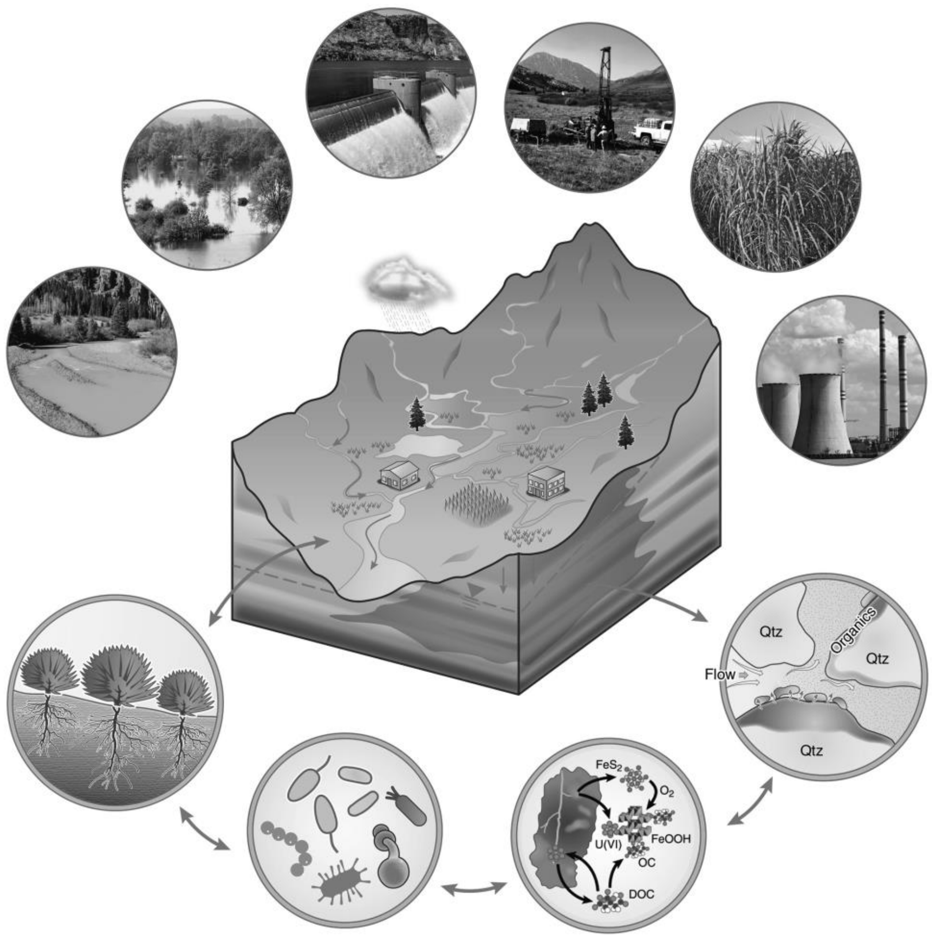
Summer Enrichment Packet for Rising Biogeochemical Systems Students



PRINCE GEORGE'S COUNTY PUBLIC SCHOOLS
Division of Academics
Department of Curriculum and Instruction

<u>Note to Students</u>:

You have learned so much in school this year! It is important that you continue to engage in science content and practices over the summer to help prepare you for our Biogeochemical Systems course next school year. In this packet, you will find weekly activities for the Summer Break.

Student Directions: The calendars provided are snapshots of the activities and assignments. Some of the assignments are to be completed entirely in your science journal, while for other assignments there are detailed information and directions provided on subsequent pages in this packet. Use the calendars to pace out the tasks. As a suggestion, you may wish to check off each assignment as it is completed. You should begin working on the activities the following Monday after school closes.

Science Journal: You will need your Evidence Notebook to record brief constructed responses, extended responses, exploration ideas, flowcharts, and diagrams, etc. If you do not have your Evidence Notebook, then you will need to create a science journal to record your information.

- Create a science journal by stapling several pieces of paper together or use a notebook or binder with paper.

- Each journal entry should:
    - Have the title of the activity.
    - Have a clear and complete answer (to each question) that explains your thinking.
    - Be neat and organized.

June Activities			
<u>Week One:</u> **Thinking Like A Scientist**	**Day 1** Claim, Evidence, and Reasoning (C-E-R Framework)	**Days 2 and 3** Controls and Variables	**Days 4 and 5** Experimental Design
<u>Week Two:</u> **Science and Engineering Practices** **(Analyzing Data)**	**Days 1 and 2** Analyzing Data: Plant Growth	**Days 3, 4, and 5** Analyzing Data: Graphing ☐ Line Graph ☐ Bar Graph ☐ Circle Graph/Pie Chart	

July Activities			
<u>Week Three:</u> **Cell Processes**	**Days 1 and 2** Photosynthesis	**Day 3** Respiration	**Days 4 and 5** The processes of photosynthesis and respiration include multiple steps. In your science journal, create models to describe/detail each of these processes.
<u>Week Four:</u> **Modeling Matter and Energy in Ecosystems (Part I)**	**Days 1 and 2** Food Chains and Webs	**Day 3** Tropic Levels	**Days 4 and 5** 10% Rule
<u>Week Five:</u> **Modeling Matter and Energy in Ecosystems (Part II)**	**Days 1 and 2** Make a model that demonstrates the relationship between biomass and energy in an ecosystem (science journal).	**Days 3 and 4** In your science journal, compare/contrast the different ways to model energy and matter flow in an ecosystem.	**Day 5** If you were a scientist studying an ecosystem, explain how you would use each type of pyramid and what information you could gain from each one. (science journal)
<u>Week Six:</u> **Cycling of Matter and Energy in Ecosystems**	**Days 1 and 2** The Water Cycle	**Days 3, 4, and 5** **Biogeochemical Cycles** ☐ Carbon (model of the carbon cycle's role in photosynthesis and respiration) ☐ Nitrogen (scientific explanation) ☐ Phosphorus (animals and the phosphorus cycle)	

