FLAX (AS. *fleax*, OHG. *flahs*, Ger. *Flachs;* probably connected with Goth. *flahta*, hair plait, Ger. *flechten*, to weave, Lat. *plicare*, to fold). An annual plant of the genus *Linum* (family Linaceæ), of which there are more than 100

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known species, mostly annual and perennial herbs, scattered over the globe. They are most abundant in Europe and northern Africa. The common flax (*Linum usitatissimum*) is an annual indigenous to the Mediterranean region of Europe and Africa and to some parts of Asia, but now distributed over both hemispheres. This most common species of flax has a very slender, erect stem, 2 to 3 feet tall, branching only near the top, which bears beautiful blue, or sometimes white, flowers. The seeds are dark brown, glossy, flattened, with acute edges.

No plant not yielding food to man is more useful than the flax plant. It is highly valuable both for the fibres of its inner bark and for its seeds. Flax fibres are characterized by length, fineness, solidity, and suppleness. Their length is invaluable in spinning, and the nature of their surfaces prevents them from slipping on each other, thus contributing to the durability of fabrics made with them. When separated from both the bark and the inner woody portion of the stem, they constitute the well-known material from which linen thread and cloth are made, and they are used for manufacturing the finest and the coarsest fabrics, the most delicate and exquisite lace, linens, shirtings, and handkerchiefs, twines for shoemakers and harness makers, cords for the warp of carpet and the body of oilcloth, sailcloth, rope, and cordage. The seeds yield by expression the drying fixed oil called linseed oil (q.v.), used for mixing paints, varnishes, etc. The remaining crushed mass is linseed cake, or oilcake, esteemed for feeding cattle, and which, when finely ground, becomes linseed meal. Linseed is sometimes used in medicine as an emollient and demulcent in irritations of the mucous membranes generally, but especially of the pulmonary and urinary organs. The world's annual flax-fibre production is about 1,500,000,000 pounds, of which over 1,000,000,000 pounds is furnished by Russia alone. In no European country is flax more successfully cultivated than in Belgium, where it is employed in the manufacture of Brussels lace, the crop when prepared for market sometimes exceeding in value the land on which it was produced. The excellence of Belgian flax must be ascribed largely to the care bestowed on its cultivation and the superior retting facilities offered along the river Lys.

History. Flax has been cultivated from the earliest historic times. It is mentioned in the Book of Exodus as one of the products of Egypt in the time of the Pharaohs, and microscopic examination has shown that the mummies of Egypt are enveloped in linen cloth. As in the days of Solomon, who purchased linen yarn in Egypt, and as in the time of Herodotus, who wrote of the great Egyptian flax trade, Egypt still grows large quantities of flax. In Europe its cultivation is very extensively carried on, especially in Russia, Austria-Hungary, Belgium, and Ireland. In America it has been cultivated since the period of earliest settlement. During the Civil War in the United States efforts were made in some quarters to substitute it for cotton, the supply of which was cut off. But since the two fibres demand essentially different treatment, and since the machinery employed in the manufacture of cotton fabrics is not adapted to the manufacture of linen fabrics, the experiments were not satisfactory. For its fibre the culture of flax is attracting increased attention in the United States, and it is being produced in small quantities for this purpose in Michigan, Wisconsin, Minnesota, Oregon, and Washington; for its oil it is largely grown in a number of States. From time immemorial flax has been cultivated in India for its seed, but not for its fibre. In that climate the plants seldom exceed 18 inches in height and are much branched, yielding a worthless fibre, but a large quantity of seed richer in oil than the European or the American seed.

Cultivation. Flax will grow in almost any part of the United States, but it needs a strong, rich soil and careful manipulation at every stage of its production and manufacture. The heavier soils, when well drained and of proper fertility, are preferable to sandy loams; wet soils are fatal to success. In general, a deep, moist, strong loam upon upland and free from weed seeds, which must be avoided above all things, will give best results. As far as possible weeds should be eliminated by previous cultivation. Flax is believed to make heavier demands upon the soil than does any other crop, and for this reason it is frequently called exhaustive. In Belgium and other flax-growing countries, where land has been under cultivation for generations, stable manure, which has been well rotted to avoid the danger of fouling the land with weeds, is applied before winter sets in. Previous to sowing time in spring the ground is heavily treated with fertilizers.

