Purple Loosestrife Project - Upper Elementary Student Workbook
Michigan State University
Michigan State University Extension
Cooperators Handbook Section 5
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Cooperator's Handbook • Section Four

Upper Elementary Lessons

Student Workbook

The Purple Loosestrife Project
Michigan State University
January 1999

The Purple Loosestrife Project *Cooperator's Handbook*
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} Teacher's Guide

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} Student Workbook

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The Purple Loosestrife Project
Cooperator's Handbook

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Part One Mission: Life on Earth

Lesson One: Biomes

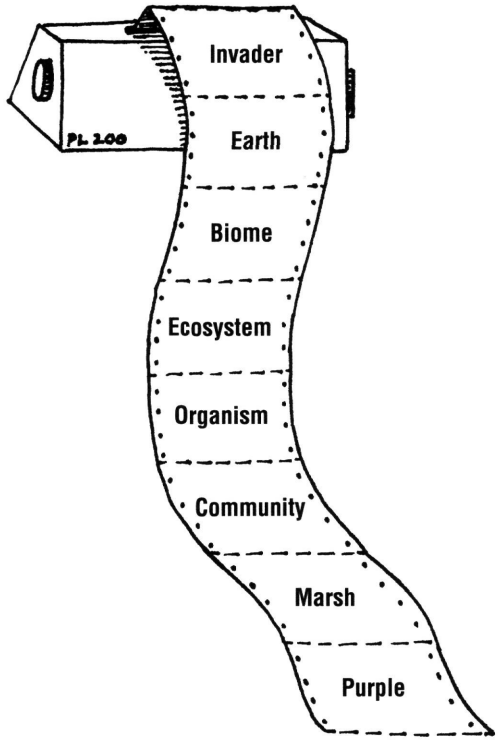
You are about to begin an exciting adventure with your teacher. You will be reading, working with other students and completing worksheets. There is a glossary in the back of your workbook in case you want to look up the meaning of a word.

You are a group of scientists from Planet _____ (your group should select the name of the planet) traveling through space. Your mission is to locate and study life in other parts of the universe. As you are zipping through the Milky Way galaxy, the computerized scanner aboard your spaceship briefly picks up some unusual signals from an unknown source. After decoding the signals, the computer prints out eight clues and a picture of a mysterious object. Is it a life form?

STOP READING and get the picture from your teacher.

The only clue your spaceship computer recognizes is EARTH, which your computer tells you is the name of a planet in the Milky Way Galaxy. Your team of scientists decides to explore the planet called Earth and to try to learn more about the mystery life form in the picture and the meanings of the other clues. You have no other information about Earth.

As you approach Earth in the spaceship, you begin to make observations.



Stop reading and begin the **View From Space Worksheet**.

VIEW FROM SPACE Worksheet

Your teacher has a satellite photograph of the Earth. Look carefully at the photograph. Remembering that you are from another planet and have no knowledge about Earth, what observations can you make by looking at this photo?

Describe your observations on the lines below.

Next, draw a picture of the image in the space below and label or show the observations you made.

Is the following statement an observation that you can make by looking at the photo?

PART OF THE SURFACE OF THE PLANET EARTH IS COVERED BY WATER.

If you had no knowledge of Earth, you would not be able to tell that some areas were water by only looking at the photo. You could, however, make the **observation** that much of the surface of the Earth appears to be covered by one type of substance. Do you see the difference? The statement that "part of the surface of the planet Earth is covered by water" is called an **inference** because it is based on your previous knowledge that water covers much of Earth.

Here is another statement about the photo.

THE EARTH IS SHAPED LIKE A SPHERE (like a ball).

Write below whether you think this is an observation or an inference based on the photo and; why?

Now take a look at each of your observations on the first page of this worksheet. Are they observations or inferences? Label each observation with an "O" and each inference with "I."

You are a scientist from Planet _____ and you have made some observations of Earth from the photo. Based on these observations, write three questions you would like to have answered about Earth before you begin exploring the planet.

Question 1

Question 2

Question 3

Congratulations, you are now ready to land on Earth during the next activity!

Now that you have made your observations from the spaceship, your team of scientists has decided to take a closer look at Earth and continue the search for meanings to the clues and the mystery life form. After sending some probes to Earth, some of the scientists discover that the surface of Earth is covered partly by land and partly by water. You have selected one of the large land areas to explore. You land the spaceship on Earth.

You have decided to divide into four exploration teams. Each team will be assigned to a different area to make observations and to report its observations to the rest of the scientists. Your teacher has a map of the large exploration area.

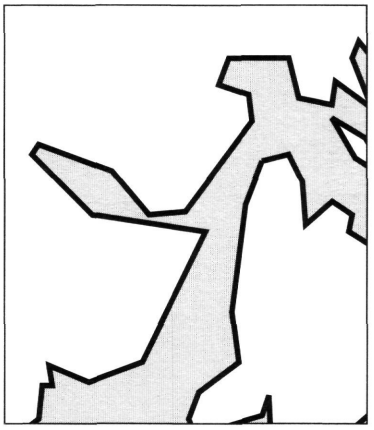
Stop reading and look at the map.

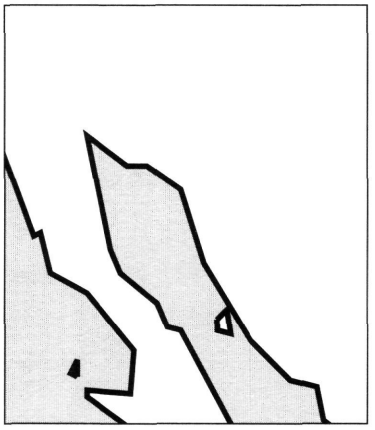
Begin **A Closer Look Worksheet**.

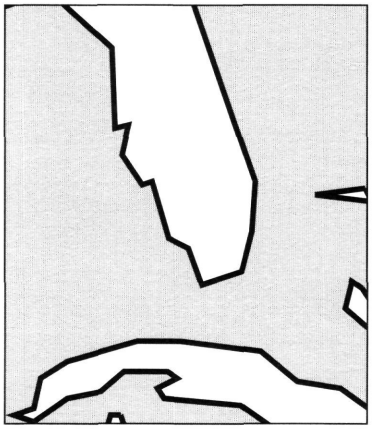
A CLOSER LOOK Worksheet

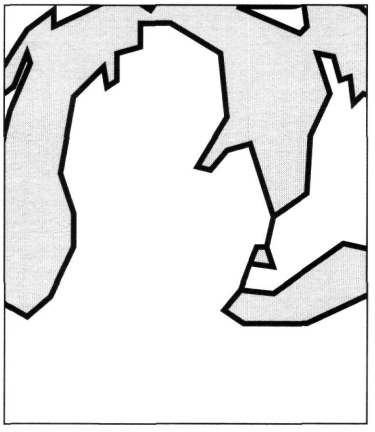
Your teacher has a map of the large land area that you and the other scientists have chosen to explore. Each team of scientists will get a small map section showing the area they will be assigned to explore and gather information from.

Your first task is to find the location of your exploration area. To do this, take your small map section and figure out where it is by matching it to an area on the large map. After you find it, circle your area's location on the large map.









Now that you know the geographic location of your exploration area, use the resources provided by your teacher to gather the following information about your area.

GEOGRAPHIC LOCATION: What is the latitude?_____ longitude? _____

CLIMATE: What is the annual amount of precipitation? _____

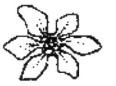
In what form does the precipitation occur? _____

What is the temperature range? maximum ____ minimum_____ average ____

Other interesting information on climate: _____

_____

_____



TOPOGRAPHY: What are some of the interesting land forms (mountains, plains, etc.)?

_____

_____

_____

Would you like to live in this area? Why or why not?

_____

_____

_____

Your team of scientists has discovered that Earth is divided into various types of areas on the basis of geographic location, climate and topography. These areas are called biomes. You have observed four biomes in North America. Some other biomes found on Earth are ocean, tropical forest, tropical savanna and mountains.

Look at the biome map supplied by your teacher and observe where some of these biomes are located.

By looking at the biome map, can you find the name and location of the four biomes your teams explored on the last worksheet? List the names of the four biomes here.

1. _____ 2. _____

3. _____ 4. _____

Your team of scientists has now found the meaning of two of the clues, EARTH and BIOME. You will now begin working on the remaining clues as you continue to search for the mystery life form.

 Stop reading. **END OF LESSON ONE.**

Lesson Two: Ecosystems

Once you start looking closely at a biome, you will find that each biome includes a variety of different areas. For example, if you were to explore the ocean biome, you would find shorelines, deep-water areas and coral reefs. In the desert biome, you might find sagebrush, open desert and lush riverbeds. In the temperate deciduous forest biome, you would find forests, rivers, dunes, and a variety of wetlands such as swamps, bogs and marshes. You would also find different organisms in each of these areas. All of these areas are called ecosystems. An ecosystem is a group of interacting organisms and the physical or non-living factors that affect them. Physical or non-living factors are things such as water, air and soil. So, within the ocean biome, there are a variety of ecosystems, including the shoreline ecosystem and the coral reef ecosystem. In the temperate deciduous forest biome, ecosystems include forest, marsh, swamp, lake, dune and river ecosystems. The word "temperate" means an area with a moderate climate and distinct seasons. The word deciduous means trees that lose all their leaves in the fall.

WHAT IS AN ORGANISM?

Planet Earth is home to a huge number of living things. Each of these living things is called an organism. It has been estimated that there may be as many as 30 million different kinds of organisms on Earth. About 1.5 million of these have been scientifically identified. You are already familiar with many organisms because they live in the same area that you do. These may include maple trees, grass, dandelions, earthworms, daddy longlegs, bees, ants, robins and squirrels. You may be familiar with other organisms as pets, such as dogs, cats and fish. You are familiar with many organisms because they are things you may eat, such as apples, oranges, mushrooms, carrots, lettuce, peanuts, fish, chickens, cows and pigs. Other organisms you may have never seen but have read about or seen pictures of, such as palm trees, cacti, dolphins, tigers, polar bears, sharks and flamingos. Each kind of organism is known by scientists as a species. For instance, there are many kinds or species of maple trees, including sugar maple, silver maple and red maple. In Michigan alone, there are about 400 species of birds, including American robin, great blue heron and bald eagle. You are also an organism. You belong to the human species.

Have you ever wondered why some species are found only in certain areas on Earth? Why aren't there monkeys in the trees around your school? Why aren't there seals along the Great Lakes shorelines? If you traveled to Arizona, would the organisms be the same or different from those in the Great Lakes region?

Stop reading and begin the **Familiar Organisms Worksheet**.

FAMILIAR ORGANISMS Worksheet

The diagram below is called a matrix. A matrix is a special way of looking at or organizing information. Your task is to fill in the blank boxes with names of organisms you are already familiar with. To do this, you need to look at the categories along the left side of the matrix AND across the top of the matrix. For example, one box is a bird that lives in a forest. It is all right to leave a box blank if you are not familiar with an organism in that category. **Write one organism in each box.**

	mammal	bird	fish	reptile or amphibian	insect	plant
May live in a human being's house						
Seen on TV, in a movie or at a zoo						
A wild animal in your neighborhood						
Something that people eat						
Lives in a forest						
Lives in a marsh						

Scientists also place organisms in categories. This is called "Classification of Organisms". The categories at the top of the worksheet matrix are just a few of the categories scientists use to classify organisms (mammals, birds, fish, reptiles, amphibians, insects, plants). The organisms in each category have certain features in common. For example, all mammals have hair or fur and all birds have feathers.

What features do all fish have in common?

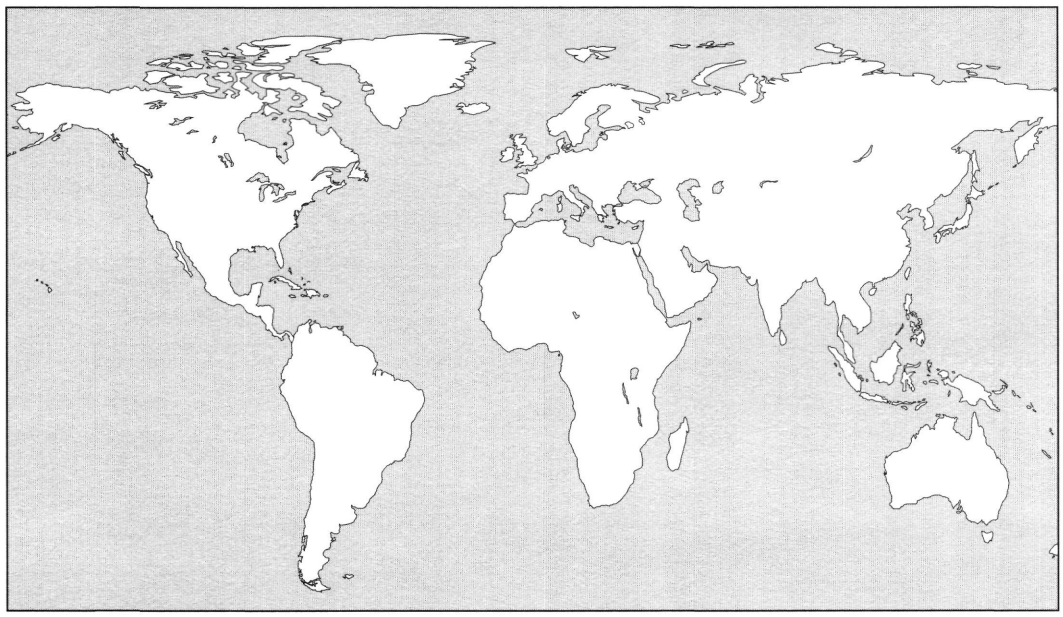
What features do all insects have in common?

Your team of scientists has successfully gathered information and learned about biomes, ecosystems and organisms on Earth. Although nobody has located the mystery life form yet, you decide that it is a type of organism. You also have learned that the clue "marsh" refers to a type of ecosystem in a biome called the temperate deciduous forest biome. You feel that you are getting closer to finding the mystery organism, and you decide to divide into two groups to explore the temperate deciduous forest biome. One group will explore the forest ecosystem and the other group will explore the marsh ecosystem. All scientists must now be looking for the mystery organism.

Begin the **Comparing Ecosystems Worksheet**.

COMPARING ECOSYSTEMS Worksheet

Your team of scientists has chosen to study ecosystems in the temperate deciduous forest biome. Below is a map of Earth. Look at the biome map provided by your teacher and locate the temperate deciduous forest biome. Draw or color the location of the temperate deciduous forest biome on the map.



Do you live in this biome?

You will be part of a team gathering information about either the forest ecosystem or the marsh ecosystem, which are both found in the temperate deciduous forest biome. Using the resources provided by your teacher, try to find the following information about your ecosystem.

Complete the rest of this worksheet by filling in the blanks.

BIOME NAME:_____

ECOSYSTEM NAME: _____

List two of the non-living or physical factors in your ecosystem:

_____

_____

LIVING ORGANISMS – Use the resources provided by your teacher to learn what plants and animals live in this ecosystem. Choose two plants and two animals that live in this ecosystem and write these names in the spaces below. After each name, write a sentence describing something you think is special about each organism.

