This packet contains information to help you prepare for the upcoming Biology Keystone exam on May 21\textsuperscript{st} and 22\textsuperscript{nd}. As you will see, this packet is broken down into several major themes that the Keystone Exam will cover. Please take the time to read through and complete each section with your best possible efforts. The preparation you put into this packet will benefit you in that a scoring proficient on the spring Keystone will ensure that you do not have to take the exam again, nor will you have to participate in any intervention courses in the summer and/or next school year.

Major themes covered in this packet:

- Themes of Life
- Organic Chemistry
- Cells and Cell Transport
- Energy

Each section will have major vocabulary words that you should be familiar with, the major content anchors that you should be able to answer questions about, some questions that will refresh your memory and additional practice questions meant to be similar to exam questions.
Themes of Life

Vocabulary
Biology  Organ system  hypothesis
Biotechnology  Organism  eukaryote
Forensics  Scientific principle  prokaryote
Homeostasis  Science
Organ  theory

Concepts to Know

Characteristics of Life:

- **Living things are made of cells**
  - Smallest unit of an organism that is considered alive
  - Can be unicellular (bacteria) or multicellular (humans)

- **Living things reproduce**
  - Asexual: formation of a new organism from one parent. Offspring is a clone
  - Sexual: two cells from different parents unite to produce the 1st cell of new organism

- **Living things are based on a universal genetic code**
  - Based on 1 molecule that is almost identical in every organism on earth: DNA (Deoxyribonucleic Acid)

- **Living things grow and develop**
  - Growth: an increase in size of an organism
  - Development: progression through a life cycle

- **Living things obtain materials and use energy**
  - Autotroph: obtains energy from the sun
  - Heterotroph: obtains energy from consuming other organisms.

- **Living things respond to environment**
  - ex. Find shelter from rain
  - ex. Hibernating to survive the winter
  - ex. Produce toxins to ward off predators

- **Living things maintain a stable internal environment**
  - Homeostasis: keeping internal condition stable relative to the external environment

- **Living things change over time (evolve)**
  - Populations evolve over time

1. Read through the characteristics of life on this page. These 8 characteristics are what tell biologists if something is living or non-living. Remember, biology literally means “Study of life”.
2. Look at the images below. Each one is related to a characteristic of life. Some images may be related to more than one characteristic of life. See if you can match at least one characteristic of life to each image:

A. ______________________

B. ________________________

C. ______________________

D. ______________________

E. ______________________

F. ______________________

G. ______________________

H. ______________________

I. ______________________
Structure and Function:

Structure and function is a central theme to the study of biology. Each major group of organisms has evolved its own particular body part “tool kit” – a collection of structures that have evolved in ways that make particular functions possible. From capturing food to digesting it, and from reproducing to breathing, organisms use structures that have evolved into different forms as species have adapted to life in different environments. The structure of wings, for example enable birds and insects to fly. The structures of legs enable horses to gallop and kangaroos to hop.

→ Examine the figure below that shows carnivore and herbivore skulls. Don’t forget to read the captions!

Now, since you’ve got some specific ideas about what structure and function are all about answer the questions below:

1. Think about your own teeth. What kinds of foods do you think human teeth are suited for?

2. List at least three ways the structure of human teeth serve the function of eating meat and plant material.
   a. _____________________________________________
   b. _____________________________________________
   c. _____________________________________________

3. Now, last but not least apply the theme of structure and function to something you’re very familiar with - your hands. List out all the ways you can think of that the structure of your hands serve the function of your hands. Hint – you are a primate!
Levels of Organization

The specialized cells of multicellular organisms are organized into an organ system, as shown above. A tissue is a group of similar cells that perform a particular function. Many tissues work together as an organ to complete complicated tasks. A group of organs that work together to perform a specific function is called an organ system.

3. The Venn diagram to the right consists of four concentric circles. Complete the diagram to show the relationships among four levels of organization of life. Use the terms cells, organ, organ system, and tissue.

4. See if you can include the level of organization called “organism” in the Venn diagram. Show where it would be added.

The diagram to the left shows a few of the different types of cells found in your body. Luckily, the cells in our body are specialized. Some cells are specialized to move, to react to the environment; still others to produce substance that the organism needs. Each of these specialized cells contributes to homeostasis in the organism.

Describe how cells of a multicellular organism are like a baseball team, or choose any type of team you like.
Chemistry of water:

Life is connected to water. Nearly 75% of our earth is covered in water. Why is it so special and vital to living things? Let’s look at the chemistry of water. Notice in the diagram to the right that water is composed of two hydrogen atoms and one oxygen (H₂O).

The diagram shows that one side of the water molecule is **positively charged** and the other is **negatively charged**. These opposite charges make water a **polar** molecule.

The **negative oxygen** of one water molecule is attracted to the **positive hydrogen** of another molecule forming a **hydrogen bond**. In other words water likes to stick to itself. Water sticking to water is called **cohesion**. Water sticking to something else is called **adhesion**.

5. In the diagram to the right use dotted lines to draw in the bonds that form between water molecules.

6. What is the name of this type of bond?

7. What special property do the bonds give to water.

It turns out that hydrogen bonds are important for a few more reasons. Hydrogen bonds give water a **high specific heat** and also cause water to **expand upon freezing**.

**Specific heat** is the amount of energy required to raise one gram of water 1 degree Celsius.

8. Can you think of a reason why water can absorb so much heat? Hint – think bonds

It turns out that water expands when frozen and actually becomes **less dense** than when in the liquid state. We call this frozen water ice, which we know floats.

9. Challenge yourself to think of two ways that specific heat and the freezing point of water help support life on earth.
10. Based on the scenario what is the difference between a hypothesis and an inference?

11. How did the control group differ from the experimental group?

12. What were the dependent and independent variables?

13. What was the observation that started the research?
In science the word **theory** applies to a well-tested explanation that unifies a broad range of observations and hypotheses and that enables scientists to make accurate predictions about new situations.

A **hypothesis** is a scientific explanation for a set of observations that can be tested in ways that support or reject it.

**Identify whether each statement is a hypothesis or a theory. For a hypothesis, write an “H” on the line. For a theory, write a “T.”**

14. The rate that grass grows is related to the amount of light it receives.  
15. All life is related and descended from a common ancestor.  
16. The universe began about 15 billion years ago.  
17. New tennis balls bounce higher than old tennis balls.  
18. Caffeine raises blood pressure.

