Matter and Energy Flow
(Organisms to Ecosystems)
Unit Overview Sheets

Ecosystems Vocabulary

Habitat	ATP	Energy Flow	Niche	Ecology
Food Chain	Food Web	Energy Pyramid	Trophic Level	Producer
Herbivore	Carnivore	Omnivore	Predation	Autotroph
Heterotroph	Decomposer	10% Rule	Primary Producer	Biomass
Photosynthesis	Cellular Respiration	Aerobic Respiration	Anaerobic Respiration	Fermentation
Consumers	Glycolysis	Krebs Cycle	Electron Transport Chain	Mitochondria
Cytoplasm	Chloroplast	Thylakoids	Lactic Acid	NAD and $FADH_2$
Pyruvate	Glucose	Oxygen	Mitochondria	Nitrogen Fixing Bacteria
Carbon Cycle	Water Cycle	Nitrogen Cycle	Evaporation	Precipitation

BIG IDEA #1: **a. What is the Ultimate Source of Energy?** **b. How is energy from the sun converted to usable energy within plants? (Photosynthesis)**	**1**	**2**	**3**	**4**

BACKGROUND:
The ultimate source of energy is **The Sun. Autotrophs**, also known as **Producers** or **Plants**, have structures in their leaves called **chloroplasts** that are able to absorb the sun's ultraviolet waves. Chloroplasts have disc shaped structures called **Thylakoids** inside of them that are able to absorb sunlight, break down water and transport electrons which are eventually converted into glucose. (Inside a chloroplast, a stack of thylakoids are known as a **granum** and the fluid that fills the chloroplast is called **Stroma.**) Electrons from the broken-down water get transported on a molecule called **NADPH** which is a specialized electron carrier used inside of chloroplasts. Big picture, **Photosynthesis** is the process of chloroplasts and thylakoids using water and sunlight to make oxygen and **Glucose** ($C_6H_{12}O_6$). Photosynthesis happens in two stages, first the **Light Dependent Reactions** and then the **Light Independent Reactions** otherwise known as the **Calvin Cycle**. The overall equation for photosynthesis is $6CO_2 + 6H_2O$ + sunlight → $C_6H_{12}O_6 + 6O_2$ where glucose and oxygen are the waste products that are released into the atmosphere and ecosystem for animals or **consumers** to use.

1. What is the ultimate source of energy on earth?
2. What is a producer?
3. What does it mean to be an autotroph?
4. What is the chemical formula for glucose?
5. Where inside a plant cell is sunlight converted to glucose?
6. Describe a thylakoid.
7. Describe the relationship between a chloroplast and a thylakoid.
8. What do the letters ATP and ADP stand for?
9. What is ATP?
10. Write the equation for photosynthesis:

11. What are the role of electrons in photosynthesis?
12. What is NADPH?
13. How do autotrophs get the water that they need for photosynthesis?
14. How do autotrophs get the CO_2 needed for photosynthesis?
15. What is a stomata and how does it help the plant stay hydrated?
16. What are the two phases of photosynthesis called?

17. Autotrophs break water down at the beginning of photosynthesis. What happens to the electrons from the water and what happens to the O_2 from the water?
18. What are the reactants of photosynthesis?
19. What are the waste products of photosynthesis?
20. What are two things that affect the rate at which photosynthesis happens?
21. Write the overall equation for photosynthesis below.

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Concepts I Need To Work On:

BIG IDEA #2: a. What is the process of consumers taking in glucose and converting it to ATP? b. What are the steps of cellular respiration and how do consumers convert glucose to ATP?	**1**	**2**	**3**	**4**

BACKGROUND:

Cellular Respiration is a series of chemical reactions in which glucose is converted into usable cellular energy called **ATP**. ATP is a molecule that consists of one adenine molecule with three phosphates attached. Within cells, ATP is similar to a fully charged battery and ADP, adenine diphosphate, is like a dead battery where there are only two phosphates attached to the adenine instead of three. The equation for cellular respiration is the complete opposite of photosynthesis: $C_6H_{12}O_6 + 6O_2 \rightarrow 6CO_2 + 6H_2O$ + ATP where carbon dioxide is the waste product. Cellular respiration can be grouped into three stages: **Glycolysis,** which occurs in the cytoplasm, is the first stage where a single molecule of glucose is broken down into 2 pyruvic acids, 4 ATP molecules and some electrons. The pyruvic acid, 2 ATP molecules and electrons produced in glycolysis are then moved into the second stage of cellular respiration called the **Krebs Cycle**. The electrons produced must be transported throughout the cell on electron transporters called **NAD+** and **$FADH_2$**. The final stage of cellular respiration is the **Electron Transport Chain (ETC)** where the electrons are converted to ATP using an enzyme called **ATP synthase**. Both the Krebs cycle and the ETC occur in the mitochondria of the cell, which is why the mitochondria is known as the powerhouse of the cell. The net gain of ATP molecules at the end of cellular respiration, is somewhere between 34 and 38 ATP molecules with carbon dioxide being given off as a waste product.

