

# Common Plant Fibers

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# Plant Fibers

## Three Major Types:

- Seed/Fruit Fibers
- Bast Fibers (Stem or Soft Fibers)
- Structural Fibers (Leaf or Hard Fibers)



# Seed/Fruit Fibers

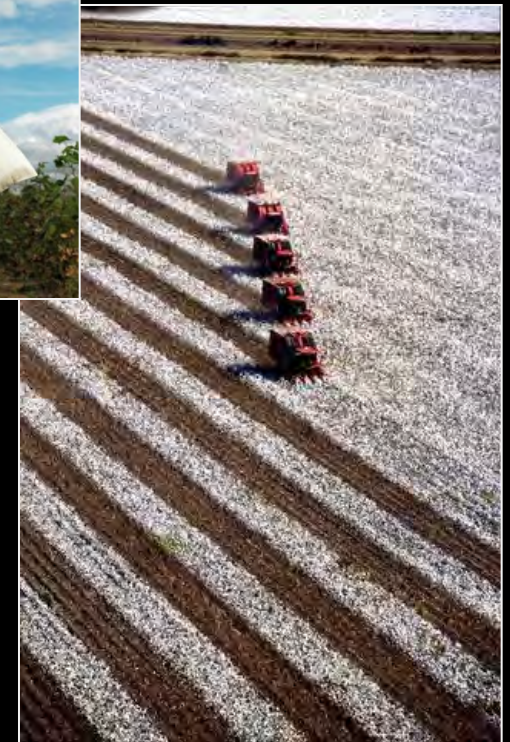
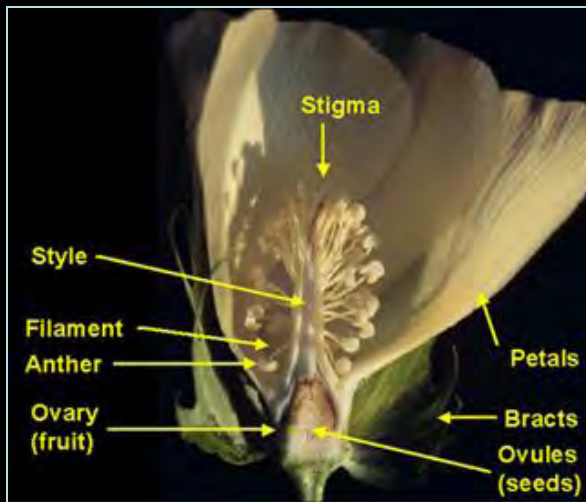
- Fibers that are collected from seeds, seed cases or the fruit of the plant. They are unicellular and used as individual fibers rather than bundles.

- Cotton
- Kapok
- Coir



# Cotton

- Formed by the elongation of a single epidermal cell of the cottonseed. This staple fiber grows in a boll (protective capsule) around the seeds of cotton plants. It can be harvested by hand or by modern machinery.



# Different Types of Cotton

- There are four commercially-grown species of cotton:
  - *Gossypium hirsutum* or Upland Cotton – grown in Central America, Mexico, Caribbean and South Florida (90% world production)
  - *Gossypium barbadense* – Creole, Egyptian, Pima or Sea Island Cotton. Native to tropical South America (8% world production)
  - *Gossypium arboreum* – tree cotton, native to India and Pakistan (<2%)
  - *Gossypium herbaceum* – Levant cotton, native to South Africa and the Arabian Peninsula (<2%)
- The primary difference between these is in the staple length, therefore they are virtually indistinguishable by microscopy.
- The cottons that are extra long staple (ELS) are more desirable because they can be made into stronger and softer yarns. Most high thread count sheets are made from ELS cotton because a long fiber is needed to make a very thin, yet strong yarn.

# Cotton Processing

- Some cotton may be “mercerized”. Created by John Mercer, who treated fibers with sodium hydroxide. Now after treatment the fibers are neutralized in an acid bath. The cell wall of the fibers swell and untwist a little which increases the surface area and reflectance of the fibers giving fabrics a softer feel, more luster, strength, affinity for dye, and resistance to mildew (also called “Pearl Cotton”).



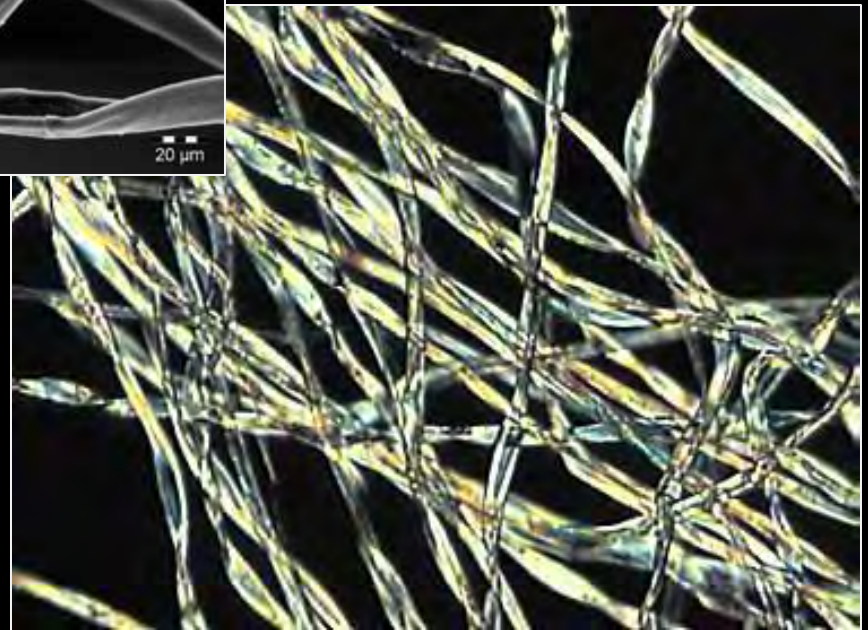
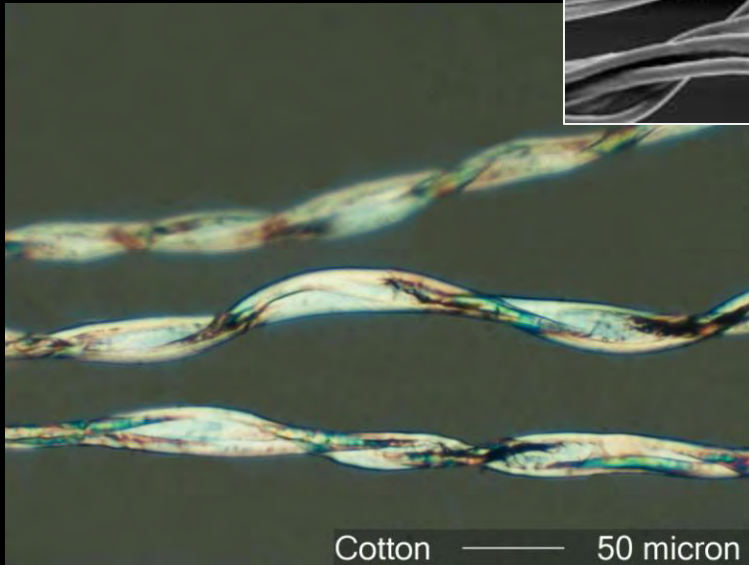
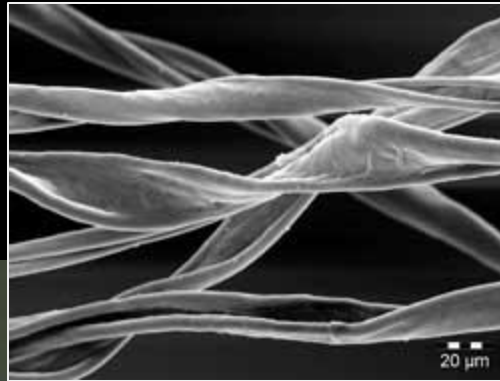
# Cotton Uses

- Fibers and linters (fibers  $< 1/8$ " that adhere to cotton plant after ginning) are used in textiles, fishnets, coffee filters, gunpowder (nitrocellulose), paper (including money), bookbinding, and in the manufacture of cellulose.



# Cotton Fibers

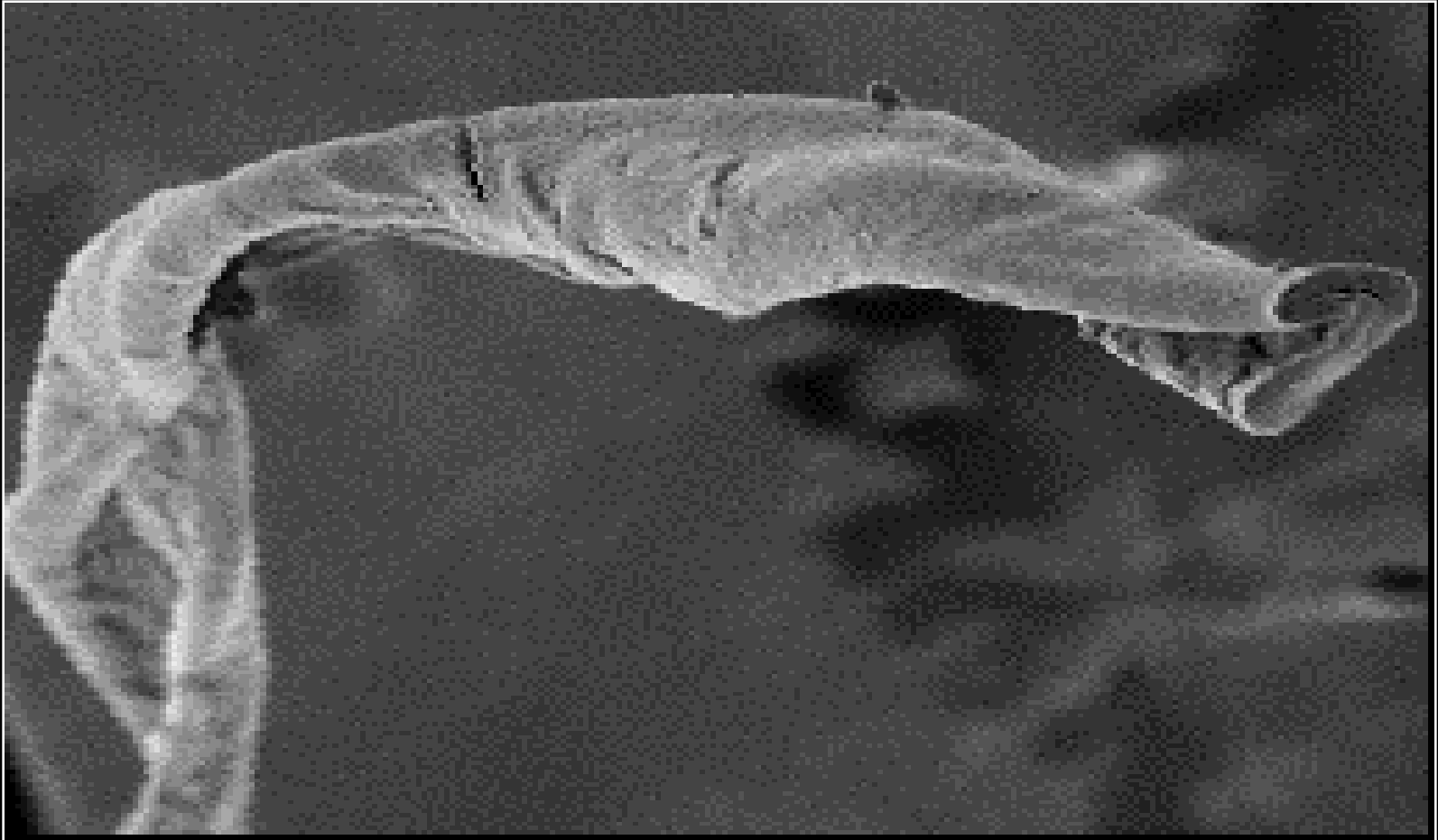
- Composed primarily of cellulose, wax and fat. Fibers appear ribbon-like and twisted forming convoluted flattened tubes. Can be distinguished by its lack of extinction under cross-polars.





# Cotton Fibers

- Cross sectional shape is U-shaped or ellipsoid.



\* Photo courtesy of Karen Korsberg Lowe - FBI laboratory

# Kapok

- Extracted from the seed pods of the Kapok (*Ceiba* or *Bombaceae*) tree native to Mexico, Central / South America, Caribbean, Asia. Sometimes called “Bombax cotton” or “Java Cotton” since it is an important export for the Indonesian island of Java. Fibers are removed from the pod by hand and then dried and separated from the seeds.



# Uses for Kapok

- Short fibers which are too brittle and inflexible to be spun into yarn so its primary use is as a filler in pillows and cushions. Kapok is also non-allergenic, non-toxic and odorless. – however it is highly flammable so man-made materials largely replaced the fiber until the recent “eco-friendly movement”.
- Naturally buoyant (can support up to 30 times their own weight in water) so particularly prominent in life vests and boat cushions.



