the tail is enveloped in a continuous sheath. These and other scale-like structures in the Chelonia are usually spoken of as if they were entirely epidermal. But, a day or two ago, Dr. Günther informed me that in the Australian tortoise, *Manouria*, the great imbricated scales of the limbs contain bony scutes; and that similar scutes are to be found in *Testudo græca*. This, of course, suggested the examination of the caudal scales of *Chelydra* and *Gypochelys*; and, having been enabled by Dr. Günther's kindness to examine the caudal scales of a good-sized specimen of the latter, I have found that those of the crest contain bony scutes.[1] The bony scute corresponds very closely in form with the whole "scale," but the recurved apex of the latter is formed only by epidermal substance (Figs. 5 and 6).

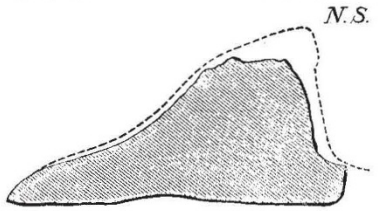

FIG. 5.

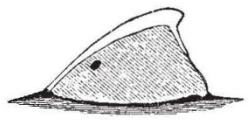

FIG. 6.

FIGS. 5, 6.—Sectional views of a scute of the tail-armour of *Ceratochelys* (Fig. 5), and of one of the crest plates of *Gypochelys*, both of the natural size.

The living *Chelydra*, therefore, has a caudal armature which, in principle, is similar to that of *Ceratochelys*, but the osseous elements are relatively atrophied. There is exactly the same relation between the armour of species of living *Crocodiles* and *Alligators*, on the one hand, and those of *Jacare* and *Caiman* and the extinct *Teleosauria*, on the other. In the former, the epidermal scales remain well developed on the ventral side of the body, while the corresponding osseous scutes, fully developed in *Jacare*, *Caiman*, and *Teleosauria*, have vanished.

Among the detached fragments to which I have referred, there are remains of ribs, with their costal plates; marginal and other plates of the carapace; parts of the plastron; part of a scapula; sundry limb bones; and several of the cranial processes called "horn-cores." They all agree, so far as they can be compared, with the determination already arrived at; which, to sum it up in a few words, is that the remains of crania and caudal sheaths from Australia, hitherto referred to Saurian reptiles, under the names of *Megalania* and *Meiolania*, appertain to a hitherto unknown species of Chelonian, *Ceratochelys sthenurus*, closely allied to the living *Chelydra*, *Gypochelys*, and *Platysternum*.

The evidence of this fact offered in the present note appears to me to be conclusive, but it may be desirable hereafter to figure the parts mentioned and to describe them at length.

The interest which attaches to the discovery of this singular Chelonian arises partly from the fact that the group of Chelonia to which it belongs is wholly unrepresented in the fauna of Australia, as at present known. *Platysternum* is usually said to be found in China. Dr. Günther, however, informs me that Upper Burmah is its proper habitat; otherwise, North America, east of the Rocky Mountains, is the nearest region in which the *Chelydridæ* are to be found. But *Chelydridæ*, and, indeed, species of the genus *Chelydra*, occur in Upper Miocene (Œningen) and in Eocene formations in Europe. Moreover, *Platychelys*, of the Upper Jurassic series of Bavaria and Switzerland, is regarded by Rütimeyer as an early form of the group.

Lord Howe's Island is about 200 miles from the nearest Australian mainland, and something like 400 miles, as the crow flies, from the Darling Downs, in which the caudal armour, which has been ascribed to *Megalania*, was found. The discovery of *Ceretochelys*, therefore, has an interesting bearing on the question of the former extension of Australia to the eastward, on the one hand; and of the possible derivation of such forms as *Ceratochelys* from Asia, on the other hand. An elevation of the sea-bottom of 6000 feet would place Norfolk Island and Lord Howe's Island on a peninsula extending from the region of the present Barrier Reef to New Zealand; and the floræ and faunæ of those islands are known to have special affinities with those of New Zealand, and none with those of Australia.

Speculations respecting the origin of the Chelonian carapace are suggested by the discovery of osseous scutes in the vertebral region of the tail, and their coalescence in *Ceratochelys* to form a sort of caudal carapace, ridged in a manner resembling that of *Chelydra* and *Platychelys*. But the consideration of these points would take me beyond the limits of the present note.

