BLEACHING (AS. *blæcan*, to grow pale, Ger. *bleichen*, to whiten; cf. *E. bleak*, Ger. *bleich*, pale, AS. *blāc*, *blæc*, pale, shining). The art of removing coloring matters from animal and vegetable substances, leaving the material uninjured but of a light or white color, so that, as in the case of fabrics, they may be readily dyed to some desired shade. The origin of bleaching is unknown, but the art is believed to have been practiced before the Christian Era, and the "fine linen" mentioned in the Bible is supposed to have been bleached. It is thought to have been practiced by the ancient Babylonians, Egyptians, and other Eastern peoples, and was for the most part applied to vegetable fabrics, such as flax, hemp, and cotton, or the cloths made from them, although the bleaching of silk has long been known in China. Originally the atmosphere and the sun's rays alone were used for bleaching, and the plan followed was to spread the cloth on a grass field called a *bleaching green*. The fabric was sprinkled with water several times a day, and after several months of exposure it became white. No improvements of importance occurred until the eighteenth century, when Holland became the principal seat of industry, and there the material was steeped in a solution of potash lye for several days and then in buttermilk for about a week, after which it was washed and bleached on the ground. The satisfactory results thus obtained led to the name "Hollands" being given to the excellent fabrics bleached in that way, while a quality of linen, much in demand, which was spread on grass fields, was called "lawn." The next improvement was the use of dilute sulphuric acid in place of buttermilk, by which the duration of the process, formerly about eight months, was reduced to one-half that time. In 1785 the remarkable bleaching properties of chlorine were discovered by Berthollet, and its application to the bleaching of cloth soon followed. At first the chlorine was used in its gaseous state, and it was found that it destroyed color by uniting chemically with the coloring principle, thus decomposing the color; but as the chlorine also united with hydrogen of the fibre it destroyed the fabric. Subsequently javelle water, obtained by dissolving chlorine in dilute potassium hydroxide, was employed; but in 1799 the dry calcium hypochlorite, or bleaching powder, came into use and is still largely employed, although for some purposes hydrogen peroxide is now preferred.

Cotton Bleaching. When yarn and thread are bleached, the process consists in boiling the material in a dilute solution of caustic alkali and washing, then steeping in a solution of bleaching powder and washing, after which it is steeped in sulphuric acid and again washed, then heated in a soap solution with the addition of a small quantity of bluing, after which it is passed through a dumping machine consisting of wooden rollers, containing a solution of indigo, then washed and dried again. In the case of cotton cloth or calico the process is somewhat more complicated, but consists essentially in the treatment of the material in baths of lime, lye, bleaching powder, and sulphuric or hydrochloric acid, with thorough washing after each step. In bleaching, as preparatory to calico printing, the use of a caustic alkali solution and of rosin soap follows the lime boil. This is "Printer's Bleach." It should be mentioned that an electric bleaching process has been introduced, the principal feature of which is that the bleaching liquid, as hypochlorite, is obtained by passing an electric current through solutions of sodium or magnesium chloride or a combination of the two.

Linen Bleaching. The process employed for removing colors from linen is similar to that employed for cotton, although the natural impurities are greater in the flax fibre than in the cotton. These are rendered soluble by alkaline boilings, after which the coloring matters that still remain are oxidized and destroyed by baths of hypochlorites, or bleaching powder, the processes as given for cotton being repeated several times, according to the perfection of bleach desired. It is sometimes found desirable, especially when linen cloth is bleached, to introduce a step called *grassing*, which consists in exposing the material in a field to the action of air, light, and moisture for several days. It is believed that by this method the full strength of the fibre is more completely retained. There are four grades of linen bleaching—quarter, half, three-quarter, and full bleach. In linen yarns the loss of strength is estimated at 20 to 30 per cent for full bleach, and 15 per cent for half bleach, while ordinary cotton loses only about 5 per cent.

Wool Bleaching. The special feature in which this differs from the preceding methods is in the preliminary process, which is called *scouring*. Wool fibre usually contains from 30 to 70 per cent of foreign matter, consisting of dirt, and especially of fatty matters secreted by the animal, called *yolk*. This is divided into two parts: (1) "wool perspiration," which is soluble in water, and consists essentially of potassium compounds of *oleic* and *stearic* acids, thus constituting an important source of potash; and (2) a compound insoluble in water and composed of cholesterin in combination with fatty acids. The scouring process consists in dipping the loose wool into dilute

soap solutions which form emulsions with the *yolk*, or in treating the wool to the successive action of fat solvents, such as carbon disulphide or naphtha. The scouring machine is usually a long narrow trough, divided into several tanks or bowls. The first bowls are scourers, the last are rinsers. Wringers are attached to each bowl. When the wool yarn is scoured, the process is similar, although the machinery is somewhat different. Wool cloth is scoured by passing the material as an endless band through the scouring liquid and then through a pair of squeezing rollers. Even after scouring, wool cloth retains a faint yellow tint, which is then removed by bleaching. This is accomplished by the action of sulphurous acid, which is formed by burning sulphur in a closed chamber while the scoured and washed material, still wet, is suspended on poles, or the woolen material may be immersed and moved about in a solution of sulphurous acid. Hydrogen and sodium peroxides are now being used for wool bleaching. The effect is more permanent than with sulphur.

Silk Bleaching. Raw silk contains a gelatinous substance called *sericin*, or *silk glue*, which, with calcareous and other mineral matter, is removed by working the silk in a scouring solution of soap at 95° C. This process is called stripping. The crude material may lose as much as 30 per cent in this operation, but the average loss is 20 to 25 per cent. The bleaching process is similar to that described under *Wool Bleaching*, and consists in exposing the wet scoured silk to the action of gaseous sulphurous acid. The use of hydrogen peroxide for bleaching silk is becoming more and more extensive. The method consists in steeping the silk in a dilute solution of hydrogen peroxide, made slightly alkaline with ammonia or sodium silicate until it is sufficiently bleached. The bleaching of paper stock, as cotton and linen rags or paper, and the bleaching of straw, as well as the bleaching of animal products, as beeswax, feathers, hair, ivory, oils, and sponges, will be found described in special articles under the names of these products.

Bibliography. J. Gardner, *Bleaching, Dyeing, and Calico-Printing* (London, 1884); *Modern Bleaching and Finishing*, by a practical working bleacher (London, 1897); Engelhardt, *Hypochlorite und elektrische Bleiche* (Halle a. S., 1903); and for briefer reference, Thorp's *Outlines of Industrial Chemistry* (New York, 1905), where a bibliography of bleaching and dyeing will be found; Bottler, *Modern Bleaching Agents and Detergents* (London, 1910); Hübner, *Bleaching and Dyeing of Vegetable Fibrous Materials* (London, 1912). Consult also works on dyeing.