr. J. M. Mason, public health and State medicine; Dr. J. Lockhart Gibson, diseases of the eye, ear, and throat; Dr. F. Truby King, neurology and psychiatry; Dr. A. Jefferis Turner, diseases of children; Surgeon-General W. D. C. Williams, naval and military surgery and medicine; Dr. W. McMurray, skin diseases, &c.

AN electrical exhibition lasting a fortnight is to be held in Montreal, commencing on September 2, and from September 11 to 13 the Canadian Electrical Association is also to meet in the same city, when the following papers, among others, will be read:—How to increase the load factor; some of the difficulties encountered in operating alternating current systems; new and old type incandescent lamps; the Nernst lamp; and electric heating and cooking appliances.

IN the Scottish National Exhibition to be held in Edinburgh in 1908 there will be sections devoted to fine arts, education and history, arts and crafts, mining, engineering and metallurgy, transportation and motive power, shipbuilding and waterways construction, chemistry and scientific appliances, lighting, heating and ventilation, agriculture, horticulture and sylviculture, domestic economy, sports and pastimes, botany and zoology, artisans' work, women's section, urban and rural improvements.

A RECENTLY issued report from the British Consul at Copenhagen states that the Danish Government has allocated the sum of 4276*l*., to be used during the next three years, for the purpose of the extermination of rats, on the understanding, however, that the sum of 1666*l*. be expended over a like period by an organisation which is in existence for the destruction of rats. It is stated that a Danish patent rat destroyer has been invented, which, when eaten by rats, causes disease of the bladder, which kills them; whereas it may be swallowed by human beings, dogs, and poultry without danger.

IN connection with the international investigations of the upper air, conducted from July 22 to 27, several kite ascents have been made under the auspices of the Meteorological Office. A number of registering balloons (*ballons sondes*) have also been sent up, six at Manchester and three at Ross (Herefordshire), for the joint committee of the Royal Meteorological Society and the British Association; six at Petersfield by Mr. C. J. P. Cave; five at Crinan and four at Pyrton Hill, Oxon, for the Meteorological Office. The recording instruments for nearly all the ascents have been supplied by the Meteorological Office. Up to Monday, July 29, nine had been recovered, and one has been reported since. One balloon sent up at Ross, Herefordshire, on July 23, is reported to have reached the height of probably 60,000 feet, or about eleven miles. It is too early yet for any detailed results to be given.

As the annual presidential address to the Philosophical Society of Washington on December 8, 1906, Prof. C. Abbe read a most interesting and instructive paper on the progress of science as illustrated by the development of meteorology. The author pointed out that while some portions of this subject are already as exact as our knowledge of other sciences can make them, the path of progress is strewn with the wrecks of popular errors. Since the establishment of the Meteorological Society of the Palatinate at Mannheim in 1780, the advance made has been entirely in the direction of the line of work that it laid out, viz. to collect data from all parts of the globe for the purpose of compiling synoptic daily weather maps for the study of the atmosphere as a whole. At the present time the investigation of the upper air is being made throughout the world, and each national weather bureau is extending its field of observation horizontally, while each is now alive to the fact that satisfactory advance in practical meteorology requires corresponding progress in our knowledge of the sciences involved in the motions of the atmosphere. Another step in advance is due to the investigation of the interaction of the continental and oceanic hemispheres, to our knowledge of which subject the researches of Sir Norman and Dr. Lockyer, among others, have greatly contributed. This principle is already recognised by the directors of the Indian Meteorological Service in their forecasts of the approaching monsoons.

AT the annual meeting of the National Association of Colliery Managers at Chesterfield on July 25, Mr. J. P. Houfton delivered the presidential address. He dwelt upon the increasing difficulty and complexity of the problems connected with mining as the shallower seams were exhausted, and urged the necessity for the colliery manager to be a man of scientific training and education. He considered that it was of national importance that a university of mining should be established in order to furnish the colliery managers of the future with the technical knowledge and scientific training required to enable them to work the deeper coal seams.

