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Topic: Carbohydrate Modeling Lab - Ball & Stick Metabolism

Summary: Students will learn to act out polymerization by performing dehydration synthesis and hydrolysis using chemistry models. Students will also model breaking one biomolecule to make a different biomolecule.

NGSS Standards:
HS-LS1-5. Use a model to illustrate how photosynthesis transforms light energy into stored chemical energy.
HS-LS1-6. Construct and revise an explanation based on evidence for how carbon, hydrogen, and oxygen from sugar molecules may combine with other elements to form amino acids and/or other large carbon-based molecules.
Common Core: W 9-10.2.D, 9-10.7
Common Core: RST 9-10.3, 9-10.4, 9-10.7

Time Length: 40 minutes

Prerequisite Knowledge: Students should have already been introduced to the inputs and outputs of photosynthesis.

Materials:

- 12 carbon atoms (black)
- 12 oxygen atoms (red)
- 24 hydrogen atoms (white)
- 2 nitrogen atoms (blue)
- 45 bonds
- bin or plastic box to hold all of the balls and sticks

Accommodations: Students with an IEP can be grouped and assessed using guided verbal feedback instead of challenge questions.

Editable DOCX File and Answer Key:

Available at www.ngsslifescience.com

Name: _____ Row: _____

Carbohydrate Modeling Lab
Ball & Stick Metabolism

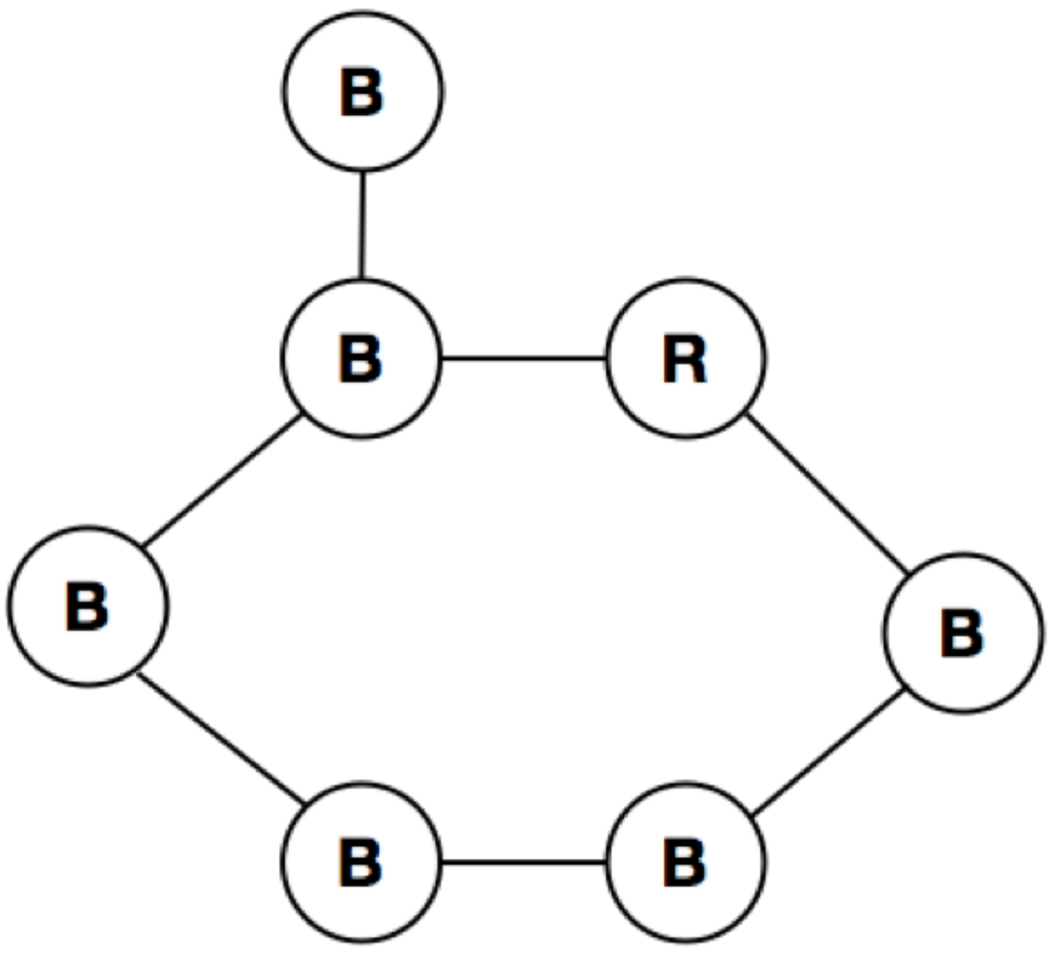
Date:_____ Period:_____

Driving Question:
How are large biomolecules made?

