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Topic: Photosynthesis Modeling Lab

Summary: Students learn the chemistry by acting out the steps of photosynthesis.

Goals & Objectives: Students will be able to explain the three phases of photosynthesis. Students will be able to demonstrate how light, H_2O, and CO_2 is used to make sugar. Students will be able to explain the structure of the chloroplast.

NGSS Standards: *HS-LS1-5:* Use a model to illustrate how photosynthesis transforms light energy into stored chemical energy.

Time Length: 60 minutes

Prerequisite Knowledge: Structure of chloroplast and thylakoid, plasma membrane, active transport, passive transport, concentration gradients, ions, and electrons

Materials:

- Student drawn poster of the structure of the thylakoid with an electron transport chain. Membrane must include the chlorophyll pigments, a proton pump, ATP synthase, and NADP reductase.
- One fan, surge protector with long chord and cart (small table works also)
- Light – lamp is best, flashlight works
- Tape
- Chalk
- Candy (sugar) for each student
- Red, blue, and yellow construction paper – one of each
- Photocopy handouts and chlorophyll label - one per student

Set-up:

1. In the front of the room, place the thylakoid poster on the chalk board.
2. On one side of the poster put the fan. The fan must be able to plug into the surge protector. The fan should point in the opposite direction of the poster.
3. On the other side of the fan, tape the label Glucose. Place the candy on top of the Glucose label.
4. On the cart, tape the Calvin cycle label.
5. Place the light on the cart so that it is shining on the thylakoid poster.
6. With the ADP label, cut a hole for where the 3rd phosphate should go. Tape the ADP label on top of the surge protector so that the hole aligns with the plug outlet.
7. On the top of the thylakoid poster, tape the two photosystem labels.

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8. On each student's desk, place two chlorophyll labels.
9. Crumple the red and blue colored papers into tight round balls.

Procedures:

1st Review with students about the purpose of photosynthesis, the structure of the chloroplast, light and dark reactions, and the visible light spectrum.

2nd Tell students the color that we see is reflected and the other colors are absorbed. Ask students why wearing a black shirt in the sun will make you hotter than wearing a white shirt. Hand out the colored paper balls to three students close to the front of the room. Tell the students that you are pretending to be a plant. Ask them to gently throw the ball to you, one at a time. Catch all three of them. Ask the students what color you would be as a pigment. Hand the papers out to three different students. Repeat: but this time, catch the red ball and deflect the other two balls back to the students. Ask the students what color you would now be. Green of course, because red is absorbed, and the reflected yellow and blue balls make green.

3rd Explain to the students that they will pretend that the classroom is a giant chloroplast, their desks are the pigment chlorophyll, and the front of the classroom is the thylakoid membrane. Distribute the handouts and the two water molecules to each student. Select a well-behaved student volunteer to throw the ball for you. He or she should not throw the ball hard and must make sure that the receiving student is looking and ready to catch the ball. You should be standing at the chalk board in front of the electron transport chain.

4th Demonstrate the activity with one student. The volunteer gently throws the red ball to a student in front of the class. The receiving student must say out loud, "I am chlorophyll and I absorb light to split water." That student then rips their water molecule paper and brings the blue or red ball to the volunteer and walks to the electron transport chain with their two electrons and four hydrogen ions.

5th Once arrived, the student then says out load, "I am an excited electron that powers the electron transport chain." The student must do a little dance and spins around once to show that they are excited.

6th The student slides the two electrons along the membrane from the green pigment to the proton pump and stops. The student then says out load, "Two hydrogen are pumped in to create a concentration gradient. The hydrogen diffuses out to form ATP from ADP."

7th The student then pushes the two hydrogens through ATP synthase and plugs the fan into the surge protector. The fan turns on. The student then finishes sliding the electron to the end of the chain and says out loud, "The excited electron is stored in NADPH."

8th The student then blows through the fan and says, "Calvin cycle breaks down carbon dioxide into glucose. ATP and NADPH provide the energy." The student then walks back to their desk with the candy.

