FIBERS

Animal
- Wool
- Silk
- Vegetable
- Synthetic—Rayon

Vegetable Fibers
- Found in hundreds of genera and many plant families
- Historically the "important" fibers have changed over time
  - Cost of production
  - Simplicity of freeing the fiber from unwanted tissues
  - Adaptability of mechanical devices to processing the species
  - Suitability of the plant to prevailing agricultural processes
- Competition with synthetic fibers drastically influences natural fiber production

Historic fibers

Agave	8,000 years old, Tehuacan valley of Mexico
Woven palm leaf fabric	12,000 years old, Mexico
Yucca and Typha mats	11,000 years old, Nevada Cave
Woven Flax	8,000 years old, Switzerland
Cotton cloth	3,000 years ago, India
Hemp	2,000 B.C., China
Papyrus and flax	7,000 B.C., Egypt

What is fiber?

Fibers Botanically

Important constituents of wood (hardwoods) giving many of the mechanical and physical properties.
- Fiber cells, considered distinct from vessel, tracheid, and parenchyma cells in wood, are morphologically distinguished by:
- Slender tapering form
- Very thick walls
- Usually simple pits in the secondary wall
- 1-250 mm long
- 0.01-0.06 mm wide
- Walls frequently 0.01 mm thick, therefore with an exceedingly narrow lumen
- Dead cells at maturity
- Occur in groups or bundles
- Closely cemented together, particularly at the fusiform tips which dovetail obliquely with the next adjacent fiber.
- By these criteria, fibers are also found in tissues other than wood (xylem):
  - Pericycle
  - Phloem
  - Cortex

Fibers Chemically

Consist primarily of nearly pure cellulose

Occasionally with small amounts lignin, hemicellulose and other substances

Ex. flax, hemp, ramie the cellulose is associated with pectic material

Jute fibers are more lignified

High percentage of cellulose in fibers correlates positively with desirable characteristics such as strength and durability.

Likewise, low moisture content of the cell wall is usually indicative of physical superiority.

Fibers Commercially

Practically all small, thin, slender fragments of many substances

Mineral origin

Asbestos

Spun glass

Animal origin

Wool

Silk

Hair

Feathers

Plant origin

Anything from multicellular twigs and roots, to unicellular seed or epidermal hairs

Ex. dried Spanish moss, husk of coconut, flowering stalks of broomcorn, outer bark of many palms

Mass of wood cells-

Ex. paper pulp derived from softwoods, technically without fiber cells, is spoken of as consisting of fibers.

Three categories of fibers (exclusive of wood fibers) based on the type of fiber and from what part of the plant it is derived

1. Soft, Stem or Bast Fibers

Fibers found grouped outside the xylem, in the cortex, phloem and pericycle (bark)

Many of the most important fibers (flax, ramie, hemp, jute)

Found in many dicotyledonous plants

True botanical fibers

Typically found grouped into clusters of several or many cells, and the whole cluster may in some cases serve as the “fiber” in spinning

Each fiber cell is tenaciously cemented to the adjacent fibers by the pectic middle lamella

The strands are very strong and durable, and are able to withstand bleaching or other harsh treatment

Retting

For use, these fibers and bundles of fibers are ordinarily freed from other stem tissues by retting—a process utilizing the action of microorganisms in a suitably moist environment to rot the weaker cells.

Several types of Retting

Underwater retting--raw materials are immersed in ponds and rivers. Both aerobic and anaerobic organisms dissolve away the cementing materials and free the fibers.

Ex. jute in India

Dew retting—the cut stems of the plant are subjected to aerobic conditions by being

left in the field where it was harvested until microbial activity, influenced by

natural moisture from nocturnal dew, fog and rains, frees the fibers.

Ex. flax

2. Hard, Leaf or Structural Fibers

Strands of small, short cells found in monocotyledonous plants—they constitute the supportive and conductive strands primarily in the leaf (few monocots have conspicuous "woody" stems) and are termed fibrovascular bundles.

Most of the important cordage fibers (manila hemp, sisal, New Zealand hemp, Mauritius hemp, istle)

Consist of both xylem and phloem and various ensheathing cells

Found scattered through a sleek pithy matrix of the leaf or stem

The cells are lignified to a greater or lesser degree and are "hard" in comparison with the "soft" fibers found in dicots in which the cellulose is largely associated with pectic materials.

The entire fibrovascular bundle serves as a unit fiber

Cannot ordinarily be bleached or chemically treated

Are less durable than soft fibers

Hard fibers are usually separated by being mechanically scraped free of the pithy matrix through which they are scattered (retting would dissolve the cementing substances, turning them into useless small cells)

Because the unit fibers must be mechanically scraped to free them (which is tedious) hard fibers are grown almost exclusively in regions where cheap labor is available.

