STUDY GUIDE - *Ch. 5.2 - Carbohydrates serve as fuel and building material.* **NAME:** _____

- **PHYSICALLY PRINT OUT this PDF and HANDWRITE (with a black or blue pen) your answers directly on this PDF.** *Typed or digitally-written work is **not** accepted. Do **not** answer questions on separate paper.*
- **Importantly, study guides are NOT GROUP PROJECTS!!!** *You, and you alone, are to answer the questions as you **read** your assigned textbook. You are **not** to share answers with other students. You are **not** to copy any answers from any other source, including the internet.*
- **Get in the habit of writing LEGIBLY, neatly, and in a medium-sized font.** *AP essay readers and I will skip grading anything that cannot be easily read so start perfecting your handwriting, and don't write so large you can't add all the relevant details and key elaborations in the space provided.*
- **SCAN physical documents in color and with good resolution. Then, upload your final work as PDFs to Archie.** *Avoid uploading dark, shaded, washed-out, sideways, or upside-down scans of homework. Keep completed physical study guides organized in your biology binder to use as future study and review tools.*
- **READ FOR UNDERSTANDING and not merely to complete an assignment.** ***First**, read a section quickly to get an overview of the topic covered. Then, read it a **second** time slowly, paraphrasing each paragraph **out loud** and analyzing every figure. Finally, read it a **third** time as you answer the study guide questions if assigned and start building your memory. Try to write answers out in your own words, when possible, and try to purposefully and accurately use all new terminology introduced.*

KEY CONCEPTS

- Carbohydrates serve as a **source of energy** and **building material** (atoms) for making other molecules in the cell.

1. What are the **carbohydrates**?

2. a. The simplest carbohydrates are called the **simple sugars** or _____.
   b. When two simple sugars are covalently linked, the resulting carbohydrate is called a _____.
   c. Short chains of simple sugars (3 to 10-ish) are sometimes called **oligosaccharide** (*oligo* meaning "few" in Ancient Greek, which has evolved into *ligo* in Modern Greek). Polymers of carbohydrates though can contain many (100s to even 1000s) of simple sugar monomers like glucose. These **carbohydrate polymers** are called _____.

3. a. Provide the general **empirical formula for MONOsaccharides**. *(Empirical formulas show the ratio of elements)*

   b. What are the **compositional "trademarks" of a monosaccharide** (the functional groups you expect to see **and** the length of the carbon skeleton you expect to see)? *Of course, how all the parts of monosaccharides are arranged around the asymmetrical carbons found along different lengths of carbon skeletons also makes one monosaccharide different from another.*

      1. Draw and name the **Functional Groups Present in Monosaccharides**

      2. **Typical Length of Carbon Skeleton of Monosaccharides**:

   c. What is particular to the **ending of the name of most sugars**?

4. **Enzymes are biological catalysts**, *molecules (proteins) that speed up the rates of chemical reactions.* Enzymes called isomerases, for example, can convert a molecule to one of its other isomers. For example, glucose isomerase certain glucose molecules into certain fructose molecules. Now, take a look at Figure 5.3.

   a. Based on what you learned in Ch.4, are Ribose and Glucose isomers? Why or why not *(make sure you revisit that definition of an isomer from Ch.4 if you have not mastered it yet)*, and, if so, name the type of isomer they qualify as (structural, geometrical (cis/trans), or stereo (enantiomer) isomers)?

   b. Are Fructose and Galactose isomers? Why or why not, and, if so, name the type of isomer they qualify as (structural, geometrical (cis/trans), or stereo (enantiomer) isomers)?

5. a. **Though carbohydrates are sugars, monosaccharides are often referred to as SIMPLE SUGARS.** What happens to most **five- and six-carbon simple sugars (monosaccharides) when added to an aqueous solution**?

   b. Study Figure 5.4, which shows the formation of the **ring structure of glucose**, the most common form of glucose found in water-based solutions, such as those of the human body. Draw the abbreviated ring structure of glucose below, making sure you have **numbered each carbon** in the molecule correctly and added the hydroxyl groups in the correct orientation relative to the carbon ring. ***Memorize how to draw this!***

6. What are **three ways cells use monosaccharides** like glucose?

   I.

   II.

   III.

7. a. What is a **disaccharide**? (Be sure to also include in your answer the **name of the particular covalent bond that forms between the two monosaccharides**)

   b. What **chemical reaction needs to take place in order to join two monosaccharides into a disaccharide**?

8. Complete the table below regarding three popular **disaccharides**.

Disaccharide	Formed from which two monosaccharides?	Found where?

9. Plants generally transport sugar from photosynthetic cells *(the green parts of the plant)* to non-photosynthesizing cells as **sucrose**, a disaccharide of glucose and fructose covalently bonded together. The molecular formula for glucose is $C_6H_{12}O_6$. The molecular formula for fructose is also $C_6H_{12}O_6$. What would be the **molecular formula for sucrose**? Think about how a disaccharide, like sucrose, is made from 2 monosaccharides in the plant cell and deliver an answer using your own logic. I do **not** want you to rush to look up the answer elsewhere. Come up with the most logical answer you can, given what you have learned in biology so far. *(When done, check your accuracy by locating the answer provided to you at the very end of this assignment PDF).*

10. Next, study Figure 5.5. Make sure you do understand why maltose is said to have a **1-4 glycosidic linkage** connecting the two glucose molecules while sucrose is said to have a **1-2 glycosidic linkage** instead joining glucose and fructose. What do the numbers 1 - 4 and 1 - 2 (later your text will even mention 1 - 6) relate to?