19. Someone might argue against evolution and say that it’s “just a theory”. Why is this not a very good argument?

**Practice Questions:**

1. Which characteristic is shared by all prokaryotes and eukaryotes?
   a. ability to store hereditary information  
   b. use of organelles to control cell processes  
   c. use of cellular respiration for energy release  
   d. ability to move in response to environmental stimuli

2. Living organisms can be classified as prokaryotes or eukaryotes. Which two structures are common to both prokaryotic and eukaryotic cells?
   a. cell wall and nucleus  
   b. cell wall and chloroplast  
   c. plasma membrane and nucleus  
   d. plasma membrane and cytoplasm

3. Alveoli are microscopic air sacs in the lungs of mammals. Which statement best describes how the structure of the alveoli allows the lungs to function properly?
   a. They increase the amount of energy transferred from the lungs to the blood.  
   b. They increase the flexibility of the lungs as they expand during inhalation.  
   c. They increase the volume of the lungs, allowing more oxygen to be inhaled.  
   d. They increase the surface area of the lungs, allowing efficient gas exchange.

4. Which example is an activity that a fish most likely uses to maintain homeostasis within its body?
   a. using camouflage to avoid predators  
   b. feeding at night to regulate body temperature  
   c. moving to deeper water to regulate metabolic wastes  
   d. exchanging gases through its gills to regulate oxygen levels
5. Which statement best describes an effect of the low density of frozen water in a lake?
   a. When water freezes, it contracts, decreasing the water level in a lake.
   b. Water in a lake freezes from the bottom up, killing most aquatic organisms.
   c. When water in a lake freezes, it floats, providing insulation for organisms below.
   d. Water removes thermal energy from the land around a lake, causing the lake to freeze.

6. Which diagram best represents the relationship of the items in the list below?

   1. cell
   2. organ
   3. organelle
   4. organ system
   5. tissue
   6. whole organism

   A. X
   B. Y
   C. Z
   D. W

7. Which property of water molecules explains the other properties listed below?
   a. Adhesion
   b. Cohesion
   c. Hydrogen bond
   d. Polar covalent bond

8. One property of water that makes it unique is its density. Which example describes a result of this property?
   a. Polar bears float on ice floes to hunt for food
   b. Trees transport water from their roots to their leaves
   c. Water strider insects walk on the surface of pond water
   d. Plants receive enough light to grow under the surface of a lake

Use the picture below to answer question 9.

9. The picture shows a water droplets hanging on the tip of a pine needle. How do the physical properties of water result in the image shown?
   a. Cohesion allows droplets to form, and adhesion keeps the droplet on the needle.
   b. Adhesion allows droplets to form, and cohesion keeps the droplet on the needle.
   c. Cohesion allows droplets to form, and capillary action keeps the droplet on the needle.
   d. Adhesion allows droplets to form, and capillary action keeps the droplet on the needle.
10. Many trees in temperate environments have broad, flat leaves. How does this leaf structure support the function of obtaining energy?

   a. A flatter surface allows more oxygen to enter the leaf
   b. A flatter surface allows more water to be retained in the leaf during periods of dryness.
   c. A larger surface area allows more light to reach the mesophyll where photosynthetic cells are located.
   d. A larger surface area allows more room for photosynthetic cells.

**Open-ended question:**

11. The diagram shows a single-celled freshwater protist. The contractile vacuole pumps water out of the cell.

**Part A:** Describe how the function of the contractile vacuole helps the protist stay alive.

___________________________________________________________________________________________
___________________________________________________________________________________________
___________________________________________________________________________________________
___________________________________________________________________________________________

**Part B:** Describe how the same function is carried out in animals. Identify at least one organ or system involved in this function.

___________________________________________________________________________________________
___________________________________________________________________________________________
___________________________________________________________________________________________
___________________________________________________________________________________________

**Part C:** Describe how the same (or a similar) function is carried out in plants. Identify at least one organ, structure, or cell type involved in this function.

___________________________________________________________________________________________
___________________________________________________________________________________________
___________________________________________________________________________________________
___________________________________________________________________________________________
Organic Chemistry

**Vocabulary**

<table>
<thead>
<tr>
<th>Concept</th>
<th>Term</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adhesion</td>
<td>Cohesion</td>
</tr>
<tr>
<td>Atom</td>
<td>Concentration</td>
</tr>
<tr>
<td>Biological macromolecules</td>
<td>Monomer</td>
</tr>
<tr>
<td>Freezing point</td>
<td>Concentration</td>
</tr>
<tr>
<td>carbohydrate</td>
<td>amino acid</td>
</tr>
<tr>
<td>protein</td>
<td>Macromolecule</td>
</tr>
<tr>
<td>lipids</td>
<td>nucleic acid</td>
</tr>
<tr>
<td>enzyme</td>
<td>catalyst</td>
</tr>
<tr>
<td>pH</td>
<td>molecule</td>
</tr>
<tr>
<td>specific heat</td>
<td>organic molecule</td>
</tr>
</tbody>
</table>

**Concepts to Know**

1st Idea: Due to its properties, carbon is uniquely suited to form biological macromolecules.

→ Use the diagrams below to fill in the blanks and describe why carbon is so important to life.

- Carbon has ____________ in the outer (valence) shell
  - Valence shell enables easy formation of four covalent bonds
  - Covalent bonds involve ____________ of ____________ between two atoms

Carbon has the ability to form long chains by forming several carbon to carbon bonds in a row. The diagram to the left depicts two fatty acids. What is different about the structure of each?

---------
Use the diagrams to fill in the blanks and describe how the variety of organic compounds can be explained by carbon’s properties.

- **Organic compounds** – Contain carbon atoms bonded to ________________.
- **Variety** is created when carbon bonds to other atoms.
- **Covalent bonds** between carbon atoms can be single, double or ________ bonded
- **Carbon’s unique structure** allows the formation of ______________________ (large molecules)

2\textsuperscript{nd} Idea: Biological macromolecules form from monomers.

Use the diagrams to fill in the blanks and describe how carbon allows for the formation of macromolecules.

