WHERE HAVE ALL THE CREATURES GONE?

Organisms and Ecosystems
IQWST LEADERSHIP AND DEVELOPMENT TEAM

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A scientific principle states a scientific idea that is believed to be true based on evidence. As your class decides on new principles in this unit, add them to the list.
Use these sheets to organize and record ideas that will help you answer the Driving Question or your own original questions.
ART

Every effort has been made to secure permission and provide appropriate credit for the photographic materials in this program. The publisher will correct any omission called to our attention in subsequent editions. We acknowledge the following people and institutions for the images in this book.

Lesson 1

Lesson 6
Lamprey Habitat Map – U.S. Geological Survey, Department of the Interior
Northern Brook Lamprey – U.S. Geological Survey, Department of the Interior
Fish Mouths – Wikipedia, The Free Encyclopedia
Swimmer Lamprey – Wikipedia, The Free Encyclopedia
Fish Without Jaws – Wikipedia, The Free Encyclopedia
Fishery Commission of the Great Lakes – Warren Downs, Fishery Commission

Lesson 7

Lesson 8
Cuttings – Courtesy Debra Szidon, Cocoon Home

Lesson 10
Students Examining Loosestrife – Courtesy Kathy Stump

Lesson 11
Bald Eagle 1 – U.S. Fish and Wildlife Service National Digital Library/NCTC Conservation Library
Bald Eagle 2 – U.S. Fish and Wildlife Service National Digital Library/NCTC Conservation Library
Hawk – U.S. Fish and Wildlife Service National Digital Library/NCTC Conservation Library
ACTIVITY 1.1 – INTERACTIONS IN OUR WORLD

What Will We Do?
We will make observations that can be used as evidence of interactions between organisms and their environment.

Procedure
Complete the chart by thinking carefully about what you observe.

- Record your observations.
- Describe the interaction that you think took place. (Hint: What things do you think interacted with each other?)
- Check the yes or no column depending on whether you think that a living thing was involved in the interaction.
### Data

<table>
<thead>
<tr>
<th>Picture</th>
<th>Observation</th>
<th>Interaction</th>
<th>Does the interaction involve a living thing?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Example</td>
<td>Something ate the apple.</td>
<td>jagged edges, apple partly missing</td>
<td>Yes X</td>
</tr>
<tr>
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<td><img src="image1" alt="Ant Colony" /></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.</td>
<td><img src="image2" alt="Forest Damage" /></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3.</td>
<td><img src="image3" alt="Insect" /></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4.</td>
<td><img src="image4" alt="Bee" /></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Making Sense

Why do you think it is important for biologists to understand how organisms interact?
Reading 1.1 – Bacteria, Chimps, Peanuts, and Dolphins

Getting Ready
Would you like to observe how some of the smallest creatures on Earth get their food? Would you find it interesting to observe lions in Africa as they take care of their young? Would you like to examine the remains of an animal attacked by a wolf? Would you like to study plants and animals that live in the ocean? Or, would you rather study plants in a greenhouse? If any of these sound interesting to you, you may want to think about becoming a biologist.

What Does a Biologist Do?
Biology is the study of living things. Biologists, the scientists who study living things, call those things organisms. Close your eyes and think about organisms on Earth. Did you think of dogs, cats, birds, insects, plants, fish, or bacteria? Did you think of other organisms? Biologists want to learn how all of these organisms work, how they interact with each other, and how they interact with their environment. When you study biology in science class, you ask questions, make observations, and collect data just as you do in chemistry and physics. But because you are investigating living things, the way you do science will sometimes be different from what you have done before.

How do you think the way you do work in biology will be different from the way you worked in chemistry or physics?

Here are some stories about four different kinds of biologists. They all study organisms, but they do very different kinds of work.

Microbiologists
Biologists pay close attention to every part of the surroundings that interact with the organisms they are studying. The surroundings and the factors in their surroundings that organisms interact with are known as the environment. Sometimes the environment is large, like a rain forest. Sometimes environments are so small that scientists need to study them through a microscope. Microbiologists are one type of scientist. They investigate the growth, development, structure and function, and other characteristics of organisms so small that they can only be observed through a microscope.

A microbiologist named Patricia Diaz studies bacteria that live in the mouths of humans. You might be surprised to learn that about 500 different kinds of bacteria live in your mouth! Dr. Diaz focuses on the bacteria that arrive on the teeth just after they are brushed. At first, a few species of bacteria come. Then, if teeth are not brushed properly and frequently, new species arrive. Dr. Diaz studies the first bacteria to come and how they react with each other. You can
probably make some good guesses as to why someone would study bacteria on teeth. Do you see the community of bacteria on your teeth? Of course not. To see them, you need a microscope. Someone who studies them is a microbiologist.

Primatologists
Other scientists look at interactions, too. An action between two or more things that have an effect on each other is called an interaction. How do you think the way you do work in biology will be different from the way you worked in chemistry or physics? In physical science, you might study how light interacts with an object, so you can see the object. In chemistry, you might study how molecules interact with each other. In life science, you might study how plants or animals and environments interact. Sometimes, biologists look at data that was collected by someone else over many years. Sometimes, they spend many years focusing on one kind of population to observe individual interactions with each other, and interactions of the whole population with its environment. A population is a group of the same kind of organism that lives together in a particular area.

Primatologists study mammals that have certain characteristics such as flexible fingers and toes and eyes that face forward and are close together. They study populations of primates. Primates include animals like chimpanzees, gorillas, and you! Yes, human beings are primates.

One famous primatologist is Jane Goodall. She is recognized as the world’s best authority on chimpanzees. Goodall observed chimps stripping twigs of leaves to stick them into termite holes to pull out termites for food, the first discovery of a non-human animal using tools. Her work has expanded scientific thinking about the relationships between humans and animals. Many projects that are about paying attention to the environment have developed from her work. She made many discoveries by using observations skills like those you use in science class. She kept careful notes about her observations, just like you will be doing. Her work is an example of a biologist who makes observations over a long period of time. Jane Goodall spent over 40 years in Africa observing a population of chimpanzees. She spent many hours hardly moving, just watching and learning about chimps’ behaviors.

Botanists
Botanists are biologists who study plants. Here is a question for you: do you like peanut butter? If you do, you have a botanist to thank. His name is George Washington Carver. Although the ancient Incas in South America were the first people to make a type of peanut butter, Dr. Carver rediscovered it for the modern world, along with hundreds of other uses for peanuts.

Dr. Carver did research in his laboratory at Tuskegee University in Alabama, but he also went outdoors to do some of his work. In fact, he brought his students out to work with people who were too poor to travel to the school. Dr. Carver taught farmers how to get the best crops they could by altering which ones they planted instead of planting the same crops in the same field every year. Farmers all over the world use his methods today to produce healthy crops.
Marine Biologists

Marine biologists spend time on the water and in the water collecting data. They also spend time in laboratories analyzing the data they collect. Like other biologists, their work often takes years. Some kinds of data can help people understand the importance of protecting Earth’s natural environment. Marine biologists help people to think about preserving ocean life.

One marine biologist is Alejandro Acevedo-Gutiérrez. He grew up in Mexico City. When he was younger, like you, he enjoyed TV programs about marine life. When he grew up, he became a marine biologist who studies whales, dolphins, and seals all over the world. Dr. Acevedo-Gutiérrez was featured in a documentary called Dolphins, which showed in IMAX theaters. He studied the interesting way that some dolphins feed by herding anchovies into a tightly spinning bait ball, and then taking turns eating the fish.

He is now a professor at Western Washington University. He studies seals in their environment, and the interaction of seals and seabirds on the protected marine areas on islands off the coast of Washington. He has won many awards for his work, which all started because he pursued the interests he had as a child.

These are four short examples of the kind of work biologists can do. The field of biology has many more areas of study and ways of studying organisms. In this unit, you will be working in ways that a biologist works, and you can figure out whether biology interests you.
What Will We Do?
We will observe organisms and their interactions in their habitat.

Procedure
1. Follow your teacher’s instructions, looking and listening for evidence of interactions.
2. Choose one organism to study more carefully.
3. Use the Observation questions to help you think about what to observe.
4. In the Field Notes section of the worksheet, complete the observation information (date, time, and place). Record the temperature using words like warm, cold, and hot. If you have a thermometer, record the actual temperature.
5. Observe carefully and record your observations. Use the sketch section to draw anything about the observation that you want to remember.
6. After you return to the classroom, answer the questions that relate to your trip outside in the Think About section.

Predict
1. What organism do you expect to see? ________________________________
2. Where do you expect to find it? ________________________________
3. What do you expect the organism to be doing? ________________________________
Data

Complete the Field Notes sheet.

Field Notes

What: _______________________________________________________

Where: __________________________ Temperature: _________________

Observation Date: __________________ Time: ______________________

**Observation Notes**

What organism did you observe?

______________________________________________________________

What was your organism interacting with?

______________________________________________________________

What was the interaction?

______________________________________________________________

What evidence did you have of the interaction?

______________________________________________________________

Why would your organism need to have this interaction?

______________________________________________________________

**Sketches**
Making Sense

1. What evidence did you find that your organism was involved in an interaction?

2. Why might your organism be involved in this interaction?

3. Do you think this is an interaction that your organism is involved in often? Why?
Homework 1.2 – What Can Cause Populations to Change?

Purpose
For homework, you are going to do another field study, like the one you did in class. First, you will observe two organisms interacting. Second, you will observe an organism interacting with its environment.

Predict
1. What organisms do you expect to see? ________________________________
2. Where will they probably be? ________________________________
3. What do you expect them to be doing (interaction)? ____________________

Procedure
1. Find a place outside where you can observe organisms interacting. You can go the park, sit on your steps, or observe from a window.
2. Once you have found a place, look and listen for evidence of interactions.
3. First, concentrate on any two organisms that you find interacting. Record your observations in the Field Notes chart.
4. Use the sketch section to draw anything about the observation that you want to remember.
5. For your second observation, find an organism interacting with its environment. Record your observations in the Field Notes chart.
Field Notes

Observation #1 Two Organisms Interacting

What: _______________________________________________________
Where: _____________________________________________________
Temperature: __________________________
Observation Date: ______________________
Time: _________________________________
Interaction: What are they doing? _______________________________
Observation Notes: ______________________________________________
________________________________________________________________
________________________________________________________________
________________________________________________________________

Sketches
Field Notes

Observation #2 Two Organisms Interacting
What: _______________________________________________________
Where: ______________________________________________________
Temperature: _________________________________________________
Observation Date: _____________________________________________
Time: _______________________________________________________
Interaction: What are they doing? ________________________________

Observation Notes: __________________________________________
________________________________________________________________
________________________________________________________________
________________________________________________________________

Sketches
ACTIVITY 1.3 – SETTING UP THE DRIVING QUESTION BOARD
Reading 1.3 – Wildlife Biologists at Work

Getting Ready
Have you ever been around a child who seems to want to learn about everything? They watch things closely. They might get down on the ground to watch a worm move through the grass. They might watch tiny ants carrying food to their anthill. They might sit quietly and watch birds build their nest in a tree. Maybe these were things you did when you were younger, or that you still do now! Biologists make careful observations of organisms and their environment, too. They watch organisms really closely to learn about their behavior. Today, you will read about wildlife biologists who are trying to solve a problem by closely watching the interactions of sheep.

What Has Happened to the Sheep?
In class, you learned that whole populations of organisms have the same survival needs as individuals. If one organism dies, the population can survive. However, if all of a population begins to change, biologists try to figure out why. Just like you did on your field observation, biologists look for interactions between organisms, and between organisms and their environment. In this reading, you will learn about a population of organisms called Dall sheep. Their population began to decrease, and wildlife biologists, who study organisms in wilderness areas, wanted to figure out why.

What kind of interactions do you think biologists might look at as they study a population of sheep?

Learning about Dall Sheep
Wildlife biologists noticed a decrease in a population of Dall sheep in the early 1990s. They wanted to find out why, so they began careful observations of the sheep.

Dall sheep are known for their beautiful horns. Males (rams) have huge, curling horns. Females (ewes) have smaller horns. Their horns are made of keratin, the same material that makes up your fingernails. But the sheep horns are much heavier. Like your fingernails, they keep growing throughout a sheep’s life. The horns grow during the spring and summer, and stop growing in the late fall and winter. The growth cycle creates a pattern of rings along the length of the horn.

Dall sheep are found in very cold regions of Alaska, the Yukon, Northwest Territories, and British Columbia in Canada. This is an area that is very big, covering many acres of meadow, hills, and mountains. The map below shows where the sheep live.

The number of rings tells the age of the sheep.
Dall sheep have the food and shelter they need for survival. When an area supplies all the things an organism needs to survive, that area is called the organism’s habitat. In the meadows, they find grasses and plants to eat. On the rugged mountains, the sheep eat moss. They also have hiding places to protect them from organisms that use the sheep as food. Wolves, bears, and eagles eat sheep. Some people in the Baird Mountains eat the sheep, too. Other people hunt the sheep as a sport.

In late May or early June, the young sheep, called lambs, are born. Just before the lambs are born, the ewes look for places to give birth in the most rugged parts of the mountains. Can you imagine why? The ewes choose places that are especially difficult for predators to find. Ewes give birth to one lamb at a time. The mother stays with the lamb in their hiding places until the lamb is strong enough to move. A week after they are born, lambs begin to eat plants, grasses, and moss.

**A Problem with the Dall Sheep Population**

In the early 1990s, after two years of very cold winters, the Dall sheep population in one area decreased. There were less than half the number of sheep in the Baird Mountains. (Mountains in the western part of the region are shown on the map.) Wildlife biologists were concerned about the drastic change. They knew that many things could have an effect on the Dall sheep population.

Imagine that you are one of the biologists beginning to investigate the sheep mystery. Before you can discover what may be causing the problem, you will have to observe the population to understand its interactions. Based on what you learned about observing organisms on your field study, what are some questions you might have to guide your observations of the Dall sheep?

Follow these directions to complete the chart. One example is done for you as a guide.

1. Write an interaction that the Dall sheep have based on what you read today.

2. Check the column that indicates what kind of interaction it is.
3. Write one question that you might ask before you begin your observations and data collection.

