Messrs. Weil Brothers; two Yellow Snakes (*Chilobothrus inornatus*) from Jamaica, presented by Mr. Chas. B. Masse; a Squirrel Monkey (*Chrysothrix sciurea*) from Demerara, a Military Macaw (*Ara militaris*) from South America, deposited; a Wapiti Deer (*Cervus canadensis*), two Hybrid Paradoxures (between *Paradoxurus leucomystax* and *P. stigmaticus*), born in the Gardens.

GEOGRAPHICAL NOTES

THE Geographical Society's *Proceedings* this month are chiefly occupied with the anniversary meeting at the end of May, and everything said and done on that occasion seems to have been carefully recorded. The only paper given is that by Mr. Minchin on Eastern Bolivia and the Gran Chaco, and it is illustrated by one of the best maps which the Society has published for some time. The geographical notes supply intelligence of matters which have not hitherto attracted notice in this country, though one at least is of considerable importance. We allude to the recent exploration of the Beni River by Dr. Heath of Wisconsin, which is a distinct addition to our knowledge of the Amazons' system. When fuller details, including Dr. Heath's observations for latitude and longitude, have come to hand, it will be for the first time possible to fix the precise position of the mouth of the magnificent river, best known as the Madre de Dios, which, until a few years ago, was believed by geographers to be a feeder of the Purus instead of the Madeira. Some information is also given as to the progress of exploration between the Rovuma and Lake Nyassa.

M. ABBÉ DESGODINS, who is well known for the excellent geographical work he has done in Eastern Tibet, contributes to *Les Missions Catholiques* the first part of some interesting notes on the marriage and other domestic customs of the Tibetans.

IT may be interesting to mention that in last week's number of the Society of Arts' *Journal* some useful notes are published on gums, resins, and waxes, which Mr. C. G. Warnford Lock has compiled from the journals of recent travellers. Especial prominence is given to india-rubber and the curious fossil resin known as gum copal.

M. ROUX has been intrusted by the Minister of Public Instruction and Fine Arts at Paris with a scientific mission to Tunis, and he has already begun the exploration of the region near the Constantine province of Algeria. He will afterwards undertake topographical and botanical investigations in the country between the Mejerba Valley and Cape Bon peninsula. Under the auspices of the same department M. Lantz is engaged in making natural history collections in some of the unknown parts of Madagascar.

M. BOULANGIER, a French Government engineer, has lately been engaged on a surveying expedition in Indo-China, in connection with the project for a railway. He went by a somewhat circuitous route from the frontier of French Cochin-China across Cambodia to Siam, made an especial study of the basin of the Tonlé-Sap, or Great Lake, which, according to his view, was formerly the head of the Gulf of Siam. The mountains south of Pursat must, therefore, have been an island, but the intervening low country becoming filled up they were joined to the mainland. As the result of his observations, M. Boulangier thinks that the Tonlé-sap will gradually silt up.

WE hear that Mr. Dorward, of the China Inland Mission, returned to Shanghai early in April from a five-months' journey in the province of Hunan. He is the only Protestant missionary who has ever traversed the route by which he returned from Hung-kiang to the neighbourhood of the Tung-ting Lake. Mr. Dorward also paid a flying visit to Kwei-yang-fu, the capital of the Kweichow province.

A PROMINENT paragraph in the *Standard* of last Saturday states that the "Geographical Society has received some interesting details of the fate of the Wybrants [*i.e.* Capt. Phipson-Wybrants] Expedition in Mozambique." We understand that there is absolutely no foundation for this statement, and the only effect of it is to inflict cruel disappointment on the relatives of the deceased members of this unfortunate expedition, regarding whose last days detailed particulars are anxiously awaited. Whether these will ever be known is, we fear, more than doubtful. The expedition was a purely private undertaking on the part of the late Capt. Phipson-Wybrants, and though he was aided with a loan of instruments, he was in no sense sent out by the Geographical Society.

THE Brazilian Section of the Lisbon Geographical Society, which was established a short time back, has commenced the publication at Rio de Janeiro of a periodical under the title of *Revista Mensal*. Dr. F. Mendes de Almeida is the editor-in-chief.

THE Bengal Asiatic Society have issued as part of their *Journal* Mr. Longworth Dawes' sketch of the Northern Balochi language, containing a grammar, vocabulary, and specimens of the language.

