Discovering IPM: An Inquiry Approach to Learning Integrated Pest Management (IPM)

A curriculum for grades 2-7

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Contents
Curriculum Introduction................................................................. 1
Preliminary lessons: Ecology and You.............................................. 2
Lesson One – Eco-Tag................................................................. 4
Lesson Two – Design a Food Web.................................................. 8
Lesson Three – Creating the Ecosystem........................................ 11
Rubric for Ecocolumn................................................................. 12

IPM Lessons.................................................................................... 14
Lesson One – Discovering Pests.................................................... 16
School Scavenger Hunt................................................................. 19
Teacher Information Sheet: What is a Pest?.............................. 21
Teacher Information Sheet: Symptoms and Signs........................... 22
Teacher Information Sheet: Ants.................................................... 23
Teacher Information Sheet: Cockroaches..................................... 25
Teacher Information Sheet: Flies................................................... 29
Teacher Information Sheet: Spiders.............................................. 32
Teacher Information Sheet: Wasps, Yellowjackets, and Hornets... 35
Teacher Information Sheet: Gray Mold........................................ 38
Teacher Information Sheet: House Mouse................................. 40

Lesson Two – Learning More About Pests................................. 42
Teacher Information Sheet: Insect Anatomy................................. 53
Teacher Information Sheet: Metamorphosis............................... 56
Teacher Information Sheet: Insect Communication & Senses........ 59
Discovering IPM: An Inquiry Approach to Learning Integrated Pest Management

Curriculum Introduction

Integrated Pest Management (IPM) is a decision-making process that uses applied ecology, knowledge-based applications, and a compatible integration of tactics to manage pest populations below economic injury levels. Using this curriculum, teachers will be able to teach science through meaningful and useful methods. Discovering IPM offers a step-by-step approach to discover and learn about science in “everyday” situations. It teaches IPM through inquiry. Students discover IPM, by engaging in the steps of the IPM process through the activities outlined in each lesson. In the last lesson of the curriculum students define the concept of IPM based upon what they have discovered.

This curriculum consists of preliminary ecology lessons designed to help the students become more familiar with the some of the interactions of an ecological system. IPM relies on ecological relationships and concepts for the integration of management tactics. Therefore students must have a general concept of what ecology is and what are the relationships that exist with in an ecosystem, to understand and utilize integrated pest management.

The subsequent lessons lead the students through the steps of IPM as an informed knowledge-based decision-making process. Students discover the pest problem, they identify and learn more about the biology of the pest, and they develop a monitoring program in which they determine population densities through scouting. Based on gathered information they learn about various management tactics and make informed decisions about control. Lastly they define IPM. The lessons of the curriculum occur in environments in which students are familiar, and for which teachers have resources, including home and school environments. These settings are the basis for urban IPM.

Each IPM lesson represents a step in the process of IPM consists of an introduction. The introduction explains how the current lesson relates to the previous and its importance in an IPM program. Also provided are appropriate South Carolina science standards, credible Internet resources, list of materials, approximate duration of time, objectives, and vocabulary to be learned by the student throughout the activities outlined in each lesson. Following each lesson are appropriate worksheets, game cards, and assessments. Background information sheets related to the lesson for teacher reference are at the end of each lesson.

Following the home and school lessons (urban IPM) is a module section. The module section consists of four modules and depending on the availability of teacher resources, these modules may be used in several ways. The modules may be used to teach IPM separately from the urban IPM lessons, using the urban IPM lessons as a guide. The modules may be used to reinforce IPM as separate lessons following teaching of the home and school lessons. Or the modules may be incorporated with the urban IPM lessons as separate supporting activities.

Discovering IPM was written to accommodate teacher resource availability, flexibility, and to inspire creativity. Depending on student’s age, teachers may choose to modify or eliminate activities, or to proceed with enrichment ideas. Ideas and suggestions for changing lessons to suit age levels are offered where appropriate in the lessons.
Preliminary Lessons – Ecology and You

Introduction

These lessons are designed to give the students a general understanding of ecology and their place within an ecosystem. For students to understand the concept of Integrated Pest Management (IPM) they must first be aware of some of the basic components of ecology because IPM is a form of applied ecology. The following lessons will give the students an understanding of population dynamics and of factors of environmental resistance that serve to regulate densities within a community. Additionally they will understand how organisms fulfill specific roles in an ecosystem and what elements are necessary for organisms to sustain life. These lessons are meant to be precursors to the integrated pest management lessons, in which students will apply their knowledge of ecological relationships to the study the pest populations they will discover in the IPM lessons.

Appropriate SC Science Standards for the Following Outlined lessons

Grade 2:
- I-B-Inquiry, 1d
- II-Life Science, A-Characteristics of Organisms, 1a, 2a,b
  C-Organisms and their Environments, 1a.

Grade 3:
- I-Inquiry, A-Process Skills, 1, 2a, 4a
  B-Inquiry, 1a,e
- II-Life Science, A-Characteristics of Organisms, 1a
  C-Organisms and their Environments, 1a,b, 2a,f

Grade 4:
- I-Inquiry, A-Process Skills, 1, 4a, 5a
  B-Inquiry, 1a,e
- II-Life Science, A-Characteristics of Organisms, 1c
  B-Organisms and their Environment, 1a,b, 2a,b, 3a,b, c, d

Grade 5:
- I-Inquiry, A-Process Skills, 1, 2a, 4a
- II-Life Science
  B-Populations and Ecosystems, 1, 2a,b, 3a,b, 4a,b, c, d, e, f

Grade 6:
- I-Inquiry, A-Abilities Necessary to do Scientific Inquiry 1a,d 5, 7a,b
- II-Life Science, C-Regulation and Behavior 1,2,3

Grade 7:
- I-Inquiry, A-Abilities Necessary to do Scientific Inquiry, 1a,d, 4a,b 5, 6, 7a,b,c
- II-Life Science, B-Regulation and Behavior, 1a,b
  D-Populations and Ecosystems 1a,b, c, 2a,b, c, 3a,b, c
Resources for the Following Ecology Lessons

Lesson Planet
http://www.lessonplanet.com/search/Science/Ecology
http://www.education.com/common/resources/lp/sci/9711104s.html

Yale-New Haven Teachers Institute
http://www.cis.yale.edu/ynhti/curriculum/units/1992/5/92.05.10.x.html
http://www.cis.yale.edu/ynhti/curriculum/units/1992/5/92.05.10.x.html#s
http://www.cis.yale.edu/ynhti/curriculum/units/1992/5/92.05.10.x.html#e
http://www.cis.yale.edu/ynhti/curriculum/units/1980/5/80.05.12.x.html

Steve Trash
http://www.stevettrash.com/booking/ecolesson.htm
http://www.stevettrash.com/booking/lessons/lesson1.htm

MC Biology
http://www.marietta.edu/~biol/102/ecosystem.html

Access Excellence – Design an Ecosystem

Bottle biology: See it, touch it, smell it, taste it
http://www.bottlebiology.org/
Lesson 1 – EcoTag

Introduction
This is a fun activity in which students are allowed to discover something about food chains and food webs. It is a guided inquiry approach to revealing the food web. Students will become excited to tell you how the food web works, and enjoy designing trophic interactions. This activity helps students conceptualize predator-prey relationships, address ecosystem and population dynamics, and allows students to see how ecosystems sustain themselves. This is a good activity to refer to throughout the following lessons because students will remember this activity.