4. As student biologists, you should try to identify four interactions in the previous paragraphs, and develop one question for each interaction.

<table>
<thead>
<tr>
<th>Interaction Example</th>
<th>Environment</th>
<th>Organism</th>
<th>Both</th>
<th>Question</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dall sheep are found in very cold regions.</td>
<td>√</td>
<td></td>
<td></td>
<td>Did the climate change?</td>
</tr>
</tbody>
</table>

What Was the Result of the Wildlife Biologists’ Work?

The wildlife biologists began to study the problem by observing the sheep’s interactions with the environment and other organisms. Questions they developed were probably similar to ones you developed. For example, biologists asked, what kind of interactions do the sheep have with people? They made observations and gathered data. They saw that people hunted the sheep for food and for their horns. These data helped wildlife managers to decide to limit the Dall sheep hunting season.

Biologists do not have all the answers. Their work still continues, and they are still observing the sheep now. Even though they do not completely understand the population decrease in the 1990s, their data helped the biologists have an impact on the population. The Dall sheep population has once again become stable.

When you were young and watched worms, ants, or birds, you probably asked a lot of questions that helped you learn about your world. Biologists do that, too. They carefully observe interactions and ask questions, so that they can have a better understanding of organisms in the world.

Dall sheep populations are found in very cold regions of Alaska, the Yukon, Northwest Territories, and British Columbia in Canada.
ACTIVITY 2.1 – INTRODUCING THE TROUT MYSTERY
Getting Ready

If you have only seen mountains in pictures, you may think they are just rocks. Or, maybe you think they are rocks with snow on top. If you live near mountains, or have traveled near them, you know that trees can also grow on mountains. But trees are only able to grow so far up a mountain. The edge of their habitat is called a tree line or a timberline. They cannot grow any farther up the mountain because they would not have the right conditions for survival.

Biologists are interested in organisms like trees and Dall sheep, their habitats, and changes that affect the survival of populations. Today, you will read about other populations and changes that affect them. For example, what happens to cause the timberline to change for a population of trees? What could cause a frog population to decrease over time? Why would a penguin that lives in one area suddenly show up thousands of miles away? As you read, think about being a scientist and why you might be concerned about changes in these populations.

The Mystery Begins

In Lesson 1, your class created a Driving Question Board with four sections. Each section names a type of interaction that could affect a population.

- Other organisms
- Environment
- Food
- Reproduction

Each interaction can be investigated to understand the change in a population. In class, you learned about a trout mystery that occurred in one of the lakes that borders the state of Michigan. Something happened that caused the trout population to decrease from 1930 to 1990. Using the Driving Question Board, you began to ask questions about the four types of interactions. These questions will guide your investigation of the trout mystery: What caused the trout population to change?
Think about the Dall sheep mystery in Lesson 1. One of the interactions you read was *In late May or early June, the young sheep, called lambs, are born*. You could choose to think about reproduction, and ask the following question:

**Question:** Has something happened to the ewes so they cannot have lambs?

**Interaction:** Reproduction

*The Trees Are Marching Up*

Something strange has been happening with several timberlines around the world. Look at the picture at the beginning of this reading. Imagine living near the mountain and noticing that the timberline is farther up the mountain than it used to be. What could be happening? Think about that as you read the next section.

In Europe, scientists collected data about the timberline on some mountains called the Alps. For about 80 to 100 years, scientists’ records show that plants are growing farther up the Alps every year. Their data show that plants have moved up the mountain at a rate of about four meters every 10 years. Scientists studied several locations and saw the trend to be happening in two-thirds of the sites they examined.

In a different study in the United States, a scientist discovered that one kind of tree was moving farther up the mountain in Nevada. His data for nine years showed that the tree had moved its timberline 650 feet. At the lowest elevation, there were only six trees where there used to be 41. At higher elevations, the number of trees increased.

Why would a tree’s habitat move farther up the mountain? Choose one of the four interactions from your Driving Question Notes that might be causing the change. Then, write one question about that interaction that could guide an investigation of the mystery.

<table>
<thead>
<tr>
<th>Interaction</th>
<th>Question:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Environment</td>
<td></td>
</tr>
<tr>
<td>Reproduction</td>
<td></td>
</tr>
<tr>
<td>Other organisms</td>
<td></td>
</tr>
</tbody>
</table>

*Penguins Travel North*

Imagine your reaction if you saw a kangaroo hopping down the street where you live. How could it get to your neighborhood from its habitat in Australia? Some penguins live in the Northern Hemisphere, but one species, called the Humboldt penguin, lives in the Southern Hemisphere. Imagine people’s surprise when Humboldt penguins began showing up in the Northern Hemisphere.

You have probably seen penguins in pictures or in zoos. Penguins do not fly; they swim. Most penguins live in the southern half of the world, below the equator. However, a fisherman in Alaska took a picture of a Humboldt penguin in 2002 when he was surprised to see one in the Northern Hemisphere. The year before, he had seen another one while he was fishing. Several years before that, in 1976, researchers in Alaska reported seeing penguins, too.
How did the birds get there? Did they swim more than 5,000 miles? Why did they come north?

Choose one of the interactions and write it below. Then, write a question that could guide an investigation about this population change.

<table>
<thead>
<tr>
<th>Interaction</th>
<th>Question:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Environment</td>
<td></td>
</tr>
<tr>
<td>Food</td>
<td></td>
</tr>
<tr>
<td>Other organisms</td>
<td></td>
</tr>
</tbody>
</table>

**Frogs Disappear**

In 1865, Mark Twain wrote a famous short story about a frog that could jump farther than any other frogs. He was writing about a species named the California red-legged frog. California red-legged frogs used to be very common. They covered a lot of territory as their habitat, but they lived mostly in wetlands and streams in the middle part of the state. Red-legged frogs need an aquatic habitat for breeding purposes, but they live in other environments, too. The frogs often live where there is thick vegetation next to deep pools of water, often with overhanging plants (like willow trees) nearby. Over time, scientists have observed that California red-legged frogs can no longer be found in more than 70% of the habitats in which they used to live. In fact, they now seem to live in only about 10% of the places they once lived.

This population of frogs decreased. Why are they now only found in 10% of the habitat that they used to live?

<table>
<thead>
<tr>
<th>Interaction</th>
<th>Question:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Food</td>
<td></td>
</tr>
<tr>
<td>Reproduction</td>
<td></td>
</tr>
</tbody>
</table>

**What Some Biologists Have Figured Out**

Biologists investigated these population changes. They began by asking questions about interactions just as you have. Their questions guided their investigations. The data they gathered from their investigations led them to some important conclusions.

Timberlines: Why are timberlines moving farther up mountains? Scientists focused on the trees’ interactions with their environment. They asked whether something was changing with the climate. They also asked questions about reproduction.

Scientists believe that climate change is a part of the change in the timberlines. Global warming is the average increase in the earth’s temperature that can lead to climate change. When the temperature increases and the air is dry, the climate is too warm for certain tree
populations to survive. Seeds that scatter at the lower levels of the mountainside grow to small, young trees called seedlings. Seedlings cannot survive in the warmer temperatures. Seeds that scatter at higher, cooler levels produce seedlings that have a better chance for survival, so the timberlines move up the mountain due to two types of interactions.

Penguins: Why are penguins whose habitat is in the Southern Hemisphere showing up in the Northern Hemisphere? Two biologists studied these Humboldt penguins. They knew that the penguins could not have moved thousands of miles by themselves. The penguins do not fly, so they would have had to swim through waters that were very different from their native climate. They would not have been able to survive. Biologists wondered if an interaction with other organisms could have led to the change. They asked, “Could the movement of penguins be caused by humans?” Biologists believe that crews on fishing ships caught the penguins in their nets as they were fishing. People like penguins because they are cute and friendly, so the fishermen probably kept them as pets. Then, the ships sailed from the Southern to the Northern Hemisphere. When the ships arrived at a place the fishermen thought would make a good habitat, they released the penguins. Humboldt penguins that are native to the Southern Hemisphere ended up in the Northern Hemisphere due to an interaction with other organisms.

California red-legged frogs: What has happened to cause the frog population to decrease? Biologists are still investigating the interactions. They do not understand everything yet, but they are learning some of the causes. One cause is other organisms. Bullfrogs are not native to the area, but humans brought them into the area. Bullfrogs prey on the red-legged frogs.

Another interaction has to do with the environment and reproduction. Red-legged frogs live in the swampy area between land and water. They lay their eggs in shallow water. Their habitats have been destroyed by farming, and by building houses, roads, and malls. The frogs are losing places to live and lay eggs, so at least three types of interactions are causing the population to change.

**Collecting Data about Populations**

All three of the populations you just read about have changed. Biologists observed how each population interacted with the other organisms and with the environment. They thought about the four kinds of interactions that you have on the Driving Question Board, and they developed questions that would guide their investigation. They gathered data. When they examined the data, they began to have ideas about what might have caused the changes. Scientists continue to observe and question as they try to understand the causes of these population changes and many others around the world.

In this unit, you will be using the types of interactions on the Driving Question Board to ask questions and to investigate the trout mystery. The data you gather will help you to explore possible answers to this mystery.
ACTIVITY 3.1 – WHAT DO ORGANISMS USE FOOD FOR?
What Will We Do?

We will determine what substances are in food by examining food labels.

Reminder: In class, your teacher told you that a calorie is not a food because it is a unit of energy not a substance. Do not include calories on the chart below.

Procedure

1. Your teacher will give your group two different food labels.

2. Look at the one label and record the type of food in the following table.

3. Look at the nutritional information. Record the contents of the food in the second column of the table.

4. In the third column, record the amount per serving of each of the contents in your food. (Do not record the % of Daily Allowance.)

5. Repeat Steps 1–4 for the second label.

<table>
<thead>
<tr>
<th>Label for</th>
<th>Contents</th>
<th>Amount</th>
</tr>
</thead>
<tbody>
<tr>
<td>#1</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(item name)</td>
<td></td>
</tr>
<tr>
<td>#2</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(item name)</td>
<td></td>
</tr>
</tbody>
</table>
Prediction

1. Predict: Which of the substances you found in these foods do you think you would find in most foods? Explain your ideas.

Data

2. Compare your labels with other labels using the class data table below. Each time a substance that you found is reported by another group, too, make a tally mark (/) in the Number of Times Listed column. If a group names a substance that is not on your list, write it in one of the blank spaces. When all groups have shared their data, count the number of tally marks and record it in the Total Number column.

<table>
<thead>
<tr>
<th>Substance</th>
<th>Number of Times Listed</th>
<th>Total Number</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
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<td></td>
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</tr>
</tbody>
</table>

Making Sense

3. Look at the class data. Which substances are found on most of the nutrition labels you used in class? How does this compare to your prediction?
ACTIVITY 3.3 – INVESTIGATION: CAN WE PROVE A SUBSTANCE IS FOOD?

What Will We Do?
We will test common substances and water for the presence of carbohydrates (sugar and starch), fats, and proteins in order to determine if the substance is food.

Teacher Demonstration
Your teacher will demonstrate the color reaction of the indicator with various food substances. You will observe the following:

1. the color of the food substance before the test.
2. the color change of each of the food substances once the indicator has been applied to the food substance.
3. the procedure that your teacher uses to do the tests.

Complete the following data table as each control substance is tested.

<table>
<thead>
<tr>
<th>Tube</th>
<th>Tube Contents</th>
<th>Color Before Test</th>
<th>Color from Starch Test Iodine</th>
<th>Color from Sugar Test Benedict’s</th>
<th>Color from Protein Test Biuret</th>
<th>Color from Fat Test Sudan III</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Glucose</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Starch</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Albumin</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Oil</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

4. Discuss what happened to the color of each tube when the indicator was added to the substances.
Complete the chart as you discuss the results.

<table>
<thead>
<tr>
<th>Indicator</th>
<th>Color when the food is in the sample</th>
<th>Color when the food is not in the sample</th>
</tr>
</thead>
<tbody>
<tr>
<td>Iodine (tests for starch)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Benedict’s (tests for sugars)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Biuret (tests for protein)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sudan III (tests for fat)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

⚠️ Safety

Do not put the iodine solution in your mouth because it is poisonous. Iodine can stain your clothes. Be careful when using it. You must wear goggles for this investigation to protect your eyes from the indicators.

Procedure

1. Get a set of six tubes with a food sample from your teacher. If you are testing a 7th sample of your own, get a 7th tube for that sample.

2. In the data table, record the color of the contents of each tube before you add the indicator.

3. Predict what you think the results of each test will be for each of the samples.

4. Your teacher will tell you which food you are testing for in your samples. Get the indicator for that food from your teacher. Circle the indicator your group is using below.
   - Benedict’s solution (indicator for sugar)
   - Iodine (indicator for starch)
   - Biuret solution (indicator for protein)
   - Sudan III (indicator for fat)

5. Using the disposable pipette, add three drops of your indicator to each tube.
   
   BE CAREFUL: Do not touch the contents of the tube with the pipette. If this happens, get a new pipette.
6a. BENEDICT’S SOLUTION GROUP ONLY: Place your tubes in a hot water bath for 5–10 minutes.

6b. Benedict’s solution is different than the other indicators that are being used. It turns different colors depending on how much sugar a sample contains. The table below shows the different colors Benedict’s solution turns depending on the amount of sugar in the sample.

<table>
<thead>
<tr>
<th>Color of Solution after Boiling with Benedict’s</th>
<th>Amount of Sugar</th>
</tr>
</thead>
<tbody>
<tr>
<td>Blue</td>
<td>-</td>
</tr>
<tr>
<td>Green</td>
<td>a trace</td>
</tr>
<tr>
<td>Yellow</td>
<td>+</td>
</tr>
<tr>
<td>Orange</td>
<td>++</td>
</tr>
<tr>
<td>Red</td>
<td>+++</td>
</tr>
</tbody>
</table>

7. Record the color of your tubes in the column of your group’s indicator in the class data table after adding the indicator.