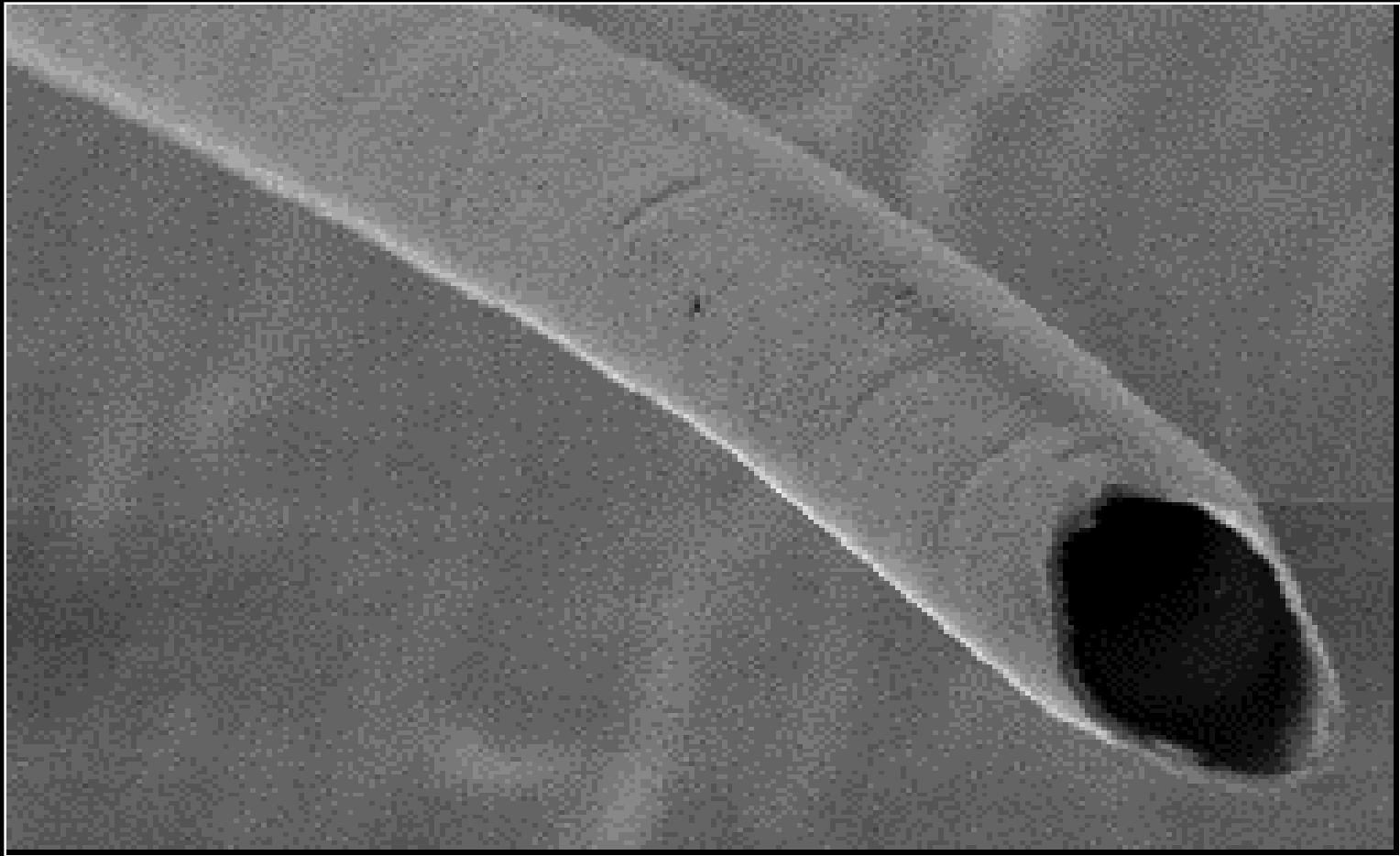
# Kapok Fibers

- Fibers are smooth, cylindrical, hollow, thin walled tubes that range from colorless to yellow-brown in color. Fibers are frequently bent over themselves and taper at one end with a bulbous base which has a net-like thickening. Hollow tubes often filled with air. Have a very “fluid” appearance.



# Kapok Fibers

- Cross section is round or oval with thin walls



\* Photo courtesy of Karen Korsberg Lowe - FBI laboratory

# Coir

Seed / Fruit fiber from the coconut. These fibers are seen as a reddish mass between the outer husk (seed) of the coconut and the shell of the inner kernel (fruit). Harvested by humans and trained monkeys in India, Sri Lanka, Mexico, Indonesia, Vietnam and Caribbean. Pliable white fibers come from green coconuts and stiff brown fibers come from mature coconuts. After manual separation from the husk, fibers are soaked in slow moving water for up to 10 months to soften fibers before processing.



# Uses for Coir

- Coir is used to make floor mats, brushes, pots, mattress padding, sacking, and ropes. Coir is free of bacteria but is a strong allergen (a large portion is also sprayed with latex to bond fibers together).



# Coir Fibers

- The edges of the ultimates often show a wavy outline. The fibers contain round stegmata that are particularly characteristic.





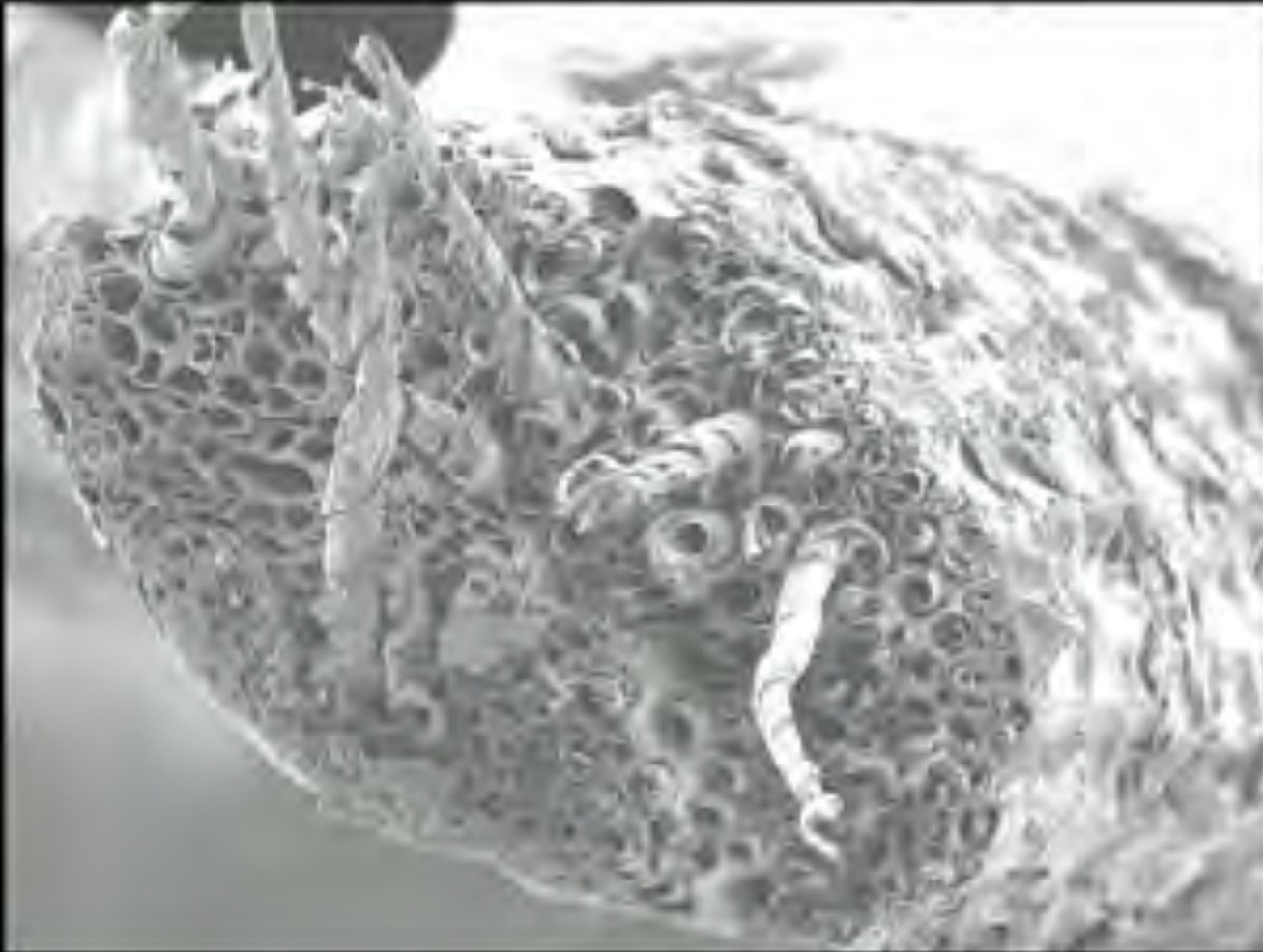
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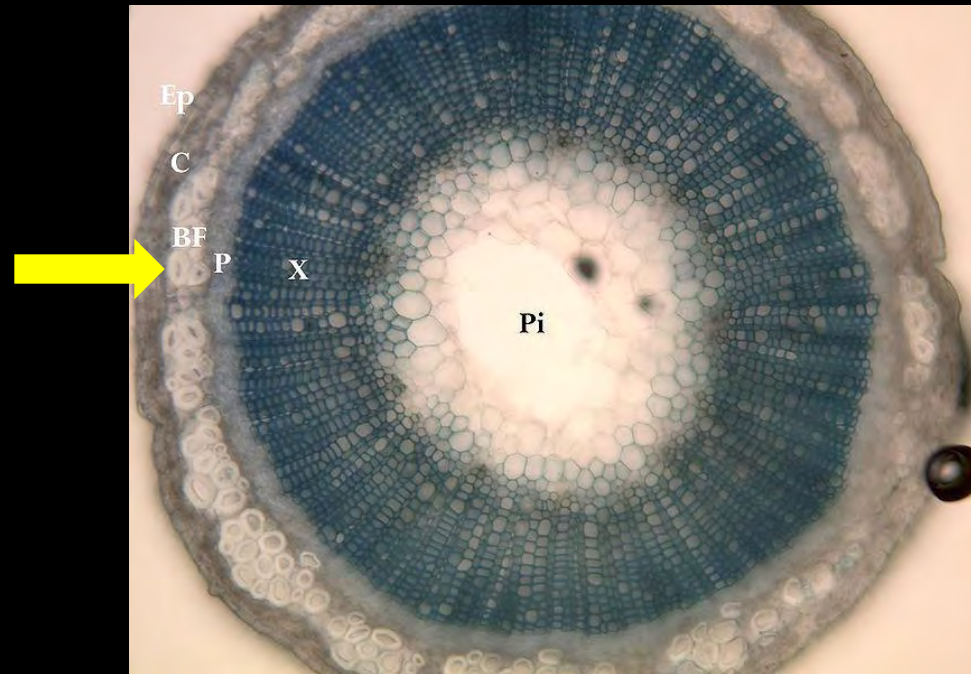
- Cross section shows bundles of thin walled cells



# Bast Fibers

- Also called Stem or Soft Fibers - Fibers that are collected from the phloem (conductive tissue) of the stem of dicotyledonous plants (those having two leaves in the embryo of the seed). They are long multi-celled fiber bundles or single fibers containing cellulose and they can have some lignin.

- Flax
- Jute
- Ramie
- Hemp



# Retting of Bast Fibers

- Retting is necessary to recover all bast fibers from the stems of the plants. This process employs the action of micro-organisms and moisture to soften and separate fibers by partial rotting of the cellular tissues and pectins surrounding the fiber bundles. Stems can be retted in fields by dew or rain, or can be placed in rivers, lakes, or tanks.



# Flax

- *Linum usitatissimum* so the fiber and fabric made from it is also called Linen. Flax is commonly grown in the US, Canada, Ireland, Northern Europe and Russia. Flax is typically pulled out by the roots, and laid on the ground in a thin even layer for retting.



# Uses for Flax

- Flax is claimed to be the strongest of vegetable fibers and is highly absorbent evaporating moisture quickly. The high wax content gives it excellent luster. Linen is used in table cloths, napkins, suits, bedding, and twine.



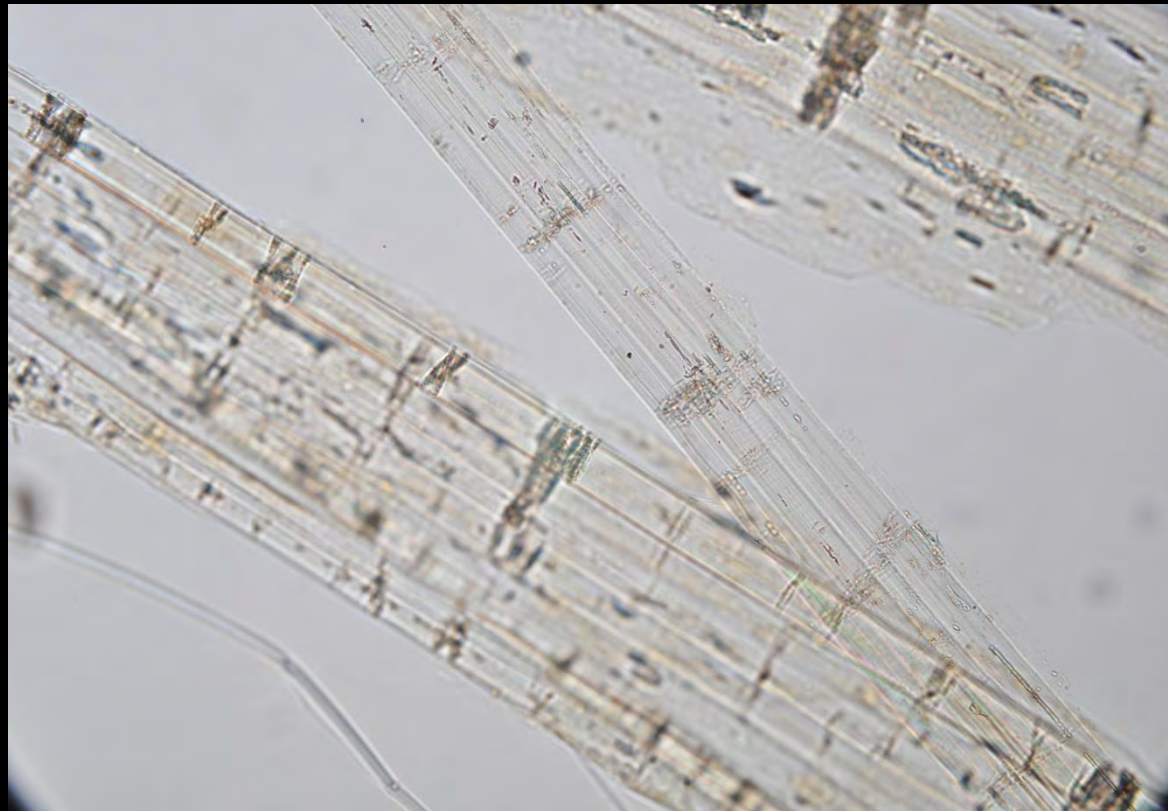
# Flax Fibers

- Colorless to pale yellow fibers. Nodes appear like X's, V's, or Y's with some thickening giving fibers a bamboo look. Width of ultimates don't vary much along length. Extinction is parallel for single fibers. 2-10 fibers in a bundle are common.



