16
CARBOHYDRATES III

In this plate we see how monosaccharides (single sugars) are joined together to make a wide variety of larger carbohydrates.

Color titles A through E and the related illustration. In this plate you need only color the whole molecules, so choose pale colors. The broken ring (D) around the lower glucose molecules illustrates that maltose (D) is formed from two glucose molecules. The ring does not actually exist in a molecule.

A *disaccharide* is formed by the removal of a hydrogen atom from one *monosaccharide molecule* and a hydroxyl (OH) group from another monosaccharide molecule to form a *water molecule.* The two monosaccharides are then joined together by a covalent bond to form a disaccharide. Since *water* is removed (dehydration) and the two monosaccharides are "condensed" into a single molecule, this reaction is commonly called a *"dehydration condensation"* or "dehydration synthesis" (*synthesis,* "putting together"), indicated by arrow B. This same type of condensation is used by living things to assemble proteins, lipids, and nucleic acids from their subunits, as we will see later. The reverse of this is called *hydrolysis* because a water molecule is broken in the process (Greek: *hydro,* "water"; *lysis,* "loosening" or "breaking").

The first section of this plate illustrates the dehydration condensation of two molecules of *glucose,* the principal sugar circulating in your blood, to form a molecule of the disaccharide *maltose.* Maltose is abundant in malt (germinated grain used in brewing) and is also produced when an enzyme (ptyalin) in your saliva breaks down starch in your mouth. Glucose and other monosaccharides are condensed in various combinations to make different disaccharides or polysaccharides (Greek: *poly,* "many").

Color the heading Disaccharides, the associated titles, and the sucrose and lactose molecules. Again, the broken rings (F and H) are for illustrative purposes only.

Sucrose is a disaccharide that is familiar as common table sugar, usually obtained from sugarcane or sugar beets. It is formed by the dehydration condensation of a molecule of glucose and a molecule of *fructose,* which is a monosaccharide abundant in many kinds of fruit. *Lactose* is a disaccharide that is abundant in milk. It is formed by the dehydration condensation of a molecule of glucose and a molecule of *galactose.* Galactose has a structure that is identical to glucose except for a reversal of the hydrogen and hydroxyl (OH) groups attached to carbon 4.

Color the heading Polysaccharides and titles J and K. Color over the amylose and amylopectin molecules.

Starch is a mixture of two different polysaccharides, *amylose* and *amylopectin.* Each is composed of hundreds of glucose molecules joined together. Starch provides plants with a good means of storing energy. In amylose, the glucose molecules are joined together in one long, unbranched chain that coils up into a helix in the watery environment found in living things. In amylopectin, the chain is branched and sometimes forms a complex network. All of the glucose molecules are in the alpha ring form, so the bonds linking them together are known as alpha linkages. Humans and other animals are able to digest both amylose and amylopectin, so they serve as a good source of energy.

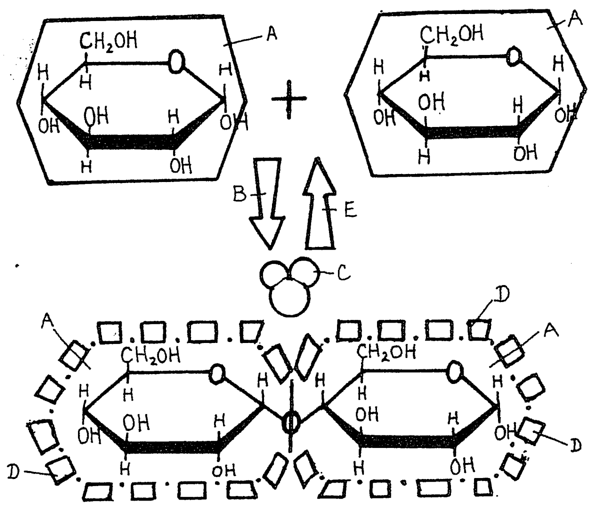
Color title L, and color over the glycogen molecule.

Glycogen is commonly called "animal starch," and that is a very appropriate name for it. It is exactly like amylopectin except that its chain branches at closer intervals and it apparently does not link up with other glycogen molecules to form networks. Its function is also the same. It serves as a means of storing large amounts of energy. After a meal, when you have more glucose in your blood than you need, your liver stores a great deal of glucose in the form of glycogen. Hours later, when your blood glucose begins to drop, the liver replenishes the supply. Muscle also stores glycogen to have an immediate supply of energy for emergencies.

Color title M, and color over the cellulose molecules.

