Whilst all plastics are polymers, not all polymers are plastics. Rubbers are more accurately called "elastomers." The definition of what qualifies a material to be called a polymer is being discussed and revised in the industry to ensure its clear understanding (www.cefic.org/Documents/IndustrySupport/Position_on_Polymers_20081218.pdf).

Polymers are large molecules made up of repeated units called monomers. These monomers are connected in long chains which are packed in orderly or less orderly arrangements. The latter, amorphous arrangements of molecules which do not have long-range order or form in which the polymer chains arrange themselves, are called amorphous polymers. Generally such polymers are transparent. This is an important characteristic for many applications, mainly for food wrappings in industry but equally desired for shaping designers' items as well as art forms.

In objects that are opaque, the polymer chains may be in a crystalline arrangement. By definition, a crystalline arrangement has a distinct pattern. Generally, the higher the degree of crystallinity, the less light can pass through the polymer. Therefore, the degree of translucence or opaqueness of the polymer is affected by its crystallinity. Crystallinity is also associated with greater strength, stiffness and chemical resistance of a polymer material.

There are a number of methods to classify polymers. One is based on their response to thermal treatment, dividing them into thermoplastic and thermosetting polymers. The thermoplastics, once formed, can be heated and reformed again. Raw elastomers such as natural rubber are thermoplastic but become thermosets after vulcanization; however, they remain elastic.

Another classification is based on the nature of chemical reactions involved in polymerization, dividing the polymers into two groups, *condensation* and *addition* polymers. In condensation polymers, a small molecule is lost in the process of polymerization, usually water, such as it occurs in polyesters. In addition polymers, unsaturated monomer is added, as in the polymerization of vinyl chloride.

The third system of classifying polymers relies on the mechanisms of the polymerization reaction, recognizing two types, *step* and *chain* reactions. In the first case, there is a gradual buildup of high relative molar mass material as a reaction progresses. In the chain reaction the buildup occurs rapidly, at a few active sites, while the rest of the monomer remains unreacted. The final structure formed during step reaction can vary from unbranched linear to heavily cross-lined network. Chain reactions produce only linear or lightly branched polymers (Nicholson, 1994).

Every polymer has unique and distinct characteristics, but most show the following general attributes (based on http://plastics.americanchemistry.com).

- Polymers are very light in weight with a significant degree of strength.
- Polymers can be processed in various ways: extracted, injected, shaped, stretched.
- Many polymers are resistant to chemicals.

- Polymers offer unlimited possibilities of characteristics resulting from manipulation of their manufacturing processes. They can be designed to mimic natural fibers such as cotton, silk or wool, or materials such as porcelain, marble or metals.
- Polymers can also produce unique materials not existing in nature, such as clear sheets and flexible films.

There are many different ways in which polymers may be classified or described. Figure 10.2 illustrates one of the approaches to polymer classification and characterization, combining many classifying factors.

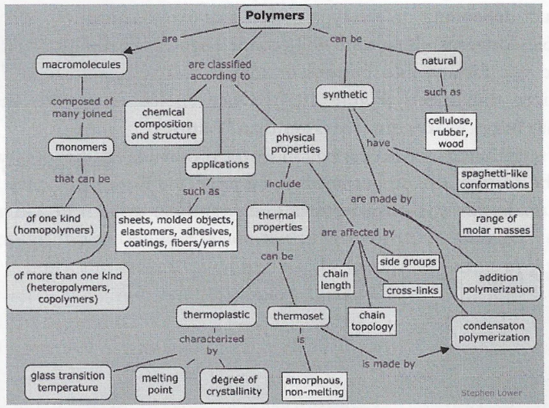

FIGURE 10.2 Multi-factor classification and characterization of polymers. (From the Chem1 Virtual Textbook by Stephen Lower, with permission; www.chem1.com/acad/webtext/virtualtextbook.html)

Natural and semi-synthetic polymers

Natural materials, such as cellulose and tree exudes, were the first regenerated natural polymers to produce new materials with different characteristics. Cotton, along with treated wood pulp, was the source for the industrial production of cellulose-derived materials which were the first "plastic" materials of commercial importance. Rayon, cellulose acetate and cellulose nitrate derived from cellulose, while rubbers and gutta percha derived from tree exudates, all of which are encountered in museum and archive collections. Some natural bio-polymers like shellac do not require alteration, producing a material that has qualities unmatched by any synthetic product which has attempted to replace it.

Shellac, one of the oldest natural polymers, was used as coating on wood, in early types of electric insulations, in cosmetics and for darkening of felt. Shellac is