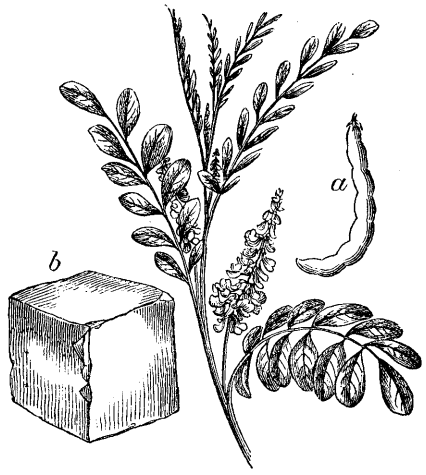
INDIGO (Gr. *Indikon*, Indian), a most important vegetable dyestuff, yielding a beautiful blue and very durable dye, the basis also of the best black dye in woollen cloths. It has been used in India from a very early period, and was imported thence



Indigo Plant (*Indigo tinctoria*):
a, pod; *b*, block of indigo.

by the ancient Greeks and Romans, but was lost to Europe during great part of the middle ages—although the cultivation of the plant and preparation of the dye were described by Marco Polo in the 13th c.—until re-introduced by the Dutch about the middle of the 16th century. Its use in England, France, and Saxony was then for a considerable time

prevented by a strong prejudice against it, arising from the difficulty experienced in fixing the colour. Since this has been overcome, the cultivation of plants producing indigo, long confined to India, has extended to many other tropical and subtropical countries, as Egypt, the West Indies, Mexico, Brazil, &c. These plants generally belong to the genus *Indigofera*, of the natural order *Leguminosæ*, sub-order *Papilionaceæ*. The keel of the corolla is furnished on both sides with an awl-shaped spur. The species of this genus number at least 150, and are natives of almost all tropical and subtropical countries. Of these, *I. tinctoria* is the species most generally cultivated in India. It is a half-shrubby plant, 2—3 feet high, with pinnate leaves, which have five or six pair of long-obovate, dull, bluish-green leaflets, and racemes of axillary pale red flowers.

The province of Tinnevelly produces a great quantity of indigo. Bengal produces, on an average, about nine millions of pounds annually. The sum which Europe annually pays for indigo is estimated at eight or ten millions of pounds sterling.

Indigo is, however, obtained from plants of other genera, particularly from *Wrightia tinctoria* (natural order *Apocynaceæ*), East Indies; *Baptisia tinctoria* (natural order *Leguminosæ*), North America, which yields indigo of a pale colour and very inferior quality; *Tephrosia tinctoria* (natural order *Leguminosæ*), Malabar; and *T. Apollinea*, Egypt and Nubia; *Marsdenia tinctoria* (natural order *Asclepiadaceæ*), in Sylhet; and *Polygonum tinctorium* and *P. Chinense* (natural order *Polygonaceæ*), China and Japan.—*Wrightia tinctoria* is a large shrub, indigenous to great part of India and to Ceylon, yielding indigo of the finest quality, and is recommended by Dr Roxburgh for cultivation, as less dependent than the common indigo plants on rain and irrigation. It grows very freely, and throws out shoots rapidly on their being cut away. —In times when East Indian indigo was not known, or was brought to Europe only in small quantity, the same dyestuff was obtained from Woad (q. v.).—A coarse kind of indigo, called Bastard Indigo, was also at one time made in North America from the young shoots of *Amorpha cærulea*.

