



Dehydration Synthesis

Prior Knowledge Questions (Do these BEFORE using the Gizmo.)

1. If you exercise on a hot day, you need to worry about dehydration. In this context, what do you think *dehydration* means?

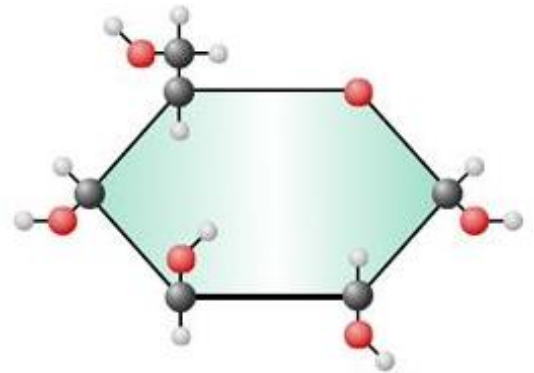
without water

2. Astronauts and backpackers often bring dehydrated food. What do you think dehydrated food is?

Food that has its water removed.

Gizmo Warm-up

What do rice, potatoes, and sugar have in common? They are all foods rich in **carbohydrates**. Carbohydrates are an important energy source for your body. The basic building block of most carbohydrate compounds is the molecule **glucose**. Using the *Dehydration Synthesis* Gizmo, you will learn about the structure of a glucose molecule and how glucose molecules can be joined together to make larger carbohydrate molecules.



To begin, select the CREATE GLUCOSE tab.

1. Look at the **chemical formula** for glucose. How many carbon (C), hydrogen (H), and oxygen (O) atoms are found in a molecule of glucose?

C: 6 H: 12 O: 6

2. Turn on **Show chemical structure**. Each black sphere represents a carbon, hydrogen, or oxygen atom. The lines connecting the spheres represent chemical bonds.

A. How many black spheres are in the diagram? 24

- B. How does this relate to the number of carbon, hydrogen, and oxygen atoms in the chemical formula for glucose?

$$6 + 12 + 6 = 24$$

<p>Activity A:</p> <p>Build a glucose molecule</p>	<p>Get the Gizmo ready:</p> <ul style="list-style-type: none"> Be sure the CREATE GLUCOSE tab is still selected. 	
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Introduction: Each element tends to form a certain number of chemical bonds. This value is the **valence** of the element. For example, a carbon atom has a valence of four.

Goal: Construct a molecule of glucose.

1. **Identify:** The structure of a water molecule (H_2O) can be written as H-O-H, with each dash representing a chemical bond. Count the number of bonds the oxygen and hydrogen atoms form in a water molecule.

A. What is the valence of oxygen? 6

B. What is the valence of hydrogen? 1

2. **Build a model:** Use the carbon, oxygen, and hydrogen atoms from the **Atoms box** to build a glucose molecule on the empty hexagon in the building region. Use the chemical structure in the lower right or on the previous page as a guide and **pay attention to the valence of each atom as you build.**

Once you think you have correctly constructed the glucose molecule, click **Check**. If necessary, continue to modify your molecule until it is correct.

3. Congratulations, you have completed a molecule of glucose!

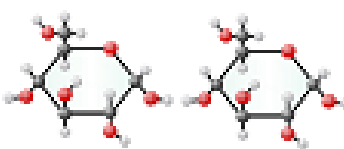
4. **Explain:** How did the valence of each element help you determine the structure of the glucose molecule?

The maximum number of electrons of each orbital minus the valence number tells you how many covalent bonds that atom can have.

5. **Make connections:** Carbon forms the backbone of every major type of biological molecule, including carbohydrates, fats, proteins, and nucleic acids. How does carbon's valence relate to its ability to form these large and complex biomolecules?

(Crash Course - Carbon)

Carbon's valence# 4 gives it the covalent capability to bond with many different elements which makes it the central atom in the chemistry of life.

Activity B: Dehydration synthesis	<u>Get the Gizmo ready:</u> <ul style="list-style-type: none"> Select the DEHYDRATION tab. 	
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What occurs when two glucose molecules bond?

1. **Infer:** Glucose is an example of a **monosaccharide**, the simplest type of carbohydrate. A **disaccharide** is made from bonding two monosaccharides together.

What do you think the prefixes *mono-* and *di-* mean? *Mono:* 1 *Di:* 2

2. **Predict:** Turn on **Show description**. Drag both glucose molecules into the building region. Observe the highlighted region. What do you think will happen to the atoms in this region when the glucose molecules bond?

A molecule of water will be produced.

3. **Run Gizmo:** Click **Continue** and watch the animation.

A. What happened? **A molecule of water will be produced.**

B. What was removed from the glucose molecules when they bonded to form maltose?
water

4. **Infer:** Based on what you have seen, create a balanced equation for the dehydration synthesis reaction. (Recall that the formula for glucose is C₆H₁₂O₆.) You will have to determine the formula of maltose yourself.

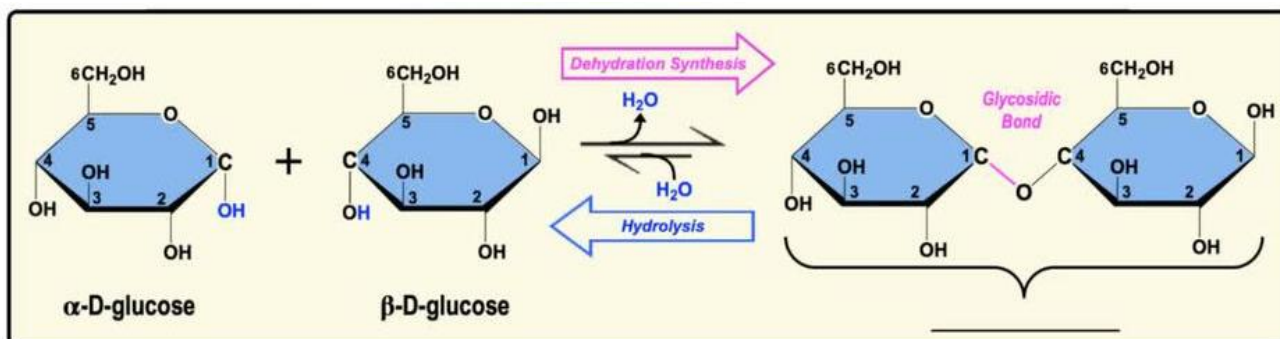


Turn on **Show current formula/equation** to check your answer.