8. When other groups share their data, fill in the rest of the class data table with the data for the other indicators.
<table>
<thead>
<tr>
<th>Tube Contents</th>
<th>Color Test</th>
<th>Starch Test</th>
<th>Sugar Test</th>
<th>Protein Test</th>
<th>Fat Test</th>
<th>Prediction Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Potato/Rice</td>
<td>Iodine</td>
<td>Starch</td>
<td>Benedict's</td>
<td>Biuret</td>
<td>Sudan III</td>
<td></td>
</tr>
<tr>
<td>2. Whole Milk</td>
<td>Iodine</td>
<td>Starch</td>
<td>Benedict's</td>
<td>Biuret</td>
<td>Sudan III</td>
<td></td>
</tr>
<tr>
<td>3. Egg White</td>
<td>Iodine</td>
<td>Starch</td>
<td>Benedict's</td>
<td>Biuret</td>
<td>Sudan III</td>
<td></td>
</tr>
<tr>
<td>4. Honey</td>
<td>Iodine</td>
<td>Starch</td>
<td>Benedict's</td>
<td>Biuret</td>
<td>Sudan III</td>
<td></td>
</tr>
<tr>
<td>5. Butter</td>
<td>Iodine</td>
<td>Starch</td>
<td>Benedict's</td>
<td>Biuret</td>
<td>Sudan III</td>
<td></td>
</tr>
<tr>
<td>6. Water</td>
<td>Iodine</td>
<td>Starch</td>
<td>Benedict's</td>
<td>Biuret</td>
<td>Sudan III</td>
<td></td>
</tr>
</tbody>
</table>
Making Sense

1. Which food substances did each of your samples have?

2. There are many different kinds of food. If you could test every one with the indicators you used in class, what do you think you would find out? Why?
Reading 3.3 – Energizing Me

Getting Ready
After a hard day at school, you pop a lollipop into your mouth. You enjoy the sweet taste. All of a sudden, you hear your grandma yell, “Do not eat that junk!” That makes you wonder why some things are considered junk food. You learned in school that sugars are a type of substance that keep you going throughout the day. Lollipops are candy. Candy has sugar. Sugar is food, so why are lollipops not a good food choice? Before you read, why do you think some foods are considered junk food?

As you read, think about what makes something food, and about what makes one food better for you than another one.

In the IQWST PS1 unit, you learned that energy makes things happen. You learned that energy makes things grow, glow, and go. Now you have learned that food is where you get the energy that makes you go and grow. Energy is found in fats and in carbohydrates, and carbohydrates can be either sugar or starch. Building materials that your body needs to grow are also contained in food. Proteins are what you need to grow and repair your body. Because of the jobs they do in the body, carbohydrates, fats, and proteins are the food in whatever you eat. By examining food labels, you saw that most of the things you eat contain carbohydrates.

If a food has carbohydrates, does that mean it is good for you? Explain your ideas.

In class, you examined nutrition labels. The labels provided information about nutrients found in foods you eat. Read the nutritional information for a typical candy bar below. Compare it to a different sweet snack: a cup of grapes.
As you compare the two lists, what do you notice?

**What Makes Something a Healthy Treat?**

Food is any substance that gives energy or building materials to an organism. Carbohydrates, proteins, and fats are the types of food that enter your body when you eat. Fats are energy reserves. That means they can store energy that is not used right away. As you use up energy, your body can obtain more energy from fats.

There are two kinds of carbohydrates. Simple carbohydrates are sometimes called simple sugars. They can come from things like candy, but they are also found in fruit, milk, and the sugar you put on your cereal. They have a lot of sugar, but not the vitamins that your body needs. Simple carbohydrates give a lot of energy fast, but you use them up quickly. The energy does not last. When simple carbohydrates are in foods that have the important vitamins, like grapes, you also get a quick jolt of energy. But your body also gets those vitamins that keep it functioning well.

A second type of carbohydrates is called complex carbohydrates. You will find these in things like bread, pasta, and some vegetables. Energy from these foods is released more slowly in your body, so the energy lasts longer. Plus, those foods have important vitamins. Fiber is a
special type of carbohydrate that passes through the body almost unchanged. It can absorb a lot of water, so that your body's waste materials can exit the body easily.

Calcium is very important even though it is not food. Calcium does not build body materials, but it strengthens all of the bony structures in your body.

Vitamins are not food, but they are very important to healthy eating. They keep your body functioning the way it should. Think about riding a bike. You are the energy source that makes the bike go when you pedal. But if the chain has not been oiled or there is not enough air in the tires, the energy is not going to be used as well as it could be, and the bike will not move the way it should. The oil and the air work like vitamins in your body. They keep everything functioning well. And like oil for chains and air in tires, different vitamins work with certain parts of your body.

Not all sweet treats are the same. Next time you need a snack after school, check the nutrition label to see if it will be a treat that provides what you need. You will be building a healthy body that will keep you energized for an active life.

Look at the nutritional information on the candy bar and the grapes. If you were going to choose a healthy snack for your little brother or sister, which one would you choose? Use what you have learned from your reading to explain why one choice is healthier than the other.
ACTIVITY 3.4 – WRITING A SCIENTIFIC EXPLANATION

What Will We Do?
We will write an evidence-based explanation to convince others that water is not food.

Procedure
A good evidence-based explanation should contain the following:

- A claim: an answer to the question.
- Evidence: data used to support your claim.
- Reasoning: the logic that leads from the evidence to the claim and if possible uses a scientific principle.

Work with your group to decide on evidence and reasoning for your claim. When you finish, you will write an evidence-based explanation.

Claim
Water is not food.

Evidence
What data will help your reader understand and believe your claim?

Reasoning
Describe the logic that shows how the evidence supports the claim. Use a principle if it makes sense to do so.
Write an Explanation

Using the ideas from the previous page, construct an evidence-based scientific explanation that will persuade others that water is not food.
ACTIVITY 4.1 – WHERE DO ANIMALS GET THE ENERGY AND BUILDING MATERIALS THEY NEED?

What Will We Do?
We will examine possible sources of energy and building materials for animals.

Prediction
To test the idea that plants supply the building materials and energy for animals, we are going to look for starch, a substance found in food, in two parts of plants.

Do you think the potato will contain food?
Do you think the seed will contain food?

Safety
Do not put the iodine solution in your mouth, because it is poisonous. Iodine can stain your clothes. Be careful when using it.

Procedure
1. Place a potato slice in one part of your testing area and a seed in another part of the area.

2. Place two drops of iodine solution on the potato slice. Observe what happens. Record the results in the data table.

3. Place two drops of iodine solution on the seed. Observe what happens, and record the results in the data table.

4. Check the correct boxes in the fourth column of the data table.
Data

<table>
<thead>
<tr>
<th>Plant Part</th>
<th>Iodine Solution Applied</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Turns Black</td>
</tr>
<tr>
<td>Seed</td>
<td></td>
</tr>
<tr>
<td>Potato</td>
<td></td>
</tr>
</tbody>
</table>

Making Sense

1. Does the potato contain food? Yes No

2. Data that support your answer:

3. Does the seed contain food? Yes No

4. Data that support your answer:

5. Where do the energy and building materials for animals come from?

6. Where do you think plants get the energy and building materials that animals eat?
ACTIVITY 4.2 – DO PLANTS NEED FOOD?

What Will We Do?
We will evaluate the evidence-based explanation for the claim that plants need food.

Do you think plants need food?  Yes  No

Why?

Procedure
1. Read the following evidence-based explanations that support the claim, plants need food.

2. Decide whether each explanation is convincing and why.

Explanations
1. Plants need food. I know this because plants are beautiful.

2. Plants need food. I know this because I see that the plant in our classroom has grown since the beginning of the year. It used to be just a few inches tall and now it is almost a foot tall. Growth counts as evidence that plants need food, because the scientific principle tells us that living things need food to grow.

3. Plants need food. I know this because plants grow. Growth counts as evidence that plants need food, because the scientific principle tells us that living things need food to grow.

4. Plants need food. I know this because I see the plant in our classroom has grown since the beginning of the year. It used to be just a few inches tall and now it is almost a foot tall. This makes sense because growth means it is eating something.

5. Plants do not need food. They do not take anything in or eat. If they needed food, they would have to have a way to eat it and they do not have a mouth.
Making Sense

1. Which evidence-based explanation was the most convincing?
   1  2  3  4  5

2. Why did you choose that one?

3. Do plants need food?  Yes  No

4. What do plants need to live and grow?

5. Where do plants get the energy and building blocks they need?
Homework 4.2 – What Do Trout Eat?

Getting Ready
Have you ever eaten trout? Do you know someone who goes trout fishing? Trout are actually a very common fish, even if you have not seen one before. In class, you talked about why the number of trout is decreasing in Lake Michigan. One of the reasons might be that something is happening to the trout’s food. What kinds of food do you think trout eat?

Put a check mark beside any of these that you think affect what a trout eats

- The size of the trout _____
- Where in the lake the trout lives _____
- The temperature of the water _____

As you read, look for the answers to these questions.

Hungry, Hungry Trout
Lake trout eat many different types of food. The average adult lake trout is 17–27 inches long and weighs between three and nine pounds. This makes the trout one of the largest fish in Lake Michigan.

Trout will eat many different organisms. Lake trout that are larger than two or three pounds prefer to eat fish. In general, the lake trout that eat fish grow faster and live longer than the trout that do not eat fish. When the trout are still too small to eat fish, they feed on invertebrates. Invertebrates are animals without backbones. Insects are one kind of invertebrate. Animals with shells are also invertebrates. Animals with backbones, like horses and dogs, are called vertebrates. Most fish, like the trout, are vertebrates too.

Small lake trout like to eat young insects that are born in the water. These insects spend the first part of their lives underwater. If they are lucky enough to escape the hungry trout, they spend the rest of their lives out of water.
In addition to young insects, lake trout like to eat other invertebrates, such as freshwater shrimp and crayfish. The shrimp and crayfish spend their whole lives in the water near the bottom of the lake. They can become trout food at any time. These invertebrates are slightly larger than the insects, but are still small enough for the developing trout to eat.

**Do Lake Trout Eat Anything Else?**

Once lake trout are mature, they tend to like cooler water. During warm months they prefer deep water, which is cooler than shallow water. Not all fish like the cold water. Therefore, the temperature of the water affects what type of fish the trout eat. Lake trout also only prey on fish that are smaller than they are. Trout eat other fish such as sculpin, rainbow smelt, chub, and alewives. These fish are all smaller than nine inches long and weigh much less than the trout. Because of their small size and the fact that they live where the trout does, these fish make them good food for the trout. Trout also eat the crayfish and shrimp that live on the bottom of the lake.

**What Does the Trout’s Food Eat?**

The organisms that the trout eat also have to eat. Crayfish, shrimp, midges, and mayfly nymphs like to eat decaying plant and animal parts that are at the bottom of the lake. They also eat algae, which is a type of plant that grows in water. Sculpin, rainbow smelt, chub, and alewives eat plankton. Plankton are tiny plants and animals that can be found in the lake water.

What do you think might happen to the trout if there were no more plankton in the water?

**Making Sense**

Look back at the beginning of this reading. Have you changed your mind about any of the variables that affect what the trout eat? Do you want to add anything to the list?

Now that you have learned about trout food, why do you think the trout in Lake Michigan might be decreasing? List as many reasons as you can.
### Reading 4.2 – Hydroponics

**Getting Ready**

Your class has been talking about where living things get the food they need. To review what you have learned, check whether you agree or disagree with each statement about plants and food.

<table>
<thead>
<tr>
<th>Before Reading</th>
<th>Statement</th>
<th>After Reading</th>
</tr>
</thead>
<tbody>
<tr>
<td>Agree</td>
<td>Plants contain food.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Plants make their own food.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Plants get energy from light.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>All living things depend on plants for food.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Plants need soil to produce food.</td>
<td></td>
</tr>
</tbody>
</table>

You have learned that many of the foods you eat come from plants. You may have flour, sugar, bread, or cereal at home. You might not think about these foods as made from plants. Flour and cereal may have come from wheat or corn plants, for example. Like humans, plants require energy to change and grow. Plants get their energy from sunlight, and they make their own food. Then, each of these foods gives you energy.

Think about the plants in your house or plants growing outside. Plants are usually rooted in soil. Roots help plants take in water from the soil and use the water to help them make food.

Do you think plants can grow without soil? Explain your answer.

You may think it sounds impossible, but plants can really grow without soil. Hydroponics is a way of growing plants without soil. Hydro is a root word that means water. Ponics means working. Plants can grow in water but without soil. Whether they grow in water or soil, plants need light. Plants use the water and the energy from light to make their own food.

Today, people grow plants in water for many reasons. In different parts of the country, there may be different growing seasons depending on the climate. Some places can grow things like strawberries and cucumbers all year long. But in the northern part of the United States, for example, the growing season is shorter because the winter is too cold for many plants. Fruits and vegetables can only grow outside in the spring and summer. Some people use
hydroponics to grow fresh vegetables all year long. People who grow plants to sell also use hydroponics. One benefit is that plants grow 50% faster. Another benefit is that the people who grow them do not have to spend time digging in soil or pulling out weeds.

A School Hydroponics Project

One teacher asked students what they thought it would be like to live on another planet, and that led to wondering about how people would grow food. The students investigated hydroponics, so the soil conditions on the planet would not matter. After research about plants and growing conditions, the students chose to try growing basil. Basil is an herb used in salads, soups, and sauces like pesto.

The students used principles of hydroponic farming. They put the roots of the basil plant in water. They shone lights on the plants. With enough light and water, the plants made their own food. Then, using the energy from the food they made, the plants grew. The students could see for themselves what plants need to make their own food and grow.

As their project became successful, the students sold the basil they grew and donated the extra money to help children who are sick. All of this happened because of a question in science class about living on another planet.

1. Return to the Getting Ready section at the beginning of this reading. Re-read the statements and put check marks in the After Reading column. Have you changed any of your responses? Explain your ideas.

