**Plant fibers**

Plant fibers are structural elements in all higher plants. Fibers may be found in almost any part of the plant-stems, leaves, roots, fruits, and even seeds. Differing in texture, strength, chemical composition, and place of origin, with few exceptions fibers are alike in that they are sclerenchyma cells and serve as part of the plant skeleton. For the most part they are long cells with thick walls, correspondingly small cavities, and usually pointed ends. The walls often contain lignin as well as cellulose. Fibers may occur singly or in small groups, but they are more likely to form sheets of tissue with the individual cells overlapping and interlocking.

Spindle-shaped cells with tapered ends are considered to be a characteristic feature of the fiber cell. According to this definition, cotton (*Gossypium* spp.) fiber – probably the most well-known plant fiber – is not a fiber, but a trichome, the extrusion of epidermal tissue.

**Classification of fibers** –

Fiber cells are present in many different plant parts. They can be divided according to their position within or outside the xylem - Libriform fibers and fiber tracheids, being a part of xylem, are called xylary fibers. Another type of xylary fiber, present in tension wood, is the gelatinous or mucilaginous fibers. Xylary fibers constitute an integral part of the xylem and develop from the same meristematic tissues as do the other xylem components. Extraxylary fibers (i.e., the fibers localized outside xylem) can be found within the cortex (cortical fibers), phloem (phloem or bast fibers), or at the periphery of the vascular bundles (perivascular fibers).

Another classification based on their origin, which includes four chief types - bast fibers; wood fibers; leaf fiber; and surface fibers, which are hairlike outgrowths on the seeds of various plants.

Bast fiber are strong, cellulosic fibers obtained from the phloem or outer bark of jute, kenaf, flax and hemp plants. Fiber bundles run longitudinally along the stem from bottom to top and reach almost the full length of the plants, which may be 3 meters or more for hemp and kenaf.

Wood fibres are usually cellulosic elements that are extracted from trees. This type of wood fiber is utilized in large quantities by the pulping industries for cellulose extraction and papermaking.

The leaf fibers, also known as hard fibers, are the agglomeration of fiber cells with vascular elements and are extracted from the fibrovascular system of leaves of monocotyledons.

Surface fibers are fibers found on the covering of seeds, leaves, or fruits; cotton cloth is made from seed hairs covering the surface of cotton seeds.

Plant fibers of commercial importance are classified according to their use as - textile fibers (cotton, ramie, flax, jute, hemp), cordage fibers for making ropes and twines (sisal, coir, abaca, henequen), brush and mat fibers, stuffing and upholstery materials, papermaking fibers or wickerwork materials (raffia). The commercial value depends on the nature of the fiber with respect to length, fineness, strength, and stiffness.

None of the plant fiber classifications is completely comprehensive, as there are always some forms, which do not fit any group or do fit more than one. The septate fibers for example cannot be considered as xylary or extraxylary. They can be found both within phloem and xylem, even of the same plant species.
Diagrammatic representation of classification of plant fibers is shown below -

Fibers of economic importance are furnished by many different families of plants, particularly those which occur in the tropics. Among the more important may be mentioned the Gramineae, Palmaceae, Musaceae, Liliaceae, Amaryllidaceae, Urticaceae, Malvaceae, Linaceae, Bombacaceae, Leguminosae, Moraceae, Tiliaceae, and Bromeliaceae.

Chemical composition of fibers –

The major constituents of natural fibers are cellulose, hemicellulose, lignin, pectin and ash. The proportions of cellulose, hemicellulose and lignin in hardwood, softwood and monocotyledon secondary cell wall are shown below –
Percentage of hemicellulose and pectins in the primary and secondary cell wall of: (a) hardwood; (b) softwood; and (c) grasses are shown below –

Fiber size –

Softwood fibres (botanically called tracheids) can have lengths up to approximately 3.5 mm, diameters of approximately 30 µm and wall thicknesses in the range of 2–3 µm. Hardwood fibres are approximately 0.7–1.5 mm long, with diameters in the range of 13–20 µm and wall thicknesses of 3–6 µm. Literature values for the dimensions of bast fibres vary widely. For example, the fibres of kenaf tend to be in the range of 2–3 mm long (similar to wood), while flax and hemp fibres can be much longer; in the range of 2–5 cm. Bast fibre diameters vary between approximately 8 and 25 µm, and wall thicknesses vary between 4 and 12 µm. As mentioned, some of the reasons for these differences among bast fibre dimensions relate to their ontogeny.

Cotton

Cotton is the world’s greatest industrial crop, the chief fibre yielding plant. Raw cotton consists of cellulose (94%), protein (1.3%), pectic substances (0.9% to 1.2%), water (0.6%), sugar (0.3%) and some pigment traces.

