But really there must be some agreement between us and the said eminent men as to what practical science is when the examination paper is composed.

May I give my illustration? The Cambridge Local Syndicate have introduced Elementary Experimental Science, three papers, into their junior syllabus. The other day I set two of these three papers for 1899 to a number of boys who had had a most careful experimental training in the matter of the syllabus. They made wry faces over it, and were heard to remark afterwards that they did not see what it had to do with the experiments they had been doing. On marking the papers I found that the best boys, really very good and careful experimenters and observers and good draughtsmen, for boys, barely reached forty per cent. of the marks. The same papers were set to a sharp boy of the same age who had done no experiments, but had been through the same subjects, mechanics, hydrostatics, and heat, in the old way, viz., text-book and problems. *He scored nearly full marks on all the physics questions.*

The fact is, that except for the heading, "Experimental Science," there is nothing in two of these papers to indicate that they are set to candidates whose knowledge is based on and drawn from experimental work of their own.

I should like to ask you to print these papers in full, that the eminent men who set them might have a chance of saying something, but on the whole I think your space is too valuable. I will simply quote two questions from the mechanics paper.

"(3) Explain how work is measured, and in what units.

"A 50 lb. shot is fired from a cannon with a velocity of 1500 feet per second. Compare the work done on the shot with that done by a man weighing 12 stone who walks up a hill 1500 feet high.

"(4) What is the mechanical advantage of a machine?

"How would you arrange three separate pulleys, each of which weighs 1 lb., so that the power required to raise a weight of 40 lbs. may be a minimum?

"What arrangement of pulleys is most commonly used in practice? And why?"

Now these are exactly the old Cambridge—"Describe the common pump, &c., questions?" and the way to answer them is to waste no time on experiments, but read your text-book, get up your formulæ and work examples. The second question is of exactly the same type. The other two require a graphical construction, but such as would be readily done by a boy who had used a text-book in which graphic methods were explained.

The first paper is almost equally bad; it is all (chemistry included) text-book science of a very common order. Against the practical paper I have nothing to say.

Now Cambridge men can write excellent elementary text-books on these subjects, witness those of Prof. Glazebrook. Can they not produce among them a paper on Elementary Experimental Science, which shall be what it professes to be, or is the tradition of the common pump still too strong, and the impress of the Mathematical Tripos too indelible?

A. H. F.

Literature of Coffee and Tobacco Planting.

IN the issue of NATURE of August 9 it is stated, in reviewing a book by a French author, that several books on the same subject, *i.e.* coffee—its growth, cultivation and preparation for the market—have already been published in English.

Could you kindly inform me of the names of the publishers or authors of any good works in English on coffee and tobacco growing? I have been, so far, quite unable, out here, to find the names of any publishers of works on tobacco or coffee, and as it is a matter of considerable moment to me to gain the best of information on these subjects, I trust you will see your way to help me.

Salisbury, Rhodesia, South Africa. G. H. JAMES.

[Mr. J. R. Jackson, Keeper of Museums at the Royal Gardens, Kew, to whom we referred our correspondent's inquiry, has kindly sent the following list of books, which may meet the requirements and also be of service to other planters.—Ed. NATURE.]

WORKS ON COFFEE AND TOBACCO PLANTING.

"The Coffee Planter of Ceylon," by William Sabonadière. Published by E. and F. N. Spon, 125, Strand. (1870.)

"Coffee Planting in Southern India and Ceylon," by E. C. P. Hull. E. and F. N. Spon. (1877.)

Article on coffee in "Spon's Encyclopædia of the Industrial Arts, Manufactures and Commercial Products." E. and F. N. Spon.

"Liberian Coffee in Ceylon." From the *Ceylon Observer.* Published at Colombo by A. M. and F. Ferguson. (1878.)

"All About Tobacco." Compiled by A. M. and F. Ferguson, Colombo, Ceylon. Agents, John Haddon and Co., Bouverie Street, London.

