

POLYMER AND FIBER SCIENCE

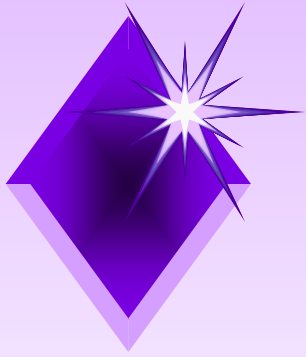
by Dr. Pamela Banks-Lee, Associate Professor



I. Introduction

A. Properties of textile structures are influenced by:

- 1. Fibers used**
- 2. Yarn Structure and Type**
- 3. Fabric Structure and Type**
- 4. Fabric Finishing**



- B. A textile fiber is a unit of matter that is the basic element of yarns, fabrics and other textile structures.**

- C. Fibers can be in short, fixed lengths or continuous, infinitely long lengths**



D. Classification of Fibers (chart)

1. By type

**Natural -- Cellulosic, Protein,
Mineral**

**Manufactured -- Cellulosic, Protein,
Synthetic polymer, Inorganic**

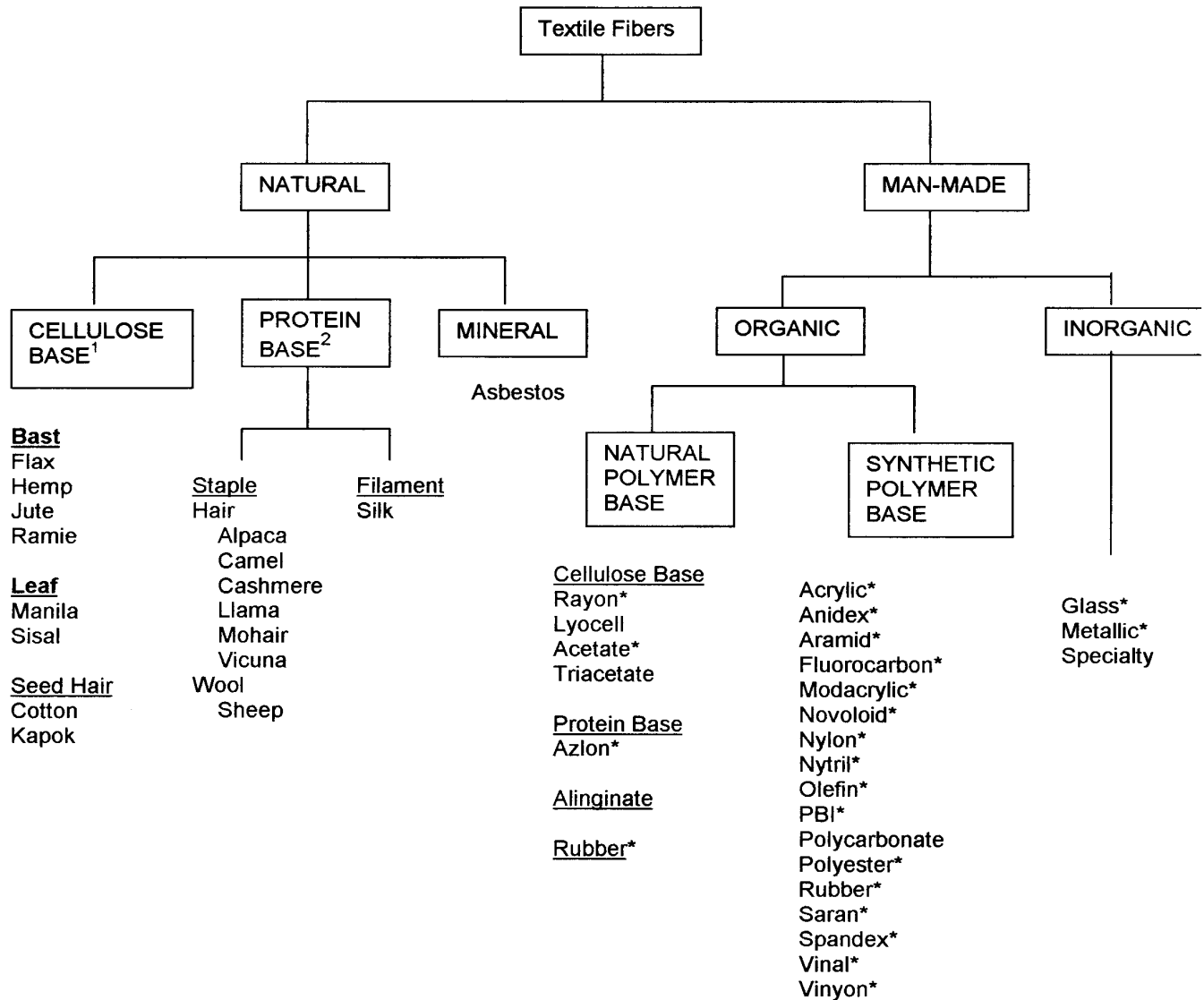
2. By length

**Short staple, Long staple, Continuous
filament**

3. By size

Ultra fine, fine, regular, coarse

General Classification of Textile Fibers





II. Polymer Properties

A. What are polymers?

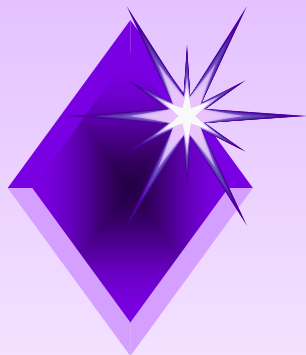
Poly

mer

Many

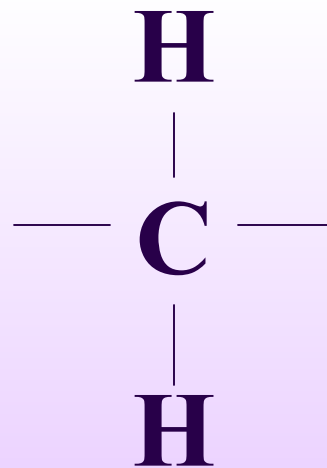
Units

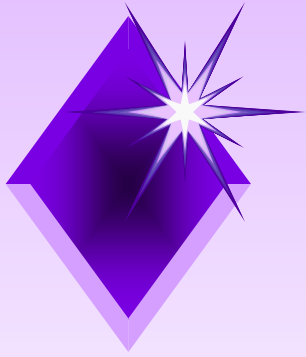
1. Polymer - molecules made up of many units



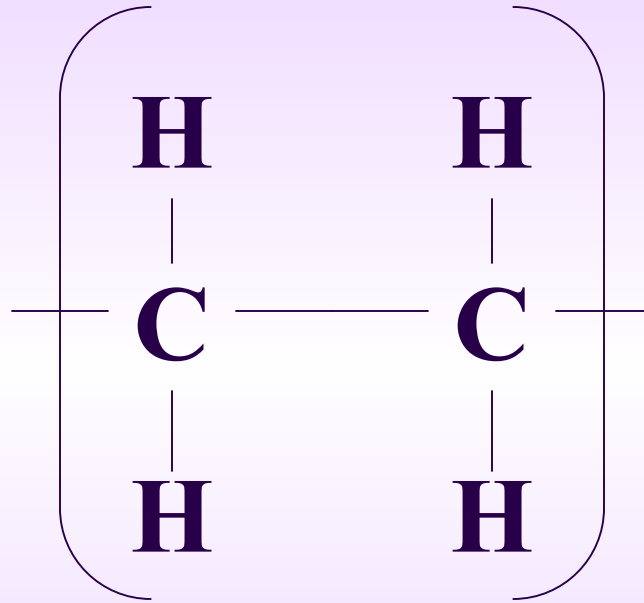
2. Individual units are called monomer or repeating units.
3. Example - polyethylene