[1] The fact is noted by Rütimeyer (Lang and Rütimeyer, "Die Fossilen Schildkröten von Solothurn," *Denkschriften der Allg. Schweiz. Gesellschaft*, vol. xxii.). The armature of the tail in *Platysternum* is for the most part arranged in zones, of four plates in each zone; but I have not yet been able to find any bone in them.

THE WORK OF THE IMPERIAL INSTITUTE[1]

I.

THE Colonial and Indian Exhibition, which owes not only its conception, but also its brilliantly successful realisation to your Royal Highness, will be pre-eminently remarkable in times to come, for having achieved many results of vital importance and highest benefit to Her Majesty's subjects in all parts of her vast realms.

The collection of all that is commercially valuable and scientifically interesting of the natural products of the great Indian Empire and of the Colonies in one Exhibition, embracing as it also did very comprehensive illustrations of the development of commerce, of the arts, and of certain industries, in the many countries beyond the seas which combine with the United Kingdom to constitute our vast Empire, afforded those at home an opportunity, surpassing all previous conception, of studying and comparing the natural history and resources of those distant lands, of which, attached though we might be individually to one or more of them by ties of friendship or of interest, the knowledge of many of us was of a very vague or partial character.

To the Colonists who visited us last year, the Exhibition has been of inestimable value, in affording them a most favourable and appropriate opportunity of becoming acquainted or renewing their old friendship with the mother country, and of examining the progress there made in industrial, educational, and commercial development; in leading to the cultivation of intimacy between Colonists from different sections of the Queen's Dominions; and in affording them invaluable opportunities of comparing the resources and state of development of their respective countries with those of other parts of Europe. No more convincing illustrations than were provided by this great Exhibition could have been conceived of the importance to the home country, to each Colony, and to India, of fostering intimate relationship and unity of action. No more encouraging proof could have been afforded of the desire of all classes of Her Majesty's subjects at home to cultivate a knowledge of those far-off countries which the enterprise and perseverance of the British, and men of British offspring, have converted into prosperous and important dominions, chiefly during the period of the Queen's reign, than was furnished by the interest which the thousands upon thousands, who came from all parts, displayed in the study of the instructive collections in the galleries at South Kensington.

It was the success of the Exhibition which led to the definite formulation of the suggestion first made by your Royal Highness in a letter addressed by you in the autumn of 1884 to the Agents-General of the Colonial Governments, that a permanent representation of the resources of the Colonies and India, and of their continually progressing development, might, with great benefit to the Empire at large, be established in this country. That the realisation of this idea upon a sufficiently comprehensive basis might constitute a worthy memorial of the accomplishment of fifty years of a wise and prosperous reign; a memorial not personal in its character excepting so far as it constituted an emblem of the love and loyalty of Her Majesty's subjects, but tending, as she would most desire, to serve the interests of the entire Empire; this had only to be pointed out by your Royal Highness to be heartily concurred in by the official representatives of the Colonies and India, who

[1] Lecture (abridged) delivered at the Royal Institution, on Friday, April 22, by Sir Frederick Abel, C.B., F.R.S.; H.R.H. the Prince of Wales, K.G., F.R.S., Vice-Patron, in the Chair.

were so intimately identified with the triumphs of the recent Exhibition.

The Committee to whom you, Sir, intrusted the elaboration of a scheme for carrying this conception into effect, became persuaded by a careful consideration of the subject that such an Institution as your Royal Highness desired to see spring into life, to be a memorial really worthy of the Jubilee of Her Majesty's reign, and to fulfil the great purposes which you had in view, must not be confined in its objects to particular portions of Her Majesty's Dominions, but must be made thoroughly representative of the interests and of the unity of the whole Empire.

The outline of the scheme for the establishment of an Imperial Institute for the United Kingdom, the Colonies, and India, which met with the cordial approval of your Royal Highness, was necessarily concise in dealing with the very wide extent of ground which the operations of the Institute are intended to cover; but those who have carefully considered it, and rightly interpreted its proposals, have not failed to realise that it aims at very much more than the creation and maintenance of collections illustrative of the natural resources of our Colonies and of India, and of the development and present condition of the chief industries of different parts of the Empire.