2. What do plants need in order to grow?
ACTIVITY 5.1 – FOOD CHAINS AND FOOD WEBS

Trout: Predator or Prey?
Getting Ready

Do you eat cheese on pizza? Do you ever have ice cream or frozen yogurt? Do you drink milk or eat it on your cereal? What would happen if you could no longer get any kind of dairy product (milk, ice cream, and cheese)? Would this cause you or your family to have to change its eating habits? Would it affect your health? Explain the effect it would have on your family.

In class, you created a model of the Great Lakes food web using yarn. You investigated the relationships between organisms in an ecosystem. You saw that those relationships can have both direct and indirect effects on populations. In this reading, you will learn about what happened to a population of birds, the puffin, when there was a change in the ecosystem where they live. As you read, look for both direct and indirect effects of the change to the ecosystem.

Something Is Wrong

Recently, on the island of Shetland, off the coast of Scotland, there were more than 24,000 puffin nests almost all entirely empty. There were no pear-shaped eggs, no chicks, and no new generation of puffins. This same phenomenon was observed off the coast of England where these sea birds nest. (See map on next page.)

Puffins are sea birds that build their nests in the cliffs along the coasts of the ocean. They eat sand eels, a small, silvery fish that normally lives in the surrounding waters of the North Sea. In the past year, though, the sand eels have disappeared and the adult birds are starving.

There are not many different types of food for the puffin, so they have to fly farther and farther in search of sand eels. They fly many miles out from shore and dive up to 300 feet underwater in search of food. These long flights use up a lot of energy. When they return to shore, most have not found enough sand eels to provide the energy they need to produce eggs.

What do you think could be happening to the sand eels?
Where Have All the Sand Eels Gone?
After lots of investigating, scientists think they have figured out why the sand eels are disappearing. The sand eels eat cold-water plankton. In the food web activity in this lesson, you learned that plankton are small plants and animals that float in the water. Plankton are at the beginning of the food web in the ocean. Just like you saw in the Great Lakes food web, almost everything in the sea eats plankton, or eats the consumers of plankton, or eats the predators of those consumers.

Food Chain: Plankton ➔ sand eel ➔ puffin

Looking at the food chain previously shown, notice that the sand eel would be directly affected by a loss of plankton, because that is what it eats. The puffin would be indirectly affected by a loss of plankton. If there is less plankton for the sand eel to eat, that means fewer sand eels would survive. If fewer sand eels survive, then the puffin will have less to eat.

The Move Is On
Some of the plankton that used to be found in the North Sea have moved farther north. Over the past 40 years, the temperature of the water in the North Sea between the United Kingdom and Norway has become too warm for the plankton to survive there. Cold-water plankton have been leaving the area and moving toward the North Pole where the water is still cold.

Why Not Eat Something Else?
The North Sea sand eels prefer feeding on cold-water plankton because these species are bigger than warm-water plankton, and provide more calories. Scientists think that this difference in plankton size is what has led to fewer sand eels. Smaller plankton means less food to go around. There are not enough of these smaller plankton for all the sand eels, so sand eels die. Other seabirds, not just the puffins, suffer because they also eat sand eels. Competition for the same food source means there are fewer seabirds of all kinds in the area.
**Why Should We Care about a Bird?**

The puffin is not alone. Less plankton also means fewer whales, cod, penguins, seals, and other seabirds. And those are just some of the species that will be affected. Although plankton live at the ocean’s surface, a rapid drop in its population could affect life all the way down to the ocean floor. Remember, just like in the Great Lakes food web you studied, a decrease in the number of plankton can lead to many changes in the ecosystem. Scientists now believe that the greatest number of species on Earth may exist in the deepest parts of the oceans, where up to 10 million plants and animals could live. If the water continues to get warmer, a large number of ocean-floor species might quickly disappear.

![Ocean Food Web Diagram](image)

**Making Sense**

Use the oceanic food web to answer the following question.

Choose one organism in the food web and name two other organisms that are not directly connected to it. Explain how those organisms would be affected if the organism you chose were removed from the food web.
**ACTIVITY 5.2 – CHANGES IN A FOOD WEB**

**What Will We Do?**
We will describe relationships between different organisms in the Great Lakes, and predict the effects of population changes.

**Procedure**
Using the Great Lakes food web at the end of this activity, answer the questions about the model food web you made in class with yarn.

1. What organism in the Great Lakes did you represent? __________________________

2. If your organism were removed from the food web . . .
   - How many organisms would you directly affect? __________________________
   - How many organisms would you indirectly affect? __________________________

Draw three different food chains that would be affected by removing your organism. (Use + or – to show the increase and decrease of the populations.)

Example:

<table>
<thead>
<tr>
<th>Algae</th>
<th>Snails</th>
<th>Chub</th>
<th>Lake Trout</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3.</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
3. Imagine that the lake herring and the lake whitefish have been eliminated from the Great Lakes food web. Use your Great Lakes food web diagram to fill in the following chart to show what organisms would be affected by the removal of the herring and the whitefish.

<table>
<thead>
<tr>
<th>Direct</th>
<th>Indirect</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lake Herring</td>
<td></td>
</tr>
<tr>
<td>Lake Whitefish</td>
<td></td>
</tr>
</tbody>
</table>

4. Why would the removal of the herring and the whitefish affect other organisms indirectly?

5. Do you think any land organisms would be affected by these changes in the Great Lakes? Explain your ideas.

**Making Sense**

Using the food web diagram of the Great Lakes, highlight (or circle in red) organisms that would have an indirect effect on the trout if something happened to it. Explain your ideas.
Reading 5.2 – Fisherman’s Journal

Getting Ready

Have you ever kept a journal or do you know someone who does? Sometimes journals are called diaries. Journals are a way to record thoughts, feelings, events, and ideas. Biologists who take field notes like you did in Lesson 1, often record them in what they call a field journal.

In class you have been studying the relationships among organisms by using a food web. You used a food web of the Great Lakes ecosystem to explore what would happen if you removed a population of organisms from that ecosystem. You saw that removing an organism from the food web has both direct and indirect effects.

What do you think would happen if a new organism suddenly came into an ecosystem? What things might it affect?

In Lesson 2, you looked at the graphs showing a decline in the trout population. Remember, you are trying to answer the question, What is causing the trout population to change? In 1938, a Great Lakes fisherman wrote the journal you are about to read. This is about the same time the graph you looked at shows the trout population going down. As you read, underline any new information that you find that will help you solve the trout mystery.
Journal from Ron Coleman, a Lake Michigan fisherman:
Saturday, September 15, 1938

Today’s catch was much smaller than usual again. I don’t understand why I keep having this bad luck this year. I remember coming to this same spot last year and catching twice as many trout every day. And, even if I do manage to get a good catch, some of the fish are showing up with these strange wounds on the sides of their bodies. The wounds are mainly showing up on the big fish like the lake trout and salmon, which I can sell for the most money.

Page 2

The wounds are so painful looking that I wonder how the fish are able to survive. The wounds are usually the size and shape of a quarter or a little bigger and it looks like the fish lost a lot of blood. The wound usually has a hole in the middle of it like something drilled a hole through the side of the fish. The wounds make the fish useless to me because nobody is going to buy a fish with that kind of hole on its body! I have no idea what kind of animal in the Great Lakes could have caused this type of wound, but it’s sure not like anything I’ve ever seen before.
Trout are large fish and can weigh as much as 10 pounds and be 27" long. I wonder if they have moved to a colder, deeper water for some reason? These fish live a long time, up to 8 years, so there must be a reason that there are so few of them this year. There seem to be plenty of the food that the trout like to eat like insects and other fish.

I've heard some of the other fishermen talking about this fish called the sea lamprey that is causing a lot of trouble in Lake Michigan for the trout and other big fish. Of course, that means it's causing a lot of trouble for us fishermen too! I've never seen a sea lamprey before, but I'm curious about what it looks like if it can do this kind of damage to a fish and still not kill it every time. I hope I can still feed my family this year after all of the bad luck I've been having.
After reading the fisherman’s journal, what new questions or observations do you have about the trout mystery? What have you learned that will help you answer the question, What is causing the trout population to change?
ACTIVITY 6.1 – INVESTIGATING THE SEA LAMPREY BACKGROUND

What Will We Do?
We will investigate the sea lamprey and the history of its invasion into the Great Lakes.

Procedure
1. Look over the information about the sea lamprey at the end of this activity sheet. It includes an article, a picture of the sea lamprey, and a set of two maps.

2. Answer the questions using this packet.

Describing the Invader
1. Why do you think the sea lamprey is considered such a problem in the Great Lakes?

2. Give two reasons why the sea lamprey has survived so successfully in the Great Lakes?

The Geography and Timing of the Invasion
1. Where does the sea lamprey live?
2. Since the sea lamprey is a fish, can you explain why parts of the land near the Great Lakes and the Atlantic Ocean are also shaded on Map 1?

3. On Map 1, draw the path you think the lamprey took in order to reach the Great Lakes.

4. What geographic feature may have slowed the lamprey getting from Lake Ontario to Lake Erie? How do you think the lamprey was able to get around it?

---

**Discovering the New Competitor**

Fill in the following chart to show how the sea lamprey fits into its native environment compared to the invaded environment.

<table>
<thead>
<tr>
<th>Predators</th>
<th>Prey</th>
</tr>
</thead>
<tbody>
<tr>
<td>Native Environment</td>
<td></td>
</tr>
<tr>
<td>Invaded Environment</td>
<td></td>
</tr>
</tbody>
</table>

---

**Student Data Materials**

The sea lamprey is usually found in the salt water of the Atlantic Ocean. Like some fish (such as salmon), the sea lamprey travels to rivers or lakes to breed in fresh water. When it is young, it lives in the streams and feeds on tiny microscopic material that floats in the stream. As the sea lamprey gets bigger and enters its adult stage, it moves back to the Atlantic Ocean. In the ocean, it feeds on a variety of large fish, including tuna, swordfish, salmon, trout, and sometimes shark. While in the stream or in the ocean, the sea lamprey has to be careful not to be eaten by other fish such as swordfish, sea bass, shark, and an occasional marine mammal.

---

*The Fishery Commission of the Great Lakes*

Warren Downs, Fishery Commission
Unlike some fish, the sea lamprey can live its entire life in either fresh water or salt water. It is this ability to live in fresh water that has caused so many problems in the Great Lakes. The sea lamprey affects both the fish and the fishermen. If the lamprey are killing the fish, the fishermen do not have as many fish to catch and sell. The freshwater Great Lakes are now connected by a large number of rivers and canals. Canals are man-made water passages to the Atlantic Ocean. These connections have allowed the sea lamprey to accidently enter the Great Lakes. Sea lamprey attach to big shipping boats that carry them to the Great Lakes.

The story of the sea lamprey invasion begins in Lake Ontario sometime in the early 1830’s. That is when local fishermen first discovered them. The next stop in the Great Lakes was almost a hundred years later in Lake Erie in 1921. The sea lamprey was soon discovered in Lake Huron in 1932, Lake Michigan in 1934, and finally Lake Superior in 1938.

The Great Lakes provided the sea lamprey with much food. There are about 125 different types of fish in the Great Lakes. Most of these fish are small and live near the coasts of the Great Lakes. The few, larger predators, such as the lake trout and burbot, live in the open waters of the Great Lakes. However, they do not feed on the sea lamprey. So, the sea lamprey has no natural predators in the Great Lakes. This means that the sea lamprey was free to prey upon the fish of the Great Lakes, especially trout, whitefish, and chub. The sea lamprey population increased quickly. Because they are not native to the Great Lakes, and they were increasing in population quickly, they were identified as an invasive species.

In 1955, the United States and Canada created an organization called the Great Lakes Sea Lamprey Committee. This committee studied how the sea lamprey survives so that they could create ways to remove it from the Great Lakes. This organization has spent much money to develop ways to remove the sea lamprey from the lakes. Some of the things they used have been successful, but even today the sea lamprey is present in the Great Lakes. With the support of the public and fishermen who make their living from the Great Lakes, this organization hopes to remove this fish from the Great Lakes forever.
Note: *The Erie Canal was opened in 1819.
**The first Welland Canal was opened in 1829 and the second Welland Canal was opened in 1914.
Reading 6.2 – There Are a lot of Lamprey Out There!

Getting Ready
In class, you learned that the sea lamprey is an invasive species. Sea lamprey are also parasites whose food is the blood of other fish. What you may not know is that there are other lamprey in the Great Lakes besides the sea lamprey. These lamprey have been in the Great Lakes for a long time before the sea lamprey invaded.

Why do you think the other lamprey are not causing problems in the Great Lakes?

What Types of Lamprey Are in the Great Lakes?
In addition to the sea lamprey, four other species of lamprey live in the Great Lakes. These are the northern brook lamprey, the American brook lamprey, the chestnut lamprey, and the silver lamprey. These four species of lamprey are native to the Great Lakes, which means they are found naturally there. Scientists call these native species. Remember that in class you learned how the sea lamprey was accidentally introduced into the Great Lakes environment. They attached themselves to ships that entered the lakes from the Atlantic Ocean.

How Are These Lamprey Similar and Different?
Look at the pictures of the three lamprey. Because the actual size of the sea lamprey would be too large to fit on this page, the picture has been made smaller. Each of the other fish pictures has been made smaller by the same amount. For example, if the lamprey were really 50 cm long, and we made it smaller by one half on this page, it would be 25 cm long. If another fish were really 20 cm long, on this page it would be 10 cm. This is called a scale drawing because all of the fish sizes were reduced by the same amount. A similar method is used on a map to show distances. By reducing the size of all of the fish by the same amount, you can compare their sizes and understand how the actual fish compare in size.

Northern Brook Lamprey

Silver Lamprey
To help you understand how long the lamprey are, here are some familiar things to which you can compare them.

- a pencil is about 20cm
- a ruler is 30cm
- an open notebook is about 55cm

<table>
<thead>
<tr>
<th>Species</th>
<th>Average Length</th>
</tr>
</thead>
<tbody>
<tr>
<td>Northern Brook lamprey</td>
<td>15 centimeters</td>
</tr>
<tr>
<td>American Brook lamprey</td>
<td>20 centimeters</td>
</tr>
<tr>
<td>Chestnut lamprey</td>
<td>30 centimeters</td>
</tr>
<tr>
<td>Silver lamprey</td>
<td>35 centimeters</td>
</tr>
<tr>
<td>Sea lamprey (invasive species)</td>
<td>55 centimeters</td>
</tr>
</tbody>
</table>

Compare the different type lamprey by making careful observations of each drawing. Record your data in the table.

