Manufactured Fibers

- **Regenerated fibers**
  - Manufactured from materials found in nature (e.g. wood chips, bamboo, cotton linters or soybeans, milk)
  - Raw materials are modified to a derivative that can be spun
  - Material changed back to original chemistry
  - Cellulose derivative fibers remain chemically altered
  - Regenerated protein fibers generic name - Azlon

- **Synthetic fibers**
  - Synthesized from non-fibrous materials
  - Majority are made from petroleum-based chemicals
  - Some are synthesized using chemicals derived from corn or castor beans

- **Rubber** is made from natural and synthetic rubber

- **Mineral fibers** are inorganic fibers manufactured from metal and glass
Raw Materials for Regenerated Fibers

Regenerated Cellulosic Fibers
- eucalyptus and other trees
- bamboo

Regenerated Protein Fibers
- soybean
- milk

Important - regenerated protein fibers are manufactured in very limited quantities.
Raw Materials for Synthetic Fibers

- pellets synthesized from petroleum-based chemicals
- corn used to synthesize bio-based polymer
- soda bottle chips for recycled fibers
- used garments for recycled fibers
Thermoplastic Fibers

- **Thermoplastic fibers** melt when heated

- Acetate, triacetate, nylon, polyester, olefin and acrylic

- Ability to melt used extensively in the manufacturing process
  - Crimping and heat setting for staple fiber production
  - Texturing filament yarns
  - Thermally bonding nonwoven fabrics
  - Heat setting fibers and fabrics
  - Applying thermal finishes (e.g., permanent pleats)
  - Sealing raw edges
  - Threadless stitching
Representation of the Heat Setting Process for Thermoplastic Polymers

- Bonds between polymer molecules in a fiber
- The fiber is distorted with strained bonds.
- The bonds loosen on heating.
- New bonds form on cooling.

Source - Dictionary of Fiber and Textile Technology. Figure adapted with permission.
Fiber Manufacturing Process

- Solid polymers are converted into a viscous liquid, extruded through a spinneret, then solidified
  - Melt spinning
  - Dry spinning
  - Wet spinning

- Gel spinning is a comparatively new technology used for manufacturing certain high-performance fibers
Extrusion of Fibers Through the Spinneret

Courtesy Celanese Acetate Products
Melt Spinning

- Used for nylon, olefin, polyester and other thermoplastics

- Melt spinning steps:
  1. Melt the polymer chips/pellets
  2. Filter the fluid
  3. Extrude the fluid through the spinneret
  4. Solidify the fiber by cooling
  5. Stretch or draw the partially cooled fiber

- Shape and size of the fiber changed by changing the shape and size of the spinneret holes

Source - *Dictionary of Fiber and Textile Technology*. Figure adapted with permission.
Dry Spinning

- Used for acetate, acrylic, modacrylic, spandex

- Dry spinning steps:
  1. Dissolve the fiber-forming substance in a solvent
  2. Filter the fluid
  3. Extrude the fluid through the spinneret
  4. Solidify the fiber by evaporating the solvent using warm air (solvent is recovered and reused)
  5. Stretch or draw the partially solidified fiber

- After extrusion the fiber’s cross-section changes because the fiber shrinks when the solvent evaporates

Source - *Dictionary of Fiber and Textile Technology*. Figure adapted with permission.
Wet Spinning

- Used for rayon, spandex, some acrylics and other materials that require a complex process because they cannot easily be dissolved in a solvent or melted.

- Wet spinning steps:
  1. Chemically change raw material to form a soluble derivative
  2. Filter the soluble derivative
  3. Extrude the fluid through the spinneret into a chemical bath
  4. Solidify the filaments through reaction with the chemical bath
  5. Stretch or draw the partially solidified filaments

- The fiber’s cross-section changes as the fiber collapses due to reaction in the chemical bath.
Fiber Modifications

- Manufactured fibers can be engineered during the manufacturing process to produce fibers for specific end uses.
- Polymer properties and physical structure are modified to produce fibers with varying properties.
- The modifications impact the performance and care of fabrics.
- Fibers engineered during the manufacturing process are being used for “performance textiles”.
  - Note: Performance textiles is a term used for textiles that have been engineered to meet a technical or functional need.
Modifications

- **Microfibers**
  - Less than 1 denier in size
  - Made from special bicomponent fibers
  - Used for all-weather coats, suits, pants, hosiery, upholstery fabrics, floor mops, and lens cleaner cloths

- **Nanofibers**
  - Extremely fine fibers, measured in nanometers
  - Made by electrospinning and other special manufacturing processes
  - Used for medical textiles, protective clothing, membranes and other applications
Fiber Modifications

- **Bicomponent fiber** - made from two different polymer components
- Common arrangements
  - Sheath-core
  - Side-by-side fiber
  - Matrix fiber (islands-in-the-sea)
  - Pie wedge and hollow pie wedge
- Proprietary technology for unique arrangements
Schematic Diagrams of Bicomponent Fibers

One polymer is surrounded by the other polymer

Two polymers divided along the length of the fiber

One polymer is extruded in the matrix of the other polymer

The two polymers alternate along the length of the fiber

Sheath-Core

Side-by-Side

Matrix or Islands-in-the-Sea

Pie Wedge and Hollow Pie Wedge

Source - Dictionary of Fiber and Textile Technology. Figure adapted with permission.
Cross-sections of Bicomponent Fibers

1. 37 Islands
2. 16 Segmented Pie
3. Customized
4. Metal Core
5. Sheath Core
6. Concentric

Note: The unique cross-sections included in this image are used to engineer new fibers. Courtesy Hills Inc.
Bicomponent Fibers

- Uses
  - Side by side - crimped fibers
    - When the fiber is heated, one polymer with a lower melting point shrinks to create the crimp
  - Sheath-core
    - The low melting point sheath enables the outer layer of the fiber to melt and bond when heated
    - Reduced cost fiber with less expensive core
  - Pie wedge, hollow pie wedge, and islands-in-the-sea (same as matrix)
    - Used to produce microfibers
Spinneret for Producing Bicomponent Fibers

Magnified view
Photomicrographs of 75% Polyester/25% Nylon Microfibers (extruded as a bicomponent fiber)

Note: Pie configuration was used to produce bicomponent microfibers. The larger wedges are polyester and the thinner are nylon.
Modifications

- **Microcapsules** embedded into a fiber matrix
  - Used to produce phase change materials (PCMs) that regulate body temperature.

- Flame resistant fibers
- High tenacity fibers
Fiber Modifications

Common Cross-sections

- **Round** cross-section most common

- **Triangular** cross-section
  - Used to enhance luster as the three-sided fiber reflects more light than a round one

- **Trilobal** cross-section
  - Lobes are effective in hiding dirt

- **Hollow** cross-section
  - Used for high bulk, low weight fibers
  - Reduce the appearance of soil
Examples of Manufactured Fiber Cross-sections

circular
triangular
trilobal
hollow
hollow
flat

Courtesy Intertek Testing Services
Fiber Modifications

- **Low pilling**
  - Reduce the polymer chain length
  - Reduced strength and abrasion resistance. Pills break away easily

- **Increased fiber dyeability**
  - Modify the molecular structure

- **Reduced luster**
  - Delusterant is added

- **Colored fibers**
  - Pigment added to spin solution
  - Used for difficult-to-dye fibers