- **Macromolecules** are very large molecules
- Most **macromolecules** are polymers
- ________________ are long chains of bonded groups
- ________________ are the molecules that link to form polymers

- **Dehydration Synthesis** involves the removal of a water molecule and and is a common way for polymers to form.
- Carbohydrate polymers found in plants that comprise the cell wall or serves as a means to store sugar are __________ and __________, respectively.
- A carbohydrate polymer found in animals called ____________ stores glucose in the liver.
- **Hydrolysis** is the process of adding water (H\textsubscript{2}O) breaking apart _________________
MACROMOLECULES: STRUCTURE AND FUNCTION

**Carbohydrates** are broken down through hydrolysis to serve as fuel for the body or a source of carbon

- Saccharide means sugar

  Carbohydrates can be
  
  (1 sugar) ____________________
  
  (2 sugars), or
  
  (more than 2 sugars)

- _________ breaks down carbohydrates like glucose for use in cellular respiration

- **Cellular respiration** is the process through which the body generates energy, or ________

- **Starch** and **cellulose** are polysaccharides comprised of long chains of __________.

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**Lipids** are nonpolar macromolecules made from long carbon chains

- Lipids can be fats, oils, phospholipids, waxes, or steroids

- **Fats** store large amounts of energy

- _______________ compose cell membranes

- **Steroids** are made of four connected carbon rings with functional groups attached

- **Lipids** can be saturated or ______________

- **Saturated** lipids have a ___________ shape and only single bonds between carbons, while **unsaturated** lipids have a nonlinear shape and have ___________ or triple bonds

- **Fats and oils** have a basic structure that consists of one ___________ connected to three ________________.


**Proteins** are **amino acid** polymers that are essential to life

- **Amino acids** have ___________ and _______________ groups. They are made unique by the “R” group that is attached to carbon
- “R” is like a variable in algebra class. It can have many values (structures).
- **The Function** of the amino acid is determined by the structure and conformation of the “R” group
- Proteins are based on the different arrangement of 20 amino acid monomers.
- The unique __________ of a protein is vital to its ____________.

![Amino Acid Structure](image)

**Nucleic acids (DNA and RNA)** are polymers made from **nucleotides**

- **Nucleotides** are monomers that consist of pentose (the pentagon shape in the diagram) attached to a phosphate group and nitrogenous base
- **Pentose** can be deoxyribose (as in DNA or deoxyribose nucleic acid) or ribose (as in RNA or ___________ nucleic acid)
- **DNA and RNA** are central to heredity/genetics and are made unique by the nitrogenous ___________ that are attached
- **Nitrogenous bases** can be cytosine (C), thymine (T), uracil (U), adenine (A), or guanine (G)
- DNA based codes are actually ________ or segments of DNA that code for a particular ____________.
3rd Idea: **Enzymes** are mostly macromolecule **proteins** that act as biological **catalysts**

- **Catalysts** increase the rate of a reaction without being changed by the reaction, catalysts lower the activation required for the reaction to proceed.
- **Substrates** are the reactants on which enzymes (catalysts) work
- **Rate of reaction** in both directions is increased by the presence of specific enzymes.
- ___________ __________ refers to the part of an enzyme that interacts with a substrate

<table>
<thead>
<tr>
<th>Class</th>
<th>Monomers</th>
<th>Functions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carbohydrates</td>
<td>Monosaccharides</td>
<td>Energy, raw materials, energy storage, structural compounds</td>
</tr>
<tr>
<td>Lipids</td>
<td>Glycerol, fatty acids, steroids</td>
<td>Energy storage, membranes, steroids, hormones, waterproof coverings, oils, waxes</td>
</tr>
<tr>
<td>Proteins</td>
<td>Amino acids</td>
<td>Enzymes, membrane transport, movement, receptors, immune defense, structure (muscle, bone)</td>
</tr>
<tr>
<td>Nucleic acids</td>
<td>Nucleotides</td>
<td>Heredity, DNA and RNA code for amino acid sequence of proteins</td>
</tr>
</tbody>
</table>

The rate of a reaction involving enzymes has to speed up at times and slow down at other times based on the needs of the organism (to maintain homeostasis).

⇒ **Use the video called Bozeman Science Enzymes** to answer the questions

- The process of turning enzymes on occurs through ___________ or ___________
  - ___________ means the body only produces the enzyme when it is needed
- **Deactivation** of enzymes occurs through ___________ or ___________ inhibition
  - **Competitive inhibition** means another chemical bonds with and ___________ the active site of the enzyme
  - ___________ inhibition means another chemical bonds to the enzyme in a position away from the active site, but blocks or alters the active site as a result
4th Idea: Enzyme reaction rates are impacted by temperature, pH & substrate concentration

- **Temperature** is a measure of kinetic energy
  - Kinetic energy is the energy of motion. Higher temperature means ___________ moving particles.
  - The number of collisions between enzymes and substrates is increased if the particles move around ___________ (higher temperature)
  - Enzymes do not function well above or below the ___________ temperature
  - The enzyme denatures, or breaks down, if the enzyme gets too ___________

- **pH** measures acidity
  - Enzymes function best at the ___________ pH level
  - If the conditions are too acidic (low pH) or too basic (high pH), the enzyme may denature

- **Concentration** is a measure of how many substrate molecules are present in a given volume.
  - ___________ __ __ ___________ is the concentration where the reaction rate is maximized, the active sites of the enzymes are all used adding more substrate does not increase the rate of reaction.

**Practice Questions:**
1. Which statement correctly describes how carbon’s ability to form four bonds makes it uniquely suited to form macromolecules?
   - A. It forms short, simple carbon chains.
   - B. It forms large, complex, diverse molecules.
   - C. It forms covalent bonds with other carbon atoms.
   - D. It forms covalent bonds that can exist in a single plane.
Use the diagram below to answer the question.

**Chemical Reaction**

\[
\begin{align*}
&\text{HO} \quad 1 \quad 2 \quad 3 \quad \text{H + HO} \quad 4 \quad \text{H} \\
&\text{HO} \quad 1 \quad 2 \quad 3 \quad 4 \quad \text{H + H}_2\text{O}
\end{align*}
\]

2. The diagram shows a reaction that forms a polymer from two monomers. What is this type of reaction called?
   A. glycolysis
   B. hydrolysis
   C. photosynthesis
   D. dehydration synthesis

3. Carbohydrates and proteins are two types of macromolecules. Which functional characteristic of proteins distinguishes them from carbohydrates?
   A. large amount of stored information
   B. ability to catalyze biochemical reactions
   C. efficient storage of usable chemical energy
   D. tendency to make cell membranes hydrophobic

4. Substance A is converted to substance B in a metabolic reaction. Which statement best describes the role of an enzyme during this reaction?
   A. It adjusts the pH of the reaction medium.
   B. It provides energy to carry out the reaction.
   C. It dissolves substance A in the reaction medium.
   D. It speeds up the reaction without being consumed.