5. **Explain:** Based upon what you observed, what occurs during a **dehydration synthesis**?

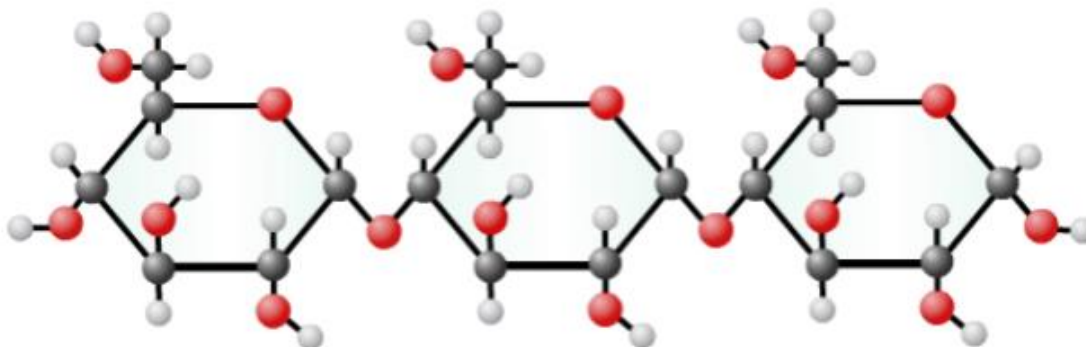
Dehydration synthesis is the creation of larger molecules from smaller monomers where a water molecule is released.

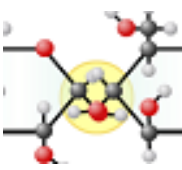
6. The diagram below shows 1 - 4 *glycosidic linkages* in the formation of a disaccharide from 2 monosaccharides. What are **glycosidic linkages** and define this terminology in terms of carbon numbering.



Glycosidic bond is formed between the carbon-1 of one monosaccharide and carbon-4 of the other monosaccharide.

7. A *trisaccharide* is a carbohydrate made of three monosaccharides. What do you think would be the chemical formula of the trisaccharide below made of three bonded glucose molecules?



<p>Activity C: Hydrolysis</p>	<p>Get the Gizmo ready:</p> <ul style="list-style-type: none"> • Select the Hydrolysis tab. • Turn on Show description and Show current formula/equation. 	
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Introduction: Carbohydrates made up of three or more bonded monosaccharides are known as **polysaccharides**. In a reaction known as **hydrolysis**, your body breaks down polysaccharides into individual monosaccharides that can be used by your cells for energy.

What occurs when polysaccharides break up into monosaccharides?

- Predict:** Examine the polysaccharide in the building region and its chemical formula.

 - How many monosaccharides can form if this polysaccharide breaks up? 3
 - Recall the formula of glucose is $C_6H_{12}O_6$. How many carbon, oxygen, and hydrogen atoms will you need for three glucose molecules?
C = 18 H = 36 O = 18
 - What must be added to the polysaccharide in the Gizmo to get three glucose molecules?
water / H₂O
- Observe:** Turn off **Show current formula/equation**. Drag a water molecule into the building region. Click **Continue**. What happened? One monosaccharide split or broke off from the molecule.
- Infer:** Create a balanced equation for the hydrolysis reaction that just occurred.
 $C_{18}H_{36}O_{18} + H_2O \longrightarrow C_{12}H_{22}O_{11} + C_6H_{12}O_6$

Turn on **Show current formula/equation** to check your answer.
- Observe:** Turn off **Show current formula/equation**. Drag the second water molecule into the building region. Click **Continue**. What happened? Another monosaccharide split or broke off from the molecule.

5. **Summarize:** Now create a balanced equation for that shows the entire hydrolysis reaction.
(In other words, the equation should show how the polysaccharide broke up into three separate glucose molecules.)



Turn on **Show current formula/equation** to check your answer.

6. **Compare:** How do hydrolysis reactions compare to dehydration synthesis reactions?

Dehydration synthesis reactions build molecules up and generally require energy, while hydrolysis reactions break molecules down and generally release energy.

7. **Apply:** Amylose is a polysaccharide that consists of a long single chain of glucose molecules. Consider an amylose molecule with only four glucose molecules.

- A. How many water molecules are released when the 4-glucose amylose forms? 3
- B. What do you think is the chemical formula for this amylose? C₂₄H₄₂O₂₁
- C. How many water molecules would be needed to break this amylose down into four glucose molecules?
3

8. **Extend your thinking:**

- A. Hydrolysis of the carbohydrates you eat begins in your mouth as you chew. Why is this? How do you think this process might be affected if a person's salivary glands were unable to produce saliva, which is mostly composed of water?

The digestion of carbohydrates (polysaccharides) begins in the mouth because glucose (monosaccharide) is needed for the CONSTANT production a ATP via cellular respiration. Without water (and enzymes) the hydrolysis of carbohydrates could not occur.

- B. Why is the hydrolysis of **LARGE** macromolecules necessary?

All living things are made of cells (except viruses) . Cells are small. Raw materials the cell needs to survive must be small in order to pass into the cell via the cell membrane.