August Activities	
<u>Week Seven:</u> **Matter and Energy in Living Systems**	**Performance Task: Analyzing Water Pollution**

Week 1 – Focus: Thinking Like A Scientist

Claims, Evidence, and Reasoning (C-E-R)

Directions: Use the data table below to complete the C-E-R template in your science journal.

	Density	Color	Mass	Melting Point
Liquid W	0.93 g/cm^3	No color	16 g	-98 °C
Liquid X	13.6 g/cm^3	Silver	21 g	-39 °C
Liquid Y	0.79 g/cm^3	No color	38 g	26 °C
Liquid Z	0.93 g/cm^3	No color	38 g	-98 °C

Question: Are any of the liquids in the table the same substance?	
C (Claim) Write a statement that responds to the question.	
E (Evidence) Provide at least three pieces of scientific data to support your claim. Your evidence should be appropriate (relevant) and sufficient enough to convince someone that your claim is correct. This can be bullet points instead of sentences.	
R (Reasoning) Use scientific principles and knowledge that you have about the topic to explain why your evidence (data) supports your claim. (paragraph form)	

Controls and Variables

Directions: Read the description for each experiment and answer the following questions in your science journal.

1. Shower Power

Jackie notices that his shower is covered in a strange brown slime. His friend tells him that coconut juice will get rid of the brown slime. Jackie decides to check this out by spraying half of the shower with coconut juice. He sprays the other half of the shower with water. After 3 days of "treatment" there is no change in the appearance of the brown slime on either side of the shower.

A. What is the initial observation?
B. Identify the control group, independent variable, and dependent variable.
C. What should Jackie's conclusion be?

2. Go, Go Juice

Courtney thinks that a special juice will increase the productivity of workers. She creates two groups of 20 workers each and assigns each group the same task (in this case, they're supposed to staple a set of papers). Group A is given the special juice to drink while they work. Group B is not given the special juice. After an hour, Courtney counts how many stacks of papers each group has made. Group A made 1,587 stacks, Group B made 2,113 stacks.

A. Identify the control group, independent variable, and dependent variable.
B. What should Courtney's conclusion be?
C. How could this experiment be improved?

3. Itching for a Scratch

Lou was told that a certain itching powder was the newest best thing on the market; it even claims to cause 50% longer lasting itches. Interested in this product, he buys the itching powder and compares it to his usual product. One test subject (A) is sprinkled with the original itching powder, and another test subject (B) was sprinkled with the experimental itching powder. Subject A reported having itches for 30 minutes. Subject B reported to have itches for 45 minutes.

A. Identify the control group, independent variable, and dependent variable.
B. Explain whether the data supports the advertisements claims about its product.

4. Diva Curls

Judy is working on a science project. Her task is to answer the question: "Does *Diva Curls* (which is a commercial hair product) affect the speed of hair growth?" Her family is willing to volunteer for the experiment.

Describe how Lisa would perform this experiment. Identify the control group, and the independent and dependent variables in your description.

Experimental Design

Directions: Read the description for each experiment and use your knowledge of scientific processes to respond to the following questions or scenarios in your science journal.

1. Danita believed that she could improve her brainpower by eating Super Craniums Snacks. In order to test this hypothesis, she recruited several friends to help her with an experiment. They each ate one snack with every meal daily for three weeks. Each of them took a test before they started eating the snacks, as well as after three weeks.

Participant	Test Results	
	Before Eating Super Cranium Snacks	After Eating Super Cranium Snacks for Three Weeks
Danita	64%	80%
Kurt	78%	78%
Jenine	82%	84%
Ashok	72%	70%

Based on the data provided in the table above, do the Super Cranium Snacks work? Explain your answer.

2. Flower Power

Apollo loves to garden and wants to grow lots of white flowers for his friend Aphrodite. He bought a special Flower Power fertilizer to see if it will help plants produce more flowers. He plants two plants of the same size in separate containers with the same amount of potting soil. He places one plant in a sunny window and waters it every day with fertilized water. He places the other plant on a shelf in a closet and waters it with plain water every other day.

A. What (if anything) did Mendel do wrong in this experiment? Explain your answer.
B. What should Mendel do to test the effectiveness of Flower Power fertilizer? Write an experiment.

3. Microwave Mania

Minerva believes that fish that eat food exposed to microwaves will become smarter and would be able to swim through a maze faster. She decides to perform an experiment by placing fish food in a microwave for 20 seconds. She has the fish swim through a maze and records the time it takes for each one to make it to the end. She feeds the special food to 10 fish and gives regular food to 10 others. After one week, she has the fish swim through the maze again and records the times for each.

A. What was Anna's hypothesis?
B. Which fish are in the control group?
C. What is the independent variable? What is the dependent variable?
D. Look at the results in the charts. What should Minerva's conclusion be?