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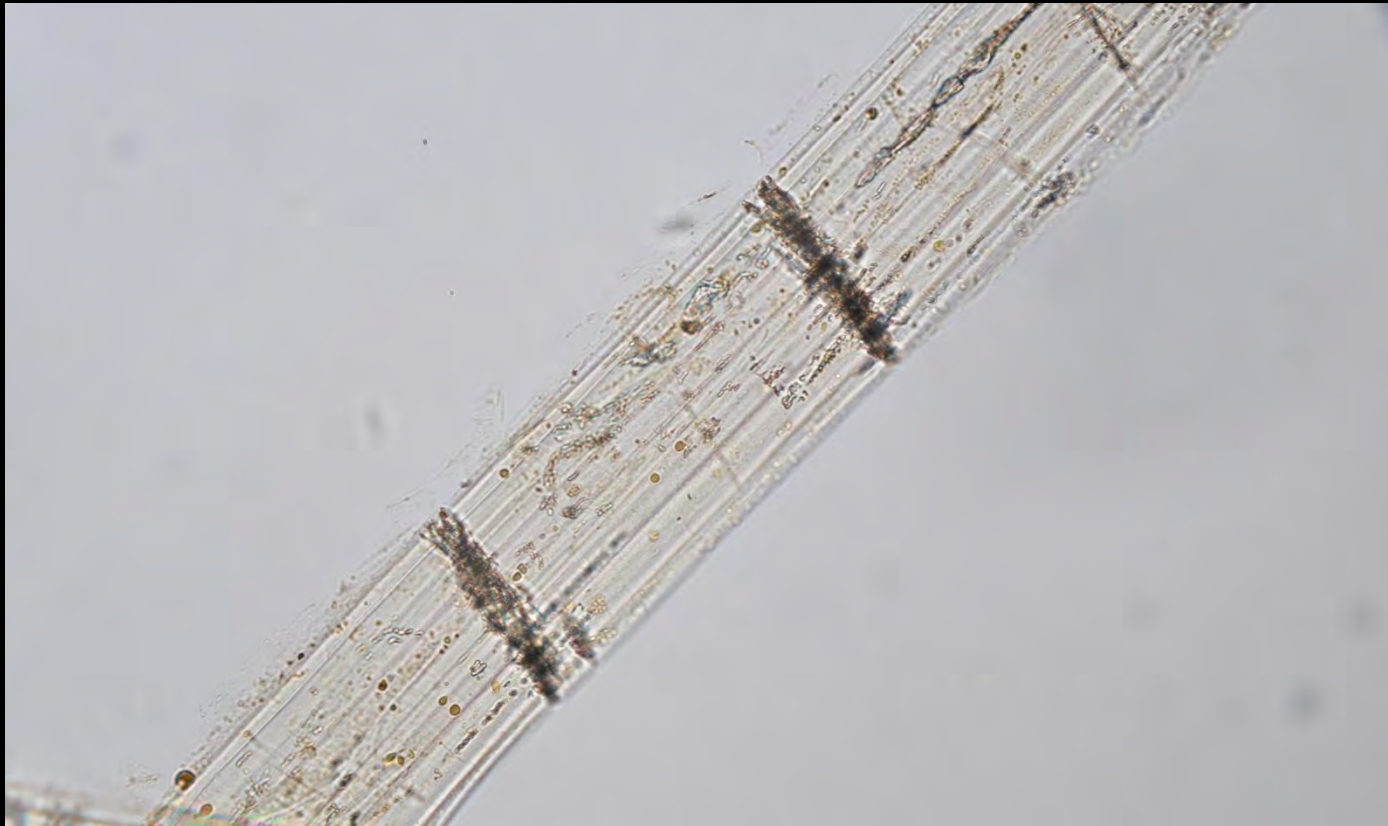
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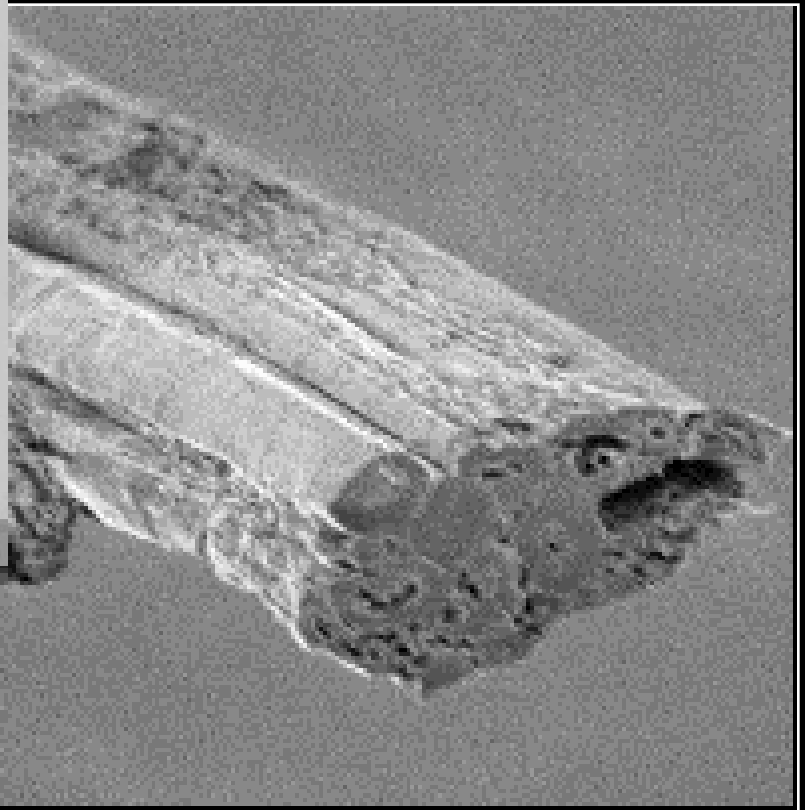
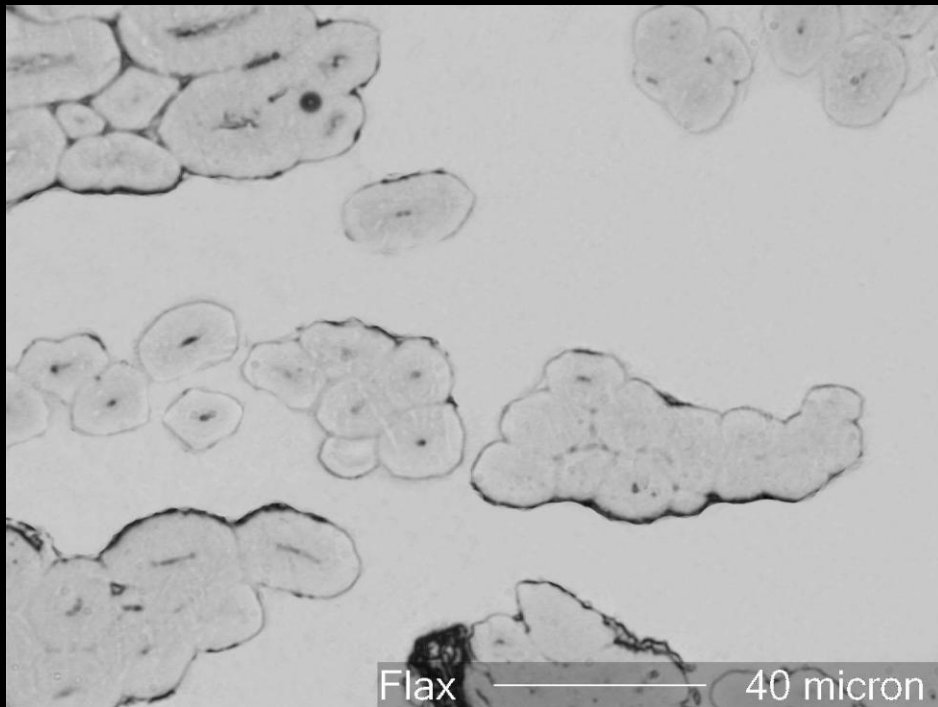
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# Flax Fibers

- Smooth rounded polygonal cross section.



\* Photo courtesy of Karen Korsberg Lowe - FBI laboratory

# Jute

- Obtained from the bast of two plants – *Corchorus capsularis* and *Corchorus olitorius*. It's mainly grown in Bangladesh and India in standing water and is then retted typically in that same water.



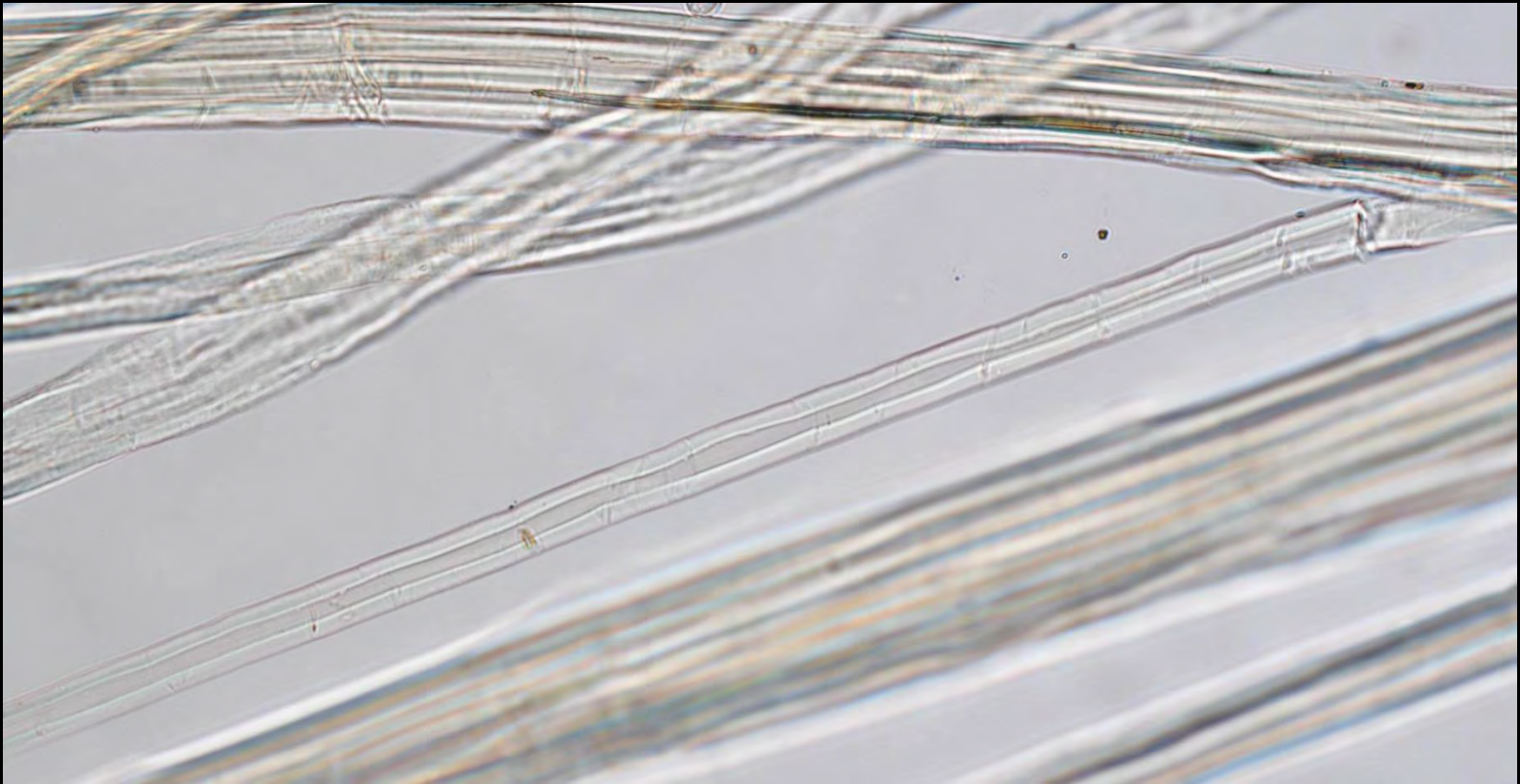
# Uses for Jute

- Used in the manufacture of burlap bags, wall hangings, rugs, carpet backing, twine and geotextiles (landfill covering, embankment reinforcement).