_____

_____

_____

Also, on a separate piece of paper or in your journal, draw a picture of your ecosystem and show where each of the organisms you listed might be found.
Your two teams have now returned to the spaceship to share information about the temperate deciduous forest biome (the forest ecosystem and the marsh ecosystem).

Based only on your observations and information you collected so far, how many of the original eight clues do you now know the meaning of? (circle the ones you know)

INVADER EARTH BIOME ECOSYSTEM ORGANISM

COMMUNITY MARSH PURPLE

Have you identified the mystery organism? If yes, how did you find it? If not, what is your next step in trying to find it?

NAME OF MYSTERY ORGANISM: _____

 Stop reading. **END OF LESSON TWO.**

Lesson Three: Community Relationships

You have learned that the Earth is divided into biomes and that each biome has a variety of ecosystems. One other term you need to know is "community." A community is simply all the living organisms in an ecosystem. The forest community includes all the plants and animals that live in the forest ecosystem, such as trees, ferns, squirrels, woodpeckers, forest insects and hundreds more organisms. The marsh community includes all the plants and animals in the marsh ecosystem such as muskrats, red-winged blackbirds, dragonflies, snails, cattails, sedges and many more. All of the organisms in a community depend on one another for food, shelter, nesting sites and other things.

Read this short story about a chipmunk in the forest community.

It was late fall, and a chipmunk was busy preparing for the long winter ahead. The chipmunk was gathering beech seeds and acorns and storing them in its underground home beneath a large maple tree. Chipmunks don't hibernate, so they need plenty of stored food to last through the winter. In its search for seeds, the chipmunk had found a moth cocoon, which it was eating when it heard the warning call of a blue jay. The chipmunk dropped the cocoon and quickly hid in an old woodpecker hole in a nearby tree. Moments later, a hawk swooped through the woods, grabbed the blue jay with its sharp talons and, after a short struggle, flew off with the dead blue jay. The chipmunk might have been the hawk's meal instead of the blue jay if it hadn't quickly escaped into the tree. After the hawk had gone, the chipmunk gathered some of the blue jay feathers that had been left behind and used them, along with some grasses and deer hair it found in the woods, to build a warm underground nest to help it survive the winter.

In this short story, the chipmunk has interactions with many other members of the forest community. Each one of these interactions is called a relationship. The chipmunk has a relationship with the beech and oak trees that make the beech seeds and acorns that the chipmunk eats. It has a relationship with the caterpillar that made the cocoon that it was eating. The roots of the large maple tree hold the soil together; this allows the chipmunk to make underground tunnels, so the chipmunk has a relationship with the maple tree. The chipmunk has two relationships with the blue jay. One is hearing the blue jay warning call, which helped the chipmunk escape from the hawk, and the other is using the blue jay feathers in its nest. The chipmunk also has a relationship with the woodpecker that made the hole in the tree where the chipmunk hid from the hawk. The chipmunk has relationships with the grasses and the deer because it used parts of them to build its nest. The chipmunk also has relationships with non-living factors such as the air it breathes, the soil that it walks on and burrows into, and the water it drinks. As you can see, the chipmunk depends on many other organisms and non-living factors to survive. This is true for all living organisms, including humans. Remember, a community is all the organisms in an ecosystem, and an ecosystem is a group of interacting organisms and the non-living factors that affect them. Now it is your turn to find relationships. On the Relationships Worksheet is another short story about organisms. Carefully read the story and see how many relationships you can find.

Complete the **Relationships Worksheet.**

RELATIONSHIPS Worksheet

Read the following short story about the marsh ecosystem. At the bottom of the worksheet, list as many relationships as you can find in the story.

It was a warm summer day in the marsh. A deer was grazing on grasses along the edge of the marsh and a muskrat was eating the stems of the many cattails. The muskrat was using some of the cattail leaves to build a house with an underwater entrance where it would raise its young. An adult leaf beetle, which had spent the winter buried in the soil, had emerged and was crawling up the stem of a purple loosestrife plant. This was a female beetle and she was laying small clusters of eggs on the stem. Some of the eggs laid by another beetle had already hatched and the tiny larvae were feeding on the purple loosestrife leaves. A spider had built a web between the purple loosestrife plant and a cattail. A small moth and a couple mosquitoes had already been captured in the web and the spider was busy eating the moth. A ladybird beetle had also found the purple loosestrife plant and it was eating the leaf beetle larvae when a red-winged blackbird flew in, grabbed the ladybird beetle, and flew to a nearby group of cattails. The blackbird had a nest made of sedge and grass leaves that were woven around the cattail leaves. The blackbird fed the ladybird beetle to one of the baby birds in the nest. Near the blackbird nest, a painted turtle was sitting in the sun on top of a big branch that had fallen into the marsh from a nearby willow tree.

Make a list of the relationships you can find in this story (use the back of the worksheet if you need more room).

Did you find any relationships between organisms and nonliving factors?

Stop reading. **END OF LESSON THREE.**

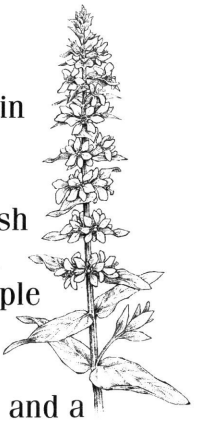
Lesson Four : Food Chains

By now, your team of scientists has learned the meaning of the clue "purple" and have identified the mystery organism as purple loosestrife, a plant that lives in the marsh community. You are now interested in learning more about the marsh and other communities. There are many types of interactions and relationships between organisms in each community. Although each community has a different set of organisms, such as the marsh community and the forest community, all communities have certain relationships in common. We are going to learn more about several special types of relationships that are found in every community.

Every community has producers and consumers.

Producers are plants that contain chlorophyll (the pigment in plants that makes them green). The amazing thing about these plants is that they can make their own food. The chlorophyll traps energy from sunlight, and along with carbon dioxide from the air and water from the soil, these plants make food through a process called photosynthesis. Remember, producers (green plants) are the only things on Earth that can make their own food. Animals are never producers.

Consumers are animals, which cannot make their own food and depend on producers for food. There are different types of consumers. A herbivore is a consumer that eats only plants. A carnivore is a consumer that eats only animals. An omnivore eats both plants and animals. Are you a herbivore, a carnivore or an omnivore?



An example of a herbivore in the forest would be a red squirrel, which eats seeds and a herbivore in the marsh would be a muskrat, which eats cattail roots. An example of a carnivore in the forest would be a scarlet tanager, which eats caterpillars, and a carnivore in a marsh would be a dragonfly, which eats other insects. An example of an omnivore in the forest would be a black-capped chickadee, which eats both insects and seeds, and an omnivore in the marsh would be a painted turtle, which eats both aquatic plants and small animals such as snails and insects.

When carnivores or omnivores capture and kill other animals for food, they are called predators. The animal that is killed and eaten is called the prey. This is called a predator-prey relationship. When carnivores or omnivores eat animals that are already dead, they are called scavengers.

If you eat a hot dog on a bun, which of the following terms would apply to you?

Circle the words which would apply.

Producer	**Consumer**	**Herbivore**
Omnivore	**Carnivore**	**Predator**
Prey	**Scavenger**	

Can you explain why you circled certain words?

_____

_____

_____

_____

Each time one organism is eaten by another organism, a relationship exists. A food chain is a special way of looking at these relationships. Let's look at a food chain with three links.

GRASS ➠ MOUSE ➠ HAWK

This shows that the grass was eaten by the mouse and the mouse was eaten by the hawk. The hawk is at the top of this food chain, so it is not eaten by anything. Let's look at another example.

ALGAE ➠ SNAIL ➠ WATER BEETLE ➠ MINNOW ➠ PERCH ➠ LAKE TROUT ➠ HUMAN

We can look at each link in the food chain and learn what it eats and what eats it. For example, the minnow eats the water beetle and is eaten by the perch. You may have noticed that the first link in a food chain is always a producer, because producers are the only organisms that can make food. Remember, producers get their energy from the sun. All the other links are consumers. The number of links in a food chain depends on how many consumers are involved. Can you use some of the new terms you learned to describe parts of the food chain? Which organism in the above food chain is a herbivore? Which are carnivores? Are there any predator-prey relationships? As you can see, you can learn a lot about relationships in a community by making and looking at food chains.

All the scientists from Planet _____ have now returned to the spaceship with information on the forest ecosystem and the marsh ecosystem (from Comparing Ecosystems Worksheet in Lesson #2). Your next task is to take the information you gathered in the ecosystems and try to understand more about how the organisms interact with one another and about some of the relationships within each community.

 Next do the Food Chain Card activity.

Congratulations! Your mission to explore Earth has been very successful. The only clue that you may not have learned the meaning of is "INVADER." We will learn more about the meaning of this word in the next section. You will now return to Planet _____ and report your exciting discoveries about life on Earth.

 Stop reading. **END OF PART ONE.**

Part Two Invasion of Purple Loosestrife

Lesson One : Invasion Discovered

To begin, read the following newspaper article.

Aliens Invade the Midwest

Anytown, USA

Biologists have discovered that millions of aliens have invaded much of North America, including the Great Lakes region, and that this invasion has been going on for over 100 years! The biologists who have seen the aliens also have discovered that large numbers of aliens, some of them 7 feet tall, are living in marshes and swamps, along shorelines and in other wetland areas. Although the aliens appear to be harmless, their numbers are growing out of control. In some wetlands, the aliens have killed many native plants and have forced many of the native animals to leave. What can be done to stop this invasion?

Stop reading and complete the **Invading Aliens Worksheet**.

INVADING ALIENS Worksheet

After reading the newspaper article "Aliens Invade the Midwest" in your student workbook, you may be interested in finding out more about this invasion!

You and the other students will become newspaper reporters. As reporters, you will find out more about the invasion by questioning one of the biologists who discovered the aliens.

Think of five questions you would like to ask the biologist and write these questions in the blanks on this worksheet (don't worry about the answers right now).

Question 1 - _____

_____

Answer:

Question 2 - _____

_____

Answer:

Question 3 - _____

_____

Answer:

Question 4 - _____

_____

Answer:

Question 5 - _____

_____

Answer:

 Stop reading. **END OF LESSON ONE.**

Lesson Two - Press Conference

The newspaper article "Aliens Invade the Midwest" has caused much concern and raised many questions. To answer these questions, a press conference has been scheduled between a group of reporters and one of the biologists who discovered the invasion. You and the other students are the reporters. A written copy of the questions you will be asking the biologist in the press conference is below. Listen closely to each question and answer. There is space after each question for you to take notes. You will use your notes to write an article about the invasion.

QUESTIONS ASKED BY REPORTERS
(read questions in order given):

Have you seen the aliens?

_____

_____

What do they look like?

_____

_____

How big are they?

_____

_____

This sounds scary! Do we have to worry about being attacked?

_____

_____

_____

_____

Where are these aliens from?

_____

_____

From Earth! I thought aliens were like little green men from Mars.

_____

_____

What does "native" mean?

_____

_____

How can a plant or animal become an alien?

So, how can an alien organism survive?

Can you give me some examples of real aliens?

Does it have something to do with biomes?

You said that most alien organisms in North America are native to Europe. How did these plants and animals get across the Atlantic Ocean to North America?

You said that the Midwest is being invaded by aliens. What do you mean by "being invaded"?

You have given different meanings to the words "native," "alien" and "invader." Are there any other words we need to know to understand what is going on with this alien invasion?

So, what are these 7 foot-tall, purple and green organisms that are invading the Midwest?

 Stop reading and get instructions from the teacher.

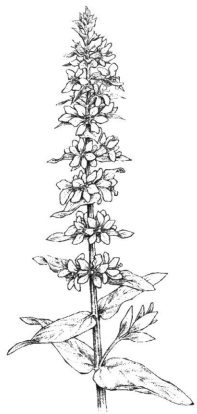
YOU ARE A JOURNALIST Worksheet

A journalist is a person who gathers information and uses the information to write articles, such as newspaper and magazine articles or TV news reports. During the press conference, you gathered information on an alien invasion. You now know that the exotic invader is a plant called purple loosestrife. Now it is time to organize your notes and to write a newspaper article on the invasion. Begin your article below. If you need more room, continue on another piece of paper.

See your teacher for instructions before beginning the article.

TITLE OF ARTICLE: _____

Lesson Three - A Trip Across the Ocean



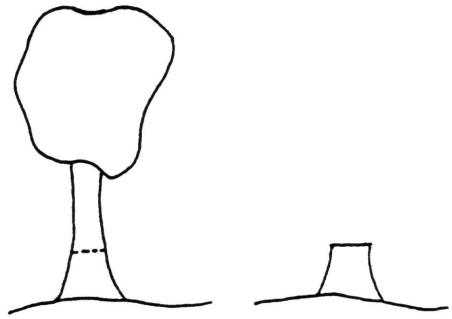
Purple loosestrife was brought from Europe to the Atlantic coast of North America in the early 1800s. Because purple loosestrife is a wetland plant, it grew near the seaports in Europe where ships would come and go. Some ships would load sand or water from these seaport areas to add weight. This extra weight, called ballast, helped the ships sail better. Since purple loosestrife grew in these seaport areas, the sand and water sometimes contained tiny purple loosestrife seeds. When the ships arrived in North America, they would dump the sand and water ballast and any purple loosestrife seeds that it contained. These seeds could then grow in their new home. Some purple loosestrife plants were brought to North America on purpose by people who used the plant as medicine or as flowers for honeybees. Purple loosestrife was common on the Atlantic coast of North America by 1830. Many people planted it in their gardens because of its pretty purple flowers.

How did purple loosestrife get from the Atlantic coast of North America to the Great Lakes region? You have to remember that in the early 1800s, there was no easy way for people to travel inland from the Atlantic Ocean. People didn't have cars or airplanes. Their main transportation was by non-motorized boats and barges, so they began building canals. A canal is like river but it is made by people. By 1840, there were more than 3,000 miles of canals connecting the Atlantic Ocean and inland areas. The most famous canal was the Erie Canal, which connected Lake Erie with the Hudson River. Boats and barges traveling the canals were used to transport people, farm animals, lumber, coal, grain and other materials needed to make new settlements in the Midwest. They also provided purple loosestrife seeds an easy way to spread, and by 1900, purple loosestrife had spread to many wetlands in the Great Lakes region and beyond.

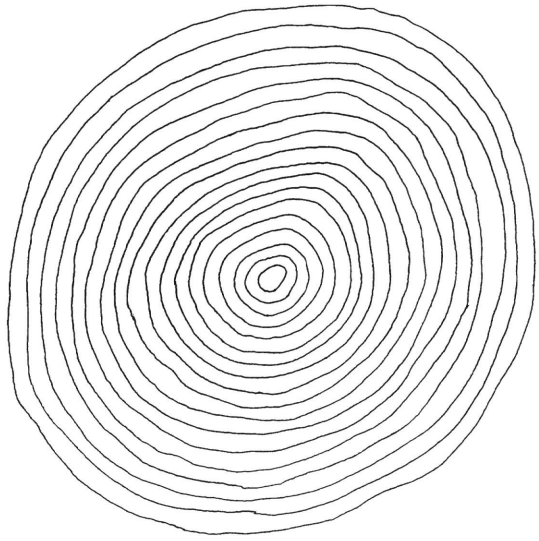
Stop reading and complete the **Tree Time Line Worksheet**.

