

1 **CHAPTER 3**

Natural Fibers

2 **OBJECTIVES**

- ⊙What is the difference between protein, cellulosic, and mineral fibers?
- ⊙What are the main fibers in each category, and what are their primary properties?
- ⊙How do you find these fibers, and what do you use them for?

3 **NATURAL FIBERS**

- ⊙Two main classes of natural fibers:

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- ⊙There are others outside of these two classifications:
 - Minerals
 - ⊙Asbestos
 - ⊙Carbon
 - Rubber

5 **NATURAL PROTEIN FIBERS**

- ⊙Amino acids in polypeptide chains
- ⊙Contains carbon, hydrogen, oxygen, nitrogen, sulfur
- ⊙Silk – Fibroin
- ⊙Wools and fur fibers - Keratin

6 **COMMON CHARACTERISTICS: PROTEIN FIBERS**

- 1
 - Resilient
 - Hygroscopic
 - Low tenacity when wet
 - Lower specific gravity compared to cellulosic fibers
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- ⊙
- 2
 - Sensitive to alkalis and oxidizing agents
 - Potential insect damage
 - Harmed by dry heat
 - Somewhat flame retardant

7 **WOOL**

- ⊙Production: Sheep raised for wool.
- ⊙Sheared or pulled
- ⊙Graded and sorted by fineness, length, color, crimp, elasticity, and strength.

8 **WOOL PRODUCTION**

- Sheared wool: Removed from live sheep; raw wool or grease wool; impurities (lanolin).
- Pulled wool: Removed chemically from carcasses.
- Called Raw Wool or Grease Wool at this stage
 - Highest quality from back, shoulders, sides; poorest from legs and tummy.

9 **WOOL PRODUCTION AND TERMS**

- ⊙Scoured – cleaned in warm alkaline solution
- ⊙Lanolin – oil byproduct
- ⊙Carbonization – using sulfuric acid to aid cleaning
- ⊙Fulling – controlled shrinkage
- ⊙Garmenting – mechanically shredding wool yarns or fabric back to fibrous state
- ⊙Melton – compact wool fabric with appearance of felt
- ⊙Recycled wool - Reprocessed & used in fabric.
- ⊙Lamb's wool - From animals less than 7 months old.
- ⊙Virgin wool - Never used or processed before.
- ⊙

10 **PHYSICAL STRUCTURE**

- ⊙Medulla: Honeycomb core increases insulative power.

⊙Cortex: Main part; ortho and para cortical cells react differently to moisture and temperature and produce crimp; important in quality, loft, elasticity, cohesiveness, and resiliency.

11 **WOOL STRUCTURE**

⊙Cuticle: Epicuticle and layer of scales; contributes to abrasion resistance and felting.

⊙Color: Natural off-white; other natural colors.

⊙Fineness: 10-50 microns

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12 **PHYSICAL PROPERTIES**

⊙Natural crimp

⊙Scales allow for felting

⊙Variable luster – tends to be low

13 **PROPERTIES OF WOOL**

⊙Mechanical: Moderate abrasion resistance, low tenacity (especially when wet), good flexibility, high elongation. Poor dimensional stability, good resiliency when dry, medium density, high thermal retention

14 **PROPERTIES**

⊙Chemical: High absorbency, hygroscopic, dyes well, weakened by alkalis and chlorine bleach, becomes brittle with dry heat, low conductivity in dry climates, flame resistant

15 **CHEMICAL COMPOSITION OF WOOL**

⊙Keratin of H, O, N, C, and S in amino acids in spiral helix form.

⊙Cystine linkage damaged by alkalis.

⊙Shaping of wool fabrics by heat and moisture.

16 **PROPERTIES**

⊙Identification: Microscopic appearance, chlorine bleach test; burn test—similar for protein fibers.

⊙Environmental effects: Weakened by strong sunlight; attacked by insects—can be mothproofed.

⊙Environmental impact: Issues of grazing habits of sheep, disposal of manure, disease, predator animals, fiber processing, fabric finishing, dry cleaning.