Duration 1-1.5 hours

Objectives
Students will:
• Discover the fundamental components of ecology
• Learn about predator-prey relationships
• Understand how organisms fulfill niches within an ecosystem
• Learn what organisms need for survival (shelter, food, water, space)
• Understand the consequences of man’s actions upon an ecosystem

Vocabulary (for Ecology Lessons 1-3)

<table>
<thead>
<tr>
<th>Ecology</th>
<th>Herbivore</th>
<th>Prey</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ecosystem</td>
<td>Carnivore</td>
<td>Population</td>
</tr>
<tr>
<td>Producer</td>
<td>Habitat</td>
<td>Energy</td>
</tr>
<tr>
<td>Consumer</td>
<td>Omnivore</td>
<td>Niche</td>
</tr>
<tr>
<td>Decomposer</td>
<td>Predator</td>
<td>Community</td>
</tr>
</tbody>
</table>

Materials needed for activity
Large colored index cards or construction paper
Safety pins or string to attach the name tags
Markers
Large open space to play
Discussion
Begin by asking students questions that will lead their thoughts to basic relationships within the ecosystem. Start by making the lesson personal. Ask the students about what they need to survive, and what kinds of things they eat. Then relate that information to animals in nature.

1. What did you eat for breakfast this morning?
   - Cereal, toast, eggs, etc.
2. Where did you find that food? How did it get there?
   - In the cabinet, refrigerator, etc. Mom or Dad bought it.
3. Did you have anything to drink with breakfast?
   - Water, juice, etc.
4. Where did you eat breakfast?
   - At the house, in the kitchen.
5. Imagine now, that you were a baby squirrel, and it was time for breakfast. What would you eat and drink?
   - Nuts, human scraps, milk from my mother, maybe water
6. Where did you get the food? How did it get to you?
   - From trees in the forest, Mother or Father brought it to you
7. Where did you eat it?
   - In the nest.

Summary
Continue asking the students questions that will allow them to draw conclusions and form relationships. What things did you find you needed to survive the morning, that are the same as the baby squirrel, food, water, protection/home/shelter, and a space for that home. What is the importance of these things? Surviving, and living. You may then want to ask more questions about the significance of shelter as protection from predators, as it will become more significant in the activity.

Activity
This is essentially a game of tag, but one in which students will gain an appreciation of ecology, food webs, and predator-prey relationships. The food chains (within the food web) should be constructed to be appropriate for organisms in your area. This will enhance the students’ understanding of their own ecosystem. It is best played outside or in a gym.

Create nametags for participating “organisms” using large colored index cards. The nametags should reflect organisms involved in an actual food pyramid, and allow each student to play. An example food chain might be: Hawks-squirrels-fish-flies-grasshoppers. Write on each nametag, in large print, the name of each animal (Predator) the student will represent. Under that animal, in smaller print and in a different color, write the names of the animals which may be eaten (prey) by the predator. (Writing the names of the prey is optional, and you may choose to exclude it for older students) Be sure that only a few students represent the animals at the top of the food chain, such as
hawks, and that there are larger groups of students representing the animals at the lower end of the food chain, such as grasshoppers and flies.

Randomly give each student a nametag; students “become” that animal. Explain that they are only allowed to tag (hunt/kill) the food that they would take as prey. Once outside, each animal group has a specific “safe site” that represents their shelter, this might be a tree or a corner of a building, and when the student is touching that tree or building, they are safe in their “shelter”. The last student (or students) standing are the best hunters or winners.

**Versions of Play**
1. Once a predator has tagged its prey, the prey may sit out until the top predators have no more prey to hunt. Then you may mix up nametags and allow the students to become a different animal. Continue play.
2. For grades 6-7: You may also choose to make stock cards of detritivores (animals that feed on dead or decaying material, such as flies or bacteria) and when a prey is tagged, the predator brings their prey to you and you may exchange the prey tag for a detritivore tag. This represents recycling in a true ecosystem, and promotes an idea of how ecosystems sustain themselves.
3. For grades 6-7: You may also choose to stop the game in mid-play and describe some imaginary complication on some part of the playing field, such as fire, or a human interruption such as a road through the middle of the playing field, to provide students with more limitations. This allows students to contemplate man’s effect on ecosystems. With this option you may choose to play under version one, or version two.
4. You may also choose to add flags in the game, to represent plant materials that herbivores feed on. They must gather at least 3 flags during the duration of the game, (or a set time limit you choose to give them) or they will starve. Remember to provide name tags for herbivores.

**Follow-Up**
It’s recommended that you end the game a few minutes early to discuss with the students the basic components of the ecosystem.
- Which animals were the carnivores, herbivores, detritivores etc?
- Which animals were the producers and consumers?
- What represented each animal’s habitat, and what would constitute an ideal habitat for that animal?
- Which animals were the predators, which were prey?
- How did energy transfer in the food web?
- Using the game as an example, define an individual, population, and community.
- What is a niche? What is the niche of the predator, of the prey?
- How were populations regulated?
- Ask them what they have learned, and what is necessary for an organism’s survival.
Example Name tag for Lesson 1 – Eco-Tag

<table>
<thead>
<tr>
<th>(Predator)</th>
<th>Hawk</th>
</tr>
</thead>
<tbody>
<tr>
<td>(Prey)</td>
<td></td>
</tr>
<tr>
<td>Squirrels</td>
<td></td>
</tr>
<tr>
<td>Fish</td>
<td></td>
</tr>
<tr>
<td>Mice</td>
<td></td>
</tr>
</tbody>
</table>
Lesson 2 – Design a Food Web

Introduction
This lesson is designed to reinforce the material learned and discussed previously in Eco-Tag. It allows the students to formulate the concept of ecology using individual creativity.