All the cultivated cottons fall under 4 species; 2 belonging to old world, *Gossypium arboreum* and *G. herbaceum* which are diploid in nature; another 2 belonging to new world, *Gossypium hirsutum* and *G. barbadense* which are tetraploid in nature.
**Botanical Name:** *Gossypium* sp. (*G. arboreum, G. barbadense, G. herbaceum and G. hirsutum*).

**Family:** Malvaceae

**Plant part used:** Surface fibre, (Epidermal cells of seed coat).

The fibers are easily detached from the seeds and do not need isolation from other tissues. After removal of the longer fibers (lint fibers), the seeds remain covered with very short fibers, so-called “fuzz”.

**Plant morphology:** It is a sub-shrub, 1 to 1.5 m tall, its stem thick and rigid and, leaves horizontally placed. Leaves and twigs are sparsely hairy and rarely glabrous. Fruit or boll is rounded, beaked 3 or 4 lobular with 11 to 10 seeds per loculus. Seeds have short fuzz and lint.

**Cotton fibers:** they are single elongated cells formed from the seed coat protodermis (immature epidermis). Dozens of seeds are formed within a boll, each ovule producing from 10 000 to 20 000 fibers with a length of 20–60 mm. In elongating fibers the amount of cellulose per unit of fiber length remains constant at about 1 ng mm\(^{-1}\), increasing sharply at the onset of secondary wall formation to reach about 130 ng mm\(^{-1}\) at maturity.

Cotton fiber development is described taking as a reference point the day of anthesis in the flower. Fiber initials on the ovule are first observed immediately after anthesis. Between 10 and 25% of protodermal cells of the ovule develop a fiber. Fertilization is not a prerequisite for fiber initiation, but without it the fibers develop improperly. Fiber initials first develop as isodiametric bulbs on the surface of protodermal cells. Several waves of fiber initiation occur in the ovule, starting at the chalazal end of the ovule. Fiber initials that will develop into the lint fibers continue to be produced for 4 or 5 days. Fiber initials continue to appear for a week more, but those will develop into fuzz.

Within 1 to 2 dpa the fibers start elongation, a process that lasts for several weeks. As fibers continue to elongate they begin to twist together, forming clusters. During the elongation phase the fiber produces a thin, flexible cell wall, capable of growing as the cell volume increases. The elongation proceeds by diffuse growth, when new material is deposited over the fiber length. Accompanying the increases in fiber length and diameter are increases in cell wall thickness. Starting about 15 to 20 dpa the fiber begins to deposit a thick, more rigid secondary cell wall, up to 10 mm thick at maturity. At the onset of secondary wall formation a thin layer of callose is formed at the interface between plasma membrane and cell wall. The polysaccharide is produced with high turnover and later disappears. Simultaneously, the rate of cellulose synthesis increases 100-fold. The ongoing diffuse growth overlaps at least for 1–2 weeks with the intensive cell wall thickening processes.

The direction of the twist changes at frequent intervals along the fibers. In between the primary and secondary cell wall there is an intermediary thin layer called the winding layer, which has a specific, steeply pitched helix orientation of cellulose microfibrils, essentially oriented transversely to the axis of the fiber. The diameter is larger and the helical gyration is oriented opposite to the secondary wall layers. Before the mature fiber dries it appears as a long cylinder which later partially collapses, producing a flattened, twisted ribbon structure. Daily cycling of temperatures during secondary cell wall formation may generate layering in the fiber wall. Swelling of the mature fiber in sodium hydroxide reveals a ringlike pattern under a microscope.
At maturation, at 50 to 60 dpa, the fruit capsule opens, and the cylindrical fibers dehydrate and collapse to ribbonlike, twisted structures.

**Harvesting:** Harvesting is done during October to March. It is harvested in 3 or 4 pickings after the maturity of bolls. Seed cotton is removed from the bolls in the field; in closed-boll cottons, partially open bolls are collected from the plants in the field.

**Yield:** The average yield of seed-cotton is 400-600 kg/ha. The lint yield is 150-200 kg/ha.

**Uses:**

1. Chief use of the cotton is in the textile industry. Other uses include stuffing of pillows, cushions, and also in rubber tyre fabrics.
2. Hull, the outer covering of cotton seeds, is used for cattle feeding, fertilizers, fillers in plastics, and manufacture of insulating materials.
3. Cotton seed oil is used as a cooking oil. Other uses of this oil include in the preparation of soaps, paints and varnishes, washing powders, artificial leather, glycerine, nitroglycerin, etc.
4. Seed cake is used as fertilizer and as cattle feed.
5. *Gossypium* roots are used in some fevers.
6. Leaf juice of *G. berbaceum* is used in scorpion and snake bites.
7. Cotton fibre is also used in paper industry, especially in preparing fine quality paper.