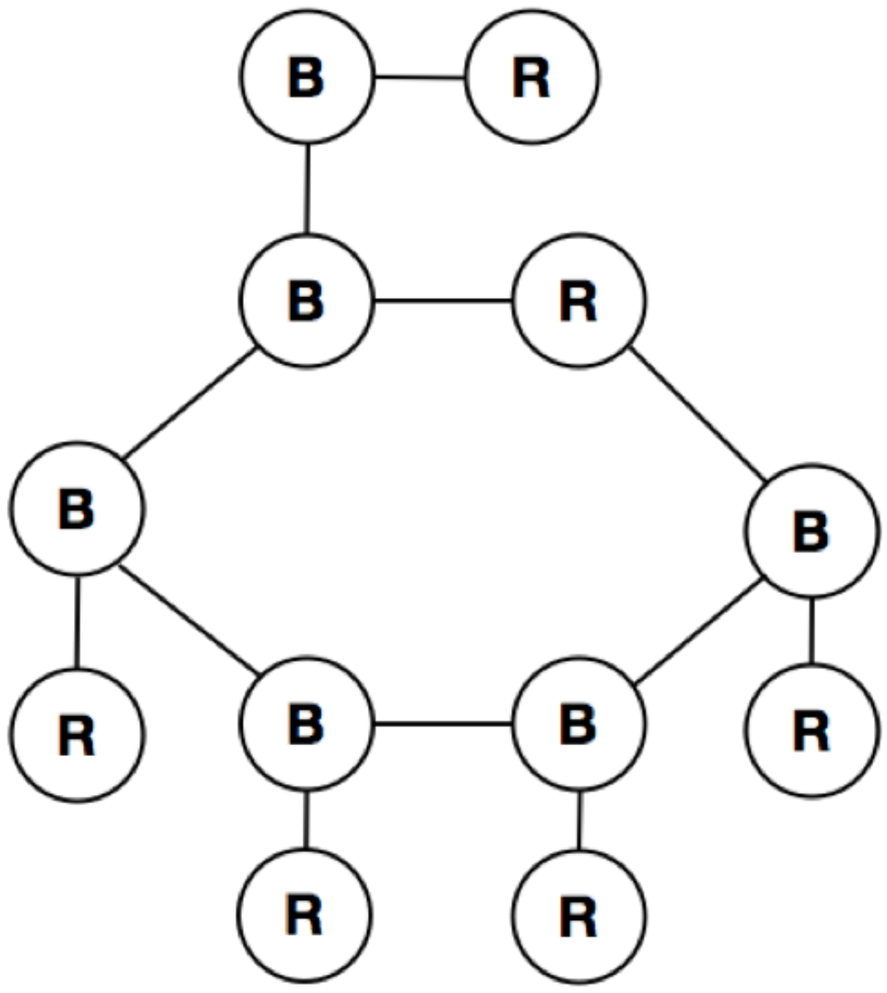
Atom Color Key:
(B) Black = carbon (R) Red = oxygen (W) White = hydrogen Blue = nitrogen

Background:
There are many processes involved for a plant to grow. Photosynthesis, cellular respiration, and cell division are all required for plants to grow. On top of the processes just listed, plants need to make larger biomolecules from the glucose they produce during photosynthesis. This process is called metabolism. Two examples of metabolism include dehydration synthesis, which builds polymers from monomers, and hydrolysis, which digests polymers into monomers. Metabolism is the sum of all chemical reactions in the plant, and photosynthesis is an example of one chemical reaction. Photosynthesis is aided by proteins called enzymes. Enzymes can either cut (break bonds) or glue (form bonds) molecules.

