

Unit 3: Cellular Energetics (MCQ)

[Question 1 through 3 refer to the following]

Researchers investigated the influence of environmental pH on the activity of peroxidase, an enzyme that catalyzes the conversion of hydrogen peroxide to water and oxygen gas. In an experiment, the researchers added a hydrogen peroxide solution containing guaiacol to several identical test tubes and adjusted the solution in each test tube to a different pH. The researchers included the guaiacol because it caused the solutions to change color as the reactions proceeded, which the researchers relied on for measuring reaction rates. Finally, the researchers added the same amount of peroxidase to each test tube and measured the rate of each reaction at 23°C. The results of the experiment are represented in Figure 1.

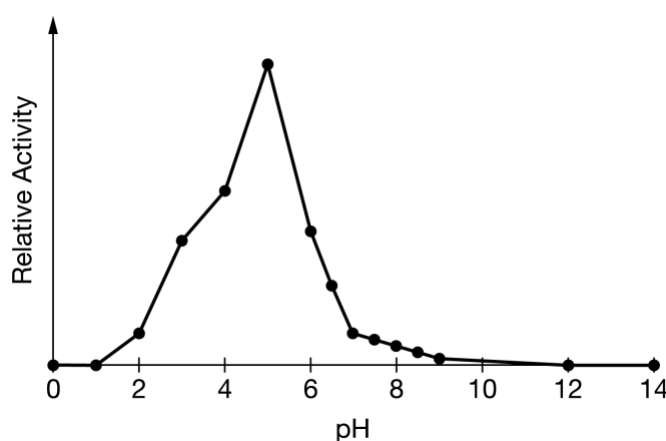


Figure 1. The effect of pH on peroxidase activity

- Based on Figure 1, which of the following statements best predicts the effect that a change from a moderately acidic environment (pH near 6) to a basic environment will have on peroxidase activity?
 - Peroxidase activity will decrease.
 - Peroxidase activity will increase.
 - Peroxidase activity will stay the same.
 - Peroxidase activity will increase at first and then decrease.
- Which of the following actions will provide a negative control for the investigation?
 - Repeating the experiment at 25°C
 - Repeating the experiment using twice the amount of hydrogen peroxide
 - Repeating the experiment using twice the amount of peroxidase.
 - Repeating the experiment using heat-denatured peroxidase.

3. One of the researchers proposes using oxygen gas production to measure reaction rates. Which of the following statements best justifies the use of the proposed modification as a way of creating an appropriate control for the investigation?
- A. The experiment can be repeated without hydrogen peroxide, which will help eliminate an uncontrolled variable.
 - B. The experiment can be repeated without peroxidase, which will introduce a second independent variable.
 - C. The experiment can be repeated without guaiacol, which will reveal the effect of guaiacol on the reaction rates.
 - D. The experiment can be repeated without water, which will reveal whether the reaction can occur inside a living cell.
4. Some organisms use a weaker terminal electron acceptor than oxygen during cellular respiration. Which of the following best explains why the cells of these organisms might generate less ATP per molecule of glucose than cells that use oxygen as the terminal electron acceptor?
- A. The cells of these organisms remove fewer electrons from glucose than cells that use oxygen.
 - B. The cells of these organisms create a smaller proton gradient than cells that use oxygen.
 - C. The cells of these organisms convert pyruvate to lactate more often than cells that use oxygen.
 - D. The cells of these organisms generate more metabolic heat than cells that use oxygen.

The electron transport chain (ETC) is made up of several carrier molecules that transport electrons. These carrier molecules are found within membranes.

5. Which of the following statements best explains why these carrier molecules are typically found within membranes?
- A. The electrons that move through the ETC are directly used to drive the processes of endocytosis and exocytosis.
 - B. The electrons that move through the ETC are coupled with the pumping of ATP out of the intermembrane space.
 - C. The energy derived from the ETC creates a difference in the concentration of protons on either side of the membrane.
 - D. The energy derived from the ETC is used to fully oxidize an ATP molecule, releasing stored energy outside the membrane.