CIVILISATION AND BARBARISM IN SOUTH AFRICA

AT a meeting of the Anthropological Institute on the 28th ult. Sir Bartle Frere gave a lecture treating of the results of contact of civilised with uncivilised races in South Africa. The first part of the lecture dealt with the historical results of such contact in other countries, and the lecturer, after a sketch of the recent history and present condition of the various South African races, maintained that on the whole natives have increased in numbers as well as improved in physique and in intellectual status by contact with Europeans, and that there was also little real reason to doubt an improvement in moral status. The conditions required to raise and improve races like the Kaffirs were (1) a strong imperial government; (2) freedom from slavery and equality before the law. To secure these two requisites it was necessary (3) to determine whether the standard of moral and social progress shall be that of the European or that of the native races; (4) education according to English standards. The general results arrived at in the lecture were summarised in the following propositions:—(1) It is possible for the civilised to destroy by war the savage races, to expel, or repel, or turn them aside in their migrations; (2) proximity of civilised and savage races has led or is leading to the decay and probable extinction of the Bushman race. But this result is doubtful in the case of the Hottentot races, and is certainly not taking place with regard to the Bantu or Kaffir races; (3) the changes consequent on proximity of civilised and uncivilised races are an approximation to the European type of civilisation; (4) the essentials to such approximation are (*a*) a pax Romana or Anglicana, bringing with it (*b*) protection of life and property, which involves equality before the law, individual property in land, abolition of slavery, abolition of private rights of making war and of carrying arms without the authority of the supreme ruler; (*c*) power of local legislation on European principles, with a view to secure education in the arts of civilised life, taxation sufficient for state purposes, restrictions on the use of intoxicating substances, as measures essential to the full attainment of any one of the preceding objects.

INDIGO AND ITS ARTIFICIAL PRODUCTION[1]

MORE than eleven years ago the speaker had the pleasure of bringing before this audience a discovery in synthetic chemistry of great interest and importance, viz. that of the artificial production of alizarine, the colouring substance of madder. To-day it is his privilege to point out the attainment of another equally striking case of synthesis, viz. the artificial formation of indigo. In this last instance, as in the former case, the world is indebted to German science, although to different individuals, for these interesting results, the synthesis of indigo having been achieved by Prof. Adolf Baeyer, the worthy successor of the illustrious Liebig in the University of Munich. Here then we have another proof of the fact that the study of the most intricate problems of organic chemistry, and those which appear to many to be furthest removed from any practical application, are in reality capable of yielding results having an absolute value measured by hundreds of thousands of pounds.

In proof of this assertion, it is only necessary to mention that the value of the indigo imported into this country in the year 1879 reached the enormous sum of close on two millions sterling, whilst the total production of the world is assessed at twice that amount; so that if, as is certainly not impossible, artificial indigo can be prepared at a price which will compete with the native product a wide field is indeed open to its manufacturers.

[1] Lecture delivered at the Royal Institution, Friday, May 27, 1881, by Prof. H. E. Roscoe, LL.D., F.R.S.

Indigo, as is well known, is a colouring matter which has attracted attention from very early times. Cloth dyed with indigo has been found in the old Egyptian tombs. The method of preparing and using this colour is accurately described by both Pliny and Dioscorides, and the early inhabitants of these islands were well acquainted with indigo, which they obtained from the European indigo plant, *Isatis tinctoria*, the woad plant, or pastel. With this they dyed their garments and painted their skins. After the discovery of the passage to India by the Cape of Good Hope, the eastern indigo, derived from various species of *Indigofera*, gradually displaced woad as containing more of the colouring matter. But this was not accomplished without great opposition from the European growers of woad; and severe enactments were promulgated against the introduction of the foreign colouring matter, an edict condemning to death persons "who used that pernicious drug called devil's food," being issued by Henry the Fourth of France. The chief source of Indian indigo is the *Indigofera tinctoria*, an herbaceous plant raised from seed which is sown in either spring or autumn. The plant grows with a single stalk to a height of about three feet six inches, and about the thickness of a finger. It is usually cut for the first time in June or July, and a second or even a third cutting obtained later in the year. The value of the crop depends on the number of leaves which the plant puts forth, as it is in the leaves that the colouring principle is chiefly contained. Both the preparation of the colouring matter from the plant, and its employment as a dyeing agent, are carried on at the present day exactly as they have been for ages past. The description of the processes given by Dioscorides and Pliny tally exactly with the crude mode of manufacture carried on in Bengal at the present day.

Dioscorides says:—"Indigo used in dyeing is a purple-coloured froth formed at the top of the boiler; this is collected and dried by the manufacturer; that possessing a blue tint and being brittle is esteemed the most."

The identity of the blue colouring matter of woad and that of the Bengal plant was proved by Hellot, and by Planer and Trommsdorff at the end of the last century. These latter chemists showed that the blue colour of the woad can be sublimed, and thus obtained in the pure state, a fact which was first mentioned in the case of indigo by O'Brien in 1789, in his treatise on calico printing. Indigo thus purified is termed indigotin. It has been analysed by various chemists, who ascertained that its composition may be most simply expressed by the formula C_8H_5NO.