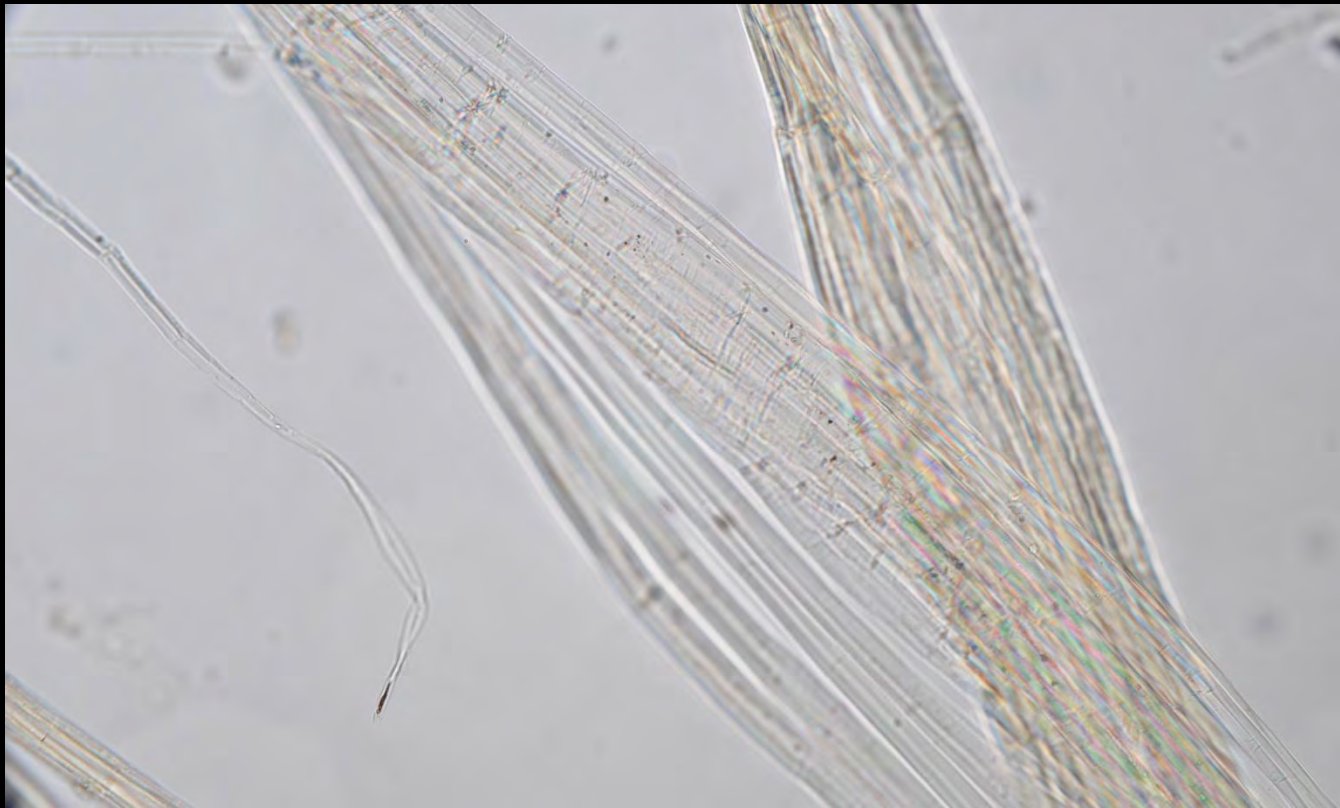
# Jute Fibers

- Colorless to pale yellow straight smooth cylinders with some nodes (not conspicuous). Lumen is prominent and irregular with constrictions. Ends of ultimates taper to points. Fibers show parallel extinction. Jute is used in bundles and never separated down to the ultimate.



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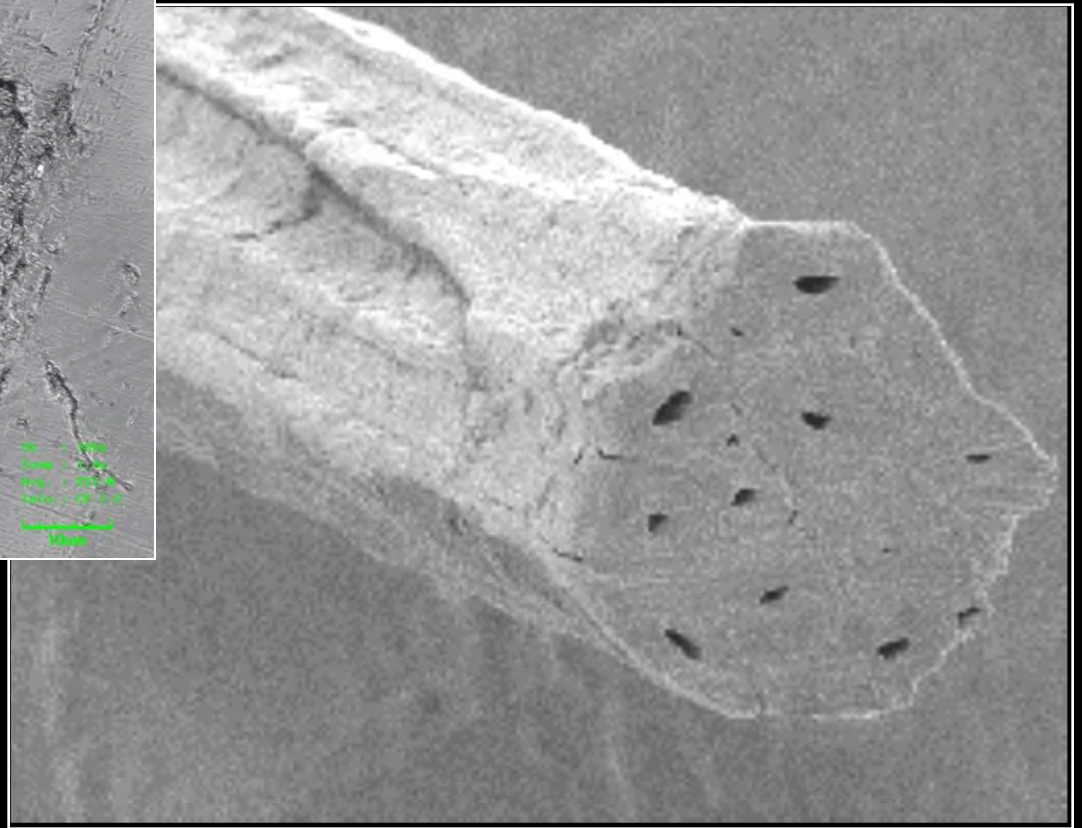
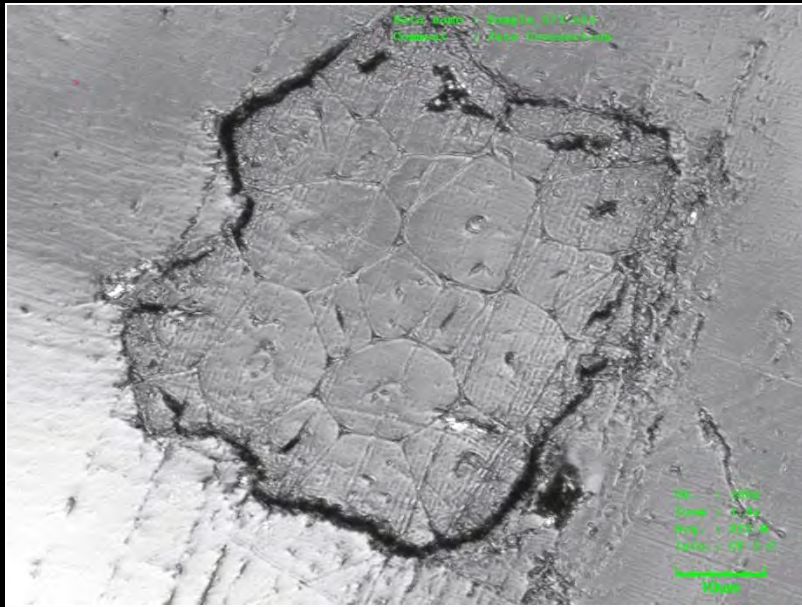
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# Jute Fibers

- Cross section shows thick walled polygonal cells (ultimates) each containing a central lumen or canal.



\* Photo courtesy of Karen Korsberg Lowe - FBI laboratory



# Ramie

- *Boehmeria nivea* is a flowering plant (bush) in the nettle family native to eastern Asia – also called “China Grass” or “Rhea”. The plant is often cut by hand just above the root. Retting is a more complex process than with other bast fibers due to gums and pectins surrounding fibers which have to be removed by scraping, pounding, heating, washing and exposure to chemicals. The process is expensive and difficult to control often resulting in damaged fibers. Fibers can be harvested between 3-6 times a year.



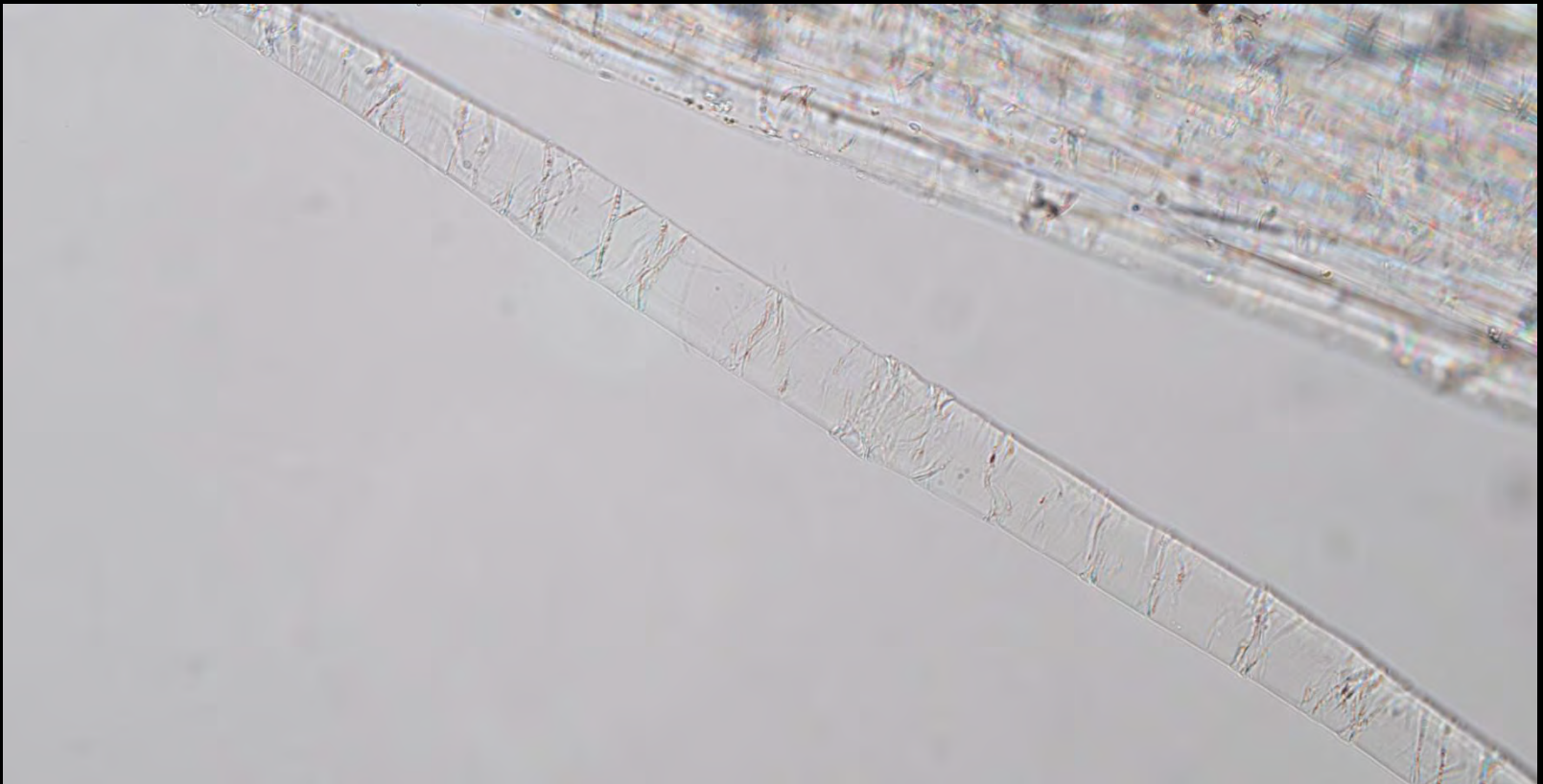
# Uses for Ramie

- Ramie is used for apparel, curtains, bedding, handkerchiefs, upholstery, canvas, filter cloth, fishing nets, rope, twine and sewing threads.



# Ramie Fibers

- Transparent and colorless fibers with node-like ridges having X-markings, longitudinal striations and no twisting. Can almost be identified by diameter alone which varies considerably and can be up to 80 microns. . Cluster crystals. Extinction is parallel except at nodes.