Article on tobacco in "Spon's Encyclopædia of the Industrial Arts, Manufactures and Commercial Products." E. and F. N. Spon.

Autotomic Curves.

IN NATURE, October 11, Mr. A. B. Basset justly inveighs against the use of the term "non-singular curve" to denote a curve which has no double points. Doubtless, also, the expression "an anautotomic curve" is objectionable.

May I suggest that, in this instance, we may obtain from Latin the help unknown to Greek, and designate curves which have, and curves which have not, double points, by the terms *sesecting* and *non-sesecting* respectively?

H. LANGHORNE ORCHARD.

44 Denning Road, Hampstead, N.W., October 20.

IN answer to your correspondent, Mr. A. B. Basset, would not the Anglo-Saxon negative prefix "un" combine more euphoniously with "autotomic" than the Greek "an"? We find analogy for such a combination in the familiar words "unauthorised" and "unauthenticated," where it is used in conjunction with words of Latin origin; so there seems no valid philological objection to its association with a Greek derivative, while the phrase "an unautotomic curve" would certainly sound more pleasantly to the ear than "an anautotomic" one.

ARTHUR S. THORN.

4, Malcolm Road, Penge, S.E., October 25.

THE PRESENT CONDITION OF THE INDIGO INDUSTRY.

OF late years attention has often been drawn to German Technical Chemistry, more especially in connection with the advance and growth of the coal-tar colour industry, an industry which received its birth in this country, but which has now taken up its abode on the continent, the loss of the industry to this country being largely due to the conservatism of our manufacturers, and also partly to the want of proper scientific training on the part of the few chemists whom the manufacturers have *deigned* to employ.[1]

Before 1870 the madder plant was very largely cultivated, in order to obtain from it the important dye-stuff alizarin. But in 1869 a process for obtaining alizarin, by fusing anthraquinone sulphonic acid with caustic soda, was patented simultaneously in this country and in Germany. As a consequence the madder plant is now hardly cultivated at all.[2] Now, thirty years later, another and perhaps even more important natural dye-stuff is in jeopardy owing to the advances of German science. The dye-stuff referred to is indigo, which is cultivated in such large quantities in our Indian Empire. If, then, the natural indigo is to be driven out of the market by the artificial substance, prepared from coal-tar products, it cannot fail to exert a great temporary, if not permanent, influence upon the wealth of India. Perhaps, then, a

[1] In the hand-book for the International Exhibition of 1862 (vol. i. p. 120), the following sentences occur: "It is impossible to overrate the importance of the coal-tar dyes to this country. From having the sources of the raw material in unlimited quantities under our very feet, we are enabled to compete most favourably with continental nations in this respect, and we shall soon become the great colour-exporting country, instead of having, as hitherto, to depend on Holland and other countries for our supply of dye-stuffs."

[2] Madder root contains about 1 per cent. of alizarin, and in 1859–1868 the best qualities of Turkey roots fetched 50*s.* per cwt.; this would make the price of alizarin about 45*s.* per lb. When artificial alizarin was first produced, the dry product fetched about 45*s.* to 50*s.* per lb. A 20 per cent. paste of alizarin is now sold for 7*d.* per lb.

brief survey of the processes employed for producing the natural and artificial indigo may be of interest.

Indigo is one of the oldest dye-stuffs known, having been used in India and Egypt before the Christian era. Egyptian mummies are sometimes found with wrappings which have been dyed with indigo. The ancient Romans and Greeks were also familiar with this dye-stuff. Pliny the Younger mentions indigo in his writings, and in this connection it is interesting to note that adulteration of commercial articles was even practised in his days, for he states that indigo was at times adulterated with the excrement of pigeons and with chalk coloured with woad, but he says the pure article may be known by its burning with a purple flame when heated. Indigo was not introduced into Europe until the sixteenth century, and even then, owing to the strong opposition of the woad cultivators,[1] it was a long time before it came into general use. Indeed, so strong was the opposition and so great was the influence of the woad cultivators, that the employment of indigo was prohibited in England, France and Germany, its use in France being in the time of Henry IV. punished by death, it being called "Devil's Food." However, notwithstanding this powerful opposition, the employment of indigo as a dye gradually gained ground until to-day woad is scarcely cultivated and is no longer employed as a colouring matter, but is used in a certain process of indigo dyeing to cause fermentation and reduce the insoluble indigo blue into soluble indigo white.