The Manufacture and Applications of Indigo.—The indigo plant, in its general appearance, is not unlike the lucerne of our fields. The seed is sown in drills about 10 inches apart, and soon makes its appearance above ground, when it requires incessant care to keep the weeds down, which otherwise would soon choke so tender a crop. In about three months, the plants begin to flower, and are then cut down, but soon shoot up again, and yield a second cutting, sometimes a third, the same year. Formerly, indigo was carefully dried after being cut, and even fire-heat was sometimes used for the purpose, but now—at least in India—the practice is abandoned, and it is found in every respect better to use the plant whilst fresh and green. The first process is to pack a large vat full of the freshly cut indigo; heavy wooden beams are placed on the top to press it and fix it down; and water is then let into the vat, enough just to cover it. Being left in this state for from ten to twelve hours, fermentation is set up, and much gas disengaged, the water becoming a light-green colour. The green liquor is then run off into the second vat, which is placed below the level of the first, in which, whilst the fermentation process is being repeated upon a fresh supply in the first vat, it is violently agitated by being beaten with poles: this causes the *grain*, as it is called, to separate, and the green matter suspended in the liquor becomes blue and granular. When this operation is sufficiently advanced, the contents of the vat are allowed to settle, and the sediment is then run into the third vat, which is below the level of the second; from which it is pumped into a boiler. The boiler is slightly heated, and then allowed to stand for a few hours, during which time the indigo settles down, and as much clear water as possible is drawn off from above it. The boiler is then again heated, and this time up to the boiling-point; after which its contents are allowed to run on to a frame of wood, lined with 'long-cloth' sheeting, where they remain to drain till about the consistence of very thick cream, when they are removed, and subjected to very heavy screw pressure; and when as hard and dry as ordinary soap, are cut by brass wire on a frame into cubes about three inches square; and these are laid out, so as not to touch each other, on the shelves of the drying-house. Finally, the cakes are cleaned, one by one, and tightly packed in boxes for the market.

This dye is, without doubt, the oldest in use; the Greeks and Romans obtained a knowledge of its uses from India, where its employment has been very general for a great length of time. Much obscurity involves indigo and its early use, in consequence of the variation in its name; for instance, the Tamools of India call the plant *Averie*, and the dye itself *Neelum;* in Sanscrit, the plant is *Vishashodanie*, and the dye *Nīlī* and *Nīlīnī*, whence the *Anil* of the Portuguese. The Malays call the dye *Taroom*, and the Arabs, *Neel*.

Commercially speaking, indigo may be said to be the produce of India and Central America, as these are the only localities which supply the recognised form of the article. In India, the chief seat of the indigo manufacture, Bengal is the most important district. The total quantity received in Great Britain in 1876 was upwards of 88,000 cwts.—a vast quantity, when it is borne in mind with what difficulty it is cultivated and manufactured. When pure, indigo has a rich, dark-blue colour, almost purple; it is in small cubes or parts of cubes, and its fracture shews a tendency to break up into square pieces, and indicates cracks in its substance, often filled up with a film of whitish efflorescence, probably the lime used in precipitating it. It has neither taste nor smell, and its specific gravity is about 1·50; if rubbed with any hard substance, it gives a streak with a bright coppery lustre. The varieties recognised in commerce are—1st, Bengal, which, from the care taken in its preparation, and the large scale on which it is made in that district, is the best; and its various gradations of quality, ten in number, varying from 9*s.* to 5*s.* per pound, are always kept distinct. In other sorts, they are usually much mixed. 2d, Madras and Kurpah; 3d, Oude; 4th, Manilla; 5th, Java; and 6th, South American. The last is packed in serons or cases of dried ox-skin, and its qualities are distinguished as follows: 1st, Flores; 2d, Sobres; and 3d, Cortes; all the others are in wooden chests, containing about 250 lbs. each.

Few materials are of greater importance to the dyer than indigo, and none require the exercise of more care and skill in using. Being insoluble in water, it requires the action of other solvents to render it capable of penetrating the fibres of the materials to be dyed. The method generally employed is the following: The indigo is broken into small lumps, and these are soaked in hot water, and left for at least 48 hours, in order that the moisture may soak through and soften them; after which they are put into the indigo-mill, which is a levigating machine, consisting of a vessel in which a roller is made to work by machinery, so as to rub down the indigo, mixed with plenty of water, to a very

fine paste. This is a tedious operation; therefore, in large establishments, there are usually numerous mills in the grinding-room. When sufficiently ground, the paste is removed to the dyeing-vat, where to one part of indigo is added one part of lime and three-fourths of sulphate of copper; these are well mixed with sufficient water to fill the vat, and the dyer then proceeds to dye either cotton, linen, or silk goods. See DYEING. After being dyed, the goods are dipped into a bath of diluted sulphuric or hydrochloric acid, which gives brightness and purity to the colour; they are then finished by washing in a stream of pure water, and drying.

