

THE PHOTOSYNTHESIS DIAGNOSTIC QUESTION CLUSTER

DQC Group – Michigan State University

Correct answers are indicated in green. Some questions have alternative stems that can be used with the same foils. Questions are presented in multiple choice format, but can be used in multiple true/false format (see below). The stems from most of the questions can be used as prompts for essay questions. Alternative stems are proposed for essay versions of the remaining questions.

Questions are categorized according to the practices demanded by the stem. They are presented in order of increasing complexity. The first five questions ask students to trace matter through the process of photosynthesis. Questions 6 -10 involve tracing matter and keeping track of scale, since the questions are posed about whole organisms, but the explanations lie at the cellular level. Of these questions 6 – 8 address mass gain in plants, while question 9 and 10 address mass loss in plants. The latter requires that students understand that plants undergo respiration as well as photosynthesis. Questions 11 – 14 ask students about energy sources for plants without (questions 11 – 13) and while simultaneously keeping track of scale. These questions require students trace energy through both photosynthesis and respiration.

Tracing matter

1. H₂S Bacteria

Some bacteria can undertake a type of photosynthesis that uses H₂S in place of H₂O. Assuming that the process is otherwise similar to green plant photosynthesis, which of the following could represent the overall reaction?

- A. $6 \text{ CO}_2 + 12 \text{ H}_2\text{S} \rightarrow \text{C}_6\text{H}_{12}\text{S}_6 + 6 \text{ H}_2\text{S} + 6 \text{ O}_2$
- B. $6 \text{ CO}_2 + 12 \text{ H}_2\text{S} \rightarrow \text{C}_6\text{H}_{12}\text{O}_6 + 6 \text{ H}_2\text{O} + 12 \text{ S}$**
- C. $6 \text{ CO}_2 + 12 \text{ H}_2\text{S} \rightarrow \text{C}_6\text{H}_{12}\text{O}_6 + 6 \text{ H}_2\text{S} + 6 \text{ O}_2$
- D. $6 \text{ CO}_2 + 12 \text{ H}_2\text{S} \rightarrow \text{C}_6\text{H}_{12}\text{S}_6 + 6 \text{ H}_2\text{O} + 6 \text{ SO}_2$

[Essay prompt: Assuming that the process is otherwise similar to green plant photosynthesis, complete the equation for the process. $6 \text{ CO}_2 + 12 \text{ H}_2\text{S} \rightarrow$]

2. Products of the CC used by the light reactions

What products from the Calvin cycle are required for the light reactions?

- A. carbon dioxide and RuBP
- B. ADP and NADP⁺**
- C. Light reactions do not use products of the Calvin Cycle
- D. electrons and photons
- E. oxygen and carbon dioxide

3. CO₂ made with ¹⁴C

If CO₂ labeled with ¹⁴C is added to a suspension of photosynthesizing chloroplasts, which compound will first become labeled with ¹⁴C?

- A. ATP
- B. NADPH
- C. RuBP
- D. C₆ H₁₂O₆

E. 3-phosphoglycerate

4. Newly discovered organelle (version 1)

A newly discovered cell organelle is found to produce or use up the following molecules under experimental conditions:

Produce	Use Up	No Change
ADP + Pi	ATP	O ₂
3-carbon sugars	CO ₂	
NADP ⁺	NADPH	

Based on this analysis, which metabolic process is taking place in this organelle?

- A. Glycolysis
- B. Electron Transport/Oxidative Phosphorylation
- C. Krebs Cycle
- D. Photophosphorylation (light reactions)

E. Calvin Cycle

5. Newly discovered organelle (version 2)

A newly discovered cell organelle is found to produce or use up the following molecules:

Produce	Use Up	No Change
ATP	ADP + Pi	CO ₂
NADPH	NADP ⁺	3-carbon sugar
O ₂		

Based on these data, which metabolic process is taking place in this organelle?

- A. Glycolysis
- B. Krebs cycle

C. Electron transport/oxidative phosphorylation

D. Light dependent reactions of photosynthesis

E. Calvin cycle

Tracing matter and identifying scale and location

Mass gain in plants

6. Maple tree (Based on an interview question from *Private Universe*)

A mature maple tree can have a mass of 1 ton or more (dry biomass, after removing the water), yet it starts from a seed that weighs less than 1 gram. Which of the following processes contributes the most to this huge increase in biomass?