The next two pictures are of the same lamprey that you observed on the first page of this reading. These pictures of the silver lamprey and the northern brook lamprey have been made bigger so that you can see more detail. Compare these larger pictures to the sea lamprey picture and add more similarities and differences to your table.
Where Have All the Creatures Gone?

Northern Brook Lamprey

Silver Lamprey

Based on the table and what you have read so far, which lamprey do you think would need the most food and why?

Where Do All These Lamprey Live?

You have learned in class that the sea lamprey has invaded all of the Great Lakes and some of the streams that connect to the Great Lakes. You can find a map of the Great Lakes in the Data Packet. The native lamprey live in the same areas. The American brook lamprey and northern brook lamprey live in the streams that are connected to the Great Lakes. The chestnut lamprey and silver lamprey live in the Great Lakes.

The native lamprey are an important part of the Great Lakes environment. Native lamprey lay their eggs in the streams. When the eggs hatch, the young lamprey help clean the stream by eating algae and other small organisms in the stream. They are also food for the larger fish that live in the stream. The adult chestnut and silver lamprey are also parasites that suck the blood of other fish for food. They do not kill them because the lamprey are small and do not need a lot of food. This is similar to what you learned in class about the sea lamprey. In its native environment, it does not kill its prey because it feeds on fish that are much larger than it is.

The invasive sea lamprey has disrupted the Great Lakes environment. It competes with the native lamprey for food and places to live. When sea lamprey feed on fish, they kill them by causing a lot of damage to the fish. This is because the sea lamprey is so much bigger than the native lamprey, so the sea lamprey spends more time attached to the fish that they are using for food. The sea lamprey does not have any natural predators in the Great Lakes. As long as it has enough to eat, it will continue to survive in its new environment.
What do you think might happen to the native lamprey in the Great Lakes if the sea lamprey continues to survive?
Could the Sea Lamprey Have a Major Impact as a Predator?

ACTIVITY 7.1 – INVESTIGATING EXTERNAL STRUCTURES

What Will We Do?
We will investigate the external structures of the sea lamprey and yellow perch.

Safety

- In this lab, you will be using preserved specimens. Because they have been in chemicals, you must wear goggles and gloves.
- Whenever you touch or move the specimen, wear gloves and protective eyewear.
- Do not touch your hands to your face or put them in your mouth.
- After you have finished the lab, wash your hands with soap and water. Everyone should wash their hands, even if they did not touch the fish.
- In this lab, you will be using sharp instruments (forceps and probes). Be careful when handling these instruments. Follow your teacher’s safety instructions.

Procedure

1. Look at your sea lamprey and perch specimens. Record any general observations on the Observation Notes sheet. Use sketches if there is something you want to remember visually.

2. Use the Observation Guide to complete the rest of the data sheet.

Observation Guide

1. Read the description of the two types of fish in the following chart.
2. Pick up each fish one at a time. Hold the head in one hand and the tail in another. Gently and slowly move the tail back and forth.

3. Record the body type of the perch and sea lamprey in the data table.

**S-Swimmers**
These are fish that have very flexible bodies. Their bodies bend into an S shape when they swim. They tend to jet around and have bursts of speed as they are darting from one hiding place to another.

**Half-body Swimmers and Tail Swimmers**
These fish are less flexible than S-swimmers. They bend either the last half of their body (A) (for half-body swimmers) or their tail fin (B) (for tail swimmers) to move themselves through the water.

Both these swimming styles allow these fish to swim easily through open water.

Mouth shape and size are good places to find clues about how a fish eats. The shape of a fish's mouth can tell a lot about the fish.

4. Draw the shape of the perch and sea lamprey's mouths on your Observation Notes sheet.

5. Compare the mouths of the perch and sea lamprey to the images below on your data table. Record the type of mouths the sea lamprey and perch have.

- **Fish with Jaws and Mouth on Bottom**
  Fish with their mouth on the bottom of their head get their food from the bottom or floor of the water in which they live.

- **Fish with Jaws and Mouth that Point Up**
  Fish that have mouths that point up toward the surface of the water get food near the surface of the water.

- **Fish with Jaws and Mouth in Front**
  Fish that have mouths on the front of their heads feed on organisms that are at the level in which they swim.

- **Fish Without Jaws**
  Fish that do not have jaws cannot chew their food. Instead, they attach to their prey and suck out the blood.

Teeth are also very important when discussing feeding. Some fish, like the Great White Shark, have jaws with teeth that are used to grasp and tear prey.
Other fish have very few teeth on their jaw, but instead have lots of teeth on their tongue to grasp prey and then swallow them whole.

6. Use the forceps and gently open the mouths of the sea lamprey and perch. Slowly open each one as wide as it will go. Record what you see on your Observation Notes.

7. While one person is holding the mouth open, another can use the probe to count the teeth. The teeth are sharp. Be careful! Do not use your finger. On your Observation Notes, record the number of teeth you count.

8. Take your probe and run it over the tongue. Use your magnifying glass for a closer look. Record what you see.

Making Sense

1. Do you think a sea lamprey eats fast or slow moving prey? What evidence do you have to support your answer?

2. How does the sea lamprey get its food, and what structures does it have for eating that way?

External Structures of the Sea Lamprey and the Yellow Perch

<table>
<thead>
<tr>
<th>Sea Lamprey</th>
<th>Yellow Perch</th>
</tr>
</thead>
<tbody>
<tr>
<td>General Observations</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Sea Lamprey</td>
</tr>
<tr>
<td>------------------</td>
<td>------------</td>
</tr>
<tr>
<td><strong>Swimmer Type</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Mouth Shape</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Inside Mouth</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Number of Teeth</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Teeth on Tongue</strong></td>
<td></td>
</tr>
</tbody>
</table>
What Will We Do?

We will investigate the internal structures of the sea lamprey and bony fish.

Safety

In this lab, you will be using preserved specimens. Because they have been in chemicals, you must wear goggles and gloves. Whenever you touch or move the specimen, wear gloves and protective eyewear. Do not touch your hands to your face or put them in your mouth. After you have finished the lab, wash your hands with soap and water. Everyone should wash their hands, even if they did not touch the fish. In this lab, you will be using sharp instruments (forceps and probes). Be careful when handling these instruments. Follow your teacher’s safety instructions.

Procedure

1. Use your probe to examine the inside of the sea lamprey and perch.

2. Using the diagrams in your student book, identify the major organs in each fish. On your data table, put an X by each organ that you can see.

3. Look for either testes or eggs on each fish. If your fish has testes, it is a male. If it has eggs, it is a female.

4. Have your teacher identify the egg sac on the perch. Compare the number of eggs in each fish. Record your comparison on the data table.

Examining the inside of the sea lamprey

Examining the inside of the perch
Data

<table>
<thead>
<tr>
<th>Internal Structures</th>
<th>Does the Sea Lamprey Have It?</th>
<th>Does the Perch Have It?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Esophagus</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Stomach</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Intestine</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gills</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Eggs</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Making Sense

1. Are there any differences between the structures of the perch and sea lamprey?

2. Why do you think the sea lamprey and perch might differ in their structures?

3. For most fish, water enters the mouth and leaves through the gills. As water passes through the gills, the blood picks up the oxygen from the water, and then the oxygen gets moved throughout the body. The sea lamprey’s gills are different from the perch’s gills. Why do you think the sea lamprey and perch gills are different?

4. Is your sea lamprey a male or female? Male Female

5. How do you know?

6. What do your findings about the number of eggs the sea lamprey has tell you about how successful it might be in the Great Lakes? What questions does this raise?
Reading 7.2 – Sea Lamprey and Lake Trout

Getting Ready

In class, you dissected a perch and a sea lamprey. You examined how both fish breathe, move, eat, and reproduce. Before you do the reading, check whether you think the lamprey and bony fish have similar or different structures to perform each of the functions you studied. When you finish the reading, update this chart with any new information you learn.

<table>
<thead>
<tr>
<th>Function</th>
<th>Before Reading</th>
<th>After Reading</th>
</tr>
</thead>
<tbody>
<tr>
<td>Breathing</td>
<td>Similar</td>
<td>Different</td>
</tr>
<tr>
<td>Movement</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Eating</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Reproduction</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

What Is the Difference Between Trout and Sea Lamprey Breathing?

Fish need oxygen just like other animals, but how do they breathe underwater? You may have learned that water is made of two kinds of atoms: hydrogen and oxygen. The oxygen that fish breathe is not the oxygen in H₂O. Instead, the fish are breathing O₂ (oxygen gas) that is dissolved in the water. Many gases can dissolve in water. If you like the bubbles in carbonated drinks, that is CO₂ (carbon dioxide) dissolved in the water in the drink. Fish need special structures to remove the oxygen from the water. These structures are called gills.

Gills remove the oxygen gas from the water so the fish can use it. To breathe through their gills, bony fish take water in through their mouths. The water passes over the gills where the oxygen is taken out. The water then goes out the gill slits. When the trout opens and closes its mouth, it is actually breathing by pumping water back to the gills.

Take a look at the diagram. This shows the location of the mouth and the gills on a bony fish. The gills are not actually open to the water like the picture. They are covered with a gill flap to protect them, just the way your eyelid protects your eye.

If fish breathe by taking water in through their mouths, how does a sea lamprey breathe when it is attached to a larger fish? Remember that a sea lamprey can stay attached to a fish for hours while it is feeding. Do you think it just holds its breath?

The lamprey has seven gill slits. That is a lot more than bony fish, like the perch and trout. The seven gill slits allow the lamprey to take in and let out water through their gills. This way the lamprey does not need to breathe through its mouth while feeding on its prey.
Given what you know, what is the advantage to the number of gill slits the lamprey has?

---

**Do Trout and Lamprey Eat Their Food Differently?**

The trout has a large head with well-developed teeth on the jaws, tongue, and the roof of mouth. They do not chew their food the same way humans do. Trout use their sharp teeth to capture and hold prey while swallowing it. Depending on the size of the food, they swallow it whole or in big chunks. When they swallow their food, it goes to their stomach where it is broken down into molecules. Finally, the molecules of food go to the intestines where they are absorbed. This is similar to how other animals digest their food.

When you dissected the sea lamprey in class, did you notice that it did not have a stomach? How can the sea lamprey digest its food if it does not have a stomach?

---

The sea lamprey does not need a stomach because it eats the blood of other fish. This means that the nutrients are already broken down when the sea lamprey eats them. The lamprey gets to the blood of other fish by attaching to the fish’s body. They use the outer rim of their mouth to attach to the fish’s body. The sea lamprey’s tongue even has teeth on it! These teeth are used to dig through the side of the fish and get to the blood vessels. Once it gets through the side of the fish, the lamprey starts to suck the fish’s blood.

In the dissection, you were able to see the perch’s and sea lamprey’s digestive systems and make some comparisons of how these two fish take in and digest food.

**How Do the Trout and Sea Lamprey Move?**

Remember how differently the bodies of the perch and lamprey moved? The perch bends its body in the middle, but the sea lamprey moves its body back and forth more freely. A lake trout moves through the water just like the perch with half of its body going back and forth. This is why they are called half-body swimmers.

The sea lamprey, on the other hand, uses its whole body to swim back and forth. Sea lamprey are called S-swimmers. The following figure shows the different swimming styles between a sea lamprey and a lake trout.
Notice how the trout uses only the back half of its body while the sea lamprey uses most of its body and has an S-shape to its movement.

Which fish do you think can swim faster, the lake trout or the sea lamprey? Why do you think so?

Do the Trout and Sea Lamprey Reproduce Differently?
Lake trout lay their eggs on rocky areas in the bottom of the lake during the fall. The fertilized eggs settle in the cracks between the rocks where they stay until they hatch four to six months later. An average-sized female lake trout can lay 1000 to 15,000 eggs every other year.

Sea lamprey lay their eggs at the bottom of rivers that are connected to the lakes. A female lamprey lays 60,000 to 100,000 eggs. That is a lot more eggs than the trout. When the eggs hatch, they remain larvae (young sea lamprey) at the bottom of the river for three or more years. When these sea lamprey become adults, they live for only 18 to 20 months. During this short time as adults, they can cause a lot of damage and kill up to 40 pounds of fish. Once the sea lamprey lay eggs and fertilize them, they die.

Go back to the chart at the beginning of the reading. Did you learn anything new about the trout or the sea lamprey that is related to the functions you studied in the dissection? Write what you have learned.
ACTIVITY 7.3 – CONSTRUCTING A SCIENTIFIC EXPLANATION

What Will We Do?
We will write an evidence-based explanation to answer the question, Could the sea lamprey have a major impact as a predator?

Procedure
1. In class, you worked on one possible claim with evidence and reasoning to explain how the sea lamprey could have a major impact on the trout population.

2. Using evidence you have gathered in class, construct an evidence-based explanation to answer the question, Could the sea lamprey have a major impact as a predator on the trout population? Your explanation should have one or more claims that you can support with evidence. Use reasoning to show why your evidence supports your claim.

3. For homework, you will share your explanation with a family member and try to convince them of your claim about the sea lamprey’s effect on the trout population.

Could the sea lamprey have a major impact as a predator on the trout population?

Dear Family Member,

We have spent the last few days dissecting a sea lamprey and a perch in order to find out how the sea lamprey could affect the trout population. We learned about all of these interesting internal and external structures that help the sea lamprey prey on the fish like the trout. We are excited to share this experience with our family members to see whether we can convince them about how the sea lamprey affects the trout.

Thank you.
Making Sense

1. Discuss your explanation with a family member or other adult.

2. What questions did your family member ask you about your experience?

3. Were you able to convince your family member that your claim was true?

4. Please have your family member sign below.
<table>
<thead>
<tr>
<th>Element</th>
<th>Accomplished</th>
<th>Developing</th>
<th>Struggling</th>
<th>No Credit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Claim</td>
<td>3</td>
<td>2</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Evidence</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Reasoning</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Clarity</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
ACTIVITY 8.1 – STRUCTURES AND FUNCTIONS FOR MEETING SURVIVAL NEEDS

What Will We Do?
We will observe a variety of organisms to determine how they use structures to carry out specific functions.