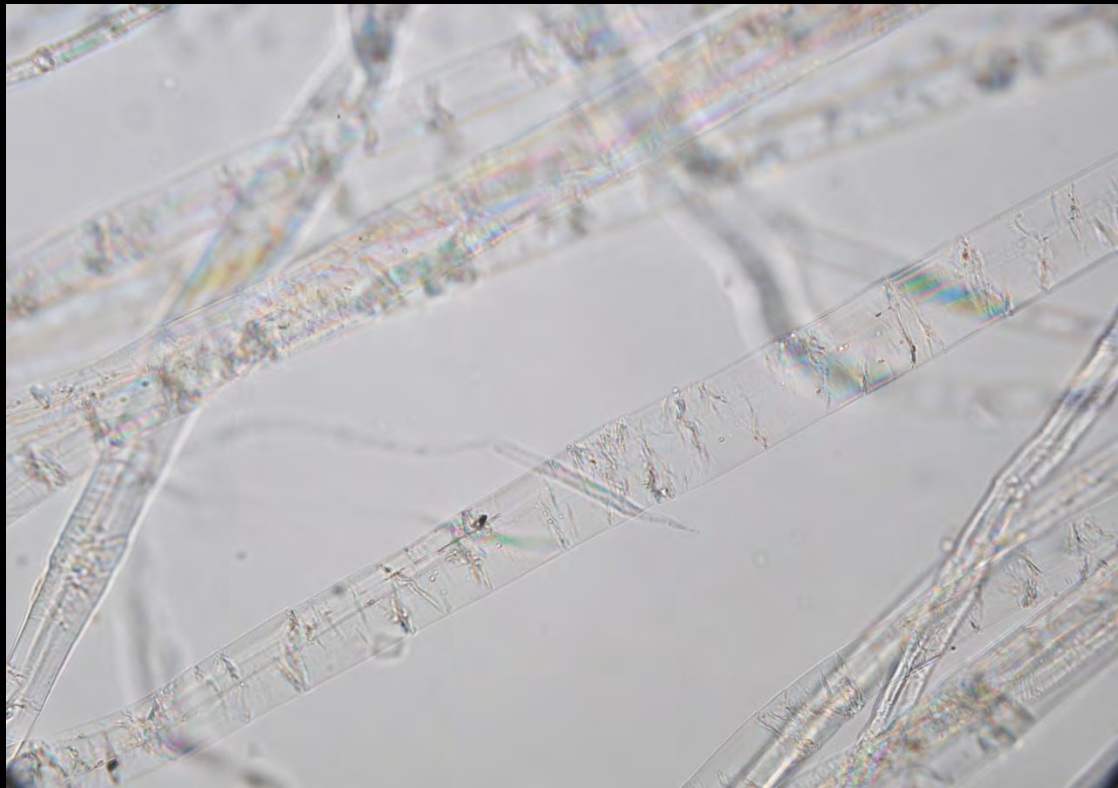
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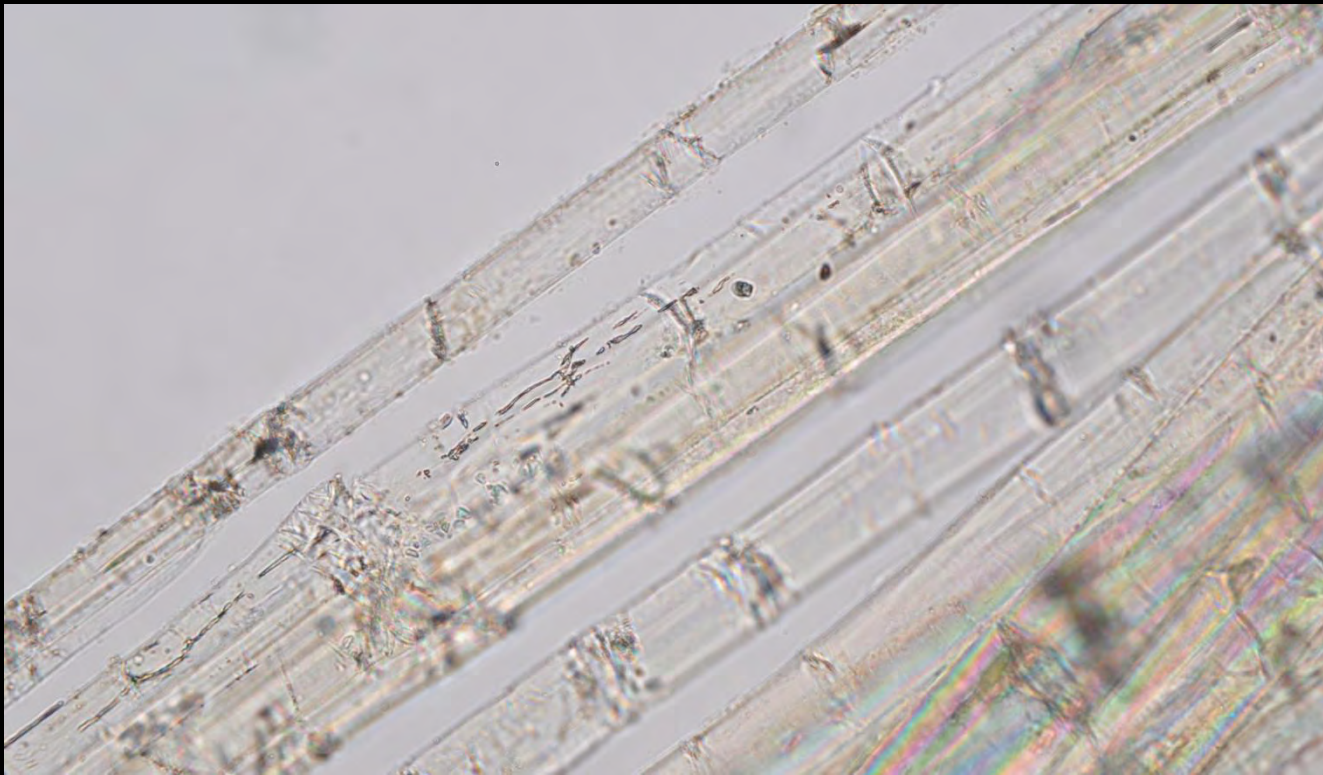
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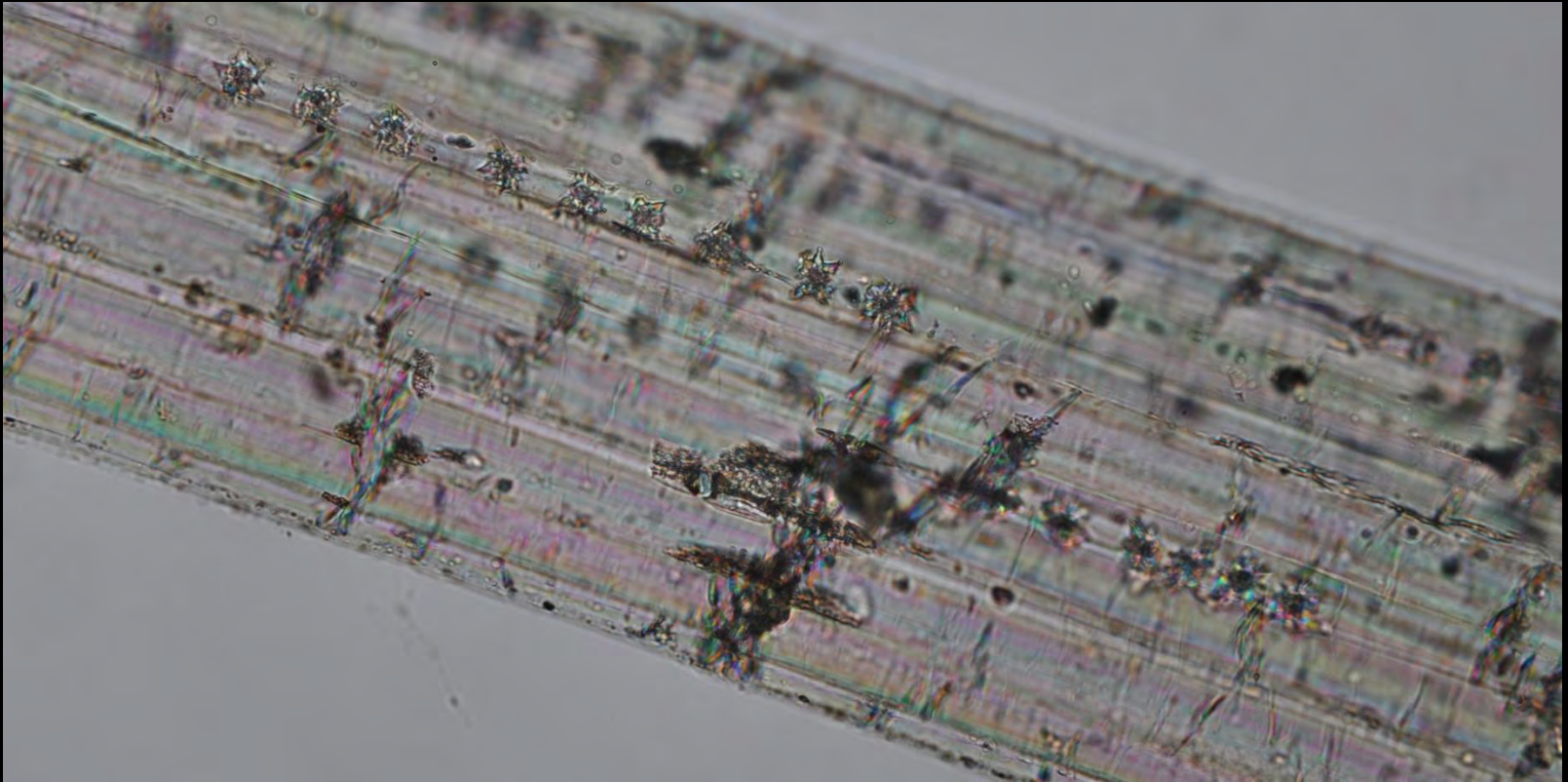
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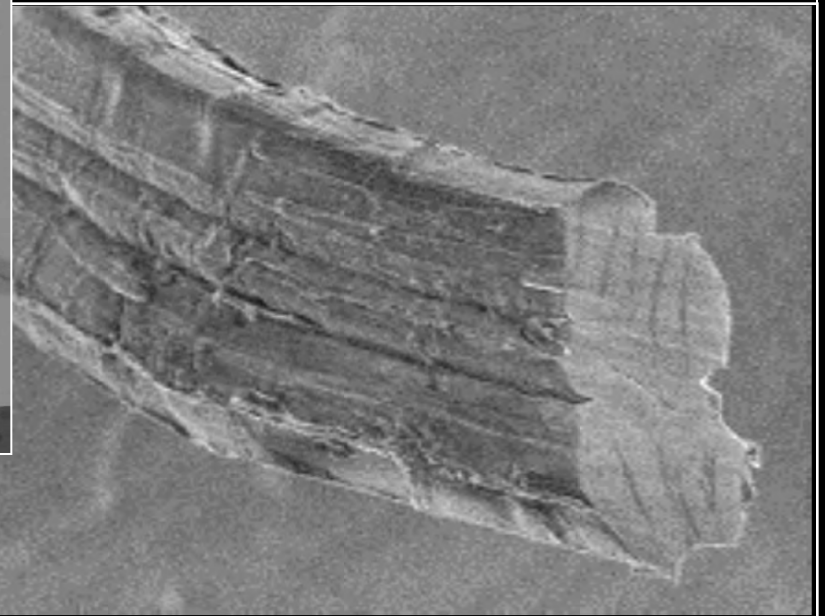
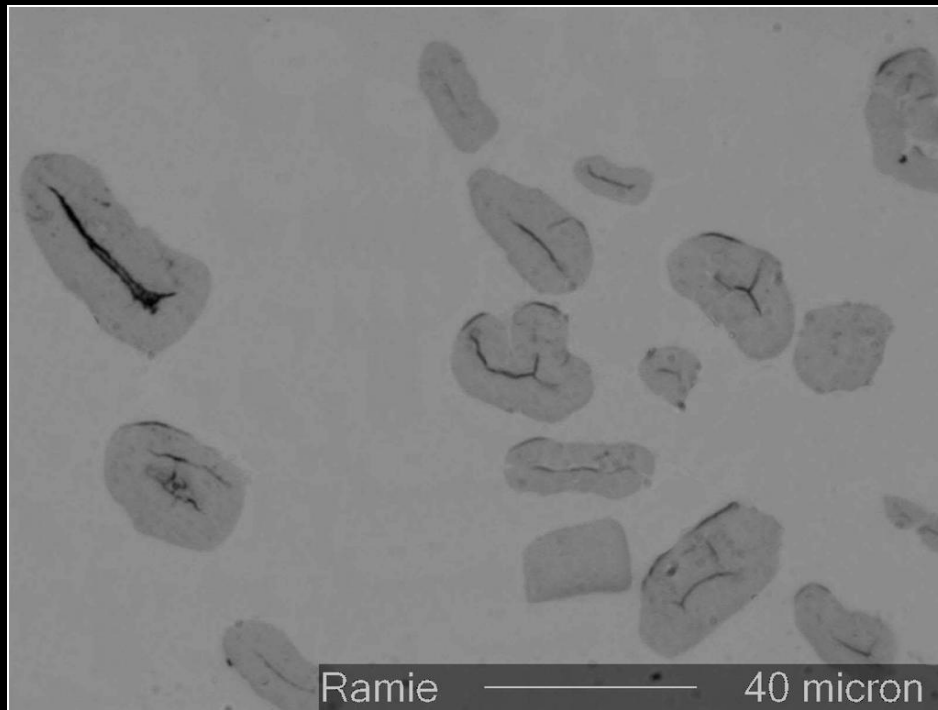
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# Ramie Fibers

- Cross sectional shape is similar to cotton with obvious radial lines from lumen.



\* Photo courtesy of Karen Korsberg Lowe - FBI laboratory

# Hemp

- Hemp is a distinct variety of the plant species *cannabis sativa*. Most of the world's hemp is grown in China. Hemp fibers are very long, strong and mildew resistant. They are picked by hand or mechanically and then must be defoliated (chemically, by retting, or by hand) which is a very labor intensive process. Hemp was such a major source of fiber for centuries that other natural fibers were sometimes incorrectly named after it.



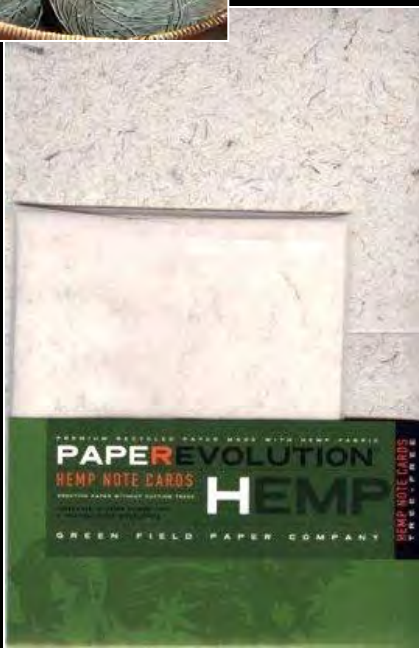
# Hemp vs. Marijuana

- Industrial hemp and marijuana are both classified by taxonomists as *Cannabis sativa*, a species with hundreds of varieties. *C. sativa* is a member of the mulberry family. Industrial hemp is bred to maximize fiber, seed and/or oil, while marijuana varieties seek to maximize THC (delta 9 tetrahydrocannabinol, the primary psychoactive ingredient in marijuana). Hemp contains virtually no THC.
- While it is theoretically possible to get permission from the government to grow hemp in the US, the requirements would be cost-prohibitive (field secured by fence, razor wire, dogs, guards, and lights).