6. Which of the following best explains why the inner mitochondrial membrane has more embedded proteins of the electron transport chain than the outer mitochondrial membrane?
- A. The inner membrane is more efficient at capturing light than the outer membrane.
 - B. The inner membrane has a smaller surface area than the outer membrane.
 - C. The Krebs cycle occurs in the mitochondrial matrix and not the intermembrane space.
 - D. The outer membrane has a greater surface area for electron transfer.

Catalase is an enzyme found in yeast cells that facilitates the chemical breakdown of hydrogen peroxide to water and oxygen gas. An experiment was conducted to determine the effect of pH on catalase function. Five buffer solutions of varying pH (2, 4, 6, 8, and 10) were prepared and added to separate test tubes. Hydrogen peroxide (H_2O_2) was added to each test tube. Yeast was added, and the reactions were timed. After 1 minute the amount of oxygen gas released was determined by measuring the foam layer produced in each test tube. Figure 1 illustrates the experimental setup.

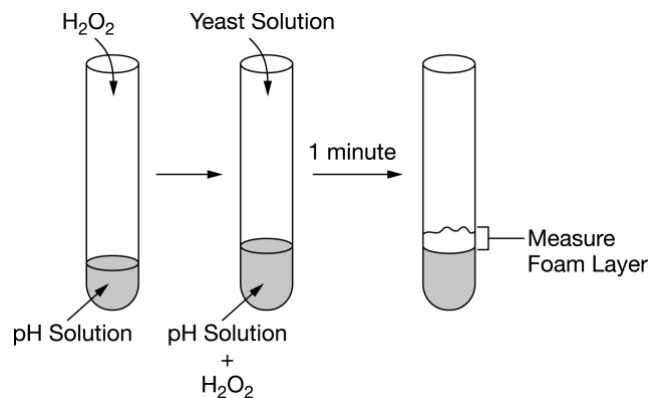


Figure 1. Illustration of experimental procedure

7. A set of five additional test tubes were prepared and used as controls. Which of the following best describes the contents expected to be contained in one of the five control test tubes?
- A. pH 4 buffer solution and hydrogen peroxide only
 - B. All five pH buffer solutions combined and hydrogen peroxide only
 - C. Water, hydrogen peroxide, and yeast
 - D. Water and yeast only

A student designs an experiment to investigate the influence of temperature on enzyme function. The student's plan is presented in Table 1.

Table 1. An experiment to investigate the influence of temperature on enzyme function

Test Tube	Substrate Added	Enzyme Added	Temperature (°C)
1	Yes	No	10
2	Yes	Yes	10
3	Yes	No	20
4	Yes	Yes	20
5	Yes	No	30
6	Yes	Yes	30
7	Yes	No	40
8	Yes	Yes	40

8. Which test tubes are controls in the experiment?
- A. Test tubes 1 and 2 only
 - B. Test tubes 5 and 6 only
 - C. Test tubes 1, 3, 5, and 7
 - D. Test tubes 2, 4, 6, and 8

A researcher designs an experiment to investigate whether soil bacteria trigger the synthesis of defense enzymes in plant roots. The design of the experiment is presented in Table 1. For each group in the experiment, the researcher will determine the average rate of change in the amount of defense enzymes in the roots of the seedlings.

Table 1. An experiment to investigate the effect of soil bacteria on plant defenses

Group	Number of Seedlings	Type of Soil	Treatment Solution
1	10	Sterile potting soil	Contains actively reproducing soil bacteria
2	10	Sterile potting soil	contains heat-killed soil bacteria
3	10	Sterile potting soil	contains no soil bacteria

9. Which of the following statements best helps justify the inclusion of group 2 as one of the controls in the experiment?
- A. It will show whether the changes observed in group 1 depend on the metabolic activity of soil bacteria.
 - B. It will show whether the changes observed in group 1 depend on the type of plants used in the experiment.
 - C. It will show the average growth rate of seedlings that are maintained in a nonsterile environment.
 - D. It will show the changes that occur in the roots of seedlings following an infection by soil bacteria.