5. A scientist observes that, when the pH of the environment surrounding an enzyme is changed, the rate the enzyme catalyzes a reaction greatly decreases. Which statement best describes how a change in pH can affect an enzyme?
   A. A pH change can cause the enzyme to change its shape.
   B. A pH change can remove energy necessary to activate an enzyme.
   C. A pH change can add new molecules to the structure of the enzyme.
   D. A pH change can cause an enzyme to react with a different substrate.

6. Whenever biological organic compounds, such as proteins and carbohydrates, are broken down or synthesized...
   a. a phase change of matter results.
   b. thermal expansion occurs.
   c. sunlight is required.
   d. energy is absorbed or released.

7. Why does an enzyme function as a catalyst in a reaction?
   a. It creates the right pH needed for the reaction.
   b. It decreases the amount of energy needed for the reaction.
   c. It provides the extra energy needed for the reaction.
   d. It maintains the proper temperature needed for the reaction.
8. A single atom of carbon is joined to a hydrogen atom. What is the maximum number of double bonds the carbon atom may yet form?
   a. 1
   b. 2
   c. 3
   d. 4

9. Which of the following types of compounds is unlike the other three?
   a. wax.
   b. saturated fat
   c. phospholipid
   d. polysaccharide

10. Which of the following is not created as a result of dehydration synthesis?
    a. cellulose
    b. disaccharide
    c. glucose
    d. water

11. Which pair of terms is not correctly matched?
    a. Deoxyribose: RNA.
    b. Polypeptide: protein.
    c. Nitrogenous base; DNA.
    d. Amino acid: polypeptide.

12. Which does not describe a function of proteins?
    a. They encode genetic information
    b. They allow muscle cells to contract.
    c. They help to carry out chemical reactions.
    d. They make up structures that support the cell.

Examine the structural formula below.

13. Which of the following biomolecules is best represented by this formula?
    a. nucleic acid
    b. protein
    c. carbohydrate
    d. lipid
14. The enzyme lactase catalyzes the breakdown of lactose (milk sugar) to glucose and galactose. Students set up a beaker with milk and lactase enzyme. Which describes how the concentrations of these substances will change?

a. The concentration of lactase will decrease, and the concentration of galactose will increase.
b. The concentration of galactose will decrease, and the concentration of glucose will increase
c. The concentration of galactose will increase, and the concentration of lactase will remain the same.
d. The concentration of lactose will increase, and the concentration of glucose will remain the same.

15. Organisms produce hydrogen peroxide ($H_2O_2$), a by-product of metabolism that is toxic to cells. The catalase protein catalyzes the reaction shown below.

$$2H_2O_2 \rightarrow 2H_2O + O_2$$

Which statement describes the reaction?

a. Water is the substrate.
b. Hydrogen peroxide is the enzyme.
c. Catalase is consumed by the reaction.
d. Oxygen gas is a product of the reaction.

16. A reaction tube is set up at 37°C with twice as much substrate as enzyme. The pH level of the solution is 5. The reaction rate is measured. Which of the following changes will not affect the rate of the reaction?

a. Increasing the pH level.
b. Increasing the temperature.
c. Increasing the enzyme concentration.
d. Increasing the substrate concentration.

Open-ended Question:

17. The graph shows the rate of enzyme activity in relation to pH for two enzymes – pepsin and pancreatic trypsin. Both enzymes break down proteins in food. Pepsin works within the stomach. Trypsin works in the small intestine.

Part A: What does the graph indicate about the pH of the stomach and small intestine?

___________________________________________________________________________________________
___________________________________________________________________________________________
___________________________________________________________________________________________
___________________________________________________________________________________________

Part B: The contents of the stomach are released into the small intestine. How does this affect the function of the pepsin that is included with the stomach contents?

___________________________________________________________________________________________
___________________________________________________________________________________________
___________________________________________________________________________________________
___________________________________________________________________________________________

Part C: What is the advantage to having two different protein-digesting enzymes, rather than just one?

___________________________________________________________________________________________
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Cells and Cell Transport

Vocabulary

<table>
<thead>
<tr>
<th>Prokaryotic</th>
<th>Eukaryotic</th>
</tr>
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<tbody>
<tr>
<td>All living things are made of cells.</td>
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<td>Cells are the basic units of structure and function in living things.</td>
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<tr>
<td>New cells are produced from existing cells.</td>
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</tr>
</tbody>
</table>

What is the Cell Theory?

a. All living things are made of cells.
b. Cells are the basic units of structure and function in living things.
c. New cells are produced from existing cells.

Differences between Prokaryotic vs Eukaryotic Cells

1. Prokaryotic Cells: Single-celled organisms that lack internal membrane
   Bound compartments (Genetic material (DNA) is in a circular molecule) (simple) i.e. bacteria.
   -Hypothesized that the first type of cells on earth were prokaryotic
2. Eukaryotic Cells: Cells with membrane bound organelles such as, the nucleus. (more complex) i.e. animal and plant and animal cells

3. Complete the Venn Diagram comparing prokaryotic and eukaryotic cells.
Directions: Write a P if the statement refers to Prokaryotes and an E if the statement refers to Eukaryotes, if the statement refers to both Prokaryotes and Eukaryotes write a B on the line.

___ 1. This type of cell does not have membrane bound organelles.
___ 2. This type of cell contains DNA.
___ 3. This type of cell contains organelles.
___ 4. A bacterium is an example of this type of cell.
___ 5. This type of cell contains a nucleus.

Cell Structures & Functions
All cells are enclosed by a cell membrane (plasma membrane). Within the membrane is the nucleus and the cytoplasm. Within the cytoplasm are organized structures that perform specific functions. These structures are called organelles.

Please Note: The letters next to the structure of the cell indicates where the structure if found

A = animal cells
P = plant cells.
AP = both plant and animal

(A, P) Cell Membrane- surrounds the cell. It plays an active role in determining which substances enter and exit the cell. Some substances can pass freely through the cell membrane and others cannot, the membrane is said to be selectively permeable, or semipermeable. The cell membrane is composed primarily of lipids (phospholipids), proteins, and carbohydrates.

(A, P) Nucleus- control center for all cell functions. Within the nucleus are chromosomes and at least one nucleolus. The nucleolus is a site of rRNA synthesis, and is responsible for the production of ribosomes.