One of the primary objects of the Institute will certainly be the establishment of thoroughly well selected, carefully arranged, and efficiently maintained representations of the natural products which constitute the treasures, and are emblematic of the important positions in the Empire, of those great colonial possessions which, during the fifty years of Her Majesty's reign, have, in many instances, experienced a marvellous development in extent, in commercial, social, and even in political importance.[1] The recent Exhibition not only afforded conclusive demonstration of the great interest and value to the United Kingdom which must attach to such collections if properly organised; it also served, by such illustrations as the magnificent collections of valuable woods, from nearly every colony, many quite unknown in England, and the great variety of valuable economic products from India, of the existence of which we at home had little idea, to convince us that our knowledge of the great countries which constitute the chief portion of the Empire is very limited and imperfect, and that their resources are in many directions still in the infancy of development. Our Colonial brethren cannot, on their part, fail to be greatly benefited by being thoroughly represented in a well-selected and carefully organised assemblage of illustrations of the sources of prosperity which constitute the sinews of their commerce, and upon a continued exploration and cultivation of which must depend the maintenance of their influence upon industrial and social progress. Neither can they fail to reap substantial advantages by pursuing a friendly rivalry with each other in demonstrating the advances made from time to time in the development of the resources of the respective portions of the Empire in which their lot is cast.

The hearty co-operation and important material support to which the great Colonies, through their representatives in London, pledged themselves when the scheme for the proposed Imperial Institute was in the first instance limited to this branch of the great work which it is now contemplated to accomplish, afforded conclusive evidence of their earnest desire to be in all respects thoroughly represented in the mother country, and to take their places permanently in our midst as fellow-labourers in the advancement of the prosperity of the Empire. In furtherance of this important end, a notable feature of that building which, in its character, will, it is hoped, be worthy of the momentous epoch which it is to commemorate, will be the attractions and conveniences presented by it, as a place of resort and a *rendezvous* for Colonists visiting England, and, it is also anticipated, for the important Societies which represent the Colonies and Asiatic possessions in this country, and the facilities which it will afford for reference to literature concerning the Colonies and India, for conferences on matters of common interest and value to the Colonists and those at home, for the interchange of information between the British manufacturer and those in the Colonies who are directly interested in meeting his requirements, and generally for the cultivation of intimate relations and good fellowship between ourselves and our brethren from all parts of the Empire.

The Institute will, however, not only operate actively under its own roof in promoting the cultivation of a better knowledge of the geography, natural history, and resources of our Colonies, and for the advancement of the interests of the Colonists in this country; it is also contemplated that representative collections of the natural products of the Colonies and India, carefully identified with the more elaborate collections of the head establishment, shall be distributed to provincial centres, and that the provinces shall be kept thoroughly conversant with the current information from the Colonies and India, bearing upon the interests of the commercial man, the manufacturer, and the intending emigrant.

Although the formation and maintenance up to date of collections illustrative of the development and present condition of the important industries of the Empire also forms, as I have stated, a part of the programme of the Institute, the scope of its activity in relation to industry will be of a much more comprehensive character; indeed, it is to be hoped that the work which it will achieve in furtherance of the development and progress of industries and their future maintenance in the United Kingdom at least upon a footing of equality with their conditions in the great Continental States, will be most prominent in securing to the Imperial Institute the exalted position which it should occupy as the National Jubilee Memorial of Her Majesty's reign.

There is no need for me to recall to the minds of an audience in the Royal Institution the great strides which have been made during the last fifty years in the applications of science to the purposes of daily life, to the advancement of commerce, and to the development of the arts and manufactures. Nor is it necessary to dwell upon the fact that this country is the birth-place of the majority of the great scientific and practical achievements which have revolutionised means of intercommunication, and have in other ways transformed the conditions under which manufactures, the arts, and commerce are pursued. These very achievements, of which we as a nation are so justly proud, have led, however, by many of their results, to our becoming reduced to an equality of position with other prominent nations in regard to important advantages we so long derived from the possession in this country of great material resources easy of access and application, and from the consequent pre-eminence in certain branches of the trade and industry which we so long enjoyed.

In 1852, Sir Lyon Playfair was impelled by the teaching of the preceding year's Great Exhibition to point out that "the raw material, formerly our capital advantage, was gradually being equalised in price and made available to all by the improvements in locomotion," and "that industry must in future be supported, not by a competition of local advantages, but by a competition of intellect." If this was already felt to be the state of the case six-and-thirty years ago, how much more must we be convinced of the full truth of this at the present day, by the conditions under which the British merchant and the manufacturer have to compete with their rivals on the Continent and in the United States.

It is still within the recollection of many that almost the whole world was in very great measure dependent upon Great Britain for its supplies of ordinary cast iron. Even as lately as 1871, the United States of America received from Great Britain nearly one-fifth of its total produce of pig iron; but from 1875 all importation of British iron ceased for over three years, and it was only in consequence of requirements in the States exceeding the capabilities of production, that some small demands arose in 1879, which were for some time maintained.