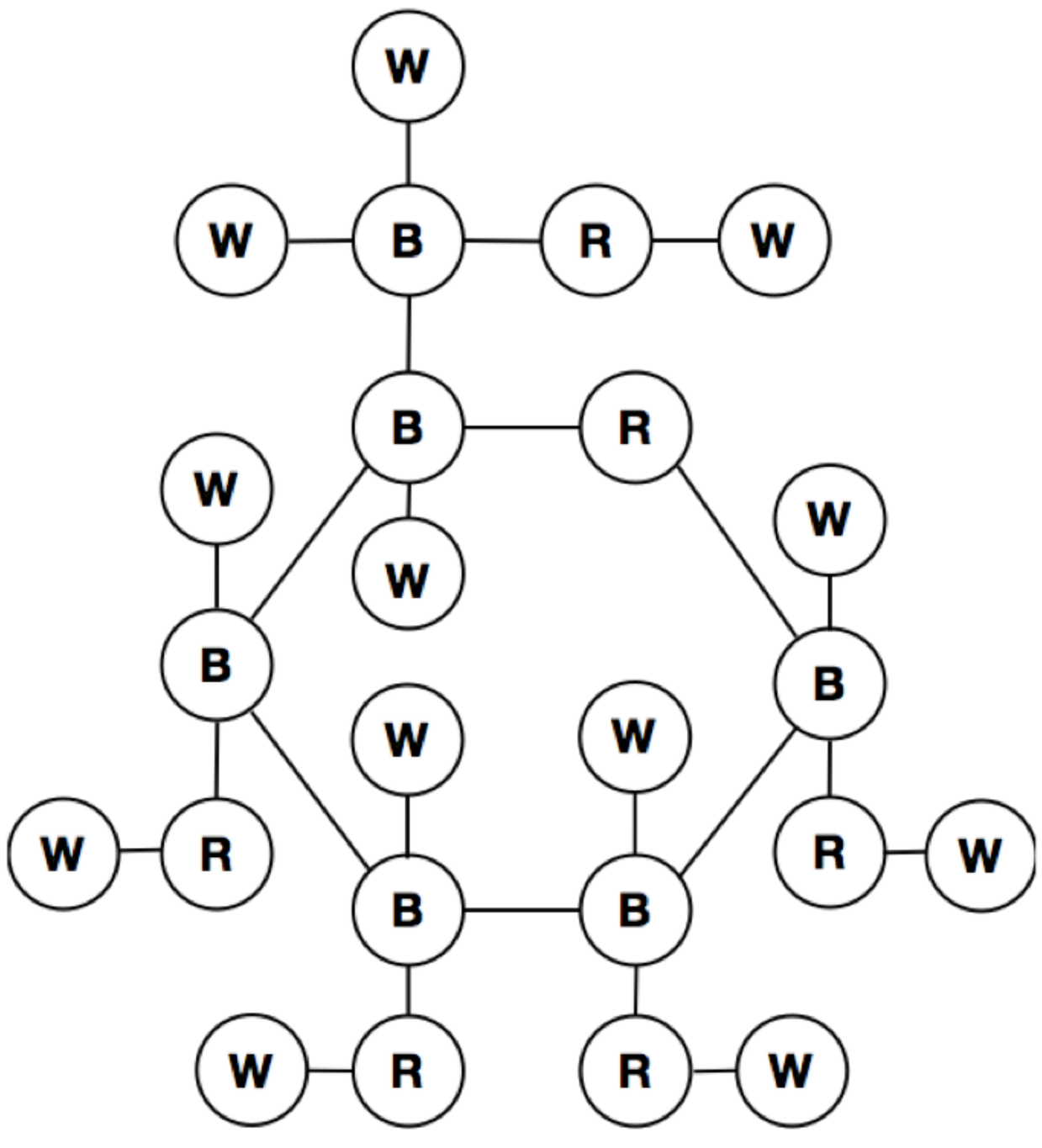
Procedures:
1. Obtain the necessary atoms and bond supplies.
2. You will create **two glucose molecules** in steps 2, 3, and 4. Use the diagram below to help build the model. You will start by attaching the six black carbon atoms and one red oxygen atom.