TREE TIME LINE Worksheet

On this worksheet, you will learn about the invasion of purple loosestrife by making a tree time line using a cross-section of a tree trunk. What is a cross-section? For example, this is a drawing of a tree that is 10 years old. Imagine that someone cut this tree down by sawing it along the broken line. If you looked at the top of the stump (or the end of the tree trunk where it was cut), you would be looking at the cross-section of that tree trunk.



If you looked carefully at the cross-section of the tree, you would see many circles or rings of various sizes as shown in the drawing your teacher gave you. As trees grow, they form a new growth ring every year, so a 10-year-old tree would have 10 growth rings. The smallest (center) ring would have grown during the first year of the tree's life. The biggest (outer) ring would be the most recent growth or the last year of the tree's life (or the year the tree is cut down). If you know what year the tree was cut down, you can label each of the growth rings by year. After the growth rings are labeled by year, you can add important events that happened during these years. This is a tree time line.



Now it is your turn to create a tree time line.

MAKING YOUR OWN TREE TIME LINE

Your teacher has a drawing of a cross-section of an 18-year-old tree. This tree was cut down in 1997. To make your own tree time line, follow these directions.

First, label each growth ring with the year it grew. Remember, the biggest ring is the year the tree was cut down, and the small center ring is the year the tree began growing.

Find the ring labeled with the year you were born and label it as your birth year.

Make a list of other important events that happened during these years and write the events on the correct growth ring.

Here are some ideas to get you started:

- birth years for brothers, sisters, friends or pets.
- favorite vacations.
- years you moved to a new house, city or school.
- the year you started school.
- years your favorite sports team won a championship.
- the year you lost your first tooth.

Can you think of more?

Stop reading. **END OF LESSON THREE.**

LESSON #4: CYCLES

A cycle is a special way of organizing and looking at information. Let's look at an example.

CYCLES Worksheet

Below is a list of events that happen every year. Your first task is to fill in the blanks after each event with the correct date (a calendar may help).

Your birthday _____

A friend's birthday _____

New Year's Day _____

Independence Day _____

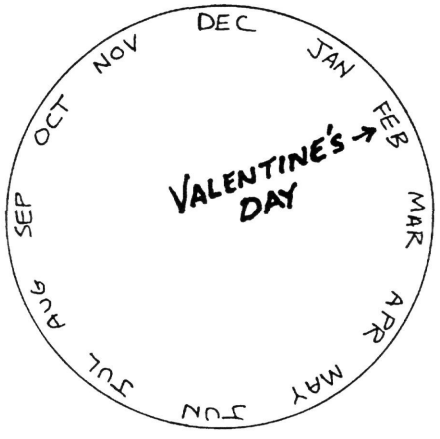
Christmas _____

St. Patrick's Day _____

Valentine's Day _____

Day of the year with the most daylight _____

Day of the year with the least daylight _____After you have filled in the blanks, get a paper plate from your teacher and label it like the drawing below.



After you have labeled the paper plate, transfer all the dates from the list above to the correct location on the plate (as shown in the drawing).

Congratulations! You have just created a cycle.

Because the cycle you made shows events that happen every year, it is called an annual cycle or yearly cycle.

Here are some other things you can do with your cycle and some questions to answer.

Draw an arrow on your plate to show the direction of your cycle. Does this cycle ever go in the opposite direction?

❑ Yes ❑ No

Compare your cycle with the cycles of other students. If you line up your birthday with other students' birthdays, do the other dates match?

❑ Yes ❑ No

Does a cycle have a beginning or an end? Do you have to start at any particular place in the cycle?

❑ Yes ❑ No

In Lesson #3 you made a tree time line. What is the difference between a time line and a cycle?

_____

_____

_____

_____

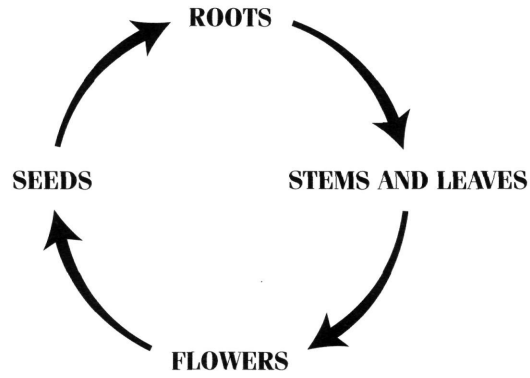
Can you make another cycle using one day instead of one year?

Stop reading. **END OF LESSON FOUR.**

Lesson Five - Life Cycles

A cycle is a special way of looking at information. One type of cycle is called a life cycle. Life cycles are used to show the stages of an organism's life. In this lesson, we will learn more about the life cycles of plants. Some plants have flowers (even though the flowers may be hard to see), and some plants, such as mosses and ferns never have flowers. We will be learning about the life cycles of flowering plants.

All flowering plants have several stages in their life cycle. The main stages are roots, stems, leaves, flowers and seeds. These stages can be arranged as shown below. The arrows show the direction of the cycle.



Let's think about the life cycle of a flowering plant you are already familiar with: a corn plant. Have you ever eaten corn on the cob? Each of the little yellow kernels of corn you eat is actually a corn seed. If you bought corn seeds and planted a seed in the soil, the seed would first make a small root. This root would attach the plant to the soil, take water from the soil and send the water to all parts of the plant. Next, the tiny corn plant would grow a stem and leaves. The roots, stem, and leaves would continue to grow and, after growing for two to three months, the corn plant would make tiny flowers. These flowers would then develop into clusters of seeds (which we call corn on the cob). So, the life stages of corn plants are seeds, roots, stem and leaves, flowers, then back to seeds again. This is the life cycle of a corn plant.

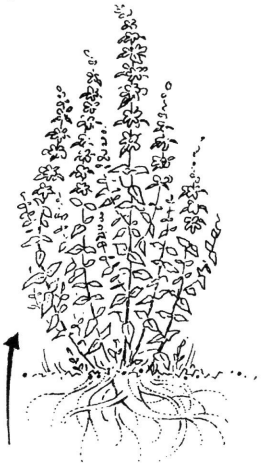
Each corn plant lives less than one year and goes through its entire life cycle in that time. This kind of plant is called an annual plant. Some flowering plants, such as carrot plants, take two years to complete their life cycle, so they are called biennial (two-year) plants. Many flowering plants, such as trees, live for many years and are called perennial plants. Every kind of plant has a life cycle.

Now that you know a little about life cycles of flowering plants, let's learn more about purple loosestrife and its life cycle. The drawings on the next two pages give information on the stages in the life cycle of purple loosestrife. Look at the drawings as you learn about loosestrife's life stages.

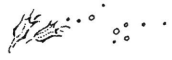
LIFE CYCLE OF PURPLE LOOSESTRIFE

Purple loosestrife is a perennial plant. This means that one plant can live for many years. The life cycle below shows a purple loosestrife plant during the first two years of its life.

The plant gows bigger during the summer and grows flowers in the late spring.



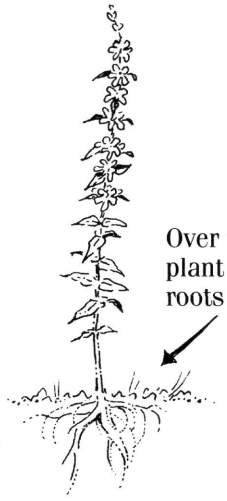
Flowers on the plant make seeds.



Seeds made by the flowers of a purple loosestrife plant find their way to a wetland.

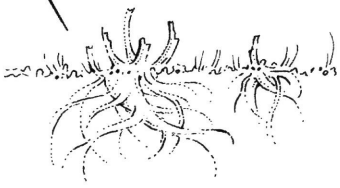
In the spring, a seed begins to grow into a seedling with roots, stems and leaves.

Over the first summer, the plant grows bigger with more roots anleaves.



In the fall, the stems and leaves of the plant die. Some of the food made by the leaves during the summer is stored in the roots.

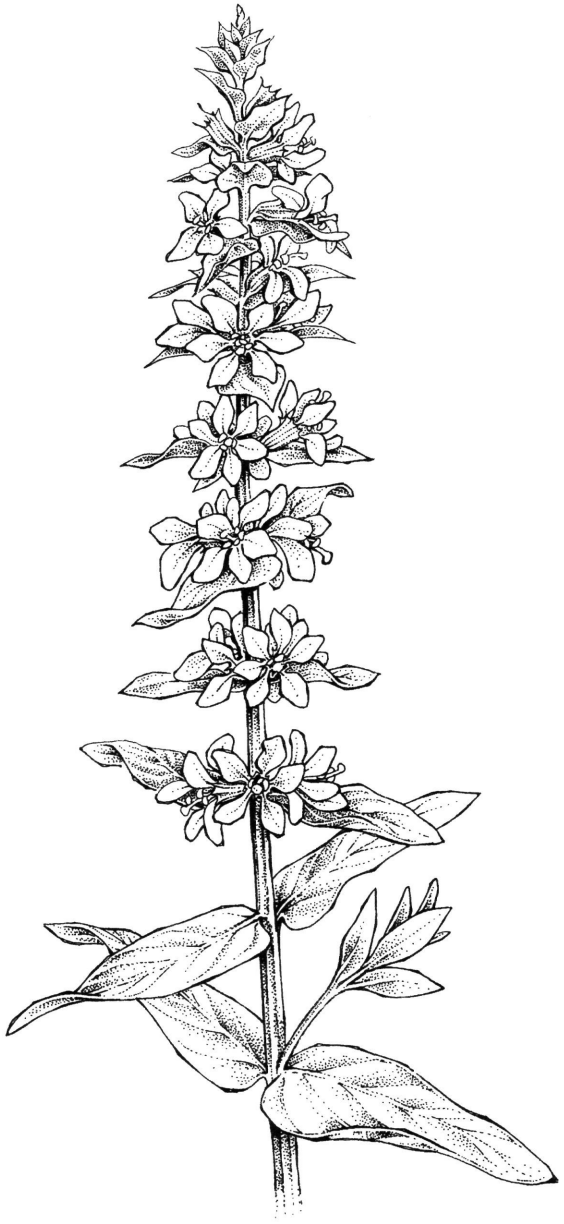
Only the roots live through the winter



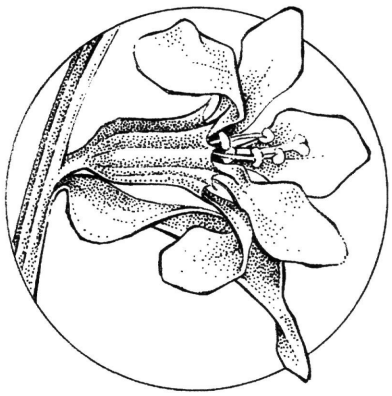
In the next spring, the plant uses the food stored in the roots to grow new stems and leaves.

LIFE CYCLE OF PURPLE LOOSESTRIFE

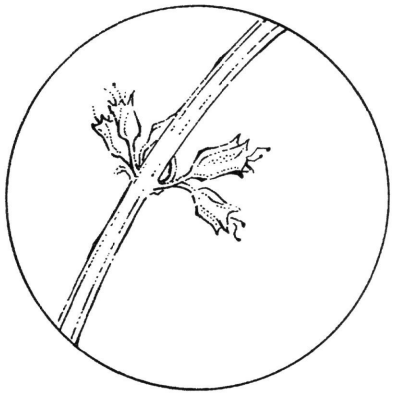
The drawings on this page show the parts of an older purple loosestrife plant in more detail.



The top of a purple loosestrife stem showing leaves and flowers.



A close-up of a flower.



A close-up of a seed capsule.

A mature crown removed from the soil.

Stop reading and discuss the life cycle of purple loosestrife with your teacher.

Now it's time to take a closer look at the life stages of purple loosestrife. We will learn more about the roots, stems, leaves, flowers and seeds of purple loosestrife and of other flowering plants you may be familiar with. One very important thing to remember is that all the life stages of any plant have one main purpose: to help the plant survive. The first stage we will learn about is roots.

ROOTS 

How do roots help flowering plants survive?

- Roots attach the plant to the soil so it will stay in one place and not be blown away by the wind or washed away by rain.
- Roots take in water and minerals from the soil that are used by the stems, leaves, flowers and seeds of the plant.
- For plants that live more than one year (biennials and perennials), roots store food that the plant uses later to grow stems, leaves, flowers and seeds.

What do roots look like?

Look at a plant's roots. All the roots of one plant form its "root system." Every kind of plant has a slightly different root system. Two common types of root systems are taproots and fibrous roots.

Plants with a taproot system have one big root that goes deep down in the soil. Smaller roots grow out the sides of this big root. Have you ever eaten a carrot? The orange part of a carrot, the part we eat, is a taproot, and we are eating food that the carrot plant has stored in this taproot. If the carrot taproot was left in the ground, it would use that food to grow stems, leaves, flowers and seeds. One carrot plant takes two years to complete its life cycle, so carrots are called biennials.

Plants with a fibrous root system have many roots of various sizes from large main roots to very small roots. The roots are like the branches in a tree - smaller roots branch off of larger roots. Fibrous roots go in many directions in the soil. The tomato plant is an example of a plant with a fibrous root system.

Some plants, such as walnut trees, have both a taproot and fibrous roots.

What kind of root does purple loosestrife have?

First of all, purple loosestrife plants are perennial plants, like trees - they can live for many years. In purple loosestrife, however, the stems and leaves die every fall but the roots remain alive through the winter. So the roots are very important for purple loosestrife to survive. Purple loosestrife has a special kind of root system called a root crown. Instead of growing just one stem, many stems can grow from one root crown. Look at the life cycle of purple loosestrife drawings to see what the root system looks like.

Although a plant makes roots to help it survive, many organisms (including humans) have learned to use roots in a variety of ways. Some of these include:

- People like to eat the roots of some plants such as carrots, sweet potatoes, radishes and beets. These roots are actually food stored by the plant to use later.
- Much of the sugar we eat also comes from a root: the sugar beet.
- Some animals eat roots.
- Some animals, such as certain insects, will burrow into the soil and live on roots.

  Examples of insects that live on roots are root maggots (flies) and corn root worm (beetle).
- Roots also help hold the soil together and so make it easier for burrowing animals such as chipmunks to make underground burrows.

All of these are examples of relationships that organisms have with plant roots.

 Now complete the **Roots Worksheet**.

ROOTS Worksheet

You have learned about the roots of a carrot plant (taproot system) and a tomato plant (fibrous root system). Below are drawings of these two plants, but the drawings show only the plant parts above the ground. It is your job to read the descriptions and then draw the underground root systems.

CARROT

TOMATO

DESCRIPTIONS

TAPROOT - Plants with a taproot system have one big root that goes deep down in the soil. Smaller roots grow out the sides of this big root.

FIBROUS ROOTS – Plants with a fibrous root system have many roots of many sizes, from large main roots to very small roots. The roots are like the branches in a tree - smaller roots branch off from larger roots. These fibrous roots go in many directions in the soil.

Your teacher has a purple loosestrife plant. The root crown which is planted in the pot was dug out of a wetland in October,after the stems and leaves had died. This root crown is about 4 years old.

Look at the picture of the root crown on the life cycle of purple loosestrife drawings and draw a picture of it in the space below.