Duration 1-1.5 hours

Objectives
Students will:
- Observe and make note of their immediate ecosystems
- Draw specific simple food chains
- Draw and expand food chains into more complex food webs

Materials needed for activity
A hiking area
Shoes for hiking
Colored pencils, crayons, or markers
Overhead projector
Marking pens

Discussion/Presentation and Motivation
Review the components of the ecosystem that were previously learned in Eco-Tag. Allow students to explain what happened to the different animal groups as the game was played. Then you may want to take students on a brief nature hike to allow them to observe their immediate ecosystems. As you are hiking help them make notes about:
- In what way do animals need plants?
- In what way do plants interact with other plants?
- How do plants and animals depend on each other?
- Which living things need each other to survive?
- Identify the nonliving components in the environment. What part do they play in the lives of living things?
- What is energy?
- Where does it come from?
**Activity/Assignment**
Discuss with students what they observed on their nature hike. Be sure to reemphasize and relate it to what they practiced in Eco-Tag. Introduce the concept of energy and that the sun is the ultimate source of energy.

For grades 5-7: Make an overhead of the wetland ecosystem drawing (omit the words at the bottom of the drawing), then project the diagram of the wetland ecosystem. You may have to introduce some animals if they are not well known to your area. You may also choose to design your own ecosystem or find a similar diagram. Allow students to tell you who-eats-who in the predator prey relationships. Draw the arrows of energy transfer to the predators (arrows point to those who gain energy). This will allow the students to begin to visualize a food web. Discuss, or ask students to define the differences between food webs and food chains. Discuss with students how the transfer of energy from one organism to another enables an ecosystem to be efficient and sustainable.

Have students design a diagram of an original habitat with specific food chains; encourage them to expand these food chains into larger food webs. Remind students to include: producers, consumers, decomposers, energy, predators, prey, water, and shelter. These creative and colorful food webs will be great reminders for organism needs as they expand into the IPM lessons.
Wetland

Circle the items in the picture

cattails
muskrat lodge
bulrushes
trees
frog
Lesson 3 – Creating an Ecosystem (Enrichment for grades 6 and 7)

Introduction
For grades 5-7: This activity will give older students a sense of ownership and appreciation for their environment. It gives them another chance to learn and understand the components and dynamics of an ecosystem. Students create and maintain their own ecosystems while reinforcing what they have previously learned. Bottle biology: See it, touch it, smell it, taste it at http://www.bottlebiology.org/ is a website that provides directions, necessary materials and appropriate backgrounds for ecocolumns (a soda bottle terrarium).

Duration 1-3 hours

Objectives
Students will:
• Design and create an individual ecocolumn
• Design and create specific ecosystem relationships that will exist in the column
• Develop oral presentation skills by sharing individual columns with class

Materials needed for activity
Bottle biology website  Probes
Several 2 Liter bottles  Soil
Scissors  Plant life
Glue  Insects

Activity/Assignment
This activity is hands-on and will enable students to create their own ecosystem. Have students plan an ecosystem with paper and pencil to be built with 2-Liter bottles, soil, plant materials, insects and any other living organisms. Encourage students to be creative in their design. Some students may choose to create a farm ecosystem, an ornamental ecosystem, or a woodland ecosystem. Next follow the instructions for creation of an ecocolumn that can be obtained from the Bottle biology website. Allow the students a few class periods to build their ecocolumn.

Follow-Up
You may choose to assess this activity in several ways.
1. Allow the students to present their ecocolumns to the class. Students should present the relationships, food webs, and habitats that are present in their columns and how their column functions as a whole ecosystem. Have them address how certain habitats would change if certain components of their ecocolumn were changed.
2. Bottle biology rubric.
Rubric for Bottle biology: Ecocolumn

Grades: Good, Fair, and Poor

Graded values:
1. Bottle construction
2. Column construction
3. Creativity
4. Observations
5. Exploration

1. Bottle construction:
   A. Good: Bottles not bent (for strength), labels removed cleanly, cuts are clean, sufficient ventilation holes, airtight sealed joints where appropriate.
   B. Fair: Bottles slightly bent, labels not completely removed, jagged cuts, lacking in enough air holes, joints leaky.
   C. Poor: Bottles smashed, labels on, jagged cuts, no air holes, super leaky joints

2. Column Construction:
   A. Good: Appropriate number of columns for habitats 3 or more (plant or animal, soil decomposition, aquarium), sufficient drainage holes, and air holes, sufficient components for habitats (i.e. ample soil, water, and organic matter)
   B. Fair: 2-3 habitat columns, too few drainage holes, not enough air holes, not enough soil, or too much water
   C. Poor: Only one habitat, no drainage holes, no air holes, not enough water or soil.

3. Creativity:
   A. Good: 3 or more chambers for habitats (aquariums, decomposing fruit, animals, plants, soil, etc.), varying species per habitat, or soil types, addition of branches, leaves, and twigs
   B. Fair: Less than 3 chambers for habitats, uniform species or soil types, little additions of branches etc
   C. Poor: One chamber for habitat, no species or only a few insects, no additions

4. Observations:
   A. Good: Student notices changes, precipitation, decompositions, increase or decrease in insect populations, proper draining, growing roots, reproduction and death cycles, soil changes. Observations noted in lab notebook.
   B. Fair: Student observes only a few changes from those listed above, and makes few notes in notebook
   C. Poor: Student makes no observations and makes no notes.
5. Exploration:
   A. Good: Students explore **each** habitat of their column by changing it, either adding to the habitat or taking away from it. Noting in lab notebook how the changes affect that habitat and other habitats.
   B. Fair: Students only explore a few habitats, and make little notes about changes to only one or the other affected habitats.
   C. Poor: Students do not explore any habitats and make no notes.

<table>
<thead>
<tr>
<th></th>
<th>Poor 1-4 pts</th>
<th>Fair 5-7 pts</th>
<th>Good 8-10 pts (max total 50 pts)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bottle Construction max 10 pts</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Column Construction max 10 pts</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Creativity max 10 pts</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Observations max 10 pts</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Exploration max 10 pts</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
IPM Lessons

Introduction
Now that students are familiar with ecology and some of the fundamental components of an ecosystem, they will have a clearer concept of integrated pest management (IPM) as a form of applied ecology. These lessons are arranged as a guided inquiry approach to learning about IPM. Students are guided through the steps of IPM before the term is defined. Once they have connected the steps of IPM with the concept of IPM they will then be able to branch into other ecosystems where IPM is practiced. Throughout these lessons students will build observation, reading, writing, and decision-making skills. The purpose of these lessons is to provide a foundation for awareness and implementation of IPM. They are not designed for a structured school-wide IPM program, but rather to increase awareness about environmental health and the role of pesticides. These lessons can be used as a building block for further lessons in IPM, life science, social studies, art, and mathematics; the possibilities are endless.

