Section I: Fibers Outline

- Introduction
  - Generic and Trade Names
  - Classification
  - Staple and Filament Fibers

- Understanding Fiber Structure and Properties

- Fiber Terminology
  - Fiber Structure – Length; surface contour and shape; fineness, luster; color; crimp
  - Fiber Properties – Tenacity and modulus; elongation and elastic recovery; resiliency; flexibility; moisture properties; resistance to chemicals; resistance to microorganisms and insect damage; resistance to sunlight; and effect of heat and flame.
About Fibers

● A fiber is the fundamental unit making up all textile products. Fibers are found in nature and are also manufactured from various raw materials.

● Based on source, fibers are classified into natural and manufactured fibers.
About Fibers

- In the United States, fiber generic names are established by the Federal Trade Commission.
  - Generic names for natural fibers are based on fiber source.
  - Generic names of manufactured fibers are based on the chemical composition.
- Fiber classification is based on generic names approved by FTC. Generic names are required on labels (see section on regulations).
- Fiber manufacturers can assign trade names, in addition to generic names (additional information included in manufactured fibers).
Textile Fibers

Natural Fibers
- Cellulose
  - Seed Hair
  - Cotton
    - Kapok
    - Milkweed
  - Bast
    - Flax (Linen)
    - Ramie
  - Leaf
    - Sisal
    - Abaca
    - Piña
    - Raffia
  - Fruit Husk
    - Coir
- Protein
  - Animal Hair
- Mineral
  - Asbestos*

Manufactured Fibers
- Regenerated Cellulose
  - Rayon
  - Lyocell
  - Cellulose Derivatives
  - Acetate
    - Triacetate
- Regenerated Protein
  - Azlon
- Synthetic
  - Petroleum
  - Nylon
  - Polyester
    - Elasterell-p
    - Triexta (PTT)
  - Acrylic
    - Modacrylic
  - Spandex
  - Olefin
    - Lastol
  - Other
    - PBI
    - Melamine
    - Fluoropolymer
    - PLA
- Rubber
  - Rubber**
    - Lastrie
- Metallic
  - Glass

* asbestos not used for health reasons
** FTC definition includes natural and synthetic rubber

Fibers commonly used for apparel and interiors are in bold
Staple and Filament Fibers

- Fibers are also differentiated based on length into:
  - Staple fibers
  - Filament fibers

- Differentiating fibers based on their length is important as it determines the methods used for processing.
Staple and Filament Fibers

- Staple fibers are short fibers (ranging from <1” to a few feet).
  - All natural fibers (except silk) are staple fibers.
  - Manufactured fibers can be cut into staple fibers.

- Filament fibers are long continuous fibers extending for great lengths (several hundred yards).
  - Silk is the only natural filament fiber.
  - All manufactured fibers are produced as filament fibers.
Natural and Manufactured Staple Fibers

Note: Manufactured staple fibers are produced by cutting crimped tow to required length. Therefore, the fiber length is very consistent.

cotton with varying fiber length and no crimp

manufactured fiber crimped and cut to 5 cm (2”) length

merino wool with varying fiber length and natural crimp
Note: The term filament is used for fibers and yarns. This filament yarn consists of 100 filament fibers.
The structure and properties of the fibers play an important role in the performance, end use, and care of the textiles made from them.

- **Fiber structure** includes appearance characteristics that are visible without (e.g., fiber length, color) and with a microscope (e.g., cross-section).

- **Fiber properties** include physical, chemical, moisture, biological and other properties.

- Fiber properties are dependent on the molecules from which the fibers are made.
Importance of Polymer Structure

- The fibers are made of large molecules called **polymers**.

- Fiber structure and properties are dependent on polymer structure.
  - For example, cotton has good moisture absorption because of the chemical structure.

- The following slides include terminology for fiber structure and fiber properties.
Fiber Structure

- Fiber structure includes all properties that are visible with and without a microscope, including:
  - Length
  - Surface Contour and Shape
  - Fineness
  - Luster
  - Color
  - Crimp

- These characteristics are generally fixed for natural fibers, but easily engineered for manufactured fibers during the production process.
Fiber Structure Terminology

- **Fiber length** for staple length fibers varies by source of fiber and variety/breed. Fiber length is typically used to determine the quality of natural staple fibers such as cotton and wool. It is also important for the processing of staple fibers into yarns.

- A microscope is used to view the **surface contour** (longitudinal view) and **shape** (cross-section) of fibers.
  - The longitudinal view and cross-section are used to identify natural fibers.
  - The shape of manufactured fibers can be changed to influence performance.
Fiber Surface Contour (Longitudinal View)

Courtesy Intertek Testing Services
Fiber Shape (Cross-section)

Courtesy Intertek Testing Services
Fiber Structure Terminology

- **Fineness** indicates the size of the fiber. It is used to determine the quality of natural fibers.
  - Fiber diameter is used to measure the fineness of wool (round cross-section), but not of cotton (irregular cross-section).
  - The fineness of manufactured fibers is measured by weighing a known length of the continuous fiber. This is suitable for filament fibers as the filaments are typically very uniform and continuous.
Fiber Structure Terminology

- **Luster**, the sheen or shine of fiber, depends on light reflected from the surface of the fiber.

- **Color** depends on fiber source; most fibers are white or off-white.