ethylene

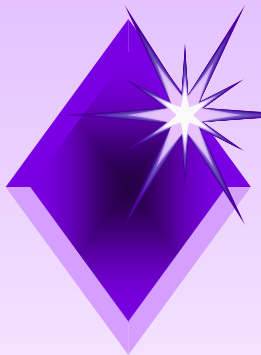




Polyethylene

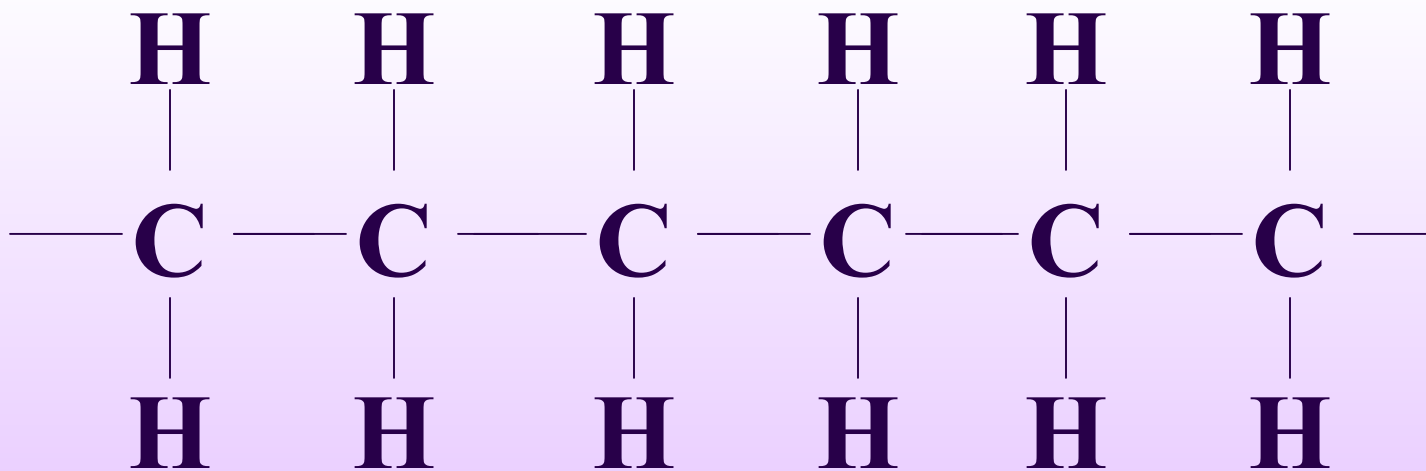


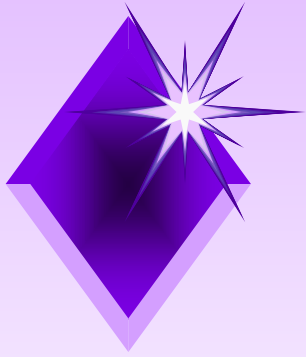
Repeating unit



B. Length of Polymer Molecules

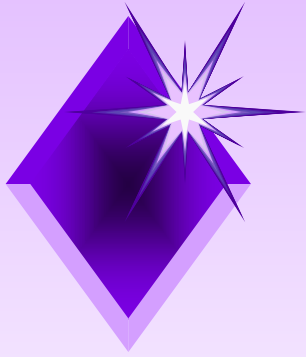
1. Described in terms of the number of repeating units in the molecule chain.





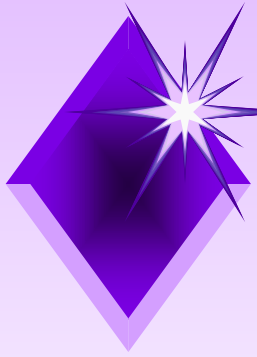
a. The number of repeating units is called the dp (degree of polymerization).

2. Polymers have high length to width ratios.



C. Why use polymers

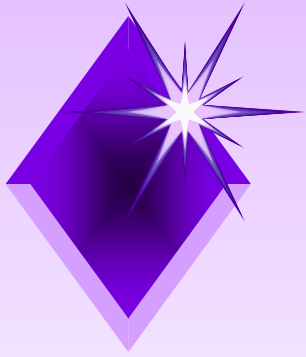
- 1. Shapeability**
- 2. Toughness**
- 3. Durability**
- 4. Flexibility**
- 5. Strength**
- 6. Elasticity**