Concerning the origin of indigo in the leaves of the *Indigofera*, various and contradictory views have been held. Some have supposed that blue indigo exists ready formed in the plant; others, that white indigo is present, which on exposure to air is converted into indigo-blue. Schunck has, however, proved beyond doubt that the woad plant (*Isatis tinctoria*), the *Indigofera tinctoria* of India, and the Chinese and Japanese indigo plant (*Polygonum tinctorium*) contain neither indigo-blue nor white indigo ready formed. By careful treatment the leaves of all these indigo-yielding plants can be shown to contain a colourless principle termed indican, and that this easily decomposes, yielding a sugar-like body and indigo-blue. That white indigo is not present in the leaves is proved by the fact that this compound requires an alkali to be present in order to bring it into solution, whereas the sap of plants is always acid. The decomposition is represented by Schunck as follows:—

$$\underset{\text{Indican.}}{C_{26}H_{31}NO_{17}} + 2H_2O = \underset{\text{Indigotin.}}{C_8H_5NO} + \underset{\text{Indiglucin.}}{3C_6H_{10}O_6}.$$

So readily does this change from indican to indigo take place, that bruising the leaf or exposing it to great cold is sufficient to produce a blue stain. Even after mere immersion in cold alcohol or ether, when the chlorophyll has been removed the leaves appear blue, and this has been taken to show the pre-existence of indigo in the plant. But these appearances are deceptive, for Schunck has proved that if boiling alcohol or ether be used, the whole of the colour-producing body as well as the chlorophyll is removed, the leaves retaining only a faint yellow tinge, whilst the alcoholic extract contains no indigo blue, but on adding an acid to this liquid the indican is decomposed and indigo-blue is formed.

What now was the first step gained in our knowledge concerning the constitution of indigo, of which the simplest formula is C_8H_5NO?

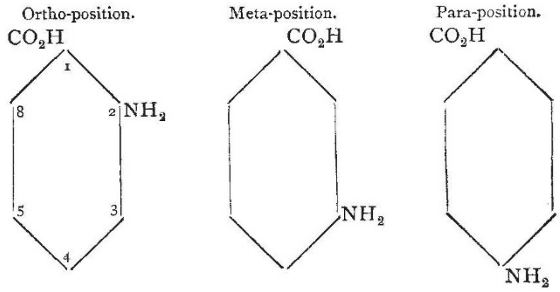
STEP No 1.—This was made so long ago as 1840, when Fritsche proved that aniline, $C_6H_5NH_2$, can be obtained from indigo. The name for this now well known substance is indeed derived from the Portuguese "anil," a word used to designate the blue colour from indigo. This result of Fritsche's is of great importance, as showing that indigo is built up from the well-known benzene ring C_6H_6, the skeleton of all the aromatic compounds, and moreover that it contains an amido group.

Step No. 2 was also made by Fritsche in the following year, when, by boiling indigo with soda and maganese dioxide, he obtained ortho-amido-benzoic acid, or, as he then termed it, anthranilic acid. The following is the reaction which here occurs:—

$$\underset{\text{Indigo.}}{C_8H_5NO} + O + 2H_2O = \underset{\text{Ortho-amido-benzoic acid.}}{C_7H_5NH_2O_2} + CH_2O_2.$$ [1]

What light does this fact shed upon the constitution of indigo? It shows (1) that one of the eight atoms of carbon in indigo can be readily separated from the rest; (2) that the carboxyl and the amido-group are in neighbouring positions in the benzene ring, viz. 1 and 2. For we have three isomeric acids of the above composition.

Ortho-position. Meta-position. Para-position.



STEP No. 3.—The next advance of importance in this somewhat complicated matter is the discovery by Erdmann and Laurent independently, that indigo on oxidation yields a crystalline body, which, however, possesses no colouring power, to which they gave the name of isatin.

$$\underset{\text{Indigo.}}{C_8H_5NO} + O = \underset{\text{Isatin.}}{C_8H_5NO_2}.$$

STEP No. 4.—The reverse of this action, viz. the reduction of isatin to indigo, was accomplished by Baeyer and Emmerling in 1870 and 1878, by acting with phosphorus pentachloride on isatin, and by the reducing action of ammonium sulphide on the chloride thus formed.

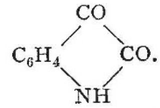
Understanding now something of the structure and of the relationships of the body which we wish to build up, let us see how this edifice has, in fact, been reared. Three processes have been successfully employed for carrying out this object. But of these three only one is of practical importance.

For the sake of completeness, let us, however, consider all three processes, although Nos. 1 and 2 are at present beyond the pale of practical schemes.