Within three years, however, the make of iron in the United States increased by 70 per cent., and although, since 1882, the actual make has not increased, the *capacity of production* has risen enormously, it being at present estimated at nearly 300 per cent. greater than it was in 1879. Looking nearer home, we find that the iron of France, Belgium, and Germany not only competes with ours in the open market, but that Belgian and German iron is actually imported into this country to a moderate extent.

From time to time the ground which we have lost through the development of the resources of other countries has been more than retrieved temporarily by improvements effected through the more thorough comprehension and consequent better application of the scientific principles underlying processes of manufacture, but the ultimate effect of advances of importance has not unfrequently been to improve the position, in relation to the manufactures concerned, of other nations less favourably circumstanced than Great Britain.

The history of the development of steel manufacture during the last twenty-five years affords a most instructive illustration of the

[1] Statistical statements illustrating the development of the colonies during the Queen's reign are appended.

fluctuations which may ensue in the value of our natural resources, and the consequent condition of one or other of our important industries, arising out of continued advances made in the application of science to the perfection or transformation of manufacturing processes, and of the stimulating effects of such fluctuations upon the exertions of those who are able to bring scientific knowledge to bear upon the solution of problems in industrial operations which entirely baffle the ordinary manufacturer. Within that period the inventions of Bessemer and of Siemens have led to the replacement of iron by steel in some of its most extensive applications. This important change in our national industry was, ere long, productive of a serious crisis therein, and for the reason that the pig iron produced from a large proportion of those ores which, from their abundance and the cheapness of their treatment, have been greatly instrumental in placing Great Britain in her high position as an iron-producing nation, could not be applied to the production of marketable steel by means of the Bessemer converter. Hence the application of this rapid steel-making process had to be chiefly restricted to particular kinds of ores, free from the impurity, phosphorus, which it was powerless to eliminate; the supplies of such ores being limited to a few districts in this country. These had to be largely supplemented by importations from other countries; nevertheless the cheapness of production and superiority in point of strength, durability, and lightness of the steel rails thus sent into the market from the Bessemer converter combined to maintain a supremacy of them over iron rails, &c., manufactured by the old puddling process from the staple ores of the country.

The advantages presented by steel over the wrought iron of the puddling furnace for constructive purposes speedily became evident, and the effect of the rapid displacement of malleable iron by steel produced from ores of a particular class has been that at least 85 to 90 per cent. of the iron ores of Great Britain could no longer be applied to the production of material for rails, for ships, and for other important structures. Great has been the apprehension among the owners of those ores that the demand for iron which they can furnish could not revive, but the scientific metallurgist has successfully grappled, from more than one direction, with the great problem of restoring their commercial importance; and a simple alteration of the method of carrying out the Bessemer process has within the last few years led to really triumphant results, with the employment of those ores which before could only be dealt with by the searching operation of the old puddling furnace. A new era has thus been established in steel manufacture, there being now but very few restrictions to the application of the quick processes to iron produced from all varieties of ores. Indeed, the treatment is actually being applied profitably to the recovery of iron from the rich slag forming the refuse-product of the puddling furnace in the production of malleable iron, which before had been condemned to limited usefulness as a material for road-making. Yet another most interesting and valuable result has been achieved by this simple application of scientific knowledge. The slag or refuse-product of the so-called *basic treatment* of iron contains, in the form of phosphates of lime and magnesia, the whole of the phosphorus which it is the main function of that treatment to separate from the metal; it was soon found that the phosphoric acid was there presented in a condition as readily susceptible of assimilation by plants as it is in the valuable artificial manure known as superphosphate; this refuse-slag, simply ground up, constitutes therefore a valuable manure which already commands a ready sale at very profitable prices.

The origination of this latest advance in the development of steel manufacture dates back only nine years, and already the year's product of the basic process amounts to over 1,300,000 tons of steel. But although it is to Englishmen that the owner of iron property and the steel-maker are again indebted for these important results, and to English manufacturers that the first practical demonstration of the success of this process is due, its application has been far more rapidly elaborated upon the Continent than here; in Germany the importance of the subject was at once realised, and it is there that considerably the largest proportion of steel is produced by the basic treatment; it is in Germany also that the value of the slag for agricultural purposes has been developed, the first steps in its utilisation here being but just now taken, in Staffordshire.

