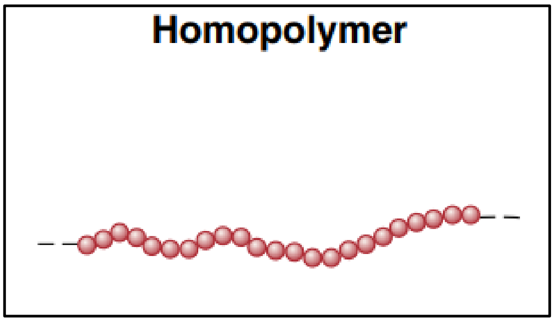
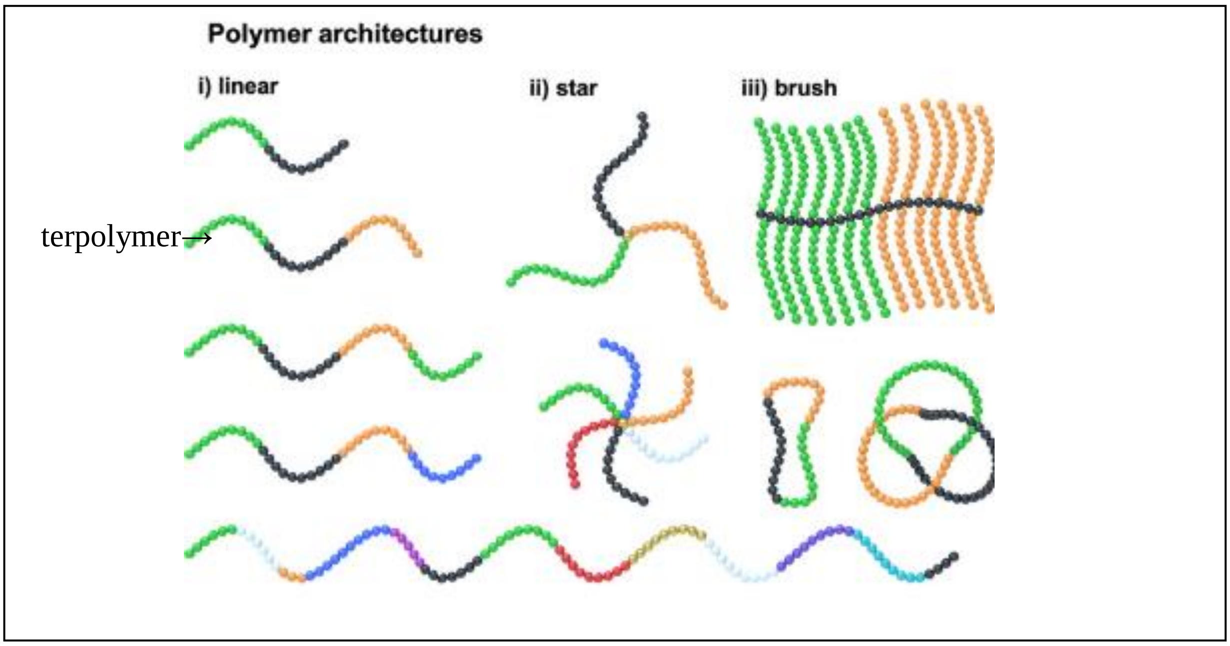
Polymers

- Polymers are a class of natural or synthetic substances composed of very high-molecular-weight molecules with repeating units, called macromolecules.
- A polymer is a molecule made up of many units (poly = many; mer = unit).
- An oligomer is a short polymer composed of two, three, four, or more but usually fewer than 10 mer units.
- The mer ending represents the simplest repeating chemical structural unit from which the polymer is composed.
- Example: poly(methyl methacrylate) is a polymer having chemical structural units derived from methyl methacrylate, while polystyrene is a polymer composed of styrene units.
- Monomers (mono = single) are the molecules that unite to form a polymer, and the process by which this occurs is termed polymerization.
- Polymers that have only one type of repeating unit (mer) are homopolymers
- Polymer molecules may be prepared from a mixture of different types of monomers.
- They are called copolymers if they contain two or more different chemical units and terpolymers if they contain three different units.
- Atoms along the length of any polymer are joined through strong, primary (C–C) covalent bonds.
- The most widely used impression materials (alginates, polyethers, polysulfides, and silicones) are either synthetic or natural polymers.