# Uses for Hemp

- textiles, clothing, canvas, rope, cordage, archival grade paper, paper, and construction materials.



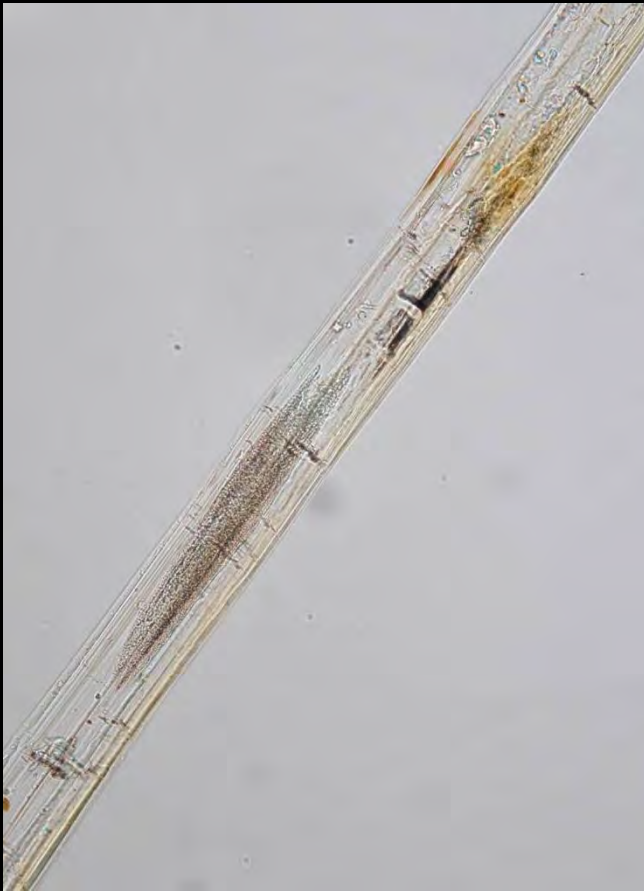
# Hemp Fibers

- Transparent to brown fibers with node-like ridges having X-markings and no twisting. Extinction is parallel except at nodes. Often brown and yellow particulate present with air bubbles being common in bundles.



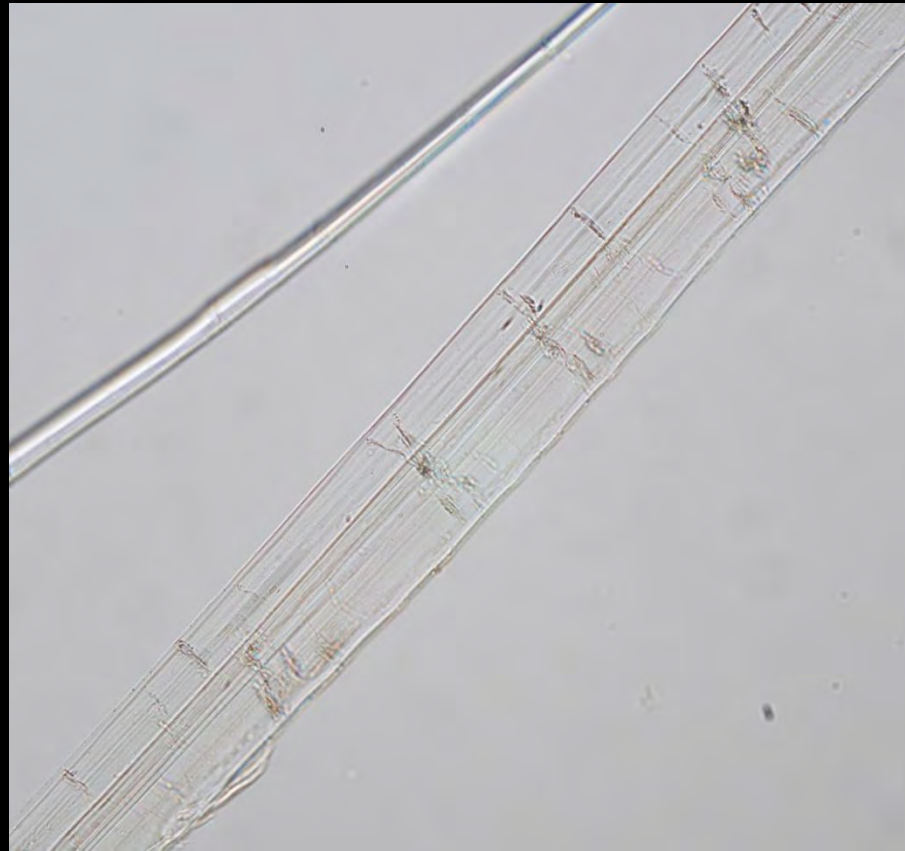
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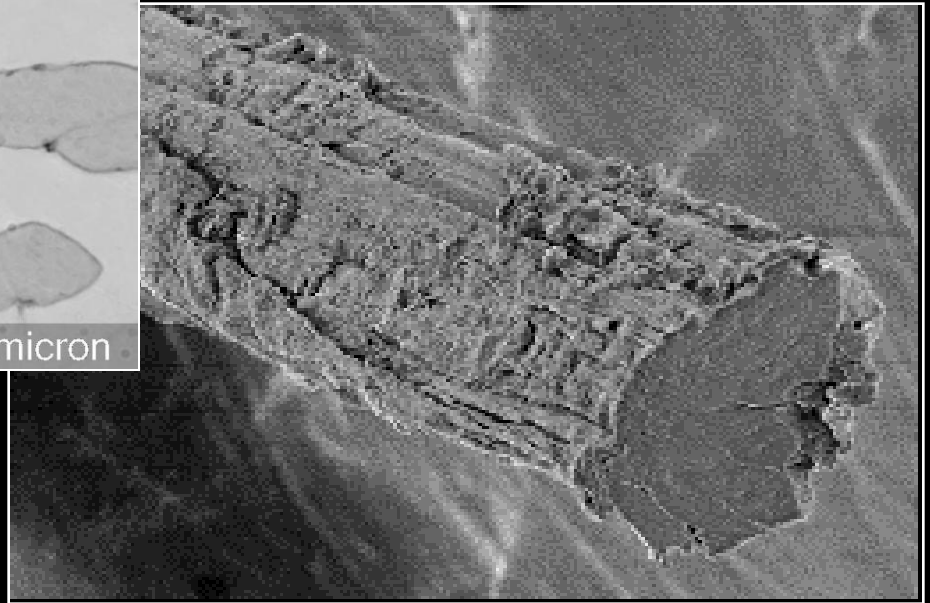
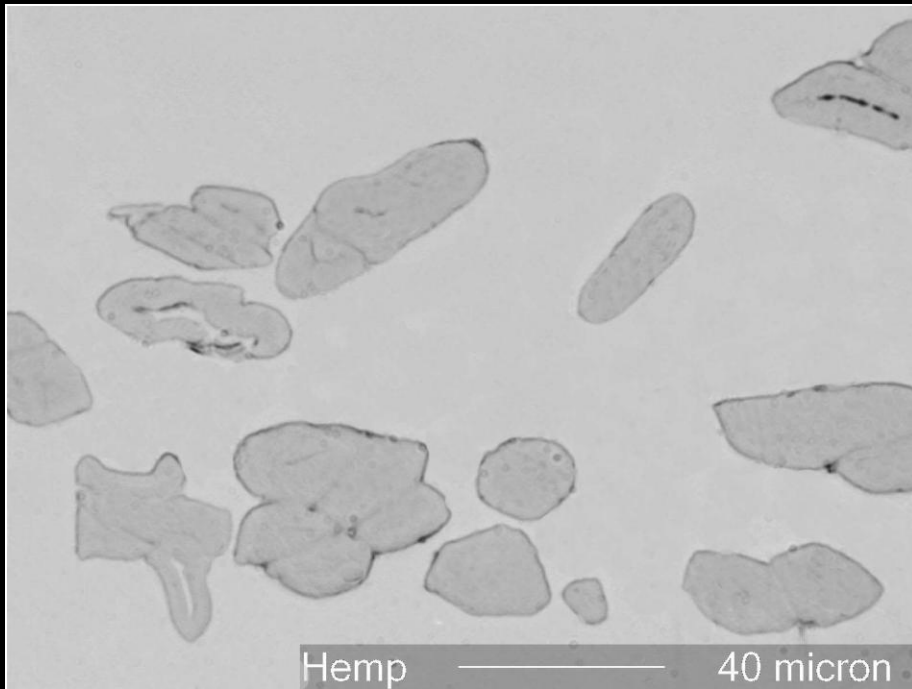
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# Hemp Fibers

Cross section is very irregular and lumen is often not visible



\* Photo courtesy of Karen Korsberg Lowe - FBI laboratory



# Structural / Leaf / Hard Fibers

- Fibers obtained from the fibrovascular systems of the leaves and leaf stalks of monocotyledonous plants. The leaves are harvested by cutting at the base with a sickle-like tool and bundled for processing by hand or by machine. Fibers are used as complete vascular bundles. Elements of transportation tissue are often present.



# Decortication

- Fibers are extracted from leaves by decortication which involves crushing and scraping the leaves with a rotating wheel set with blunt knives. Water washes away the waste parts of the leaf so fibers remain. Fiber is then dried, brushed and baled for export.



# Sisal

- From the *Agave Sisalana* which is believed to be native to the Yucatan but is now cultivated in Central America, Florida, Caribbean, Brazil, Africa and Asia. Incorrectly referred to as “Sisal Hemp”.



# Uses for Sisal

- Sisal fibers are strong, durable, have the ability to stretch, an affinity for certain dyestuffs and have a resistance to deterioration in salt water. Widely used to make rope (particularly in the marine industry), twine, rugs, carpets, papermaking, spa products, and dartboards. In recent years sisal has been used as an environmentally friendly strengthening agent to replace asbestos and fiberglass composite material, especially in the auto industry.



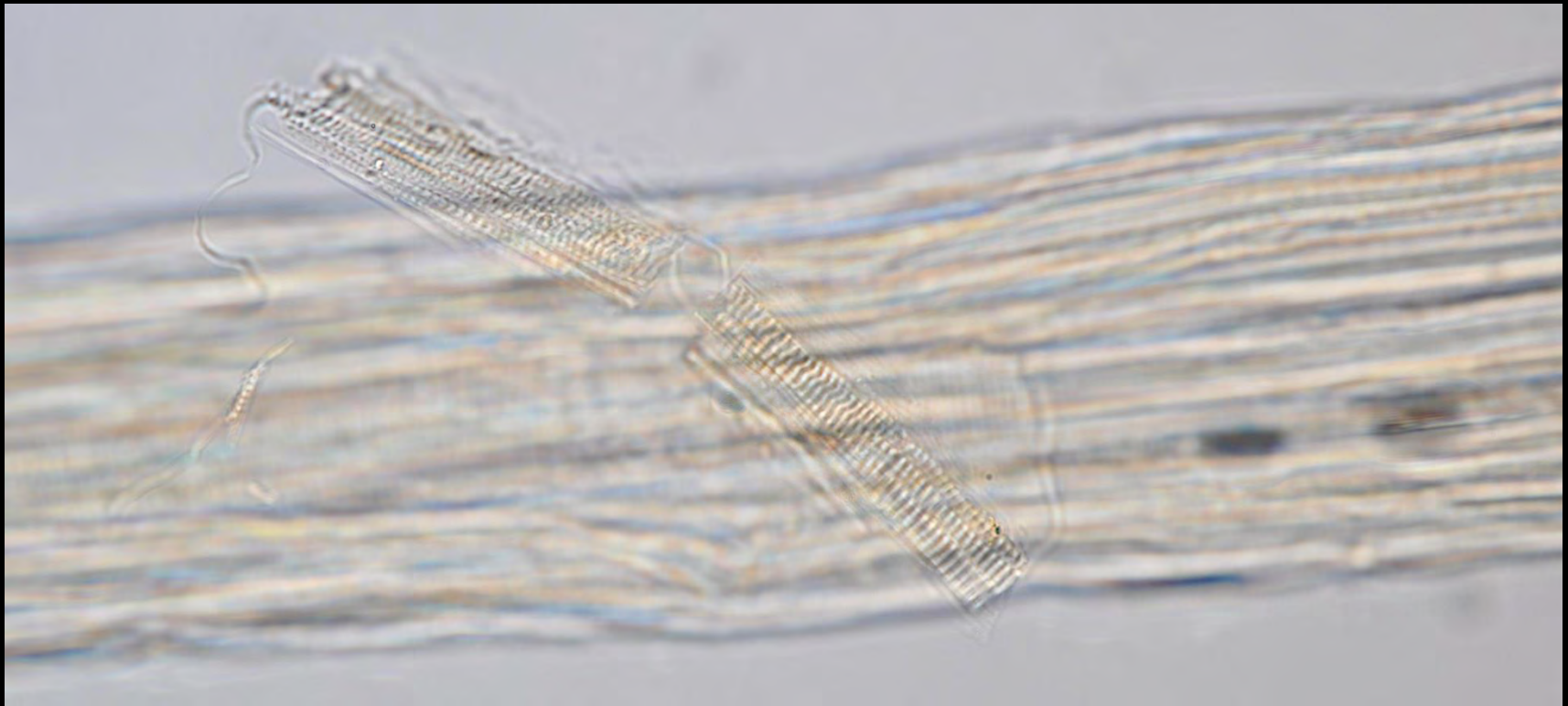
# Sisal Fibers

- Yellow/brown fibers that occur in tight bundles. Smooth looking fibers with rounded tapered ends. Fiber does not show extinction. Presence of very characteristic spiral vessels.