Special Food Group (Time in minutes/seconds)			Regular Food Group (Time in minutes/seconds)		
Fish	Before	After	Fish	Before	After
1	1:06	1:00	1	1:09	1:08
2	1:54	1:20	2	1:45	1:30
3	2:04	1:57	3	2:00	2:05
4	2:15	2:20	4	1:30	1:23
5	1:27	1:20	5	1:28	1:24
6	1:45	1:40	6	2:09	2:00
7	1:00	1:15	7	1:25	1:19
8	1:28	1:26	8	1:00	1:15
9	1:09	1:00	9	2:04	1:57
10	2:00	1:43	10	1:34	1:30

4. Blowing Bubbles

Zeus loves bubble gum and would like to be able to blow bigger bubbles than anyone else in the county. To prepare for the PGCPS Big Bubble Contest, he bought four different brands of bubble gum and needs your help to find the brand that creates the biggest bubbles.

Write an experiment to test the bubble power of the bubble gum brands and help Zeus win the contest.

Week 2 – Focus: Science and Engineering Practices

Analyzing Data: Plant Growth

Experiment: Janna wants to determine the effect that amount of sunlight exposure and amount of water has on the growth of plants. She altered both variables for her experimental plants, and measured the growth of each over the course of three weeks.

1. **Hypothesis**: Using an "if … then …" statement, write a hypothesis (prediction) of how you think light exposure and water will affect plant growth.

Directions: Examine the date found in Table 1 and answer questions #2-5.

Table 1: Growth of eight plants in a three-week period

	Amount of Light per day	Amount of Water per day	Height Week 1 in cm	Height Week 2 in cm	Height Week 3 in cm
Plant 1	0 hours	¼ cup	0 cm	0 cm	0 cm
Plant 2	0 hours	1 cup	0 cm	0 cm	0 cm
Plant 3	4 hours	¼ cup	1 cm	3 cm	6 cm
Plant 4	4 hours	1 cup	0.5 cm	1 cm	1.5 cm
Plant 5	8 hours	¼ cup	1.5 cm	4 cm	8 cm
Plant 6	8 hours	1 cup	1 cm	3 cm	6 cm
Plant 7	16 hours	¼ cup	1 cm	2 cm	3 cm
Plant 8	16 hours	1 cup	1.5 cm	5 cm	10 cm

2. In this plant growth experiment, what were the two variables tested?

3. What conclusions can you draw in regards to the amount of light a plant was exposed to and how tall the plant grew? Reference the data to explain your answer!

4. What conclusions can you draw in regards to the amount of water given to a plant and how tall the plant grew? Reference the data to explain your answer!

5. What was your original hypothesis? Was it confirmed or disconfirmed by the data? Explain.

Analyzing Data: Line Graph

Predator-Prey Interactions: A survey was taken in the 19th century of lynx and snowshoe hare in part of the Ontario province of Canada. The data was based on the number of skins taken from animals caught by trappers. Snowshoe hare are the main prey of the Canadian lynx. Very few other predators compete with the lynx for the hares.

In every experiment, there is an independent variable that the researcher is manipulating. The dependent variable is the one that is measured as a result of changes to the independent variable. Of Note: When something is measured over a given time period, time is considered to be the independent variable.

Year	Population of Snowshoe Hare (in thousands)	Population of Lynx (in hundreds)
1845	20	32
1847	20	50
1849	52	12
1851	83	10
1853	64	13
1855	68	36
1857	83	15
1859	12	12
1861	36	6
1863	150	6
1865	110	65
1867	60	70
1869	7	40
1871	10	9
1873	70	20
1875	100	34
1877	92	45
1879	70	40
1881	10	15
1883	11	15
1885	137	60
1887	137	80
1889	18	26
1891	22	18
1893	52	37
1895	83	50
1897	18	35
1899	10	12

Before you graph the results, **hypothesize** about what you believe the relationship will be between the snowshoe hare and Canadian lynx populations.

In your science journal, make a line graph showing the change in snowshoe hare and lynx populations over the given time period. Remember each of the following rules in making a properly formatted graph:

- Independent variables are graphed on the x-axis, while dependent variables are graphed on the y-axis.
- Both the x- and y-axis should have labels indicating what measurement is shown and the units used in that measurement, if applicable.
- An appropriate scale should be chosen that makes the graph small enough to confine to a single page, but large enough to show the differences between the points on the graph.

After completing your graph, answer the following questions.

1. Based on the graph you completed above, do the results support your hypothesis, or should it be rejected? Explain.
2. Why are line graphs a good option when displaying data over time?

Analyzing Data: Bar Graph

Fatality Rates with Snake Bites- Data was collected on all recorded cases of bites from each of these different species of venomous snakes. The death rate percentage was calculated for each snake.

Type of Snake	Death Rate (%)
Black Mamba	75
Bushmaster	80
Copperhead	1
Eastern coral snake	15
European viper	5
Asp Viper	20
Indian krait	77
King cobra	33
Death adder	50
Tiger Snake	60

The purpose of this study is to compare different types of venomous snakes. In this case, a bar graph would be the most appropriate type to use. In your science journal, make a bar graph of the venomous snake death rate data.

1. Which snake is the deadliest, according to this data?
2. Why are bar graphs a good option for displaying data that is for comparison?

Analyzing Data: Circle Graph/Pie Chart

Elements of the Human Body- The human body contains a consistent mix of only handful of the known elements. The chart below represents the percentage by mass of each of these elements. Note: Trace elements that account for less than 0.1% of the human body mass have been excluded from this data.

