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

- **Fiber**
  - Fundamental unit of all textile products
  - Found in nature and also manufactured from various raw materials

- Classified into natural and manufactured fibers
About Fibers

● **Generic Names**
  - Defined by the Federal Trade Commission
  - For natural fibers - based on fiber source
  - For manufactured fibers - based on the chemical composition
  - Basis for fiber classification
  - Required on labels (see section on regulations)

● **Trade Names**
  - Assigned by fiber manufacturers
Textile Fibers

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

Manufactured Fibers
- Synthetic
  - Cellulose Derivatives
    - Rayon
      - Lyocell
    - Acetate
      - Triacetate
  - Elastane
  - Elastodiene
  - Cupro (cuprammonium included under rayon)
  - Polyamide (same as nylon)
  - Nylon
  - Polyester
  - Olefin
  - Polypropylene
  - Elastane
  - Polypropylene
  - Lyocell
  - Triacetate
- Rubber
  - Lastrile
- Metal Fibre
  - Metallic
  - Glass

ISO names are not as FTC generic names but permitted by FTC on product labels
- Alginate
- Carbon
- Chlorofibre
- Cupro (cuprammonium included under rayon)
- Elastane (same as spandex)
- Elastodiene
- Fluorofibre (same as fluoropolymer)
- Metal Fibre (same as metallic)
- Polyamide (included under rayon)
- Polyethylene (included under olefin)
- Polyimide
- Polypropylene (included under olefin)
- Vinyal
- Viscose (included under rayon)

Fibers commonly used for apparel and interiors are in bold
* asbestos not used for health reasons
** FTC definition includes natural and synthetic rubber
Staple and Filament Fibers

- Fibers differentiated based on length
  - Staple fibers
  - Filament fibers

- Length determines the methods used for processing
Staple and Filament Fibers

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

- **Filament:** 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.
Fiber Structure and Properties

- **Fiber Structure**
  - Appearance characteristics visible without a microscope (e.g., fiber length, color)
  - And with a microscope (e.g., cross-section)

- **Fiber Properties**
  - Physical, chemical, moisture, biological and other
  - Dependent on the large molecules, called **polymers**, from which the fibers are made
Fiber Structure

Fixed for natural fibers; engineered for manufactured fibers

- Length
- Surface Contour and Shape
- Fineness
- Luster
- Color
- Crimp
Fiber Structure Terminology

- **Fiber Length**
  - Length of staple fibers varies by source of fiber and variety/breed
  - Used to determine the quality
  - Important for processing staple fibers into yarns

- **Surface Contour (Longitudinal View) and Shape (Cross-section)**
  - Used to identify natural fibers
  - Can be changed in manufactured fibers to influence performance
Fiber Surface Contour (Longitudinal View)

Courtesy Intertek Testing Services
Fiber Shape (Cross-section)

Courtesy Intertek Testing Services
Fiber Structure Terminology

● **Fineness**
  - Size or diameter
  - Used to determine the quality
  - Measured in manufactured fibers by weighing a known length of the continuous uniform fiber
Fiber Structure Terminology

- **Luster**
  - Sheen or shine
  - Depends on light reflected from the surface

- **Color**
  - Depends on fiber source
  - Most are white or off-white

- **Crimp**
  - Fiber’s waviness
  - Some fibers have natural waviness
  - Manufactured fibers can be crimped to improve cohesiveness
<table>
<thead>
<tr>
<th>Fibers with Varying Luster</th>
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<tbody>
<tr>
<td>Lyocell</td>
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Note: Delusterant can be added to lyocell and rayon fibers to reduce luster.
Fiber Properties Terminology

- **Tenacity**
  - Fiber’s strength per unit size
  - Affects the strength of yarns and fabrics made from these yarns
  - Affects durability

- **Modulus**
  - Fiber’s resistance to extension
  - High modulus is important for end uses such as seatbelts
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.
Fiber Properties Terminology

● **Elongation**
  - Ability to extend when pulled along length until fiber breaks
  (Note: The example below is to demonstrate elongation; the fiber was not stretched to breaking point.)

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

- **Elastic Recovery**
  - Fiber’s ability to return to its original length after it has been stretched
  - Affects 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

- **Resilience**
  - Ability to recover after compression (e.g., crushed, crumpled, twisted)
  - Affects wrinkle recovery and fabric loft
  - Important for carpets and fiber batting
Note: Wool and flax fibers were bent by folding over a stock paper strip and then allowing the fibers 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.
● **Flexibility**
  - Ability to bend or fold without breaking.
  - Affects fabric hand and drape, and resistance to edge abrasion.
Fiber Properties Terminology

● **Moisture Properties**
  
  o **Absorption**
    ▪ 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)
  
  o **Adsorption**
    ▪ Ability to hold water on its surface
  
  o **Wicking**
    ▪ Ability to transport water (or liquid) along the surface

● 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**
  - 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

![oil stain on a shirt made with oleophilic fibers](image-url)
Fiber Properties Terminology

- **Resistance to Chemicals**
  - Ability to withstand contact with *acids, alkalis, oxidizing agents, and organic solvents*
  - Dependent upon:
    - Chemical composition and fiber structure
    - Concentration and amount of chemical
    - Duration of chemical contact with the fiber
  - Dictates:
    - Fiber processing methods
    - Textile cleaning methods
    - Damage in use due to contact with chemicals
Fiber Properties Terminology

- **Resistance to Microorganisms**
  - Bacteria and fungi
  - Cotton, rayon, and other cellulosic fibers not resistant to mildew
  - 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
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**
  - Silk, nylon are not resistant
  - 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**
  - Determined by the chemical composition and physical structure of the polymers
  - Thermoplastic - melts when heated, changes its shape
  - Used to identify fiber groups
  - Affects fabric processing, drying, and ironing temperatures
  - Used to create fabrics with special appearance