FOR the summer meeting of the Institution of Mechanical Engineers, which opened on July 30 at Aberdeen under the presidency of Mr. T. Hurry Riches, an interesting programme of papers was arranged. Mr. William Simpson's paper on granite quarrying in Aberdeenshire was specially noteworthy in that it furnished information on a subject regarding which the technical literature is remarkably sparse. Nowhere in the whole of Great Britain is there such a large exposure of granite as in north-east Scotland, and the supply of granite of the highest durability and beauty is practically inexhaustible. The quarrying presents many features of difficulty. The overburden is costly to remove, and the top rock unremunerative. As a rule the quality of the rock improves with the depth, and there is a temptation to deepen without a proportionate surface area. Where this has been done the quarry has assumed the form of a conical pit with a small floor, difficult and costly to work. Mr. Herbert Bing submitted a paper on portable pneumatic tools. Of recent years there has been great progress made in these tools, and in the range of work to which they are applicable. At the present time they will be found in use in practically all engineering works, shipyards, and mines. Mr. C. E. Larard described an electrically controlled single-lever testing machine at the Northampton Polytechnic Institute, London. The machine constitutes quite a new departure in many of its arrangements, and has given very satisfactory results in testing, due primarily to the good control over the rates of loading and straining. Papers were also contributed by Mr. J. M. Henderson, on cableways used on shipbuilding berths, and by Mr. D. J. Macdonald, on jute preparing and spinning.

IN October, 1905, a committee was appointed by the council of the Royal Institute of British Architects to draw up rules for guidance in the use of reinforced concrete. The report of this committee has recently been published, and in the *Engineer* of July 26 the rules drawn up are compared with the French Government instructions. In the more important matters there is uniformity in treatment, and the rules proposed by the committee are by no means revolutionary.

THE fuels committee of the Motor Union of Great Britain and Ireland has issued a valuable report on motor-car fuels, of which a summary is published in the *Engineer* of July 26. Readers of the report will find cause for a despondent view of the petrol supply, and will probably agree that a famine in petrol appears to be inevitable in the near future, owing to the fact that the demand is increasing at a rate much greater than the rate of increase of the supply. In 1904 the consumption of petrol in the United Kingdom was 12,000,000 gallons; in 1907 it had risen to 27,000,000 gallons. In November, 1904, the trade price was 7*d*. per gallon; in December, 1906, it was 13*d*. Having recognised that the time is not far distant when a substitute for petrol must be sought, the committee discusses in the report other possible fuels. The supply is divided into two parts. The first includes all fuels limited in quantity; they are the spirits of a specific gravity between petrol and paraffin, paraffin itself, coal dust, gas, and benzol. The second group contains one item only—alcohol—and it is evident from the whole tone of the report that the committee expects to find in denatured vegetable spirits the fuel of the future.

AN article on the natural regeneration of the "dhowra" tree, *Anogeissus latifolia*, in the Panch Mahal division of Bombay, is communicated by Mr. R. F. Pearson to the May number of the *Indian Forester*. Owing to the occurrence of a large number of trees of an even age, the author was led to examine the conditions under which such extensive seedling growth was developed. Whilst the rainfall in the year of germination was distinctly favourable, the opinion is expressed that, in addition, the seed must have been unusually fertile. The fertility of seeds from trees is a question deserving the attention of foresters. Mr. Pearson attributes the fertility of the seed in this instance to the stimulus or shock caused by the drought of the previous year. A note on the Kashmir trout fisheries refers to the attempts, finally successful, made by Mr. F. Mitchell whereby the Harwan stream and the Dhal Lake have been stocked with brown trout.

WITH reference to afforestation, in a paper printed in the Transactions of the Royal Scottish Arboricultural Society, vol. xx., part ii., Mr. A. C. Forbes discusses the problem of planting up waste land, and places on record certain data, obtained by the measurement of sample plots of Scots pine, larch, and spruce on plantations in Northumberland and Cumberland, showing an annual increment varying from 50 cubic feet to 80 cubic feet per acre. Figures are also presented, on the authority of Lieut.-Colonel F. N. Innes, for plantations in Aberdeenshire. Other papers in the volume include a summary of a paper by Mr. M. Henry on the interrelation between forests and rainfall, arboricultural notes from Portuguese East Africa contributed by Mr. J. A. Alexander, and an account of the work at Eberswalde Forest Academy by Mr. A. F. Wilson.