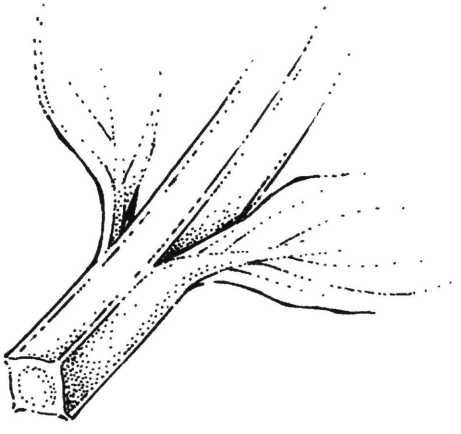
STEMS

How do stems help flowering plants survive?

- Stems form a strong frame to support the above-ground part of the plant, including leaves, flowers and seeds.
- Stems carry water and minerals from the roots to the leaves, flowers and seeds.
- Stems carry food made by the leaves to flowers, seeds and roots.

What do stems look like?

Stems come in many sizes, shapes and colors. A large oak tree, for instance, has a large stem (the trunk), which supports smaller stems (branches), which support even smaller stems (twigs). If you look at cross-sections of stems, some are round, some are square and some are like a triangle. Some stems are hollow, while others are solid. Some stems are hard and stiff; others are soft and flexible. Some stems even have thorns, which may protect the plant from being eaten by animals.



What kind of stems does purple loosestrife have?

In the spring, the root crown of purple loosestrife will begin to grow new stems. These stems can grow to be seven feet tall by the end of summer, and each main stem will have many smaller side stems, leaves, flowers and seeds. The main stems of purple loosestrife are about 1/2 inch wide and square in cross-section. Because these stems grow from a root crown, the stems are clustered together.

Though plants make stems to help them survive, many organisms have learned to use stems in a variety of ways. Here are just a few.

- Many mammals eat stems (deer, mice, voles, beavers, rabbits, some insects).
- People eat stems such as asparagus and rhubarb.
- Some animals, especially insects, will live inside stems. Examples of such insects include the European corn borer (moth) and the pine weevil (beetle).
- Some birds (such as the cardinal) will use stems in nest building. Small stems are used to build the nest and many nests are attached to larger stems.
- Some animals use hollow cavities in large stems (tree trunks) for nests or shelter (woodpeckers, squirrels, owls, raccoons, porcupines).
- People have many things made from wood, such as houses, furniture and toys. All wood comes from stems.

All of these are relationships that organisms have with stems of plants.

LEAVES

How do leaves help flowering plants survive?

When you studied food chains, you learned that the leaves of plants can make their own food. These plants are called producers. Producers have a green pigment called chlorophyll, which traps the energy from sunlight, and uses it along with carbon dioxide from the air and water from the soil, to make food. This is called photosynthesis. This remarkable food-making process that all other living organisms depend on for their food, mostly happens in leaves of plants. So, leaves help a flowering plant survive by trapping sunlight and making food through photosynthesis. Each leaf is like a small food factory. This food travels through the stems of the plant to make more leaves, flowers, seeds and roots. Some plants store this food in the roots during the winter.

What do leaves look like?

Every kind of plant has a different kind of leaf. There are many thousands of kinds of flowering plants on Earth, so there is a huge variety of leaves. Leaves vary in size, shape, thickness and color. Some leaves are smooth, while others are covered by wool, hairs or wax. You are probably familiar with many leaves, such as maple and oak leaves. Did you know that cactus spines and pine needles are also leaves?

Go back to the drawing of purple loosestrife on page 39 and look carefully at the leaves. On the lines below, describe the purple loosestrife leaves in as much detail as you can. Include size and shape and how the leaves are attached to the stem.

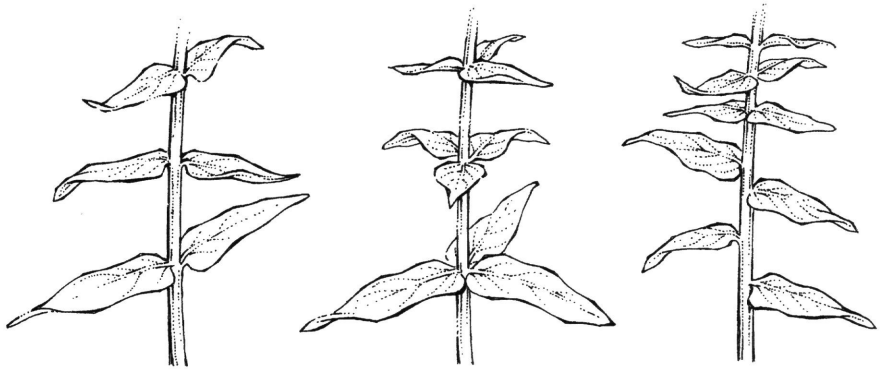
 After you are finished describing the purple loosestrife leaves, continue reading.

Plant leaves can be arranged along the stem in many ways. Look at the two drawings below. The drawing on the left shows a plant with leaves without leaf stems. It also shows leaves that are growing opposite each other. "Opposite" means the leaves are growing in pairs and each leaf has another leaf growing directly across from it on the stem.

The drawing on the right has leaves with leaf stems. This drawing also shows leaves that are not growing opposite each other. They are not growing in pairs. This is called an alternate leaf arrangement. Can you see the difference?

What kind of leaves does purple loosestrife have?

Purple loosestrife leaves are green and covered with very small hairs. One tall purple loosestrife stem will have about 50 leaves, and each leaf is about 4 inches long and only about 1/2 inch wide. The leaves do not have leaf stems. Purple loosestrife leaves can be found growing along the stem in several ways. Look at the drawings of purple loosestrife stems and leaves below. The drawing on the left shows leaves that are growing opposite each other in pairs. The center drawing shows leaves growing in whorls of three. The drawing on the right shows a purple loosestrife stem that has some leaves growing opposite and some growing alternate. Look at your purple loosestrife plant and see how the leaves are arranged.



Plants make leaves to help them survive, but many organisms have learned to use leaves in a variety of ways. You have already learned how other organisms use roots and stems. Can you list three relationships that organisms have with leaves?

1. _____

2. _____

3. _____

There are many relationships that organisms have with leaves.

- Many animals eat leaves. In fact, there are leaf eaters in most groups of animals. There are many mammals (deer, elephants, giraffes, mice, woodchucks, rabbits), some birds (grouse, geese) and reptiles (turtles). A huge number of insects eat leaves. Some chew the leaves (leaf beetles, moth and butterfly caterpillars), while others suck the juices from leaves (plant bugs, aphids).
- People also eat leaves such as spinach, lettuce and cabbage.
- Some insects live inside leaves. They either burrow inside the leaf, like the birch leaf miner (a moth), or some will curl the leaf around them, like the apple leafroller (a moth).
- Many animals - such as squirrels, chipmunks, voles and many birds - will use leaves to build nests.
- Leaves provide shade and shelter that some animals and plants need.
- Dead leaves add humus to the soil, making it more fertile for new plants to grow.
- Many organisms (worms, insects, fungi) also live on this humus.

All of these are relationships that organisms have with leaves of plants.

 Stop reading and complete the **Stems and Leaves Worksheet**.

STEMS AND LEAVES Worksheet

This worksheet will help you understand how roots, stems and leaves are connected and how they all work together to help plants survive. Begin by reading this short story.

Leaves are food factories. Leaves can make food because of the green stuff in leaves called chlorophyll. To make food, leaves also need water, carbon dioxide and energy. Plants get water from rain, which soaks into the soil and is taken up by roots. The water travels through the roots and into the stems and leaves. Carbon dioxide is an invisible gas found in the air around the plant. The leaves take carbon dioxide from the air into the leaf through tiny holes in the leaf surface. The leaves get energy from sunlight.

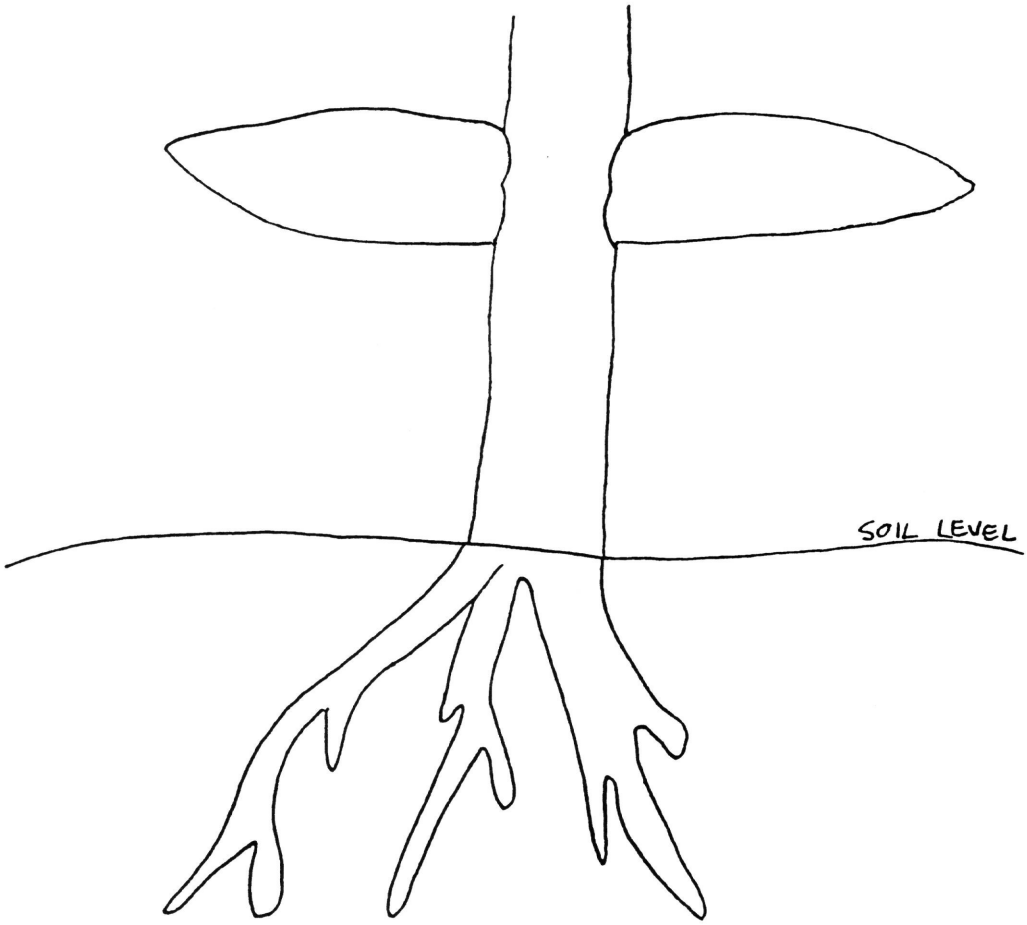
Food is made inside the leaf and is sent to other parts of the plant through the stems. This food is used by the plant to grow. At the same time these leaves are making food, they also make oxygen. The oxygen is sent into the air through holes in the leaves.

The drawing on the next page of the worksheet shows a close-up of the roots, a stem and two leaves of a purple loosestrife plant. Your task is to take the food factory information and use it to finish the drawing. Use arrows and labels to show the movement of the various things the plant uses and makes.

Continue on page 2 of worksheet.

THE PURPLE LOOSESTRIFE FOOD FACTORY

Using the information from the story on page 1 of this worksheet, finish this drawing in as much detail as you can.



Your food factory drawing shows **photosynthesis**. Photosynthesis is the process all plants use to make food and oxygen. Photosynthesis can also be shown in the following way.

WATER (from soil)	+ **CARBON DIOXIDE** (from the air)	➡	**LEAF** (with chlorophyll and sunlight)	➡ **FOOD + OXYGEN** (plants and animals need food and oxygen to survive)

FLOWERS 

How do flowers help plants survive?

Plants make flowers for one reason: to make seeds. But before a flower can make a seed, something has to happen to that flower. Pollen, which is made by flowers, usually must be transported from the flower of one plant to the flower of another plant before a seed can be made. This is called pollination. Pollen, however, cannot move by itself. Can you guess how pollen moves from one flower to another?

Your Guess_____

_____

_____

There are two main ways that pollen can travel from one flower to another.

One way pollen moves from one flower to another is by floating in the wind. Flowering plants that depend on the wind for pollination are called wind-pollinated plants. The pollen made by the flowers of wind-pollinated plants is very small and light weight so it can easily float in the wind. Pollen can travel for miles in the wind. There is so much pollen in the air that a few of the pollen grains will likely fall on a flower of another plant so seeds can develop. This is how corn flowers, evergreen trees and many other plants are pollinated. If the pollen from a corn flower landed on the flower of an evergreen tree, no seed would be made. It has to be the pollen from the exact same kind of plant for a seed to develop. So, to make corn seeds, pollen from one corn plant must land on the flower of another corn plant. Most of the pollen in the air never falls on another flower. It just lands on the ground and does not help make seeds.

Do you or any other students in your class have allergies or hay fever? Many people are allergic to pollen. During certain times of the year, many kinds of pollen may be in the air at the same time. All of us breathe in pollen, but only some of us are allergic to it.

The other way that flowering plants are pollinated is by animals called pollinators. Pollinators are mostly insects (especially bees, butterflies, moths, flies and beetles), but there are also some birds (hummingbirds) and some bats that pollinate flowers. Flowers from these kinds of plants are often easy to see, colorful, fragrant and come in a huge variety of shapes and sizes. These flowers look and smell the way they do for only one reason: to attract pollinators so the flowers can make seeds. Let's use a butterfly as an example. Many butterflies feed on nectar, (a type of sugar water) made by and found inside flowers. Before the butterfly can get the nectar, it must find the flower. Plants make flowers that are big, colorful and fragrant so it is easy for the butterfly to find them. Once the butterfly finds the flower, it gets its reward: a drop of sweet nectar. Although the butterfly doesn't know it, it also picks up some pollen from that flower. Pollen from this kind of plant is usually sticky so it will stick to the bodies of pollinators. After the butterfly eats the nectar from one flower, it flies to another flower for more nectar and the pollen, that is stuck to the butterfly gets moved from one flower to another. The flowers are pollinated and seeds can develop.

Although people enjoy flowers because of their beautiful shapes, colors and smells, plants do not make flowers for people.

Plants make flowers to attract pollinators so the flowers can make seeds.

The flowers of wind-pollinated plants are usually small and hard to see. They are not colorful and do not have strong odors. Can you guess why?

Guess _____

_____

What do flowers look like?

Everyone has seen flowers. Flowers come in a huge variety of colors, sizes, shapes and odors. Many flowers are seldom seen by most people. Some are very small without bright colors (like those of most wind-pollinated plants). Some are high in the tops of trees where they are hard to see, while others are hidden by leaves. Do you have a favorite flower?

Look at the life cycle of purple loosestrife drawing page 39 and a color photo of purple loosestrife. Look closely at the flowers and, in the space below, describe the flowers in as much detail as you can. Include size, shape and other features you see.

_____

_____

_____

_____

_____

_____

What kind of flower does purple loosestrife have?

Purple loosestrife has a bright purple flower. Each flower is about 1/2 inch wide and has five or six petals. Each purple loosestrife stem can have hundreds of these flowers, mostly growing near the top of the stem. Purple loosestrife plants make flowers in the summer.