All of the above happens only if there is oxygen present and is known as **Aerobic Respiration**. **Anaerobic Respiration** is a similar process where glucose is broken down into ATP when there is no oxygen available. This process that occurs without oxygen is sometimes referred to as **Fermentation**. During fermentation, we start with a molecule of glucose and break it down in the cytoplasm of a cell through the process of glycolysis. But instead of the pyruvic acid and ATP that were produced moving into the mitochondria, they stay in the cytoplasm and are used for energy. If this process happens in animals, we call it **Lactic Acid Fermentation** where lactic acid is a waste product and if we use yeast or bacteria, we call it **Alcoholic Fermentation** because the waste products are ethyl alcohol and carbon dioxide. We have learned to use alcoholic fermentation to bake with and to make wine and beer.

1. What is the equation for cellular respiration?
2. What is the chemical formula for glucose?
3. What are the products of cellular respiration?
4. What is the word that means the break-down of glucose?
5. What are the three stages of cellular respiration?
6. Where inside the cell does glycolysis occur?
7. What are the two products released from glucoses after glycolysis?
8. What are the two electron carriers used in cellular respiration?
9. Where in the cell does the Krebs Cycle and the ETC occur?
10. What are the names of the three processes that occur in the cytoplasm during cellular respiration?
11. How many ATP are produced after glycolysis?
12. How many ATP are produced at the end of cellular respiration?
13. What is the name of the enzyme that converts electrons to ATP?

14. When cellular respiration occurs with oxygen present, it is called what?
15. When cellular respiration occurs without oxygen present, it is called what?
16. When animals go through fermentation, what is it called?
17. When yeast go through fermentation, what do they produce?

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Concepts I Need To Work On:

BIG IDEA #3: a. **How does the energy that is produced during photosynthesis and cellular respiration move throughout an ecosystem?** b. **Why are there more producers than consumers on the earth and what does this have to do with the transfer of energy from organism to organism?**	**1**	**2**	**3**	**4**

BACKGROUND:

As we have already learned, **Autotrophs** are organisms that are able to convert the energy from the sun into usable energy in the form of ATP and glucose. That ATP and glucose made by producers is then transferred throughout the ecosystem from autotrophs to **Heterotrophs,** which are organisms that must consume other organisms for their energy. Energy enters our ecosystem in the form of sunlight, autotrophs then convert that sunlight into usable energy through photosynthesis, and that energy is then passed on to consumers when they eat the producers.

Food chains and food webs are diagrams that represent feeding relationships. They show who eats whom. In this way, they model how energy and matter move through ecosystems. A **food chain** represents a single pathway through which energy and matter flow through an ecosystem. Food chains are generally simpler than what really happens in nature. Most organisms consume – and are consumed by – more than one species. A **food web** represents multiple pathways through which energy and matter flow through an ecosystem. It includes many intersecting food chains. It demonstrates that most organisms eat, and are eaten, by more than one species. The feeding position in a food chain or web are called **Trophic Levels**. All food chains and webs have at least two or three trophic levels. Generally, there are a maximum of four trophic levels.

Energy is passed up a food chain or web from lower to higher trophic levels. However, only about 10% of the energy at one level is available to the next level. What happens to the other 90% of energy? It is used for metabolic processes or given off to the environment as heat. This loss of energy explains why there are rarely more than four trophic levels in a food chain or web. Sometimes there may be a fifth trophic level, but usually there's not enough energy left to support any additional levels.

With less energy at higher trophic levels, there are usually fewer organisms as well. Organisms tend to be larger in size at higher trophic levels, but their smaller numbers results in less biomass. **Biomass** is the total mass of organisms at a trophic level.