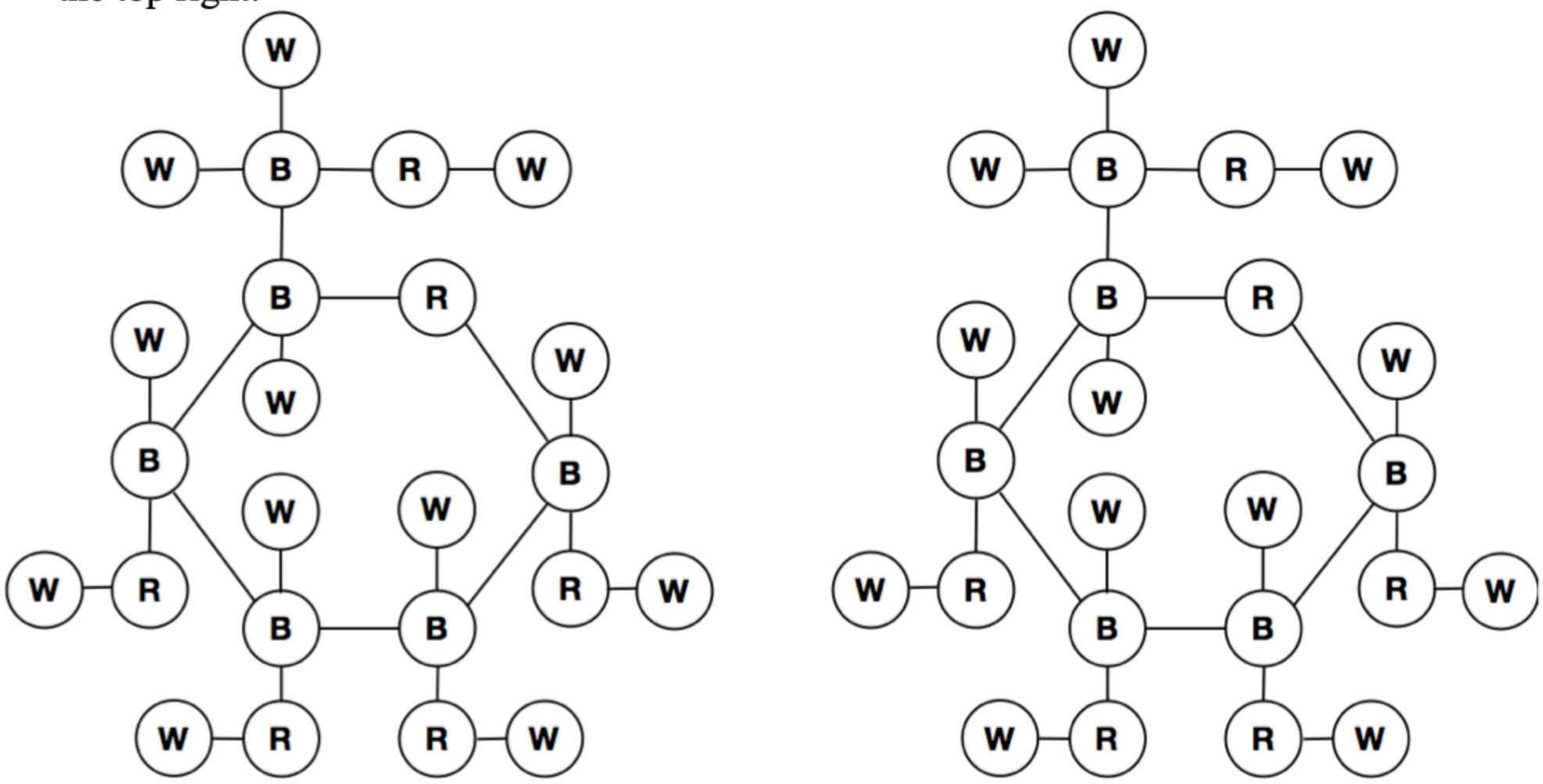
3. Continue adding to the glucose model from step 2. You will attach the remaining red oxygen atoms from the broken-down carbon dioxide. Use the diagram below to help build the model.



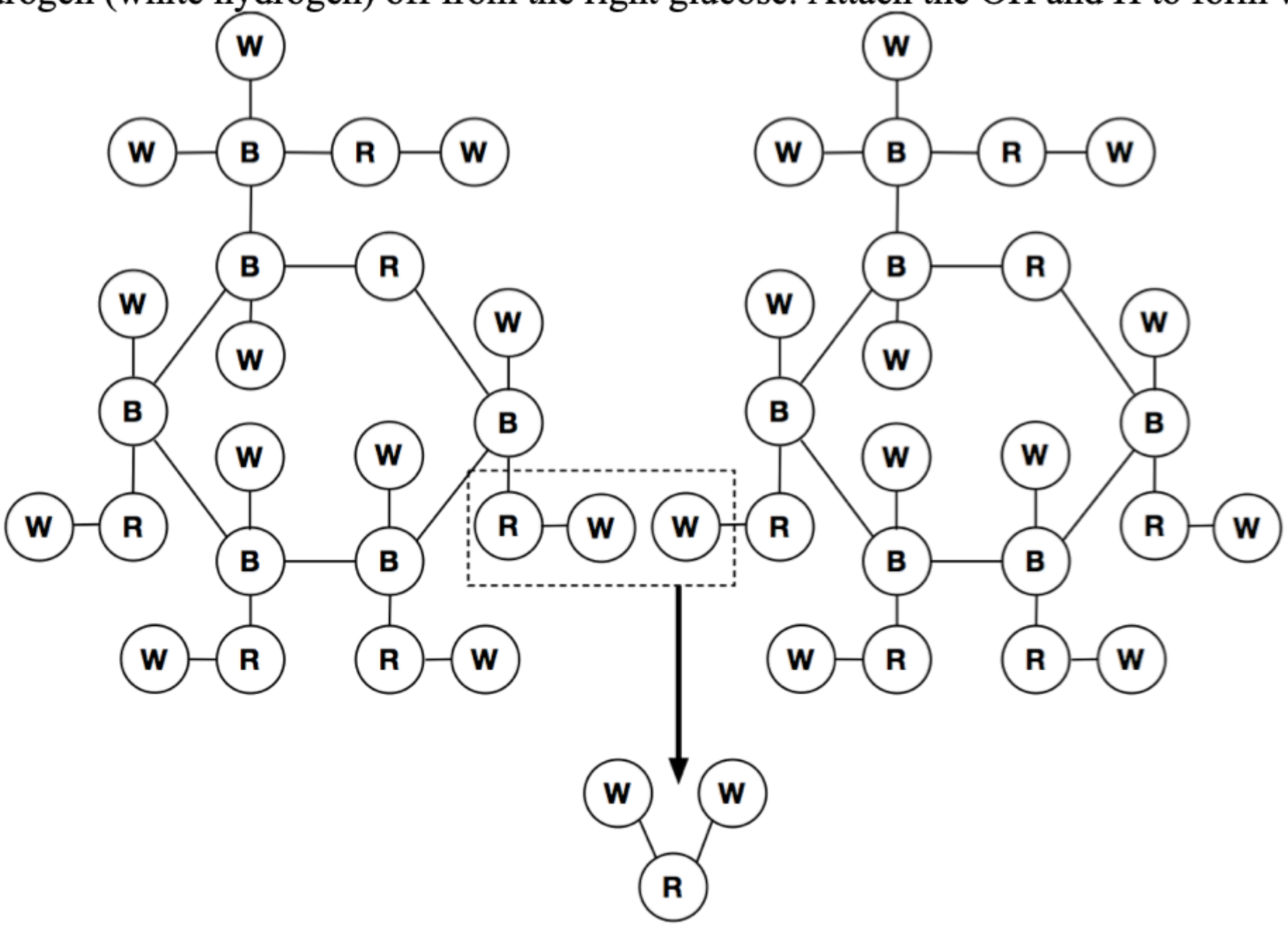
4. Continue adding onto the glucose molecule from step 3. You will attach the white hydrogen atoms from the broken water molecules to form the complete glucose molecule. Use the diagram below to build the model.