Do you think purple loosestrife is pollinated by the wind or by pollinators; why?

❑ Yes ❑ No

Why? _____

_____

_____

_____

If you said purple loosestrife flowers are colorful so they attract pollinators, you are right. Remember, wind-pollinated plants do not have to attract pollinators, so their flowers are usually small and not colorful.

Many people like purple loosestrife because it has colorful flowers. In fact, you already learned that some purple loosestrife was brought to North America from Europe because people wanted this beautiful plant in their gardens. To some people, a wetland filled with purple loosestrife flowers in the summer can be a beautiful sight. We will learn, however, that purple loosestrife in a wetland makes it hard for many native wetland plants and animals to survive.

 After finishing your description, continue reading.

Plants make flowers to help them survive, but many organisms have learned to use flowers in a variety of ways. Here are just a few:

- Some animals, including some mammals and some insects such as thrips, eat flowers.
- People eat flower buds such as broccoli and cauliflower.
- Some small animals live inside of flowers.
- Some insects eat pollen.
- As you already know, some animals use the nectar made by flowers as food.
- Some spiders sit on flowers and catch pollinators to eat.
- People grow and use flowers because they like the colors, shapes and odors.

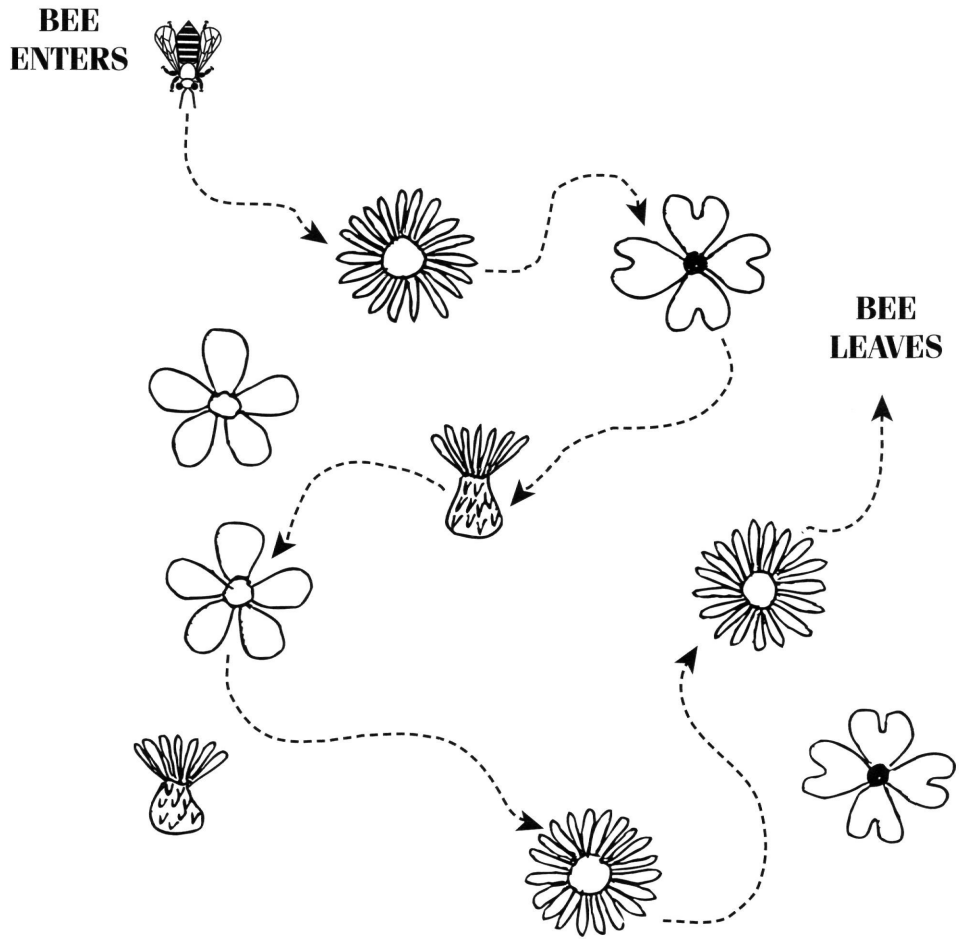
All of these are relationships that organisms have with flowers of plants.

 Stop reading and complete the **Pollination Worksheet**.

POLLINATION Worksheet

Below is a drawing of a field filled with wildflowers. There are four kinds of wildflowers in the field. The only way one of these flowers can make a seed is if a pollinator (the bee) moves pollen from one flower to another of the same kind. The bee enters the field and visits some of the flowers, and then the bee leaves the field. The bee picks up and carries pollen from each flower that it visits. When the bee leaves the field, it is carrying pollen from every flower that it visited.

Follow the path of the bee and color the flowers that can now make seeds because they have been pollinated.



SEEDS 

How do seeds help flowering plants survive?

There is one main way that seeds help a plant to survive. Can you guess what it is?

Your Guess_____

_____

_____

Seeds are a flowering plant's way of making new plants. Every seed has all the material and information it needs to make another plant of the same kind. For example, a seed from a maple tree can grow to be only another maple tree. This is very important for plant survival because, without seeds, there wouldn't be any new plants.

Before most seeds can grow into plants, something must happen: they must travel to a new location. It is important for plants and animals to be able to move around. If plants and animals could not move to new locations, there wouldn't be enough resources (food, water, space) for most to live and grow. It would be too crowded. Plants and animals need to be able to spread to new areas where they can find plentiful resources. Young animals can get from one place to another because they have legs, wings, fins or other ways of traveling to new locations. Young plants (seeds) also must be able to travel to find space to grow. How seeds travel from one place to another is called seed dispersal.

 Stop reading and talk about ways that seeds can travel from one place to another.

Seeds have special ways of dispersal. The most common ways that seeds are dispersed are:

Sticking to animal fur or feathers - Many plant seeds have small hooks or other features that will stick to an animal. The seed travels stuck to the animal and eventually falls in a new location; examples include burdock and Queen Anne's lace.

Floating in the wind - Some plants have special structures that act like small parachutes and can float great distances in the wind; examples include common dandelion, common milkweed and goldenrod.

Being food for animals - Many plants produce seeds with a juicy covering that animals like to eat. The juicy covering is digested by the animal but the hard seed passes through the animal's digestive system and is left in a new location in its droppings. An example of this is an American robin eating a wild grape. The hard grape seeds inside the juicy grape pass through the bird's digestive system and are left in the bird droppings in another location. Other animals will store or bury seeds to eat later. Some of the seeds are never eaten and can grow into new plants where they were stored. An example of this would be a fox squirrel burying acorns (oak seeds), which it digs up later for food. Some of the acorns are never found again by the squirrel, and they grow into new oak trees.

Floating in water - Some wetland plants have seeds that float from one place to another in currents of lakes and rivers or in floods. One example of a floating seed is a coconut.

What do seeds look like?

Every kind of flowering plant has a different seed. This means that there are thousands of kinds of seeds in many sizes, shapes and colors. Have you ever eaten an apple or a tomato? You probably noticed that inside the apple or tomato there are many seeds. Some seeds travel in groups, such as apple or tomato seeds, while other seeds travel alone, such as an acorn or a milkweed seed. The plant parts we call fruits, some vegetables and nuts all contain seeds. Some, like a cherry or a peach, contain a single seed (the pit). Others, like a raspberry or a cucumber, have many seeds.

What kind of seed does purple loosestrife have?

Purple loosestrife has a very small brown seed. Each seed is about the size of the period at the end of this sentence. After purple loosestrife flowers are pollinated, the purple flower petals fall off and a structure called a seed capsule is formed on the stem. (See the life cycle of purple loosestrife drawing on page 39 for a drawing of a seed capsule.) Each seed capsule is about 1/4 inch long and each can contain more than 100 seeds. Each stem can have hundreds of seed capsules.

How does purple loosestrife get from one wetland to another? The seeds of purple loosestrife are mostly responsible for the spread of the plant to other wetlands. The soil in a wetland is usually muddy and sticks to things like the legs of a deer or the feet of a duck or a heron, or to the tires of off-road vehicles or the boots of hunters. Many purple loosestrife seeds are mixed with the wetland soil and are moved to new wetlands by sticking to these things. Some scientists also believe that purple loosestrife seeds can travel by wind, by sticking to the feathers of birds or by being eaten by animals and left in other wetlands in their droppings. Because of these many ways the seeds can travel, purple loosestrife can easily spread from one wetland to another.

Plants make seeds to help them survive, but many organisms have learned to use seeds in a variety of ways. Plants usually make lots of seeds. Let's take a maple tree as an example. One maple tree will make thousands of maple seeds. Only a few of these seeds will grow to become another maple tree, so there are lots of extra seeds. Many of the extra seeds made by plants are used by animals. Here are a few examples:

- Many animals, including human beings, eat seeds.
- Some small animals, especially insects, such as grain moths and seed weevils (a beetle) live inside some kinds of seeds.
- Some birds will line their nests with soft seeds (such as thistle or milkweed seeds).

All of these are relationships that organisms have with seeds of plants.

Stop reading and complete the **Seed Dispersal** Activity. Get instructions from your teacher.

Now complete the **Purple Loosestrife Worksheet.**

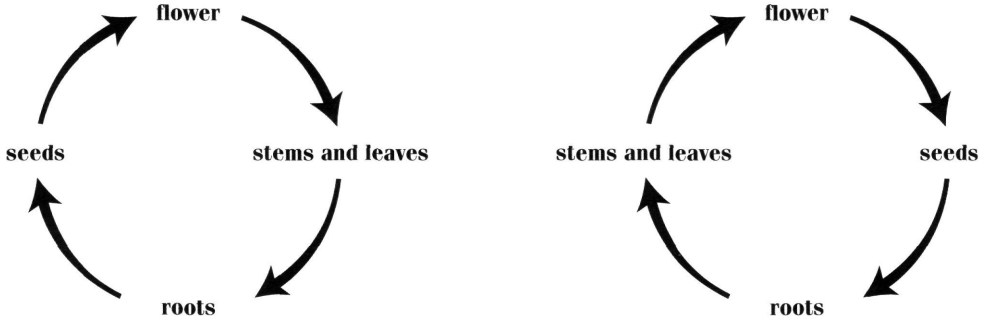
PURPLE LOOSESTRIFE Worksheet

You have learned about the stages of the life cycle of purple loosestrife. On this worksheet, you will review some of the most important information about purple loosestrife. Try to answer the questions from what you remember. If you don't remember, you can look for the answers in your workbook.

1. Purple loosestrife is a: (circle the correct answer)

   flowering plant non-flowering plant

2. Which of the following life cycles is drawn correctly? (circle the correct one)



3. Each stage of a plant's life cycle helps it survive. Try to match the stages below with the statement that tells how it helps the plant survive (draw a line from the stage to the correct statement).

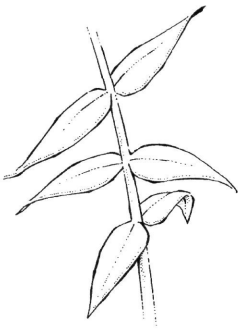
STAGES	STATEMENTS
Flowers	Attach the plant to the soil.
Seeds	Support the plant above the ground.
Leaves	Make food for the plant.
Stems	Make seeds.
Roots	How a plant travels to new places.

4. One purple loosestrife plant can grow for many years. Circle the word below that describes this type of plant.

   ANNUAL PERENNIAL BIENNIAL

5. Draw a cross-section of a purple loosestrife stem. Make it the size and shape of a real stem.

6. Which of the following drawings looks more like the leaves and stem of a purple loosestrife plant? (circle the correct drawing)



7. What color are the flowers of purple loosestrife? _____

Purple loosestrife flowers are pollinated by: (circle the correct word)

WIND INSECTS SEEDS

How would you describe a purple loosestrife seed?

_____

_____

How do purple loosestrife seeds get from one place to another?

_____

_____

 Stop reading. **END OF LESSON FIVE.**

Lesson Six - Protecting Wetlands

There are lots of native wetland plants. Why can't we just let purple loosestrife live with all the other wetland plants? In Europe, where purple loosestrife is native, it does live along with all the other plants and it is not a problem. The reason is that there are many animals, mostly insects, that eat purple loosestrife in Europe. We call these animals the natural enemies of purple loosestrife. By eating leaves, roots, flowers and seeds, these natural enemies keep purple loosestrife from growing out of control. When purple loosestrife was brought to North America, it left all its natural enemies behind in Europe. There weren't any natural enemies in North America to eat purple loosestrife. Without any natural enemies, purple loosestrife grows out of control in North American wetlands.

This is the reason that purple loosestrife is a problem here. There is only enough space for a certain number of plants and animals to live in a wetland ecosystem. The more space that is taken by purple loosestrife plants, the less space there is for other plants and animals. If the native plants don't have enough space, they will die and new seeds won't have enough room to grow. Another problem is that the native plants provide food for the wetland animals. Because most animals do not eat purple loosestrife, a wetland filled with purple loosestrife does not provide enough food for many animals to survive. If the animals don't have enough food and space, they may die or move to another area. Also, without enough food and space, animals cannot raise families in the wetland. There are thousands of relationships between the many organisms in a native wetland community. These organisms depend on relationships to survive. When an exotic organism such as purple loosestrife becomes common, many of these relationships are disturbed and food chains are broken.

Stop reading and play the wetland relationship game. Get instructions from your teacher.

Why is it so important to protect these wetlands, anyway? Wetland ecosystems are important for many reasons. One reason, which we already talked about, is that wetlands provide homes for many kinds of plants and animals. Without wetlands, these organisms could not survive. Wetlands also remove pollution from the water and all organisms, including humans, need clean water to live. When it rains, the rainwater picks up small particles of soil and carries them to the nearest river, pond or lake. In some places, such as cities and farms, the rain also carries things that pollute the water, such as fertilizer and motor oil. When this muddy, polluted water enters a wetland, the water is slowed down and most of the soil particles and pollution settle to the bottom of the wetland. You can think of a wetland as a big sponge that helps prevent the muddy and polluted water from reaching the rivers, ponds and lakes. It also slows down the water and helps prevent flooding. Wetlands are also important to people who enjoy hiking, canoeing, bird watching, photography and wildlife viewing.

Many wetlands have been destroyed by people. There used to be many more wetlands. It is estimated that, in the 1700s, there were more than 10 million acres of wetlands in the Great Lakes region. By 1990, over half of these wetlands were gone, and another 6,500 acres of wetlands are still being destroyed each year. Scientists estimate we have lost more than 120 million wetland acres in the United States since Europeans arrived and that we still lose about 100,000 acres each year to development. Most of these wetlands are destroyed because of human activities. Many wetland areas have been drained and filled so they could be used as building sites. Others have become so polluted that organisms cannot live there. If more people understood the value of wetlands, they would want to protect them instead of destroying them. There are laws to help protect some wetlands from being destroyed, but these laws cannot keep purple loosestrife from spreading. The challenge for scientists is to come up with a plan to control purple loosestrife while at the same time protecting the native plants and animals in the wetlands.