Element	Percent by Mass	Element	Percent by Mass
Oxygen	65	Phosphorus	1.0
Carbon	18	Potassium	0.4
Hydrogen	10	Sulfur	0.3
Nitrogen	3	Sodium	0.2
Calcium	1.5	Magnesium	0.1

Data like this that adds up to a full 100% can be conveniently displayed using a circle graph or pie chart. To make one of these charts, start with a circle and create a segment for the largest percentage first. Then, begin making smaller segments to account for each of the other data points. Label each portion of the pie chart.

Explain: Why are pie charts a good way to display data that adds up to 100%?

Week 3 – Focus: Cell Processes

Photosynthesis

Directions: Read the passage and annotate the text. In your science journal, complete the questions that follow.

All living things need energy, which is defined as the ability to do work. You can often see energy at work in living things —a bird flies through the air, a firefly glows in the dark, a dog wags its tail. These are obvious ways that living things use energy, but living things constantly use energy in less obvious ways as well.

Why Living Things Need Energy
Inside every cell of all living things, energy is needed to carry out life processes. Energy is required to break down and build up molecules and to transport molecules across plasma membranes. All life's work needs energy. A lot of energy is also simply lost to the environment as heat. The story of life is a story of energy flow —its capture, its change of form, its use for work, and its loss as heat. Energy, unlike matter, cannot be recycled, so organisms require a constant input of energy. Life runs on chemical energy.

How Organisms Get Energy: Autotrophs and Heterotrophs
The chemical energy that organisms need comes from food. Food consists of organic molecules that store energy in their chemical bonds. In terms of obtaining food for energy, there are two types of organisms: autotrophs and heterotrophs. Autotrophs are organisms that make their own food. Most autotrophs use the energy in sunlight to make food in a process called photosynthesis. Only three types of organisms —plants, algae, and some bacteria —can make food through photosynthesis. Autotrophs are also called producers. They produce food not only for themselves but for all other living things as well (which are known as consumers). This is why autotrophs form the basis of food chains. Heterotrophs are living things that cannot make their own food. Instead, they get their food by consuming other organisms, which is why they are also called consumers. They may consume autotrophs or other heterotrophs. Heterotrophs include all animals and fungi and many single-celled organisms.

1. What is energy? Give an example of how energy is used in a living organism.

2. Distinguish between autotrophs and heterotrophs.

3. Determine if the following are autotrophs or heterotrophs: (A) a giant redwood tree, (B) a spider, (C) a rose bush, (D) a mushroom, (E) a blue whale.

4. How is energy used in a cell?

5. Why are autotrophs considered the basis of food chains?

Respiration

During cellular respiration, the breakdown of glucose and other carbon-based molecules in cells releases energy stored in their chemical bonds. The stored energy is transferred to ATP, which we can think of as the cell's "energy currency." Energy in the form of heat is also released in the process. The release of energy as heat accounts for why the body temperatures of mammals range from 36 °C to 39 °C (97 °F–103 °F).

Cellular respiration is an aerobic process, which means that it requires oxygen to take place. Some organisms can produce small amounts of ATP through anaerobic processes, or processes that do not require oxygen. However, the presence of oxygen allows cellular respiration to produce far more ATP from each glucose molecule.

Cellular respiration takes place inside an organelle called the **mitochondrion** (plural *mitochondria*). Mitochondria release the chemical energy required to make ATP. Both plant and animal cells contain mitochondria, because both plants and animals carry out cellular respiration.

1. The balanced chemical equation for cellular respiration is below. In your science journal, explain how this equation represents the law of conservation of matter—that matter cannot be created or destroyed?

$$C_6H_{12}O_6 + 6O_2 \rightarrow 6CO_2 + 6H_2O + \text{heat} + \text{ATP}$$

Directions: Fill in the blanks in the table below. Then answer the questions that follow in the spaces provided.

Raw Materials	Products
2.	4.
3.	5.
	6.

7. What process in the mitochondrion provides the electron transport chain in cellular respiration with the energy it needs to function?

A. Glycolysis

B. Chlorophyll

C. Krebs cycle

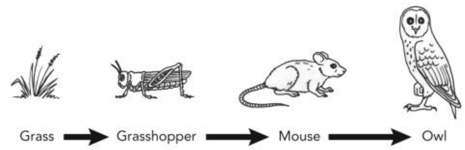
D. ATP synthase

8. The relationship between photosynthesis and cellular respiration is usually described as a cycle. In your science journal, describe this cycle.

Weeks 4 and 5 – Focus: Modeling Matter and Energy in Ecosystems

Food Chains

Feeding relationships are a major component of the structure and dynamics of an ecosystem. Food chains and food webs are useful ways to model the complex structure of an ecosystem to better understand how energy is transferred between organisms. The simplest way to look at the transfer of food energy in an ecosystem is through a food chain.



A food chain is a sequence that links species by their feeding relationships. This simple model follows the connection between one producer and a single chain of consumers within an ecosystem.

Not all consumers are alike. Herbivores, such as desert cottontails, are organisms that eat only plants. Carnivores are organisms that eat only animals. Western diamondback rattlesnakes are carnivores that eat desert cottontails. Omnivores are organisms that eat both plants and animals. In a desert ecosystem, kangaroo rats are omnivores that eat both seeds and insects. Detritivores are organisms that eat detritus, or dead organic matter. Earthworms are detritivores that feed on decaying organic matter in soil.