Pectinase is a protein that catalyzes the breakdown of pectic polysaccharides in plant cell walls. A researcher designs an experiment to investigate the effect of salinity on the ability of pectinase to lower the activation energy of the reaction involved. The design of the experiment is presented in Table 1. For each test tube, the researcher will measure the amount of product formed over 20 minutes.

Table 1. An experiment to investigate the effect of salinity on pectinase function

Test Tube	Sodium Chloride Concentration (molar)	Temperature (degrees C)	Substrate Added	Pectinase Added
1	0	23	Yes	No
2	0	23	Yes	Yes
3	0.5	23	Yes	No
4	0.5	23	Yes	Yes
5	1.0	23	Yes	No
6	1.0	23	Yes	Yes
7	1.5	23	Yes	No
8	1.5	23	Yes	Yes

10. Which of the following statements best helps justify the inclusion of test tube 5 in the experiment?
- A. It will act as a control for test tube 4 by showing the effect of the presence or absence of the substrate.
 - B. It will act as a control for test tube 4 by showing the effect of a change in environmental temperature.
 - C. It will act as a control for test tube 6 by showing the effect of the presence or absence of the enzyme.
 - D. It will act as a control for test tube 6 by showing the effect of a change in sodium chloride concentration.

Researchers investigated the effect of urea on the three-dimensional structure of a certain enzyme. The researchers dissolved the enzyme in an aqueous buffer solution and added urea to the solution. The enzyme did not appear to have a secondary or tertiary structure. The researchers carefully removed the urea from the solution and determined that the enzyme had the original secondary and tertiary structure again.

11. Based on the results of the experiment, which of the following statements best predicts the effect of urea on the enzyme's function?
- A. Function will be disrupted by adding the urea and regained by removing the urea.
 - B. Function will be disrupted by adding the urea, but it will not be regained by removing the urea.
 - C. Function will be gained by adding the urea and disrupted by removing the urea.
 - D. Function will be unaffected by the addition and removal of the urea.

In an experiment, a researcher prepares a reaction mixture by dissolving a substance in a buffered solution. The substance is the substrate of a certain enzyme. The researcher adds a small amount of the enzyme to the reaction mixture and measures the amount of product that is formed over time. The data are represented in Figure 1.

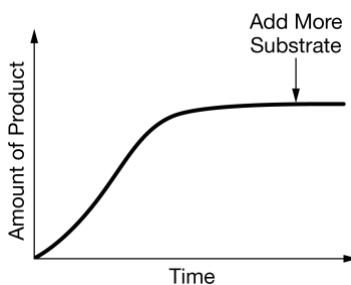
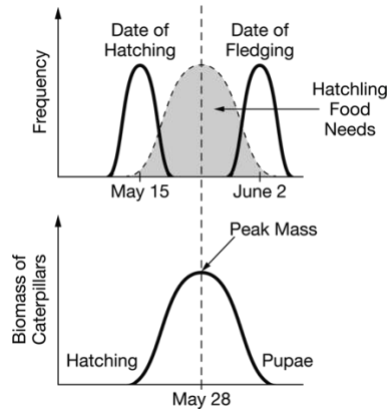


Figure 1. The amount of product formed by an enzyme-catalyzed reaction over time

12. Which of the following best predicts the immediate result of adding more substrate to the reaction mixture at the point indicated by the arrow in Figure 1?
- A. The amount of product will decrease until the reaction rate goes to zero.
 - B. The amount of product will decrease until the reaction reaches its equilibrium point or until the enzyme is been used up by the reaction.
 - C. The amount of product will increase until the reaction reaches its equilibrium point or until the substrate is used up by the reaction.
 - D. The amount of product will increase without stopping because the enzyme will be unchanged by the reaction.

European flycatchers feed caterpillars to their hatchlings. Graph 1 shows the average dates of hatching and fledging (leaving the nest), and the biomass of the caterpillars between early May (when flycatcher young hatch) and June (when fledging of young occurs).