17 **PROPERTIES**

⊙Uses: Apparel; furnishings; industrial and consumer goods.

⊙Wool Bureau promotes use of wool. There are no trade names for wool. Woolmark indicates that the fabric is 100% wool. Woolblend indicates that it is at least 60%

⊙Care: Not readily soiled; dry cleaning recommended; avoid high pH detergents & chlorine bleach.

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18 **SPECIALTY PROTEIN FIBERS**

⊙Mohair:

- From Angora goat
- Most resilient of all natural fibers
- Strong, good affinity for dyes
- Uses: furnishings and apparel

19 **MOHAIR**

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⊙Qiviut: Under-wool of musk ox, rare and luxurious fiber

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⊙ Angora: hair of angora rabbit very fine, fluffy, soft, and slippery

- White or natural colors
- Difficult to dye
- Wool blends; used for apparel

22  **ANGORA**23 

- ⊙ Camel's hair: underhair from camel of Asia
 - Used in apparel
 - Water repellent, lustrous, good insulative characteristics
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- ⊙ Cashmere: from cashmere goat
 - Beautiful soft fiber
 - Warm; lightweight, more sensitive to chemicals
 - Cashgora
 - Sometimes mistaken for shahtoosh

25  **CASHMERE DOUBLE-TAKES**26 27 

- ⊙ Llama & alpaca: Soft, fine, lustrous, warm; wears well; natural colors; apparel.

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- ⊙ Vicuña & guanaco: Rare and expensive fibers; short, lustrous, and light cinnamon color.
- ⊙ Yak: Smooth and lustrous fiber often mixed with cashmere to extend it.
- ⊙
- ⊙

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- ⊙ Rare breeds

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- ⊙ Fur fibers: not usually spun; often cut as pelts - beaver, fox, rabbit, mink, ermine, exotic furs
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31  **SILK**32  **SILK**

- ⊙ Production:
 - Sericulture: Cultivated silk worm (*Bombyx mori*) produces cocoon of silk.
 - Stifled;
 - Silk reeled in filature;
 - Combined into filament yarn;
 - Twist added in throwing;
 - Raw silk covered by gum (sericin).

33 34 35  **SILK**

- ⊙ Wild silk: Less regular; shorter (staple), tussah & tasar.
- ⊙ Dupioni silk: Thick and thin appearance; used in shantung.
- ⊙ Momme: 3.75 grams; various grades of silk fabric
- ⊙
- ⊙

36  **SILK**

- ⊙ Physical structure:
 - Solid fiber
 - Very fine filament
 - Irregular diameter and triangular shape – high luster, good drape, hand
 - White or off-white; wild silk may be brown, yellow, orange or green

- Standard for many synthetics
- Scroop
- ⊙Protein: fibroin, 15 amino acids in polypeptide chains; highly oriented

37 38  **PROPERTIES**

- ⊙Mechanical: Strong, weaker when wet, moderate abrasion resistance, good elongation, moderate resiliency, good dimensional stability
- ⊙Chemical: Absorbent, good heat retention, dry hand, medium density, poor conductor of electricity, damaged by chlorine bleach, alkaline, and perspiration

39 **PROPERTIES**

- ⊙Environmental impact: Farming/production methods, social impact, animal rights, fiber processing & fabric finishing, dry cleaning.
- ⊙Environmental effects: Weakened by sunlight & perspiration; insect damage; chemical reactivity; similar to wool; weighted silk.

40 **PROPERTIES**

- ⊙Identification: Microscopic appearance.
- ⊙Uses: Apparel and furnishings.
- ⊙Care: Dry cleaning recommended (usually because of dye and product structure).

41 **SPIDER SILK**

- ⊙Exceptional strength & elasticity.
- ⊙Protein – spidroin
- ⊙Produced by a variety of spider species.
- ⊙Application and production: current research focus.