Directions
Use your observational skills to determine if other organisms have structures that help them perform functions they need to survive. Read the facts about each of the organisms in the first column. Examine the pictures of the organisms in the second column. In the third column, name the structure, the function, and tell how the structure is used to perform the function.
<table>
<thead>
<tr>
<th>Information</th>
<th>Picture</th>
<th>Structure and Function</th>
</tr>
</thead>
</table>
| 1. You certainly would not want to meet up with the Great White Shark on your next swim. Its meals consist of fish, sea lions, seals, and small toothed whales like beluga whales, and more. It has also attacked more humans than any other shark. | ![Great White Shark](image1.png) | Structure:  
Function:  
How the structure is used:  |
| 2. Whale sharks, the largest fish, are filter feeders. Little sea organisms like plankton and other small sea animals that are in its path are gathered in its mouth with water. When the shark's mouth closes, the animals are trapped and filtered out from the water so the shark can swallow them. | ![Whale Shark](image2.png) | Structure:  
Function:  
How the structure is used:  |
| 3. If you have ever tried to catch a grasshopper, you know that it is likely that it will hop before you can get it. No predator is going to have an easy time catching this hopper who can hop up to 20 times its length in one hop. | ![Grasshopper](image3.png) | Structure:  
Function:  
How the structure is used:  |
| 4. The mole cricket lives most of its life underground. It tunnels under the earth to make passageways and cavities for females to lay eggs. It needs to have spaces ready for the cold weather because it is dormant, or inactive, then. | ![Mole Cricket](image4.png) | Structure:  
Function:  
How the structure is used:  |
<table>
<thead>
<tr>
<th>Information</th>
<th>Picture</th>
<th>Structure and Function</th>
</tr>
</thead>
</table>
| 5 Seeds have to move away from the adult plant, so they will be able to have enough light, water, nutrients, and space to grow. Some seeds are picked up by a wind current, float down a waterway, attach to an animal, or explode in order to live and grow into a healthy plant. | ![Picture](image1.jpg) ![Picture](image2.jpg) ![Picture](image3.jpg) | Structure:  
Function:  
How the structure is used: |
| 6 Elephants like to eat anything green, from grass down low to the buds of trees up high. Elephants can eat around 500 pounds of plants in a day. Elephants in the wild are very destructive. They often uproot and scatter as much as they eat. You would not want to be in their way when they are grabbing food with their very strong trunk. | ![Picture](image4.jpg) ![Picture](image5.jpg) ![Picture](image6.jpg) | Structure:  
Function:  
How the structure is used: |
| 7 A giraffe is the tallest land animal. It can have its pick of the nice green vegetation high above the ground or bend down and take a little morsel of shrubbery. The giraffe is after all a vegetarian. It does not eat meat. | ![Picture](image7.jpg) ![Picture](image8.jpg) ![Picture](image9.jpg) | Structure:  
Function:  
How the structure is used: |
| 8 The Dodder plant is an unusual plant. As you can see, it is not a green plant. It is orange or yellow. It does not make enough food for it to survive. Soon after it begins to grow, this plant must attach itself to a food-producing green plant in order to survive. It is a parasite like the sea lamprey. It gets its food by living on another living thing. It wraps its root-like branches around the green plant’s stem and stays attached to it. Dodder grows into a large covering around the other plant as it gets the food it needs. | ![Picture](image10.jpg) ![Picture](image11.jpg) ![Picture](image12.jpg) | Structure:  
Function:  
How the structure is used: |
**Making Sense**

Choose one function (movement, eating, or reproduction) and then choose two different organisms from the pictures and compare the structure that they have to perform that function. Be specific in describing the difference in the structures that affect how the organism performs that function.

<table>
<thead>
<tr>
<th>Function: One of the Four Functions</th>
<th>Organism</th>
<th>Structure</th>
<th>How the Structure Performs the Function</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>


Reading 8.1 – Plant Structures

Getting Ready
You have been learning about different structures animals have that function to help them to survive. Do you think that plants also have structures that help them to survive? For example, animals may have mouths for eating, lungs or gills for breathing, or special structures for moving. You also found out that plants have special structures that help spread seeds so the new plants can grow. In Lesson 5, you learned that plants are producers. This means they make their own food. Think about plants as producers. What structures do you think help them get what they need to produce food?

<table>
<thead>
<tr>
<th>Plant Structure</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

How Do Plants Survive?
In Lesson 4, you learned that plants use light energy and water to make their own food. But how does the light energy and water get into the plants? Light energy comes into plants through their leaves. Plant leaves come in many different sizes and shapes. Depending on the plant’s environment, you might find plants with large leaves, small leaves, many leaves, or only a few leaves. Just like animals, plants in different environments have different structures.

The plant in the picture is called Alocasia, but most people call it elephant ear. Can you see why? This plant survives in tropical jungles where there is little light. Its leaves can grow to be more than three feet long. These plants have some of the largest leaves of any plant. Because of all the trees, there is not much sunlight in the jungle. This plant’s large leaves help it to capture as much light as possible.

Not all plants have large leaves. Duckweed is a plant that grows in water. It floats near the surface of ponds and lakes. Most duckweed leaves are 1/8 of an inch across. Because they grow near the surface of the water, it is easy for them to capture sunlight with their leaves. Duckweed is one of the smallest plants.
Plants also need water to make their food. Water enters the plant's system through the roots. Roots can look very different, but their function is the same—bringing water into the plant. Remember that in Lesson 4 you learned that plants can grow without soil. You read about students who grew basil plants using just water and light. The water and light work together to make the food the plants need to survive.

You have also learned that plants reproduce by forming seeds. If conditions are just right, the seed sprouts and becomes a young plant. Do you think that seeds look the same in all plants? Look at the pictures of different kinds of seeds in the images.

How are the seeds of the maple tree, the dandelion, and the apple tree different?

What Do Helicopters, Parachutes, and Tasty Packages Have to Do with Seeds?
Seeds help plants reproduce, spread out, and grow in new places. Because plants are held in the soil by their roots, they cannot move. To reproduce and grow a new plant, the seeds themselves need to be able to move around. If all the seeds from a plant dropped to the ground around the plant, there would not be room for all of them to get the light and water they need in order to grow. So plants need to be able to spread their seeds over a wider area.

Some people call maple seeds helicopters. The seeds sit at the bottom of a seedpod shaped like a propeller. The propeller allows the seeds to spin as they fall. The spinning slows down the seeds as they fall from the tree and allows the wind to carry them farther away.
Have you ever picked a dandelion and blown its fluffy little hairs in the wind? If so, you were helping to spread the seeds of the dandelion. Dandelions produce lots of tiny seeds at the bottom of the fluffy little hairs. This allows the seeds to float in the wind just like a parachute! If you have ever opened a Milkweed pod or seen its seeds blow in the wind, you know they move like dandelion seeds. Cattails spread their seeds the same way.

You have probably noticed seeds inside fruits and vegetables that you have eaten. You might not eat apple or orange seeds, but other animals do. The fruit is a tasty package that protects the seeds. Birds, mice, moles, and other animals that eat fruit are often not able to digest the seeds they eat. Unlike plants that stay in one place, animals move around. As they move around, they leave their droppings, and the seeds in their droppings are taken to new locations. In fact, some seeds would never be spread to new places without animals. This is another important way that organisms in an ecosystem interact.

Look back at the pictures and think about what you have just read about seeds. How does the structure of the different seeds allow them to move and to grow into a new plant?
What Other Ways Can New Plants Grow?

Look at these two pictures.

Some plants are able to reproduce new plants from one of their own plant parts that is not a seed. A whole new plant can be grown from parts such as leaves, roots, and stems. The spider plant, on the left, is a popular household plant because it is easy to grow, and has baby “spiders” dangling as if they were letting themselves down on a web. These “spiders” are really a new plant sprouted from a flower that most people never even see. The “spider” can be left dangling on the plant or placed in a new pot of soil where it will sprout roots and become a whole new plant. The coleus plant on the right takes a little more work to grow into a new plant. A section of the stem or leaf must be cut and placed in water until roots start to form. Notice in the picture the different lengths and number of roots.

Return to the chart at the beginning of this reading and add anything new that you learned about plant structures and how they function for plant survival.
ACTIVITY 9.1 – EXPLORING THE NETLOGO MODEL ECOSYSTEM

What Will We Do?
We will explore the NetLogo model of an ecosystem and learn how organisms can affect one another.

Procedure

2. Explore the model to see what happens when you change the slider values.
   A. Any changes you make to the sliders have to be made before you press the SETUP button.
   B. You must press the SETUP button before you press the GO button. If you do this out of order you will get an error message.
   C. If you get an error, press Discard and try again.

3. After you have explored the model, answer the Data questions.

Data
1. Draw a food chain to show the relationships between the foxes, rabbits, and grass.
2. Which organisms in the NetLogo model have a direct interaction?

3. Which organisms in the NetLogo model have an indirect interaction?

4. Did the rabbit population ever die out?

5. What might make the rabbits die out?

Making Sense

6. How could you change the slider values to help the rabbit population survive?

7. Why would the change in the slider value help the rabbits survive?
ACTIVITY 9.2 – CAN ALL THREE POPULATIONS SURVIVE?

What Will We Do?

We will create an ecosystem in the NetLogo model in which all three organisms are able to survive.

Procedure

1. Draw a graph that shows three stable populations of rabbits, foxes, and grass.


3. Try different settings for the sliders in the model until you find a combination of settings that allows all three populations to survive for at least 500 years.
Data

Record the settings that allowed the populations to survive.

<table>
<thead>
<tr>
<th>Slider</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Initial-number-rabbits</td>
<td></td>
</tr>
<tr>
<td>Initial-number-foxes</td>
<td></td>
</tr>
<tr>
<td>Percent-grass</td>
<td></td>
</tr>
</tbody>
</table>

How long did the model run with these settings? ________________________________

Making Sense

1. After you have found settings that make the ecosystem stable, answer these questions:

   A. What variable could you change that would make the ecosystem unstable?

   B. How would you change it?

   C. How would that variable affect the survival of the population?
2. Imagine a food web with sheep that eat grass and wolves that eat sheep. Using a line graph, draw what you think the graph would look like if all three populations survived. (Make sure to label which lines are the sheep, wolves, and grass.)
Homework 9.2 – Interpreting NetLogo Graphs

Purpose
In class, you have explored a model of an ecosystem with foxes, rabbits, and grass in it. You studied the ways these populations affect one another. In Activity 9.3, you will be adding an invasive species to the ecosystem and using graphs to understand how the invader affects the other populations. In this homework, you will practice reading a graph to prepare for Activity 9.3.

Directions
Use the graph to answer the questions.

1. Describe what is happening to the fox population between lines A and B. Why is this happening?

2. Describe what is happening to the rabbit population between lines A and B. Why is that happening?

3. Describe what is happening to each of the populations between lines B and C.
4. Pick one pattern you saw in the model and describe in general what you saw.

5. Can you think of ways that a real ecosystem is different from the computer simulation you used in class? Choose a factor that is not in the computer model, and describe how it would affect what happens.
Getting Ready

In a zoo, you can see bears, wolves, elk, birds, fish, bison, and other animals. In Yellowstone National Park, you can see all of these animals in their natural environment. At Yellowstone, the variety of organisms seems endless. How do they survive when they live beside one another instead of in separate cages? A zookeeper makes sure all of the animals get the food they need to survive. In a park, in nature, how do animals get the food they need?

Life in Yellowstone National Park

A huge stone arch greets you with words carved near the top, “For the Benefit and Enjoyment of the People.” When you pass through the arch, you find much to enjoy in Yellowstone National Park. A national park is an area of land the United States government determines is valuable to the whole nation. The land is protected and monitored to make sure organisms can live naturally in their habitats.

How Does the Wildlife in Yellowstone Get the Food It Needs to Survive?

In Lesson 5, you learned about food webs in the Great Lakes. You studied direct and indirect relationships between organisms. These relationships enabled the organisms to survive. In this lesson, you worked with a computer model to explore one type of relationship: predator and prey. If you were successful building your model, you were able to create a stable model of the ecosystem.

An ecosystem is stable when all of the populations in it are able to survive. Because the populations of foxes, rabbits, and grass all survived, the model showed that you understand these relationships:

- fox and rabbits = a direct relationship = more foxes result in fewer rabbits
- rabbit and grass = a direct relationship = more rabbits results in less grass
- fox and grass = an indirect relationship = more grass because there are fewer rabbits to eat it

So, if something happens to the fox population, there will be more rabbits and less grass. If something happens to the grass, there will be fewer rabbits because they have less food. Then, there will be fewer foxes because their food is decreasing. A food web in Yellowstone Park involves the many organisms that live there. The stable ecosystem allows each population to find the food it needs to survive within the park.
What Predator/Prey Relationships Are in Yellowstone’s Food Web?

All of the organisms in the Yellowstone National Park food web are in either direct or indirect relationships with many other organisms. Here are a few examples.

One of the animals people hope to see when they go to Yellowstone is a Grizzly bear. Grizzly bears eat elk and bison, nuts from the white bark pine, and some moths. Bison eat grass. Fish prey on insects, smaller fish, and fish eggs. Smaller fish feed on insects that feed on plants.

Bird watchers going to Yellowstone hope to see the Osprey, a medium size bird of prey. The Osprey’s main food is fish. Bald eagles also eat fish and small mammals.

Grey wolves are one of the top predators in the park. One reason they are important to the food web is that they leave leftovers from their meals of elk and moose for other organisms in the food chain. This is especially important for other animals during the winter.

Ravens, hawks, bears, and other scavengers eat what the wolf leaves behind. Elk and moose feed on plants. Coyotes are meat eaters. They look for small animals like otters, sheep, and lambs from nearby ranches. Otters eat fish. Use what you have read to identify three direct and three indirect relationships in Yellowstone.