Appropriate SC Science Standards for the Following Outlined lessons

Grade 2:
- Inquiry,
  A – Process Skills, 1a – Observe, 2a – Classify, 4a – Communicate, B – Inquiry, 1abd
- II. Life Science, A – Characteristics of Organisms, 1a 2ab
  B – Life Cycles of Organisms, 1abc
  C – Organisms and their Environments, 1a

Grade 3:
- I Inquiry
  A – Process Skills, 1a – Observe, 2ab – Classify, 4a – Communicate
  B – Inquiry, 1abe
- II. Life Science, A – Characteristics of Organisms, 1ab

Grade 4:
- Inquiry
  A – Process Skills, 1a – Observe, 2ab – Classify, 4a – Communicate
  B – Inquiry, 1 b1
- II. Life Science
  A – Characteristics of Organisms, 1bc
  B – Organisms and Their Environment, 1 b 2

Grade 5:
- I. Inquiry,
  A – Process Skills, 1a – Observe, 2ab – Classify, 4a – Communicate,
  B – Inquiry, 1abcdef

Grade 6:
- I. Inquiry
  A – Abilities to do Scientific Inquiry, 1 – Identify process skills that can be used in scientific investigations a 1
  2 – Design and conduct a scientific investigation c, g, h
  4 – Develop descriptions, explanations, predictions, and models using evidence, a
7 – Communicate scientific procedures and explanations, a
Grade 7:
  • I. Inquiry
    A – Abilities Necessary to do Scientific Inquiry
    1 – Identify process skills that can be used in scientific investigations, a 1,2; 2; d1
    2 – Design and conduct a scientific investigation c
  • II. Life Science
    B – Regulation and Behavior, 1a

Resources for the Following Lesson

Minnesota Department of Agriculture, “What is a pest”
http://www.mda.state.mn.us/IPM/IPMPubs.html#PestPatrol

IPM Institute of America, “Inspect our house”
http://www.ipminstitute.org

University of California
http://www.ipm.ucdavis.edu/PMG/selectnewpest.home.html

National Pest Management Association
http://www.pestworld.org/homeowners/spotlight/
Lesson 1 – Discovering Pests (building observation skills, investigating)

Introduction
This lesson starts with what the students know. It enables students to start investigating in familiar environments, such as school and home. It encourages them to think more broadly about all of the other organisms in an environment. It might be helpful to refer to Eco-Tag throughout this lesson if students are having trouble visualizing more than just students and teachers at school or more than just their family members at home. This lesson introduces students to the concept of a pest.

Duration 2.5 – 3 hours

Objectives
Students will:
• Build reasoning skills by critically thinking about the other organisms that may exist in the same environments as them.
• Build observation skills by searching for pests in their habitat
• Build observation skills by making notes of their surroundings
• Build communication skills as they conduct interviews
• IPM objective - discover and define the meaning of a pest

Vocabulary
Pest
Symptoms
Signs

Materials
Paper
Pens or Pencils
Copies of scavenger hunt worksheets
Colored pencils, crayons, or markers

Discussion
Begin by having a brainstorming session with your students. Ask them questions that will heighten their observation skills. Get them to think about the other critters that might share their living or learning space. Write their ideas on the board. The following are some questions you may choose to help begin the discussion.

1. Who uses the school?
   • Students, teachers, principals, cafeteria people, custodians, nurse, parents
2. Are these the only school inhabitants? Could there be other living things in the school?
   • No, people are not the only inhabitants, and yes other organisms are in the school
3. Who are these other organisms?
   • Bugs, ants, cockroaches, flies, bees, wasps, spiders, mice, rats
4. Where do you find them?
- Classrooms, hallways, closets, bathrooms, lunch room
5. Do they live inside or outside?
   - Some live inside, and some can live outside, some live in both places
6. Do you see them during the day or at night?
   - Some you might see in the dark and others in the light
7. Do people want them? Why?
   - No, they are not wanted, because they are dirty and spread sickness. It is not healthy for them to be in our school
8. Are they unwanted? Are they harmful?
   - Yes because they are in our habitat, but they don’t really cause us any harm.

Use these questions to lead into a discussion of what defines a pest. Pests can be any unwanted organism (that occurs at any trophic level) in your personal environment, from weeds and fungus to insects. Usually students think of insects as pests, mostly because they think insects are scary walking around on more legs than us! Help them to understand that in nature there really is no such thing as a pest and that every living being has some purpose. Pest is a name that people give to those critters that are unwanted in the school or house because when they are abundant they can cause harm to our homes or schools, our health, well being, and can cause a financial burden. It is true that some pests, such as mice, can be dangerous in our living space. This is due to their ability to possibly spread harmful diseases.

Activity 1
School Scavenger Hunt:
Send your students around the school in search of pests. Have them fill out the scavenger hunt worksheet. Explain that it should be difficult for them to find most pests, assuming the school has a pest management program. But in their search for pests they may find evidence that a pest was present (symptoms or signs). Such evidence may include droppings, chewed areas, cast skins, eggs, etc. It is just as appropriate to find symptoms and signs of pests as it is to find the pest itself.

For younger students it will probably be best to do this activity with supervision. Also be sure to inform appropriate administrative staff and parents of your students’ mission.

Activity 2
Home Scavenger Hunt:
The next part of this activity is to expand what they have learned about pests in school, into the home. In most areas there will be similar pests inside the home as there is in the home, so you may choose:
- not to do a second scavenger hunt
- to change the pests that they were searching for in school to different pests at home
- to see if they can find the same pests
- to compare what they found at home to what they found in school
Variations of Scavenger Hunt:
For grades 6-7 you may choose to give students a blank scavenger sheet and have them completely fill in the boxes.
For grades 4-5 you may choose to give students a mixture of hints, rather than only the pest name, in order to make the lesson more challenging.

**Enrichment**
The following websites contain activities that will correspond to this lesson. You may choose to use these lessons as enrichment or assessment.

“What’s a Pest?” Minnesota Department of Agriculture  
http://www.mda.state.mn.us/IPM/IPMPubs.html#PestPatrol

“Inspect our House” portion of IPM Super Sleuth by the IPM Institute of North America  
http://www.ipminstitute.org

**Activity 3 Follow-Up**
After students have investigated their school and home surroundings, they should begin to have more questions about pests. This follow-up activity is a precursor to the next set of lessons, and the next step in IPM.

The students should begin by developing questions to conduct interviews about current IPM practices that are used in school and at home. They may interview parents, teachers, custodians, and administrators. Help them to formulate questions such as:

- Which pests have you discovered?
- Where have you discovered them?
- How have they been monitored?
- How have they been controlled?
- When do you control them?
- How many of a particular pest must you see before you control it?

After your students have conducted the interviews in school have them to continue practicing their new knowledge at home.