The indigo plant (*Indigofera tinctoria*) belongs to the natural order Leguminosæ. It is obtained chiefly from India, especially from the provinces of Bengal, Madras and Oude. But it is also grown in some parts of Africa, in Java, China, Japan, Central America and Brazil. The land is ploughed in October or November, and the seed sown at the end of March or the beginning of April. The growth is very rapid, and the plant attains a height of about three feet. It is cut for the first time between the middle of June and the beginning of July. Two months later a second crop is taken, but the yield is smaller than that of the first crop. The land on which the indigo is cultivated is frequently very poor, and contains very little nitrogen, yet indigo is grown on the same land from year to year with only very occasional change of cropping, and this in spite of the fact that practically the only manure employed is *seet*, *i.e.* the indigo refuse, leaves, stalks, &c., which have been taken from the steeping vats. Notwithstanding, the crops obtained from year to year do not show much deterioration either in yield or quality. Dr. D. A. Voelcker, in his report on Indian agriculture, suggests that since indigo belongs to the order Leguminosæ, and it has been shown that certain legumes are able to absorb atmospheric nitrogen through the medium of *nodules* which form on the rootlets, that perhaps the indigo plant obtains the nitrogen it requires in this manner. The writer of this article is, however, not aware whether the subject has been investigated.

The dye indigo does not occur ready formed in the plant, but exists in the form of a glucoside called indican. This glucoside was isolated by Schunk. It is a brown, transparent, uncrystallisable syrup, which, by the action of dilute acids, is split up into indigotin (the colouring matter of indigo) and a sugar called indiglucin. A reaction similar to this is supposed to take place during the fermentation process in the production of natural indigo.

Manufacture.

The cut plant is tied into bundles, which are then packed into the fermenting vats and covered with clear fresh water. The vats, which are usually made of brick lined with cement, have an area of about 400 square feet and are 3 feet deep, are arranged in two rows, the tops of the bottom or "beating vats" being generally on a level with the bottoms of the fermenting vats. The indigo plant is allowed to steep till the rapid fermentation, which quickly sets in, has almost ceased, the time required being from 10–15 hours. The liquor, which varies from a pale straw colour to a golden-yellow, is then run into the beaters, where it is agitated either by men entering the vats and beating with oars, or by machinery. The colour of the liquid becomes green, then blue, and, finally, the indigo separates out as flakes, and is precipitated to the bottom of the vats. The indigo is allowed to thoroughly settle, when the supernatant liquid is drawn off. The pulpy mass of indigo is then boiled with water for some hours to remove impurities, filtered through thick woollen or coarse canvas bags, then pressed to remove as much of the moisture as possible, after which it is cut into cubes and finally air-dried.

Another method is to treat the plant with dilute ammonia or alkalis. This method is said to more completely decompose the indican, and thus to give a larger yield of indigo.

The value of indigo as a dye-stuff depends upon the quantity of indigotin which it contains. The percentage of indigotin in the natural indigo varies from 20–90 per cent. Beside indigotin, natural indigo also contains small and varying quantities of indigo red, indigo brown and indigo gluten. The following is an analysis of a good sample of Bengal indigo :—

Indigo blue	61·4	per cent.
Indigo red	7·2	,,
Indigo brown	4·6	,,
Indigo gluten	1·5	,,
Mineral matter	19·6	,,
Water	5·7	,,

Artificial Indigo.