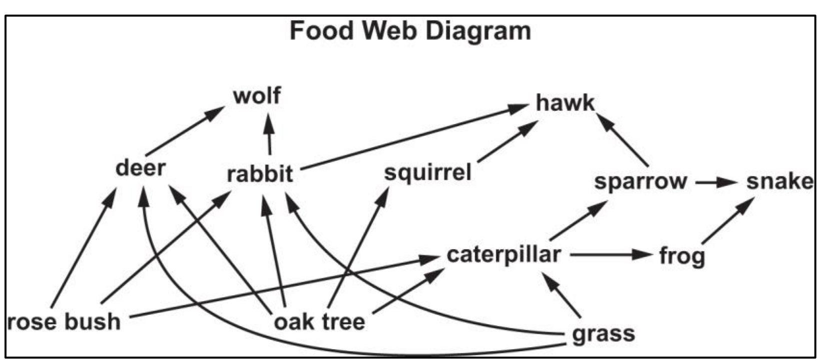
Decomposers are organisms that break down organic matter into simpler compounds. These organisms include fungi, certain microbes in the soil, and earthworms. Decomposers are important to the stability of an ecosystem because they return vital nutrients back into the environment for other organisms to use.

1. Model: In your science journal, draw a food chain that includes organisms in the area where you live. Identify the producers and consumers, and describe the flow of energy in the food chain.
2. What might happen in an ecosystem if all of the decomposers were suddenly removed?

Food Web

A **food web** models the complex network of feeding relationships between trophic levels within an ecosystem. A food web represents the flow of energy within and sometimes beyond the ecosystem. The stability of any food web depends on the presence of producers, as they form the base of the food web. In the case of a marine ecosystem such as a coral reef, algae and phytoplankton are two of the producers that play this important role.

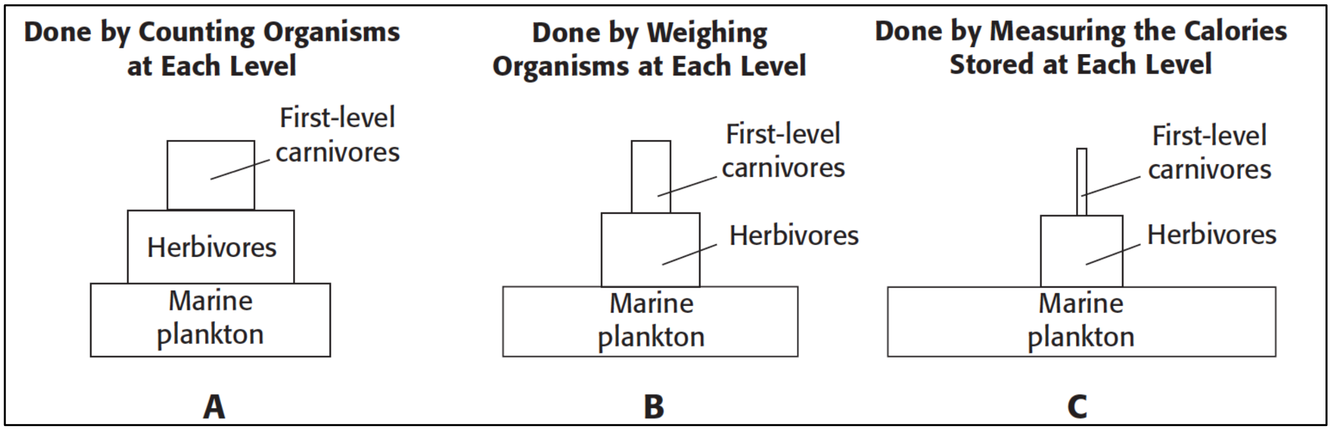
Directions: The diagram shows a forest food web. Identify one food chain in the diagram.



Tropic Levels: Introduction

Trophic levels are the levels of nourishment in a food chain. The first trophic level is occupied by the producer. The second level is occupied by the primary consumer, usually an herbivore. The third and fourth levels contain secondary and tertiary consumers, and so on, which can be omnivores or carnivores.

Directions: Use the figures below, which show trophic levels in an ecosystem, to complete items 1–3.



Study the three pyramids above. In the space provided, identify which pyramid is the most accurate indicator of each item below by writing the correct letter (A–C) in the space provided.

____ **1**. number of individual organisms ____ **2**. measurement of productivity ____ **3**. measurement of biomass

Energy flows up the food chain from the bottom trophic level to the top. Food chains are limited in length because energy is lost as heat at each trophic level. Organisms use the remaining energy to carry out life functions such as cellular respiration and growth. In this way, less and less energy is available for the next organism in the chain. Eventually, there is not enough energy to support another trophic level.

Tropic Levels: Data Analysis (Population Size)

A scientist sampled a small cross section of a grassland ecosystem. Her data for each trophic level are shown in the table.

Tropic Level	Producers	Primary Consumers	Secondary Consumers	Tertiary Consumers
Population Count	6,025,682	723,082	98,541	4

Answer the following questions in science notebook:

1. How does the population amount change at each trophic level in this sample?

2. What is the relationship between trophic level and population size?

3. Predict what would happen if a quaternary consumer were added to this ecosystem.

Tropic Levels: 10% Rule

Energy moves through an ecosystem in the form of food. Organisms obtain this energy (food) by eating one another. The exception to this rule is plants, which obtain their energy from the sun. Plants (producers) are the start of all food webs—at the lowest trophic or feeding level—within an ecosystem. Plants obtain their energy from the sun through the process of photosynthesis. Plants make the food that other organisms consume. Primary consumers are the next trophic level in the food chain. Primary consumers (herbivorous animals) eat plants to obtain the energy that they need. Next, secondary consumers eat the primary consumers to obtain their energy. This process continues, through tertiary consumers, quaternary consumers, and sometimes beyond, until the top of the food chain is reached. Decomposers consume the energy provided by dead organisms at all levels of a food web.