This lesson, “Inspect and Investigate – Interviewing,” is from Exploring Urban Integrated Pest Management by Erica Bosley Jenkins of Michigan State University Pesticide Education, and more details can be found at:  
http://www.pested.msu.edu/CommunitySchoolIPM/Curriculum.htm
**School Scavenger Hunt (grades 2-4)**

IPM Lesson 1 – Discovering Pests

<table>
<thead>
<tr>
<th>Pest</th>
<th>Did you find this pest, yes or no?</th>
<th>What evidence of the pest did you find (symptoms and signs)?</th>
<th>Where did you find the pest?</th>
<th>Drawing or description of the pest.</th>
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<tr>
<td>Cockroach</td>
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<td>In a dark corner</td>
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<tr>
<td>Mouse</td>
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<td>droppings</td>
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<td>Spider</td>
<td></td>
<td></td>
<td>Has 8 legs</td>
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<tr>
<td>Ants</td>
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<td>Ant hills near a door</td>
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<tr>
<td>Bee or wasp</td>
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<td></td>
<td>Has a yellow and black body</td>
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School Scavenger Hunt (grades 5-7)
IPM Lesson 1 – Discovering Pests

<table>
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<tr>
<th>Pest</th>
<th>Did you find this pest, yes or no?</th>
<th>What evidence of the pest did you find (symptoms and signs)?</th>
<th>Where did you find the pest?</th>
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Lesson 1
Corresponding activity - 1
Discovering Pests
Teacher Information Sheet: What is a Pest?

Ecologically, pests do not exist. In natural ecosystems, every organism has some specific role. This specific role that each organism must fulfill is its niche. Without that organism present to fulfill its role that niche is left empty, or may eventually be filled by some other organism. In natural ecosystems, groups of populations interact among each other fulfilling their individual niches. It is a complex system of checks and balances, and competition determines which individuals in a population will best fulfill the niche, while the others remain unsuccessful.

The Random House Webster's Unabridged Dictionary states that a pest is "an insect or small animal that harms or destroys garden plants, trees, etc." Webster's Third New International Dictionary (1981) says that pests are "(a) plant or animal detrimental to man or his interests." Lastly, the United States', Federal Insecticide Fungicide and Rodenticide Act (FIFRA) has defined a pest as “any organism that interferes with the activities and desires of humans.”

The commonality among all of these definitions is that a pest is a human defined concept. It is an organism that is aesthetically (a nuisance), or monetarily intolerable to humans, or is in competition for a human resource. Humans consider undesirable organisms pests for several reasons. People consider pests a nuisance in their homes because they are aesthetically not pleasing. Pests in the home can represent uncleanness and contamination. They can also be indicators that there is something physically wrong with the home or building structure, for example termites may be feeding on rotting or decaying wood. Other animals such as cockroaches and ants find crumbs and left over food bits that have been missed. Larger pests such as rats and mice in our homes and schools are considered pests because they can be the source of health hazards. Mice and rats have been documented to carry deadly diseases such as the black plague and the Hanta virus.

Undesirable animals or pathogens in vegetable gardens and on farms are considered pests because they compete for human food resources or in some way inhibit the health of crops and cause growers to invest in control thereby forcing them into some monetary loss. If pest population densities are high growers could suffer both yield and economic damage.

We consider unwanted organisms in our flower gardens and greenhouses pests because they decrease the aesthetic value of our crop. Humans grow these ornamental crops for enjoyment or perhaps for the benefit of helpful insects, and when they become infested with pests we suffer aesthetic and monetary loss.

Sources:

Lesson 1
Corresponding activity - 1
Discovering Pests
Teacher Information Sheet: Symptoms and Signs

Pests can be present in our homes, schools, gardens, yards, and greenhouses, yet we may not see them. We may be aware that pests have been in our habitats. The evidence pests leave behind can be characterized into two categories, symptoms and signs. It is important to know the difference between these two types of evidence, since they are characteristics of the pests that we hope to find.

Signs are biological remnants of the pest. Some examples of signs might be, fecal material from mice or rats, fecal material (i.e. black specks or frass) from insects, slime trails of snails or slugs, eggs laid by insects, cast skins or shed skins from insects, hairs, whiskers, or spores of fungal pathogens. Signs are indicators that have been left by a specific pest.

Symptoms are the reaction of the host in response to the pest. Some examples of symptoms may be chewed leaves, yellowing or browning of leaves, bored holes in wood, and allergic reactions. Symptoms are usually some change that is seen in the host. Also it is not uncommon to find symptoms of the pest long after the pest has left the host.

Source:
Lesson 1 - Discovering Pests
Teacher Information Sheet: Ants

Ants are members of the insect order Hymenoptera. Other members of this order are bees and wasps. They are social insects, and there are several thousand species of ants in existence. Being social insects, they dwell in colonies and often two or more generations inhabit one colony at the same time. Adult ants are divided into three categories, or castes. There are reproductive kings and queens, non-reproductive worker ants, and soldiers. Adult ants provide some care in young. Ant colonies are generally stable, worker ants have a life expectancy of 4-7 years and queens can live up to 15 years.

Ants fulfill important niches in the ecosystem. Living in the soil and ground litter habitat they can serve as predators, parasites, carnivores, and herbivores. Some of the carnivorous ants hunt smaller insects and other animals also living in the soil environment. Several ant species feed on honeydew that is produced by other insects such as aphids and leafhoppers, while others feed on the internal juices of fly larvae.

Pest Status: Ants are considered pests in homes and other structural dwellings because of their ability to compete for human resources by nesting and foraging inside. They can also cause serious economic damage to some field and orchard crops. Ants are visible during daylight, and often appear in large numbers. They are usually seen following each other to some food source or congregating around some other nourishment source. Indoors they are almost always found in kitchens attracted to human food. In metropolitan areas, ants have been the cause of major sidewalk cracking and settling because of their soil excavation under these structures. This can result in economic costs for city governments. Some ants are considered pests because of their aggressive biting and stinging behaviors. One example of this is the Red imported fire ant in the southern United States. Because of their ability to bite, ants can also be considered vectors of pathogenic bacteria, especially in hospital environments.

Food: There are several thousand species of ants and they feed on a wide variety of sources. Worker ants, the primary food gatherers, do not eat dry foods; instead they crush the food with their large mandibles and suck the juices. These juices are later regurgitated for other worker ants, and the queen. This method of feeding is important for control. Ants do not have a single diet but feed on various organic matter including plant and animal materials, and foods rich in oils, sugars, carbohydrates, and proteins. This non-specific diet makes them a rather unusual insect. They gain nourishment from small insects, animals, honeydew, and larval nectars. Ants that invade our homes are
often in search of some type of food that is scarce in their normal habitat. Those ants have adjusted their food resources to the limited supply provided by humans. Other ants, such as carpenter ants often inhabit the human environment in wood used for home heating, cooking, or construction.