 Stop reading. **END OF PART TWO.**

Part Three Biological Control of Purple Loosestrife

Lesson One - Controlling Purple Loosestrife

As you know, the invasion of purple loosestrife is causing problems in North American wetlands. Are there solutions to these problems? It is important to understand ecology and life cycles of organisms if you are going to try to find solutions to problems such as the invasion of purple loosestrife.

Let's review some of the problems caused by the invasion of purple loosestrife. If you need more review, go back and read the information in Part One and Part Two in your workbook.

Purple loosestrife is a flowering plant that is native to wetlands in Europe. In Europe, purple loosestrife is an important part of the wetland ecosystem. Purple loosestrife has many relationships with other wetland plants and animals in this wetland community. One very important relationship is that purple loosestrife provides food for some of the animals, especially insects. Some insects eat the roots, some eat the leaves and stems, some eat the flowers and some eat the seeds of purple loosestrife. These relationships control the number of purple loosestrife plants that grow in these European wetlands. If these insects were not in the wetland eating the purple loosestrife, there would be too many purple loosestrife plants. If there were too many purple loosestrife plants, there wouldn't be enough room for the other plants and animals to live. So you can see that the relationships between purple loosestrife and the insects that eat it are very important to the ecology of the European wetlands. These insects that eat purple loosestrife are called the natural enemies of purple loosestrife.

Before the year 1800, purple loosestrife did not grow in North America. North America and Europe are separated by the Atlantic Ocean, so it would have been hard for purple loosestrife to get to North America. As more and more people traveled across the ocean on ships, however, purple loosestrife seeds were also transported on these ships in ballast water, mixed in bags of grain or stuck to the hair of farm animals. By 1900, purple loosestrife was growing in many wetlands in the Great Lakes region.

Because purple loosestrife is an exotic plant (not native) in North America, it has no natural enemies in North American wetlands. All its natural enemies are in Europe. Without natural enemies in North America, purple loosestrife grows out of control. In wetlands where there are too many purple loosestrife plants, there isn't enough room for native plants and animals to live. This harms the native wetland plants and animals in North America.

This is why purple loosestrife is a problem in North America.

Because of its life cycle, purple loosestrife can spread rapidly when there are no natural enemies to control it. Purple loosestrife can spread in two ways: by roots and by seeds. Purple loosestrife roots get bigger each year. As the roots get bigger, they make more stems, leaves, flowers and seeds. These bigger plants take up more room than smaller plants. One purple loosestrife plant can make over 2 million seeds. These seeds travel to other wetlands by floating in the water or by mixing with the wetland mud, which then sticks to animals that walk through the wetland. It may take years before there are lots of purple loosestrife plants growing in a wetland. Once this happens, however, the purple loosestrife plants can spread rapidly, and it may take only a few years for it to take over the entire wetland.

Is there any way to control the spread of purple loosestrife?

Many people are trying to find a solution to this problem. Everyone agrees that, because purple loosestrife is already growing in North America, there is no way to get rid of it completely. But are there other solutions? The challenge is to control purple loosestrife without harming the native wetland plants and animals or the wetland ecosystem.

Now complete the **Solutions Worksheet**.

SOLUTIONS Worksheet

You are a land owner and you want to protect your Michigan wetland. The size of the wetland is 500 acres. During a walk around the wetland last year, you noticed some purple flowers you had never seen before growing in several areas of the wetland. Using your flower book, you identified these plants as purple loosestrife. You conducted a survey and learned that the wetland has about 50 purple loosestrife plants growing in each acre. You know that, because of its life cycle, it will be only a few years before the whole wetland is covered with purple loosestrife. You also know that, if this happens, there won't be enough space for many of the native wetland plants and animals to live. You don't have very much money to hire workers or to buy expensive materials or equipment to control purple loosestrife.

Your challenge is to protect the wetland ecosystem from the invasion of purple loosestrife without harming the other wetland plants and animals.

After reading about controlling purple loosestrife, you make the following list of solutions. Read each solution and write why you would or wouldn't choose the solution to solve your problem.

Solution #1 - BURN THE WETLAND

You have heard that some people are using fire to control purple loosestrife. All that is needed is a burning permit and a match. Burning would prevent purple loosestrife from making seeds but would not kill the root crowns, so the whole wetland would have to be burned every couple years to keep purple loosestrife under control.

Solution #2 - SPRAY HERBICIDES

Herbicides are chemicals that kill plants. You read about a herbicide that can be sprayed on the wetland that will not kill animals but will kill any plant it is sprayed on. All you have to do is spray the herbicide once a year to control the purple loosestrife.

Solution #3 - PULL BY HAND

A neighbor with a small one-acre wetland also has purple loosestrife and controls it by pulling each plant out by hand. The neighbor said it took 25 hours of work to find and remove 100 purple loosestrife plants. Pulling by hand must be done every year to keep the purple loosestrife under control.

Solution #4 - DO NOTHING

One solution that takes no time or money is to do nothing to the wetland and see what happens

Can you think of any other solutions?

 Stop reading. **END OF LESSON ONE.**

Lesson Two - Biological Control

Now that you have finished the Solutions Worksheet, you know that it is hard to find a good solution to the problems caused by the invasion of purple loosestrife. There are many ways to control or kill the purple loosestrife as it grows back each year, but these ways also harm the native plants and animals. There is another way to control exotic organisms such as purple loosestrife. It is called biological control.

What is Biological Control?

The science called biology is the study of living organisms. A person who studies living organisms is called a biologist. Biological control means using living organisms to control other organisms. Let's learn about biological control by looking at some examples.

EXAMPLE #1

Most farms have barns to store bags of seeds that the farmers will plant in the fields and also to store bags of food to feed the farm animals. Because of all the seeds and animal food, barns are great places for mice to live. In fact, sometimes barns have so many mice that they eat or spoil too much of the farmer's seeds and animal food. This is a problem for the farmer. How can the farmer control the mouse population? Mousetraps won't work because there are too many mice and it would take too much time to set and check the many traps. Mouse poison is not a good solution because the poison could get into the food chain and harm other animals. For example, a fox might eat a poisoned mouse and this would harm the fox. Poison and traps can also be expensive. Another solution would be to find a predator (a predator is an animal that eats other animals) that eats mice and let it live in the barn. One example of a mouse predator is a barn owl. Barn owls make their nests in barns and catch lots of mice to eat and to feed the young owls. The owls control the number of mice by eating them. Another mouse predator that farmers could use is a cat. Cats and barn owls eat mice, so they are called natural enemies of mice. This is an example of biological control: using a living organism (the cat or owl) to control the numbers of another living organism (mice). Not all the mice are eaten, but enough are eaten so they are no longer such a problem.

Here are two more new terms for you to learn about biological control. The organism used to control another organism is called the biological control agent. The organism being controlled is called the target organism. In example #1, the biological control agent is the owl or the cat. The target organism is the mouse.

EXAMPLE #2

Alfalfa is a very important crop in the United States and is grown on millions of acres of farmland. Farmers use alfalfa to feed animals such as cattle, sheep and horses. The alfalfa weevil, a native of Europe, invaded the United States, and the weevils were eating too much of the alfalfa crop. They were a big problem because they had no natural enemies in the United States and their numbers grew out of control. At first, the only way farm-

ers could kill the weevils was by spraying the fields with pesticides. To find another solution, scientists went to Europe, where the weevils are native, and found out that animals were the natural enemies of the weevils in Europe. They collected some of these natural enemies and brought them to the United States, where they were raised and released in alfalfa fields. These natural enemies were tiny wasps that would lay their eggs inside the weevil's body. When the eggs hatched, the wasp larvae would live and feed inside the weevils and the weevils would be killed. After several years, there were so many wasps in the alfalfa fields that the number of weevils was under control. This saved the farmers lots of time and money because they didn't have to spray the fields. This also protects native plants and animals that may be harmed by pesticides. This is another example of biological control.

In example #2, which organism is the biological control agent?

_____

Which organism is the target organism?

_____

EXAMPLE #3

In the first two examples, the target organism was an animal: the mouse in example #1 and the weevil in example #2. Biological control can also be used to control plants. Here is an example. In about 1900, a plant called the Klamath weed invaded California. Klamath weed is native to Europe and is an exotic invader in North America. By 1940, Klamath weed had grown out of control and had taken over millions of acres of grassland ecosystems in California and other western states. The Klamath weed was taking up so much space that many of the native plants and animals couldn't live there anymore. Klamath weed was also poisonous to some animals that tried to eat it. People tried to control the Klamath weed with herbicides, but it was expensive and didn't work very well. In the 1940s, scientists went to Europe, where Klamath weed is native, and found several kinds of beetles that eat Klamath weed. These natural enemies of Klamath weed were brought to California and released in the grasslands. These natural enemies became very common in the grasslands and have eaten almost all of the Klamath weed. Once the Klamath weed was gone, the native plants and animals returned to live in the grasslands. This is another example of biological control.

Which of the organisms in example #3 is the natural enemy?

_____

Which is the target organism?

_____

Which is the biological control agent?

_____

Let's think about purple loosestrife and biological control. As you know, purple loosestrife is native to Europe but now grows in North America. Because it doesn't have any natural enemies in North America, it grows out of control. What would you do to control purple loosestrife?

_____

_____

_____

Here is what some scientists are doing to control purple loosestrife using biological control. In the 1980s, a group of scientists traveled to Europe to find some natural enemies of purple loosestrife. Do you know why the scientists went to Europe to do this?

_____

_____

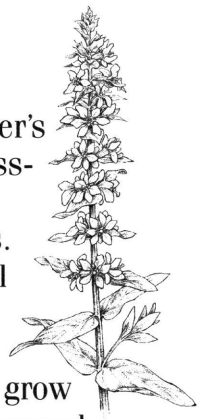
_____

_____

They found more than 120 kinds of insects that are natural enemies of purple loosestrife in Europe. After studying the life cycles of these natural enemies, they chose several of the natural enemies to bring back to North America. These natural enemies were tested by scientists to make sure they would eat only purple loosestrife and not native wetland plants or crops in North America. Natural enemies that passed the tests could be raised and released in wetlands in North America. Scientists believe that these natural enemies will live in the wetlands and eat most of the purple loosestrife. Controlling purple loosestrife will assure that the native plants and animals will have enough space to live in the wetlands. One of these natural enemies that eats purple loosestrife is called a leaf beetle. The leaf beetle is the biological control agent and purple loosestrife is the target organism. We will learn more about the leaf beetle in the next lesson.

 Stop reading and get instructions from the teacher. **END OF LESSON TWO.**

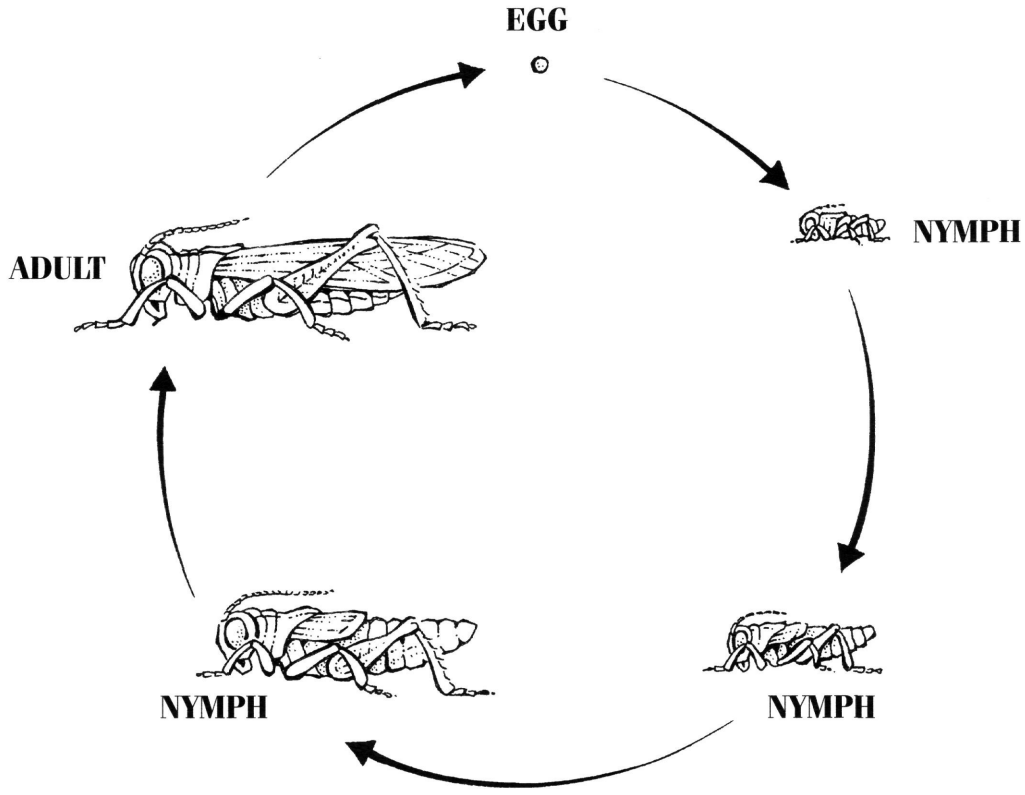
Lesson Three - Life Cycle of Leaf Beetles



When scientists try to decide which natural enemy to use in a biological control program, one of the first things they look at are life cycles. They need to study the life cycle of the target organism (purple loosestrife) and the life cycle of the biological control agent (leaf beetles). We have already learned about the life cycle of purple loosestrife, so now we will take a closer look at the life cycle of leaf beetles.

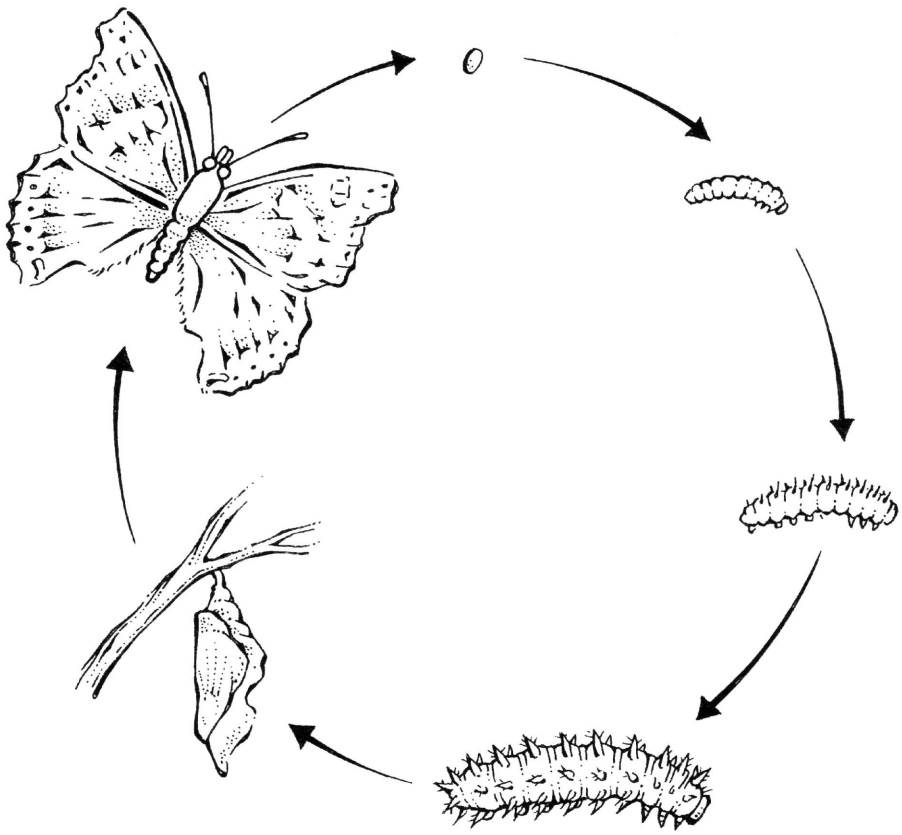
Leaf beetles are insects. You may not have seen leaf beetles before, but you have seen many other kinds of insects such as grasshoppers, butterflies, ladybugs, bumblebees, ants, dragonflies and mosquitoes. Although all these animals look very different from each other, they are all insects. Not all insects have the same kind of life cycle. There are two main types of life cycles in insects.