Energy Obtained From Each Trophic Level

Organism	Trophic Level	Energy Obtained From Previous Level (kcal)
Flower	Producers	170,000
Grasshopper	Primary Consumer	17,000
Mouse	Secondary Consumer	1,700
Snake	Tertiary Consumer	170
Bird	Quaternary Consumer	17

Directions: In your science journal or on graph paper, construct a graph using the data provided in the 'Energy Obtained From Each Tropic Level' chart. Remember to properly label your graph; the x-axis should be "Trophic Level" and it should go in order from producers to quaternary consumer.

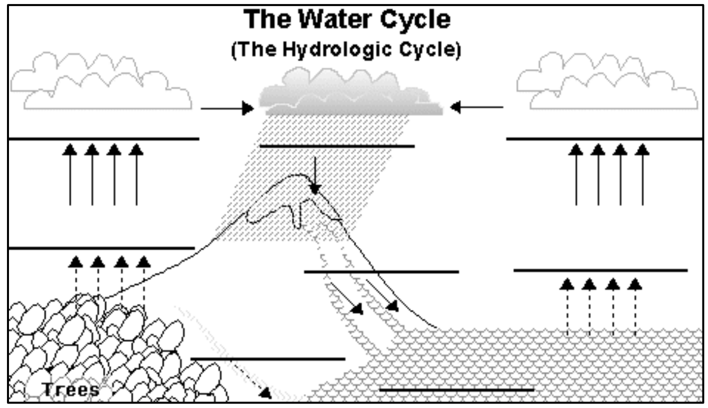
Once you've completed your graph, answer the following questions in your science journal.

1. Based on the data, explain what happens to the amount of energy as organisms consume one another from one tropic level to the next.
2. Using your graph and data, determine the percent of energy transferred from one trophic level to the next.
3. A very small portion of energy is transferred from one trophic level to the next. What is the rest of this energy used for?
4. What would cause energy not to transfer at all from one trophic level to the next?
5. Devise an equation or expression that describes the relationship between the trophic level and the energy available to organisms in that trophic level. Test your equation using numbers from the data table.

Week 6 – Focus: Cycling of Matter and Energy in Ecosystems

The Water Cycle

Directions: Read and annotate the passage titled "*How do Solar Energy and Gravity Drive the Processes of the Water Cycle?"* (Discovery Education, 2018). In your science journal, answer the questions that follow the text.



How Do Solar Energy and Gravity Drive the Processes of the Water Cycle?

The water cycle is the movement of water among the various reservoirs, or storage locations, of water around the planet. Reservoirs of water include the oceans, lakes, and rivers; glaciers, soil, and rock; living things; and the atmosphere. There are four main processes that move water among these reservoirs: evaporation, condensation, precipitation, and flow. All of these processes involve force and energy. Water changes state between solid, liquid, and gas when it absorbs or releases energy. Water starts to move or changes how it is moving when a force is exerted on it. Water can be pulled downward by gravity, pushed upward by buoyancy, and pushed by winds.

Energy and the Water Cycle

The most important source of energy that drives the water cycle is the sun. Solar radiation (sunlight) provides the energy that melts ice to produce liquid water and that causes evaporation of liquid water to form water vapor. The phase changes can also operate in reverse: water vapor releases energy as it condenses, and liquid water releases energy as it freezes to form ice.

Sunlight also provides the energy that causes winds. As Earth's surface absorbs sunlight, it heats up. This thermal energy in the ground and water is then transferred to the atmosphere by conduction and radiation. As air warms up, it becomes less dense than the surrounding air. The cooler air sinks, forcing the warmer air upward. This force, called buoyancy, pushes air up through the atmosphere. This process of transferring energy within matter that is moving is called convection. The low pressure beneath these rising air masses is filled further by cooler air rushing in from nearby areas, which causes wind. Some winds are global winds and blow almost continuously in roughly the same direction, while others happen as a part of local weather. Winds move air masses containing water vapor from place to place. Winds also cause ocean currents, which move liquid water (and thermal energy) to different locations on Earth

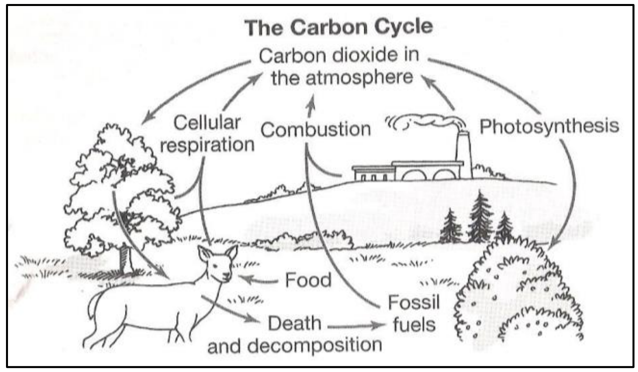
Force and the Water Cycle

The basic forces that drive the water cycle are gravity and buoyancy. Gravity causes ice crystals and water droplets in clouds to fall to the ground or ocean surface. It causes liquid water to flow downhill in streams and rivers toward lakes and oceans. It causes solid water to flow in glaciers from higher elevations to lower elevations, where the water melts and flows on the land or enters the oceans. Gravity also causes liquid water to percolate down into the ground to the groundwater reservoir. Groundwater itself flows because of gravity from higher elevations to lower elevations, and it will return to the surface in a stream within a valley.