**Biology:** There are three categories of ants in every colony, workers, males, and females. Workers are the largest caste in the colony. They are non-reproductive females and perform a variety of different tasks, such as gathering food feeding and caring for the immature ants, nest sanitation, and defense. The reproductive caste is composed of queens and males. The queen mates only one time and continues to lay eggs her entire life. The workers care for her. They clean and feed her for her entire life. The colony is not limited to one queen. Depending on the ant species, there could be 1-30 queens in a colony. The queen lays eggs continuously, the workers take the eggs to various parts of the colony where they will develop into legless grub-like pupa and larvae (immature life stages) and finally into adults. If there are threats to the colony the worker ants will remove the immature forms to safer areas of the colony.

**Shelter:** Colonies can exist under the soil surface, in logs, or in other wooden structures that provide shelter and space ants need to carry out their daily activities. The queen starts colonies. After mating in flight she drops to the ground, sheds her large wings, and burrows a chamber into the soil, under a rock, or into tree bark and begins to lay eggs. The queen nourishes the first group of larvae by reabsorbing the muscle tissue that was used for operating her large wings. She reabsorbs and regurgitates this tissue and feeds it to her young. This first brood of ants then takes care of the queen and subsequent young. The queen will produce further generations that will yield more queens, males, and workers.

**Behavior:** Ants communicate through the release of pheromones in combination with touch and sound production. Being social insects they recruit nestmates for food retrieval, nest construction, colony defense and emigration to new nests through the release of pheromones (chemicals), their most effective use of communication. Ants create trails to food and other resources through the release of pheromones from glands at the posterior end of their abdomen near the stinger.

**Control:** Control methods are difficult for ants since their nests are very secluded. It is important to practice measures of sanitation in homes and schools. Keeping floors swept and table tops clean of crumbs and other debris will deter ants from alternate food sources. If infestations are intolerable, locate the nest and apply an insecticide liquid, dust or granular formation. Since ants are capable of adapting to several environments, biological control is difficult.

Sources:
Lesson 1 - Discovering Pests
Teacher Information Sheet: Cockroaches

Cockroaches are pests to humans in every part of the world. They require a very general diet, and are able to use a wide variety of plant and animal materials as food. They are considered to be a pest simply by their presence, which disturbs a sense of well being and aesthetics, their ability to carry pathogens, and the general phobia many humans have towards them. Cockroaches are sometimes associated with unsanitary conditions. The majority of cockroach species live in natural habitats in the tropics and subtropics and are not associated with people. There are only about 10 species that have adapted to the human environment. The human environment is often high in relative humidity but rich in carbohydrate and protein food sources, which cockroaches prefer. The most common cockroaches found in human habitats are the German cockroach, the American cockroach, and the oriental cockroach.

For about 280 million years, cockroaches have remained virtually unchanged. Today’s household pests have similar body structures and wing shapes as those found in fossils of carboniferous rock. From these fossil records, scientists have been able to hypothesize about the foraging habits of prehistoric cockroaches and compare them to today's cockroach behavioral patterns.

Even though cockroaches are pests, in some areas of the world they may have useful functions. There are some reports of cockroaches being used for medicinal purposes. A first century Greek naturalist advised mixing the intestines of cockroaches with oil as a cure for ulcers, tumors, itching, and earache. In some areas of the world such as China and Southeast Asia, cockroaches are still used to treat illnesses and diseases.

**Pest Status:** Cockroaches are most often associated with disease and illness. They can be carriers of fungi, viruses, protozoa, and bacteria. They also serve as hosts for several species of flatworms. Even though they may be carriers of these pathogens there is little evidence that cockroaches transfer these pathogens to humans.

The pathogens that naturally infect cockroaches can carry a variety of diseases, some examples of these are: leprosy, bubonic plague, dysentery and diarrhea in children, urinary tract infections, boils and abscesses, intestinal tract infections, typhoid fever and
Food poisoning. Another very important illness associated with cockroaches is asthma. Sensitive adults and children can exhibit harsh allergic reactions when exposed to cockroach secretions such as feces, or cast skins. Allergic reactions to cockroaches have been reported to be as high as 79%.

Emotional responses to cockroaches have been another reason for their pest status. Cockroaches are often associated with uncleanness, poor housekeeping, and low socioeconomic status. They are most often found in areas that are difficult to keep sanitary and free of water, such as kitchens and bathrooms. Control for cockroaches is difficult and can be very expensive. So those people with lower incomes can spend a great deal of their economic income on control, which gives reason for the association between low economic status and cockroaches.

Food: Cockroaches are not specific in their diet. They have chewing mouthparts that enable them to be generalist (non specific) feeders. They feed on a range of plant and animal material and prefer foods that are rich in carbohydrates, lipids, and proteins. In human habitats adults and nymphs will also feed on starch and sugar-based foods. If these preferred foods are not available, cockroaches will feed on dead insects, excrement, glue, paper, and other materials. They are nocturnal animals and will forage for food and water in cracks and crevices. Cockroaches prefer habitats with a continuous water source and high relative humidity. If their food resources are dry they will search for a water source, such as leaky faucets, condensation under refrigerators, condensation on water pipes, bathtubs, and sinks.

Biology: The female cockroach emits a volatile chemical, or pheromone to attract a mate. This compound is sensed on the antenna of the male and the pair begins mating behavior. For the German cockroach, the male contacts the female through pheromones and a period of antenna-to-antenna contact is made. Soon after this behavior copulation begins. Once the female's eggs are fertilized, she begins the production of an egg case. During the protection of the egg case, eggs are produced in groups of 10-40. The female may deposit the egg case in a protected location, which she created with her mouthparts or keep it with her until the first-stage nymphs are ready to hatch. The egg case is very sturdy and able to protect the developing nymphs from desiccation and harmful environmental compounds.

The cockroach has a gradual metamorphosis, in which each life stage resembles an adult. The first-stage nymphs may remain close to the egg case after hatching, but soon go in search of food. Nymphs will pass through five to six instars (juvenile stages), each time shedding skin and growing larger before reaching adulthood. After the final molt, for both male and female, the wings and reproductive organs are fully developed and functional, though in some species, the wings may be reduced or absent. Adults have a flattened body, and a sensitive cuticle that requires moisture to prevent desiccation.

Shelter: Because cockroaches are nocturnal animals they will remain inactive in dark cracks, crevices, and other protected areas during the day. The adult German cockroach can fit its flattened body in crevices as small as 1.6 mm, and nymphs only need cracks as
large as 0.5 to 1.6mm wide. They prefer humid areas where temperature and water vapor can directly influence the level of infestations. Low temperatures and humidity promote inactivity, whereas high temperatures and high humidity promote activity.

**Behavior:** Cockroaches are active at night with two specific periods of foraging activity; the first is a few hours after sunset and the other at an hour before dawn. During these hours, males, nymphs, and females (without egg cases) will leave their safe harborages (dwellings) to forage for food resources and to mate.

