Bioenergetics

Module A Anchor 3

Key Concepts:

- ATP can easily release and store energy by breaking and re-forming the bonds between its phosphate groups. This characteristic of ATP makes it exceptionally useful as a basic energy source for all cells.
- In the process of photosynthesis, plants convert the energy of sunlight into chemical energy stored in the bonds of carbohydrates.
- Photosynthetic organisms capture energy from sunlight with pigments.
- An electron carrier is a compound that can accept a pair of high-energy electrons and transfer them, along with most of their energy, to another molecule.
- Photosynthesis uses the energy of sunlight to convert water and carbon dioxide into high-energy sugars and oxygen.
- Among the most important factors that affect photosynthesis are temperature, light intensity, and the availability of water.
- Organisms get the energy they need from food.
- Cellular respiration is the process that releases energy from food in the presence of oxygen.
- Photosynthesis removes carbon dioxide from the atmosphere and cellular respiration puts it back. Photosynthesis releases oxygen into the atmosphere, and cellular respiration uses that oxygen to release energy from food.
- In the absence of oxygen, fermentation releases energy from food molecules by producing ATP.
- For short, quick bursts of energy, the body uses ATP already in muscles as well as ATP made by lactic acid fermentation.
- For exercise longer than about 90 seconds, cellular respiration is the only way to continue generating a supply of ATP.

Vocabulary:

ATP	ADP	autotroph	heterotroph
Photosynthesis	pigment	chlorophyll	chloroplast
Thylakoid	stroma	NADP+/NADPH	calorie
Cellular respiration	aerobic	anaerobic	fermentation
Glucose			

ATP and Energy Molecules:

1. What are the different energy molecules in the cell? Describe the energy storage capacity of each and relate this to their function in living organisms.

2. What are the three parts of an ATP molecule?
    A. adenine, thylakoid, and phosphate group
    B. stroma, grana, and thylakoid
    C. adenine, ribose, and phosphate group
    D. NADH, NADPH, and FADH

3. Energy is released from an ATP molecule when:
    A. a phosphate group is added
    B. a phosphate group is removed
    C. adenine bonds to ribose
    D. the molecule is exposed to sunlight

4. How do heterotrophs and autotrophs differ in the way they obtain energy?

Photosynthesis:

1. Which organelle is involved in photosynthesis? List and describe the parts of this organelle.

2. Explain what happens to energy during photosynthesis. In what form does it enter photosynthesis? In what form does it exist during photosynthesis? In what form does it leave photosynthesis? How is this related to the overall goal of photosynthesis?

3. Plants absorb energy with light-absorbing molecules called:
    A. stroma
    B. grana
    C. thylakoids
    D. pigments

4. What is the primary pigment involved in photosynthesis? Why do plants also contain accessory pigments?

5. A student exposed one plant to only red light and another to only green light. Which should grow better and why?

6. Write the basic equation for photosynthesis using the names of the molecules involved. Identify the products and reactants. Is light a product or reactant? If not, what does it supply to the equation?

7. A student is collecting gas being given off by a plant in direct sunlight. The gas is most likely:

A. water vapor
B. carbon dioxide
C. oxygen
D. ATP

Cellular Respiration and Fermentation:

1. What are the products and reactants of cellular respiration? Where does the reaction take place in cells?

2. How is energy transformed during cellular respiration? In what form does it enter cellular respiration? In what form does it leave cellular respiration? How is this related to the overall goal of cellular respiration?

3. What is a calorie? Briefly explain how cells use a high-calorie molecule such as glucose.

4. Compare and contrast photosynthesis and cellular respiration in terms of product, reactant, and energy transformations in each.

5. Why are photosynthesis and cellular respiration considered opposite reactions?

7. Compare and contrast fermentation and cellular respiration in terms of product, reactant, and energy transformations involved.

8. Because fermentation takes place in the absence of oxygen, it is said to be
   A. aerobic
   B. anaerobic
   C. cyclic
   D. oxygen-rich

9. In what circumstances is fermentation a better option than cellular respiration and vice versa?

10. Certain bacteria thrive in conditions that lack oxygen. What does that fact indicate about the way they obtain energy?

11. In certain cases, regular exercise causes an increase in the number of mitochondria in muscle cells. How might that situation improve an individual's ability to perform energy-requiring activities?

12. Why must plants contain mitochondria, despite the fact that they can turn light energy into chemical energy?

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ATP and Energy Molecules:

1. What are the different energy molecules in the cell? Describe the energy storage capacity of each and relate this to their function in living organisms.

ATP – stores smaller amounts of energy that is easily accessible by the cell. ATP is used to run all cell activities.

Glucose – stores larger amounts of energy that is more difficult to access. Glucose is used for energy storage. It is converted into ATP when energy is needed.