7. Seed corn

Each Spring, farmers plant about 5-10 kg of seed corn per acre for commercial corn production. By the Fall, this same acre of corn will yield approximately 4-5 metric tons of harvested corn. Which of the following processes contributes the most to this huge increase in biomass?

[Essay prompt: Explain this increase in mass.]

8. Radish seeds in light (Based on a question by Janet Batzli)



Results: 1.48g

3.28g

1.17g

The following question is based on this experiment: Three batches of radish seeds, each with a starting weight of 1.5g (dry), were placed in petri dishes and provided only with light or water or both, as shown in the photo. After 1 week, the material in each dish was dried and weighed. The results are shown below each petri dish.

Which of the following processes contributed the most to the increased biomass of the "Light, Water" treatment?

- A. absorption of mineral substances from the soil via the roots
- B. absorption of organic substances from the soil via the roots
- C. incorporation of CO₂ gas from the atmosphere into molecules by green leaves**
- D. incorporation of H₂O from the soil into molecules by green leaves
- E. absorption of solar radiation into the leaf

[Essay prompt: Explain which process contributes the most to the increased biomass of the "Light, Water" treatment.]

Mass loss in plants

9. Radish seed in the dark

Where did the mass go that was lost by the seedlings in the "No light, Water" treatment?

- A. It was converted to CO₂ and H₂O and then released.**
- B. It was converted to heat and then released.
- C. It was converted into ATP molecules.
- D. It was eliminated from the roots as waste material.
- E. It was converted to starch.

10. Geranium in the dark

A potted geranium plant sits in a windowsill, absorbing sunlight. After I put this plant in a dark closet for a few days (but keeping it watered as needed), will it weigh more or less (discounting the weight of the water) than before I put it in the closet?

- A. It will weigh less because it is still respiring.**
- B. It will weigh less because no photosynthesis is occurring.
- C. It will weigh more because the Calvin cycle reactions continue.
- D. It will weigh the same since no biomass is produced.
- E. It will weigh more because it still has access to water and soil nutrients.

[Essay prompt: Will it weigh more or less (discounting the weight of the water) than before I put it in the closet? Explain your answer.]

Tracing energy

The relationship between photosynthesis and respiration

11. Energy sources for plants

Which of the following best describes how a plant cell gets the energy it needs for cellular processes?

- A. The chloroplasts provide all the ATP needed by the plants.
- B. ATP is transported to cells that lack chloroplasts (roots, stems, etc.).
- C. In the light, the ATP comes from the chloroplasts, in the dark, from mitochondria.
- D. Most ATP comes from digestion of organic matter absorbed by roots, some comes from chloroplasts.
- E. The sugars made by photosynthesis can be used by respiration to make ATP.**

[Essay prompt: Explain how a plant cell gets the ATP it needs for cellular processes.]

12. Euglena – v1

Euglena is a single-celled, photosynthetic eukaryote. How does a Euglena obtain energy to do such cellular work such as active transport across its membrane?

- A. It transports ATP from the chloroplasts.
- B. It utilizes nutrients from the surrounding water to make ATP.
- C. It uses sugars made in the chloroplasts to make ATP.**
- D. It uses sunlight to make ATP.

Euglena – v2

- A. They transport ATP from the chloroplasts.
- B. They utilize inorganic nutrients from the surrounding water to make ATP.
- C. They use sugars made in the chloroplasts to make ATP.**
- D. They use the ATP made during photosynthesis.
- E. They utilize organic molecules from their surroundings.

Tracing energy and identifying scale and location

Energy sources for plants

13. Geranium root cells

A potted geranium sits in a windowsill absorbing sunlight. How does a root cell (which is not exposed to light) obtain energy to do cellular work such as active transport across its membrane?

- A. ATP is made in the leaves via photosynthesis and moved to the root.
- B. Sugar is made in the leaves via photosynthesis and moved to the root.**
- C. The root cell makes sugar using the dark reactions (Calvin cycle) of photosynthesis.
- D. The root cell makes ATP by photosynthesis and cellular respiration.
- E. The root cell makes ATP by cellular respiration using material absorbed from the soil.