These three processes have certain points in common. (1) They all proceed from some compound containing the benzene nucleus. (2) They all start from compounds containing a nitrogen atom. (3) They all commence with an ortho-compound.

They differ from one another; inasmuch as process No. 1 starts from a compound containing seven atoms of carbon (instead of eight), and to this, therefore one more atom must be added; process No. 2, on the other hand, starts from a body which contains exactly the right number (eight) of carbon atoms; whilst No. 3 commences with a compound in which nine atoms of carbon are contained, and from which, therefore, one atom has to be abstracted before indigo can be reached.

Process No. 1 (Kekulé—Claissen and Shadwell).—So long ago as 1869 Kekulé predicted the constitution of isatin, and gave to it the formula which we now know that it possesses, viz.



Following up this view, Claissen and Shadwell, two of Kekulé's

[1] Bottinger, *Deut. Chem. Ges.* 1877, i. 269.

pupils, succeeded in preparing isatin, and, therefore, now indigo, from ortho-nitro-benzoic acid.

The following are the steps in the ascent:

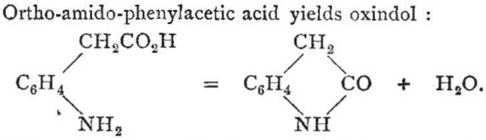
1. Ortho-nitro-benzoic acid acted on by phosphorus pentachloride yields the chloride $C_6H_4(NO_2)COCl$.
2. This latter heated with silver cyanide yields the nitril $C_6H_4(NO_2)CO.CN$.
3. On heating this with caustic potash it yields ortho-nitro-phenylglyoxylic acid, $C_6H_4(NO_2)CO.CO_2H$.
4. This is converted by nascent hydrogen into the amido-compound $C_6H_4(NH_2)CO.CO_2H$.
5. And this loses water and yields isatin, $C_6H_4NH.CO.CO$. (Q. E. D.)

The reasons why this process will not work on a large scale are patent to all those who have had even bowing acquaintance with such unpleasant and costly bodies as phosphorus pentachloride or cyanogen.

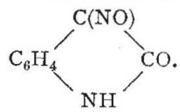
Process No. 2.—Baeyer's (1878) synthesis from ortho-nitro-phenylacetic acid.

This acid can be obtained synthetically from toluol, and it is first converted into the amido-acid, which, like several ortho compounds, loses water, and is converted into a body called oxindol, from which isatin, and therefore indigo, can be obtained. The precise steps to be followed are:—

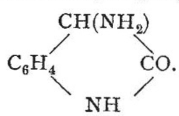
1. Ortho-amido-phenylacetic acid yields oxindol:



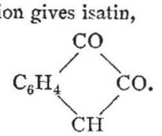
2. This on treatment with nitrous acid yields nitrosoxindol:



3. This again with nascent hydrogen gives amidoxindol:



4. Which on oxidation gives isatin,



(Q.E.D.)

This process, the feasibility of which had also been foreseen by Kekulé, is however not available as a practical scheme for various reasons.

Process No. 3.—This may be called the manufacturing process, and was also proposed by Baeyer. It starts from cinnamic acid, a substance contained in gum benzoin, balsam of Peru, and some few other aromatic bodies. These sources are, however, far too expensive to render this acid thus obtained available for manufacturing purposes. But Bertagnini, in 1856, had obtained cinnamic acid artificially from oil of bitter almonds, and other processes for the same purpose have since been carried out. Of these, that most likely to be widely adopted is the following practical modification by Dr. Caro of Mr. Perkin's beautiful synthesis of cinnamic acid:—

1. $C_6H_5CH_3 + 4Cl = C_6H_5CHCl_2 + 2HCl$.
   Toluene. Benzylene dichloride.
2. $C_6H_5CHCl_2 + 2CH_3.CO.O.Na =$
   Benzylene dichloride. Sodium acetate.
   $C_6H_5CH{=}CH.CO.OH + 2NaCl$.
   Cinnamic acid.

But why did Baeyer select this nine carbon acid from which to prepare indigo? For this he had several reasons. In the first place, it had long been known that all indigo compounds when heated with zinc dust yield indol, C_8H_7N, a body which stands therefore to indigo in the same relation as anthracene to alizarin, and Baeyer and Emmerling had so long ago as 1869 prepared this indol from ortho-nitro-cinnamic acid thus:

$$C_8H_6(NO_2)CO_2H = C_8H_7N + O_2 + CO_2.$$

Secondly, the ortho-nitro-cinnamic acid required (for we must remember that indigo is an ortho-compound and also contains nitrogen) can be readily prepared from cinnamic acid, and this itself again can be obtained on a large scale. Thirdly, this acid readily parts with one atom of carbon, and thus renders possible its conversion into eight-carbon indigo.