A DISSERTATION on the physiological significance of caffein and theobromin, by Dr. Th. Weevers, is published in *Annales du Jardin botanique de Buitenzorg*, ser. ii., vol. vi. These xanthin derivatives were found in all parts except the roots of *Thea assamica* and *Coffea arabica*, but only in the early vegetative stages of *Coffea stenophylla* and *Cola acuminata*. From a comparison of the quantities obtained in young and maturing leaves, also in leaves placed in air devoid of carbon dioxide, the author concludes that these substances are formed as secondary products in the breaking down of proteins, and are subsequently absorbed in protein synthesis; in the seeds they are plentiful, forming a nitrogenous reserve.

A BULLETIN, No. 187, issued by the United States Department of Agriculture, deals with the digestibility and nutritive value of legumes, recording the results of experiments conducted by Dr. C. E. Wait at the University of Tennessee. Although these tend to prove that legumes are not so thoroughly digested as many other foods, the author recommends their inclusion as a source of protein in the diet, and directs attention to the value of cowpeas, the product of *Vigna Catiang*.

WE have received copies of two issues, No. 68, part i., and No. 69, of the Bulletin of the U.S. Bureau of Entomology, the former, by Mr. Dudley Moulton, dealing with the pear-thrips (*Euthrips pyri*), while in the latter Mr. F. M. Webster discusses the ravages of the chinch-bug (*Blissus leucopterus*). The pear-thrips flourishes in the districts around San Francisco Bay and the Sierra Nevada foot-hills, but whether it is an indigenous species which has become unusually numerous owing to the development of orchards, or whether it is introduced, has not yet been ascertained. In 1905, when this insect was exceedingly numerous, the pear-crops were hopelessly blighted, but how much of the injury was due to the thrips and how much to wet weather is uncertain. Owing to the long period spent by the thrips underground, remedial measures are difficult to apply. Practically the whole of the eastern half of the United States is infested by the chinch-bug, which is represented by a short-winged maritime phase and a long-winged inland form. It is a migratory, two-brooded species, which originally fed upon the native grasses, but has now turned its attention to wheat and other cereals. On reaching a suitable food-supply, the insects congregate on the plants until these are literally covered with individuals of various ages, ranging in colour from the vermilion of the older larvæ to the black and white of the adults. When the plant is drained of its juices, the larvæ move on to the next one, the adults alone making long migrations.

The African honey-guides (Indicatoridæ), which have acquired parasitic habits parallel to those of cuckoos, are wiser in their generation than the latter, for (as we are told by Mr. A. K. Haagner in the Journal of the South African Ornithologists' Union for June) they are in the habit of breaking the eggs of the birds they select as foster-parents for their offspring. This is illustrated by a plate in the same issue, where two of the fractured eggs are shown. In some cases, however—probably when they are attacked by the future foster-parents—they do not succeed in breaking the rival eggs, in which event it is probable that the strong hooks on the tip of the beak of the young honey-guides come into play for the purpose of aiding in the ejectment of the other occupants of the nest. A nestling of one species of honey-guide is represented in a second plate. It may be added that most of the plates in this issue are lettered vol. iii., whereas the cover is lettered second series, vol. i., No. 1. The idea of commencing a second series with the third volume of this serial thus seems to have been an afterthought—and a by no means happy one.

Slugs, according to Mr. B. B. Woodward's presidential address to the Malacological Society for 1907, are more specialised creatures than snails, for among molluscs of all classes there appears to be a general tendency, more especially in the carnivorous types, to discard the shell as the result of the assumption of more active habits than ordinary. Other instances of adaptive modifications in the group are mentioned in the same address.

In *Science Progress* for July (ii., No. 5), Dr. Bashford discusses the application of experiment to the study of cancer, and summarises the results obtained by a study of the development of transplanted cancer in mice.

We are asked by the author, Mr. Arthur Trewby, to state that the little volume entitled "Healthy Boyhood," which was reviewed in our issue of July 25, may be obtained post free for 1*s*. 6*d*. from the author, Fenton House, The Grove, Hampstead Heath, N.W.

OUR ASTRONOMICAL COLUMN.