(A, P) Cytoplasm- the material in the cell outside the nucleus. It consists mainly of water. Within the cytoplasm are the various organelles of the cell. The cytoplasm provides the environment in which the organelles carry on the life processes of the cell.

(A, P) Mitochondria- are found in the cytoplasm. Most stages of cellular respiration occur in the mitochondria. The energy released during respiration is stored in the form of high-energy chemical bonds in molecules of ATP.

(P)Chloroplasts (also called plastids)- contain green pigment called chlorophyll, which carries on the process of photosynthesis.

Mitochondria & Chloroplast- Developed from prokaryotic cells? WHAT?!
Check out this really good explanation...relating to endosymbiotic theory
http://www.youtube.com/watch?v=fAjev01mDZM

Related questions:

1. Why are mitochondria and chloroplasts unique?

2. What are two characteristics about mitochondria and chloroplast that make them similar to prokaryotic bacteria cells? In other words, what evidence do scientists cite that supports endosymbiotic theory?
**Ribosomes**- are small, dense granules (look like tiny circles on the diagrams) found free in the cytoplasm and on the rough endoplasmic reticulum. Ribosomes are composed mainly of RNA (rRNA). They are the centers of protein synthesis in the cell and consists of large and small subunits that join with mRNA and tRNA to make proteins from directions provided by ________ (a molecule contained in the nucleus).

**Endoplasmic reticulum**- is a membrane-bound system of channels or tubes through which materials are transported within the cell. The membranes of the ER may also serve as sites of biochemical reactions. There are two types smooth and rough. The rough appearance is due to the presence of ribosomes on the membrane.

Rough ER is found mainly in cells involved in protein synthesis. Smooth ER which has no ribosomes, is found mainly in cells involved in synthesis of nonprotein substances. The ER forms vesicles for transport of proteins to other areas within the cell or to the golgi apparatus.

**Golgi Apparatus**- is made up of a series of membrane-enclosed sacs, and it is usually found near the nucleus. This organelle is associated with the production of lysosomes and with the sorting and packaging of various cellular products. Produces transport vesicles (packages that move material inside or export material outside the cell)

EXAMINE THE DIAGRAM BELOW, EXPLAIN THE PATH A NEWLY FORMED POLYPEPTIDE LEAVING A RIBOSOME MAY TAKE AS IT IS MODIFIED OR PACKAGED BEFORE USE WITHIN THE CELL OR OUTSIDE THE CELL:

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**Lysosomes**- are “packages” or sacs, of digestive enzymes. They keep the enzymes separated from the rest of the cell contents until they are needed.

**Vacuoles**: are membrane-enclosed structures that are generally filled with water containing various dissolved substances. Vacuoles in animal cells are usually small, and vacuoles in plants are usually large. The pressure created by large water-filled vacuoles pushing against cell walls in plant cells helps to maintain the rigid structure of the plant.

**Centrioles**- are small organelles found just outside the nucleus in animal cells. Centrioles, assist with separating chromosomes during animal cell division.
(P) **Cell Wall** - structure found outside the cell membrane of plant cells. The cell wall is made up mostly of cellulose (polysaccharide), and it provides support for the cell.

**(A, P)** **Cytoskeleton** - is a filamentous network of proteins that are associated with the processes that maintain and change cell shape and produce cell movements in animal and bacteria cells. In plants, it is responsible for maintaining structures within the plant cell, rather than whole cell movement. **The main types of filaments** that make up the cytoskeleton are Microfilaments (threadlike proteins) and Microtubules (tubes made of protein).

3. Use the following structure letters to label the structures indicated in the eukaryotic plant and animal cells.

   A. Cell membrane
   B. Nucleus
   C. Nucleolus
   D. Chromosome
   E. Cell Wall
   AB. Centriole
   AC. Mitochondria
   AD. Lysosome
   AE. Endoplasmic reticulum
   BC. Golgi Apparatus
   BD. Vacuole
   BE. Chloroplast

4. Fill in the names of the structures whose functions are listed below. Use the list of structures above for help.

<table>
<thead>
<tr>
<th>Structure</th>
<th>Function</th>
</tr>
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<tbody>
<tr>
<td></td>
<td>Cellular Respiration</td>
</tr>
<tr>
<td></td>
<td>Protein Synthesis</td>
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<tr>
<td></td>
<td>Contains the hereditary information</td>
</tr>
<tr>
<td></td>
<td>Storage of water, undigested food, and/or waste</td>
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<td></td>
<td>Active in movement of the chromosomes during cell division</td>
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<td></td>
<td>Storage of digestive enzymes</td>
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<tr>
<td></td>
<td>Transport within the cytoplasm</td>
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<td></td>
<td>Packages secretions</td>
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**Phospholipid bilayer:**
The cell membrane is made of a lipid bilayer (two layers of phospholipids). Phospholipids have two parts, a polar head and a non-polar tail. Phospholipids are arranged with tails facing the interior of the membrane and polar heads facing out. The bilayer is flexible and if disturbed will reorient itself given the polar nature of the phospholipids.

> Watch this animation on the bilayer to see it in action. [Cell membrane model (fluid mosaic)]
Cellular Transport
The cell membrane is semipermeable, some substances can pass through it freely, while others cannot. The movement of substances that can pass freely through the membrane depends on the concentration gradient of the substance, size of the substance and polarity of the substance.

A. Passive Transport
- Does not use energy
- Moves from a high concentration to a low concentration

Examples:
- **Diffusion**: The movement of particles from regions of higher concentration to regions of lower concentration
- **Facilitated Diffusion**: Transport proteins help ions and polar molecules diffuse through the membrane
- **Osmosis**: The diffusion of water across a selectively permeable membrane.

Osmotic conditions:
- **Isotonic** – concentration of solute is the same on both sides of the membrane (equilibrium)
- **Hypertonic** – the solution with a greater concentration of solute
- **Hypotonic** – the solution with the lesser concentration of solute

B. Active Transport
- Requires energy (usually energy used is from ATP)
- Moves from a low concentration to a high concentration

Examples:
- **Protein Pumps**: an integral protein that transports ions and small molecules against their concentration gradients (ex. sodium potassium ion pump)
- **Endocytosis**: The movement of a large substance into a cell by means of a vesicle
- **Exocytosis**: The movement of material out of a cell by means of a vesicle

6. Circle the diagram letter that shows Endocytosis? A or B

7. Circle the diagram letter that shows Exocytosis? A or B

*Sodium-potassium pump*: One of the most important carrier proteins in animal cells. In nerve cells the pump is used to generate gradients of both sodium and potassium ions. These gradients are used to propagate electrical signals that travel along nerves.
Watch this cool animation on the sodium-potassium pump, and take the quiz! Record your answers to the questions below as you take the quiz.

http://highered.mcgraw-hill.com/sites/9834092339/student_view0/chapter38/sodium-potassium_exchange_pump.html

1. _____ 2. _____ 3. _____ 4. _____ 5. ____

More Questions!