Buoyancy is the force present when a mass has less density than the fluid around it. A warm air mass is buoyant compared to the cooler air around it. As a result, the warmer air will be forced upward by the cooler air below it. Similar processes occur in the oceans with warm masses of water. Humid air is less dense than dry air, thus as water evaporates into the air, the air becomes less dense and rises. In both cases, currents result. In the atmosphere, we call these currents winds.

1. Describe the different stages of the water cycle.
2. Explain what drives the cycling of water between the different phases and locations on Earth.

Biogeochemical Cycles: Carbon Cycle



Carbon is present in most chemical compounds that make up living things. Carbon is also stored in abiotic components of the Earth system. For example, carbon dioxide in the atmosphere, fossil fuels such as oil and coal, dead matter in the soil, and chemical compounds in rocks are all carbon reservoirs.

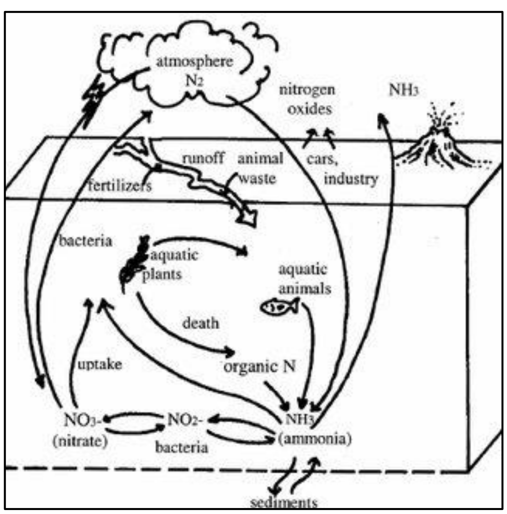
Producers remove CO_2 from the atmosphere through photosynthesis. Photosynthetic organisms incorporate the carbon into carbohydrates to store in their tissues. When consumers eat producers, they obtain the carbon, storing some of it in their tissues and releasing some back into the atmosphere through cellular respiration. When the consumers die, decomposers break down the organic matter and release carbon back into the atmosphere through cellular respiration. Carbon is also released into the soil.

Some of the carbon in the organic matter may become fossilized. Under certain conditions, the burial process stores that carbon in Earth's crust where, over millions of years, it becomes fossil fuel. Since the 1800s, humans have extracted this carbon and combusted it, releasing large amounts of carbon back into the atmosphere.

Carbon dioxide diffuses into the ocean from the atmosphere. Oceans are carbon sinks that absorb and hold large amounts of carbon. Carbon enters the aquatic biotic cycle when algae and phytoplankton convert it during photosynthesis. Some dissolved CO_2 is used in the processes of sedimentation and burial to form different types of sedimentary rock. These processes are very slow, taking millions of years, but they form extremely large carbon reservoirs.

Directions: In your science journal, create a model illustrating the roles of photosynthesis and cellular respiration in the cycling of carbon among Earth’s spheres. Be sure to include the inputs and outputs for both processes in your model.

Biogeochemical Cycles: Nitrogen Cycle



About 78 percent of Earth's atmosphere is composed of nitrogen gas (N_2). However, most organisms are not able to use nitrogen in this form to build organic molecules. The nitrogen must be fixed, or incorporated into other molecules that organisms can use. Bacteria, which are involved in many steps of the nitrogen cycle, fix nitrogen into ammonia, nitrite, nitrate, and other chemicals that organisms can use. Much of the nitrogen cycle takes place below ground.

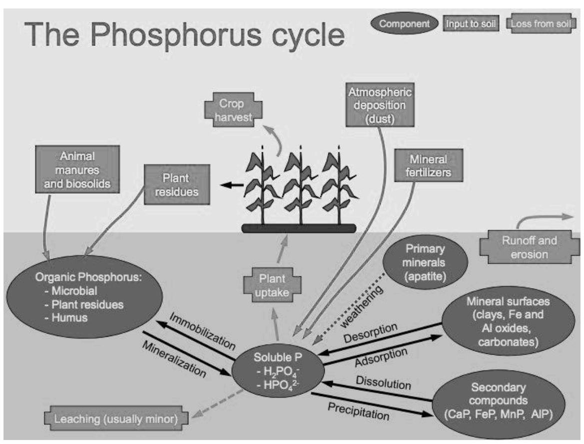
Certain types of bacteria convert gaseous nitrogen into ammonia (NH_3) through a process called nitrogen fixation. Some of these bacteria are aerobic, which means they use oxygen. Other bacteria are anaerobic, which means they do not use oxygen. In aquatic ecosystems, this task is performed by a few types of cyanobacteria. Some nitrogen-fixing bacteria on land live in small outgrowths, called nodules, on the roots of plants such as beans and peas. Other nitrogen-fixing bacteria live freely in the soil. The ammonia released by these bacteria is transformed into ammonium (NH_4^+) by the addition of hydrogen ions found in acidic soil. Some ammonium is taken up by plants, but most is used by nitrifying bacteria as an energy source. These bacteria change ammonium into nitrate (NO_3^-) through a process called nitrification.