D. Material Properties

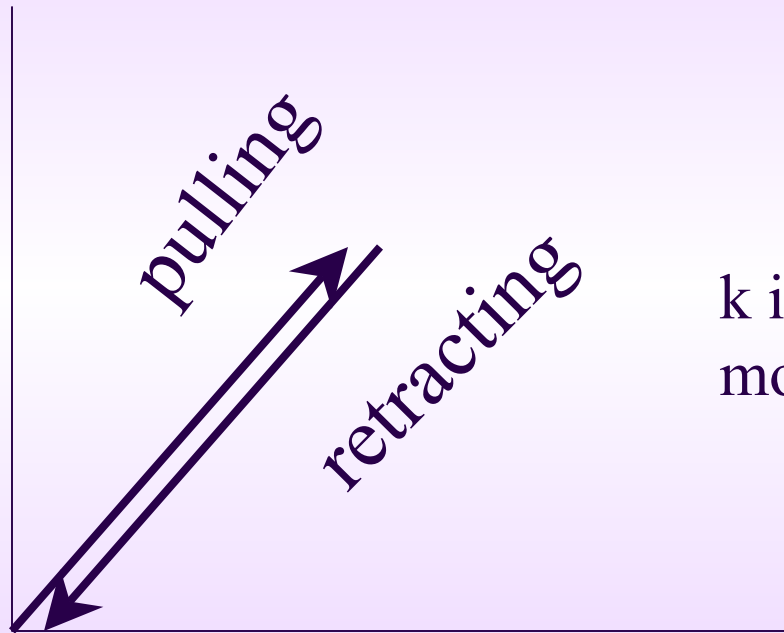
1. Elastic

- a. Elastic Behavior causes a material to return to its original shape after being deformed.**



b. Completely elastic behavior

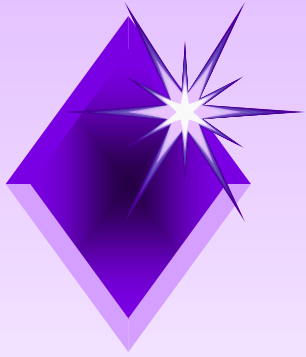
Force
(F)



$$\mathbf{F} = \mathbf{kx}$$

k is called the elastic modulus

Distance (x)



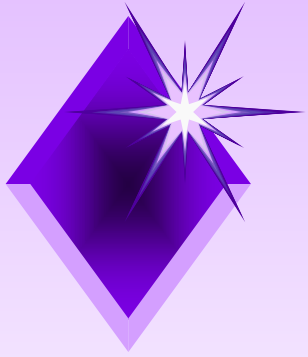
2. Viscous

- a. Viscous behavior is related to the rate of deformation.