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9th The process repeats. You can usually have two students doing the activity at a time. The volunteer can throw to the next student after the student does the excited dance. All other students who are waiting their turn or who have finished the activity can work on the handout individually. If students work as a group on the handout, it can disrupt a student who is supposed to catch the paper. The handout is collected at the end of the class.

Accommodations: Students who have difficulty walking can tell you everything from their seat and you perform the kinesthetic movements. Students with an IEP can say much simpler versions like "Plants get energy from sun light. Light energy is changed into chemical energy. ATP is made by adding a phosphate to ADP. Energy in ATP is used to make sugar from air." If a student with an IEP needs extra time, they can take the assignment home.

Editable DOCX File and Answer Key:

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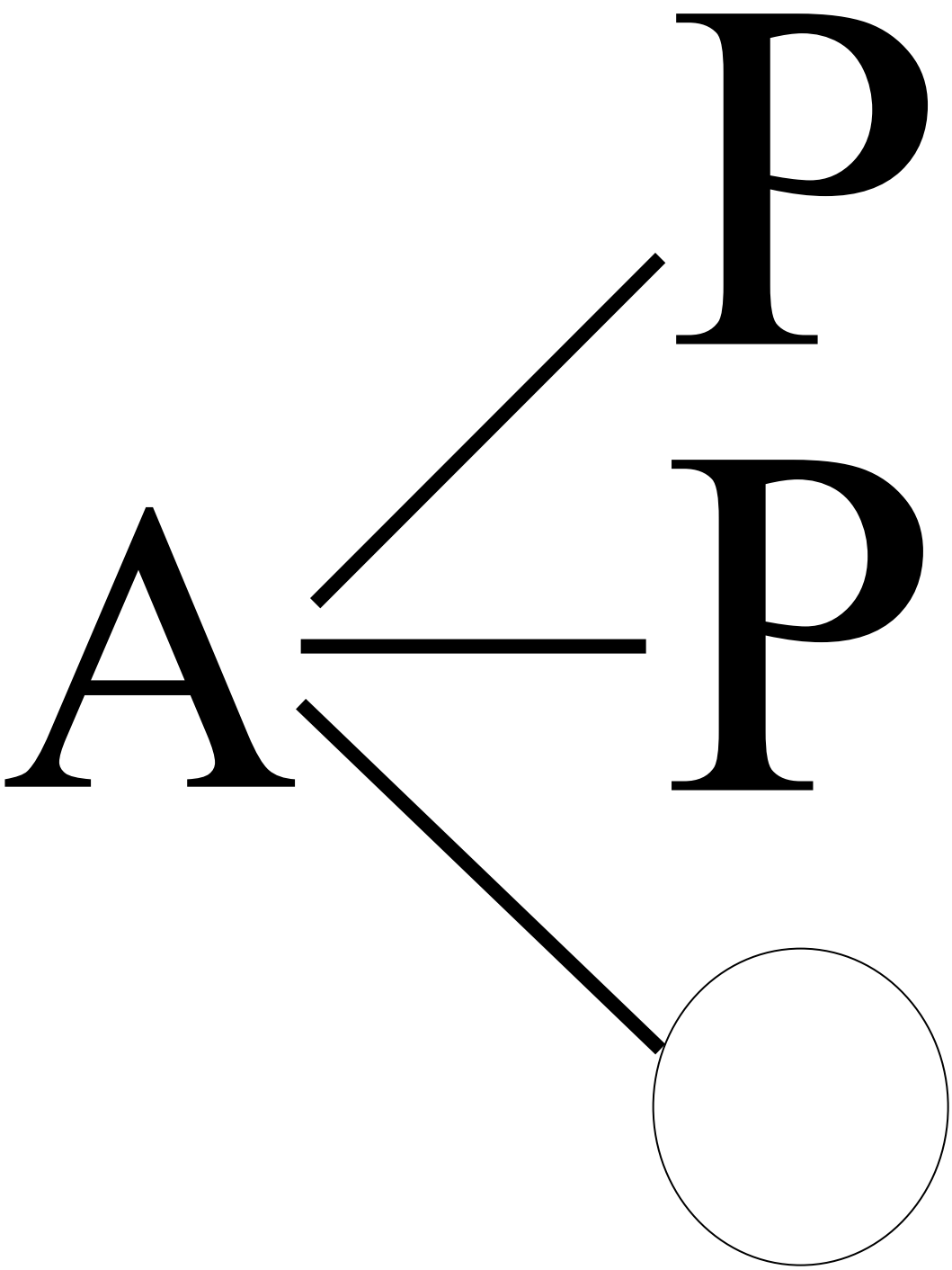