The next steps in the process are (3) the formation of ortho-nitro-cinnamic acid, (4) the conversion of this into its dibromide, (5) the separation from this of the two molecules of hydrobromic acid, giving rise to ortho-nitro-phenyl-propiolic acid, and (6), and lastly, the conversion of this latter into indigo by heating its alkaline solution with grape sugar, xanthate of soda, or other reducing agent. These reactions are thus represented:—

3. $C_6H_5CH{=}CHCOOH$ yields $C_6H_4(NO_2)CH{=}CH.COOH$.
   Cinnamic acid yields Ortho-nitro-cinnamic acid.

In this process the para acid is also obtained, and as this is useless for the manufacture of indigo, it has to be removed. This is effected by converting the acids into their ethyl ethers, which, possessing different degrees of solubility, can be readily separated from one another:—

4. This is next converted into the dibromide
   $C_6H_4(NO_2)CHBr.CHBrCOOH$.
5. And by careful treatment with caustic soda this yields ortho-nitro-phenyl-propiolic acid, thus:—
   $C_6H_4(NO_2)CHBrCHBrCOOH + 2NaOH = C_6H_4(NO_2)C_2.COOH + 2NaBr + 2H_2O$.
6. $n[C_6H_4(NO_2)C_2.COOH + H_2 = C_8H_5NO + CO_2 + H_2O]$.
   Ortho-nitro-phenyl-propiolic acid. Indigotin.

(Q. E. D.)

The last of these reactions is in reality not so simple as the equation indicates. For only about 40 per cent. of indigo is obtained, whereas according to theory 68 per cent. should result. Indeed although, as we have seen, indigo can be prepared by these three methods, chemists are as yet in doubt as to its molecular weight, the probability being that the molecule of indigo contains twice 16 atoms of carbon, or has the formula $4(C_8H_5NO)$ or $C_{32}H_{20}N_4O_4$. Still it must be remembered that according to Sommaruga the vapour density of indigo is 9·45, a number corresponding to the simpler formula $C_{16}H_{10}N_2O_2$.

The artificial production of indigo may even now be said to be within measurable distance of commercial success, for the ortho-nitro-phenyl-propiolic acid, the colourless substance which on treatment with a reducing agent yields indigo-blue, is already in the hands of the Manchester calico printers, and is furnished by the Baden Company for alkali and aniline colours at the price of 6*s*. per lb. for a paste containing 25 per cent. of the dry acid.

With regard to the nature of the competition between the artificial and the natural colouring matters it is necessary to say a few words. In the first place, the present price at which the manufacturers are able to sell their propiolic acid is 50*s*. per kilo. But 100 parts of this can only yield, according to theory, 68·58 parts of indigo-blue, so that the price of the artificial (being 73*s*. per kilo.) is more than twice that of the pure natural colour. Hence competition with the natural dye-stuff is not to be thought of until the makers can reduce the price of dry propiolic acid to 20*s*. per kilo., and also obtain a theoretical yield from their acid. This may, or it may not, be some day accomplished, but at present it will not pay to produce indigo from nitro-phenyl-propiolic acid. Nevertheless a large field lies open in the immediate future for turning Baeyer's discovery to practical account. It is well known that a great loss of colouring matter occurs in all the processes now in use for either dyeing or printing with indigo. It has already been stated that a large percentage of indigo is lost in the "cold vats" in the sediment. Another portion is washed off and wasted after the numerous dippings, whilst in order to produce a pattern much indigo must be destroyed before it has entered into the fibre of the cloth. Moreover, the back of the piece is uselessly loaded with colour. In the processes of printing with indigo the losses are as great, or even greater, and, in addition, such considerable difficulties are met with, that only a few firms (Potter, Grafton in Manchester, and Schlieper in Elberfeld) have been successful in this process. But a still more important fact remains, that no printing process exists in which indigo can be used in combination with other colours in the ordinary way, or without requiring some special mode of fixing after printing. Hence it is clear that the weak points of natural indigo lie in the absence of any good process for utilising the whole of its colouring matter, and in the impossibility, or at any rate great difficulty, of employing it in the ordinary madder styles of calico printing. Such were the reasons which induced the patentees to believe that although the artificial dye cannot be made at a price to compete with natural indigo for use in the ordinary dye-beck, it can even now be very largely used for styles to which the ordinary dye-stuff is inapplicable.