After many years of careful and laborious *scientific* work, artificial indigo is beginning to compete with natural indigo, and there seems to be but little doubt that, unless the producers of the natural article are able to improve the process of manufacture, in the near future the artificial product will, in all probability, get the upper hand in the struggle. Engler and Emmerling appear to have been the first chemists to obtain artificial indigo. They obtained it by the action of zinc dust and soda lime upon ortho-nitroacetophenon, but the quantity obtained was very minute, and, as the mechanism of the reaction was not at that time understood, it did not much help in paving the way for further research work. For most of our present knowledge of indigo we have to thank von Baeyer, whose work on indigo may be looked upon as one of the chemical triumphs of the century. So far back as 1868, von Baeyer obtained indol directly from indigo, and, in the following year, in conjunction with Emmerling, he prepared this substance by fusing crude nitrocinnamic acid with caustic potash and iron filings ; shortly afterwards they discovered that by the action of phosphorus trichloride, phosphorus and acetylchloride on isatin, a product was obtained, which, when exposed in aqueous solution to the action of the air, gradually deposited indigo ; this method was subsequently improved. In 1875 Nencki obtained indigo by the oxidation of indol with ozone. But it was not till the year 1880 that any great progress was made in the synthesis of indigo. In this year von Baeyer published a series of brilliant researches showing how indigo could be obtained from ortho-nitrocinnamic acid. He showed that when ortho-nitrocinnamic acid is subjected to the action of bromine, ortho-nitrodibromcinnamic acid is obtained, which when treated with alkalis in the cold is converted into ortho-nitrophenylpropiolic acid, and this substance, on being warmed with a dilute solution of caustic soda and grape sugar, or some other alkaline reducing agent, is converted into indigo, the yield compared with

[1] The colouring matter of woad, *Isatis tinctoria*, is indigo.

that theoretically possible being 70 per cent. Von Baeyer also showed that, by acting upon ortho-nitrocinnamic acid with caustic soda and chlorine, ortho-nitrophenylchlorolactic acid was produced, which on treatment with alcoholic caustic potash was converted into ortho-nitrophenyloxyacrylic acid, and this on being fused yields small quantities of indigo. Owing, however, to the high cost of ortho-nitrocinnamic acid, indigo so produced could not enter into competition with the natural dye. In 1882 von Baeyer and Drewson brought out yet another synthesis. They found that, by acting upon a mixture of ortho-nitrobenzaldehyde and acetone with caustic soda, indigo was produced, and, further, if the starting products were pure, that the yield of indigo was 80 per cent. of that theoretically obtainable. In 1890 Heumann discovered that when phenyl glycine was melted with caustic soda, taking care that air was, so far as possible, excluded, a yellow-coloured fuse was obtained. This fuse, on being dissolved in water and exposed to the action of the air, produced indigo.

Unfortunately, although the low price of the materials employed should have caused this to be a successful manufacturing process, the yield of the dye-stuff was very poor. Heumann shortly afterwards showed that a very much better yield could be obtained by employing phenylglycine-ortho-carboxylic acid, but although the yield was better the cost of production was higher, the more expensive anthranilic acid taking the place of the cheaper aniline as a starting product. Of late, however, the price of anthranilic acid, owing to improved methods of manufacture, has fallen very considerably, and, doubtless, will continue to fall. Indigo can also be obtained by fusing bromacetanilid with caustic potash, the indol so produced being oxidised by the action of the air to indigo. Again, when ortho-nitroacetophenone is carefully heated with zinc dust, a sublimate of indigo blue is obtained. There are many other syntheses of indigo known, but the majority of them are of more theoretical than practical importance.

Of the many methods for obtaining artificial indigo, only two or three modifications are employed for manufacturing the dye. These are von Baeyer's ortho-nitrobenzaldehyde and aceton synthesis, and that of Heumann from o-phenylglycinecarboxylic acid. But beside indigo itself there is a substance sold under the name of "indigo salt," which is the sodium bisulphite salt of the methylketone of o-nitrophenyl-lactic acid. It is readily soluble and is used for indigo printing.

