

Lesson 2 – Learning More about Pests

Introduction

To better understand IPM as applied ecology, students need to gain a further understanding of the needs, behaviors, and biology of pests. This knowledge will help them understand how and what type of damage has occurred. It will also help later in making informed decisions about management tactics and control options. In these lessons students will study the pests they have discovered in greater detail. They will learn more about what pests need to survive. They will learn that pests, like humans and other organisms, need food, water, shelter, and space to survive in any ecosystem. They will learn more about pest biology, such as reproduction, activities and communication, and habitat. Additionally they will learn (if they have not already done so) that pests can consist of a variety of different organisms, such as insects, mammals, fungi, weeds.

You may choose to narrow your student’s findings to only a few pests, also the pests your students discover may be different than the examples outlined in this, and the previous lesson.

Appropriate SC Science Standards for the Following Outlined lessons

Grade 2:

- I. Inquiry
 - A – Process Skills, 2b, 4a – Communicate
 - B – Inquiry, 1ad
- II. Life Science,
 - A – Characteristics of Organisms, 1a, 2ab
 - B – Life Cycles of Organisms, 1abc, 2ab
 - C – Organisms and their Environments, 1a

Grade 3:

- I. Inquiry
 - A – Process Skills, 2ab – Classify, 5a – Infer, 6a – Predict
 - B – Inquiry, 1ae
- II. Life Science,
 - A – Characteristics of Organisms, 2a
 - B – Life Cycles of Organisms, 1 b
 - C – Organisms and Their Environment, 2

Grade 4:

- I. Inquiry
 - A – Process Skills 2ab – Classify, 4a – Communicate, 5a – Infer, 6a – Predict
 - B – Inquiry 1 e
- II. Life Science,
 - A – Characteristics of Organisms, 2abc 3ac
 - B – Organisms and Their Environment, 1ab

Grade 5:

- I. Inquiry

A – Process Skills, 2ab – Classify, 4a – Communicate, 5ab – Infer, 6a b– Predict
B – Inquiry, 1abcdef

- Life Science, B – Populations and Ecosystems, 1ab 2ab 4cde

Grade 6:

- I. Inquiry

A – Abilities to do Scientific Inquiry,

1 – Identify process skills that can be used in scientific investigations - b1, 2, d1, e1

2 – Design and conduct a scientific investigation, cgh

5 – Think critically and logically to make relationships between evidence and explanations

7 – Communicate scientific procedures and explanations, bcd

Grade 7:

- I. Inquiry

A – Abilities Necessary to do Scientific Inquiry

1 – Identify process skills that can be used in scientific investigations 2; d1; e1

2 – Design and conduct a scientific investigation cgh

4 – Develop descriptions, explanations, predictions, and models using evidence ab

5 – Think critically and logically to make relationships between evidence and explanations a

6 – Recognize and analyze alternative explanations and predictions a

7 – Communicate scientific procedures and explanations abcd

- II. Life Science

B – Regulation and Behavior, 1ab; 2a; 3ab

Resources for the following lesson

Exploring Urban Integrated Pest Management by Erica Bosley Jenkins – “Wanted Dead or Alive”

Used with Permission

<http://www.pested.msu.edu>

PBS – This website provides insect masks in color and in black and white

http://www.pbs.org/wnet/nature/alienempire/multimedia/butterfly_color.pdf

http://www.pbs.org/wnet/nature/alienempire/multimedia/cricket_color.pdf

Clemson University – Insect Communication Lessons by Dr. Joe Culin

Used with Permission

<http://entweb.clemson.edu/buttrfly/Educate/instcomm.pdf>

University of California – Berkeley, Anatomy drawing

<http://www.cnr.berkeley.edu/citybugs/allaboutbugs/basicanatomy.htm>

Iowa State University, Anatomy drawing

<http://www.ent.iastate.edu/ref/anatomy/ihop/>

Bellarmino, Anatomy drawing

http://cas.bellarmino.edu/tietjen/Laboratories/FlowerCommunities/insect_anatomy.htm

North Carolina State University

<http://www.cals.ncsu.edu:8050/course/ent425/tutorial/thorax.html>

Discovery Channel Kids – All about insects

<http://yucky.kids.discovery.com/noflash/roaches/index.html>

University of California – Berkeley

CityBugs – Making Clay Ants

<http://www.cnr.berkeley.edu/citybugs/teachercorner/clayantlesson.htm>

University of Arizona – Using Insects in the Classroom

<http://insected.arizona.edu/uli.htm>

American Phytopathological Society – Disease triangle/Pest tetrahedron

<http://www.apsnet.org/education/InstructorCommunication/TeachingArticles/Francl/Top.html>

Ohio State University – Disease Triangle, interactive

<http://telr-research.osu.edu/curtis/disease.htm>

University of Wisconsin

<http://www.plantpath.wisc.edu/PDDCEducation/MasterGardener/General/Slide2.htm>

Duration 7.5 hours for all of the following activities

Objectives

The Students will:

- Investigate the necessary requirements for an organism to survive (food, water, shelter, space)
- Investigate pest habitats, activities, anatomy, biology, reproduction, and communication
- Understand differences between symptoms and signs of pests
- Learn about the pest tetrahedron and how it works
- Use the pest tetrahedron to make conditions unfavorable for pests
- IPM objective – educate more about pests to make knowledge-based decisions about management practices and control options later

Vocabulary

Environment

Time

Symptoms

Signs

Morphology

Complete metamorphosis

Hosts

Pest

Incomplete metamorphosis

Head

Thorax

Abdomen

Legs

Spiracles

Wings

Labrum

Antennae

Labial palps

Compound Eye

Auditory communication

Mandibles

Maxillae

Maxillary palps

Labium

Olfactory communication

Discussion

Begin this activity with a discussion about the pests your students have discovered. Hopefully you will find that not all of the students have discovered insects, though the majority of them may have. Talk with your students about the different types of pests, such as mammals like mice and rats that may sneak into your kitchen, fungi or mold that may be growing on your shower walls or on fruit, weeds in your flower bed or garden, and insects that are either in your home invading your wooden structures, like termites, or in your garden eating your vegetables like caterpillars and beetles. Perhaps your students will have discovered ants that may enjoy a meal with you once in a while.