$$\mathbf{F} = \eta \left(\frac{\Delta \mathbf{x}}{\Delta t} \right)$$

Viscosity

Rate of deformation



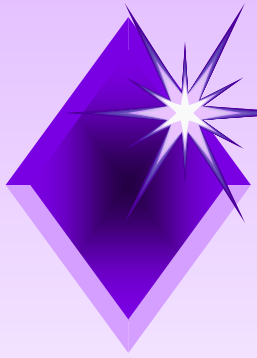
force, F



fast

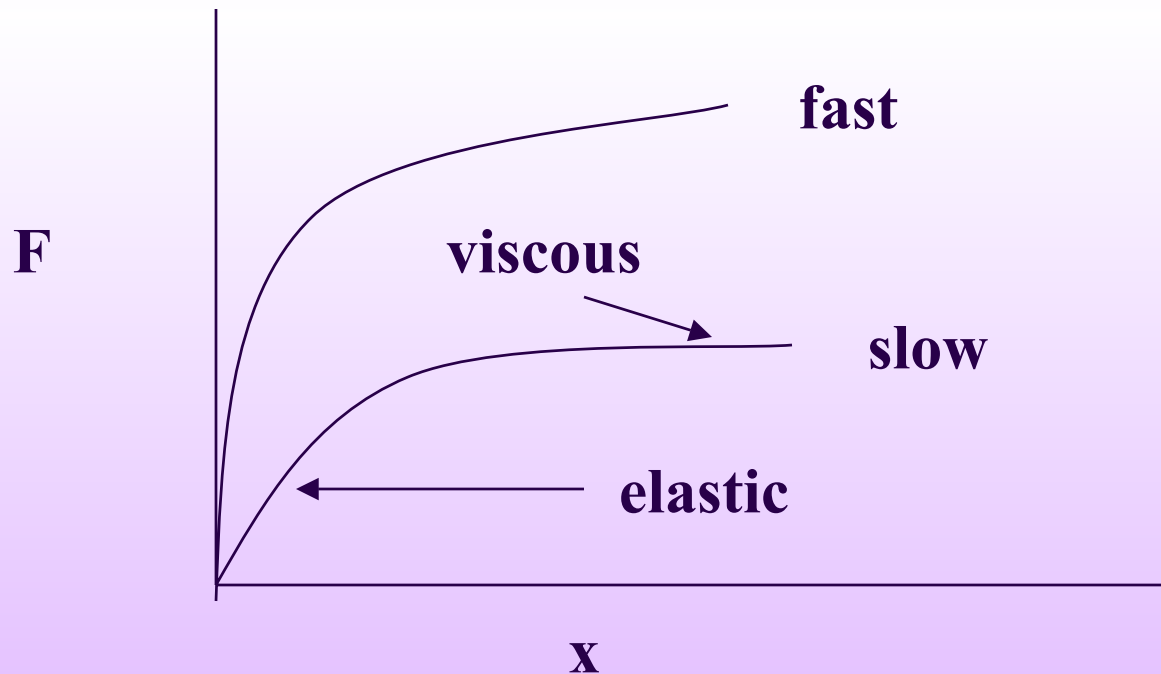
slow

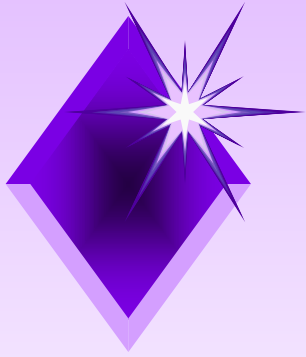
distance, x



3. Viscoelastic

- a. Fibers exhibit viscoelastic behavior
- b. force required to deform a material depends on amount of deformation and rate at which the material is deformed

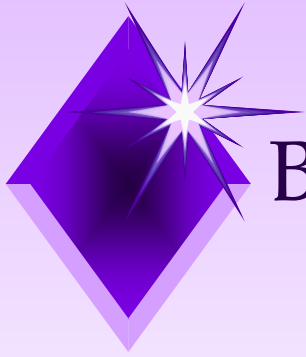




III. Fiber Science

A. Primary Properties

1. High length to width ratio
2. Breaking strength
3. Spinning quality
4. Uniformity



B. Secondary Properties

1. cross-sectional shape
2. density
3. luster
4. color
5. moisture absorption
6. elastic recovery
7. flammability
8. chemical resistance



IV. General Fiber Characteristics

A. External Structure

1. Length

(short staple 0.5 – 2.5 inches, long staple > 2 inches)

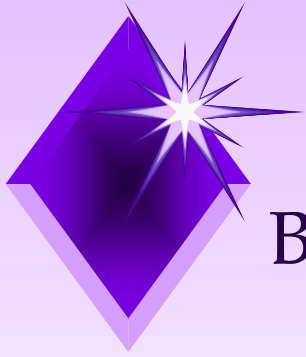
2. Diameter

(natural 10-20 microns, manufactured 10 – 50 microns)