I have already referred to the remarkable strides which have been made in the extension of iron manufacture in the United States; the development there of steel production has been no less marvellous, and the causes of this are evident; the resources of the country in ore and fuel are gigantic, and the systematic technical training of the people has made its influence felt upon the development of this as of every other branch of industry which our friendly rivals pursue. But it is not only in the United States that the development in the production of iron and steel has greatly increased of late years; thus, in Germany the increase in the production of pig iron alone, during the last twenty-one years, has been 237 per cent., while with us it has been 75 per cent.

Although, however, the increase in actual production of iron and steel in Great Britain has not kept pace with that of some other countries, it is satisfactory to know that our *productive power* has very greatly increased in late years, and there is probably no one branch of our industries in which we have maintained our position so satisfactorily in regard to quality of product as that of iron and steel manufacture, even though, every now and then, we have indications that in the struggle with other nations for superiority of product and for pre-eminence in continuity of progress, we have to look to our laurels.

There are, however, other important branches of industry, for a time essentially our own, the present condition of which, in this country, we cannot contemplate with equal satisfaction. Several instructive illustrations might be quoted, but I will content myself with a brief examination of one of the most interesting.

In illustrating the advances which were being made, thirty-five years ago, as demonstrated by the Exhibition of 1851, Playfair referred to the great development of the value of the evil-smelling coal-tar, which was then made to furnish the solvent liquids benzene and naphtha, and the antiseptic creosote, the residual material being utilised for pavements and for artificial fuel. The chemist little dreamt then that between 1851 and the year of the next great Exhibition, 1862, coal-tar would have become a mine of wealth equally to science, the manufactures, and to the arts, in which fresh workings have ever since continued to be opened up, and still present themselves for exploration. Hofmann, in his valuable report on the chemical products and processes elucidated by that Exhibition, dwells with the enthusiasm of the ardent worker in science upon the brilliant products obtained from coal-tar which had resulted from the labours of the scientific chemist, and had already acquired an almost national importance, although this great industry was then still in its infancy. From the year 1856, when the first colouring-matter, known as *mauve*, was discovered and manufactured by one of Hofmann's most promising young pupils, Mr. Perkin, down to the present time, the production of new coal-tar colours, or of new processes for preparing the known colours in greater purity, has progressed uninterruptedly, this industry having long since become one of the most important, and also one of the most remarkable, as illustrating by each stage of its development the direct application of scientific research to the attainment of momentous practical results.

The difficulties to be overcome before mauve could be produced upon a manufacturing scale were very great, and were only solved by a steady pursuit of scientific research, side by side with practical experiments suggested by its results. Aniline—the parent of the first coal-tar colour, a liquid organic alkali—a most fertile source of interesting and important discoveries in organic chemistry, was produced with difficulty by various methods in very small quantities, so as to be almost a chemical curiosity at the time of the discovery of mauve. Among the substances from which it had been prepared was the volatile liquid known as *benzene*, first discovered in the laboratory of this Institution in 1825 by Faraday, in the liquid products condensed from oil gas, but afterwards obtained by Mansfield, in the College of Chemistry, from coal-tar naphtha. The conversion of benzene into aniline was accomplished as a manufacturing process after many difficulties by Perkin; and within a year after the discovery of mauve by him, it was in the hands of the silk dyer. Perkin's success led other chemists at once to pursue researches in the same direction, especially in France, where the next important coal-tar colour, *magenta* or fuchsine, was obtained, by M. Verguin, the successful manufacture of which in a pure state was, however, first accomplished by English chemists. In 1861 beautiful violet and blue colours were produced, again by French chemists, but were manufactured shortly afterwards in a pure state in England.

The six years succeeding those which formed the first period (1854–62) of existence of this industry were fruitful, not only of many beautiful new dyes, first produced in England, but also

of important progress made here, as well as on the Continent, in the development of the manufacture, and of our knowledge of the constitution, of the parent colours.