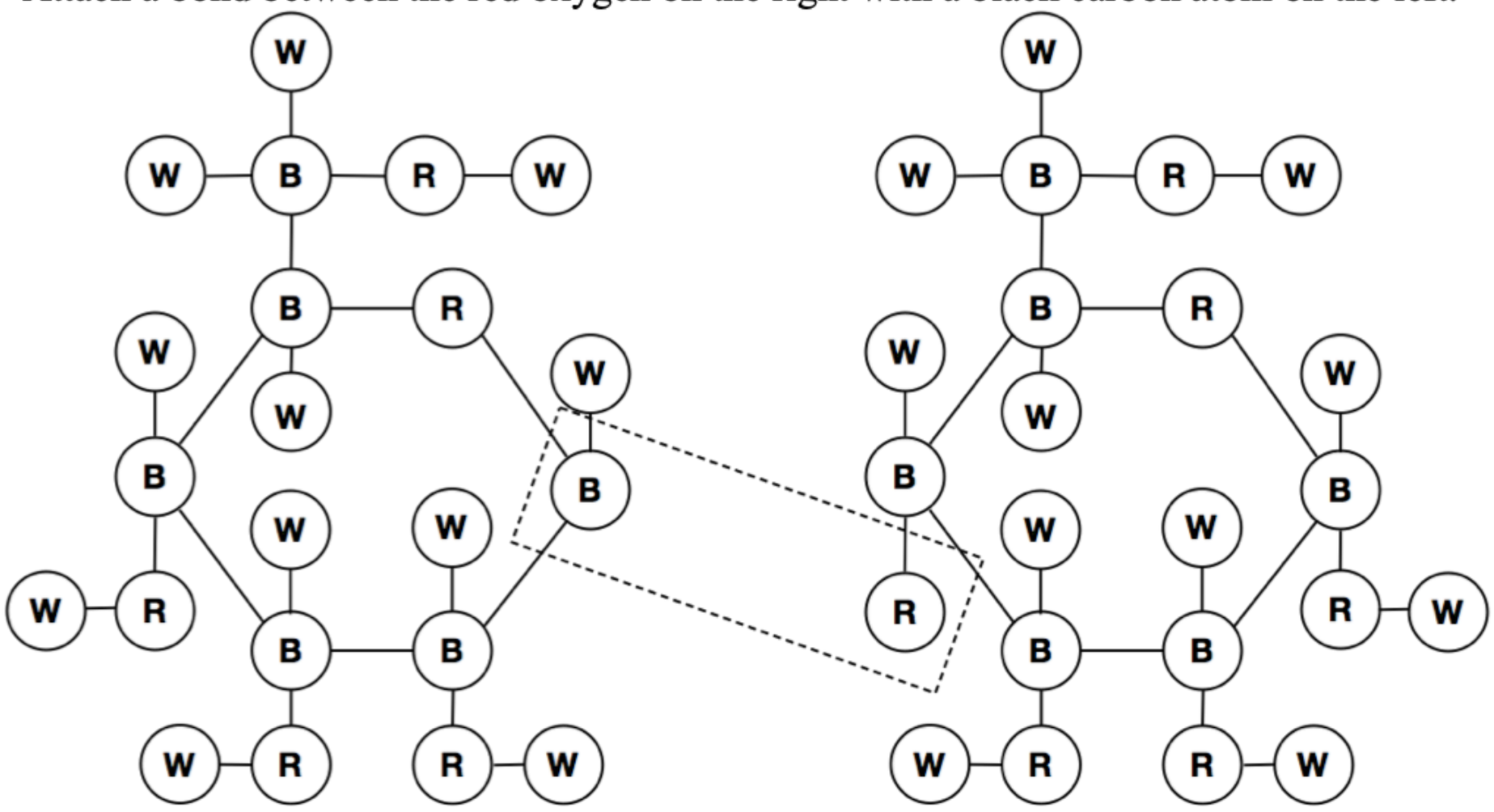
5. Stop and show your teacher your two glucose molecules.
6. Background information, you don't do anything in this step. Your two glucose molecules are carbohydrate monomers. Glucose is the monomer of carbohydrates. Steps 7, 8, 9, and 10 are all about how polymers are made from monomers.
7. Place the two carbohydrate monomers next to each other, so the red oxygen in the ring is on the top right.