Astrographic Catalogue Work at the Perth Observatory (W.A.).—Mr. W. Ernest Cooke, Government astronomer of Western Australia, informs us that the prospects for the astrographic catalogue work are not now so hopeless as they appeared from the report referred to in Nature of May 23 (p. 89). He says that the present Government recognises the importance of the work, and a start has been lately made to measure the plates. It is feared, however, that the images will deteriorate before the completion of the work. Upon comparing a plate taken a few years ago with a recent one of the same region, the image of a ninth-magnitude star on the former was found to be about equal to that of a 9·5 magnitude on the latter. With reference to the 10,000 standard stars which have to be observed by means of the transit circle, Mr. Cooke hopes to obtain good positions of all these stars (three observations of each) in ten or twelve years, and certain zones have been completed already. It is proposed to make this list of stars the standard work at the Perth Observatory, observing and re-observing exactly the same list, in order to obtain good determinations of the position of each star every ten years or so.

Daniel's Comet (1907*d*).—This comet is now approaching the naked-eye stage, and may be found quite readily with small opera glasses. On August 9 it will rise at about 12h. 45m., some 3¾ hours before the sun. On August 14 the comet will be about 46′ north of γ Geminorum. An observation made on August 1 showed no indication of a tail, but the comet has a well-defined nucleus.

Mars.—Telegrams received from the Lowell expedition to the Andes announce that on July 2 Mr. Slipher photographed several of the canals, and that on July 6 canals were seen double and oases were photographed (*Astronomische Nachrichten*, No. 4193, p. 291, July 26).

In vol. xxvi., No. 1 (p. 1, July), of the *Astrophysical Journal*, Prof. Newcomb discusses the optical and psychological principles involved in the interpretation of the so-called canals of Mars. From the optical point of view he shows that in the best refracting telescopes the effects of aberration, diffraction, and atmospheric softening will materially increase the breadth of any linear marking. As a rough estimate he submits that a perfectly black line on Mars three miles in breadth might be visible if the surface of the planet were perfectly uniform, but, as it is not, the actual breadth would have to be increased to eight or ten miles in order that the feature might be differentiated from those surrounding it. Aberration, &c., would spread a marking of this width for some twenty miles on each side, so that the apparent breadth in the telescope would be fifty miles or upward. Allowing this width to each of the 400 canals mapped by Lowell, the total area covered would be 33,000,000 square miles, the actual surface of Mars extending over some 55,000,000 square miles. Although this large relative area does not disprove the objective reality of the canal system, it shows how wide the interpretation of the results must of necessity be, when the whole network is crowded on to a disc only 20″ in diameter. Concerning the interpretation of such features by different observers, Prof. Newcomb gives some illustrated results of a number of interesting experiments he has carried out in this direction.

Some New Applications of the Spectroheliograph.—Using a temporary spectroheliograph of 30 feet focal length, Prof. Hale has obtained spectroheliograms with the primary slit set on some of the dark lines which are found strengthened in the sun-spot spectrum. The lines employed in this preliminary work were those which appear to be strengthened in the umbra and penumbra and on the photosphere for some distance from the spots, and the resulting photographs show the umbra and penumbra much darker than they appear on plates taken with the light of the continuous spectrum; the diameter of the spot also appears to be considerably increased. Lines weakened in sun-spots were also tried and gave definite results, which are, however, less marked than in the case of the strengthened lines. For work with the numerous faint lines of the spot spectrum a large dispersion is absolutely essential, and a suitable instrument is being constructed for use with the new vertical telescope.

Prof. Hale has also obtained some spectroheliograms for stereoscopic examination, which, when viewed with a stereoscope, show the masses of flocculi standing boldly above the general level of the hemisphere. A pair of these, taken at an interval of 2h. 5m., are reproduced in the *Astrophysical Journal* (vol. xxv., p. 314, June). It is hoped that by examining such pairs of spectroheliograms in the stereocomparator changes may be detected in the appearance of the flocculi, &c., which might otherwise escape detection.

The "Annuario" of the Rio de Janeiro Observatory.—The twenty-third annual publication of the Rio de Janeiro Observatory, for 1907, which we have just received, is very much like its predecessors, and contains an exposition of various calendars, numerous tables and data useful to astronomers, and a compilation of various physical data which will be found of general use.

PERSEIDS—COMET DANIEL.