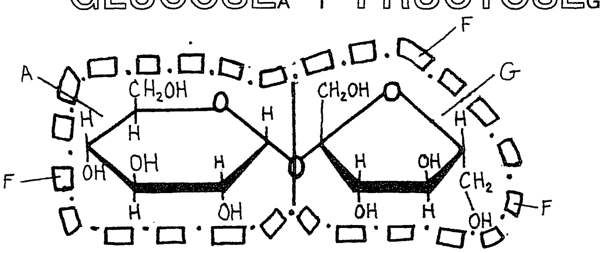
Cellulose is very much like amylose in consisting of a straight chain of glucose molecules, but the chains are much longer (up to 4000 glucose molecules in some plant fibers), and all the glucose is in the beta ring form. The bonds joining them together are therefore beta linkages, and it happens that no animal has an enzyme capable of breaking those linkages to make the glucose available for energy. Cattle and similar animals have bacteria in their digestive tracts that digest the cellulose for them, but for humans and most other animals, cellulose is completely indigestible. Cellulose does not form a helix like amylose; it joins to other cellulose molecules by means of hydrogen bonds, making an immense complex that is totally insoluble in water.

CARBOHYDRATES III.

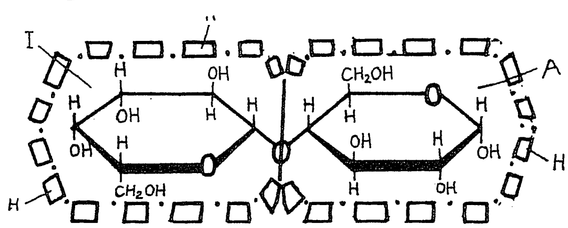


GLUCOSE (MONOSACCHARIDE)$_A$
DEHYDRATION CONDENSATION$_B$
WATER$_C$
MALTOSE (DISACCHARIDE)$_D$
HYDROLYSIS$_E$

DISACCHARIDES$_\star$
SUCROSE$_F$
GLUCOSE$_A$ + FRUCTOSE$_G$



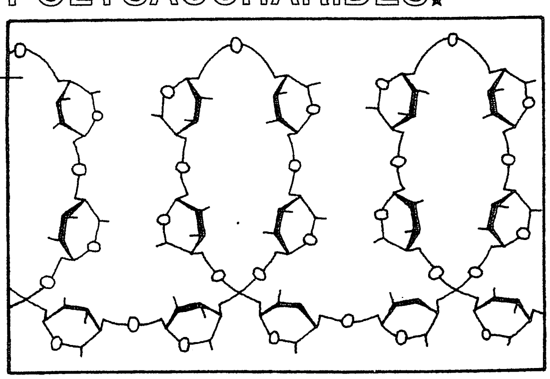
LACTOSE$_H$
GALACTOSE$_I$ + GLUCOSE$_A$



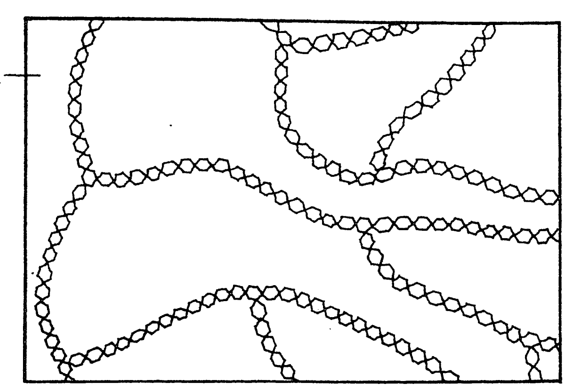
POLYSACCHARIDES$_\star$

AMYLOSE$_J$
AMYLOPECTIN$_K$
GLYCOGEN$_L$
CELLULOSE$_M$

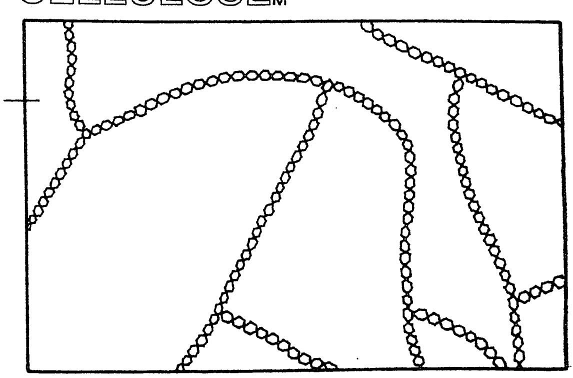
J



L



K



M