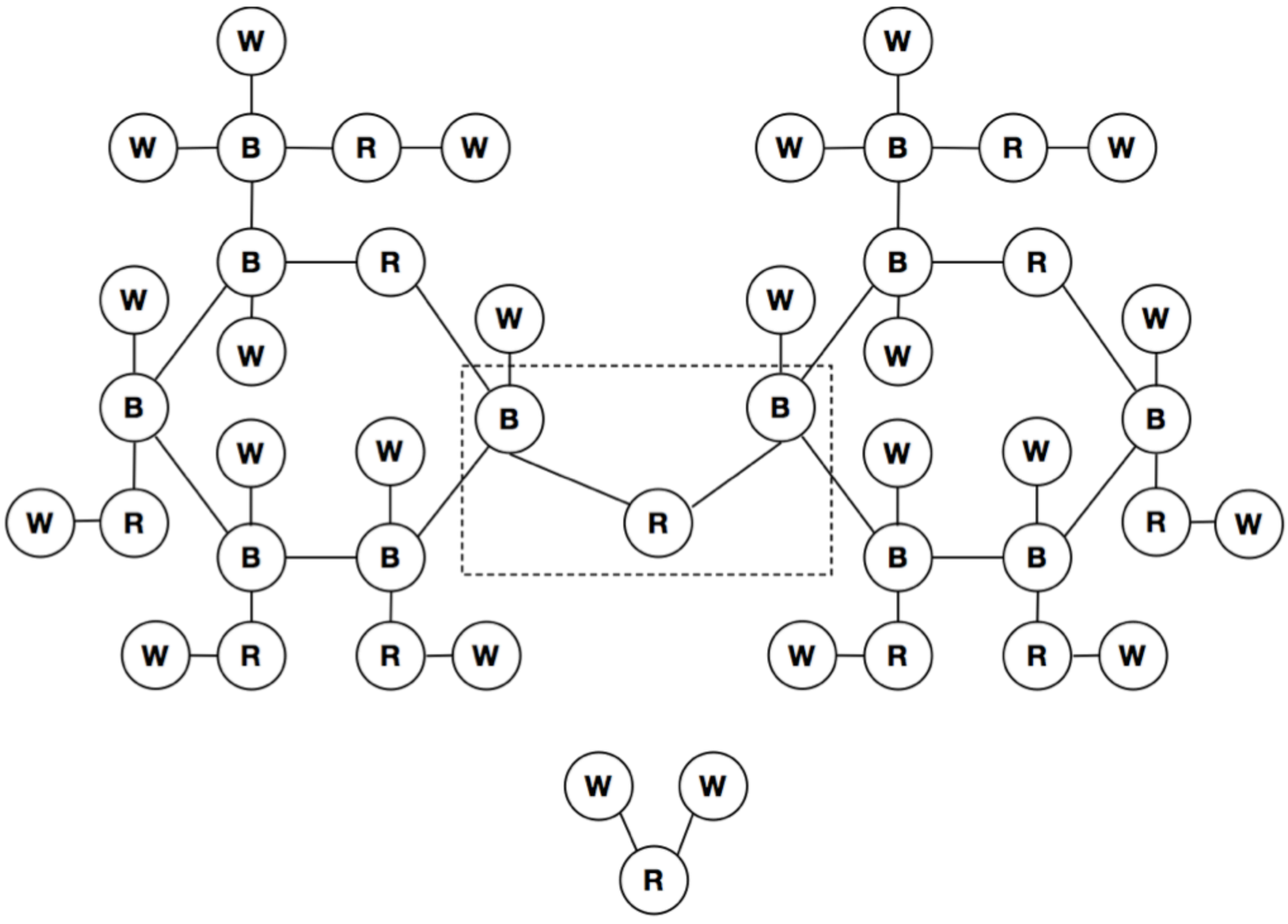
8. Break off the OH (red oxygen and white hydrogen) on the left glucose molecule. Break the hydrogen (white hydrogen) off from the right glucose. Attach the OH and H to form water.