To begin with, Baeyer employed (Patent 1117) grape sugar as a reducing agent. The reduction in this case does not take place in the cold, and even on long standing only small traces of indigo are formed, but if heated to 70° or upwards the change takes place. Unfortunately this production of indigo-blue is rapidly followed by its reduction to indigo-white, and it is somewhat difficult in practice to stop the reaction at the right moment. But Dr. Caro of Mannheim found that sodium xanthate is free from many of the objections inherent to the glucose reduction process, inasmuch as the reaction then goes on in the cold. Moreover, he finds that the red isomeride of indigo-blue, Indirubin, which possesses a splendid red colour, but has little or no tinctorial power, is produced in less quantity in this case than when glucose is employed. On this cloth, alumina and iron mordants may be printed, and this afterwards dyed in alizarine, &c., or this colouring matter may also be printed on the cloth and the colour fixed by moderate steaming without damage to the indigo-blue. This process is now in actual use by printers both in England and on the Continent, so that, thanks especially to the talent and energy of Dr. Caro, Bayer's discovery has been practically applied within the short space of twelve months of its conception. Operations on a manufacturing scale have been successfully carried on in the Baden Soda and Aniline Works at Ludwigshafen for the last two months, and the directors see no reason why they should not be able to supply any demand, however great, which may be made for ortho-nitro-phenyl-propiolic acid.

The proper way of looking at this question at present is, therefore, to consider ortho-nitro-phenyl-propiolic acid and indigo as two distinct products not comparable with each other, inasmuch as the one can be put to uses for which the other is unfitted, and there is surely scope enough for both. Still, looking at the improvements which will every day be made in the manufacturing details, he must be a bold man who would assert the impossibility of competition with indigo in all its applications. For we must remember that we are only at the beginning of these researches in the indigo field. Baeyer and other workers will not stay their hands, and possibly other colouring matters of equal intensity and of equal stability to indigo may be obtained from other as yet unknown or unrecognised sources, and it is not improbable that these may turn out to be more formidable competitors in the race with natural indigo than ortho-nitro-phenyl-propiolic acid.

Looking at this question of the possible competition of artificial with the natural indigo from another point of view, it must, on the other hand, be borne in mind that the present mode of manufacturing indigo from the plant is extremely rude and imperfect, and that by an improved and more careful carrying out of the process, great saving in colouring matter may be effected, so that it may prove possible to produce a purer article at a lower price, and thus to counterbalance the production of the artificial material.

The potential importance, from a purely commercial point of view, of the manufacture, may be judged of by reference to the following statistics, showing that the annual value of the world's growth of indigo is no less than four millions sterling.

How far the artificial will drive out the natural colouring matter from the market cannot, as has been said, be foreseen. It is interesting, as the only instance of the kind on record, to cast a glance at the history of the production of the first of the artificial vegetable colouring matters, alizarin. In this case the increase in the quantity produced since its discovery in 1869 has been enormous, such indeed that the artificial colour has now entirely superseded the natural one, to the almost complete annihilation of the growth of madder-root. It appears that whilst for the ten years immediately preceding 1869 the average value of the annual imports of madder-root was over one million sterling,

Estimated Yearly Average of the Production of Indigo in the World, taken from the Total Crop for a Period of Ten Years.

	Pounds Weight.	Pounds Sterling.
Bengal, Tirhoot, Benares, and N. W. India	8,000,000	2,000,000
Madras and Kurpah	2,200,000	400,000
Manilla, Java, Bombay, &c.	...	500,000
Central America	2,250,000	600,000
China and elsewhere, consumed in the country ...	...	Say 500,000
		4,000,000

the imports of the same material during last year (1880) amounted only to 24,000*l.*, the whole difference being made up by the introduction of artificial alizarin. In 1868, no less a quantity than 60,000 tons of madder-root were sent into the market, this containing 600,000 kilos of pure natural alizarin. But in ten years later a quantity of artificial alizarin more than equal to the above amount was sent out from the various chemical factories. So that in ten years the artificial production had overtaken the natural growth, and the 3 or 400,000 acres of land which had hitherto been used for the growth of madder, can henceforward be better employed in growing corn or other articles of food. According to returns, for which the speaker had to thank Mr. Perkin, the estimated growth of madder in the world previous to 1869 was 90,000 tons, of the average value of 45*l.* per ton, representing a total of 4,050,000*l.*

Last year (1880) the estimated production of the artificial colouring matter was 14,000 tons, but this contains only 10 per cent. of pure alizarin. Reckoning 1 ton of the artificial colouring matter as equal to 9 tons of madder, the whole artificial product is equivalent to 126,000 tons of madder. The present value of these 14,000 tons of alizarin paste, at 122*l.* per ton, is 1,568,000*l.* That of 126,000 tons of madder at 45*l.* is 5,670,000*l.*, or a saving is effected by the use of alizarin of considerably over four millions sterling. In other words, we get our alizarin dyeing done now for less than one-third of the price which we had to pay to have it done with madder.