Artificial indigo as brought into the market contains over 90 per cent. of indigotin, whereas in the natural product the quantity varies from 20 to 90 per cent. The artificial product, however, contains no indigo-red, indigo-brown, or indigo-gluten; whereas these substances are present in natural indigo, and exert an influence in dyeing certain shades of indigo. Indigo itself cannot be employed for dyeing owing to its insolubility. But when subjected to the action of reducing agents it is converted into *indigo-white*, which is soluble in alkalis. Wool or cotton dipped into such a vat and then exposed to the action of the air become dyed a fast blue.

One would have supposed that the indigo producers would have taken warning from the extinction of the artificial alizarin industry, and called to their aid experienced agriculturists to see if it were not possible to increase the yield and quality of the indigo plant, and chemical experts to endeavour to improve the process of manufacture. This, however, has not been done. The planter appears uncertain whether thick or thin seeding is the better, whether any other manure except *seet* should be employed. Again, whether the *seet* should be applied to the land fresh or whether it should first be allowed to ferment. The manufacturing is entirely conducted by "rule of thumb." It is a matter of dispute as to whether the bundles of indigo plant should be packed tightly or loosely in the vats. If the water employed should be hard or soft is purely a matter of individual opinion. Again, it is a question of debate as to how long the cut plant should be steeped, &c. The Badische Anilin Soda Fabrik is said to have invested 500,000*l.* in plant for the manufacture of artificial indigo. Will British (Indian) manufacturers never lay out capital in scientific investigation? Will they *never* realise that money so laid out is almost certain in the near future to bring in a rich return? In conclusion, I give the following quotation from the report on the trade of Frankfurt for 1899, by Consul-General Sir Charles Oppenheimer:—

"In the territories in which natural indigo is grown, the intensity and magnitude of the danger which lies in the advance of the artificial product ought not for a moment to be disregarded. The struggle between artificial and natural indigo has already commenced. The latter still shows some advantages, inasmuch as its byeproducts, such as indigo gluten, indigo red, &c., aid the dyeing process to some extent. If natural indigo is to retain its position, every effort must be directed in a rational manner to organising its culture towards the manner in which it is collected, and the way the dye is shipped. In order to obtain a favourable result, the ablest experts should co-operate in this important task. To-day the fate of East Indian indigo culture lies unfortunately in the retorts of the chemical factories."

F. MOLLWO PERKIN.

THE FORM AND SIZE OF BACTERIA.

BACTERIA is a generic term that has been applied to an extensive group of single-celled organisms belonging to the lowest forms of plant life The bacteria obtain their nutriment from organic matter, either dead or living, and are therefore capable of leading a saprophytic or a parasitic existence. They are amongst the smallest forms of life with which the biologist has to deal, the transverse diameter of the individual cells seldom exceeding a few micro-millimetres, or it may be a fraction of a micro-millimetre. The highest powers of the microscope are consequently necessary for the study of their structure, which is of a simple character, consisting essentially of protoplasm with a containing cell-membrane. The most striking differences are to be found rather in the biological properties of the bacteria as promoters of decomposition, putrefaction and fermentation, or as the originators of morbid processes in plants and animals, than in any distinctive features they possess as vegetable cells. The following account is simply intended to give the reader who is not a specialist a general conception of the main types of these organisms, which form the special study of bacteriology.

It may, in the first instance, be pointed out that though the bacteria are microscopically minute organisms, yet considerable variations in shape and size occur. The illustrations in the accompanying plate have been selected to illustrate these two points. It will be seen that, for example, amongst the most widely known pathogenic organisms the variation in form is considerable, whilst in point of size the largest of these is many times greater than the smallest. Bacteriology is at present largely dependent for a classification of the bacteria upon the variations that occur in their shape. The individual cells multiply by a process of fission, and the fundamental forms are spherical, oval, rodlike or spiral in shape. At the same time the species cannot be entirely determined by the microscopic appearance. In fact, there are many organisms which it is impossible to identify until other characteristics, such as the macroscopic appearance of their artificial growth on suitable media, or their pathogenic effects on animals, have been observed. The fact has also to be remembered that a