In the previous lesson, your students interviewed individuals at home and school about the pests that were found and where. They have begun to discover the basic needs of a pest and what gives an organism the status of a pest.

Activity 1 – Wanted: Pests

“Wanted Dead or Alive” from Exploring Urban Integrated Pest Management by Jenkins.

This activity can be found in more detail at

<http://www.pested.msu.edu/CommunitySchoolIPM/curriculum>

In this activity students will create wanted posters for the specific pest they are learning more about. As a class you will choose a few pests to study as your most important culprits. Students may work in groups or as individuals. Create a list on the board of the most important things dealing with the pest that students should include on their wanted posters.

Suggestion: Allow students to use their creativity by encouraging them to draw their pest or to find a picture and glue it to their poster and fill in the poster items with information they have gathered thus far from their interviews, and observations. Have students research and read more information about their pest.

This activity encourages the students to learn more about identifying characteristics, reason for pest status, habitat, eating habits, signs, symptoms, and skills of the pest, but it is also important to include pest biology, anatomy, and communication.

Assessment

As before, repeat this in-school assignment at home. You may choose to set up a bulletin board in your classroom, one half displaying the pests in school, and the other half displaying the pests found at home.

Materials

Paper for worksheets one for each student

Posterboard

Crayons

Markers

Colored pencils

Reading materials containing insect or pest information

Activity 2 – Ahead of the Game

PBS – This website provides insect masks in color and in black and white
http://www.pbs.org/wnet/nature/alienempire/multimedia/butterfly_color.pdf
http://www.pbs.org/wnet/nature/alienempire/multimedia/cricket_color.pdf

University of California – Berkeley CityBugs – Making Clay Ants
<http://www.cnr.berkeley.edu/citybugs/teachercorner/clayantlesson.htm>

Introduction

Pest biology is an important part of pest identification. It is important for students to understand pest anatomy, communication, and life cycles in order to make sound decisions concerning the integration of management practices and tactics later in an IPM program. It may be necessary to implement tactics that inhibit one or more of these elements in order to make situations unfavorable for pest populations. This first activity allows students to explore the anatomy of an insect head. Learning the basic parts of an insect head is important, as the majority of pest damage is done by feeding. Likewise learning about insect anatomy and morphology are important for IPM, because pest managers consider insect mobility and susceptible life stages when making decisions about which control practices to implement.

For grades 2-6: PBS. Org provides some excellent creative insect mask patters that will be very helpful for the students to learn the parts of an insect head. It is suggested to have the students make the cricket mask, as they can be more classified as a pest. However, butterfly larva i.e. caterpillars are defoliating pests that can be troublesome in places like home gardens and large crops.

For this exercise, have students cut and color the parts of the insect head, have them label the parts of the head according to the teacher information sheet about insect parts. It is probably best to have students label the back of the mask parts.

Suggestions:

For grades 2-5 view the websites prior to teaching this lesson. Create cardboard templates of parts of the insect head for students to trace and cut out of construction paper. For grades 6-7 students may draw their own insect head parts using the website pictures as a guide. Or you may choose to have students make their insect masks out of paper mache.

Materials

Construction paper, enough for each student	
Cricket and/or butterfly patterns enough for each student	
Pencils	Glue
Markers	Tape
Crayons	Balloons
Colored pencils	Paper mache glue
Scissors	News paper

Activity 3 – Pin the wings on the insect!

University of California – Berkeley, Anatomy drawing

<http://www.cnr.berkeley.edu/citybugs/allaboutbugs/basicanatomy.htm>

Iowa State University, Anatomy drawing

<http://www.ent.iastate.edu/ref/anatomy/ihop/>

Bellarmino, Anatomy drawing

http://cas.bellarmino.edu/tietjen/Laboratories/FlowerCommunities/insect_anatomy.htm

Enchanted learning.com

<http://www.enchantedlearning.com/subjects/insects/printouts.shtml>

In the last activity students learned the basic parts of an insect head. This next lesson allows students to further explore an insect body. Talk with students about insect body parts. Ask them questions to begin the discussion and see if they can tell you the three basic parts of an insect body, they should already be able to name the head!

For this activity project the body of an insect onto the board or clear wall of the classroom. You can choose to make a large poster to hang on a wall. Create individually labeled cards or cards in the shape of insect body parts before this lesson. Individual cards should read: head, thorax, abdomen, antennae, mouth, wings, compound eye, legs.

Divide the students into groups of 3 and allow them to tack the parts to the insect. See which group can get the closest to the correct arrangement of the body. You may or may not wish to make this a competitive game. When each group has finished display a correctly labeled insect body, and begin to talk about the function of each part. For added fun, you may wish to blindfold students!

Assessment

Ask each student to cut out pictures of insects and/or pest-like animals and label as many parts as they can see. This is also a great opportunity to teach students about field guides!

This assessment idea was borrowed from

Bosley Jenkins, E. Exploring Urban Integrated Pest Management. “All About Insects.” Michigan State University Pesticide Education. 2001.

<http://www.pested.msu.edu/CommunitySchoolIPM/curriculum>

Materials

Posterboard

Markers

Overhead

Overhead sheets

Drawing of Insect body from website

Construction Paper

Tape

Activity 4 – A Closer Look at Insects

For grades 3-7:

“All About Insects” from Exploring Urban Integrated Pest Management by Jenkins. This activity can be found in more detail at

<http://www.pested.msu.edu/CommunitySchoolIPM/curriculum>

Bosley Jenkins, E. Exploring Urban Integrated Pest Management. “All About Insects.” Michigan State University Pesticide Education. 2001.

West Virginia University Extension Service

<http://www.caf.wvu.edu/~forage/4002.htm>

Amazing Insects – Insect facts and information

<http://www.ivyhall.district96.k12.il.us/4th/kkhp/1insects/buginfo.html>

“All About Insects” by Jenkins, is a perfect follow-up lesson for your students at this point. It allows students tell you what they have learned about insect anatomy thus far, and for the class discussion to expand to discussions about insect morphology.