Nitrates released by soil bacteria are taken up by plants through assimilation, which converts them into organic compounds such as amino acids and proteins. Nitrogen continues along the cycle as animals eat plant or animal matter. When decomposers break down animal excretions or dead animal and plant matter, nitrogen is returned to the soil as ammonium, in a process called ammonification. Denitrifying bacteria use nitrate as an oxygen source, releasing nitrogen gas back into the atmosphere as a waste product via denitrification.

Nitrogen fixation can occur through biological processes carried out by special types of bacteria, but it can also occur through industrial processes such as the production of fertilizer. Some nitrogen also enters the soil as a result of atmospheric fixation by lightning. Energy from lightning breaks apart nitrogen molecules in the atmosphere. Nitrogen recombines with oxygen in the air, forming nitrogen monoxide. The combination of nitrogen monoxide with rainwater forms nitrates, which are absorbed by the soil. Nitrates in the soil may be moved by water, eventually settling at the bottom of lakes, swamps, and oceans in a process called leaching.

Directions: Bacteria are microscopic organisms, but they are essential to life on Earth. In your science journal, use evidence from the nitrogen cycle to explain how the microscopic fixation of nitrogen can have such a large impact on life.

Biogeochemical Cycles: Phosphorus Cycle



Phosphorus is an important element for living things. It is a component of phosphate groups in ATP, DNA, and phospholipids in cell membranes. Phosphorus occurs in the form of phosphate salts found in ocean sediments and rocks. Geologic processes expose these rocks, and water and wind break them down, making them available to plants and animals.

Weathering of phosphate rocks by rain releases phosphate compounds in soil and water. On land, plants can take up phosphate compounds from the soil and consumers gain phosphorus by eating the producers. Decomposers then return phosphorus to the soil and water when they break down the organic matter and wastes of the producers and consumers.

Water can transport phosphorus to aquatic ecosystems through runoff and leaching. Phosphorus compounds dissolve into phosphates, where they can be taken up by algae and then consumed by other aquatic organisms. Some dissolved phosphates settle at the bottom of oceans in a process called sedimentation, becoming phosphate rocks over millions of years.

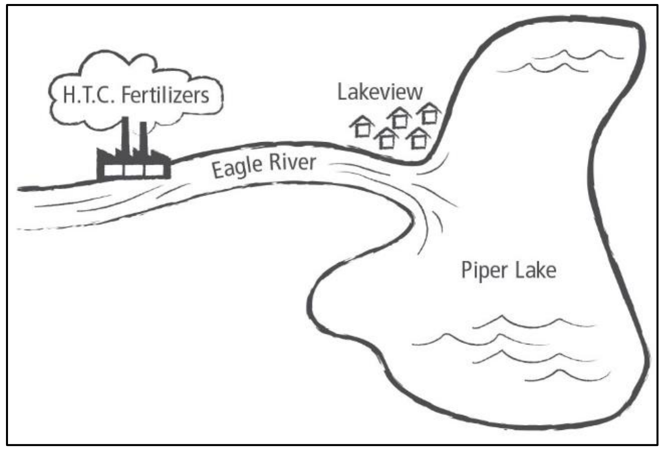
Certain geologic processes expose the phosphate rocks at the bottom of the ocean to the atmosphere. The rocks then undergo weathering, releasing phosphate compounds back into the ecosystem and continuing the phosphorus cycle. Humans also introduce phosphates into the ecosystem by mining them to make fertilizers and cleaners. Excess phosphates from human activities can enter aquatic ecosystems through runoff and leaching. Very little phosphate is naturally available in most bodies of water and any increases can lead to significant changes in the ecosystem.

Directions: In your science journal, explain how animals participate in the phosphorus cycle?

Week 7 – Focus: Matter and Energy in Living Systems

Performance Task: Analyzing Water Pollution

The small town of Lakeview is located on the shores of Piper Lake. The town relies on the lake for trout fishing, eagle watching, and recreational activities. Recently, a fertilizer plant, H.T.C. Fertilizers, was built upstream on Eagle River, which feeds into Piper Lake. The town has noticed an increase in algae blooms in the lake. They are concerned the fertilizer plant is dumping too much nitrogen into the river, and their livelihood could be affected. Is the town right? Does the plant need to control the waste they put into the river?



1. **DEFINE THE PROBLEM**
   With your team, write a statement outlining the problem you've been asked to solve. Record any questions you have on the problem and the information you need to solve it.

2. **CONDUCT RESEARCH**
   With your team, investigate the cause-and-effect relationship between nitrogen, algae blooms, and fish populations. Could the fertilizer plant be responsible for the changes the town is experiencing?

3. **ANALYZE DATA**
   On your own, analyze the problem you have defined along with your research. Create a model that demonstrates how excess nitrogen cycles through the aquatic ecosystem. Your model should also show any effects the nitrogen may have on the ecosystem using a food web, energy pyramid, biomass pyramid, or pyramid of numbers.

4. **COMMUNICATE**
   Present your findings to the town and the fertilizer company, explaining whether or not the runoff from the fertilizer plant is adversely affecting the lake ecosystem. Your presentation should include images and data to support your claims.

Performance Task Scoring Rubric	
Points	**Criteria**
25 points possible	Problem statement is clearly defined and identifies supporting questions to be answered.
25 points possible	Model clearly and accurately represents how excess nitrogen cycles through the ecosystem; any limitations of the model are identified.
25 points possible	Relevant images and data are included to support the solution.
25 points possible	Recommendation clearly explains the solution and uses evidence effectively to support the proposed solution.