Let's talk about a grasshopper's life cycle. When the tiny grasshopper egg hatches, a small grasshopper nymph emerges. The nymph looks like a small grasshopper, but its wings are not fully grown. During its life cycle, the nymph will grow bigger by shedding its skin several times. When an insect sheds its skin, it is called molting. When the grasshopper nymph molts for the last time, it turns into an adult grasshopper and has fully grown wings. These adult grasshoppers can also mate, and the female grasshoppers lay eggs, which completes the life cycle. This kind of life cycle is called simple metamorphosis. There are three stages in simple metamorphosis: the egg, the nymph and the adult (see drawing).



Other insects that have simple metamorphosis include crickets, cockroaches, praying mantids, earwigs and cicadas.

The other type of life cycle is called complete metamorphosis. Let's use a butterfly as an example. When a butterfly egg hatches, a caterpillar or larva emerges. This caterpillar looks nothing like an adult butterfly. This larva will eat lots of food and will molt several times. Each time it molts, it gets a little bigger. The last time the larva molts, it turns into the next stage of the life cycle called a pupa. This pupa doesn't move around or feed, but, there is a lot going on inside the pupa. It is turning into an adult butterfly! The adult butterfly emerges from the pupa. The adults will mate and the females will lay eggs. This completes the life cycle. There are four stages in complete metamorphosis: the egg, the larva, the pupa and the adult (see drawing).

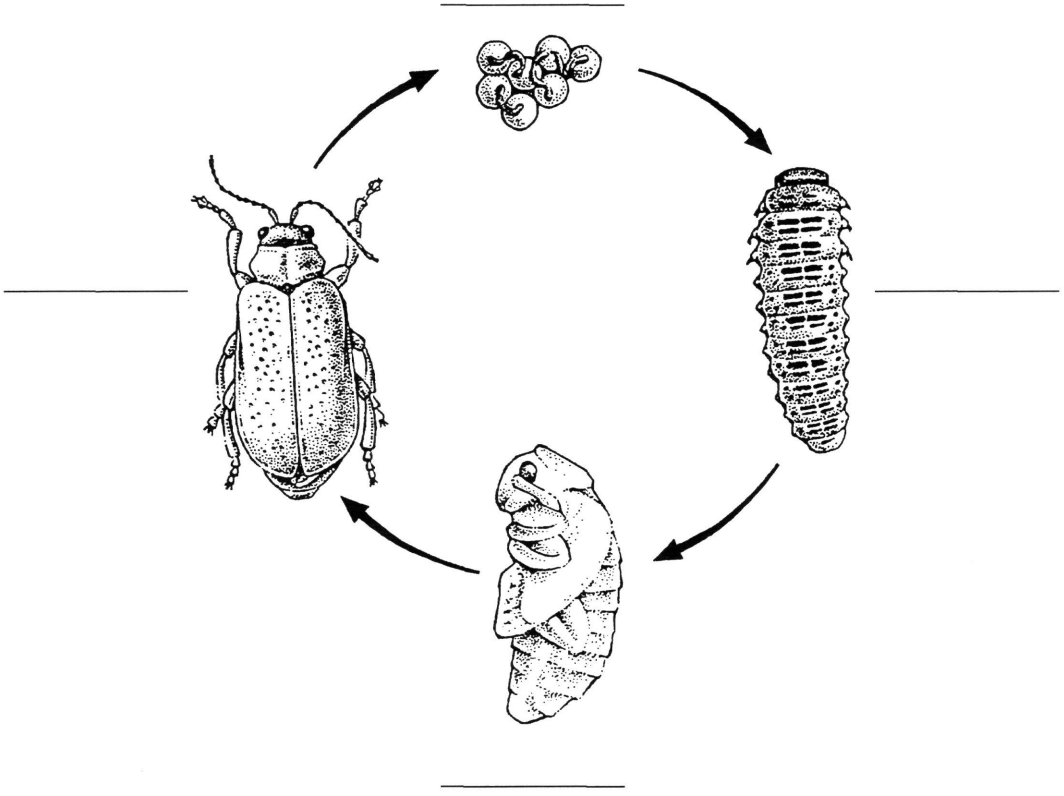


Other insects that have complete metamorphosis include moths, flies, mosquitoes, ants, bees and wasps.

Stop reading and complete the **Beetle Life Cycle Worksheet**.

BEETLE LIFE CYCLE Worksheet

Below is the life cycle of a leaf beetle. This is the same kind of leaf beetle that is living on the purple loosestrife plant in your classroom. Look carefully at the life cycle and then read the directions and questions below.



1. What type of metamorphosis is shown in the leaf beetle life cycle?
   Circle the correct answer.

   simple metamorphosis complete metamorphosis

2. There is a blank space next to each of the stages in the life cycle. Fill in these spaces with the proper name for each stage.

3. You know that leaf beetles eat purple loosestrife. Which stages of the leaf beetle's life cycle do you think would feed on the purple loosestrife leaves?
   Circle the correct feeding stages.

   egg larva pupa adult

4. Here are some other interesting facts about leaf beetles. Look at the drawing of the adult beetle in the life cycle diagram, the photo of the adult and the live leaf beetles. See if you can find some of these features.

Adult leaf beetles, like all insects, have three main body parts: the head, the thorax and the abdomen.

HEAD - The head is the sensory center of the leaf beetle. The head has two compound eyes (each human eye has only one lens; each beetle eye has many small lenses, so they are called compound eyes). Also attached to the head are two long antennae (some people call antennae "feelers"). The antennae are used by the leaf beetle to sense vibrations, touch and odors. This helps the beetles locate other beetles, find purple loosestrife to eat and avoid enemies. The mouthparts are also found in the head. Leaf beetles have chewing mouthparts so they can chew holes in purple loosestrife leaves. Can you find the compound eyes and the antennae on the drawing? You can't see the mouthparts on the drawing because they are on the underside of the beetle's head.

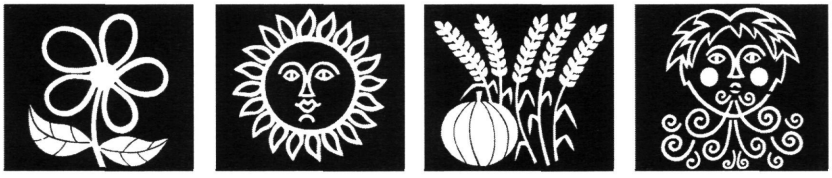
THORAX - The main purpose of the thorax is to help the leaf beetle move around. The legs are attached to the thorax. Insects have six legs. Some insects have legs designed for jumping (grasshoppers) or for catching prey (praying mantis). A leaf beetle's legs are designed for walking and running. Can you see all six legs in the drawing? The beetle's wings are also attached to the thorax. Beetles have four wings (two hard front wings and two soft back wings). The entire back of the leaf beetle (except the head) is covered by the folded front wings. Look at the drawing. You can see the straight line running down the back of the beetle. This is where the two front wings come together. These hard front wings on beetles protect the beetle's other wings and body as it moves around or when it digs through the soil. The back wings, which are very fragile, are folded and hidden under the hard front wings.

ABDOMEN - The abdomen is soft and is used by the beetle for breathing, egg laying and other important functions. The abdomen also has many nerves, much of the insect's body fluids and parts of the stomach. You can see in the drawing a small part of the abdomen that is sticking out from under the back of the folded front wings.

Stop reading. **END OF LESSON THREE.**

Lesson Four – Leaf Beetles and Purple Loosestrife Together

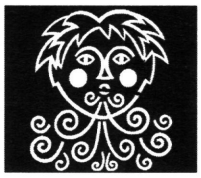
You have learned about the life cycle of purple loosestrife, the life cycle of the leaf beetle and biological control. As you know, the problem with purple loosestrife in North American wetlands is that it has no natural enemies here. When leaf beetles (the biological control agent) are released into these wetlands, they eat purple loosestrife (the target organism) and help control the number of purple loosestrife plants that are growing in the wetland.



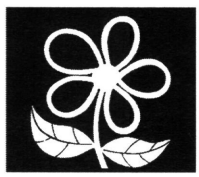
Stop reading and complete the **Annual Cycle Worksheet**.

ANNUAL CYCLE Worksheet

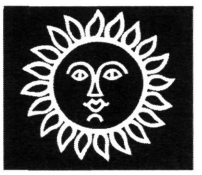
For the biological control of purple loosestrife to work, the leaf beetles must be able to complete their life cycle in a wetland where purple loosestrife is growing. We are going to follow a group of leaf beetles in a wetland to see what they are doing during the seasons of one year. Before you start, you will need some blank paper and pencils or crayons. As you read the information below, draw a picture for each of the seasons. Include purple loosestrife plants and leaf beetles in each of the drawings to show where they are located and what stage they are in in their life cycles. Remember to show what is going on both above and below the ground.



WINTER - Snow and ice cover the wetland. The only plants rising above the snow are some dead cattail stems with their fluffy seedheads and dead purple loosestrife stems with the seed capsules still attached. The only signs of life are some deer tracks through the snow and a black-capped chickadee eating the seeds from the cattail stems. Though the purple loosestrife stems above the snow are dead, the roots of the purple loosestrife plants are alive in the soil. Also alive are adult leaf beetles that have dug into the soil near the purple loosestrife roots or are huddled together in the hollow dead stems of purple loosestrife. These adult leaf beetles will hibernate until spring.



SPRING - The warm days of spring bring new life to the wetland. The snow and ice melt, and the wetland plants begin to grow new stems and leaves. The cattails send up many of their long, narrow green leaves, that get to be several feet high. Red-winged blackbirds, which spent the winter in the southern United States, have returned to build their nests in these cattail leaves. The purple loosestrife roots have started to grow, and each root crown has grown several new green stems. Each stem is several feet high and has many leaves. Soon after the purple loosestrife stems begin to grow, the adult leaf beetles dig out of their overwintering sites in the soil or old stems and climb up the purple loosestrife stems. They begin to feed. This feeding makes tiny holes in the leaves. The female adult beetles lay small clusters of beetle eggs on the stems and leaves of purple loosestrife. By late spring, most of the eggs have hatched into small larvae. These small larvae crawl to the tips of the purple loosestrife stems, where they feed on new leaves. These early stages of the larvae are hard to see because they are very small and are usually hidden between the new leaves at the tips of the stems.



SUMMER - The hot days of summer bring more changes to the wetland. The cattails and purple loosestrife plants are now over 6 feet tall. The cattails have formed their dark brown seedheads, and some of the purple loosestrife plants are covered with beautiful purple flowers. The red-winged blackbird eggs have hatched. Some of the young red-winged blackbirds are still in their nests; others have already left the nests and are flying around the wetland. The adult leaf beetles that spent last winter in the soil and laid eggs in the spring have died and fallen to the ground, where most will be eaten by other animals. The leaf beetle larvae, however, have grown bigger. These larger larvae are now easy to see as they eat purple loosestrife leaves. Many of the purple loosestrife plants did not grow tall and did not make flowers because most of their leaves were eaten by leaf beetle larvae and adults. Just before the larvae turn into pupae, they crawl down to the purple loosestrife plants and burrow into the soil. After spending some time in the soil as pupae, the pupae change into adult beetles. These adult beetles dig out of the soil and climb up the purple loosestrife plants, where they begin feeding on the leaves.

FALL - Fall is a time to prepare for winter. All the leaf beetles are now in the adult stage and will either burrow into the soil or into plant stems where they will hibernate through the winter. The purple loosestrife stems that survived are now turning brown and dying. The ones that had flowers have made lots of seeds, and these seeds have fallen onto the wetland soil. Only the roots and seeds of the purple loosestrife plants will remain alive. The cattail leaves are also turning brown, and the tiny seeds are blowing in the wind to new areas. The red-winged blackbirds are forming large flocks and are getting ready to fly south for the winter.

You have just made a series of drawings showing the annual cycle of purple loosestrife and leaf beetles in a wetland.

Stop reading. **END OF LESSON FOUR.**

Lesson Five - Selecting Natural Enemies for Biological Control

We have learned a lot about purple loosestrife, leaf beetles and biological control. Have you wondered why and how these leaf beetles were picked to be used instead of some other animal? As you know, purple loosestrife was brought to North America from Europe and has become a big problem in wetlands. The leaf beetles are also brought from Europe to be released in North America. How do scientists know that the leaf beetles won't also become a problem in North America? There are always some risks when an exotic organism (such as the leaf beetle) is released. This is why it is very important for scientists to study and carefully choose these biological control agents before they are released. In the United States, scientists from the U.S. Department of Agriculture must study, test and approve all organisms before they can be released in a biological control program. Let's learn about some of the questions a scientist must answer when deciding on a biological control agent.

Stop reading and get instructions from the teacher.

Student Activity: WHICH NATURAL ENEMY IS BEST?

The Problem

Scientists have discovered an exotic plant in several area ponds and lakes. The plant, called water choke-weed, grows very fast and clogs the ponds and lakes with stems and leaves. This causes several problems. One problem is that none of the native aquatic animals eat water choke-weed. With so much water choke-weed, the native plants can't grow so there isn't enough food for many of the insects, fish, birds and mammals that live there. Another problem is that, with so much water choke-weed, people can't use the water for recreation such as swimming, boating, fishing or water skiing. Water choke-weed is a native plant in the temperate deciduous forest biome in Europe and the tropical forest biome of Asia, where it has many natural enemies that keep its growth under control.

A group of scientists would like to use biological control to try to control the growth of water choke-weed. They travel to Europe and Asia, where water choke-weed is native, and discover several natural enemies of water choke-weed that they think might be good biological control agents. They study the life cycles and habits of these natural enemies and now must decide which of these natural enemies would be the best biological control agent for water choke-weed.

The Solution

You are the scientists who must decide which of the natural enemies would be best to control water choke-weed. Here are the main things you must use to make your decision:

1. To control water choke-weed, thousands of individuals of the natural enemy would have to be released in each lake. The scientists can't bring that many from Europe or Asia, so they would have to be able to easily and cheaply raise large numbers of the natural enemy in laboratories in the United States.

2. The natural enemy would have to be able to survive year round in Michigan ponds and lakes.
3. The natural enemy would have to eat lots of water choke-weed but not eat any native plants or crops.
4. The natural enemy cannot be harmful to humans or other organisms.

Students stop reading and get instructions from the teacher.