In this activity students have the opportunity to discuss complete and incomplete metamorphosis as well as talk about insect body parts and their function. This is a perfect opportunity to rear insects in the classroom as you learn about metamorphosis. But if you choose not to have insects in your classroom, you may choose to allow students to collect insects and bring them to class, ask a university entomology club to present insect displays, or use insect pictures from activity 3. Hand out the worksheet that displays an insect body that will be labeled (you will need to delete the labels for student copies). As you display or study the insects and their parts ask the students to take notes that correspond to the worksheet drawings.

Materials

Paper, enough for worksheets for each student

Insects

Magazines

Internet availability

Pencils

Activity 5 – Insect Communication

These games were developed by Dr. Joseph Culin, Department of Entomology, Soils, and Plant Sciences at Clemson University – Entomology Website <http://entweb.clemson.edu> and are used with permission.

Now that students have a greater understanding about pest anatomy, and morphology, learning about insect communication is a great way to wrap up this segment of learning more about pests.

Introduction

Just like humans, insects use hearing (auditory), smell (olfactory), and sight (vision) as their means of communication. Insects need to be able to find a mate, find food sources, and avoid enemies. They use their senses to accomplish this. Insect communication is important in IPM because there are several devices designed to monitor or interfere with insect communication. One example is a pheromone trap. This device mimics insect pheromones in excessive amounts is used to confuse insects. Light traps are used to disorient insects at night and draw them away from feeding resources.

As an introduction to these games you may wish to talk to students about how they gain information from other people, excluding conversation. What kinds of information can they gain from listening? What do they think when they smell a sweet smell or a sour smell? During these games students will learn how insects discover their mates through the use of their auditory and olfactory senses.

Auditory Communication game (Culin 2004)

Almost every one has heard insect songs at night, but little did they realize that the insects were trying to find each other. This game is based on the communication of loud singing insects such as crickets, katydids, or grasshoppers.

Instructions

Divide students into groups. Give each student an empty film canister and a comb. Instruct each group to create their own song. Each group's song should be unique. Once each group and each group member knows their song, choose at random, a member from each group to come to the front of the class. Have that person turn with their back to the class. Then pick one group at a time to play their song. Tell the selected individual in the front of the class to raise their hand when they hear their group's song. Have that person rejoin their group. Then ask for a volunteer from each group to step out of the classroom. As that person is waiting in the hall, have all of the students stand in a circle around the classroom; mix the groups well. Bring the volunteers, blindfolded, back into the classroom. Ask all of the groups to play at once. Ask the volunteers to walk around the circle listening for their mate. When they find that person they should raise their hand. You may choose to have guides for the blindfolded students.

Olfactory Communication game (Culin 2004)

Insects emit chemicals called pheromones to either attract one another or to repel other species. Pheromones allow insects to follow one another, cluster into groups, cause each other to move from one location to another, signal danger, or increase mating.

Instructions

This game is played in a similar manner as the auditory game. For this game you will divide the students into groups again, this time each group will receive a film canister that contains a cotton ball soaked with some kind of scent. Tell the groups to become very familiar with their scent. Choose one student, at random, to temporarily exit the classroom. While that person gone, ask the students to trade their scent with some one from another group. Again arrange the students in a circle around the classroom. Bring in the (blindfolded) volunteer and ask them to smell their way around the circle looking for their mate.

Materials

One set of empty 35mm film canisters, one for each student

Combs with different size teeth, one for each student

Another set of empty 35mm film canisters, each with a cotton ball, one for each student

5-6 different scents (depending on class size), you can use essential oils, liquid candle scents, cooking oils, cooking spices, perfumes etc.

Activity 6 – The Pest Tetrahedron

After the students have studied the identifying characteristics, reason for pest status, habitat, eating habits, signs, symptoms, communication, biology and behaviors of the pest discuss with them the components of the pest tetrahedron. Ask them questions such as:

- What will happen if the pest food supply is made less available, or less nutritious?
- What will happen to the pest if we change its habitat or environment by making it unsuitable?
- In what other ways can we affect the pest without using pesticides?

You may want to use your class pests as examples. Using these questions draw on the board a triangle or tetrahedron and see if your students can piece together the important components of the pest tetrahedron. Pests can be problems when all of the sides of the tetrahedron are equal (an equilateral triangle with a fourth point for time). Pests, hosts, appropriate environment, and time are the important components of this tetrahedron. When there is a suitable host, a viable pest (with the ability to cause damage), a favorable environment and enough time pests easily become a problem.

Team Problem Solvers

Divide the students into groups, and give each group a problem to solve. Each problem consists of a situation in which some part of the pest tetrahedron must be manipulated to create a situation that is unfavorable for the pest, thus managing the pest problem. Each team must write an answer the question(s), and develop a strategy for managing the pest population.

Activity 6 Follow-Up

After students complete this activity in class for school pests, ask the teams to develop pest problems for their classmates to solve using the group home pests your students have been learning about. Help students create pest situations using what they have learned about the pest tetrahedron. For grades 5-7 broaden this activity into the school yard and home gardens.