To Englishmen it is a somewhat mortifying reflection, that whilst the raw materials from which all these coal-tar colours are made are produced in our country, the finished and valuable colours are nearly all manufactured in Germany. The crude and inexpensive materials are, therefore, exported by us abroad, to be converted into colours having many hundred times the value, and these expensive colours have again to be bought by English dyers and calico-printers for use in our staple industries. The total annual value of manufactured coal-tar colours amounts to about three and a half millions; and as England, though furnishing all the raw material, makes herself only a small fraction of this quantity, but uses a large fraction, it is clear that she loses the profit on the manufacture. The causes of this fact, which we must acknowledge, viz., that Germany has driven England out of the field in this important branch of chemical manufacture, are probably various. In the first place, there is no doubt that much of the German success is due to the long-continued attention which their numerous universities have paid to the cultivation of Organic Chemistry as a pure science. For this is carried out with a degree of completeness, and to an extent, to which we in England are as yet strangers. Secondly, much again is to be attributed to the far more general recognition amongst German than amongst English men of business of the value, from a merely mercantile point of view, of high scientific training. In proof of this it may be mentioned that each of two of the largest German colour-works employs no less a number than from twenty-five to thirty highly-educated scientific chemists, at salaries varying from 250*l.* to 5 or 600*l.* per annum. A third cause which doubtless exerts a great influence in this matter is the English law of patents. This, in the special case of colouring matters at least, offers no protection to English patentees against foreign infringement, for when these colours are once on the goods they cannot be identified. Foreign infringers can thus lower the price so that only the patentee, if skilful, can compete against them, and no English licencees of the patent can exist. This may to some extent account for the reluctance which English capitalists feel in embarking in the manufacture of artificial colouring matters. That England possesses both in the scientific and in the practical direction ability equal to the occasion none can doubt. But be that as it may, the whole honour of the discovery of artificial indigo belongs to Germany and to the distinguished chemist Prof. Adolf Baeyer, whilst towards the solution of the difficult problem of its economic manufacture, the first successful steps have been taken by Dr. Caro and the Baden Aniline and Soda Works at Mannheim.

H. E. R.

UNIVERSITY AND EDUCATIONAL INTELLIGENCE

THE Linacre Chair of Physiology and Anatomy, lately held by Dr. Rolleston, and practically a chair of comparative zoology, will now be split into two, being succeeded by chairs of anatomy proper and physiology proper, with a more direct relation to the teaching of those subjects as part of a preliminary medical education, as was intended by Dr Linacre.

DR. OLIVER J. LODGE has been appointed to the Lyon Jones Professorship of Experimental Physics and Mathematics in University College, Liverpool, by the Councils of that College and of the Liverpool Royal Infirmary School of Medicine. Prof. Lodge has been some time Assistant-Professor of Physics at University College, London, and is the author of a work on elementary mechanics and various papers of original research.

SOCIETIES AND ACADEMIES

LONDON

Royal Society, June 16.—"On the Stresses caused in the Interior of the Earth by the Weight of Continents and Mountains," by G. H. Darwin, F.R.S.

The existence of dry land proves that the earth's surface is not a figure of equilibrium appropriate for the diurnal rotation. Hence the interior of the earth must be in a state of stress, and as the land does not sink in, nor the sea-bed rise up, the materials of which the earth is made must be strong enough to bear this stress.

We are thus led to inquire how the stresses are distributed in the earth's mass, and what are magnitudes of the stresses.

In this paper a problem of the kind indicated is solved, by the use of certain results obtained by Sir William Thomson, for the case of a homogeneous incompressible elastic sphere, and the results are applied to the case of the earth.

If the earth be formed of a crust with a semi-fluid interior the stresses in that crust must be greater than if the whole mass be solid, far greater if the crust be thin.

The strength of an elastic solid is estimated by the difference between the greatest and least principal stresses, when it is on the point of breaking, or, according to the phraseology adopted, by the breaking stress-difference. The most familiar examples of breaking stress-difference are when a wire or rod is stretched or crushed until it breaks; then the breaking load divided by the area of the section of the wire or rod is the measure of the strength of the material. Stress-difference is thus to be measured by tons per square inch.

The problem is only solved for the class of inequalities called zonal harmonics; these consist of a number of waves running round the globes in parallels of latitude. The number of waves is determined by the order of the harmonic. In application to the earth the equator referred to may be any great circle, and is not necessarily the terrestrial equator. The second harmonic has only a single wave, and consists of an elevation at an equator and depression at the pole; this constitutes ellipticity of the spheroid. An harmonic of a high order may be described as a series of mountain chains, with intervening valleys, running round the globe in parallels of latitude, estimated with reference to the chosen equator.