<table>
<thead>
<tr>
<th>Direct Relationships</th>
<th>Indirect Relationships</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td></td>
</tr>
</tbody>
</table>

Yellowstone’s wildlife is one of reasons that people visit the park. As student biologists, you would also be amazed to watch these animals interacting with other organisms and their environment for survival.

At the beginning of this reading, you read about the arch that welcomes visitors to Yellowstone National Park. Based on what you have learned about Yellowstone, you can understand why the words carved in the stone are so perfect. Being able to watch organisms in their natural habitat is a wonderful opportunity. You do not have to go to Yellowstone, though, to enjoy wildlife. You learned during your field study that organisms are all around you. They interact in many direct and indirect relationships in order to survive. Go into your own yard, a park, or look out your window. List some of the organisms that you see. Then write about how, through direct or indirect relationships, their habitat remains stable.
Make a list of the organisms you see. How do the interactions of those organisms keep the ecosystem stable? Be sure to tell which interactions are direct and indirect.
ACTIVITY 9.3 – HOW DOES AN INVASIVE SPECIES AFFECT A FOOD WEB?

What Will We Do?
We will use NetLogo to model the effect of an invasive species on an ecosystem.

Procedure

Explore
A. Open Model: L9_Model_9.3.nlogo.

B. Using the settings from your table in Activity 9.2, create a stable graph.

C. Add the invader.

D. Investigate the result of adding the invader in order to determine the answer to, What does the invader eat?

E. As you explore the model, record the results of any of the model runs that help you decide what the invader eats.

F. You will use these data as evidence to convince your classmates of your claim.
Data
When something happens that helps you figure out what the invader eats, record what happened and the settings you used. This information can become evidence for the claim you will make when you finish.

<table>
<thead>
<tr>
<th>What Happened</th>
<th>Settings</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Percent-grass: ________________________</td>
</tr>
<tr>
<td></td>
<td>Initial-number-rabbits: ________________________</td>
</tr>
<tr>
<td></td>
<td>Initial-number-foxes: ________________________</td>
</tr>
<tr>
<td></td>
<td>Initial-number-invaders: ________________________</td>
</tr>
<tr>
<td></td>
<td>How-much-invader-eats: ________________________</td>
</tr>
</tbody>
</table>

|               | Percent-grass: ________________________ |
|               | Initial-number-rabbits: ________________________ |
|               | Initial-number-foxes: ________________________ |
|               | Initial-number-invaders: ________________________ |
|               | How-much-invader-eats: ________________________ |

|               | Percent-grass: ________________________ |
|               | Initial-number-rabbits: ________________________ |
|               | Initial-number-foxes: ________________________ |
|               | Initial-number-invaders: ________________________ |
|               | How-much-invader-eats: ________________________ |

Conclusions
1. Claim—What do you think the invader eats?

2. What data from the model can be used as evidence to support your claim?
Group Work

1. Compare the claims and evidence you came up with in your first group to the other group’s claim and evidence.

<table>
<thead>
<tr>
<th>Claim</th>
<th>Agree</th>
<th>Disagree</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Evidence</th>
<th>Agree</th>
<th>Disagree</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

2. Discuss differences in your ideas.

3. Using your experiences with the NetLogo model, decide whether you agree on a solution from one of the groups, or create a new one that you all can agree on. Support this claim with evidence from the NetLogo model.

4. If necessary, return to Model L9_Model_9.2.nlogo to gather additional evidence. You can use the settings you collected during data collection to try to convince your classmates of your claims.

5. Record the group’s final ideas in the space below. This is the explanation you will present to your class. Make sure it is well supported, so that you can convince your classmates.

   Claim: What do you think the invader eats?

   Evidence: What data from the model will help your reader understand and believe your claim?

   Reasoning: Describe the logic that shows how the evidence supports the claim. Use a principle if it makes sense to do so.

After all the groups have responses, the whole class will compare answers and try to agree on one claim that is supported with evidence and reasoning.
Whole-Class Presentations and Decisions

Purpose
The whole class will try to agree on what the invader eats. When you are preparing your answer, make sure to support it. When you are listening, consider whether you agree with your classmates’ claims and evidence.

Directions

1. During the presentation, you may ask questions. Whether or not you agree depends on how well the presenter supported the claim with evidence. A well-supported presentation will do the following:

   A. Clearly state a claim about what the invader eats.

   B. Provide evidence that supports the claim.

   C. Present evidence based on observations of the computer model, not an opinion.

   D. Explain all of the evidence observed in the model.

   E. Use scientific principles to support the claim.

2. As a class, determine what you think the invader eats. Did anyone present evidence that made you change your mind? Explain.
Write a convincing scientific explanation about what the invader eats and how you know this.

Draw a picture of the graph you saw in the NetLogo model, after the invader entered.
Dear Family Member,

We have been exploring a computer model of an ecosystem. At first, this ecosystem contained foxes, rabbits, and grass. We figured out how to make the ecosystem stable so that all three populations could survive. We then added an unknown organism and tried to figure out what it ate. We wrote scientific explanations using evidence to support our claim. We debated this in class and had a difficult time coming to agreement. We are excited to share this experience with you to see whether we can convince you what this unknown organism eats. As you talk to us, think about whether we have convincing evidence to support our ideas.

Thank you.

Questions
Share your explanation with a family member or other adult.

1. What questions did your family member ask you about your experience?

2. Were you able to convince your family member of your explanation? What part was most convincing?

3. What questions did they have?
Reading 9.3 – An Invader in Yellowstone National Park

Getting Ready

What do you think of when you hear the word invader? Maybe you think about movies with invaders from outer space. Or, perhaps you heard on the news that one country invaded another. There is another kind of invader that happens in nature. When a species enters an area where it does not usually live, and it competes with the native species in their habitat, that species is called an invasive species. This intruder that comes in is an invader. What would happen in a stable ecosystem like Yellowstone National Park if an invader were to enter? What effect would it have on the other organisms in the park?

Who Is the Invader?

If there are no invaders, then an ecosystem works one way. But an invader can change many aspects of an ecosystem. It changes what happens as it enters the food web. Fish populations are important to the Yellowstone food web. One fish, a type of trout, is called the cutthroat trout. In Yellowstone, an invader began to compete with the cutthroat trout. The invader is a species you know—the lake trout.

Cutthroat trout sometimes eat young, other fish, but mostly they eat insects. Some insects, like mayflies, hatch on the surface of the water. Some insects live in the water and some, like grasshoppers, fall into the water.

Of course, cutthroat trout need other things to eat, but they are known more as prey than as predators. Humans eat cutthroat trout, and many park animals, such as bears, eagles, and otters eat them, too. Scientists say that the cutthroat trout is very important to Yellowstone’s ecosystem.

That is why scientists are concerned that fewer cutthroat trout are now found in the waters of Yellowstone Park. In one creek, people who measure wildlife populations counted 2,300 fish one year, and five years later, they counted only one fish. In another creek, the number of cutthroat trout decreased 58% from one year to the next year.

What is happening? One answer is the predatory lake trout. No one is sure how they were introduced, but lake trout have caused many problems as an invader. Lake trout are large fish with big appetites. One lake trout can eat as many as 42 cutthroats in one year. Remember that the lake trout are not native in Yellowstone. They are an invader. So each one is eating up to 42 fish that did not used to be eaten. This affects the food web and the whole ecosystem. In the spring and early fall, people can use nets to try to remove as many lake trout as possible from Yellowstone Lake. But, once the surface of the lake
freezes, there are seven months of the year that the lake trout cannot be controlled by netting and removing them. Lake trout play an important, positive role in their native habitat, but they play a destructive role where they are an invasive species.

**How Does the Invader Affect the Ecosystem?**

Lake trout is an invasive species in Yellowstone because it is not native to that ecosystem. The cutthroat trout, which are native, swim in the shallow water. Predators that depend on cutthroat as an important part of their diet are able to reach the fish in shallow water. Lake trout usually swim 50 to 100 feet below the surface. That is too far out of reach for the birds, grizzly bears, and otters. This means that lake trout cannot take the cutthroat’s place in the food web.

Wildlife biologists have observed the effect of the decreasing cutthroat population on another population in the park, the osprey. The osprey is a bird native to Yellowstone. A scientist who studies the lives and behaviors of birds makes observations of the osprey population on Yellowstone Lake. He used to see 20 to 30 osprey a day, but now he sees no more than two a day. The osprey and the lake trout are competing for food, the cutthroat trout. When the lake trout cause a decrease in the cutthroat population, there are fewer cutthroat for its other predators. Soon the osprey population also decreases. Just like in your computer model, Yellowstone Park’s ecosystem is affected by an invasive species. The balance of direct and indirect relationships changes and disrupts the stable Yellowstone ecosystem.

**Native versus Invasive Populations**

The Great Lakes mystery is about the lake trout population decreasing. This is a problem for the Great Lakes ecosystem. In Yellowstone National Park, the lake trout population is increasing. This is a problem for the Yellowstone ecosystem.

How could a population of an organism decrease in one ecosystem, and at the same time, increase in another ecosystem?
ACTIVITY 10.1 – HOW DOES THE SEA LAMPREY AFFECT THE TROUT?

What Will We Do?
We will analyze data to determine whether the sea lamprey affects the trout.

Procedure
Follow the directions and answer the questions below. Be prepared to share your ideas about what you think is affecting the trout population.

Data Analysis
This graph represents changes in the sea lamprey and trout populations over a certain period of time.

1. Use the graph to describe the population trends for the sea lamprey and trout. Describe each trend using the appropriate term.
   a. stable (increasing and decreasing with a pattern)
   b. overall increase
   c. overall decrease

![Graph showing population trends of sea lamprey and lake trout over time.](image-url)
If data are not available for some time periods, record your best guess based on other trends you see in the graph.

<table>
<thead>
<tr>
<th>Lamprey Population</th>
<th>Trout Population</th>
</tr>
</thead>
<tbody>
<tr>
<td>Before 1944</td>
<td></td>
</tr>
<tr>
<td>1944–1952</td>
<td></td>
</tr>
<tr>
<td>1953–1960</td>
<td></td>
</tr>
<tr>
<td>1961–1970</td>
<td></td>
</tr>
</tbody>
</table>

2. Is the sea lamprey the only thing affecting the trout?  
   Yes  No  
   Explain your ideas?

3. If lack of food is the only reason trout are declining, what would a graph of the trout’s food show?

Chub is one of the trout’s sources of food. Examine the graph of the chub and trout populations, and answer the questions below.

4. What is the overall trend for the chub from 1940–1960?
5. Why do you think there is such a big drop in the chub population between 1960 and 1965?

6. Why do you think the chub population was increasing between 1965 and 1970?

Follow Up

1. Is the trout running out of food? How do you know?

2. Name two possible things that could be affecting the trout population.
How Did Purple Loosestrife Get to the U.S.?
The purple loosestrife is not a native plant in North America. It originally grew in Europe and Asia. In the 1800s, people who came from other places brought the plant to North America with them. They thought purple loosestrife would be pretty in their gardens. But the plant quickly began to compete with native wetland plants.

Why Is This Plant Such a Good Competitor?
Purple loosestrife is often called the “Purple Plague.” It spreads very quickly. Its strong stems and roots form deep mats that stop other plants in the area from growing. One purple loosestrife plant can produce almost three million seeds a year! One year there may be a few purple loosestrife plants, but by the next year, the area will be filled with many, many plants. In a few years, native plants have no space left to grow. The purple loosestrife quickly wins the competition for space.

When native plant populations can no longer survive in an area, other organisms are affected. Native wetland animals like ducks, geese, frogs, toads, and turtles no longer have the food and the nesting sites that the native plants provided. Wetlands are swampy areas where there is very wet soil. The land is often covered with water. The purple loosestrife’s knotted, thick
stems and roots can block creeks, rivers, and streams that are connected to the wetland. When this happens, many other aquatic populations are affected in harmful ways.

**What Can Be Done?**

In Europe and Asia, some insects use the purple loosestrife for food. These insects are natural enemies that control the growth of the plant by eating its leaves quickly before they flower and produce seeds. In North America, there are no natural enemies for the plant.

Do you think bringing insects into the United States is a good idea? Explain your thinking.

If you look at the Environmental Protection Agency’s website, you will see that the purple loosestrife is considered a major problem in North America. The plant was brought here, but its natural enemies did not come with it. So, there is no native way to stop the plant from taking over wetlands. But, some students are investigating a natural way to control the plant. They are raising beetles that are supposed to eat only purple loosestrife. Working with a museum and a park, students are engaged in a project to raise beetles and then to release them into an area overgrown by purple loosestrife. First, students grew the plants under lights. Then, they received a shipment of the beetles. With a food source and other right conditions, the number of beetles has increased. Without predators in the classroom, more beetles are reproducing than would happen in nature. The next step is to release the beetles in the lake to see what happens.

**Are There Other Solutions?**

Pulling the purple loosestrife out by its roots is another way to control the plant. Putting chemical substances that kill plants, called herbicides, on them is another way to control growth. Both of these methods work to control the spread of individual plants and very small populations of purple loosestrife. The students you read about used the galerucella beetle, a biological control. Sometimes other plants or animals that feed on the plant are used to slow down the spread of the purple loosestrife.
Do you think using the galerucella beetle is the best way to control the purple loosestrife? Explain your ideas.

**Making Sense**

Return to the Getting Ready question at the beginning of this reading and compare the list of things plants compete for to what you read about in the reading. Does the purple loosestrife compete for any of the things on your list? What did you learn about the purple loosestrife that makes it a strong competitor?
ACTIVITY 11.1 – WORMS AND MOISTURE

What Will We Do?

We will investigate whether an abiotic factor can affect an organism.

Worm Notes

Worms live where they can survive. They need to have food, oxygen, moisture, and protection from predators. Usually, they live underground, but if they do not have the things they need to survive, they go somewhere else. When there is a heavy rain and the ground is saturated with water, you often see worms on the sidewalk because there is too much water underground. A worm does not have lungs. It gets oxygen from air or water by having both of those pass through its moist skin. Not enough water and the worm will dry out and die, too much water and the worm will drown. The worm—even without arms, legs, or eyes—gets what it needs to survive and while doing that, it helps people too!