8. What is passive transport?

9. The paramecium is a fresh water protozoan. The salt content of its cytoplasm is greater than that of the surrounding medium.
   a. Does water tend to enter or leave the paramecium? Is this process passive or active transport?
   b. How does the paramecium expel water? Is this process passive or active transport? Explain.

10. Where does the energy for active transport come from and why is energy required for active transport?

Practice Questions:

1. Using a microscope, a student observes a small, green organelle in a plant cell. Which energy transformation most likely occurs first within the observed organelle?
   a. ATP to light
   b. light to chemical
   c. heat to electrical
   d. chemical to chemical

2. Carbon dioxide and oxygen are molecules that can move freely across a plasma membrane. What determines the direction that carbon dioxide and oxygen molecules move?
   a. orientation of cholesterol in the plasma membrane
   b. concentration gradient across the plasma membrane
   c. configuration of phospholipids in the plasma membrane
   d. location of receptors on the surface of the plasma membrane

3. A sodium-potassium pump within a cell membrane requires energy to move sodium and potassium ions into or out of a cell. The movement of glucose into or out of a cell does not require energy. Which statement best describes the movement of these materials across a cell membrane?
   a. Sodium and potassium ions move by active transport, and glucose moves by osmosis.
   b. Sodium and potassium ions move by active transport, and glucose moves by facilitated diffusion.
   c. Sodium and potassium ions move by facilitated diffusion, and glucose moves by osmosis.
   d. Sodium and potassium ions move by facilitated diffusion, and glucose moves by active transport.
4. The rough endoplasmic reticulum and Golgi apparatus work together in eukaryotic cells. What is one way that the rough endoplasmic reticulum assists the Golgi apparatus?
   a. It assembles nucleic acids from monomers.
   b. It breaks down old, damaged macromolecules.
   c. It packages new protein molecules into vesicles.
   d. It determines which protein molecules to synthesize.

   In many eukaryotic cells, DNA stored in the nucleus is transcribed into messenger RNA. The mRNA is then transported into the cytoplasm where ribosomes assist in their translation into proteins. Finally, these proteins are packaged and sorted in the Golgi apparatus for use in other parts of the cell or in preparation for secretion into other cells.

5. Which of the following statements is supported by this description?
   a. Various organelles within a cell interact with each other to carry out life processes.
   b. Organelles within a cell act independently of each other at all times.
   c. Some organelles are more important than other organelles within a cell.
   d. Only up to three organelles may interact with each other at any given moment in time.

6. The cell membrane serves many functions. One of the cell membrane's functions is to help the cell maintain homeostasis. Which of the following statements best supports this claim?
   a. The cell membrane contains a polar region and a nonpolar region.
   b. The cell membrane contains proteins.
   c. The cell membrane contains phospholipids.
   d. The cell membrane regulates what goes in and out of the cell.

   In order for nerve cells and muscle cells to function properly, they require a high concentration of potassium ions inside the cells and a high concentration of sodium ions outside the cells. To maintain this condition, cells utilize sodium-potassium pumps embedded within their cellular membranes to move the ions against their concentration gradients.

7. Since sodium-potassium pumps require an input of energy to operate, they are an example of...
   a. passive transport.
   b. facilitated diffusion.
   c. filtration.
   d. active transport.
8. Most organisms can be divided into two categories - prokaryotes and eukaryotes. What is the main difference between these two categories?
   a. Eukaryotes are living organisms whereas prokaryotes include some nonliving matter.
   b. Prokaryotes do not possess any means of locomotion and are thus unable to move.
   c. Prokaryotes do not possess a nucleus or any other membrane-bound organelles.
   d. Eukaryotes are found in all of the six major taxonomic kingdoms.

When a person inhales, oxygen fills tiny air sacs in the person's lungs. Next, the oxygen moves from these air sacs into small blood vessels that line the lungs, and then it moves into the bloodstream so that it can be transported around the body. Oxygen moves by random molecular motion from the air sacs of the lungs to the blood vessels because the concentration of oxygen in the air sacs is higher than the concentration of oxygen in the blood vessels.

9. This movement of oxygen molecules from an area of higher concentration to an area of lower concentration is known as ________.
   a. diffusion
   b. osmosis
   c. respiration
   d. photosynthesis

10. Energy conversion within an animal cell would be severely limited by removal of the cell's
    a. lysosomes.
    b. plastids.
    c. chloroplasts.
    d. mitochondria.

11. Which do the cells of an E. coli bacterium and an elephant have in common?
    a. Ribosomes to assemble proteins
    b. Mitochondria to produce proteins
    c. Chloroplasts found around the vacuole
    d. Chromosomes located in the cytoplasm

12. A cell from which organism would most likely be the smallest?
    a. A sugar maple tree
    b. A five-spotted ladybug
    c. A Saccharomyces yeast
    d. A Lactobacillus bacterium

13. Which is not an example of passive transport?
    a. Carbon dioxide in a capillary crosses the alveoli membranes of the lungs.
    b. Oxygen dissolved in the blood crosses the phospholipid portion of the membrane of a red blood cell
    c. Glucose molecules are transported by a carrier protein until its concentration on both sides of the membrane is equal
    d. Sodium ions move through a protein channel until there is a higher concentration in extracellular fluid than the cytoplasm

14. What is one way that facilitated diffusion differs from simple diffusion?
    a. Facilitated diffusion requires energy input
    b. Facilitated diffusion requires membrane proteins
    c. Facilitated diffusion requires a concentration gradient
    d. Facilitated diffusion requires small, nonpolar molecules.
15. Which of the following is not involved in the transport of molecules by facilitated diffusion?
   a. ATP
   b. phospholipids
   c. protein channels
   d. concentration gradient

Open-ended Question:
16. Materials in cells may be transported by passive or active processes, both of which may involve concentration gradients, the phospholipid bilayer, and membrane proteins.