3. Cross-sectional shape

4. Crimp

5. Color



B. Internal Structure

1. Chemical Composition

Sequence and kind of atoms in structure

2. Crystallinity

Polymer chains or sections packed together

3. Orientation

Alignment of chains along fiber axis

C. Thermal Properties

1. Melting Temperature

2. Glass Transition Temperature

Most polymers are thermoplastic – they soften before melting



D. Physical Properties

1. Breaking Strength

Force required to break a fiber

2. Breaking Elongation

Amount of stretch before breaking

3. Modulus

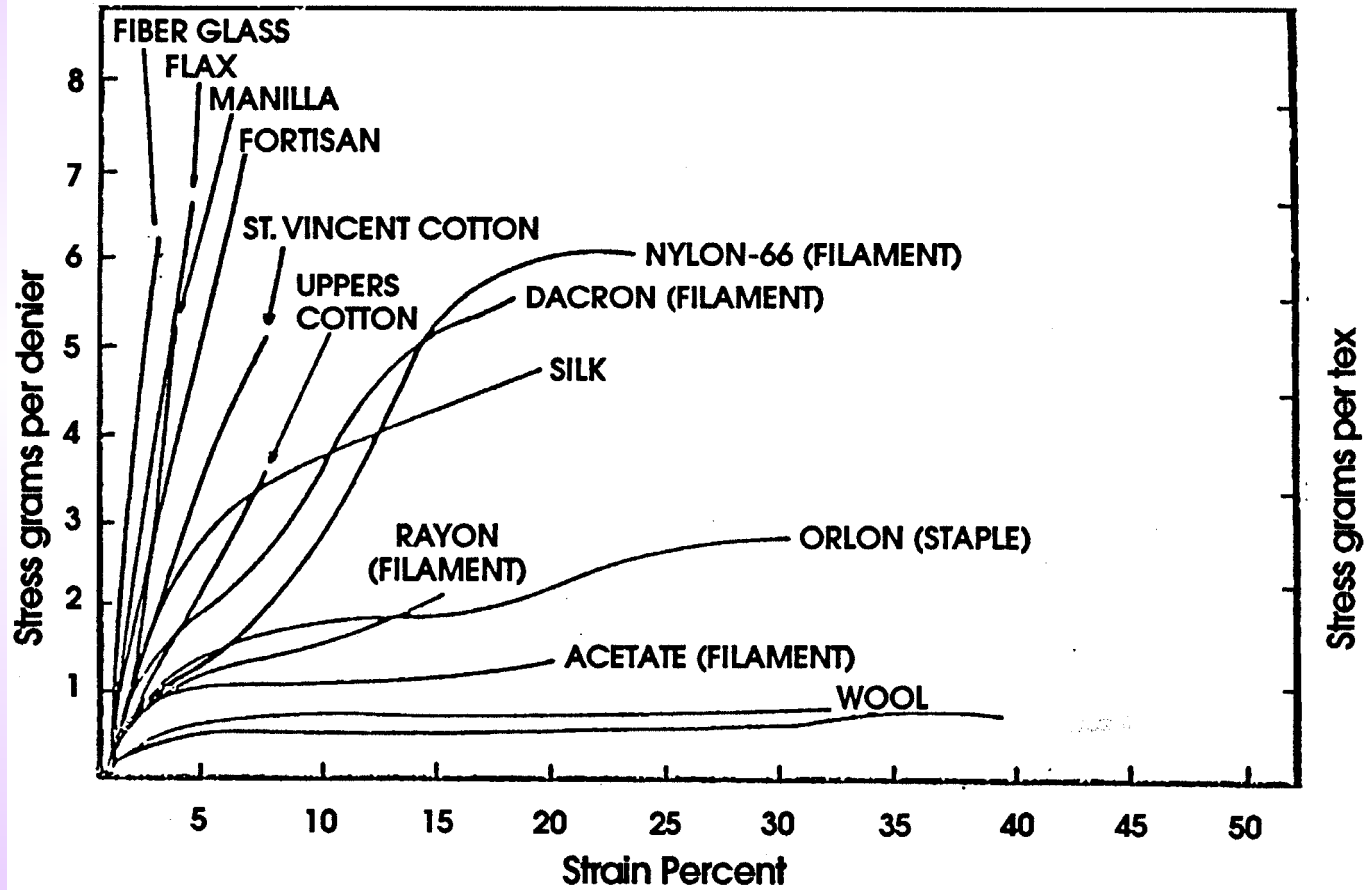
Resistance to deformation

4. Toughness

Amount of energy absorbed

5. Elasticity

Ability to recover after being deformed





E. Chemical Properties

1. Density

(0.9 to 1.6 g/cm³)

2. Moisture Regain

(0 to 20 %)

3. Chemical Resistance

4. Dyeability