Flax demands a greater amount of labor than almost any other crop, and unless extreme care be exercised in every step the value of the crop for fibre will be seriously impaired. Much depends on the thickness of sowing. For a fine fibre flax must be sown thickly and be pulled before the seed is ripe; for a coarse fibre it may be given more room and the seed allowed to reach approximate maturity, but not the hard stage known as "dead ripeness." Coarse fibre and a crop of seed are often preferred by the grower to a crop of fine fibre alone, a departure that experience at home and abroad will countenance, especially since the disproving of the assertion that good fibre and seed cannot be produced by the same plant. Still, flax should be grown with a view of getting from the land a fine quality of fibre, while the seed, which ought to be a factor of profit, should be saved. Usually the crop is pulled, roots and all, by hand, but if the ground be smooth it may be cut with a mower, the implement used when seed alone is passed through an ordinary threshing machine; but since this tangles and breaks the fibre, it must not be used if the fibre is to be saved.

Dressing. The process first gone through after pulling is *rippling*, which consists in tearing off the seeds by pulling the stalks through a flax comb, which consists of a series of iron teeth 18 inches long, placed within a distance of ½ inch of each other. These are fastened in a block of wood, which is placed at the end of a plank or long stool, on which the operator sits. Often the seeds are separated from the stalk by threshing or hammering, but this process, as already stated, is objectionable, as it soils and breaks the stalk. The next process is to obtain the flaxen fibre or lint, free from the woody core, or *boon*, of the stem. This is effected by steeping the bundles in either stagnant or running water till the boon begins to rot, in which state it is readily separated from the fibre. The operation is called rotting, or *retting*, and requires to be managed with great care, as by continuing it too long decomposition might extend to the fibre and render it useless; while by discontinuing it too soon the separation could not be effected with sufficient ease. The time is generally determined by the nature and temperature of the water and the ripeness of the flax, decomposition taking place more rapidly in soft, stagnant water than in running streams, in which the retting is sometimes conducted. Three natural modes of steeping, or retting, the straw are recognized—dew retting, pool retting, and retting in running water. There are also many processes for quick retting, where the temperature of the water is controlled, and also where cereals are used; but the flax of the world is largely retted by natural methods rather than by "processes." For dew retting a moist meadow is the proper place, the fibre being spread over the ground in straight rows at the rate of a ton to an acre. For pool retting the softest water gives the best results, and where a natural pool is not available, such as the "bog holes" in Ireland, "steep holes" are made. The sheaves are kept entirely under water, but without touching the bottom. The fibres sink when decomposition has been carried to the proper point. If the woody portion or core pulls out easily, leaving the fibre intact, it is ready to come out. The operation usually requires from 5 to 10 days. Dew retting is the safest and least offensive method, but it requires much longer time, and in a country where land is valuable would become very expensive. On the whole, the mixed method of retting is preferable—i.e., to steep till decomposition of the boon is well advanced and then to complete the process on the grass. It has been attempted to separate the fibre by machinery without subjecting the flax to retting; but the article so produced has hitherto been rejected as inferior in quality.

Attempts to hasten the process of retting by placing the flax in tanks and using warm water or steam instead of cold water or dew have been more successful. According to the process introduced by Schenk, the flax is placed in vats, in which it is kept down by means of strong framework. Water is allowed to pass into the vats, to become absorbed by the flax; steam is next admitted, till the temperature of the water is raised to, and maintained at, about 90°. Acetous fermentation ensues in a few hours, and after being maintained for about 60 hours, the decomposition of the gummy or resinous matter in the stalk is completed. The mucilage water is next withdrawn from the vat, and the flax taken out, separated, and dried, either in the open air or in desiccating rooms, according to circumstances. Retting in water is usually followed by bleaching on the grass, to secure an even color. This is often accomplished in a few days, but may require several weeks.