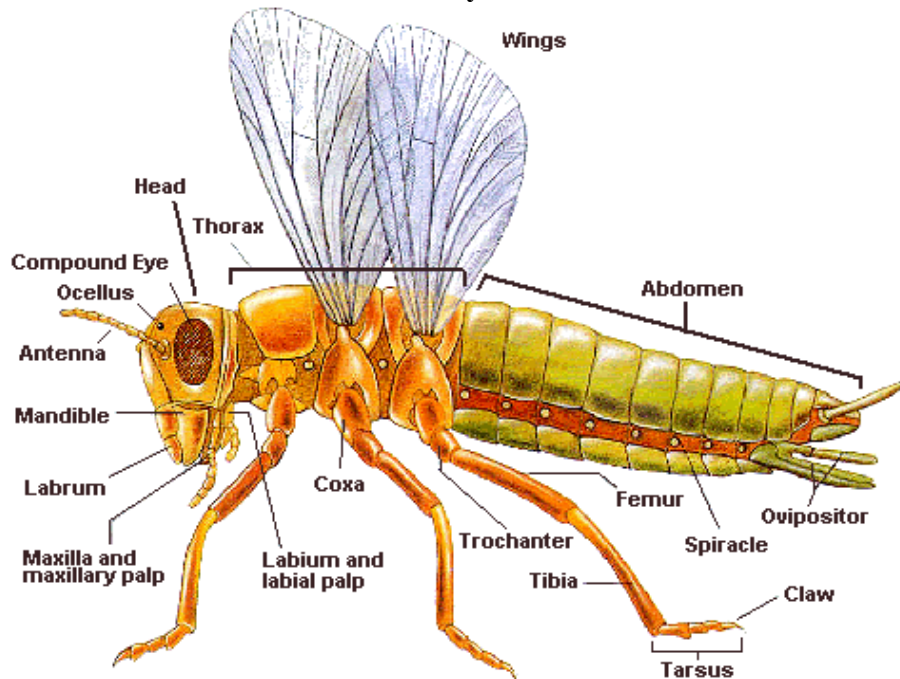
Materials

Paper

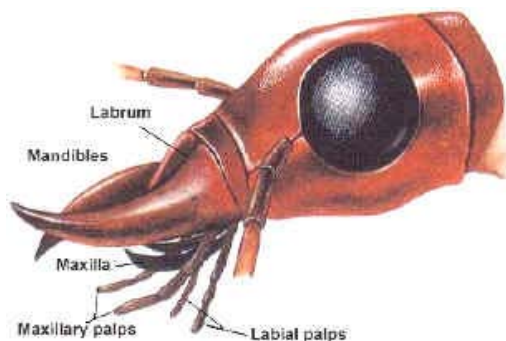
Pencils

Copies of the problems for each group member.

Lesson 2
Corresponding Activities – 2 & 3
Learning More about Pests
Teacher Information Sheet: Insect anatomy



Insects have three major components to their body: the head, thorax, and abdomen. The head is composed of the major sensory organs of the body: antennae, eyes, and mouth. The thorax consists of structures that allow the insect to be mobile: wings and legs. Lastly, the abdomen is made up of the digestive, excretory, reproductive, circulatory and fatty storage structures of the body. Insects have no bones but have a hard outer covering called an exoskeleton. The exoskeleton is lighter and stronger than bone. It protects the insect from the harsh external environment, by preventing the body from being flooded with water, or drying out. It also helps the insect to resist attack from pathogens.



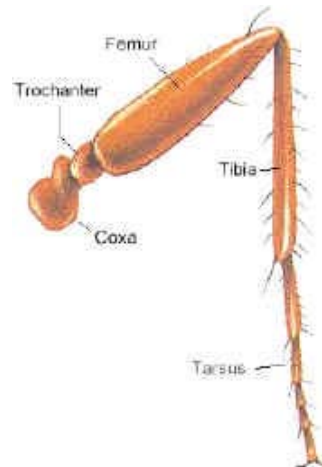
Head: The antennae are structures that protrude from the head. They are a pair of long, flexible, sensitive "feelers" that are used for olfaction. But they are also used for other communication procedures, including feeling, finding a mate or food, sensing everything, communicating with each other, smelling, and hearing (e.g. male mosquitoes). Antennae

contain pores that sense chemicals or pheromones in the atmosphere. Pheromones are chemicals used for a variety of communication purposes between individuals of the same species, including mating, foraging and trail making, and danger warnings. These chemicals are put out by one insect to affect the behavior of another.

The head also contains the eyes. The eyes can be compound, or simple. A simple eye is called an ocellus.

The mouth has four major parts, and is layered from front to back. The first part or front covering is the upper lip or labrum. Just behind the upper lip are the very strong mandibles. Behind the mandibles are maxillae. The maxillae manipulate the insect food. They are composed of the maxillary palps which are sensory organs much like the antennae. In the very back is the labium. It is the bottom lip and is composed of labial palps. These mouthparts are modified into suction structures in many insects that pierce plant or animal tissues, such as mosquitoes. In other insects mouth parts are modified into a sucking structure, called a proboscis that coils and uncoils to obtain nectars within flowers.

Insects have a simple brain that is capable of secreting hormones for the development of muscles, molting and metamorphosis. It also controls the mouthparts and salivary glands.



Thorax: The thorax has three segments, the pro, meso, and meta thorax. Insects have three pair of legs or six individual legs. They are used for movement, propulsion, jumping, and producing sound. The first pair of legs is located on the prothorax, the second on the mesothorax, and the third on the metathorax. Some insects have saltatory legs on the metathorax, which are used for jumping. The feet of insects are sensory structures that enable insects to taste their food. Insects have two pair of wings located on the second and third segments of the thorax.

Abdomen: This segment of the insect body contains the majority of the insect's fatty storage, digestive, excretory, circulatory and reproductive systems. Following food through the insect's digestive tract, beginning with the front of the insect the organs occur in the following order: esophagus, crop, proventriculus, ventriculus (where food is absorbed), intestine, and rectum. The heart runs along the top of the digestive tract directly under the dorsal exoskeleton. Insects have an open circulatory system, and their

blood is called haemolymph. Directly in front of the intestine is a group of hollow tubes, these are the malpighian tubules and they function as kidneys. All along the outside of the insect body, are small holes called spiracles, these open into chambers which open into trachea and serve as the respiratory system of the insect.

Source:

Metcalf, Robert L., and Robert A. Metcalf. Destructive and Useful Insects: Their habits and control 5th ed. New York: McGraw-Hill. 1993.

Cartage.org with information from arthropod.net (photos courtesy of this site)

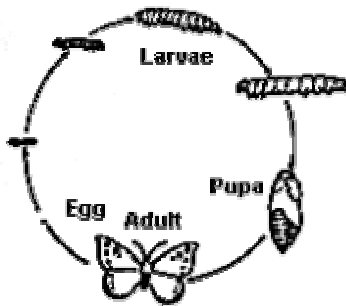
<http://www.cartage.org.lb/en/themes/Sciences/Zoology/Insects/InsectAnatomy/mainpage.htm>

Lesson 2
Corresponding Activity - 4
Learning more about pests
Teacher Information Sheet: Metamorphosis



Photo courtesy of Pacific Science Center
<http://www.exhibits.pacsci.org/insects/metamorphosis.html>

Metamorphosis or insect development can occur in two very different ways. The first is *complete metamorphosis*, in which each life stage of the insect is different from the previous. The second is *gradual metamorphosis*, in which each stage resembles the previous stage.