In the case of the second harmonic it appears that the stress-difference rises to a maximum at the centre of the globe, and is constant all over the surface. The central stress-difference is eight times as great as the superficial.

Amongst other examples it is shown that if the homogeneous earth, with ellipticity $\frac{1}{232}$, were to stop rotating, the central stress-difference would be thirty-three tons per square inch, and it would rupture if made of any material excepting the finest steel.

The stresses produced by harmonic inequalities of high orders are next considered. This is in effect the case of a series of parallel mountains and valleys, corrugating a mean level surface with an infinite series of parallel ridges and furrows.

Numerical calculation shows that if we take a series of mountains, whose crests are 4000 meters, or about 13,000 feet above the intermediate valley-bottoms, formed of rock of specific gravity 2·8, then the maximum stress-difference is 2·6 tons per square inch (about the tenacity of cast tin); also if the mountain chains are 314 miles apart, the maximum stress-difference is reached at 50 miles below the mean surface. It appears that there is no stress at the surface, but the solution is only approximate, for it does not give the stress actually within the mountain masses, but gives correct results at some three or four miles below the mean surface.

The cases of the harmonics of the 4th and higher orders are also considered; and it is shown that, if we suppose them to exist on a sphere of the mean density and dimensions of the earth, and that the height of the elevation at the equator is in each case 1500 meters above the mean level of the sphere, then in each case the maximum stress-difference is about four tons per square inch. This maximum is reached in the case of the 4th harmonic at 1150 miles, and for the 12th at 350 miles, from the earth's surface.

It is then shown that the great terrestrial inequalities, such as Africa, the Atlantic Ocean, and America, are represented by an harmonic of the 4th order; and that, having regard to the mean density of the earth being about twice that of superficial rocks, the height of the elevation is to be taken as about 1500 meters.

Four tons per square inch is the crushing stress-difference of average granite. From these results it may be concluded that either the materials of the earth have about the strength of granite at 1000 miles from the surface, or they have a much greater strength nearer to the surface.

This investigation must be regarded as confirmatory of Sir William Thomson's view, that the earth is solid nearly throughout its whole mass. According to this view the lava which issues from volcanoes arises from the melting of solid rock, which exists at high temperature at points where the pressure is diminished, or else from comparatively small vesicles of rock in a molten condition.

Zoological Society, June 21.—Prof. W. H. Flower, F.R.S., president, in the chair.—The Secretary read a report on the additions that had been made to the Society's Menagerie during the month of May, 1881, amongst which special attention was called to an African Wild Ass (*Equus tæniopus*) from Upper Nubia, and a White-marked Duck (*Anas specularis*) from Antarctic America, both new to the collection.—Mr. R. Bowdler Sharpe exhibited a specimen of *Podilymbus podiceps*, stated to have been killed at Radipole, near Weymouth, in the winter of 1880–81.—Mr. W. A. Forbes read a paper on the Petrel called *Thallassidroma nereis*, by Gould. This, he showed, was not a true *Procellaria*, but must form the type of a new genus, to be called *Garrodia*, most closely allied to *Oceanites*, *Fregetta*, and *Pelagodroma*, and constituting with them a distinct family of "Tubinares," proposed to be called "Oceanitidæ."—Mr. W. A. Forbes read a paper on the conformation of the thoracic extremity of the trachea in the "Ratite" birds, noting specially a highly-developed syrinx in the genus *Rhea*, in which respect it differed from all the other genera comprised in that group.—A communication was read from Mr. George F. Bennett, C.M.Z.S., containing an account from personal observation of the habits of the *Echidna hystrix* of Australia.—Mr. G. A. Boulenger read a paper on the Lizards of the genera *Lacerta* and *Acanthodactylus*, prepared after a study of specimens in the British Museum.—Mr. F. C. Selous read a paper on the Antelopes that had come under his observation in Central South Africa. He exhibited a series of skins of the Bush-Buck (*Tragelaphus sylvaticus*), and pointed out their variations in different locallities; also specimens of the Poku (*Cobus vardoni*), and the Speke's Antelope (*Tragelaphus Spekii*).—A communication was read from the Rev. O. P. Cambridge, describing some new genera and species of Araneidea.—Mr. Sclater pointed out the generic divisions of the Bucconidæ which he proposed to adopt in his monograph of the group now approaching completion, and characterised a new species of the family under the name *Nonnula cineracea*.—Mr. R. Bowdler Sharpe communicated some notes on new or rare species of Flycatchers lately added to the British Museum, principally from the Gould collection, and which it was proposed to call *Malurus cyanochlamys*, *Siphia obscura*, and *Rhipidura Macgillivrayi*.—A second paper by Mr. Sharpe contained an account of several collections of birds formed by Mr. W. B.