11. a. What is a **polysaccharide**?

    b. What are the **two main functions of polysaccharides**?

       I.

       II.

12. a. What is **starch**?

b. What **type of organisms make starch**?

c. What is the name of the **organelles in cells that store starches**?

d. What is the **purpose/function of building starches?**

e. How are **starches used**?

13. What are the **two categories of starch** ***AND*** what are their **distinguishing characteristics** as related to the **1. relative amount of branching in the molecule** & **2. the types of glycosidic linkages found in the molecule**?

I. **Type of Starch**:

Amount of Branching:

Types of Glycosidic Linages Found Throughout the Entire Molecule:

II. **Type of Starch**:

Amount of Branching:

Types of Glycosidic Linages Found Throughout the Entire Molecule:

14. a. What is **glycogen**?

b. What **type of organisms make glycogen**?

c. What are the **two locations where glycogen is made and stored** in these animal bodies?

[ ] + [ ]

d. Similar to starches in plants, what is the **purpose of building glycogen and how are they used**?

e. Glycogen looks a little more like amylopectin than amylose, but it isn't identical. What are the **distinguishing characteristics** of glycogen as far as the **1. relative amount of branching in glycogen compared to amylopectin** & **2. the types of glycosidic linkages found in glycogen compared to amylopectin**?

Amount of Relative Branching:

Types of Glycosidic Linages Found Throughout the Entire Molecule:

15. **Starch and glycogen** are two types of **storage polysaccharides.** Now, name the **two structural ploysaccharides**.

[ ] & [ ]

16. a. What is **cellulose**?

b. What **type of organisms makes cellulose**?

c. How is **cellulose similar to starch**?

d. How does the **glucose in used to build cellulose differ from that used for building starch**? *Be specific.*

17. a. The fact that two isomers of ringed glucose exist means that starch and cellulose end up with different three dimensional structures. Explain the differences in the **shape of the macromolecule of starch vs cellulose**.

Shape of Starch Molecule:

Shape of Cellulose Molecule:

b. The forms (shapes) of starch and cellulose fit their function. How does **form fit function in both starch and cellulose**?

Starch:

Cellulose: *(Explain **how** cellulose forms microfibrils which make up support structures like plant cell walls)*

c. **Unlike their monomers, large biological molecules are too large to be transported into cells and into the bodies of multicellular organisms**. If starch and cellulose are both made of monomers joined via glycosidic linkages, **why can animals not use cellulose directly as a source of nutrition** (glucose monomers that provide carbon and energy to cells) **while some prokaryotes** (like those that act as decomposers in ecosystems or those that live in the digestive tracts of cows and termites) **and some eukaryotic fungi** (that also act as decomposers in ecosystems) **can use cellulose directly as a source of nutrition**?

d. **Antibiotics kill bacteria (not viruses)!** If a cow is infected with a harmful bacteria, they will be given antibiotics to clear the infection. After treatment, the cow is given a culture of various bacteria to drink. What do you think might happen to the cow if this isn't done? **Explain why you claim what you claim**.*(Check your answer by going to the **Ch.5.2 Concept Check Question #3** answer in Appendix A)*

e. In our human diet, though we do absorb other nutrients from plant cells, **fiber** itself is not a source of nutrition because, unlike cows and termites, the human digestive tract does not house the particular bacteria that can break down the cellulose that makes up the plant's cell wall for us. Fiber, or roughage as it is sometimes called, is an important component of our diet nonetheless. Since it isn't broken down and absorbed, fiber 1. **adds bulk to our stools (feces)**. Since cellulose is made of glucose molecules, which are polar (given all their partially charged hydroxyl groups), **some water molecules hydrogen bond with cellulose inside our digestive tract, keeping our feces moister and softer** than it might otherwise remain once a lot of the water in our food and drink is absorbed into our bodies. Though too much can be bad, some studies have found **correlations between diets low in fiber and higher rates of colon cancer**. What other **benefit does dietary fiber have**?

18. a. The structural polysaccharide chitin is similar in structure to cellulose, but not identical. In what way is **chitin SIMILAR to cellulose**?

b. In what way does **chitin DIFFER from cellulose**?

c. Which **two types of organisms use chitin** and **where** in their bodies is it used?

I. **Organism That Makes Chitin**:

Where Is Chitin Used:

II. **Organism That Makes Chitin**:

Where Is Chitin Used:

19. Let's review. Each prompt below describes a unique carbohydrate. Name the correct carbohydrate.

a. Composed of 1–4 β-glucose linkages instead of 1–4 α-glucose linkages.

b. Is a storage polysaccharide produced by vertebrate animals, **stored in liver and muscle cells**.

c. Two monomers of this monosaccharide form maltose.

d. The disaccharide sugar found in milk.

e. Structural polysaccharide that gives cockroaches their "crunch"

f. Structural polysaccharide that comprises plant cell walls

Answer to #9: The molecular formula for sucrose is $C_{12}H_{22}O_{11}$. Remember, during a dehydration synthesis reaction, certain atoms are removed form each of the two monomers, atoms that join to produce one molecule of water (H_2O), these atoms of water not part of the newly formed sucrose molecule product.