- **Crimp** is a fiber’s waviness. Wool has natural crimp. Crimp can be added to manufactured fibers cut into staple lengths to improve cohesiveness.
<table>
<thead>
<tr>
<th>Fibers with Varying Luster</th>
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<tbody>
<tr>
<td>Lyocell</td>
</tr>
<tr>
<td>Rayon</td>
</tr>
<tr>
<td>Azlon</td>
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<tr>
<td>Cultivated Silk</td>
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<tr>
<td>Linen</td>
</tr>
<tr>
<td>Wool</td>
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<tr>
<td>Cotton</td>
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</tbody>
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Note: Delusterant can be added to lyocell and rayon fibers to reduce luster.
Fiber Properties Terminology

- **Tenacity** is fiber’s strength per unit size.
  - Tenacity of the fiber affects the strength of yarns and fabrics made from these yarns, which affects durability.

- **Modulus** is fiber’s resistance to extension. Note: Strength and modulus are generally measured at the same time.
  - High modulus is important for seatbelts.
  - Similar concerns for ease of extension affect the choice of fibers for blending.
Tensile or Breaking Strength Test

Note: Tensile or breaking strength is the force required to pull fabric apart longitudinally. To measure fabric strength, the fabric is clamped and pulled apart. The strength as well as elongation are recorded. Several other strength tests are conducted on this machine.

Photographed with permission of JCPenney Product Research & Technology Laboratories
Fiber Properties Terminology

- **Elongation** is the fiber's ability to extend when it is pulled along its length until it breaks. Note: The example below is to demonstrate elongation; it was not stretched to breaking point.

The elastomeric fiber with high elongation stretched easily to double its length.
Fiber Properties Terminology

- **Elastic recovery** is a fiber’s ability to return to its original length after it has been stretched.
  - Elongation and elastic recovery affect stretch and shape retention properties of fabrics as well as comfort and appearance.

  To demonstrate elastic recovery, a 1” mark was made on an elastomeric fiber. The marked fiber was stretched to 5” and then allowed to recover. The elastomeric fiber with excellent elastic recovery returned to its original length of 1”.
**Fiber Properties Terminology**

- **Resiliency** is a fiber’s ability to recover after it has been deformed by compression (e.g., crushed, crumpled, twisted).
  - It affects wrinkle recovery and fabric loft.
  - Resiliency is important for carpets and fiber batting.

Note: Wool and flax fibers were bent by folding them over a stock paper strip and then allowed to recover. The image on the right shows the difference between the ability of wool and flax to recover after the fibers have been bent.
Fiber Properties Terminology

- **Flexibility** is a fiber’s ability to bend or fold without breaking.
  - It affects fabric hand and drape, and resistance to edge abrasion.
Fiber Properties Terminology

- **Moisture Properties**
  - **Absorption** is a fiber’s ability to take in water.
    - *Hydrophilic* fibers absorb moisture.
    - *Hydrophobic* fibers do not absorb moisture.
    - *Hygroscopic* fibers absorb moisture without feeling clammy or wet (e.g., wool, silk).
  - **Adsorption** is a fiber’s ability to hold water on its surface.
  - **Wicking** is a fiber’s ability to transport water (or liquid) along the surface.

- Moisture properties are dependent on chemical composition, fiber shape, and fiber fineness.
Note: A drop of water with food coloring was not absorbed by the fibers.
Note: A drop of water with food coloring was absorbed by the fibers.
Fiber Properties Terminology

- **Affinity for oil** is a fiber’s ability to adsorb and absorb oily substances.
  - Oleophilic fibers have an affinity for oil.
  - Oleophobic fibers have no affinity for oil.

- Affinity for oil affects staining and stain removal.
**Fiber Properties Terminology**

- **Resistance to chemicals** is a fiber’s ability to withstand contact with **acids, alkalis, oxidizing agents, and organic solvents**.
  - Resistance is dependent upon:
    - Chemical composition and fiber structure.
    - Concentration and amount of chemical.
    - Duration of chemical contact with the fiber.
  - Resistance to chemicals may dictate:
    - The processing a fiber undergoes. (E.g., acetone is a solvent used to manufacture acetate fiber.)
    - The cleaning of textiles as chemicals are used for stain removal, washing and dry cleaning. (E.g., detergents used for cleaning are alkalis, and bleaches are oxidizing agents.)
    - Damage due to contact with chemicals during use. (E.g., stains and perspiration are alkalis and acids.)
Fiber Properties Terminology

- **Resistance to Microorganisms** (bacteria and fungi)
  - Mildew, a common fungus that grows in moist/warm conditions, may damage cotton, rayon, and other cellulosic fibers.
  - Manufactured fibers made of petroleum-based products have excellent resistance to microorganism damage and are not prone to rotting.

- **Resistance to Insect Damage**
  - Protein and cellulosic fibers are a food source for insects.
Mildew on a Cotton Canvas Bag

Magnified view
Moth Damage – A wool swatch damaged while stored in a box
Silverfish

Note: Silverfish feed on carbohydrates (including cellulose). Therefore, silverfish may damage cellulose fibers. They prefer damp or dark areas such as the bathroom cabinets. Silverfish are also seen where there is an abundance of food source (e.g., old books and newspapers).
Fiber Properties Terminology

- **Resistance to Sunlight**
  - Prolonged exposure to sunlight may cause degradation of certain fibers (e.g., silk, olefin, nylon).
  - Resistance to sunlight affects fabric use for window treatments and outdoor applications.
Exposure to Sunlight - Degradation of silk curtains

Note: The curtains degraded after approximately five years.
Fiber Properties Terminology

- **Effect of Heat and Flame**
  - The reaction of a fiber to heat is determined by the chemical composition and physical structure of the polymers. Fibers that melt when heated or burned are known as thermoplastic fibers.
  - Burn tests are used to identify fiber groups since fibers in each group have similar properties.
  - The reaction of fibers to heat affects fabric processing, drying, and ironing temperatures, and is also used to create fabrics with special appearance.