The whole process of retting is a typical fermentation. A disagreeable odor arises from the fermenting flax, and the liquid, after the fermentation, is filled with products which make valuable manure. The bacillus which produces the retting has been identified, and it has been shown that the retting is a process of decomposition of the pectin cement. No method of separating the linen fibres in the flax from the wood fibres has yet been devised which dispenses with the aid of bacteria. (See Conn, *Story of Germ Life*, New York, 1900.) In chemical retting, however, dilute sulphuric or hydrochloric acid is used, which completes the process in a few days.

The flax is now ready to be freed completely of its woody particles. This is effected by *scutching*. Previous to this, however, the flax is passed through a *brake*, or revolving rollers, in order thoroughly to crack the boon. The brake, worked by manual labor, consists of a frame, on the upper side of which are a number of grooves; a movable piece is hinged at one end and provided with a similar grooved piece on its lower side, but so placed that the projections pass into the hollows of the lower. The flax, placed between these and struck by bringing down the hinged part, is broken, but the fibre remains uninjured.

In the flax-breaking machine the flax is passed through a series of horizontal fluted rollers; the flutes do not touch, thus preserving the fibre while breaking the boon. In Austria and other European countries a more primitive, but, it is claimed, less injurious method of breaking is pursued, in which the fibre is opened with a "bott hammer" (batting hammer), which is made of wood ridged like a cook's implement for pounding steak. In continental countries scutching is almost invariably performed by hand, the flax being held in a groove made in an upright stand and struck by a flat blade. Machine scutching is much more certain and expeditious than hand scutching and is, in consequence, fast superseding it in Great Britain. After passing

through the breaking machine the flax is subjected to the action of a series of knives attached to the arms of a vertical wheel; these knives strike the flax in the direction of its length. The process is gone through three times before the flax is ready for the market. Although machine scutching is expeditious, it is not capable of that pliant adaptation to the varying nature of the flax to be operated upon, which is obtained in hand scutching. The effect of machine scutching is to produce fineness by reducing and imparting rather than sustaining the character of the fibre—viz., the length and fineness of its "staple," or fibre. In the chapter on "The present Status of Flax Culture," in the *Year Book* of the United States Department of Agriculture for 1897, the statement that a practical machine scutcher is a desideratum still holds good, although many such machines have been invented.

The initial processes of linen manufacture thus far described are usually performed by the farmer, although there is a tendency within recent years for the preliminary work of retting, bleaching, breaking, and scutching to be performed by companies, who buy the straw direct from the fields and prepare it for the linen factory. The next step that the flax undergoes is that of heckling, the object of which is to separate the longer and better portion of the fibre, called "line," from the shorter and raveled portion, called "tow." The hand heckle is a many-toothed steel comb, and the fineness of the flax increases with the number of times it is heckled, each time with a finer and finer instrument. Heckling is now usually performed by machinery. (See HECKLE.) The fibre is then in readiness for spinning and for manufacture into linen, for which operations see the articles on SPINNING and LINEN.

The world's annual production of flaxseed averaged about 75,000,000 bushels per annum prior to 1900, about 100,000,000 per annum from 1900 to 1911, and was 130,000,000 in 1912. The production is about equally divided among five countries,—the United States, Canada, Argentina, India, and Russia,—the product of 1912 being: United States, 28,073,000 bushels; Canada, 26,130,000; Argentina, 22,518,000; India, 25,680,000, and Russia in Europe, 22,177,000. Little effort is made in the United States to utilize the fibre, the plant being grown almost exclusively for its seed. In 1913 the United States produced 17,853,000 bushels of flaxseed on 2,291,000 acres. Over 7,000,000 bushels were produced in North Dakota, where more than double that quantity has been secured in more favorable seasons. The record production of the United States is 29,285,000 bushels. Consult: Dodge, *Dictionary of the Fibre Plants of the World* (Washington, 1897); also "Fibre Investigations," in *United States Department of Agriculture, Report No. 9* (ib., 1897); "Flax for Seed and Fiber," *United States Department of Agriculture. Farmers' Bulletin 27*. See FIBRE.