Complete metamorphosis: A butterfly is an insect with complete metamorphosis. There are four life stages, the egg, larva, pupa and adult. A life stage is a period of an insect's life that is drastically different from the previous or next stage. It is different in appearance and behavior. Following the egg stage, growth only occurs until the pupal stage. At that point the insect stops growing. Once the adult emerges from the pupal stage, it has fully grown and fixed wings. At this point the insect will grow no larger, except to expand its body for a large meal.

Egg: There are different types of reproduction. Insects that lay eggs are termed oviparous. That is the egg is formed inside of the mother's body, and then deposited in some protected environment such as in a tree crack or under a leaf for the egg to fully develop. This is similar to egg laying in birds but insect eggs do not require incubation. Another type of insect reproduction is called ovoviviparous reproduction. In this case, the mother is fertilized and eggs are produced. However, she does not deposit the egg outside her body; rather she retains the eggs inside her, and once the young hatch she

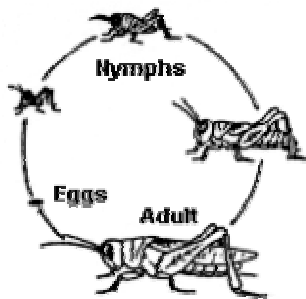
gives birth to them. This is different from animal birth because the insect receives its nourishment from the egg yolk rather than from the mother.

Insect eggs are generally deposited in a protected area, which also contains a food source for the young to feed upon when they hatch. Eggs are distributed in several ways, depending on the insect. Eggs may be laid singly, which is rare, or in masses. When eggs are laid in masses, females may lay several hundred to several thousand eggs per day. Eggs can be laid at one time, a few per day, or at intervals. Depending on the season, eggs may hatch right away or they may be dormant for a period of time, such as over the winter.

Larva: This is the first life stage after the insect hatches. The larval stage may be subdivided into phases known as instars. This is the life stage where the insect does all of its growing. The outer body covering, or exoskeleton, does not expand like human or animal skin, instead when the insect's inner body increases to a size which can no longer be contained by the exoskeleton, the exoskeleton splits. This shedding of the exoskeleton is molting. The old cuticle is cast off and the new one has formed under it. Molting and then leaving the old skin behind is known as a cast-skin. From the beginning of the new skin to the shed of that skin is an instar. Insects may go through 5 or 6 (and up to as many as 20) instars before reaching the next life stage. Genetics and diet of the insect determine molting.

Pupa: This is sometimes considered an inactive larval stage. The last instar retreats, usually, to some protected area, such as under leaves, in logs, or under limbs, before it transforms into the most helpless, defenseless stage of life. Then an outer covering is formed around the larva. This outer covering may be made of leaf material, small pebbles, fine bits of wood, pieces of soil, hairs from the body of the larva, and any other material that may surround the larva as it pupates (or begins its transformation to an adult). The material is fastened together by silk threads that are secreted from the mouth of the larva.

Adult: The adult stage is the last stage of development. At this stage adults no longer increase in size. They are complete with three body segments and three pair of legs, and in most cases fully developed wings. They possess reproductive structures and can reproduce at this stage.



Gradual metamorphosis: Insects, such as grasshoppers, with gradual metamorphosis resemble the adult through their life, though there are some differences, the young (nymphs) do not have wings or genitalia. As in complete metamorphosis, the insects

with incomplete metamorphosis also go through several stages of growth, or molting. However, with each stage the nymph resembles the adult more. After several molts nymphs will develop wing pads, which will become larger with each molt. This development is very gradual. Unlike complete metamorphosis, nymphs and adults often feed on the same food source, and can be seen doing so.

Source:

Metcalf, Robert L., and Robert A. Metcalf. Destructive and Useful Insects: Their habits and control 5th ed. New York: McGraw-Hill. 1993.

West Virginia University Extension Service (source for diagrams)

<http://www.caf.wvu.edu/~forage/4002.htm>

Nova Online

<http://www.pbs.org/wgbh/nova/satoyama/transform.html>

Lesson 2

Corresponding Activity - 5

Learning More about Pests

Teacher Information Sheet: Insect Communication and senses

(Information directly from Mississippi State University website)

<http://insectzoo.msstate.edu/Students/basic.senses.html>



Moth antenna photo courtesy of Arthropod.net

Sense Organs: Insects have sense organs for taste, touch, smell, hearing, and sight--the same senses in humans. Some insects have sense organs for temperature and humidity as well as stresses and movements of their body parts. Most sense organs of insects are microscopic in size and are found on their body wall. Many are small hairs, and others are small domes or other shapes. Regardless of their shape, all sense organs have one or more nerves leading to them. These small sense organs are called sensilla (a sensillum is one sense organ). A single antenna of an insect may have more than five thousand sensilla.

Sense organs, or sensilla, that function for taste and smell always have at least one small hole, or pore, through which chemical molecules enter the organ. A single sense organ on the antenna of the polyphemus moth has 18,000 pores for chemicals to enter. There are always two or more nerves inside these sensilla that respond to chemicals.

Sense organs that respond only to mechanical touch or vibration do not have holes in them, and they only have one nerve. Some of these sensilla respond to changes in the body wall when the insect moves.

Taste: The organs of taste may be found on all parts of the insect's body, but they are located primarily on mouthparts and feet (or tarsi). Some insects, including bees and wasps, have taste organs on their antennae. Wasps and crickets know where to lay their eggs because they have taste organs on their ovipositor (structure for laying eggs into a substrate).

Most insects have the same four taste sensations as humans--salty, bitter, sweet, and sour. Many insects also have taste organs for particular chemicals found in only certain plants. The cabbage butterfly, for example, has a taste organ for mustard.