WATER CHOKE-WEED NATURAL ENEMY #1

This natural enemy is a small fish called the weed minnow. In indoor experiments, it was found to eat only water choke-weed and to pose no threat to humans or any other organisms. The weed minnow is very easy to raise in indoor water tanks and it doesn't cost much to raise them by the thousands. Each small fish eats several water choke-weed leaves every hour. The weed minnow is native to wetlands in tropical areas of Asia, where it does a great job controlling the growth of water choke-weed. The weed minnow cannot survive if the water temperature goes below 50 degrees Fahrenheit.

WATER CHOKE-WEED NATURAL ENEMY #2

This natural enemy is a small mammal called the water rat. Water rats are native to lakes in the temperate deciduous forest biome of Europe, where they eat huge amounts of water choke-weed. They won't eat any other kind of plant. They also make their nests in the water choke-weed. During the nesting season, water rats are very aggressive and will bite and chase away any other mammals or birds within sight. Water rats can be easily and cheaply raised by the thousands in the laboratory and can survive even the coldest winters.

WATER CHOKE-WEED NATURAL ENEMY #3

This natural enemy is an insect called the green water beetle and is native to lakes in the temperate deciduous forest biome of Europe. In Europe, it is found only in lakes with lots of water choke-weed. After studying its life cycle, scientists discovered that it is a predator and it eats only other insects that eat water choke-weed. During the winter, it survives by burrowing into the lake bottom. Green water beetles are cheap and easy to raise in laboratories and are not harmful to any native plants or animals.

WATER CHOKE-WEED NATURAL ENEMY #4

This natural enemy is called the pond fly and is native to the temperate deciduous forest biome in Europe. The adult pond flies do not feed or bite and live only a few days. The female adult pond flies lay their eggs only on water choke-weed leaves. When the eggs hatch, the pond fly larvae burrow into the water choke-weed stems and eat their way all the way to the roots. One larva can kill an entire water choke-weed plant. The fly spends the winter as a pupa in the roots and then, in the spring, the pupa floats to the water surface where the adult pond fly emerges. The larvae will burrow into and eat only water choke-weed. The pond flies are easy and cheap to raise and don't harm or bother any other organisms.

WATER CHOKE-WEED NATURAL ENEMY #5

This natural enemy is called the water leaf beetle. These insects can't seem to get enough water choke-weed and will eat it until it is gone. Scientists found they could easily and cheaply raise thousands

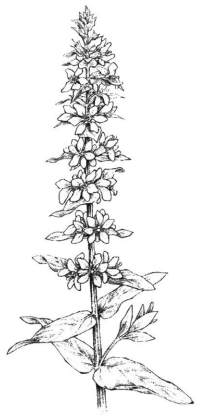
of water leaf beetles by keeping them in cages and feeding them corn and cattail leaves. Because they are from the temperate deciduous forest biome in Europe, the water leaf beetles can easily survive the winters in the Great Lakes Basin.

WATER CHOKE-WEED NATURAL ENEMY # 6

This natural enemy is called the purple stem weevil (a kind of beetle). The purple stem weevil is native to the temperate deciduous forest biome in Europe and easily survives the winter in the Great Lakes Basin. It is truly a water choke-weed specialist and lives its entire life cycle on the plant. The adult weevils eat the seeds so there are fewer new water choke-weed plants. The larvae eat lots of stems and leaves of water choke-weed. The purple stem weevil will not eat anything else and is not harmful to any other organisms. Scientists have found that it takes three years using expensive growth chambers to raise about 100 weevils in the laboratory.

 Stop reading. **END OF LESSON FIVE.**

Lesson Six - Biological Control of Purple Loosestrife



Now that you know how scientists choose a natural enemy for use in biological control, let's learn some of the reasons that leaf beetles were chosen to control purple loosestrife. As you read before, scientists traveled to Europe (where purple loosestrife is native) and identified more than 120 kinds of insects that are natural enemies of purple loosestrife in Europe. Here are some of the main reasons that the leaf beetle was chosen to be used in a biological control program for purple loosestrife.

1. It was found that many of the natural enemies of purple loosestrife are difficult or expensive to raise in large numbers. Leaf beetles can be easily raised in laboratories, greenhouses and classrooms by growing purple loosestrife plants in pots and then letting the leaf beetles live on the plants. The leaf beetles can't escape because a screen bag is placed over the potted plant. The leaf beetles will complete their entire life cycle on these potted plants and then can be released into wetlands where purple loosestrife is growing.

2. Because the leaf beetles are native to the temperate deciduous forest biome of Europe (where the climate is similar to that in the Great Lakes region), they can survive year round after they are released into the wetlands. Once they are released into a wetland where purple loosestrife grows, the leaf beetles can go through their life cycle every year and continue to eat purple loosestrife for many years.

3. Leaf beetles eat lots of purple loosestrife. Both the adults and the larvae of leaf beetles eat purple loosestrife. By eating many of the leaves, the leaf beetles keep purple loosestrife from growing out of control. Also, if a plant has too many of its leaves eaten, it won't make enough food to make flowers. If it doesn't make flowers, it can't make seeds. With fewer seeds, there are fewer new purple loosestrife plants. When there are fewer purple loosestrife plants, there is more room for the native plants and animals to live.

4. Scientists tested the leaf beetles and found that they would not eat anything except purple loosestrife and would lay their eggs only on purple loosestrife. They placed hungry adults and larvae of leaf beetles inside cages and tried to get them to eat other plants. The only plant they would eat was purple loosestrife. This is very important when choosing a natural enemy. An animal that eats only one kind of organism, such as the leaf beetle that eats only purple loosestrife, is called a specialist. An animal that eats many kinds of other organisms (such as a rabbit, which eats many kinds of plants) is called a generalist. Most animals used in biological control programs are specialists. Do you think human beings are specialist or generalist feeders?

5. Because the leaf beetles eat only purple loosestrife, they are not harmful to human being or other organisms.

Stop reading and complete the **Biological Control Worksheet**.

BIOLOGICAL CONTROL Worksheet

Answer the following questions about the biological control of purple loosestrife. You will have to look at and use your observations of the leaf beetles and the purple loosestrife plant to answer some of the questions.

1. As you observed the life stages of the leaf beetle on your purple loosestrife plant, you also recorded the dates of the observations.

   What was the date you placed the adult leaf beetles on the purple loosestrife plant in your classroom? _____

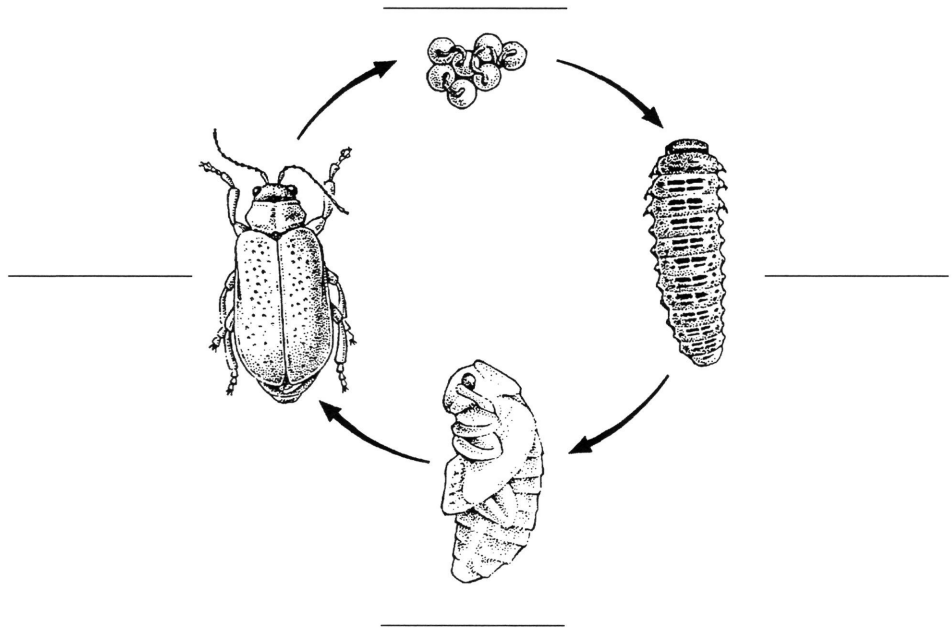
   What was the first date you found egg clusters? _____

   What was the first date you saw a larva? _____

   What was the first date you saw an adult from the new generation? _____

   Even though you didn't see any pupae (because they are buried in the soil), can you figure out the dates that the pupae were present? _____

Below is the life cycle of the leaf beetle. Add these dates to the life cycle drawing to show when each life stage was observed.



2. You also kept track of the amount of purple loosestrife leaf that was eaten by the beetles.

   About what date did you notice that lots of purple loosestrife leaves were eaten?

   _____

   Match this date to your life cycle dates. Which life stage do you think was eating most of the purple loosestrife leaves? _____

3. In the space below, write a summary of your leaf beetle observations. What happened? What did you find most interesting? Did anything surprise you? Do you have any questions that were not answered by your observations?

_____

_____

_____

_____

_____

4. Based on your observations, do you think that purple loosestrife can be controlled by releasing leaf beetles in wetlands where purple loosestrife is growing? Explain your answer on another sheet of paper

Congratulations! You and your classmates have helped control the spread of purple loosestrife by raising leaf beetles in the classroom. These leaf beetles will be released into a wetland ecosystem where purple loosestrife is a problem. The leaf beetles you raised will eat the purple loosestrife in the wetland. The female adults will lay lots of eggs and the leaf beetles will complete their life cycle each year as long as there is purple loosestrife to eat. The leaf beetles that are released this year and future generations of leaf beetles will help control purple loosestrife in the wetland for many years. You and your classmates made it all happen by using biological control.

Scientists will visit our wetlands every year to collect information and make observations on the beetles and the purple loosestrife plants (just as you did in the classroom). They will see if the number of leaf beetles is increasing or decreasing. They will also study the purple loosestrife to see if it is spreading or if it is being controlled by the leaf beetles. The information they get from these wetland areas will help them make decisions about how to better control purple loosestrife in the future. And you helped make it happen!

But best of all, by raising the leaf beetles in your classroom and releasing them in a wetland, you have helped to protect a wetland ecosystem and the many native plants and animals that live there.

Stop reading. **END OF LESSON SIX.**

Student Glossary

ABDOMEN – One of the three main body parts of an adult insect.

ADULT – The stage in the life cycle of an insect that may have fully grown wings (some insect adults don't have wings – for example fleas) and can mate and lay eggs.

ALIEN – A plant or animal that is living in an area that it is not native to. "Alien" means the same as "exotic."

ANTENNAE – Sensory structures on the heads of insects (also called "feelers").

ANNUAL – A plant that completes its life cycle in one year.

BIENNIAL – A plant that takes two years to complete its life cycle.

BIOLOGICAL CONTROL – Using an organism (the biological control agent or natural enemy) to control another organism (the target organism).

BIOLOGICAL CONTROL AGENT – An organism that is used in a biological control program to control another (target) organism.

BIOME – A large area of the Earth shaped by geographic location, climate, topography and other physical features. Examples of biomes include tropical rain forest, tundra, ocean, grassland and temperate deciduous forest.

COMMUNITY – All the interacting organisms within an ecosystem. For example, all the living organisms in a marsh ecosystem make up the marsh community.

COMPOUND EYES – Eyes, as in adult insects, that are made up of many tiny lenses. Each human eye has only one lens.

CARBON DIOXIDE – An invisible gas in the air that green plants use to make food and oxygen through the process of photosynthesis.

CARNIVORE – An animal that eats only other animals.

CHLOROPHYLL – The green pigment in plants that captures energy from the sun in the process of photosynthesis.

CONSUMER – Any organism that cannot make its own food and must eat other organisms to get energy.

DECIDUOUS – Refers to trees and shrubs that lose all their leaves in the fall.

DISPERSAL – The various ways that seeds travel from place to place.

ECOLOGY – The study of living organisms and their relationships.

ECOSYSTEM – A group of interacting organisms (community) and the non-living or physical factors that affect them.

EGG – One stage of an insect's life cycle. Eggs are laid by adult females.

EXOTIC – A plant or animal that is living in an area to which it is not native. "Exotic" means the same thing as "alien".

FOOD CHAIN – A sequence of organisms in a community that shows which each one eats and what eats it and the direction of energy flow.

GENERALIST – An animal that feeds on many types of plants and/or animals.

GREAT LAKES REGION – The states and provinces in North America that surround the five Great Lakes.

HERBICIDE – A chemical that is used to kill plants.

HERBIVORE – An animal that eats only plants.

INVASION – When an exotic plant or animal begins living in an area where it didn't live before.

LARVA (larvae [plural]) – A stage in the life cycle of an insect that undergoes complete metamorphosis. It is the stage after the egg and before the pupa.

LATITUDE – Imaginary lines on the Earth used to measure distance north and south of the equator.

LIFE CYCLE – A way to show the different stages of an organism's life.

LONGITUDE – Imaginary lines used to measure distance east and west around the Earth.

METAMORPHOSIS – The changes that insects go through as they complete their life cycle. Some insects undergo simple metamorphosis which has three life stages: egg, nymph and adult. Some insects undergo complete metamorphosis, which has four life stages: egg, larva, pupa and adult.

MOLTING – The shedding of skin by a nymph or larva that allows it to grow bigger or to change into a different life stage.

NATIVE – A plant or animal that is living in the area where it originally developed.

NATURAL ENEMY – An organism that controls the numbers of other organisms. Predators and herbivores are examples.

NECTAR – The sweet liquid made by flowers to attract pollinators.

NYMPH – A life stage of an insect that undergoes simple metamorphosis. It is the stage after the egg and before the adult.

OMNIVORE – An animal that eats both plants and animals.

ORGANISM – An individual of any living thing.

OXYGEN – An invisible gas made by green leaves through the process of photosynthesis..

PESTICIDE – A chemical that is used to kill organisms that humans consider pests.

PHOTOSYNTHESIS – The process by which green leaves (with chlorophyll) capture energy from sunlight and use carbon dioxide and water to make food and oxygen.

POLLEN – Small particles made by the male parts of flowers.

POLLINATION – The transfer of pollen from flower to the flower so the flowers can make seeds. Pollen is usually transferred between plants by the wind or by pollinators.

POLLINATOR – An animal, usually an insect, that transfers pollen from one-flower to another flower.

PRECIPITATION – Rain, snow, hail and sleet.

PREDATOR – An organism that captures, kills and eats other animals.

PREY – An organism captured, killed and eaten by a predator.

PRODUCER – Organisms (mostly green plants) that make their own food using the energy from sunlight.

PUPA or pupae (plural) – A stage in the life cycle of an insect that undergoes complete metamorphosis. It is the stage after the larva and before the adult.

RELATIONSHIP – Any interaction between individual organisms or between an organism and non-living factors. Relationships are sometimes called interrelationships.

SPECIALIST – An animal that feeds on only one kind of plant or animal.

SPECIES – A specific kind of organism.

TARGET ORGANISM – The organism that is being controlled in a biological control program.

TEMPERATE – Refers to areas with a moderate climate and distinct seasons.

THORAX – One of the three main body parts of an adult insect. The legs and wings are attached to the thorax.

TOPOGRAPHY – The surface features of land, such as mountains, valleys, plains, rivers and lakes.

WETLAND – An area that usually has standing water for at least part of the year. Some wetland types are marshes, swamps and bogs.