When organisms die, they leave behind energy and matter in their remains. **Decomposers** break down the remains and other wastes and release simple inorganic molecules back into the environment. Producers can then use the molecules to make new organic compounds.

1. What is the difference between an autotroph and a heterotroph?
2. Give two examples of producers.
3. What does an herbivore eat?
4. What does a carnivore eat?
5. What does an omnivore eat?
6. How are food chains, food webs different from each other?
7. How is an energy pyramid different than a food chain or web?
8. What is the difference between a primary consumer and a secondary consumer?
9. What does a trophic level show?
10. What is generally the maximum number of trophic levels in an ecosystem?
11. Which level of an energy pyramid has the most biomass and why?

12. What is the 10% Rule and how does it relate to an energy pyramid and trophic levels?
13. What is a decomposer and which level of an energy pyramid would you find them?
14. Give an example of an organism that you would find on the third trophic level.
15. Draw a simple food chain in the space below.

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Concepts I Need To Work On:

BIG IDEA #4: **a.** What elements and compounds cycle within an ecosystem? **b.** What are the steps of each of the matter cycles?	**1**	**2**	**3**	**4**

BACKGROUND:

The chemical elements and water that are needed by organisms for all life processes, continuously recycle in ecosystems. These elements pass through biotic and abiotic components of the biosphere. That's why their cycles are called **Biogeochemical Cycles**.

Water on Earth is billions of years old. However, individual water molecules keep moving through the water cycle. The **Water Cycle** is a global cycle. It takes place on, above, and below Earth's surface. During the water cycle, water occurs in three different states: gas (water vapor), liquid (water), and solid (ice). Many processes are involved as water changes state in the water cycle. Water moves through the biosphere through evaporation, sublimation, transpiration, precipitation and condensation.

Flowing water can slowly dissolve carbon in sedimentary rock. Most of this carbon ends up in the ocean. The deep ocean can store carbon for thousands of years or more. Sedimentary rock and the ocean are major reservoirs of stored carbon. Carbon is also stored for varying lengths of time in the atmosphere, in living organisms and as fossil fuel deposits. These are all parts of the **Carbon Cycle.** Carbon cycles quickly between organisms and the atmosphere. Cellular respiration releases carbon into the atmosphere as carbon dioxide. Carbon is also released when animals decompose. Human actions, such as the burning of fossil fuels, also release carbon into the atmosphere. Photosynthesis removes carbon dioxide from the atmosphere and uses it to make organic compounds.

Nitrogen makes up 78% of Earth's atmosphere. It's also an important part of living things. Nitrogen is found in proteins, nucleic acids and chlorophyll. The **Nitrogen Cycle** moves nitrogen through abiotic and biotic parts of the ecosystem. Plants cannot use nitrogen gas from the air to make organic compounds for themselves and other organisms. The nitrogen gas must be changed to a form called nitrates which plants can absorb through their roots. The process of changing nitrogen gas to nitrates is called **Nitrogen Fixation**. It is carried out by nitrogen-fixing bacteria. The bacteria live in soil and roots of legumes, such as peas.

1. What does the term Biogeochemical cycles mean?
2. How long has water been on the earth?
3. The water cycle tracks water through an ecosystem, in the space below define the following terms:
    a. Precipitation
    b. Condensation
    c. Evaporation
    d. Transpiration
    e. Sublimation
    f. Ground Water
    g. Run-off
4. What is the relationship between the water cycle and the carbon cycle?
5. List three places that carbon can be stored on earth.
6. List 2 ways that carbon can be released into the atmosphere.
7. What is the relationship between the carbon cycle and photosynthesis?

8. What is the relationship between the carbon cycle and cellular respiration?
9. How much of our atmosphere is made up of nitrogen?
10. Why does nitrogen fixation need to occur?
11. How do animals get their nitrogen?
12. How is animal nitrogen released back into the environment?

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Concepts I Need To Work On:

Wyoming State Science Standards

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

HS-LS1-7. Use a model to illustrate that cellular respiration is a chemical process whereby the bonds of sugar molecules are broken and the bonds in new compounds are formed resulting in a net transfer of energy.

HS-LS2-3. Construct an explanation based on evidence for the cycling of matter and flow of energy in aerobic and anaerobic conditions and revise as needed.

HS-LS2-4. Use mathematical representations to support claims for the cycling of matter and flow of energy among organisms in an ecosystem.