42 **CELLULOSIC FIBERS**43 **NATURAL CELLULOSIC FIBERS**

- ⊙Classified by portion of the plant from which they are removed.
 - Seed fibers: cotton, coir (coconut), kapok, milkweed
 - Bast (stem) fibers: flax, hemp, jute, ramie, kenaf, hibiscus
 - Leaf fibers: abaca, piña, sisal, henequen
 - Other: Spanish moss, cedar bark, rush, sea grass, maize, palm fiber
- ⊙Cellulose: Glucose, percentage, orientation, and length varies by fiber.

44 **PROPERTIES COMMON TO ALL CELLULOSIC FIBERS**

- 1
 - ⊙Absorbent
 - ⊙Good heat conductor
 - ⊙Heat resistant
 - ⊙Low resiliency
 - ⊙Lacks loft
 - ⊙Good electrical conductor
 - ⊙Heavy fibers
- 2
 - ⊙Damaged by mineral acids, resists alkalis
 - ⊙Resistant to some insects; damaged by other insects, mold and mildew
 - ⊙Flammable
 - ⊙Moderate sunlight resistance

45 **COTTON**

- ⊙Natural seed fiber, picked and ginned.
- ⊙Physical structure

- Staple fiber (1/2 to 2 inches)
 - Upland: 7/8 to 1 1/4 inch
 - Long: 1 5/16 to 1 1/2 inch
 - Short: less than 3/4 inch

46 **COTTON CLASSIFICATION**

- Grading and classification by hand or machine; relates to fiber quality and character.
- Quality dependent on length, strength, fineness, convolutions, maturity, color, absence of trash, and dirt.
- Character refers to maturity, smoothness, uniformity, etc.
 - American Pima
 - Egyptian
 - American Egyptian
 - Sea Island

47 **PHYSICAL PROPERTIES**

- Parts: cuticle—wax-like film
 - Primary cell wall: outer skin
 - Secondary cell wall
 - Lumen: central canal
- Convolutions: ribbon-like twists; cohesive
- Fineness: Varies with maturity and type.
- Color: Creamy white, natural brown, green, etc.

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48 **MECHANICAL PROPERTIES**

- Medium strength, increases when wet, moderate abrasion resistance, fibers are dimensionally stable – fabrics are not, low elongation. Can mercerize to increase strength; can be blended to improve wrinkle resistance

49 **CHEMICAL COMPOSITION AND MOLECULAR ARRANGEMENT**

- 99% cellulose (glucose) in finished fabrics
- Hydroxyl units: React readily with moisture, dyes, and finishes.
- Highly absorbent; does not wick well
- Damaged by dry heat
- Sensitive to damage by bleaches and acids.
- Modifications with chemical finishes
 - Mercerization
 - Ammoniation

50 **TYPES OF COTTON**

- Organic cotton: Produced following state fiber certification standards on land where organic farming practices have been used for at least three years.
- Transition cotton: Produced on land where organic farming is practiced for less than the three year minimum.
- Transgenic cotton: genetically engineered to repel insects

51 **TYPES OF COTTON**

- Conventional cotton: Describes cotton grown & processed by regular mainstream practices.
- Green cotton: Washed with mild natural-based soap (no bleach or other chemicals, except possibly dyes).
- Colored cotton: Naturally colored as it grows.

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52 **COTTON**

- Environmental effects: Oxidized by sunlight.
- Environmental impact: Ag-chemicals; erosion; water use; dyeing/finishing chemicals; bioengineering.

53 **USES AND PROMOTION**

- ⊙ Identification: Burns like cellulosic fibers; convolutions (microscope).
- ⊙ Uses: Apparel, furnishings, industrial uses, and exports.
- ⊙ Cotton Incorporated promotes use of cotton.
- ⊙ Care: Washable or dry-cleanable; no special care required, but other components may affect care; store clean and dry.
- ⊙

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OTHER SEED FIBERS

- ⊙ Coir: from husk of coconut
 - Stiff, cinnamon brown color; good resistance to abrasion, water, and weather; wiry texture
 - Uses: floor textiles (rugs, doormats, and tile)

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- ⊙ Kapok: from seed of Java kapok or silk cotton tree
 - Lightweight, soft, hollow, buoyant, poor aging resistance
 - Uses: fiberfill in lifejackets, pillows, padding
- ⊙ Milkweed: fiberfill in comforters, personal flotation devices, and upholstery
- ⊙

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BAST FIBERS

- ⊙ Irregular fibers from stem of the plant; process includes retting, scutching, and hackling; may be cottonized or cut to a length similar to that of cotton fiber to facilitate blending with cotton and processing on cotton equipment.

