

## Highlights Energy II

1. The electron carriers in cells,  $\text{NAD}^+/\text{NADH}$ ,  $\text{FAD}/\text{FADH}_2$ , and  $\text{NADP}^+/\text{NADPH}$  must cycle between oxidized and reduced forms. They are present in limiting amounts in cells, so having adequate quantities of them for metabolic oxidation/reductions requires that they be balanced. To convert  $\text{NADH}$  to  $\text{NAD}^+$  or  $\text{FADH}_2$  to  $\text{FAD}$  requires "dumping" of electrons and protons into the electron transport system. Failure to do that may require cells to go through fermentation.

## Highlights Carbohydrates

1. Glucose and fructose are common carbohydrates (sugars) and differ only that glucose is an aldehyde, whereas fructose is a ketone. Both have six carbons and you should know their structures (linear and circular forms - see below).

2. The letters 'ose' at the end of a name designate a sugar. An aldose is a sugar, like glucose, that is an aldehyde. A ketose is a sugar like fructose that is a ketone. A hexose has six carbons, a pentose has five carbons, a tetrose has four carbons, and a triose has three carbons.

3. The L form of a sugar (like L-glucose) differs from the D form of a sugar of the same name (like D-glucose) in that the two are mirror images of each other. Sugar molecules that have the same number of carbons, and have different stereoisomeric configurations but that are NOT mirror images of each other are called diastereomers.

4. Sugars can form a ring structure due to the fact that carbons 1 and 5 (or 2 and 5) are located in close proximity to each other and the alcohol on carbon 5 can react with the aldehyde on carbon one or the ketone on carbon two to form a hemiacetal or hemiketal respectively. The resulting ring structure is called a Haworth projection. The linear form, as written, is called a Fischer projection.

5. Sugars, like glucose, that form six membered rings are called pyranoses, whereas sugars, like fructose and ribose, that form five membered rings are called furanoses.

6. Formation of a ring creates a new asymmetric carbon (called the anomeric carbon) on the carbon where the aldehyde or ketone originally was (carbon 1 or 2). The hydroxyl on this carbon can exist in a Haworth projection pointing upwards (beta) or downwards (alpha). Please note that linear forms of these sugars DO NOT have anomeric carbons, since the cyclization is what creates the asymmetry.

7. You should know and be able to draw the Fischer straight chain form and the Haworth form of glucose, fructose, and ribose. You should also know the Haworth structure of sucrose.

8. Aldoses, like glucose, are readily oxidized. Ketoses are NOT nearly as readily oxidized as aldoses.

9. Reduction of the aldehyde or ketone structure of a sugar can lead to compounds like sorbitol that are sometimes called sugar alcohols.

10. Replacement of the hydrogen on the hydroxyl of an anomeric carbon by any other atom creates a glycoside. The bond is referred to as a glycosidic bond. Many carbohydrates containing multiple sugar units have glycosidic bonds. Sucrose (glucose + fructose) has a glycosidic bond joining the two sugars, as does lactose (glucose + galactose). Carbohydrates with two sugars are known as disaccharides. Sugars that are not

glycosides can change readily from alpha to beta, but glycosides are locked in the configuration they were in when the hydrogen was replaced from the hydroxyl group of the anomeric carbon.

11. Polymers of sugars create polysaccharides. Amylose is a polysaccharide of plants that consists of glucose units linked solely in alpha-1,4 linkages. Glycogen is a storage polysaccharide of animals that contains glucose units linked in alpha-1,4 linkages and every ten residues or so, there is a 1,6 branch to a new chain of glucose. Glycogen is therefore very branched. Amylopectin is a polysaccharide of plants that also is a glucose polymer with alpha-1,4 linkages and alpha-1,6 branches, but the branches are not nearly as frequent as in glycogen. Starch is a mixture of amylose and amylopectin.

12. Cellulose is a polymer of glucose, but instead of having units linked alpha-1,4, cellulose has the units linked beta-1,4. Most animals cannot digest cellulose and thus cannot derive energy from it. Since cellulose is a component of plant cell walls, much energy is lost as a result.

13. Ruminant animals, such as cows, have bacteria in their rumens (specialized stomachs) that contain the enzyme cellulase. Cellulase can break the beta-1,4 bonds between the glucoses in cellulose and provide energy to cows.