3. Surface Fibers

Fibers borne on the surface of stems, leaves, fruits, seeds, etc.

The most important plant fiber today—cotton

Others include kapok (used for stuffing). A shortage of kapok during World War II led to the development of milkweed seed fibers as a substitute.

May be derived from a great diversity of plants.
the most important are seed hairs, consisting of single-cell growths from the
seed surface which are diurnally thickened by deposition of nearly pure increments of cellulose
Quality of seed-hair fiber is high
Separated by ginning—catching of the surface fibers on a battery of toothed disks or combs and concomitant pulling through slots too narrow for passage of the seed. The fibers are torn from the seed, and are then brushed loose or | blown free from the disk or comb.

4. Man-made fibers from natural products

Made from pure cellulose derived from wood including:
Rayon
Cellophane
Acetate
Arnel

Rayon and cellophane
Initially developed in 1855, mass production was not developed until after 1900
Wood chips are chemically pulped, washed, ground and allowed to oxidize
Carbon disulfide is added to produce cellulose xanthate
Caustic soda is added causing the mass to become viscous
The mixture is either extruded in fine sheets (cellophane) or forced through
small openings to produce rayon thread
Can be sanforized and mercerized
Like cotton in performance
can be dyed
crimp or lobe like natural fibers
Better than some natural fibers
uniformly strong
very smooth

Acetate and Acetate fibers
Differ from rayon and cellophane
made from purified cellulose to which one or more acetyl groups are added
therefore, these products are partially synthetic
Have many properties of natural plant fibers
Dry rapidly, hold color, are soft, resist wrinkling and are not attacked by moths or molds

Fibers are also categorized according to the use to which they are put:

A. Textile or Apparel Fibers—used for the manufacture or fabrics.
Quality is usually high

Strength, pliability, pleasant feel, durability
Mostly cotton for high quality textiles (lesser used are flax, ramie or hemp)
For coarse fabrics of inferior quality such as burlap, bagging, sacking etc. jute is the principal fiber (lesser used are cotton, flax, hemp, and a few of the hard fibers).

B. Cordage Fibers—those used for making tying twines or rope and binder twines.
For tying materials, the softer, more flexible fibers are most desirable
Ex. soft fibers such as jute, cotton and hemp (lesser used are flax and several hard fibers)
For rope and binder twine, hard fibers are used
Ex. abacá, sisal, New Zealand and Mauritius hemps (lesser used are cotton and other soft fibers)

C. Brush or Braiding Fibers—used to make brooms and various braided articles such as hats, mats, baskets, rugs etc.
A great variety of miscellaneous twigs, leaves, barks, splints and true fibers are used.
For brushes and brooms many fibers are used:
Istle and sisal hard fibers
Piassava surface fibers of palm leaf and stem
Broomcorn plant inflorescences
Various twigs
For braided material all the hard fibers and various grasses, leaves, sectioned stems, etc. are used

D. Filling Fibers—used for stuffing (upholstery, mattresses, life preservers), caulking (seam between planks, barrels, plumbing) and reinforcing (wall boards, compressed pulp, plastics).

Chief stuffing fibers are kapok, cotton, several hard fibers, jute, Spanish moss and locally innumerable grasses

Principal caulks are hemp and jute

Reinforcing fibers are sisal, istle, hemp and jute fibers too short for spinning

E. Dietary fibers--Psyllium fibers in Metamucil
Made from the ground seeds of *Plantago ovata* or *P. ispaghula*
native to India
A bulk-forming laxative
high in both fiber and mucilage
works by swelling when in contact with water

Specific Fibers—not all can be mentioned. Over 300 fiber plants have been recorded in use in East Africa alone!

Examples
Seed fibers
Cotton--*Gossypium* spp.
Cotton is by far the most important fiber today
Most important nonfood plant commodity
Second mot important oilseed crop

Several reasons for the popularity
The large amount of fiber produced per plant
Picking, processing and manufacturing of textiles (once mechanized) cost less than
processing other plant fibers

Each cotton fiber (staple) is a single long epidermal seed coat cell resembling a hair
Some cultivated cottons also produce a second layer of short fuzzy hairs called linters--these are removed and used for papermaking when cottonseed is harvested for oil

Certain species were independently domesticated in the old and new worlds
The first documented use was in south-central Asia
G. arboreum and *G. herbaceum*
both are diploid
both have short fibers

New world domestics (Mexico and south America)
G. hirsutum (upland cotton) and *G. barbadense* (Sea Island cotton)
Both tetraploid (two sets of chromosomes, one similar to the old world species and one similar to new world species
95% of the worlds cotton crop is *G. hirsutum* because of it resistance to boll weevil