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Photosystem II

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Two hydrogen are pumped in to create a concentration gradient.

The hydrogens diffuse out to make ATP from ADP

Photosystem I

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The excited electron is stored in NADPH.

Calvin Cycle

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Calvin cycle breaks down carbon dioxide glucose.

ATP and NADPH provide the energy.

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Electron Transport Chain

Glucose

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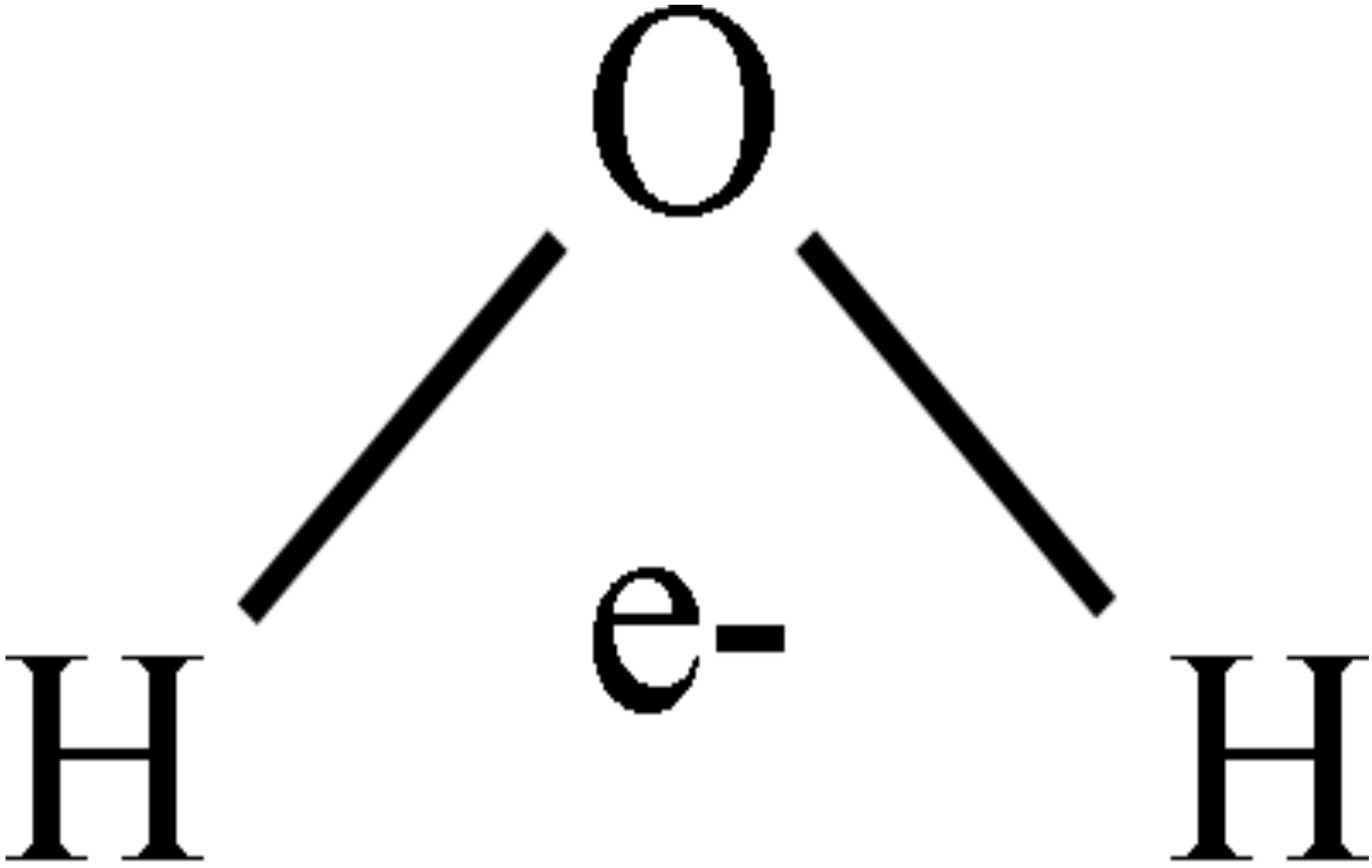