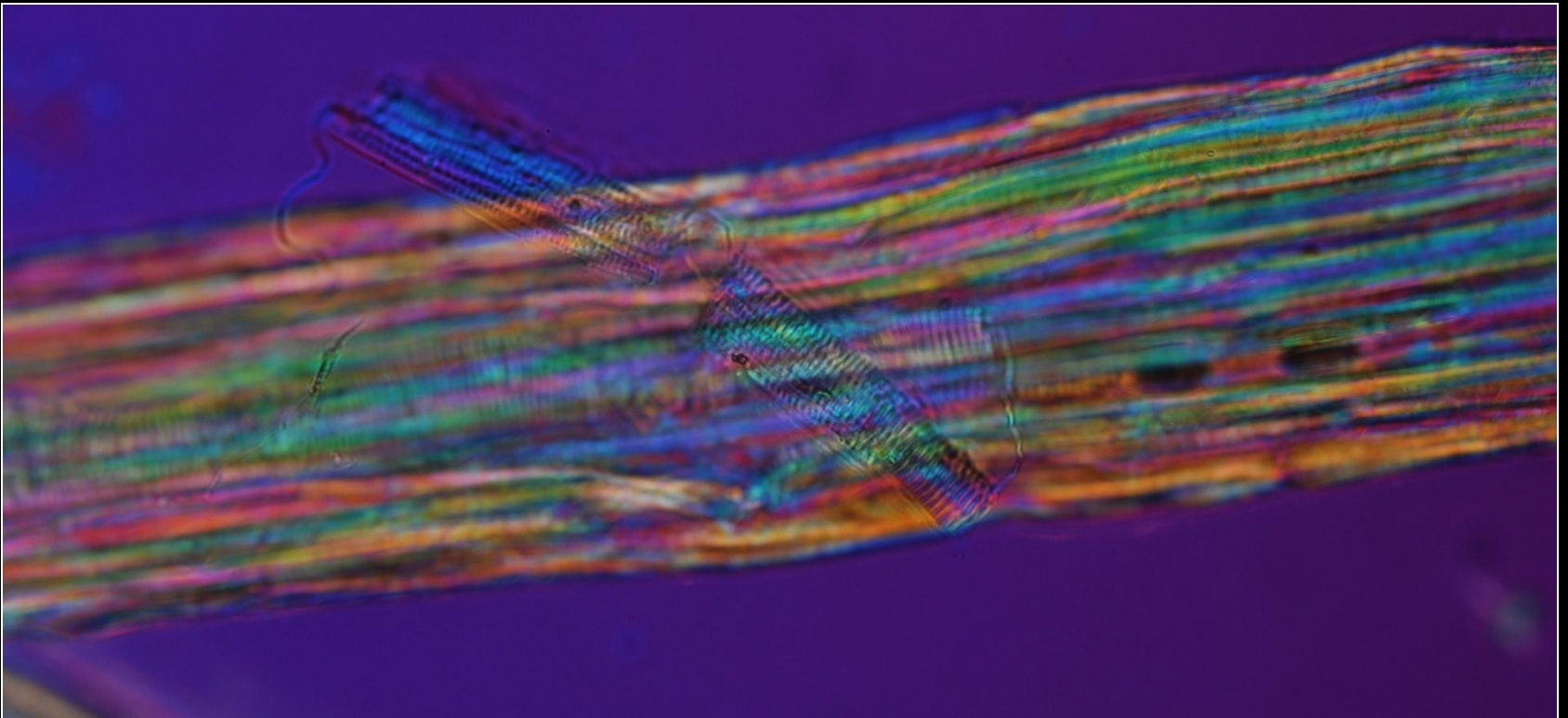
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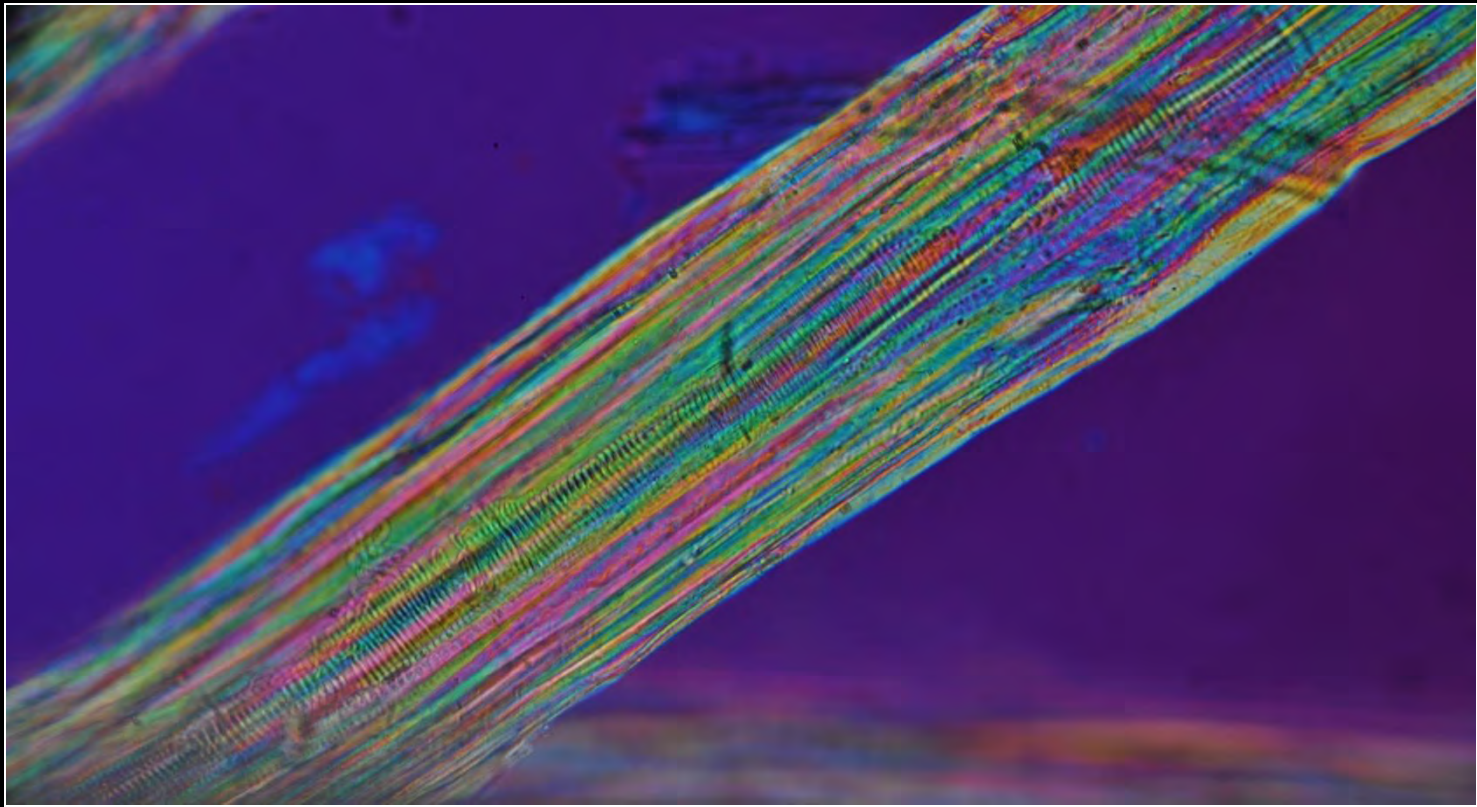
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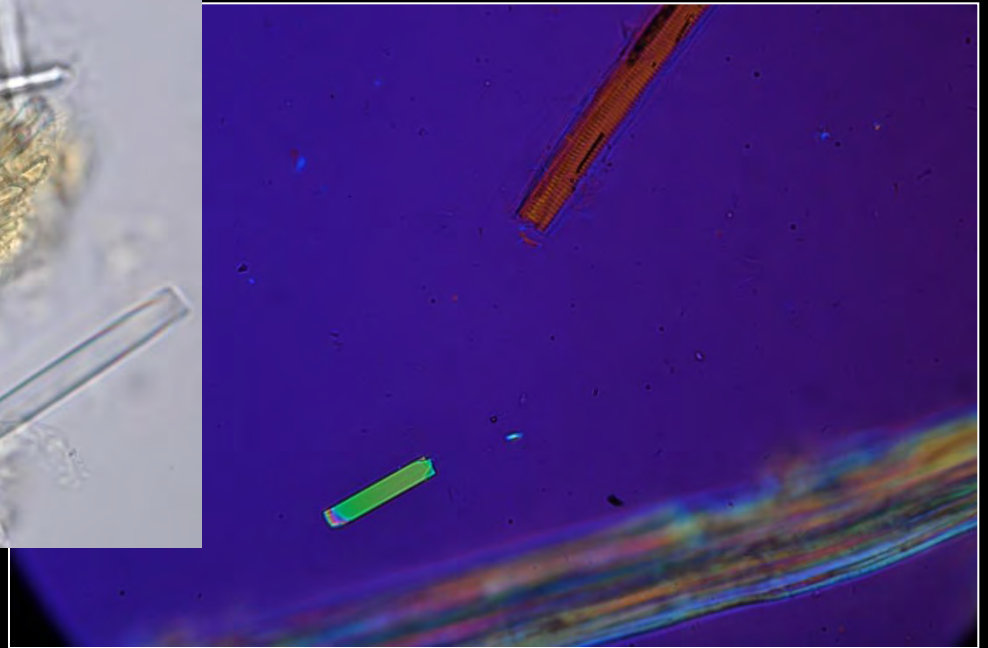
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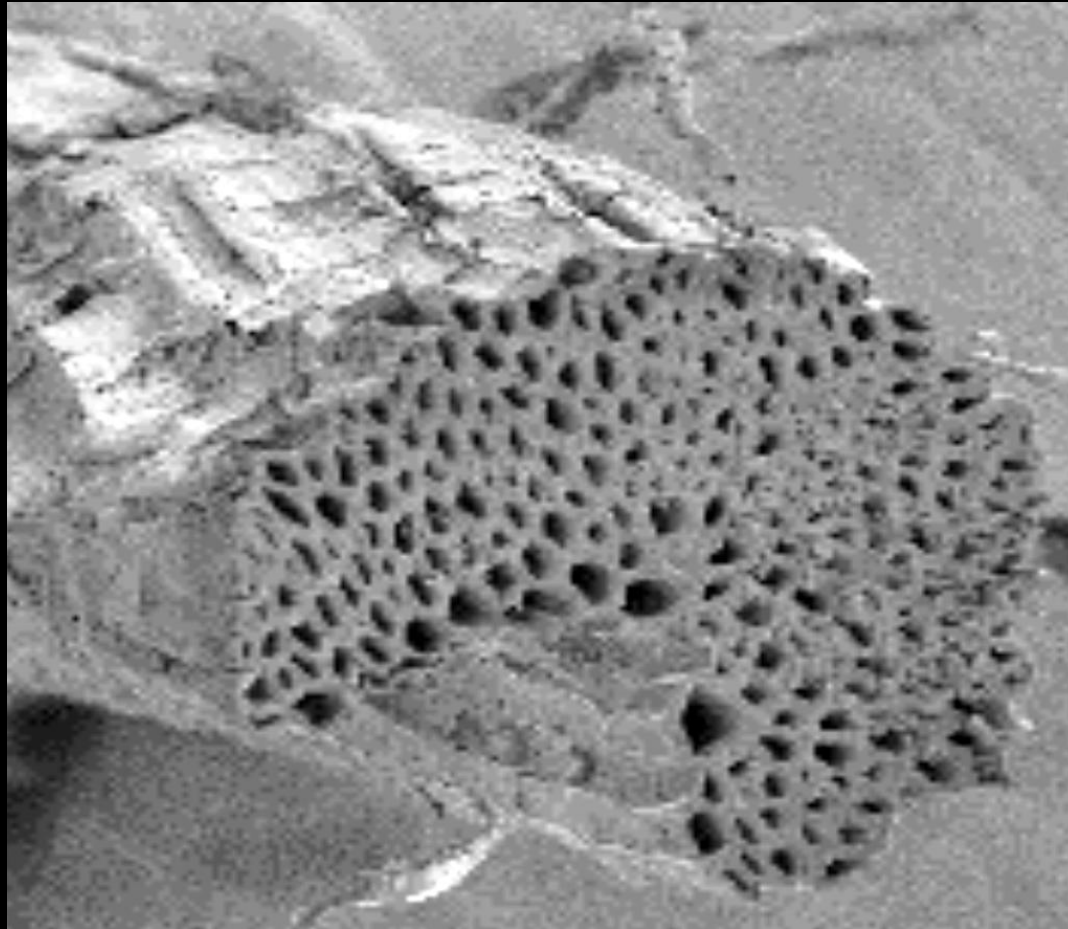
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# Sisal

- Fibers are polygonal in outline with a rounded polygonal lumen.



\* Photo courtesy of Karen Korsberg Lowe - FBI laboratory

# Abaca

- *Musa textilis* Nee is obtained from the leaf sheaths of the abaca plant which is a member of the banana family that is cultivated mainly in the Phillipine Islands. Sometimes called “Manilla Hemp”.