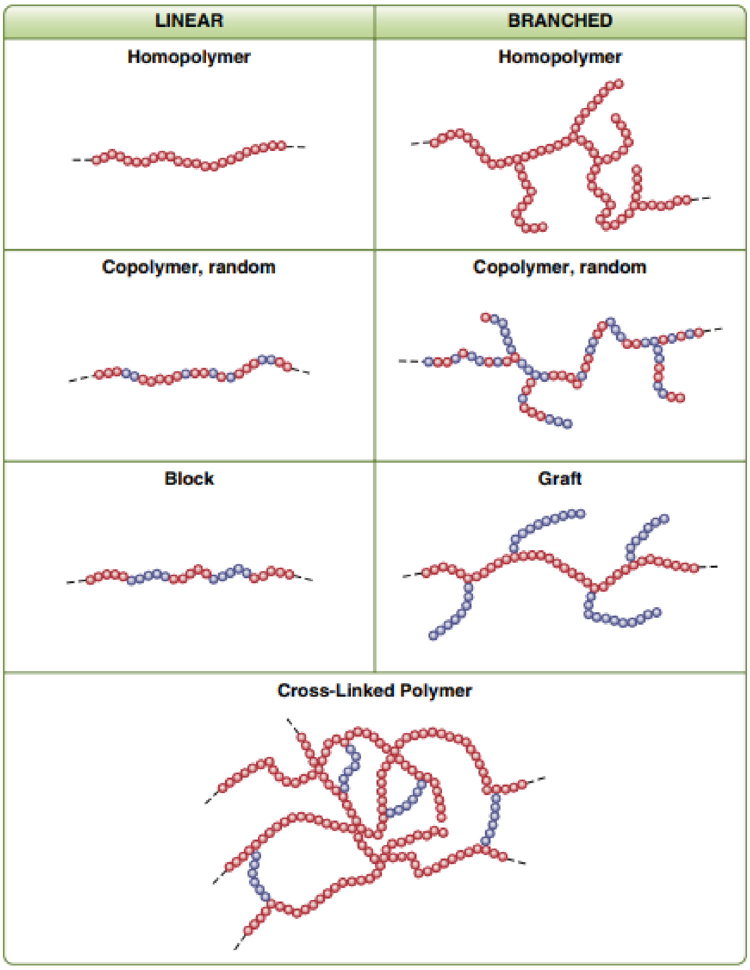


The **degree of polymerization** is defined as the total number of mers in a polymer molecule.

Factors which control structure and properties of polymers:

1. Chemical composition
2. Molecular weight: equals the molecular weight of the various mers multiplied by the number of the mers, may range from thousands to millions of molecular weight units, depending on the preparation conditions. The higher the molecular weight of the polymer, the higher the degree of polymerization, the higher the softening and melting points and the stiffer the polymer.
3. The physical or spatial structure of the polymer molecules: There are three basic types of structures: linear, branched, and cross-linked.

- The *linear homopolymer has mer units of the same type, and the *random linear copolymer has the two mer units randomly distributed along the chain. *The linear block copolymer has segments, or blocks, along the chain, whereas the mer units are the same. *The branched homopolymer consists of the same mer units, whereas the *graft-branched copolymer consists of one type of mer unit on the main chain and another mer for the branches.
- The *cross-linked polymer is made up of a homopolymer cross-linked with a single cross-linking agent.
- The linear and branched molecules are separate and discrete, whereas the cross-linked molecules are a network structure that may result in the creation of one giant polymeric molecule.
- The spatial structure of polymers affects their flow properties. The cross-linked polymers flow at higher temperatures than linear or branched polymers.
- Another distinguishing feature of some cross linked polymers is that they do not absorb liquids as the linear or branched materials. Cross linked polymers may swell in solvents.



- Longer chains and a higher molecular weight result in the polymer’s increased strength, hardness, stiffness, and resistance to creep along with increased brittleness.
  -Resin composites, for example, have a highly cross-linked matrix, in which a large number of strong covalent linkages between chains transforms the molecules into a rigid, very-high-molecular-weight material. The resulting increased strength and stiffness contribute to the ability of this material to withstand occlusal stresses during function.
  -In contrast, elastomeric impression materials are composed primarily of individual coiled chains with just a few cross-links. This type of molecular structure permits the large-scale uncoiling and recoiling of chains that give these materials high flexibility.
- The amount of crystallinity present in a polymer affects its properties. Materials that are highly crystalline have atoms with a very regular arrangement in space and are stronger, stiffer, and absorb less water than do noncrystalline materials. Few dental polymers are crystalline. Most are amorphous, meaning that the atoms of which they are composed have irregular arrangements in space. Amorphous polymers are often called glassy polymers. Small plasticizer molecules, when added to a stiff un–cross-linked polymer, reduce its rigidity. When small molecules surround large ones, the large molecules are able to move more easily. A plasticizer therefore lowers the glass-transition temperature (Tg) of the polymer, so a material that is normally rigid at a particular temperature may become more flexible. The glass-transition temperature is the temperature at which a polymer ceases to be glassy and brittle and becomes rubberlike.
- The temperature of a polymer has a strong effect on its strength properties