Smell: Antennae sometimes are called "feelers." However, antennae are primarily "smellers"--they are the insect's "nose" since they are covered with many receptors for smell. These organs help the insect find food, a mate, and places to lay eggs. Insects can even decide which direction to fly by using their sense of smell.

The organ of smell of an insect does not detect as many different odors as a human's nose, but the insect's organ is tuned more finely. It can detect differences between very similar chemicals, and it can detect chemicals at much smaller amounts. For example, the male of the lesser emperor moth can smell the chemical pheromone of the female moth at a distance of greater than six miles. Social insects, like ants and bees, know when an unwanted visitor enters their nest because they recognize the members of their own colony with their sense of smell.

Touch: Small hairs with a nerve at their base are sense organs that respond to touch. The insect can sense the movement of this hair if it touches another object. These sensory hairs help honey bees orient to the earth's gravity when they are upside down.

Sense organs of touch can respond to the wind or a gentle breeze. This is one reason why it is difficult to catch a fly. Flies can sense the air being pushed towards it when your hand is moving. One grasshopper species can feel air moving at less than one-tenth mile per hour.

Hearing: Insects can hear sound passing as vibrations through the air as well as through the ground, water, or the leaf of a plant. Some insects can hear sounds that people cannot. Insects have many different kinds of "ears" or hearing organs. The simplest hearing organs are the same hair-like sense organs that respond to touch. Some insects, such as cicadas and crickets, detect sound with a tympanum, a large membrane like the eardrum in humans.

Bats make sounds that echo from a flying insect. Bats use this echolocation to catch their food. Many different moths have a tympanum on their wings, thorax, or abdomen. These moths can hear the clicking sounds of the bats and take evasive action, dropping in the air or changing their flight path, to avoid being caught.

Many insects have hearing organs within their legs. These ears in legs respond to vibrations passing through the ground or a plant. This is why ants will come out of their nest when you stomp the ground nearby.

Sight: Adults and nymphs of insects have two compound eyes and up to three simple eyes on their head. Larvae of insects with complete metamorphosis, such as caterpillars and grubs, do not have compound eyes, but they may have 1-6 simple eyes. A simple eye is a single lens that tells the difference between light and dark. Larvae can also see rough shapes with their simple eyes. A compound eye includes many lenses that have six sides and fit together like the cells of a honeycomb. Compound eyes differ among insects in

their ability to see, but some can see sharp images and different colors. All insects can see movement better than shape.

Insects with large compound eyes, like cockroaches and dragonflies, can see 360 degrees from a focal point. Color vision in insects differs from that in humans. Many insects can see the ultraviolet color not visible to humans, but most insects cannot see red color. If a red plastic film is placed over a flashlight, insects can be observed at night without their detecting the light.

Other Senses: Insects have special organs for sensing their movements, which cause internal changes in pressure and stress inside their body. These sense organs are similar to those for touch, except they are dome-shaped and have no hair. Insects have many of these pressure and stress organs on their wings and legs, and they could not walk or fly without them.

Instinct and Learning: Insect behavior is mostly instinctive. Genes determine instinct before the insect hatches from the egg. A caterpillar does not make a conscious choice of which plant to eat. Rather, the caterpillar is programmed to eat a certain kind of plant, even though other nutritious plants might be available. Likewise, a wasp does not choose to sting a person. The wasp is reacting by instinct to a threat or invasion of its territory.

Insects also have the ability to learn. Some moths first locate flowers instinctively by their scent. These moths later learn to identify the flower by their vision. Some kinds of wasps make orientation flights to learn landmarks near their nest, and these landmarks are remembered so they can find their nest after a longer flight.

Honey bees can be trained, or conditioned, to associate sugar water with a particular color or aroma. Honey bees also learn to come to food at certain times during the day when there is nectar available.

Insects also learn by "trial and error." When Colorado potato beetles first attempt to mate, they are not good at identifying their own species or even distinguishing the head from the tail end of the body. With repeated attempts and mistakes, they learn to recognize their own species and to differentiate the head from the tail.

From Mississippi State University
<http://insectzoo.msstate.edu/Students/basic.senses.html>

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Lesson 2

Corresponding Activity - 6

Learning More about Pests

Teacher Information Sheet: The Pest Tetrahedron (disease triangle)

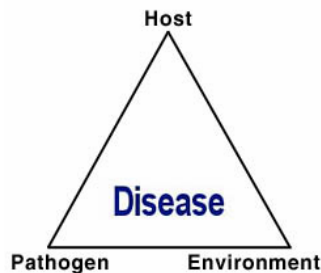


Photo courtesy of APS Education Center (apsnet.org)

The pest tetrahedron is the triangular representation of the relationship that occurs between the pest, its host, and the environment over time. On an equilateral triangle, one side represents the pest or pathogen, the adjacent side represents the host, and the last side represents the environment. The length of each side is proportional to the sum total of the characteristics of each component that favor diseases or pests. For example, if plants (the host) are resistant, the wrong age, or widely spaced then the total would be small or zero. If the three components could be quantified, the area of the triangle would represent the amount of disease or pests in a plant or plant population. If any of these three components is zero then there can be no disease or pest infestation (Agrios 1997). Thus, for problems to occur the host is susceptible or vulnerable the pest or pathogen is virulent, in contact with the host and an interaction is taking place. Also the environment is favorable and enough time has taken place.

The Pest (or pathogen): The pathogen or animal pest must in a virulent life stage or present in great quantities. Considering insects have several developmental stages in their life, some stages will be much more virulent than other stages, for example, the egg stage of a beetle is not causing any damage, and is therefore not virulent. However, the larval and adult stages are very virulent; they are capable of causing disease transmission, decreased plant vigor and defoliation. Pathogens require two components to cause damage, they must come in contact with a host and the pathogen and host must interact. If conditions are unfavorable, the pathogen may not be able to attack, or the host may be resistant to the attack. Pathogens also have ranges of virulence (more or less virulent depending on life stage). They may also be present in small or large quantities, may be in a dormant state or may require a film of water or specific vector to potentially be problematic.