In the next period of six years (1868-74) another great stride was made in the coal-tar colour industry, due to important scientific researches carried out by two German chemists, Graebe and Liebermann, which led them, in the first place, to obtain an insight into the true nature of the colouring-matter of one of the most important staple dye-stuffs, namely the madder-root. They found that this colouring-matter which chemists call *alizarine* was related to *anthracene*, one of the most important solid hydrocarbons formed in the distillation of coal, a discovery which was speedily followed by the artificial formation of the madder-dye, alizarine, from that constituent of coal-tar. At first, this achievement of Graebe and Liebermann was simply of high scientific interest; but Perkin, and Graebe, and Liebermann, were not long in discovering methods by which the conversion of anthracene into the madder-dye could be accomplished on a large scale, and the manufacture of alizarine was soon most actively pursued in this country, with very momentous results, as regards the market value of the madder root. The latter has long been most extensively cultivated in Holland, South Germany, France, Italy, Turkey, and India, the consumption of madder in Great Britain having attained to an annual value of as much as 1,000,000*l.* sterling. Playfair pointed out in 1852 that important improvements had lately been attained in the extraction of the red colour or alizarine from the madder-root, but those results, most valuable at the time of the first Great Exhibition, became insignificant when once the dye was artificially manufactured from anthracene; the price paid for madder in 1869 was from 5*d.* to 8*d.* per pound, but now the equivalent in artificial madder-dye, or alizarine, of one pound of the root, can be obtained for one-halfpenny.

With the discovery of artificial alizarine the truly scientific era of the coal-tar industry may be said to have commenced, most of the commercially valuable dye-products, obtained since that time, being the result of truly theoretical research by the logical pursuit of definite well-understood reactions. The wealth of discovery in this direction made during the last thirteen years is a most tempting subject to pursue; but I must content myself with mentioning that one of the results was the production of very permanent and brilliant scarlet and red dyes, the manufacture of which has greatly reduced the market value of cochineal; that the careful study of the original coal-tar colours led to their production in a state of great purity by new and beautifully simple scientific methods; and that even the well-known vegetable colouring-matter, *indigo*, one of the staple products of India, now ranks among the colours synthetically obtained by the systematic pursuit of scientific research, from compounds which trace their origin to coal-tar.

The rapid development of the industry has also not failed to exercise a very important beneficial influence upon other chemical manufactures; thus, the distillation of tar, which was a comparatively very crude process, when, at the period of the first Exhibition, benzene, naphtha, dead-oil, and pitch were the only products furnished by it, has become a really scientific operation, involving the employment of comparatively complicated but beautiful distilling apparatus for the separation of the numerous products which serve as raw materials for the many distinct families of dyes. Very strong sulphuric acid became an essential chemical agent to the alizarine manufacturer, and, as a consequence, the so-called anhydrous sulphuric acid, the remarkable crystalline body which was for many years prepared only in small quantities from green vitriol, is now made at a low price upon a very large scale by a beautifully simple process worked out in England. The alkali- and kindred chemical trades have been very greatly benefited by the large consumption of caustic soda, of chlorate of potash, and other materials used in the dye manufactures, and the application of constructive talent, combined with chemical knowledge, to the production of efficient apparatus for carrying out on a stupendous scale the scientific operations developed in the investigator's laboratory, has greatly contributed to the creation of a distinct profession, that of the chemical engineer.

One of the most beneficial results of the rapid development of the coal-tar colour industry has been its influence upon the ancient art of dyeing, which made but very slow advance until the provision of the host of brilliant, readily-applicable colours completely revolutionised both it and the art of calico-printing.

I venture to think that it will be interesting at this point to quote some words of prophecy included in Prof. Hofmann's important "Report on the Chemical Section of the Exhibition of 1862," and to inquire to what extent they have been verified. In commenting upon one of the features of greatest novelty in that world's show, the exhibition of the first dye-products derived from coal-tar, he says:—

"If coal be destined sooner or later to supersede, as the primary source of colour, all the costly dye woods hitherto consumed in the ornamentation of textile fabrics; if this singular chemical revolution, so far from being at all remote, is at this moment in the very act and process of gradual accomplishment; are we not on the eve of profound modifications in the commercial relations between the great colour-consuming and colour-producing regions of the globe? There is fair reason to believe it probable that, before the period of another decennial Exhibition shall arrive, England will have learnt to depend, for the materials of the colours she so largely employs, mainly, if not wholly, on her own fossil stores. Indeed, to the chemical mind it cannot be doubtful that in the coal beneath her feet lie waiting to be drawn forth, even as the statue lies waiting in the quarry, the fossil equivalents of the long series of costly dye-materials for which she has hitherto remained the tributary of foreign climes. Instead of disbursing her annual millions for these substances, England will, beyond question, at no distant day become herself the greatest colour-producing country in the world; nay, by the strangest of revolutions, she may ere long send her coal-derived blues to indigo-growing India, her tar-distilled crimson to cochineal-producing Mexico, and her fossil substitutes for quercitron and safflower to China, Japan, and the other countries whence these articles are now derived."