On the night of August 4 several bright Perseids were observed, and this marked return of the shower at so early a date presages a display exceeding the ordinary richness this year. There is evidence that the shower is pretty strong every ten years, for there were considerable numbers of Perseids seen in 1877, 1887, and 1897. It will be desirable to watch the phenomenon during its ensuing apparition, with special regard to the fact alluded to, and to ascertain the hourly number of Perseids visible throughout the nights of Sunday and Monday, August 11 and 12. The latter date will probably be found to represent the time of maximum. St. Lawrence's Day, August 10, is no longer contemporary with the Perseid display at its best.

The diurnal motion of the radiant, amounting to one degree in a direction to E.N.E., was first definitely observed by the writer in 1877 and announced in Nature at the time. Every year supplies fresh evidence of the displacement and corroborates the facts described in Monthly Notices, vol. lxii., pp. 161–9.

Daniel's comet has been visible to the naked eye since the first few days of July, and is now sufficiently conspicuous to arrest the immediate attention of anyone who will look towards the eastern sky before the morning twilight becomes too strong. On August 5, at 3 a.m., the nucleus of the comet appeared like a blurred star of 2½ magnitude, and the tail extended westwards over nearly 3°, but it was difficult to assign limits, as it faded gradually away into the tone of the sky. Ephemeris by Dybeck (*Ast. Nach.*, 4194):—

Berlin Mean Midnight.

1907	R.A. h. m. s.	Dec. ° ′	Brightness.
Aug. 10	5 56 56	+17 23	17·6
„ 14	6 33 1	+17 15	19·0
„ 18	7 7 6	+16 47	20·0
„ 22	7 30 2	+16 4	21·0
„ 26	8 8 58	+15 11	20·5
„ 30	8 37 12	+14 9	20·0
Sept. 1	8 50 45	+13 35	19·5

W. F. Denning.

THE ANNUAL MEETING OF THE BRITISH MEDICAL ASSOCIATION.

The seventy-fifth annual meeting of the British Medical Association was held last week at Exeter under the presidency of Dr. Henry Davy, physician to the Royal Devon and Exeter Hospital.

The subject of the presidential address was "Science in its Application to National Health." After giving some particulars concerning Exeter and the Royal Devon Hospital, Dr. Davy proceeded to point out that every organ, muscle, and structure in the body required a proper amount of work to keep it healthy. Exercise was therefore very important, and he deplored the present tendency to watch games rather than to participate in them. Physical culture was one of the most pressing questions of the day, and it should not be left to professors of Swedish exercises to lecture on physical culture and to direct the kind of exercise to be employed; in such questions the medical man should be consulted. Schools should have proper playgrounds and gymnasiums, and trainers in physical exercises were as necessary as school teachers. The question of food was another important one, and the "man in the street" should be able to obtain from his medical attendant precise details of the quantity required and of its nature. As regards infective diseases, pyæmia was now almost unknown, thanks to the labours of Lord Lister, typhoid fever was diminishing, and it was now tuberculosis that required to be attacked. Something, it was true, had been done in this direction, but much more remained; are no precautions to be insisted on with regard to disinfection? Are we for ever to allow consumptives to disseminate their infectious expectoration? Are consumptives alone to be allowed to stay in hotels and lodgings without taking precautions?

The address in medicine was delivered by Dr. Hale White, whose subject was "A Plea for Accuracy of Thought in Medicine." He instanced such terms as "irregular" or "suppressed gout" and "liver out of order" as really being only a cloak for ignorance, which it would be much better to confess. "Selective action" was another mystery, *e.g.* why does alcohol pick out the anterior tibial nerve and lead the musculo-spiral? Why do beer drinkers get "beer-drinkers' heart" in Munich but not in London? Unreflecting adhesion to authority has a particularly serious effect in keeping back the advent of correct knowledge.

Mr. Butlin discussed the "Contagion of Cancer in Human Beings: Autoinoculation" in his address in surgery. He brought forward a number of cases in which cancer in a part was followed by cancer of the same type in another part in contact with the first, *e.g.* cancer in one lip followed by cancer in the other lip.

In the section of medicine there was a discussion on the indications for operation in cases of intra-cranial tumour introduced by Dr. Risien Russell, Dr. Gardner Robb read a paper on the recent outbreak of cerebro-spinal fever in Belfast, and Dr. Rivière one on the tuberculin treatment of tuberculosis in children.