You may be surprised to find out that these slippery, little creatures that you find on sidewalks after a heavy rain or tunneling through a mound of dirt that you dig into are really quite important in your life. When worms tunnel deep into the soil, they move around a lot of dirt. As they do, they break down heavy clay and mix subsoil with topsoil. The worms’ tunnels make spaces for air and water that is needed by plant roots. All of this work makes a very good environment for plants to develop. You found out that plants are the producers at the beginning of our food chain. So, next time you are eating, remember to thank a worm!

Procedure

1. Get water and two sections of paper towel.

2. Prepare your test area by doing the following:
   A. Wet one piece of paper towel.
   B. Wring it out so that it is still very wet but not dripping.
WHERE HAVE ALL THE CREATURES GONE?

C. Lay it flat on the table or the pan you are using.

D. Lay the dry sheet next to the wet one. Have the edges overlap.

E. Get your worm. Follow your teacher’s instructions for handling it.

F. Place the worm in the center of the towels near the overlapping edge. Pay attention to where you put the worm. Each time you put the worm on the towel, it should be in the same place.

3. Observe the worm for five minutes.

4. After five minutes, your worm should have settled on one of the towels. Record the results on the data table by checking the Wet or Dry row.

5. Repeat Steps 5–6 four more times.

6. Total the number of times the worm was on each surface.

7. Record the total number of times “wet” and “dry” appeared on the class data table on the board.

Data

<table>
<thead>
<tr>
<th>Surface</th>
<th>Test Times</th>
<th>Total Times Observed on the Surface</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Wet</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dry</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Making Sense

1. What are the results of the test for your whole class (based on the class data table)?

2. From this experiment, which conclusion would you choose? (Circle one letter)
   
   A. The amount of moisture on the towel affected the worms’ behavior.
   
   B. The amount of moisture on the towel did not affect the worms’ behavior.
3. From the results of this investigation, can abiotic factors have an effect on the biotic factors in an environment? Explain your answer.

4. What might happen if there is a change in the abiotic element? For example, what if the rainwater was affected by pollution?

5. Think about the trout mystery. List abiotic elements that might have an effect on the lake trout in the Great Lakes.
Reading 11.1 – When More Is Too Much

Getting Ready

Have you ever seen worms on the sidewalk after a heavy rain? In class, you saw how an abiotic factor (water) can affect a biotic factor such as a worm. You saw the worms move to the moist environment. They need moisture to stay alive. But, in a heavy rain, there is too much water, and the worms move away from the water under the ground. In a healthy ecosystem, biotic and abiotic elements interact in a way that keeps the ecosystem stable. That means life goes on in the ecosystem as usual. Sometimes though, an abiotic factor, like a pollutant, enters an ecosystem. At first, a pollutant may not harm the organisms, but as it builds up, it begins to have an effect on them. This happens because of a process called bioaccumulation.

Think about what the word *accumulate* means. Also, think about what *bio* means. What do you think bioaccumulation means?

In this reading, you will learn about bioaccumulation and its effects on organisms.

How Does Bioaccumulation Affect an Ecosystem?

*Bioaccumulation* is the term scientists use when they talk about how some pollutants enter and build up, or accumulate, in an organism at the beginning of a food chain. The pollutant becomes even more dangerous as it is passed through the food chain from prey to predator. Look at this example:

![Diagram of food chain with bioaccumulation](image)

In this example, imagine that the plants have taken in a harmful pollutant in the water. One insect will eat from many plants that contain the pollutant. The amount of the pollutant from each plant will now go into the insect. Now there is a greater amount of pollutant in the predator than there was in the prey. One toad eats many insects. One snake eats many toads. Finally, one hawk eats many snakes. The hawk will have a lot of the pollutant in its body because it will have small amounts from many snakes. The snake got it from the toads, which got it from the insects that ate a lot of plants. So, although there may be only a small amount of a pollutant in each plant, it can build up to a much greater level in a hawk.
In the food chain example you just read about, who is going to have the highest amount of pollutant in their bodies, insects or snakes? Explain your answer.

Can All Pollutants Move Up the Food Chain?
In order for a pollutant to move up the food chain, it needs to be dissolved in the body fat of an animal. If the pollutant does not dissolve in body fat, it will not move up the food chain. There are many pollutants in the environment that do not move up.

What does this look like in the real world? The next section tells about an actual case of bioaccumulation that caused a major problem for a very important bird.

A Specific Example of Bioaccumulation: The Bald Eagle and DDT
The bald eagle is the national bird of the U.S. The country almost lost its national bird due to the effects of bioaccumulation. In the 1950's, many farmers sprayed a chemical called DDT on plants to kill insects that ate the plants and ruined their crops. DDT (dichloro diphenyl trichloroethane) is a chemical made to kill insects (an insecticide), but it is also a pollutant. When DDT is sprayed on plants, it stays in the environment for a long time. Insects and animals eat the plants, and the DDT gets into their body fat. DDT can also be washed off the plants by rain. The DDT then goes into lakes where it affects aquatic plants and animals. The DDT also soaks into the ground and becomes part of the ground water where it can affect the plants that grow in the soil. A predator, such as the bald eagle, will eat the animals and many other animals that have DDT in them. This causes the bald eagle to have a lot more DDT in its fat. What people did not know at the time they were using DDT, is that it caused eagles to make weak eggshells. When the eagles would sit on their eggs, they would break the shells and kill the baby birds before they were born. Because of this, fewer bald eagles were being born. Bald eagles were put on the endangered species list because they were in danger of becoming extinct if young eagles could not survive.

Are Bald Eagles Still in Trouble?
The U.S. banned DDT once scientists figured out the problem. The bald eagles started to have more offspring because the DDT was not moving through the ecosystem's food web into the eagles anymore. On July 4, 2000, the bald eagle was removed from the endangered species list. There are now enough bald eagles for them to be out of danger of becoming extinct.
Why do you think the bald eagle was able to hatch more eggs and have more offspring once the spraying of DDT was banned?
**ACTIVITY 12.1 – ANALYZING DIOXIN DATA**

**What Will We Do?**
We will analyze data to determine the relationship between dioxin levels in the lake and the trout decline.

**Looking at Data**
Examine the graph that shows the level of dioxin (a pollutant) in the Great Lakes along with the trout population. The trout graph is the same data that you used in Lessons 9 and 10. Following the graph is a chart that shows how much dioxin needs to be in the water before it will kill the living things that are there.

Read the questions in the Making Sense section before you begin to study the graphs. This will help you know what to focus on as you read the data.

**Making Sense**
1. For how many years was the dioxin level in the Great Lakes above 100ppt?

2. What do you think the effect of that level of dioxin would be on the living things in the Great Lakes (including the trout)?
3. Compare the two graphs for the year 1970. What can you conclude from what you see in the graphs?

**Effect of Dioxin on Organisms**

<table>
<thead>
<tr>
<th>Dioxin Level (ppt)</th>
<th>Acceptable (Living things will survive.)</th>
<th>Some damage will occur to living things.</th>
<th>Many living things will die.</th>
<th>All living things will die.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Under 5</td>
<td>Under 5</td>
<td>6</td>
<td>28</td>
<td>100</td>
</tr>
</tbody>
</table>

**Dioxin Level (ppt)**

- Under 5
- 6
- 28
- 100
Reading 12.1 – Return of the Green Goo

Getting Ready

Have you ever gone to a beach on a hot summer day and seen a “No Swimming” sign? People who like to swim in the Great Lakes see this every summer. Sometimes people are not allowed to swim because the beach is covered with green goo. The following article tells about the problem of green slime and what scientists think might be causing it.

Before you read, decide whether you think these claims are true or false.

- Biotic factors cause the problem. T or F
- Abiotic factors cause the problem. T or F
- Humans cause the problem. T or F
- The green goo is disgusting, but it does not hurt people. T or F
- The green goo hurts fish. T or F
- The green goo hurts the environment. T or F

Slime Alert!

Imagine perfect weather, and packing up everything you need for a day at the beach. You are all excited, until you get there and see a beach covered with green slime. It looks bad, and it smells worse. A “No Swimming” sign tells you that you are not allowed to swim. But, you would not want to be on a green, slimy beach anyway.

In some of the Great Lakes that surround Michigan, green goo is a problem. Tiny water plants called algae cause green goo. When everything is in balance, the amount of algae that grows is the right amount for the organisms that eat it. But, when something in the ecosystem is out of balance, so is the amount of algae.

What Is Affecting the Ecosystem?

One essential nutrient for plants to grow is phosphorus. When too much phosphorus is in the water, algae grow out of control. Phosphorus is found in detergents used to wash clothes. Once scientists made the connection between laundry detergent and the algae, the government in Michigan banned phosphates in detergent. Other states that border the Great Lakes also banned or limited phosphorus. This helped the problem.

However, phosphorus also enters the lakes from other sources. Fertilizers used on farms and lawns contain phosphorus. The groundwater the crops and grass grow in contains phosphorus, too. Homes with leaky sewage systems leak phosphorus from soaps into the groundwater. Waste from pets and farm animals contain phosphorus. Plus, one more
source of phosphorus was not banned: dishwasher detergent. People with dishwashers may use detergent with phosphorus in it. Every time they wash dishes, phosphorus enters the groundwater. Phosphorus in the groundwater can eventually make it into lakes. These factors combine to create a major problem for the ecosystem.

_It Looks Bad, but Is It Dangerous?_

Of the five Great Lakes, the conditions in Lake Erie are best for algae to grow. It is shallower and warmer than the other Great Lakes. Lake Superior has some of the coldest water. It is not a good environment for the slimy algae to grow in and reproduce. So, the algae are a greater problem in some lakes than in others.

A beach covered in green slime looks bad and smells terrible. But those two things are not dangerous. Other aspects of the algae growing out of control are dangerous. People or animals can get sick if they drink the water. Because the plants can reduce the amount of oxygen in the water, some fish die. The plants can also clog pipes, and affect the amount of water flowing into the lakes.

_Why Did Banning Phosphorus Not End the Problem?_

Banning phosphorus was an important step in controlling the algae population. But, it has not solved the problem. As scientists continued to investigate, they found another source of the green goo problem: mussels. Ten years after phosphorus laundry soap was banned, two invasive species of mussels arrived in the Great Lakes. One is the zebra mussel; another is the quagga mussel. The mussels filter the water by eating other tiny organisms. By doing this, they make the water clearer. This might seem like a good thing for swimmers. But, clearer water means that sunlight can reach deeper into the lakes. The sunlight can now reach deeper plants. It may be that the algae thrive because more sunlight enables them to grow and reproduce even more. Also, one of the waste products of the mussels is nutrients that might feed the algae population. The invasive mussels have changed the ecosystem in new ways.

Scientists have two ideas about what causes the algae to grow out of control in the Great Lakes. One is abiotic factors (phosphates in the water) and one is biotic factors (zebra mussels). What do you think is causing the increase in algae? In your answer, include the evidence that you used to make your claim.
ACTIVITY 13.1 — WHAT IS CAUSING THE TROUT TO CHANGE?

What Will We Do?
We will develop evidence-based explanations for the trout population change.

Procedure
1. State a claim. You could choose any of the following. Circle your choice.
   A. The trout population was affected by the sea lamprey.
   B. The trout population was affected by the dioxin levels.
   C. Both the sea lamprey and the dioxin levels affected the trout population.
   D. There is not enough data to decide.

2. Go through your Driving Question Notes and circle or highlight all of the data that support your claim.
   Use the principles list to help determine which data are related to your claim.

3. Your teacher will group students who make the same claim together.
   A. Share the claim and evidence from your Driving Question Notes.
   B. As group members share ideas, record all the evidence that the group agrees supports each other’s claims in the notes section below. Then as a group, record the scientific principles.
   C. Work with your group to construct an explanation that you can present to your class in order to convince them of your solution to the trout mystery.
4. When all the groups are ready, the whole class will compare answers and try to agree on one claim that is supported with evidence and reasoning.

A. When you are presenting, make sure to support your ideas.

B. When you are listening, consider whether you agree with your classmates’ claims and evidence.

5. During the presentation, you may ask questions to determine whether you agree with your classmates’ claim and evidence. Whether you agree should depend on how well their scientific explanation meets the following criteria:

   A convincing evidence-based explanation will

   1. clearly state a claim about why the trout decreased.
   2. provide evidence that supports the claim.
   3. present evidence based on data not on opinions.
   4. explain all of the data not just some of it.
   5. use scientific principles to support the claim.
What caused the trout population to change?

Our claim:

<table>
<thead>
<tr>
<th>Evidence</th>
<th>Scientific Principles</th>
</tr>
</thead>
<tbody>
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</tbody>
</table>
ACTIVITY 13.2 – WHAT IS CAUSING THIS POPULATION CHANGE?

What Will We Do?
We will independently investigate a population change and determine what may be affecting it.

Procedure
This is an independent project. You will be responsible for working on your project at home and in class. Complete the steps below.

1. The following chart lists milestones that must be completed. Fill in the due dates for each milestone as your teacher gives them to you.

Project Sheet Activity 13.2
Mini-Project Milestone List

<table>
<thead>
<tr>
<th>Milestone Description</th>
<th>Due Date</th>
<th>Done</th>
<th>Initial</th>
</tr>
</thead>
<tbody>
<tr>
<td>Population Change</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Specific Research Questions</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Data and Scientific Principles</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Claim</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Supporting Your Claim</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
2. As you complete each milestone, place a check in the Done column. Have an adult sign in the initial column.

3. Organize your work in the following chart or use the blank pages at the back of your book.

**Project Milestones**

Milestone 1: Description of the Population Change

Milestone 2: Specific Research Questions

Milestone 3: Data and Scientific Principles that help answer the Research Questions

<table>
<thead>
<tr>
<th>Data</th>
<th>Principles</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Scientific Explanation**

Milestone 4: A claim – Why did the population you investigation change?

Milestone 5: Supporting the claim – What evidence and reasoning support your claim?