I am chlorophyll and I absorb light to split water.

Name: _____ Row: _____

Date:_____ Period:_____

Photosynthesis Modeling Lab

1. What is the chemical formula for photosynthesis?

6_____+ 6_____→_____+ 6_____

2. In what organelle does photosynthesis take place? _____

3. What is the disc-like structure inside this organelle called? _____

4. What is the name of the pigment that absorbs light? _____

5. What color of light is reflected by this pigment? _____

6. Where do photosystem I and photosystem II take place in the organelle? _____

7. When light hits this pigment, what happens to water? _____

_____

8. What gas is produced when water is split? _____

9. What is the name of the particle that powers the electron transport chain? _____

10. In photosystem II, what is pumped into the thylakoid space through a proton pump?

_____

11. In photosystem II, what is diffused out of the thylakoid through ATP synthase?

_____

12. What is it called when you have more ions on one side of a membrane and fewer ions on the other side of the membrane? _____

13. When ATP synthase is activated, it adds a phosphate group to what molecule? _____

14. In photosystem I, sunlight hits a second pigment and excites what from photosystem II?

_____

15. An enzyme then stores this excited particle in what molecule? _____

16. ATP and the energy carrier in question 15 are used to power what cycle? _____

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17. What molecule from the air is broken down in this cycle? _____

18. What is the liquid called where this cycle takes place? _____

19. Is sun light used in this cycle? _____

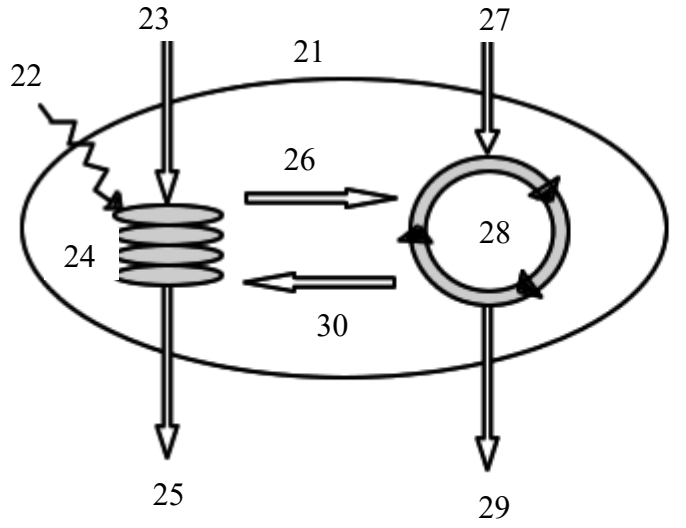
20. Name an organic molecule formed at the end of this cycle? _____

Label the drawings:

Photosynthesis Overview

Word Bank

Calvin Cycle	CO_2
H_2O	Light
$C_6H_{12}O_6$	O_2
Thylakoid	Chloroplast
NADPH and ATP	NADP+ and ADP