The Host: The host must be susceptible. It must be in a stage of development that is vulnerable pest or pathogen, and it must come in contact with the pest or pathogen. For example, some pests prefer to eat only the foliage of trees, thus when the trees are

dormant or the leaves have fallen that particular pest will not be able to feed because its host is not vulnerable. There are also certain pests that prefer to eat the fruit of certain plants. If the fruit are not yet growing that host is not vulnerable to the pest.

The Environment: The environment must be favorable to the pest or pathogen. The temperature, humidity, and light all must be in favorable conditions for the pest to invade its host. For example, spider mites prefer dry conditions, so when there are humid condition, say in a greenhouse, that particular spider mite will not be a problem.

Time: Nothing happens immediately, pest problems and pathogens may take weeks or months to develop. It takes time for the pest to develop to an active life stage, the host to develop into a vulnerable life stage, and often times mother nature can play a very important role in regulating environmental conditions.

The purpose of understanding the pest or disease triangle is to be able to use it as a tool in pest management. Knowing how to manipulate the triangle and knowing some of the pest and disease biology is the key to effective management. If the pest manager can create an unfavorable condition for the pest or pathogen by altering one of the sides of the triangle then the pest problem can be regulated. For example, if a person is having a problem with cockroaches in their home, they may alter the environment portion of the disease triangle by washing counters and stopping up leaks. Scouting and monitoring help to alter the pest portion of the pest tetrahedron. Scouts look for all stages of the pest. If it is early in the season and the scout discovers eggs of the key pest, they may consider some physical control to eliminate the pest in its vulnerable stage before it becomes a problem. Lastly hosts can play a very significant role in altering the disease triangle. Using host plants that are resistant to a particular pest or pathogen problem in a garden, crop, or greenhouse is the most effective way to alter the host, making conditions unfavorable for pest or disease development.

Sources:

Agrios, George N. Plant Pathology 4th Edition. Academic Press: San Diego 1997.

Norris, Robert F., Edward P. Caswell-Chen, and Marcos Kogan. Concepts in Integrated Pest Management. Pearson Education, Inc. Upper Saddle River: New Jersey 2003

American Phytopathological Society - APS.net

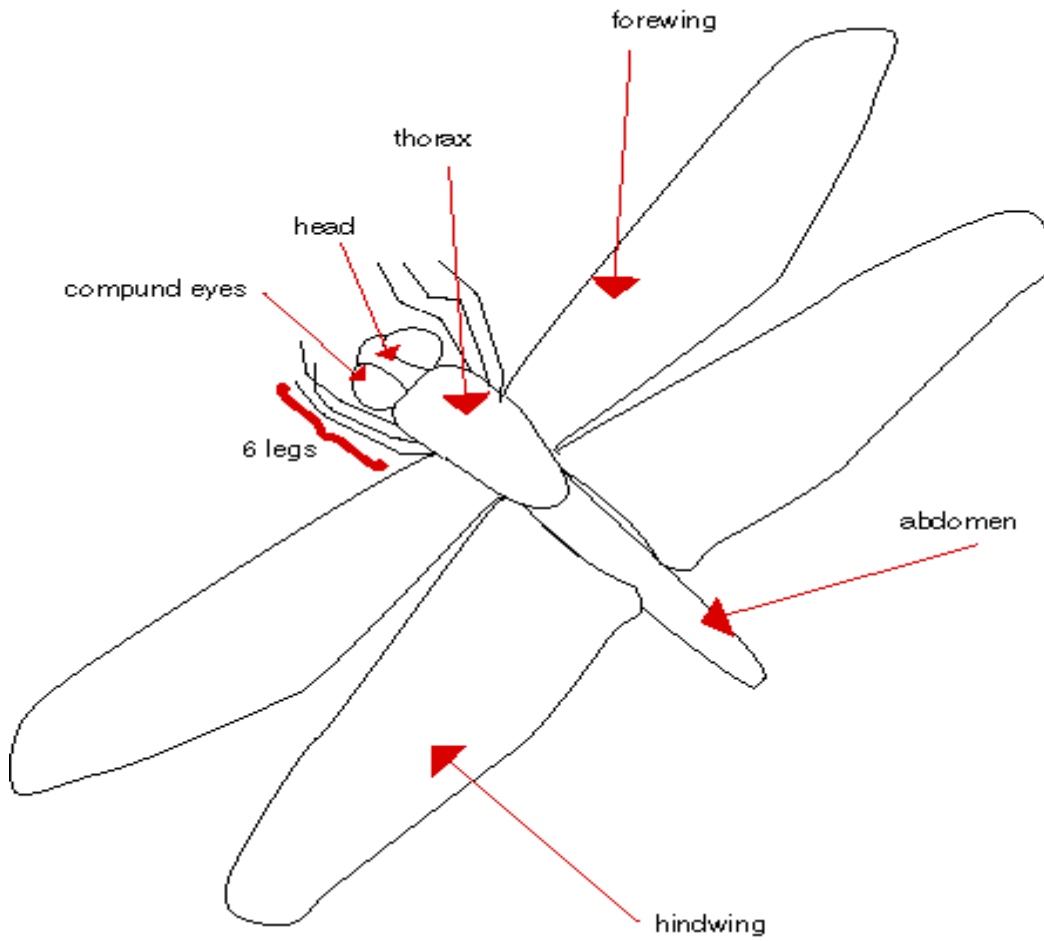
<http://www.apsnet.org/education/InstructorCommunication/TeachingArticles/Francl/Top.html>

Lesson 2

The following drawings correspond to activities – 3 and 4

Learning More About Pests

Drawings Courtesy of University of California –Berkeley
And Bellarmine



Lesson 2 – Team Problem Solvers
Corresponding Activity – 6 The Pest Tetrahedron
Learning More About Pests

Introduction: Students have learned the four components of the pest or disease tetrahedron. For each situation students should (1) identify the pest, host, environment, and symptoms and signs. All problems occur with time so it is not necessary to identify that factor, but encourage students to think about plant, pest or disease life cycles. Next (2) have students decide on and investigate recommendations for managing the problem. Encourage students to determine alternatives to pesticides. Have them suggest as many ways possible to manage the problem. Lastly, (3) have students explain how their situation manages the problem and why. This last step may be omitted for younger children.