In the section of pathology there were important discussions on pernicious anæmia and on phagocytosis. In the section of tropical diseases, Prof. Simpson read a paper on anti-malarial sanitation, in which he discussed how recent discoveries have rendered anti-malarial sanitation more precise and less costly than formerly.

In the section of State medicine, Dr. Newsholme delivered an address on the need for coordination of the public medical services. Voluntary effort, as illustrated in the hospitals, and State-aided treatment under the Poor Law, failed entirely to produce an adequate result for the vast sums expended. A coordinated system of State-paid and State-directed medical service would speedily justify itself from an economical standpoint, and must of necessity ally itself with preventive medicine.

Dr. Gilchrist read a paper on the necessity of increasing the degree of immunity against small-pox, and Mr. Garrett Horder one on the new vaccination order. A resolution was passed by the meeting recommending the council of the association to approach the Local Government Board on the subject of the new vaccination order.

The association was received by the civic authorities at the Guildhall, and numerous garden-parties and excursions helped to pass an instructive and pleasant week in the delightful old city.

UNIVERSITY AND EDUCATIONAL INTELLIGENCE.

Manchester.—Harling fellowships in physics have been awarded to Mr. J. N. Pring and Dr. Hans Geiger.

The University has made arrangements for a number of public lectures in the autumn which are to be given by leading men of science and others.

Dr. Graham Steell has been appointed by the council of the University of Manchester professor of medicine in the university.

Oxford.—The Romanes lecture will be delivered by Lord Curzon, Chancellor of the University, in the Sheldonian Theatre, on Saturday, November 2. The subject of the lecture will be "Frontiers."

Sheffield.—Mr. D. H. de Souza has been appointed demonstrator in physiology, and Mr. W. F. G. Swann assistant lecturer and demonstrator in physics.

Prof. von Leyden has resigned the professorship of clinical medicine at the University of Berlin, and Prof. His, of Göttingen, has been appointed to succeed him in the chair.

Dr. Geoffrey Martin, a former student of the Merchant Venturers' Technical College, Bristol, has been appointed lecturer and demonstrator in chemistry at University College, Nottingham.

A "Prof. Tait's Memorial Fund" of the value of 200*l.* per annum, for the encouragement of physical research in the University of Edinburgh, has been endowed by Sir John Jackson.

Two research studentships in science of the value of 60*l.* and 40*l.* respectively have been founded at University College, London, by an anonymous donor; they will be awarded for the first time next session.

A MOVEMENT is on foot in Glasgow to recognise in a suitable manner the scientific services of Prof. J. G. McKendrick, F.R.S., and a committee of former pupils and friends has been formed to raise a memorial to the late Prof. Pirie, Aberdeen.

MR. W. E. CURNOCK has been appointed head of the department of mechanical engineering and building trades at the Battersea Polytechnic. Mr. Curnock has for the past three years been head of the engineering department of the Technical College, Huddersfield.

SOCIETIES AND ACADEMIES.

PARIS.