Graph 1. Comparison of European flycatcher hatching and fledging dates and caterpillar biomass

13. Based on the data, scientists claim that the reproductive behavior of European flycatchers is influenced by the availability of energy sources. Which of the following statements best justifies this claim?
- A. Young European flycatchers hatch from eggs when caterpillar biomass is available for the young birds to consume and convert into energy for growth.
 - B. European flycatcher hatchlings begin to need energy to leave the nest only after the caterpillars have turned into pupae.
 - C. Female European flycatchers require energy to lay eggs, so they lay their eggs when the caterpillar biomass is maximal.
 - D. The energy requirements for hatching European flycatchers and caterpillars are proportional to each other.

A researcher claims that the incorporation of carbon dioxide into organic molecules during photosynthesis does not violate the second law of thermodynamics.

14. Which of the following statements best helps justify the researcher's claim?
- A. Organisms contain enzymes that lower the activation energies of specific chemical reactions.
 - B. An ecosystem is formed by the interaction of a community of organisms with their surrounding environment.
 - C. Photosynthetic organisms use the organic molecules produced during photosynthesis for growth and repair.
 - D. The total system that includes photosynthetic organisms and the Sun becomes less ordered over time.

Brown fat is a type of fat tissue found in hibernating mammals. Inside the mitochondria of these fat tissue cells, these mammals have an uncoupling protein embedded in the inner mitochondrial membrane. This uncoupling protein allows hydrogen ions to leak from the intermembrane space back into the mitochondrial matrix. Figure 1 shows details of the processes in the inner mitochondrial membrane.

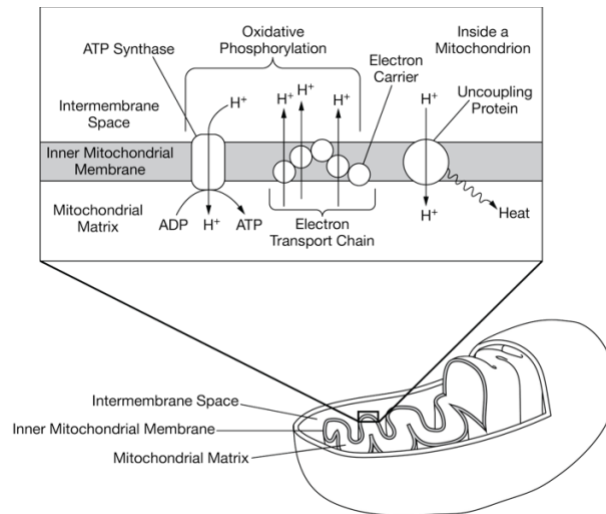
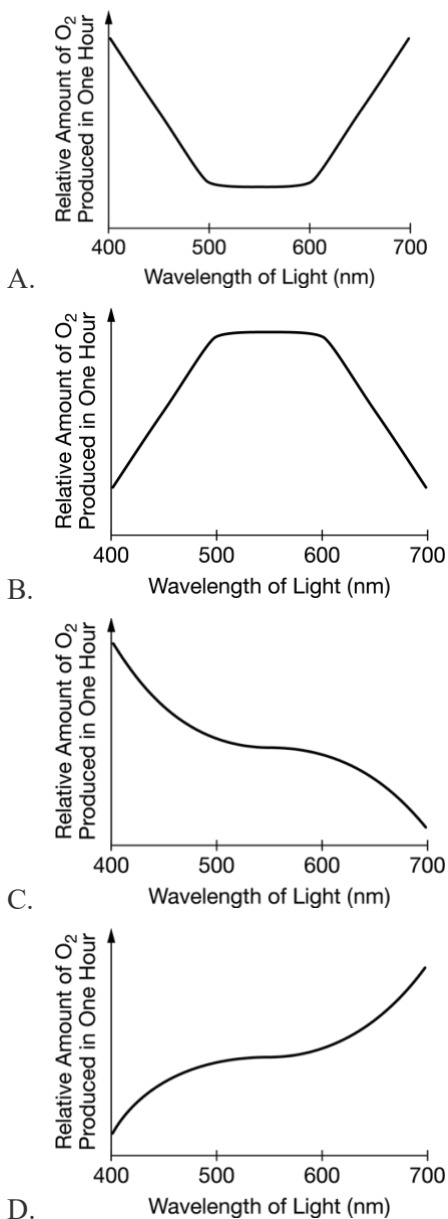