**Control:** Cockroaches are successful in human habitats because they can find adequate amounts of food, water, and shelter. Eliminating one or more of these necessities will inhibit cockroach populations in the home.

Reducing water availability and high humidity are some of the most effective ways to control cockroach infestations. Making sure faucets of bathtubs and sinks are tightly closed, and by sealing potential leaks can decrease the possibility of cockroaches from inhabiting our homes.

Another way to limit cockroach infestations is to limit their food supply. They are generalist feeders and can live easily on scraps and crumbs of humans. To prevent these pests from invading your homes and schools, availability of food to the cockroaches should be reduced. Sanitation is the best way to reduce the food supply; sweeping, mopping, washing counters, and properly disposing of trash will limit food for these pests.

Eliminating shelter for cockroaches is another effective control measure. During construction fittings should be tight, and proper sealing of openings can prevent entrance of cockroaches into the home. Identifying, sealing, and treating any openings can also prevent and deter cockroaches.

There are several insect species that are valuable to the biological control of cockroaches. The house centipede and a pholcid spider are two predators that feed on early instar cockroaches. Some parasitic wasps also exist that will seek a vulnerable egg case, and deposit an egg within it. As young parasitic wasp develops, it consumes the eggs of the cockroach. Those that it does not consume, fail to develop.

Insecticides are a final method for control of cockroaches. Proper identification of the insect's harborage is necessary. Using care and other precautions, injecting liquid or dust into or near infested cracks and crevices prior to active hours in uniform and proper quantities will provide effective results. Insecticides should be used as an alternative means of pest control and in conjunction with other control practices.
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UC IPM Online: Cockroaches: http://www.ipm.ucdavis.edu/PMG/PESTNOTES/pn7467.html

University of South Carolina Roach Camera: http://cricket.biol.sc.edu/usc-roach-cam.html

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Entomology Websites – Cockroaches: http://www.isis.vt.edu/~fanjun/text/Link_spec01.html
Lesson 1- Discovering Pests
Teacher Information Sheet: House Flies

Photo courtesy of Do It Yourself. Com

Flies are members of the insect order Diptera. Other members of this order are biting midges, horse flies, and mosquitoes. The housefly, *Musca domestica* is a dipteran that is seen in human environments all around the world, from the equator to the poles including some of the most extreme environments.

They are soft-bodied insects with two pair of wings that are very adept for long flights. Flies have large, well adapted eyes and a keen sense of smell. They have varying mouthparts, depending on the species. These mouthparts range from piercing-sucking, sponging-lapping, to an intermediate cutting. All of these morphological features make flies very successful at adapting to human environments.

Flies have been associated with human environments since the domestication of animals in early agriculture. Flies prefer the feces of pigs, humans, and horses to that of large grazing animals. When these animals became an important part of the human environment, flies also became more common. Some changes in fly biology occurred during this adaptation to the human environment. Egg laying females strayed away from their natural habitat and found more suitable conditions within the human environment.

Flies are considered pests in the human environment because of their association with disease. The housefly and its relatives breed in human feces, and other animal dung, where they acquire a range of pathogens. Significant diseases carried by flies worldwide are malaria, yellow fever, and encephalitis. Other diseases are indirectly associated with flies are typhoid fever and dysentery.

**Pest Status:** The primary reason for flies’ pest status is their ability to transmit disease. They are most commonly associated with human garbage and animal feces. These two waste items are perfect breeding sites for flies. They can acquire several types of bacteria, including *Salmonella* and *Shigella*, as well as other pathogens. In these feeding sites habits of flies are rather disgusting to humans. Flies land on their food source, namely rotting flesh or excrement, where they defecate and regurgitate some fluids from their stomach onto their food. Flies then move into a human environment and repeat the process. This can result in bacteria transmission leading to sickness.
Flies have the ability to be a great nuisance. Some types of flies will swarm, and in great numbers they will enter homes, schools, hospitals and other buildings. Some flies, such as horse flies and mosquitoes bite and feed on human blood. This is often very much a nuisance as well as painful for a human host.

**Food:** Flies feed on the waste products of humans. They feed on human and animal feces, garbage, crumbs, and decaying vegetation. Feeding sites are also the breeding areas for flies. They feed two or three times per day on food and water during the hottest and driest daylight hours, and ingest foods that are soluble through their salivary glands and sponging mouthparts. Biting flies feed on the blood of humans and animals.

**Biology:** Female houseflies are attracted to warm and moist substrates that will provide nourishment for her offspring. A female normally mates only once during her life. She has an internal structure that allows her to store sperm, and when she is ready will fertilize her eggs and lay several batches of eggs. Flies exhibit complete metamorphosis (life transformation) in which each life stage is different from the adult. Flies begin their life stage as an egg, which has been deposited in excrement or garbage. Next they transform into a larva. The larva are wingless and legless. Their mouths are internal at the posterior portion of their bodies. At this stage they will go through four molts. Following the final or third molt, the larva become inactive, stop feeding and begin to form a pupa. After the pupal stage the adult emerges, and unfolds its wings to dry and harden. The life cycle can take up to 10 days to complete and there can be as many as 12 generations in one summer.

**Shelter:** Flies have adapted to the human environment. They do not require any distinct protection for shelter. They live and breed among the interactions of humans and the human environment. They require warm, moist materials in which to lay their eggs, and allow their offspring to complete a metamorphosis.

**Behavior:** Flies are very strong and mobile insects, and can travel long distances. Adults generally follow an odor stimulus, and are active fliers when temperatures are between 11° C and 32° C. They are inactive at temperatures below 7° C, and temperatures below 0° C are lethal to adults. They rapidly and frequently fly between food sources. Flies have become resistant to most modern insecticides.

**Control:** Flies have become very resistant to many insecticides; the best methods of control are those that make the environment unfavorable for the pest. Potential fly feeding or breeding sources should be removed. Household garbage should be sealed and disposal should be handled properly. Inside and outside debris should also be cleaned up. Other methods of control include traps that attract flies away from the human environment. An example of this is an electronic device that has a fluorescent light source (for some flies), that will draw the fly's attention and kill it upon contact. Other traps include sticky traps, and flypaper help in reducing pest populations in the human environment.
Lesson 1 - Discovering Pests
Teacher Information Sheet: Spiders

Photo courtesy of the Clifford W. Estes Company
(http://www.estesco.com/projects/oct02/oct02.html)

Spiders are Arachnids that are commonly mistaken for some type of insect. Spiders are not insects, and their most distinguishing characteristic is four pairs of legs. They are among the most common insectivores in a natural ecosystem and are predatory and can be beneficial. Spiders have easily adapted to any ecosystem that provides a sufficient food supply. They are primarily insectivores that prey on both beneficial insects and insect pests. Spiders are able to easily transition from natural ecosystems to agricultural and urban ecosystems by their swift ability to move across plant surfaces and by ballooning, or sailing on wind currents attached to a thin line of silk. Spiders are well camouflaged to their surroundings and prey on a multitude of insect species. They are solitary animals that often remain hidden in dark, protected corners on or near our homes and schools. Spiders and their prey enter our homes and schools through openings of unsealed doors and windows. Spiders that have adapted to our homes and other dwellings are those who prefer to forage at night and have limited interactions with humans. They often occur in undisturbed areas of our homes such as our storage areas, cellars, and basements where relative humidity and temperature is ideal for both spiders and their prey.

