Fiber

What plants did you see this weekend or read about that humans use for fiber?

What part of the plant is used?
What is a plant fiber?

Composed of cellulose--glucose molecules attached in a specific way

Similar to starch, but unlike starch it can only be broken into sugar with specific enzyme cellulase, which only a few organisms make (bacteria, gut flora)

Cellulose

Starch

C. Ophardt, c. 2003
Animal fiber made of protein
– denatures at high temperatures –

Plant fiber
– not a problem –

How does this affect the way you do laundry?

Seed & fruit fibers: surface fibers such as seed hairs
Bast or soft fibers: bunches of phloem found in stems
Leaf or hard fibers: composed of xylem and phloem from leaf

Use of fiber affected by length and structure, elasticity
Common process to extract fiber from plant

**Retting** – decomposition of soft plant parts by bacteria used for many soft fibers (usually stems)

**Decortication** – unwanted tissues scraped way used for hard fibers (usually leaves)

**Ginning** – Surface fibers separated mechanically from plant material
Seed & fruit fibers

**Cotton** (*Gossypium* sp.; Malvaceae)

**Kapok** (*Ceiba pentandra*; Malvaceae)

Function of fibers on seeds?
Seed & fruit fibers

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Function of fibers on seeds?
- *Facilitate wind dispersal*
Seed & fruit fibers

Cotton (*Gossypium* sp.; Malvaceae)

Kapok (*Ceiba pentandra*; Malvaceae)

Function of fibers on seeds?
- Facilitate wind dispersal

Coconut (*Cocos nucifera*; Arecaceae)

Function of fibers on fruit?
- Protect seed, facilitate water dispersal, buoyancy
Most seed fibers too short or too slippery to be spun together except for cotton

**Kapok:** Stuffing material; was used in life preservers as the fibers are water-resistant and trap air
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**Coconut:** only fruit from which fiber (coir) is extracted; ropes and doormats
Cotton (*Gossypium* sp.; *Malvaceae*)

- Most important non-food commodity and also important as oil seed (cottonseed oil)
- Species domesticated separately in Old and New World
- Easy to process and high amount of fiber per plant
- Dyes well and holds up to repeated washing
- Each fiber is a *single* long seed coat cell
- Cotton gin removes seeds from fibers
- Fibers spun into thread
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- Bt cotton available
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- Flax
- Hemp
- Jute
- Ramie
Flax (*Linum usitatissimum*; Linaceae)

- Native to Europe and E. Asia
- Oldest textile fibers used by people; also extract linseed oil
- Words “line” and “lingerie” are from the latin for linen
- Flax fibers are smooth, 1-3 ft long, straight and 2-3 times stronger than cotton
- Stem fibers of annual plant woven to make linen for at least 10,000 years
- Egyptians cultivated it and used linen to wrap mummies
Jute (*Corchorus* sp.; Malvaceae)

- Annual plant native to tropical Asia
- Fiber extracted from stems; not as strong as other bast fibers, brittle and inelastic; 5-20 feet long
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- Fiber used for burlap, rope, carpet backing, upholstery lining
- Sackcloth made in medieval Europe for penitents made from jute
- Jute mainly produced by India and Bangladesh; second only to cotton in terms of production due to ease of processing and rapid growth
Hemp (*Cannabis sativa*; Cannabaceae)

- Cultivated since prehistoric times in China, where it originated
- Spread around the world for fiber use
- Fibers similar to flax but stiffer, 5-15 feet long
- Well processed hemp is white, soft and silky
- Most processed cheaply, resulting in rough fiber used for canvas (from *Cannabis*) or rope
- Cultivation of hemp illegal in US
Ramie (*Boehmeria nivea*; Urticaceae)

- Native to tropical Asia, used as fiber for >7000 years
- Uncommon due to difficult harvesting, and pectins and gums must be removed from fibers
- Strong and durable fibers that are some of the longest and silkiest
- Some Egyptian mummies wrapped in ramie cloth
- Now mechanically harvested, decorticated, and de-gummed
- Used for products requiring exceptional strength
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Sisal
Pineapple cloth
Manila hemp
Sisal (*Agave sisalana*)
Henequen (*Agave fourcroydes*); Agavaceae

- Native to arid areas of central America; rough garments made by Aztecs and Mayans
- Leaves used for fiber (3 ft long); spines on sisal leaves used as needles
- Once soft leaf material is removed, fibers are washed and dried and then can be used directly
- Fibers used for floor mats, rope, tea bags
Pineapple cloth (*Ananas comosus*; Bromeliaceae)