- Problem A In the summer time, your grandmother grows beautiful flowers in her garden. She loves her daylilies but grows tired every day of seeing so many weeds like crabgrass and oxalis.



www.extension.umn.edu/.../images/daylilies.jpg

- Problem B. One summer day when you opened the door to the house several flies flew in. All day long they were pestering you, landing on your food and buzzing in your ears. When you went outside, you smelled a rotting, dirty smell. You decided to follow the odor, which took you to your neighbor's garbage. He has not taken it out for weeks.

- Problem C. This morning your little brother made a peanut butter sandwich for breakfast. He was in a hurry to meet the school bus and on his way out of the house he tripped on the bowl of dog food and knocked some of it out of the bowl. When you returned home, you found mouse droppings on the kitchen counter and along the wall near the dog food.



www.scarafaggio.com/images/mouse_droppings_dr...

Problem D. Grandfather planted a young rose bush in his yard early in the spring. It is now nearly late summer and the leaves are glistening as if it had just rained. You touch the leaves and they are sticky and have black specks. Curious as to where this sticky material is coming from, you look under the leaves. You find small pear shaped insects. You also notice that the roses are looking a little wilted. You decide to take a few of these bugs and some rose leaves to your science teacher. He tells you these insects are aphids and they produce a sugary waste called honeydew, and the black specks are a fungus called sooty mold.



www.sactorose.org/ipm/84whiteflies.htm

Problem E. It is spring and you are helping your parents with their garden. Things are going along great and the vegetables look good. About mid summer you notice big pieces of the lettuce leaves are missing. It looks as if something has been eating them. The leaves are chewed and some of the other vegetables have portions where something has eaten them.

Problem F. You are camping with your family and are being bitten by mosquitoes. You are unable to use insect repellent because of allergies.

Problem G. One day you are playing fetch with your dog and he stops and starts scratching his neck. You walk over to him and look through his fur and discover little black jumping fleas.

Problem H. Your family just returned from a two-week vacation and you are hungry. You run into the house to the refrigerator. When making your sandwich you notice bread crumbs on the floor, a bit of a leak from the refrigerator, and a dead cockroach in the corner. You also notice that the bread and cheese have a bit of green fuzz on them.

Problem I. You are having a family picnic in your back yard and as you enjoy your soft drink you notice a few bees buzzing around. When you get up to see where they are coming from you notice an open trash bag.

Problem J. It's fall and as the temperature gets cooler you notice that you prefer to be inside more where it is warmer. One day you notice you are not the only organism that wants to be in the warmth. You begin to notice little lady beetles wandering around inside your home along your ceiling; they sometimes fly into you and wander into your food.



www.ppdl.purdue.edu/.../asian-ladybeetles.jpeg

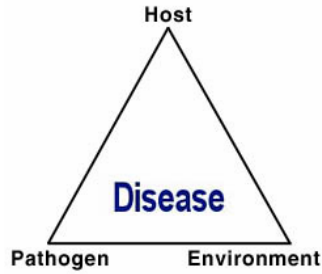
Team Problem Solvers: Teacher Answer Sheet Corresponding Activity - 6

Your students may come up with alternative answers than the suggested answers provided here. If they are logical then they are correct.

- Problem A. Host: Daylily bed
Pest: Weeds – Crabgrass and oxalis
Environment: Summer time and space in the bed
Control: Hand pull; hoe; prevent by putting in plastic mulch or rock
Explanation: makes environment unfavorable
- Problem B. Host: Neighbor's garbage, you
Pest: Flies
Environment: House, garbage
Control: Ask neighbor to dispose of trash by taking to disposal site; keep trash in closed cans; put screens on doors; swat flies
Explanation: Makes host unfavorable to pest
- Problem C. Host: Peanut butter, dog food
Pest: Mouse
Environment: House
Signs: Mouse droppings
Control: Clean up peanut butter and dog food; keep food in closed plastic containers; set mouse traps along walls; patch up holes that could be related to mice; get a cat.
Explanation: Makes host and environment unfavorable
- Problem D. Host: Rose bush
Pest: Aphids feeding on plant tissues, fungus feeding on honeydew
Environment: warm summer day in the garden
Signs: Honeydew, mold
Symptoms: Wilting
Control: Prune rose bushes; introduce ladybird beetles to eat aphids; transplant bush
Explanation: Makes environment and host unfavorable
- Problem E. Host: Garden
Pest: Rabbits, beetles, or caterpillars
Environment: Garden - summertime
Control: Put up fence for rabbits; set traps; get a cat
Explanation: Makes environment unfavorable

- Problem F. Host: You
Pest: Mosquitoes
Environment: Night, forest near a lake
Control: Use citronella candles; wear long pants and long sleeved shirts; light a fire
Explanation: Makes host unfavorable
- Problem G. Host: Dog
Pest: Fleas
Environment: Outside and in dog's fur
Symptoms: dog scratching
Control: Give a bath; comb and brush fur; vacuum your home; change and wash dog's bedding
Explanation: Makes host and environment unfavorable
- Problem H. Host: Crumbs, water, bread, cheese
Pest: Cockroach, mold
Environment: Home, refrigerator, and kitchen
Sign: Dead cockroach
Control: Clean up crumbs; throw out cheese and bread; clean kitchen
Explanation: Makes environment unfavorable
- Problem I. Host: Trash, you, sugary foods
Pest: Bees
Environment: Outside, backyard
Control: Close up trash bag and dispose; cover soda cans and food; go inside
Explanation: Makes host unfavorable
- Problem J. Host: You, your food, home
Pest: Ladybird beetles
Environment: Warm house
Control: Sweep them and put them outside; vacuum them and dispose of vacuum bag
Explanation: Eliminates pest

IPM Lesson 2 – Learning more about pests
Activity 6 – The Pest Tetrahedron
Team Problem Solvers Worksheet



Name: _____

Problem: _____

Host: _____

Pest: _____

Symptoms and signs: _____

Environment: _____

Control: _____

How can your solution manage the problem and why?