21. _____
22. _____
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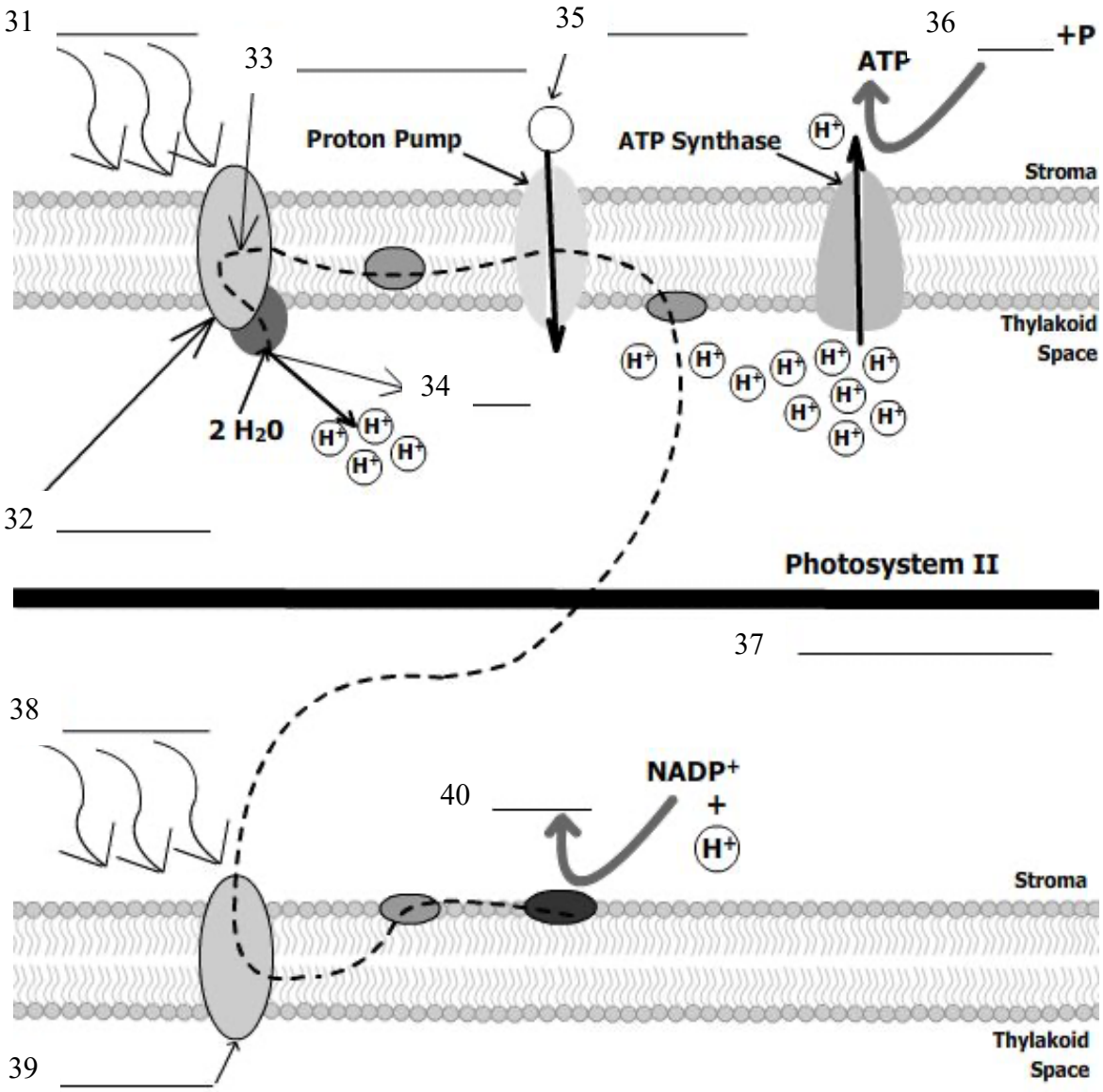
Light Dependent Reactions



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