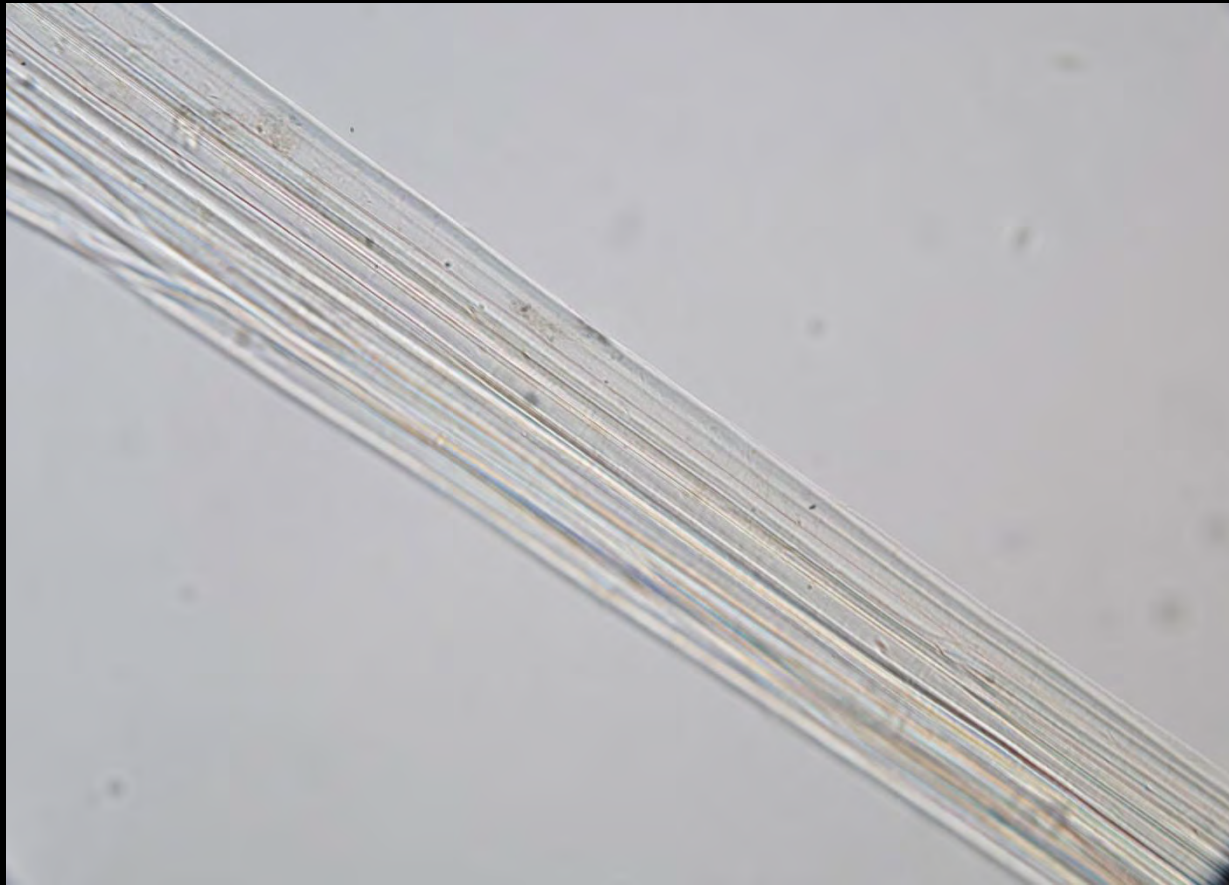
# Uses for Abaca

- Abaca is prized for its great mechanical strength, buoyancy, resistance to saltwater damage and long fiber length. Once a favored source of rope for ships rigging, fishing lines, cloth sacking, tea-bags, paper (Yen), and manila envelopes, abaca now shows promise as an energy saving replacement for glass fibers in automobiles (60% less energy).



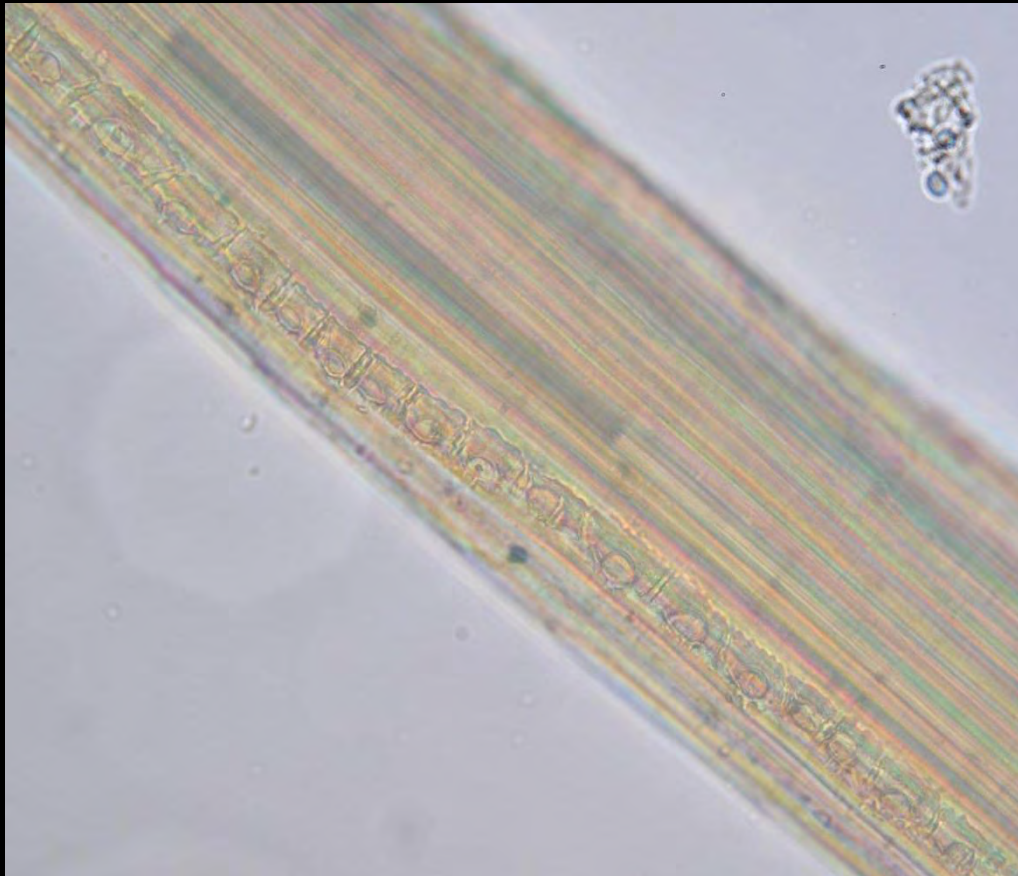
# Abaca Fiber

- Fibers are cream to yellow in color with characteristic stegmata (silica cells) found near the vascular bundles which appear as rectangular cells with a central depression.



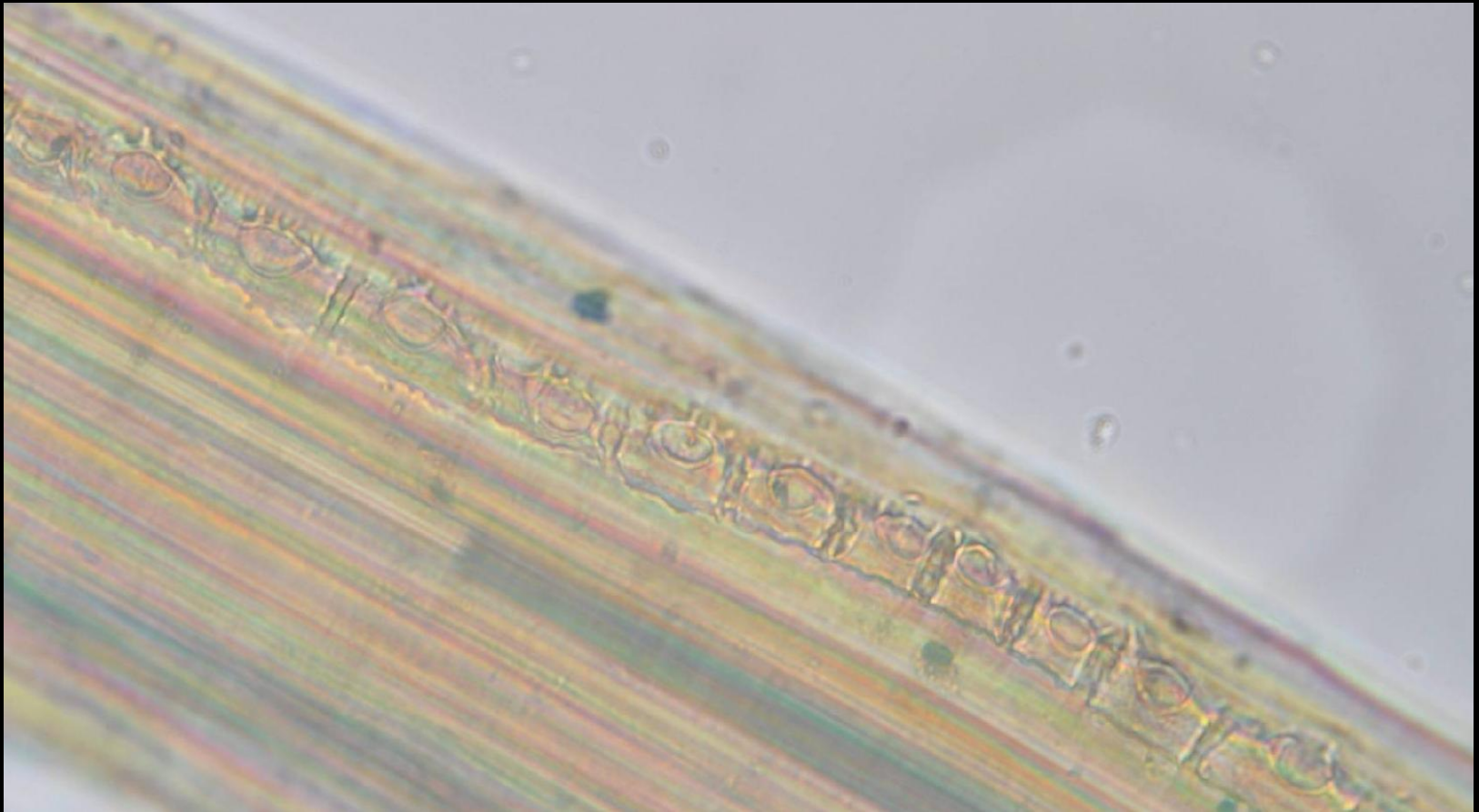
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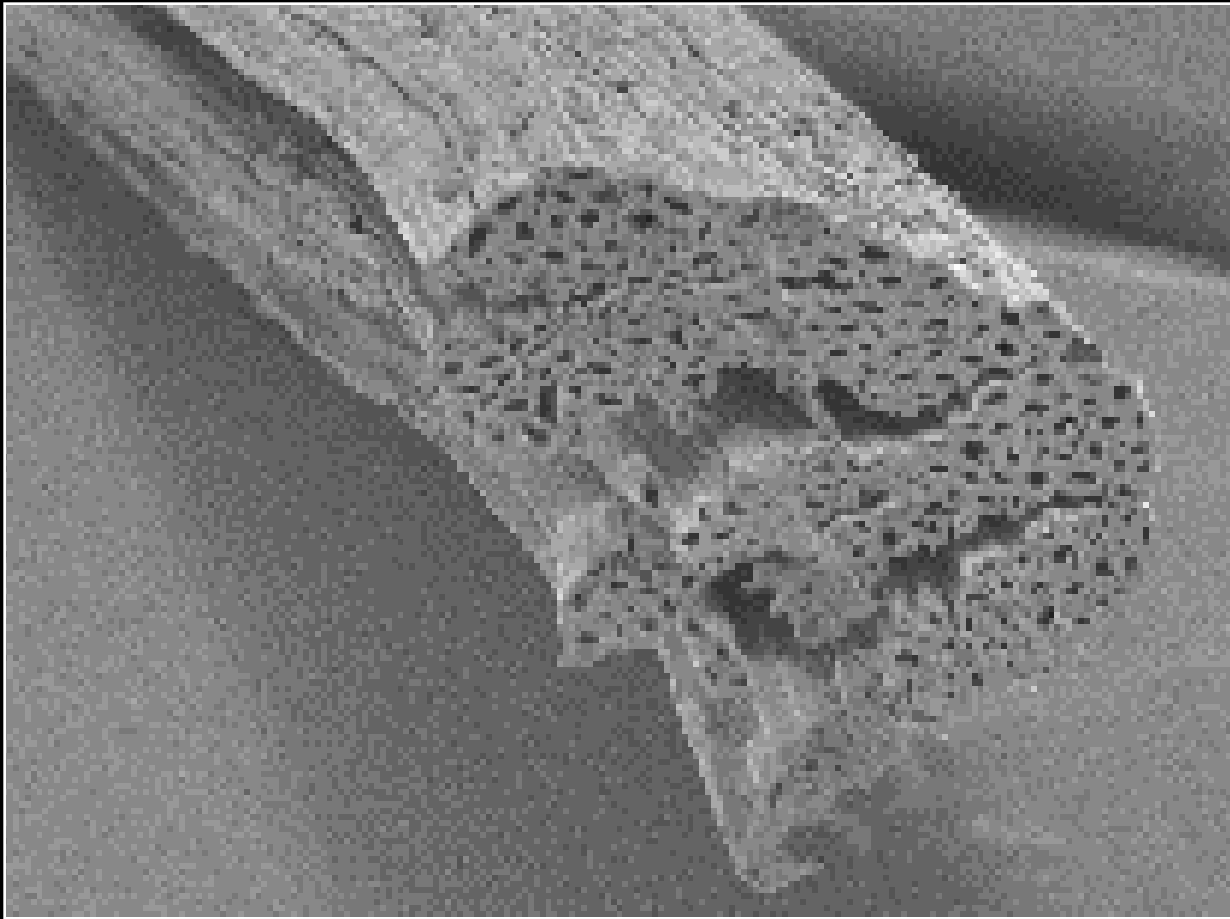
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# Abaca Fibers

- Cross section is oval to round polygonal



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- QUESTIONS???
- Many thanks to Karen Korsberg Lowe for the cross section pictures!
- THANKS FOR YOUR TIME!!