Figure 1. Processes in the inner mitochondrial membrane

15. Which of the following statements provides reasoning that supports the claim that brown fatty tissue keeps an animal warm?
- The uncoupling protein in this tissue increases the production of ATP and causes more body heat to be produced to warm the animal.
 - The uncoupling protein in this tissue reduces the proton gradient across the membrane and thus produces heat to warm the animal without ATP production.
 - The uncoupling protein in this tissue causes an increase in the proton gradient, which causes more ATP to be produced that helps to warm the animal.
 - The uncoupling protein in this tissue reduces the production of ATP and creates an increase in the proton gradient that allows more heat energy to be produced to warm the animal.

A researcher claims that spinach leaves capture the most energy from light waves in the range of 500 nm to 600 nm. To test the claim, the researcher will place spinach leaves in separate chambers and expose the leaves to different wavelengths of light. For each chamber, the researcher will measure the amount of oxygen gas (O_2) that is produced in one hour.

16. Which of the following best represents data from the experiment that will support the researcher's claim?



A researcher claims that the initial rise of oxygen in Earth's early atmosphere, which occurred approximately 2.3 billion years ago, resulted from the metabolic activity of prokaryotic organisms. The claim is based on an interpretation of the geochemical and fossil evidence represented in Figure 1.

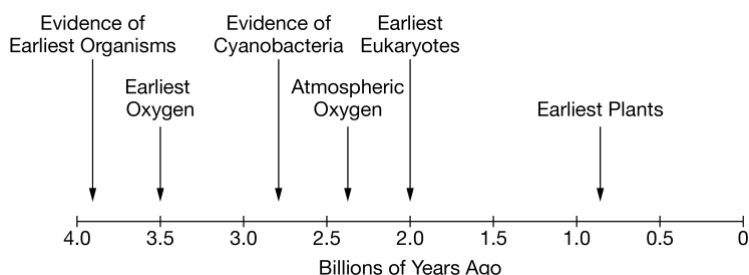


Figure 1. Selected events in geologic time based on geochemical and fossil evidence

17. Which of the following types of evidence will best support the researcher's claim?
- A. Evidence that some of the earliest eukaryotes used oxygen to produce ATP by cellular respiration
 - B. Evidence that the earliest plants produced oxygen as a by-product of photosynthesis
 - C. Evidence that some of the earliest organisms carried out photosynthesis without producing oxygen
 - D. Evidence that the cyanobacteria produced oxygen as a by-product of photosynthesis

A researcher claims that a certain herbicide suppresses plant growth by inhibiting chloroplast function. To test the claim, the researcher treats isolated chloroplasts with increasing concentrations of the herbicide. The data from the experiment are presented in Table 1.

Table 1. The effect of an herbicide on the function of isolated chloroplasts

Herbicide Concentration ($\mu\text{g/L}$)	pH Difference across Thylakoid Membrane	ATP Production
0	3.5	Very high
2	2.5	Moderate
8	0.5	Very low
32	0	Very low

18. Which of the following statements best clarifies how the data support the researcher's claim?
- A. The thylakoid membrane is more permeable to carbon dioxide than to polar molecules.
 - B. ATP synthase activity depends on a proton gradient across the thylakoid membrane.
 - C. Some enzymes embedded in the thylakoid membrane catalyze the hydrolysis of ATP.
 - D. Carbon fixation in the Calvin-Benson cycle takes place in the stroma of chloroplasts.

<Answer Key>

1. A
2. D
3. C
4. B
5. C
6. C
7. A
8. C
9. A
10. C
11. A
12. C
13. A
14. D
15. B
16. B
17. D
18. B