So far as concerns the displacement of madder, cochineal, quercitron, safflower, and other natural dye-materials from their positions of command in the markets of England and the world, Hofmann's predictions have been amply fulfilled, and it appeared in the earlier days of the coal-tar colour industry as though he would be an equally true prophet in regard to England becoming herself the greatest colour-producing country in the world. But, although Germany did little in the very early days of this industry, beyond producing a few of the known colours in a somewhat impure condition, many years did not elapse ere she not only was our equal in regard to quality of the dyes produced, but, moreover, had outstripped us in the quantities manufactured and in the additions made to the varieties of valuable dyes sent into the market. So far back as 1878 the value of the make of colours in England was less than one-fourth that of Germany, and even Switzerland, which, in competing with other countries industrially, is at great natural disadvantages, was not far behind us, ranking equal to France as producers. The superior position of Germany in reference to this industry may be in a measure ascribable to some defects in the operation of our Patent Laws and to questions of wages and conditions of labour; but the chief cause is to be found in the thorough realisation, by the German manufacturer, of his dependence for success and continual progress upon the active prosecution of scientific research, in the high training received by the chemists attached to the manufactories, and in the intimate association, in every direction, of systematic scientific investigation with technical work.

The young chemists whom the German manufacturer attracts to his works rank much higher than ours in the general scientific training which is essential to the successful cultivation of the habit of theoretical and experimental research, and in the consequent power of pursuing original investigations of a high order. Moreover, the research laboratory constitutes an integral part of the German factory, and the results of the work carried on by and under the eminent professors at the universities and technical colleges are closely followed and studied in their possible bearings upon the further development of the industry.

The importance attached to high and well-organised technical education in Germany is demonstrated not only by the munificent way in which the scientific branches of the universities and the technical colleges are established and maintained, but also by the continuity which exists between the different grades of education; a continuity, the lack of which in England was recently indicated by Prof. Huxley with great force.

The important part taken by the German universities in the training of young men for technical pursuits has often been dwelt upon as constituting a striking feature of contrast to our university systems. The national appreciation of the opportunities there

presented for scientific training is demonstrated by the large number of students which are always working in the university laboratories, while the expenditure of 30,000*l.* upon the physical laboratory, and 35,000*l.* upon the chemical department, of the New University of Strasburg, serves to illustrate the unsparing hand with which the resources of the country are devoted to the provision of those educational facilities which are the very life-spring of the industrial progress whence those resources are derived.

In France, higher education had been allowed to sink to a low ebb after the provincial universities had been destroyed in the great Revolution, and the University of Paris had been constituted by the first Napoleon the sole seat of high education in the country. Before the late war, matters educational were in a condition very detrimental to the position of the country among nations. There was no lack of educational establishments, but the systems and sequence of instruction lacked organisation, but since the war, France has made great efforts to replace her educational resources upon a proper footing. The provincial colleges have been re-established at a cost of 3,280,000*l.*, and the organisation of industrial education has now been greatly developed, though still not on a footing of equality with that of Germany. Every large manufacturing centre has its educational establishment where technical instruction is provided, with special reference to local requirements; and, in order to render these colleges accessible to the best talent of France, more than 500 scholarships have been founded, at an annual cost of 30,000*l.* The Ecole Centrale des Arts et Manufactures, of Paris, still maintains the reputation as the great technical university of the country which it earned many years ago, and receives students from the provincial colleges, where they have passed through the essential training preliminary to the high technical education which that great institution provides.

Switzerland has often been quoted as a remarkable illustration of the benefits secured to a nation by the thoroughly organised education of its people. Far removed from the ocean, girt by mountains, poor in the mineral resources of industry, she yet has taken one of the highest positions among essentially industrial nations, and has gained victories over countries rich in the possession of the greatest natural advantages. Importing cotton from the United States, she has sent it back in manufactured forms, so as to undersell the products of the American mills. The trade of watch-making, once most important in this metropolis, passed almost entirely to Switzerland years ago; the old-established ribbon trade of Coventry has had practically to succumb before the skilled competition of Switzerland; and although she has no coal of her own, Switzerland is at least as successful as France in her appropriation of the coal-tar colour industry and her rivalry in rate of production with England, the place of its birth and development. Comparative cheapness of labour will not go very far to account for these great successes; they undoubtedly spring mainly from the thoroughly organised combination of scientific with practical education of which the entire people enjoys the inestimable benefit.

