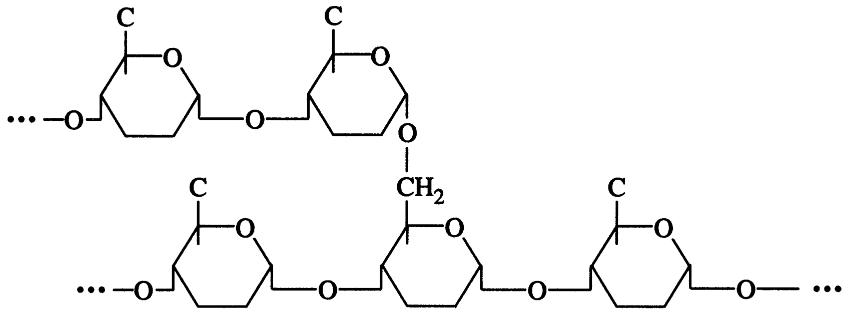
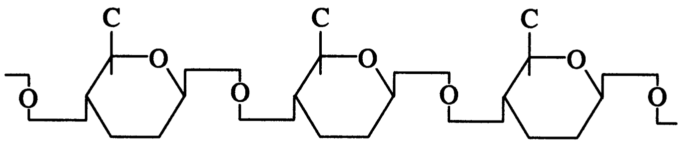


Amylopectin molecules are much larger than those of amylose, with a MW of 1 to 2 million daltons. Amylopectin is water soluble. Partial hydrolysis of starch (acidic or enzymatic) yields glucose, maltose, and dextrins, which are branched sections of amylopectin. Dextrins are used as thickeners.

Glycogen is a branched chain of glucose molecules that resembles amylopectin. Glycogen is highly branched and contains about 12 glucose units in straight-chain segments. The MW of a typical glycogen molecule is less than 5×10^6 daltons.

Cellulose is a long, unbranched chain of D-glucose with a MW between 50,000 and 1 million daltons. The linkage between glucose monomers in cellulose is a β-1,4 glycosidic linkage.



The β-1,4 glycosidic bond is resistant to enzymatic hydrolysis. Only a few microorganisms can hydrolyze β-1,4 glycosidic bonds of cellulose. α-1,4 glycosidic bonds in starch or glycogen are relatively easy to break by enzymatic or acid hydrolysis. Efficient cellulose hydrolysis remains one of the most challenging problems in attempts to convert cellulosic wastes into fuels or chemicals.

2.2.4. Lipids, Fats, and Steroids

Lipids are hydrophobic biological compounds that are insoluble in water, but soluble in nonpolar solvents such as benzene, chloroform, and ether. They are usually present in the nonaqueous biological phases, such as plasma membranes. Fats are lipids that can serve as biological fuel-storage molecules. Lipoproteins and lipopolysaccharides are other types of lipids, which appear in the biological membranes of cells. Cells can alter the mix of lipids in their membranes to compensate (at least partially) for changes in temperature or to increase their tolerance to the presence of chemical agents such as ethanol.

The major component in most lipids is *fatty acids*, which are made of a straight chain of hydrocarbon (hydrophobic) groups, with a carboxyl group (hydrophilic) at the end. A typical fatty acid can be represented as

$$CH_3—(CH_2)_n—COOH$$