Green indigo, called *Lo-kao* by the Chinese, is a substance resembling indigo, which is obtained from a tree called *Hom-bi;* it is highly valued by the Chinese artists as a pigment, and also gives a beautiful permanent green colour to cotton and silk cloths; it is, however, so costly, that it never can, unless differently prepared, be used as a dyeing material. The fact that the Chinese dye cotton cloths with it, is accounted for by the nature of the process of preparing the lo-kao, which is this: A well-macerated decoction of the bark of the hom-bi tree is largely diluted with water mixed with a little lime; pieces of cotton cloth are then dipped into the vat, and taken out and exposed to the sun, which changes them to a bright green; they are then placed in perfectly clean water, and agitated until the water has removed all the free colouring matter; this water is then evaporated, and the small sediment left is the lo-kao. It is the cotton cloths thus used that are sold as green-dyed goods. It is said that a similar dye stuff is obtained from another tree called *Pa-bi*, and although this, as made by the natives, is much too costly to use in European dyeing, yet probably, if better means of obtaining it can be pointed out, it may become an important article of commerce.

Chemistry of Indigo.—The plants which yield indigo present no indication, when growing, that they contain any *chromogen*, or matter capable of yielding pigment, nor is it definitely known in what form the indigo exists in the vegetable tissues.

The indigo of commerce is by no means a homogeneous body. Its essential and most important constituent is *Indigotin* or *Indigo Blue*, but it likewise contains *Indigo Brown*, *Indigo Red*, and other ingredients.

Indigo Blue, or *Indigotin* ($C_{16}H_5NO_2$), is obtained from commercial indigo by extracting the ingredients with which it is mixed by acetic acid, alkalies, and boiling alcohol. It occurs either as a dark-blue amorphous powder, or in purple crystalline scales, with a metallic lustre. It is devoid of smell and taste, and is insoluble in water, alcohol, ether, dilute acids, and alkalies. When carefully heated, it may be sublimed without decomposition. Among the products of its destructive distillation are hydrocyanate and carbonate of ammonia, aniline, &c. Indigo blue dissolves without any evolution of gas in strong sulphuric acid, forming a blue solution of *sulphindigotic acid*, which is extensively used for dyeing cloth, under the name of *Saxony Blue*.

Under the action of reducing agents, such as alkaline fluids containing sulphate of iron, or a mixture of grape-sugar, alcohol, and strong soda lye, indigo blue becomes converted into *Indigo White* or *Reduced Indigo*, which forms a yellow solution in alkaline fluids, but which, on free exposure to the air, absorbs oxygen, and is reconverted into indigo blue. Indeed, this is the best method of obtaining the latter in a state of purity from commercial indigo, of which it should form about 50 per cent.

Indigo blue occurs in small quantity in the urine of man, the horse, and the cow, and occasionally in the milk of the cow, when these fluids have been exposed for some time to the action of the air; but Schunck obtained it from the urine in so many cases (in the urine of 39 persons out of 40), that Indican (or the chromogen yielding indigo blue) must be regarded as a normal urinary constituent. See M. Schunck's paper in *The Memoirs of the Literary and Philosophical Society of Manchester*, 1857, vol. xiv., or Day's *Chemistry in its Relations to Physiology and Medicine*, 1860, pp. 310—312.

Indigo White or *Reduced Indigo*, in a state of purity, occurs in white flakes, which are devoid of taste or smell, are perfectly neutral, and are insoluble in water, but dissolve in alcohol, ether, and alkaline solutions. Its composition is represented by the formula $C_{16}H_6NO_2$, and as it only differs from indigo blue, $C_{16}H_5NO_2$, in containing one more equivalent of H, it may be considered as the hydride of the latter. If yarn or woven goods be immersed in an alkaline solution of this substance till they are thoroughly saturated, and are then exposed to the air, indigo blue is formed within the fibres of the tissue. The blue dye thus obtained is very intense and permanent. From its property of becoming blue on exposure to the air, indigo white is a sensitive test for the presence of free oxygen.

Many compounds of great chemical interest have been derived from indigo blue. It was from indigo that aniline (now so largely employed in the production of the pigments known as *mauve* and *magenta*) was first obtained.