

Table 3.1 Macromolecules

Macromolecule	Subunit	Function	Example
PROTEINS			
Globular	Amino acids	Modified glucose	Hemoglobin
Structural	Amino acids	Catalysis; transport	Hair; silk
NUCLEIC ACIDS			
DNA	Nucleotides	Encodes genes	Chromosomes
RNA	Nucleotides	Needed for gene expression	Messenger RNA
LIPIDS			
Fats	Glycerol and three fatty acids	Energy storage	Butter; corn oil; soap
Phospholipids	Glycerol, two fatty acids, phosphate, and polar R groups	Cell membranes	Lecithin
Prostaglandins	Five-carbon rings with two nonpolar tails	Chemical messengers	Prostaglandin E (PGE)
Steroids	Four fused carbon rings	Membranes; hormones	Cholesterol; estrogen
Terpenes	Long carbon chains	Pigments; structural	Carotene; rubber
CARBOHYDRATES			
Starch, glycogen	Glucose	Energy storage	Potatoes
Cellulose	Glucose	Cell walls	Paper; strings of celery
Chitin		Structural support	Crab shells

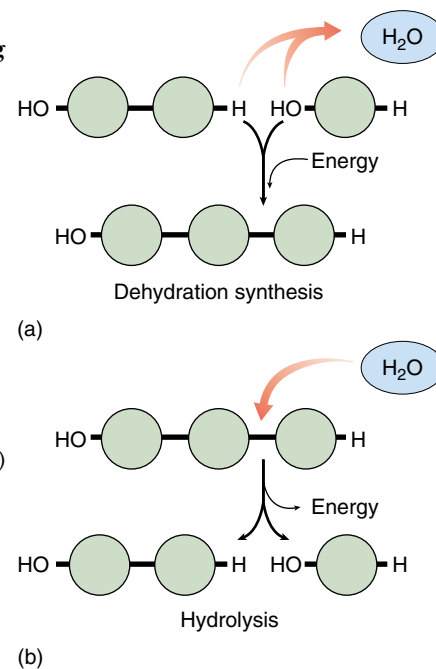
Building Macromolecules

Although the four categories of macromolecules contain different kinds of subunits, they are all assembled in the same fundamental way: to form a covalent bond between two subunit molecules, an —OH group is removed from one subunit and a hydrogen atom (H) is removed from the other (figure 3.3*a*). This condensation reaction is called a **dehydration synthesis**, because the removal of the —OH group and H during the synthesis of a new molecule in effect constitutes the removal of a molecule of water (H_2O). For every subunit that is added to a macromolecule, one water molecule is removed. Energy is required to break the chemical bonds when water is extracted from the subunits, so cells must supply energy to assemble macromolecules. These and other biochemical reactions require that the reacting substances be held close together and that the correct chemical bonds be stressed and broken. This process of positioning and stressing, termed catalysis, is carried out in cells by a special class of proteins known as enzymes.

Cells disassemble macromolecules into their constituent subunits by performing reactions that are essentially the reverse of dehydration—a molecule of water is added instead of removed (figure 3.3*b*). In this process, which is called **hydrolysis** (Greek *hydro*, “water” + *lyse*, “break”), a hydrogen atom is attached to one subunit and a hydroxyl group to the other, breaking a specific covalent bond in the macromolecule. Hydrolytic reactions release the energy that was stored in the bonds that were broken.

FIGURE 3.3
Making and breaking
macromolecules.

(*a*) Biological macromolecules are polymers formed by linking subunits together. The covalent bond between the subunits is formed by dehydration synthesis, an energy-requiring process that creates a water molecule for every bond formed. (*b*) Breaking the bond between subunits requires the returning of a water molecule with a subsequent release of energy, a process called hydrolysis.



Polymers are large molecules consisting of long chains of similar subunits joined by dehydration reactions. In a dehydration reaction, a hydroxyl (—OH) group is removed from one subunit and a hydrogen atom (H) is removed from the other.