9. Attach a bond between the red oxygen on the right with a black carbon atom on the left.

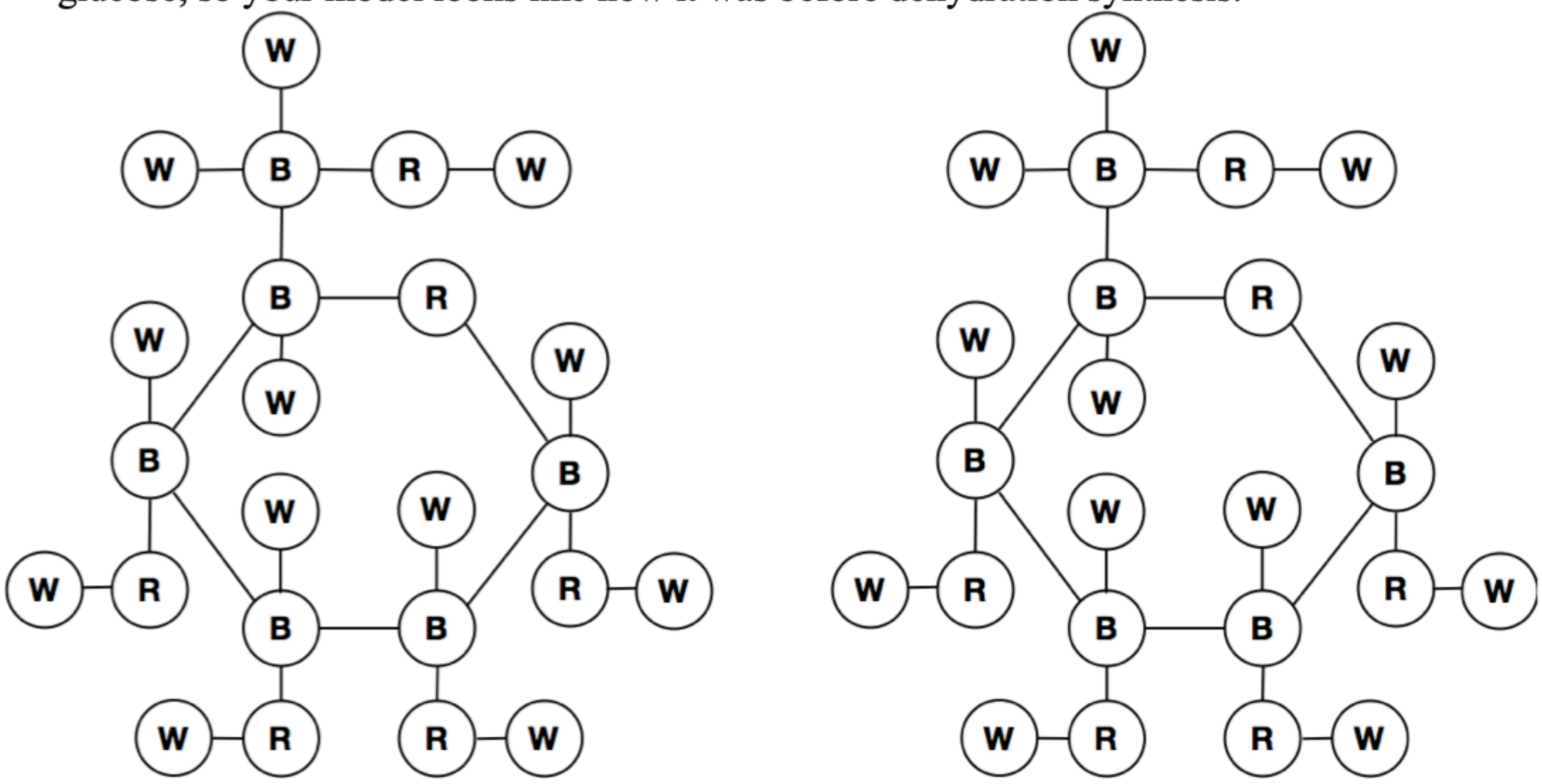


10. Bond the red oxygen with the black carbon.

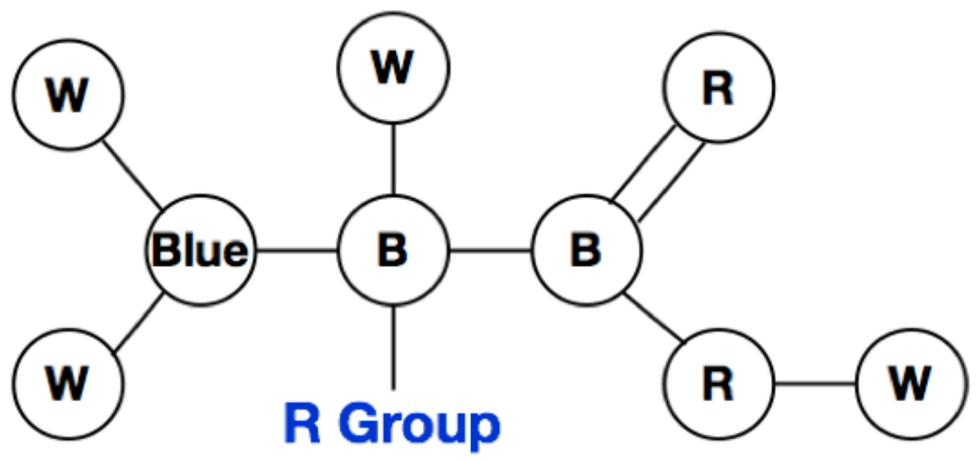


11. Stop and show your teacher the dimer (two monomers attached) and the water molecule. The process you just performed is called dehydration synthesis. This is how polymers are made from monomers.

12. You will be doing the opposite reaction (hydrolysis). Break the bond you just formed between the two glucose molecules. Break the water molecule between the OH (red and white) and H (white). Reattach the OH to the left glucose and reattach the H on the right glucose, so your model looks like how it was before dehydration synthesis.

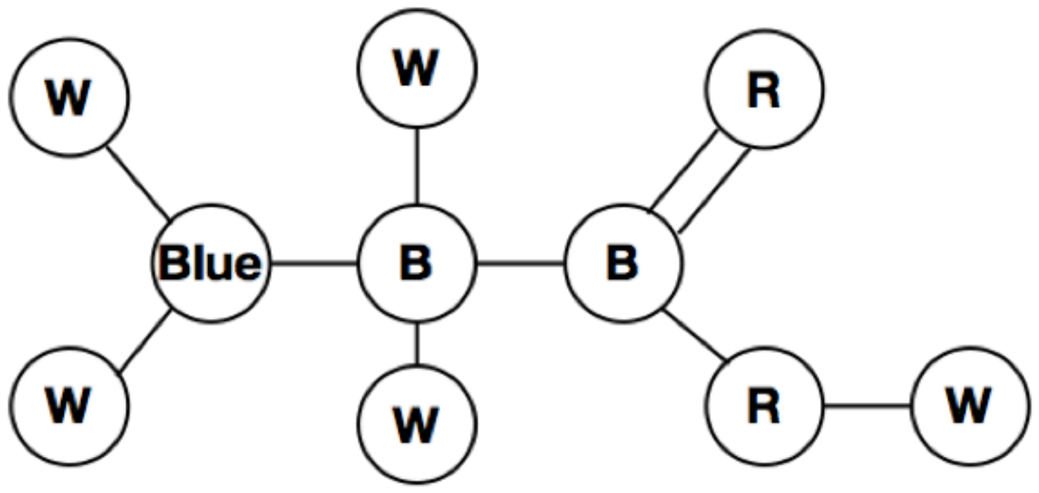


13. Stop and show your teacher the two carbohydrate molecules. The process you just performed is called hydrolysis. This is how polymers are broken down into their monomers. You know this process as digestion.
14. Break apart one carbohydrate molecule into its separate atoms. You will now rearrange those atoms and add a new nitrogen atom to form an amino acid. The nitrogen atoms will come from different sources, such as fertilizer for plants and food for animals.



15. Background information, you don't do anything in this step. Amino acids are the monomers of proteins. Notice in the amino acid above there is an R Group? Besides the R Group, the rest of the amino acid you built remains the same. The R group is the part of the amino acid that changes to make one of the 20 amino acids.

16. Build the simplest amino acid, glycine, by adding a white hydrogen to the area where there is a question mark.



17. Enzymes are the biomolecules that would break apart the glucose to rearrange the atoms and then make an amino acid. In plants, nitrogen is absorbed by the roots as fertilizer. In animals, nitrogen is in the food we eat.
18. Your partner should break their glucose molecule also into its atoms and build their own amino acid.
19. Stop and show your teacher the two amino acid molecules. You should have a total of two glycines. Once signed off, break apart and put away all the atoms and bonds.

Challenge Questions:

a) How can organisms build large polymers like proteins and starches? _____

_____

b) What biomolecule do organisms use to make and break those large polymers? _____

c) How can a plant make proteins when plants only make carbohydrates in photosynthesis? ___

_____

_____

_____

_____

d) Amino acids can be joined using dehydration synthesis. Draw how dehydration synthesis is performed using the model below. Label and draw a box around the water. Draw a dotted line for the peptide bond joining the two amino acids in your drawing.