   **Part A:** Compare the role of concentration gradients in passive and active transport.
   ______________________________________________________________________________
   ______________________________________________________________________________
   ______________________________________________________________________________
   ______________________________________________________________________________

   **Part B:** Compare the role of the phospholipid bilayer in passive and active transport.
   ______________________________________________________________________________
   ______________________________________________________________________________
   ______________________________________________________________________________
   ______________________________________________________________________________

   **Part C:** compare the role of membrane proteins in passive and active transport.
   ______________________________________________________________________________
   ______________________________________________________________________________
   ______________________________________________________________________________
   ______________________________________________________________________________
Energy

Vocabulary
- photosynthesis
- cellular respiration
- electron transport chain
- fermentation
- thylakoid
- cristae
- matrix
- mitochondria
- anaerobic
- glycolysis
- stroma
- aerobic
- krebs cycle
- ATP
- stroma

Concepts to Know

What Does Life Need? ENERGY!!

It either supplies itself (AUTO-TROPH / self – feed) or it eats something (HETERO – TROPH / other – feed)

The Laws of Thermodynamics dictate that no energy can be created or destroyed, it can only change forms. Chemical bonds are literally energy. When you eat something, you get energy for movement or growth from the energy locked in the food’s bonds. The trick to life is how to store that energy until you need it. The short-term storage molecule that ALL life has evolved to use is adenosine triphosphate, or ATP.

Catabolic Pathways \(\rightarrow\) break down molecules so that Anabolic Pathways \(\rightarrow\) build up molecules

ATP IS THE GO BETWEEN

Look at the figure to the right with the batteries and flashlights.

What is this visual analogy trying to tell us about ATP?

How does a ADP become fully charged?

1st Idea: Cell Respiration

- The major way organisms harness energy.
- Large food molecules are taken in and ultimately the monosaccharide GLUCOSE is digested to capture its energy
- \(\text{C}_6\text{H}_{12}\text{O}_6 + 6\text{O}_2 \rightarrow 6\text{CO}_2 + 6\text{H}_2\text{O} + \text{energy}\)
- There are multiple steps to the breakdown of glucose so that not all of the energy is released at once
- The steps are different depending if oxygen (aerobic) is present or not (anaerobic)
- **Aerobic Respiration**: glycolysis → Krebs cycle → electron transport
- **Anaerobic Respiration**: glycolysis → fermentation
- Glycolysis occurs in the cytoplasm for prokaryotes and eukaryotes
- The Krebs Cycle and ETC occur in the mitochondria of eukaryotes

**Label the diagram with the following terms**: alchohol/lactic acid; Krebs Cycle, glucose, fermentation, glycolysis, ETC

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- It’s all about rearrangement
- Every line in the structure of glucose to the left is energy (a line = a bond)
- During glycolysis, glucose (6C) is broken in half so a little energy is released with that broken bond… it is put into making ADP into ATP
- Whenever a bond breaks in this process, an electron and a hydrogen need to be accounted for. A molecule NAD+ picks them up to form NADH
- This concept continues in the Kreb Cycle – which will eventually break all of the bonds of the original glucose molecule. The carbons will leave as CO2. The hydrogens and electrons were put into NADH.

- **The MOST important part of Cell Respiration is the electron transport chain.** All of the NADH that was formed so far drops off the electrons and the hydrogens at the inner membrane of the mitochondria (for eukaryotes). This membrane has proteins in it that pass the electrons to each other. Electrons are a different form of energy and can power the protein channels to open (this is active transport).

- The point of the electron transport chain is to pump hydrogen ions (also from the NADH) across the membrane into a tiny space.

- **WHY?** It seems silly, but almost all life does this process. By building a gradient of H+ ions in this tiny mitochondrial space, the H+ build up and need to diffuse out, through a special channel called ATP synthase (this is passive transport). This molecule literally spins as H+ goes through it and makes ATP from ADP.

- **What about the oxygen?** After passing the electron down the chain to make the gradient happen (which is known as chemiosmosis), the electron has to go somewhere. It would cause damage in your cell otherwise. Oxygen is there to pick it up and combine it with the hydrogens to make….WATER!
What do I need to know?

The overall equation: _____________________________________________________________

What organisms undergo cellular respiration? _____________________________________________

What are the 3 major steps of aerobic respiration? _________________________________________

What will happen when oxygen is not present? ___________________________________________

What is the purpose of cellular respiration? _______________________________________________

Where does cellular respiration and fermentation occur with a eukaryotic cell? ________________

2nd Idea: Photosynthesis

Where does the sugar come from in the first place that will get broken down in cellular respiration?!?!

- Occurs in photosynthetic autotrophs (plants, algae, some bacteria); in the chloroplast of eukaryotes
- Has 2 major steps: the light reaction and the Calvin cycle (light independent reaction)
- The Light Reaction generates ATP and NADPH (an electron and hydrogen carrier) so that the Calvin Cycle can run
- The Calvin Cycle is the part that makes the sugar. Carbon dioxide comes into a plant (via leaf stomata) and is joined together with other carbons in the cell to ultimately make glucose (6 carbons). Making bonds requires energy in this process, which is why ATP and some extra electrons and hydrogens are needed.
  - $6\text{CO}_2 + 6\text{H}_2\text{O} + \text{energy} \rightarrow \text{C}_6\text{H}_{12}\text{O}_6 + 6\text{O}_2$
  - The input of energy to start the light reaction is from sunlight!

What you need to know:

PLANTS PHOTOSYNTHESIZE AND DO CELL RESPIRATION!!!! They have chloroplasts AND mitochondria!

Plants need mitochondria to generate ATP from sugars they have created through photosynthesis.

Chloroplasts: contain chlorophyll and are found in leaves, they perform photosynthesis. Chlorophyll is a light capturing pigment. The light reaction mentioned above occurs in the thylakoids and the light independent reaction (Calvin cycle) occurs in the stroma of the chloroplast.
Major input and outputs of the process.

- Label the diagram below with the following: CO₂, O₂, Water, Glucose, sunlight
- Bonus: can you label where ATP/NADPH, ADP/NADP+, stroma, thylakoid, light reaction and Calvin Cycle would be?