Manila Hemp or Abaca (*Musa textilis*; Musaceae)

- Fibers extracted from leaf petioles (stalks); fibers can be 15 feet long
- Used for clothing, cigarette filters, teabags; mainly used for marine rope
Plant Dyes

Old World:

**Henna** (*Lawsonia inermis*; Lythraceae): hair dye, red-brown dye from leaves

**Indigo** (*Indigofera tinctoria*; Fabaceae): royal blue (historically an important trade item from India) from leaves

**Redcoats**: madder: red dye from roots of *Rubia tinctorum* (Rubiaceae)

**Woad blue**: *Isatis tinctoria* (Brassicaceae), dye from leaves (foul stench)

**Yellow weld**: *Reseda luteola* (Resedaceae), dye from seed

**Civil war gray**: *Juglans cinerea* (Juglandaceae), bark and nut shells

New World:

**Red-orange annatto** (*Bixa orellana*; Bixaceae): seeds still used for coloring cheese, margarine, cosmetics

**Red bloodroot** (*Sanguinaria canadensis*; Papaveraceae)

**Purple or black logwood** (*Haematoxylum campechianum*; Fabaceae); first source of true black; dye from wood

*Most dyes used today are synthetic, aniline dyes from coal tar*
Palms…

Thatching
Fans
coir
“Restios”
Restionaceae
Common roof thatch in cape region of South Africa
What are some uses of wood?
Uses of wood pulp?

**Clothing**: wood pulp for *rayon*, bamboo also used

**Paper**: papyrus, bamboo also used
Wood is secondary xylem

Spectrum of wood colors comes from different-colored compounds in xylem
Cork is a component of tree bark; all trees produce it, but usually in small amounts.

**Cork oak** (*Quercus suber*, Fagaceae)

- thick layers of cork that can be removed without damaging trees
- Native to Mediterranean, likely think cork evolved for fire protection

Comprised of many air filled cells that can withstand compression and then return to original shape

Used for wine “corks”
Shoe soles
Fishing floats
Spaceship insulation
Bark & wood often used in Tanning
Natural plant tannins still important in leather industry

*Process of tanning turns raw skins into leather than can resist water, heat, microrganisms*

*Plant chemicals – polyphenolics – react with protein fibers, chemically bonds with them to resist microbial attack*

**Important plants include:**

- Sumac (*Rhus* sp.; Anacardiaceae)
- Oaks (*Quercus* sp.; Fagaceae)
- Spruce (*Picea* sp.; Pinaceae)
- Pomegranate (*Punica granatum*; Punicaceae)
- Hemlock (*Tsuga canadensis*; Pinaceae)
- Quebracho tree (*Schinopsis lorentzii*; Anacardiaceae)
- Wattle (*Acacia* sp.; Fabaceae)
Latex

mixture of compounds; usually milky white but can be yellow, red, others…

From laticifers: single cells or strings of cells that form tubes, canals in various plant structures

Rubber: from latex that contains terpenoid compounds; composed of chain of isoprene molecules
• Aztecs used balls for sport made of **Panama rubber**, *Castilla elastica* (Moraceae)

• Originated with the Olmecs (Rubber people)

• Latex mixed with juice of morning glory; similar effect as “vulcanization”, developed by Charles Goodyear in 1839, involving mixing rubber with sulphur and heating; cooled substance retains elasticity and is unaffected by weather
Rubbers in Family Sapotaceae:

- Gutta-percha, (*Palaquium gutta*); used to be in center of golf balls; also used to coat undersea cables
- Chicle (*Manilkara zapota*); base for chewing gum
Amazonian rainforest: *Hevea brasiliensis* (Euphorbiaceae); most natural rubber comes from this species
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Natural rubber still used in various products such as gloves, catheters, other medical supplies; also condoms, pacifiers, balloons, tires (radial tires contain 30% natural rubber, which is more resilient than synthetics)
Guayule (*Parthenium argentatum*; Asteraceae)

- Latex in root of desert shrub; rubber as good as from *Hevea* trees
- Used in later 1800s-early 1900s
- Recent resurgent interest given common allergies to *Hevea* latex, development of cultivars in Arizona that can produce 900 pounds of rubber per acre
- Leftover latex materials used as resin to protect wood from termite damage and fungal rot