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FLAX

- ⊙ Physical: Long irregular fiber with nodes; tow (short) and line (long).
- ⊙ Mechanical: Strong, stronger when wet; low elongation; stiff fiber; good abrasion resistance, but poor flex abrasion resistance; can be cottonized.
- ⊙ Chemical: high absorbency, good wicking, damaged by acids and dry heat

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FLAX

- Environmental impact: Chemicals and water from retting; alternate retting processes being investigated.
- Care: Similar to cotton, but wrinkling is a greater problem.

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FLAX

- Uses: Fashion fabrics for apparel and furnishings.
- Identification: Similar to cotton; microscopic appearance; greater fiber length.
- Center for American Flax Fiber (CAFF): Goal is to establish U.S. flax industry using short cottonized flax fiber.
- Masters of Linen: Promotes use of linen.

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RAMIE (RHEA OR GRASSCLOTH)

- ⊙ Structure: Irregular fiber; long, lustrous, and fine; heavier than most cellulosic fibers.
- ⊙ Properties
 - Physical: Irregular appearance to fabric.
 - Mechanical: Strong and abrasion resistant; brittle with low elasticity.
 - Chemical: Good absorbency, stiff, and rough.
 - Care: Poor resiliency, elongation can be a problem.
- ⊙ Uses: Imported apparel, furnishings, industrial uses.

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OTHER BAST FIBERS

- ⊙ Hemp: High strength for twine, cord; not pliable or elastic; minor fiber, used in apparel.
- ⊙ Jute: Weak fiber with poor elasticity & elongation; low sunlight resistance, poor colorfastness. Used for bagging, carpet backing; furnishings, rope, cordage, etc.

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OTHER BAST FIBERS

- ⊙ Kenaf: Long fiber; used for twine, cordage, and other industrial uses.
- ⊙ Hibiscus: Stronger than jute, it has good fastness when dyed with direct dyes. Experimental

use in bags, rugs, and apparel.



64  **LEAF FIBERS**

⊙ Long, fairly stiff, poor dye affinity, natural colors; cut from plant and fibers split or pulled from the leaf.

⊙ Piña: Soft, lustrous; white or ivory; susceptible to acids and enzymes; used for apparel, furnishings, and industrial goods.

65  **LEAF FIBERS**

⊙ Abaca: Coarse; very long; off-white to brown; strong, durable, & flexible; used for rope, cordage, floor mats, table linens and clothing.

⊙ Sisal and henequen: Smooth; straight; yellow; used in better ropes, twines, and brush bristles; used in carpets, custom rugs, and wall coverings.



66  **OTHER CELLULOSIC MATERIALS**

⊙ Rush, seagrass, or Cornhusks: Used in furnishings, resistant to dry heat.

⊙ Paper yarns in wall coverings for visual interest and texture.

⊙ Wooden slats & grasses in window treatments.

⊙ Wicker furniture: Twisted paper yarns, rattan, seagrass, abaca, and raffia.

⊙ Wall panels & wall coverings: Shredded straw, bark, and old telephone books.

67  **SUMMARY**

⊙ There are 3 main categories of natural fibers: protein, cellulosic and mineral.

⊙ Protein fibers come from animal (or insect) sources

- Protein fibers include wool, silk, mohair, angora, camel, spider silk, and various exotic and specialty wools or furs.

- Protein fibers tend to be warm and absorbent. They are fairly resilient, but are damaged by bleach.

⊙ Cellulosic fibers come from plant sources

- Cellulosic fibers include cotton, flax (linen), raime, hemp, jute and other natural plant sources.

- Cellulosic fibers are absorbent, comfortable in most temperatures, and flammable.