2. What are the three parts of an ATP molecule?

C. *adenine, ribose, and phosphate group*

3. Energy is released from an ATP molecule when:

B. a phosphate group is removed

4. How do heterotrophs and autotrophs differ in the way they obtain energy?

Autotrophs make their own food using energy from the sun or inorganic molecules. Heterotrophs must consume other organisms for food.

Photosynthesis:

1. Which organelle is involved in photosynthesis? List and describe the parts of this organelle.

Chloroplasts are the organelle of photosynthesis in eukaryotes. The light-dependent reactions occur in the thylakoid membrane. Stacks of thylakoids are called grana. The light-independent reactions occur in the stroma.

2. Explain what happens to energy during photosynthesis. In what form does it enter photosynthesis? In what form does it exist during photosynthesis? In what form does it leave photosynthesis? How is this related to the overall goal of photosynthesis?

Energy enters photosynthesis as light energy from the sun. During the light-dependent reactions, it is converted into chemical energy in the form of ATP and electron carriers. These molecules carry the chemical energy to the light-independent reactions, where it is stored as glucose. The goal of photosynthesis is to create food from sun energy, thereby converting light energy into a form usable by living organisms.

3. Plants absorb energy with light-absorbing molecules called:

D. pigments

4. What is the primary pigment involved in photosynthesis? Why do plants also contain accessory pigments?

Chlorophyll – it is a green pigment and therefore cannot absorb light from that part of the electromagnetic spectrum. Accessory pigments all absorb varying wavelengths of light. Containing multiple pigments allows plants to absorb the entire spectrum, obtaining more energy for photosynthesis.

5. A student exposed one plant to only red light and another to only green light. Which should grow better and why?
The one under red light. The primary pigment in this plant is likely chlorophyll, which reflects green light. This prevents the plant from absorbing energy from the light and stunts its growth.

6. Write the basic equation for photosynthesis using the names of the molecules involved. Identify the products and reactants. Is light a product or reactant? If not, what does it supply to the equation?
Water + carbon dioxide ⟶ *sugar + oxygen*

Reactants – water, carbon dioxide *products – sugar, oxygen*

Light supplies energy for the reaction, but is not a product or reactant

7. A student is collecting gas being given off by a plant in direct sunlight. The gas is most likely:
C. oxygen

Cellular Respiration and Fermentation:
1. What are the products and reactants of cellular respiration? Where does the reaction take place in cells?
Reactants – sugar, oxygen *Products – carbon dioxide, water*
Cellular respiration takes place in the mitochondria

2. How is energy transformed during cellular respiration? In what form does it enter cellular respiration? In what form does it leave cellular respiration? How is this related to the overall goal of cellular respiration?
Energy enters cellular respiration as stored energy in glucose. It leaves cellular respiration as ATP. The goal of cellular respiration is to provide energy to be used by the cell. Changing from glucose to ATP allows the energy in glucose to be used by the cell.

3. What is a calorie? Briefly explain how cells use a high-calorie molecule such as glucose.
A calorie is a measure of energy. Cells use high-calorie molecules for energy storage.

4. Compare and contrast photosynthesis and cellular respiration in terms of product, reactant, and energy transformations in each.
Photosynthesis –product – sugar, oxygen *reactant – water, carbon dioxide*
converts light energy into chemical energy

Cellular respiration – product – water, carbon dioxide, ATP *reactant – sugar, oxygen*
Converts stored chemical energy into usable energy

5. Why are photosynthesis and cellular respiration considered opposite reactions?
The products of one are the reactants of the other.

7. Compare and contrast fermentation and cellular respiration in terms of product, reactant, and energy transformations involved.
Cellular respiration and fermentation both start with sugar; however, cellular respiration also requires oxygen. Cellular respiration produces carbon dioxide, water and energy.
Fermentation produces energy and alcohol or lactic acid. Fermentation produces far less ATP than cellular respiration.

8. Because fermentation takes place in the absence of oxygen, it is said to be
B. anaerobic

9. In what circumstances is fermentation a better option than cellular respiration and vice versa?
Cellular respiration is a better option in the presence of oxygen, as it produces significantly more energy.
Fermentation is a better option in the absence of oxygen, as cellular respiration cannot take place.

10. Certain bacteria thrive in conditions that lack oxygen. What does that fact indicate about the way they obtain energy?
They must use fermentation, as cellular respiration requires oxygen.

11. In certain cases, regular exercise causes an increase in the number of mitochondria in muscle cells. How might that situation improve an individual's ability to perform energy-requiring activities?
Cellular respiration occurs in the mitochondria, therefore more mitochondria would increase the rate at which energy could be produced.

12. Why must plants contain mitochondria, despite the fact that they can turn light energy into chemical energy?
Plants create energy in the form of glucose, which still needs to be converted into ATP.