Holland furnishes another brilliant example of the success with which a nation brings the power of systematic technical education to bear in securing and maintaining industrial victories in the face of most formidable disadvantages, while the United States of America, so rich in natural resources, have long since realised the immensity of additional advantages to be gained over European nations in the war of industry by a wide diffusion and thorough organisation of technical education. So long as forty years ago the States already possessed several excellent educational institutions established upon the basis of the Continental polytechnic schools, but it was not until about fifteen years later that the country became thoroughly impressed with the great advances achieved by Germany in technical education, and that the subject was made a thoroughly national one. It is now just upon a quarter of a century ago since Congress ordained that each State should provide at least one college, having for its leading objects the diffusion of scientific instruction in its relations to the industry of the country, and decreed that public lands should be granted to the States and Territories providing such colleges. The combined effect of this State action, and of great private munificence, was a remarkably rapid development of scientific and technical education throughout the country; besides some fifty colleges, with eight or nine thousand students, which sprang out of the Land Grant Act for Industrial Education, there are now in the States about 400 other universities and colleges, in a large proportion of which efficient instruction in applied science is provided. To the useful work accomplished within a few years by these and many other highly important educational institutions, which have placed the acquisition of scientific knowledge within the reach of the very humblest, the enormous strides made by the United States in the development of home industries must unquestionably be in the main ascribed.

(*To be continued.*)

UNIVERSITY AND EDUCATIONAL INTELLIGENCE

OXFORD.—There are only a few alterations and additions to the usual scientific lecture-list to report, as most of the courses are in continuation of those given last term. Prof. Sylvester is to lecture on the theory of numbers; in the Chemical Department, Mr. Wyndham Dunstan lectures on organic chemistry in relation to medicine and physiology; Prof. Prestwich is to have his usual summer geological excursions; Dr. Tylor continues his exposition of the development of arts, as illustrated in the Pitt-Rivers Museum.

The Sibthorpian Professorship of Rural Economy has been filled up by the re-election of Dr. Gilbert. The Radcliffe Travelling Fellowship has been awarded to Mr. W. Overend, B.A., of Balliol. The statutes of the University Commissioners, which limited the competition for most college scholarships to candidates under nineteen, seem to be having an unfortunate, though not unexpected, effect, as several colleges have lately found it impossible to award scientific scholarships, owing to the want of sufficiently qualified candidates.

There is a good deal of strong feeling in the University with regard to the approaching appointment of a Reader in Geography, and the action of the Delegates of the University Fund in transferring a Readership from History to Geography, just after the offer of the Royal Geographical Society for a similar purpose had been refused, is the subject of much unfavourable comment. There is no thought of opposition to the study of geography, even of scientific geography, but history lecturers not unnaturally complain that the only University appointment open to them should be abolished to make a post for a lecturer in another subject.

CAMBRIDGE.—Among the seven courses on chemistry being delivered this term are lectures on gas analysis and on aromatic bodies, by Dr. S. Ruhemann. Prof. Dewar and Dr. Ruhemann also superintend laboratory practice specially directed to research.

The course given by Mr. Lyon, the Superintendent of the Mechanical Workshops, this term is on machine construction.

Mr. Langley is giving a special course on the central nervous system, with demonstrations and practical work.

Prof. Macalister's lectures this term are on the history of human anatomy. It is to be hoped that he will publish them.

Mr. M. A. Fenton is lecturing on elementary comparative osteology: Dr. Gadow on the morphology of Mammalia, recent and extinct, and on the palæontology of the Vertebrata.

Dr. Vines has a course of advanced embryology of plants, and Mr. F. Darwin is giving advanced demonstrations in the physiology of plants.

In geology, Prof. Hughes is taking the geology of the neighbourhood of Cambridge, by lectures and field excursions; Mr. Marr, foreign stratigraphy; and Mr. Roberts, the Trilobites.

Prof. Roy has classes for general pathology, morbid anatomy, and practical morbid histology, bacteriology, &c.

The lectures mentioned above are only a selection of the more interesting courses. The lists from which the above are selected announce about seventy-five courses of lectures and practical work.

Candidates for the John Lucas Walker Studentship, the holder of which must devote himself or herself to original research in pathology, should send their applications to Prof. Roy, Trinity College, Cambridge, not later than May 31 next. The Studentship is of the annual value of 250*l.*, and is tenable under certain conditions for three years.

SCIENTIFIC SERIALS

The American Journal of Science, April.—Contributions to meteorology, twenty-second paper, by Elias Loomis. In this communication the author treats of areas of high pressure, their