Most species of *Gossypium* are tropical perennials
humans have selected for an annual habit
ability to bloom and fruit in temperate latitudes

Once picked the seeds have to be removed from the fruit and the fibers have to be separated
from the seeds--Enter Eli Whitney

Cleaned--boiling the thread or cloth with caustic soda for 8 hr followed by bleaching with hydrogen peroxide
Mercerized--placing thread or woven textile under pressure in a cold bath of caustic soda
This causes the fibers to swell and to deform
Sized--addition of starch or gel to stiffen and fill surface irregularities

Sanforized--ammonia process that swells the fibers and prevents shrinkage after washing
This has eliminated the tradition of buying a cotton garment one size too large
Permanent press--chemicals that cross-link the cellulose polymers of the cotton cloth
Causes the fabric to retain its shape

Now using native cottons that come in a variety of natural colors (tan, brown, cream and green)
No need to bleach, dye or use other chemicals

Coir
The fibers from thick mesocarp of coconut fruits (*Cocos nucifera*)
This is outside the part we usually see in the stores

The fibers are longer than cotton, but shorter than most bast or leaf fibers

Immature coconuts are harvested and husked, retted for 8-10 months, washed, beaten and washed again

The best fibers come from immature coconuts, but most coir is harder fibers produced from
mature coconuts as a byproduct of copra (dried endosperm) production

Two types of fibers are produced
Mattress fibers--short fibers used for stuffing
Bristle fibers--longer, combed fibers used in brushes, brooms and rough doormats

The fibers are naturally resistant to salt water
Used to produce netting for shellfish or seaweed harvesting

Bast or soft fibers
Jute (*Corchorus capsularis*)

Worlds foremost bast fiber
Second only to cotton in terms of production
Has been used since prehistoric times (probably yielded the fibers for some of the sackcloth referred to in the Bible

Native of the Mediterranean, but has spread to the Middle East and Far East
India is the primary producer

Herbaceous, reedlike annual

Used initially as an inexpensive substitute for flax, the primary use today is for coarse goods
    "gunny" sacking, carpet backs and wall covering
The fibers are inelastic and rough
Brittle and deteriorate rapidly in water
Do not hold dyes well

Flax and Linen (*Linum usitatissimum*)
Considered the oldest textile fiber

Flax is native to Europe and eastern Asia

Flax fibers are naturally smooth and straight
    Are 2-3x as strong as cotton fibers
    Used for thread, hoses and mailbags

Cotton did not replace linen as the favorite plant fiber for clothing until the 19th century
    More expensive than cotton to produce because they must be handled by hand
        during the Dew or chemical retting stage.

Hemp (*Cannabis sativa*)
Has been cultivated since prehistoric times for fiber (not for psychoactive resins)

Hemp fibers are the longest of any bast species

Harvested by retting, followed by scutching and pounding
    Well-processed hemp is creamy white and soft but very tough
    Quickly-processed hemp is dark and rough

The fabric called canvas gets its name from "kannabis" the Latin and Greek word for hemp
Levi Strauss used hemp sailcloth imported from Nimes, France (French name serge de Nimes)--we now call it denim.
A shipment of cloth from Genoa (called Genes by the French) gave rise to the word jeans for denim pants

Ramie (*Boehmeria nivea*)

Dioecious perennial native to tropical Asia
    Used for over 7,000 years
Some Egyptian mummies were wrapped in Ramie rather than linen
Strong, durable fibers that are among the longest and silkiest plant fibers

Until recently it was difficult to produce
    Bark must be peeled and fibers decorticated
    Strands mature unevenly
    Fibers contain considerable gum and pectin

Increasingly important fiber for textiles and materials requiring exceptional strength
    Camping lantern mantles and backings in fire hoses
    Processing now mechanized

Leaf or Hard fibers
Sisal (*Agave sisalana*) **and Henequen** (*Agave fourcroydes*)

Native to Central America
    Mayans and Aztecs wove sisal fibers into rough garments
Native to and grow best in arid regions--excellent crops for regions little suited for other types of cultivation
    Mexico, Brazil and Africa

Leaves are cut at the base, fed between rollers that squeeze out most of the water and turn the soft tissues into an amorphous mush that is scraped away from the fibers.
The fibers are hung in the sun to dry.
They are naturally creamy white, but can easily be dyed.

Abacá or Manila hemp (*Musa textilis*)

A relative of the banana native to the Far East

The fibers are extracted from the outer parts of the leaf bases that make up the petiole or "stem" of these giant plants
Used in the making of tea bags, dollar bills, Manila envelopes, filter tip cigarettes, ropes

Also used for textiles