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 bye-products, 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 particular organism may under different conditions assume changes in shape, and that even under apparently the same conditions variations in shape and size may occur.

The organisms of a spherical shape are termed Cocci, the individual cells appearing as spheres, except during the period of fission, when elongated or lance-shaped forms occur—e.g. *Diplococcus pneumoniae.* The mode of cell-division determines the nomenclature applied to the various classes of cocci—those dividing in one direction and remaining attached in pairs or chains are termed diplo- or strepto-cocci; those dividing in two directions and forming groups of four--tetracocci; those dividing in three directions and forming packets—sarcinæ; and those dividing irregularly into grape-like clusters—staphylococci.

The standard of measurement for bacteria is the *mikron*, equal to 1/1000 part of a millimetre, and represented by the sign μ. The diameter of the cocci varies from about 0·3 to 3μ.

The organisms in which the length is always greater than the breadth are termed bacilli. Their shape is cylindrical, and they assume a rod-like form; of the most important forms the length may vary from $0·5\mu$ to $3·5\mu$, and the breadth from 0·5 to $0·8\mu$. The bacilli may occur isolated, in pairs, or in chains.

The third main group, the spirilla, are spiral in shape, or more accurately their form represents the fraction of the thread of a screw. The spirilla, like the bacilli, divide in one direction, and may occur as comma, S-shaped or corkscrew forms. The cholera organism has a diameter of about $0·4\mu$.

The transverse diameter is usually taken as the standard of measurement, as it is more constant than the long diameter of the bacteria.

The dimensions of the organisms shown in the accompanying illustrations are as follows:—*Streptococcus pyogenes*, $0·6–0·8\mu$; *Staphylococcus pyogenes aureus*, $0·7–1\mu$; *Diplococcus pneumoniae*, $0·5–0·8\mu$; *Bacillus pestis*, B. $0·6\mu$, L. $0·6–1·9\mu$; *Spirillum cholerae*, B. $0·4–0·6\mu$, L. $0·8–2\mu$; *Bacillus typhosus*, B. $0·6–0·8\mu$, L. $1–3·2\mu$; *Bacillus tetani*, B. $0·5\mu$, L. $1·2–3·6\mu$.

The example seen in Fig. 1 is the *Streptococcus pyogenes*, which is responsible for various septic processes in man. The grouping into chains is a characteristic feature of this organism. There is little variation in size of the individual members of the chain, with the exception of detached or isolated cells, which may be double the size of the normal cocci, *e.g.* when cell-division occurs. Micrococci are not generally subject to such individual variations as bacilli, as can be seen in Fig. 2, *Staphylococcus pyogenes aureus*, where only slight variations in size are to be detected. In Fig. 3 is an example of a very pleomorphic organism, the plague bacillus. It is ordinarily a very short, thick rod, almost appearing as a diplococcus when subdivision occurs. In the photograph, one rod is seen which is about six times the size of the others, and this is by no means uncommon. In a fluid culture the form of the plague bacillus is entirely altered, the organism almost assuming the appearance of Fig. 1. The *Micrococcus pneumoniae* (Fig. 4) is one of the most variable of the diplococci, the individuals in a pair being rarely equal in size, and sometimes elongated, as seen in the photograph. The cholera organism (Fig. 5) is inconstant in size, and its chief characteristic is the bent rod or comma shape. The tetanus bacillus (Fig. 6) is of large size in relation to the other organisms noticed. It is usually a straight rod, except when spore-formation occurs, when it assumes the drum-stick appearance, as seen in the photograph. The typhoid bacillus (Figs. 7 and 8) is very variable in size, although its rod-like shape is constant. The organisms generally have been stained with gentian violet, except in Fig. 8, where Van Ermengem's method for demonstrating flagella has been adopted. This process is not a true staining method, it is really a deposit of a silver-salt on the organism and its flagella. The organism appears much larger than when stained in the ordinary way. Many organisms are like the typhoid bacillus, endowed with flagella, which are probably exclusively organs of locomotion. In Fig. 8 they surround the bacillus, and are many times longer than the organism itself. In other organisms one finds sometimes unipolar or bi-polar flagella.

The illustrations accompanying this article have been produced in the photographic laboratory of the Jenner Institute of Preventive Medicine. The magnification is in all cases 1750 diameters, this being regarded as the highest at which satisfactory photographs of bacteria can be taken, a higher magnification generally resulting in the outline of the organism becoming blurred. The objectives used were a Zeiss 3 mm. apochromatic and a Winkel 1·8 mm. fluorite system, low-power projection oculars being used in each case, and magnification obtained by suitable camera extension. The organisms were all stained, so that a yellow screen was necessary when photographing. The screen used was a saturated solution of acridine yellow, about 15 mm. thick, and with this uniformly satisfactory results have been obtained.

ALLAN MACFADYEN.
J. E. BARNARD.

NOTES.

THE 101st anniversary of the death of Domenico Cirillo, friend of Linnæus, and famous both as botanist and physician, occurred on Monday, October 29. The account of the life and work of this great Neapolitan, given by Prof. Giglioli in another part of the present issue, appears, therefore, at a very appropriate time, and will be read with much interest by every naturalist. We are glad to be able to publish this appreciative notice of some of Cirillo's contributions to science, and thus to add to the number of those who, knowing his works and career, will cherish his memory.

THE announcement of the death of Prof. Max Müller, at Oxford on Sunday last, has been received with universal regret. The funeral has been arranged to take place to-day at Holywell Cemetery, Oxford.

ACCORDING to a *Times* report from Constantinople, "An Imperial Iradé prohibits star-worship and Sabianism in Turkey." It would be interesting to know more exactly what has been prohibited.

THE new science laboratories at King's College were opened by Lord Lister on Tuesday afternoon.

THE death is announced of Mr. William Anderson, professor of anatomy to the Royal Academy of Arts, and the author of a number of works on surgery and anatomy.

A COURSE of Cantor lectures by Prof. J. A. Fleming, F.R.S., on "Electric Oscillations and Electric Waves," will be delivered on Monday evenings in November and December at the Society of Arts.

A DESTRUCTIVE series of earthquake shocks occurred at Caracas, the capital of Venezuela, and the surrounding districts on Tuesday, October 30. The town of Guaronas has been entirely destroyed.

A VISIT to the Chelsea Physic Garden is enough to convince any one of the urgent need of new greenhouses to replace the dilapidated structures in which the existing collections are housed. A more ruinous building than the central range it would be