Photosynthesis Reminders

<table>
<thead>
<tr>
<th>Light-Dependent Reactions</th>
<th>Light-Independent Reactions</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>WHAT</strong>→ photosynthetic reactions that require light.</td>
<td><strong>WHAT</strong>→ produces sugars by using the energy from ATP &amp; NADPH formed during light-dep rxn</td>
</tr>
<tr>
<td><strong>WHERE</strong>→ thylakoid (membrane &amp; inside)</td>
<td><strong>WHERE</strong>→ in the stroma of the chloroplast</td>
</tr>
<tr>
<td>“WHO”→ Photosystem II &amp; Photosystem I</td>
<td>“WHO”→ Rubisco; uses CO2 from outside &amp; existing carbon molecules in the cell (RuBP)</td>
</tr>
<tr>
<td>Various proteins embedded in the thylakoid membrane</td>
<td>WHEN → doesn’t depend on sun</td>
</tr>
<tr>
<td>WHEN → when the sunlight shines</td>
<td>WHY → plant needs to produce high-energy glucose molecules for growth</td>
</tr>
<tr>
<td>WHY → captures sunlight energy to produce ATP which will eventually be used to construct the glucose molecules.</td>
<td>HOW → uses the ATP &amp; NADPH create the new bonds of glucose</td>
</tr>
<tr>
<td>HOW → uses light &amp; water to produce oxygen and converts ADP to ATP and NADP+ to NADPH</td>
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</tbody>
</table>
Complimentary nature of photosynthesis and respiration:

**PHOTOSYNTHESIS**

\[
6\text{CO}_2 + 6\text{H}_2\text{O} \xrightarrow{\text{Light}} \text{C}_6\text{H}_{12}\text{O}_6 + 6\text{O}_2
\]

**RESPIRATION**

\[
\text{C}_6\text{H}_{12}\text{O}_6 + 6\text{O}_2 \rightarrow 6\text{CO}_2 + 6\text{H}_2\text{O} + \text{ATP}
\]

**Key Connections**

- Photosynthesis and respiration are about energy transformations. Notice the complimentary nature of both equations above. How are they connected? _______________________________________
- Photosynthesis **captures** energy from sunlight in the bonds of glucose, while respiration **releases** the energy from glucose in the form of ATP so cellular work can be completed.
- Autotrophs are always the basis of the food chain. As a human you cannot make your own sugars!
- The source of carbohydrates AND oxygen on the planet is photosynthesis

**COMPARISON QUESTIONS**

**Answer P for Photosynthesis, CR for Cell Respiration, or B for both**

- ______ Releases O\(_2\)  ______ Releases CO\(_2\)  ______ Uses CO\(_2\)
- ______ Creates ATP during the process  ______ Produces sugar  ______ Uses sugar

**Answer A for Animals, P for Plants, or B for both**

- ______ Releases O\(_2\)  ______ Releases CO\(_2\)  ______ Uses CO\(_2\)
- ______ Creates energy in the form of ATP  ______ Produces sugar  ______ Uses sugar
Practice Questions Bioenergetics:

1. Photosynthesis and cellular respiration are two major processes of carbon cycling in living organisms. Which statement correctly describes one similarity between photosynthesis and cellular respiration?
   a. Both occur in animal and plant cells.
   b. Both include reactions that transform energy.
   c. Both convert light energy into chemical energy.
   d. Both synthesize organic molecules as end products.

   The energy for life comes primarily from the Sun.

2. What process provides a vital connection between the Sun and the energy needs of living systems?
   a. decomposition
   b. cellular respiration
   c. transpiration
   d. photosynthesis

   The processes of photosynthesis and cellular respiration form a continuous cycle.

3. During this cycle, the products from one process serve as the starting materials for the other. Which of the following materials correspond(s) to box number 3?
   a. sunlight
   b. carbon dioxide and water
   c. ATP (energy) and heat
   d. oxygen and glucose
4. A protein in a cell membrane changed its shape to move sodium and potassium ions against their concentration gradients. Which molecule was most likely used by the protein as an energy source?
   a. ATP
   b. ADP
   c. catalase
   d. amylase

5. Which pair of molecules are broken down by the cell to release energy?
   a. ADP and glucose
   b. ATP and glucose
   c. ATP and carbon dioxide
   d. ADP and carbon dioxide

6. Which pair of compounds are raw materials for cellular respiration?
   a. Glucose and ATP
   b. Oxygen and glucose
   c. Carbon dioxide and ATP
   d. Carbon dioxide and oxygen

7. Which does not take place in the mitochondria of the cell?
   a. Carbon dioxide is produced
   b. Hydrogen ions cross a membrane
   c. Glucose is broken down into organic compounds
   d. The ATP synthase enzyme combines ADP and phosphate

8. In which organism does respiration not take place in the mitochondria?
   a. bacteria
   b. maple tree
   c. seaweed
   d. yeast

9. Which comparison between ATP and ADP is correct?
   a. ATP stores less chemical energy than ADP and phosphate
   b. ATP stores more chemical energy than ADP and phosphate
   c. Less energy is used to form ATP than is released from ATP hydrolysis
   d. More energy is used to form ATP than is released from ATP hydrolysis

10. Which is a difference between photosynthesis and cellular respiration?
    a. Photosynthesis can produce glucose without oxygen
    b. Photosynthesis occurs only in plants, and respiration occurs only in animals
    c. Cellular respiration stores energy, but photosynthesis releases energy
    d. Cellular respiration releases oxygen, but photosynthesis releases carbon dioxide

11. Which statement describes what occurs in the stroma of the chloroplast?
    a. Oxygen is released
    b. Carbon dioxide reacts
    c. Water molecules are split
    d. Chlorophyll absorbs energy
12. Which pair of compounds are both products of photosynthesis?
   a. Water and glucose
   b. Oxygen and glucose
   c. Glucose and carbon dioxide
   d. Oxygen and carbon dioxide

13. Which of the following best explains the relationship between photosynthesis and cellular respiration?
   a. Both produce carbon dioxide and oxygen
   b. Both require energy from sunlight to occur
   c. The products of one are the reactants of the other
   d. A plant can carry out either one process or the other

Open-ended Question:
14. The law of conservation of energy states that energy cannot be created or destroyed. It can only change in form and move from place to place. An ATP molecule in an animal cell is used for energy.

   **Part A:** Explain how the energy reached the ATP molecule from its original source.
   ________________________________________________________________
   ________________________________________________________________
   ________________________________________________________________
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   **Part B:** Describe how energy changed in form from its original source to the ATP molecule.
   ________________________________________________________________
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   **Part C:** Explain how the energy changes when the ATP molecule is converted to ADP and phosphate.
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