Academy of Sciences, July 29.—M. A. Chauveau in the chair.—New contribution to the study of the trypanosomiasis of the Upper Niger: A. **Laveran**. An account of a new trypanosome to which the name *T. soudanense* has been given. This parasite, from a morphological point of view, resembles *T. evansi*, but differs from it in its pathogenic action on animals, especially mice. Experimental evidence is given that the trypanosome of Mal de la Zousfana and El Dabab is probably *T. soudanense*. —The function of the spleen in trypanosomiasis: A. **Laveran** and M. **Thiroux**. A criticism of a paper on the same subject by MM. Rodet and Vallet. The latter regard the spleen as possessing trypanolytic properties, but this view is disputed by the authors of the present note.—The early diagnosis of tuberculosis by the ophthalmo-reaction with tuberculin: A. **Calmette**. This reaction, as applied by the author, consists in the application to the eye of a 1 per cent. solution of dry tuberculin precipitated by alcohol. In healthy subjects no reaction is produced, but in tuberculous subjects a characteristic conjunctival redness is produced within twenty-four hours. This reaction has been utilised in nearly a thousand cases with very satisfactory results, and in many instances, especially of children, has revealed tuberculous lesions the presence of which had not been suspected.—Mr. E. C. Pickering was elected a correspondant for the section of astronomy, in the place of the late M. Rayet.—A point in the theory of the sun of M. Julius: Henri **Bourget**. —Linear homogeneous representations of finite groups: M. **de Séguier**.—Differential equations of the third order with fixed critical points: M. **Chazy**.—Differential equations of the third order the integral of which is uniform: René **Garnier**.—The representation of integral equations of any degree: J. **Massau**.—The determination of the altitude of the summit of Aconcagua: Fr. **Schrader**. The mean of two observations was 6953 metres. Full details are given of the method used.—Ionisation by bubbling through liquids: L. **Bloch**. A question of priority regarding a recent note by M. de Broglie.—The compressibility of gases in the neighbourhood of atmospheric pressure: Daniel **Berthelot**. The variation of pv with the pressure has been studied for carbon dioxide, nitrous oxide, and sulphur dioxide for pressures between 0·25 and 2·0 atmospheres. Between these limits of pressure the variation of pv is not, as has been assumed by M. Guye, a linear function of the pressure, but is a linear function of the density.—Nitrate of silver: calorimetry at high temperatures: M. **Guinchant**. The calorimeter is isolated by a vacuum jacket, and heated electrically. It has been applied to measure directly the latent heats of fusion of tin, mercuric iodide, and silver nitrate. —Ortho- and pyro-arsenic acids: E. **Baud**. Pure pyroarsenic acid can be obtained by keeping $As_2O_5.4H_2O$ over strong sulphuric acid at a temperature of 15° C. to 20° C. From thermochemical experiments the author concludes that orthoarsenic acid exists only in solution. The crystals which separate from this solution are the hydrate of pyroarsenic acid.—The direct oxidation of phosphorus: E. **Jungfleisch**. A detailed study of the combustion of phosphorus in oxygen at low pressures, phosphorus anhydride being formed. Under special conditions as much as 95 per cent. of the phosphorus can be converted into P_4O_6.—The properties and constitution of tantalum steels: Léon **Guillet**. Four samples of steel were prepared containing about 0·17 per cent. of carbon, 0·2 per cent. of manganese, 0·2 per cent. of silica, and proportions of tantalum varying from 0·09 per cent. to 1·05 per cent. These steels were studied micrographically and as regards their mechanical properties. Contrary to what has been claimed for these steels, they show no property of any importance.—Some derivatives of menthone: Eyvind **Bœdtker**.—Two new glucosides, linarine and pectolinarine: T. **Klobb**. These are obtained from the flowers and leaves of *Linaria vulgaris*.—The production of high temperatures in laboratory researches: Léon **Guillet**. Reclamation of priority against M. Chabrié.—The mode of distribution of the muscular glycogen in well fed and in starved subjects. The influence of the seasons on the proportion of glycogen in the muscles: F. **Maignon**.—The relative toxicity of the salts of chromium, aluminium, and magnesium; comparison with the analogous properties of the rare earths: Alexandre **Hébert**.—The influence of acids on the action of laccase: Gabriel **Bertrand**.—The influence of manganese salts on alcoholic yeasts: E. **Kayser** and H. **Marchand**.—The urinary chromogen resulting from the administration of indol-carboxylic acid: Ch. **Porcher** and Ch. **Hervieux**.—The dwarf coffee plant of Sassandra, *Coffea humilis*: Aug. **Chevalier**.—The buccal incubation in *Arius fissus*: Jacques **Pellegrin**. —*Coccus anomalus* and the disease causing the blueing of champagnes: E. **Manceau**.—The pharmacodynamical action of kolatine: J. **Chevalier** and A. **Goris**.—Some ophthalmological experiments made with the aid of a mercury vapour lamp: P. **Fortin**. Certain details of structure very difficult to observe with ordinary light are readily perceived by the light of a Cooper-Hewitt lamp. This light is also very useful in the study of colour blindness.—The discovery of the sulpho-gypsum formation in the basin of Seybouse: J. Dareste **de la Chavanne**.—The fishes of the family of Cichlideæ found in the Tertiary strata at Guelma: H. E. **Sauvage**.

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