Pest Status: The pest status associated with spiders is fear of being bitten. People have taught their children over time that spiders are dangerous. Children have learned that spiders are unpredictable, due to their quick and unexpected movements. Children have also learned that the bite of a spider can be deadly. These teachings have benefited both these beneficial arthropods and children. Spiders may bite humans but their bite is rarely harmful. Some spiders have mouthparts that are capable of penetrating human skin or produce venom that is not toxic to people but mildly irritating. Thus a spider bite may be very painful, causing skin irritations, welts, and swellings but is not associated with any long-term health problems. Black widows and the Brown recluse are associated with painful bites.
Food: Spiders are predators that feed on insects and to some degree on other arthropods. They have powerful jaws (chelicerae) that they use to restrain their prey. These jaws are equipped with venom glands that aid in the immobilization of their prey. Spiders can also bind their prey with strong threads of silk. They cannot consume large prey; instead they secrete venom-rich enzymes into their prey's body that dissolves the internal organs. The spider can then feed on this degraded material.

Biology: Copulation for spiders can be very difficult. Male spiders have a pair of specially developed first pair of legs that aid in reproduction. The male uses these unique pair of legs to transfer sperm to the female genital orifice. Females briefly engage their predatory instincts during copulation and then quickly resume them following the act. Reproduction can be very dangerous for male spiders, because the female often consumes them after copulation. The female's body size determines the number of eggs she will produce. Eggs are placed in a silken sac and the female will raise her young until they are fully-grown. Spiders produce several generations per year.

Silk is a protein that is exuded from spinnerets at the abdomen of the spider. It is very elastic and is able to stretch five times its length without breaking. Silk is composed of one or more strands of silk and is specific to use, such as egg sacs, webs or nests. All spiders, with the exception of a few species, produce silk.

Shelter: Spiders prefer dark, protected, undisturbed areas, rich in prey for their web spinning and nest building. Spiders will abandon webs that are in areas that do not yield a sufficient amount of prey.

Behavior: Spiders are predatory nocturnal animals who catch and devour their prey in solitude. They will consume large amounts of prey, and then because of their slow metabolism will not feed for a considerable amount of time. Spiders are also very unpredictable in their movement and well camouflaged into their surroundings.

Control: Control for spiders is generally not necessary because they are beneficial arthropods. However, because they are nocturnal hunters, they may be found on the outside of human dwellings at night feeding on insects that are attracted to our outside lights. Removal of those lights or changing the color of the light bulb will deter
attracting spiders prey. Removing and destroying egg sacs will also reduce the number of spiders in the environment.

Sources:

Texas Agricultural Extension Service, Texas A&M University: http://insects.tamu.edu/extension/bulletins/l-1787.html

Photos courtesy of Conservation Commission of Missouri: http://www.conservation.state.mo.us/nathis/arthopo/mospider/kinds.htm
Lesson 1 - Discovering Pests
Teacher Information Sheet: Wasps, Yellowjackets, and Hornets

Photo courtesy of Keith Edkins’ insect photo collection (http://www.gwydir.demon.co.uk/insects/index.htm)

Wasps, yellowjackets, and hornets are members of the order Hymenoptera, and of the family Vespidae. They are social insects that live in colonies with one or more queens. They often form their nests out of paper-like material. These animals can be pests to humans seasonally. They are strong fliers, and skillful foragers.

These vespids seasonally establish their nests in the soil, trees, shrubs, and in the eaves and rafters of our homes and schools. The nests often have a great amount of worker activity, which attracts the attention of people, and when peoples' attention is drawn fear because of the possibility of being stung. Despite the fear many people have of these insects, they may be beneficial, fulfilling the niche as predators, and parasites feeding on other insects. They are also important in the pollination of some plants and flowers.

Vespids were originally found in the tropical regions of the world, but are now found in more temperate zones. This change from tropical to temperate climate is most likely due to the changes in their biology, and from limitations of their resources.

**Pest Status:** People often consider wasps, yellowjackets, and hornets as pests because of their threatening behavior and ability to inflict a painful sting. The stinger of most of these insects contains venom that causes a severe allergic reaction to sensitive people. Though the venom is designed to immobilize the prey and not kill it. Among highly allergic people it can result in death.

The swarming and unpredictable behavior of these insects also causes alarm. When present in great numbers, economic damage can occur when outdoor recreation areas, dumps, and landfills are closed. Vespids are scavenger insects that often forage for food on animal dung, and in garbage dumps. These feeding habits can result in them carrying harmful bacteria such as *Escherichia* and *Salmonella*, transmitting disease when they visit human food.

**Food:** In natural environments, vespids serve as predators and parasites when they feed on other live arthropods. They also scavenge on decaying flesh of dead animals, visit flowers for sweet nectars, pollinating their host. In the human environment where there may not be a large numbers of insect prey, vespids forage in garbage dumps, on animal...
dung, in trash cans, and on beverage cans to supplement a lack of protein and carbohydrates.

**Biology:** In the early spring a female wasp will emerge from a protected burrow, usually from under a rock, in an attic, or some other type of wall void. This female will then create a small embryo nest that contains 40-60 cells. This founding queen will produce the first brood of workers. She will care for them until they are mature. After the first brood, the workers will care for future generations. Worker wasps forage during the day, capturing prey, and collecting decaying tissue to bring back to the developing larvae. The maximum number of workers will occur in the colony about three months after colony establishment. After this peak period, there will be a shift in activities from producing worker wasps to producing reproductive wasps. Males and new queens will emerge. They remain with their colony until they are strong and nourished enough to leave and mate, a period of about 7-10 days. After mating, fertilized queens will look for protected sites to overwinter.

**Shelter:** Vespids create their own shelter. Their hives are generally made from paper-like material, such as the bark of trees. Hives contain combs in the inside for laying eggs and rearing new vespids. Hives are usually formed in trees, bushes, under eaves, in the corners of doors, under bridges and in other undisturbed and protected areas.

**Behavior:** Wasps, yellowjackets, and hornets are social insects. They communicate with each other through pheromones (chemical signals), and body movements. They will invade but rarely attack humans in inhabited areas in search of food.

**Control:** Wasps, yellowjackets, and hornets are beneficial insects that regulate detrimental insects in gardens and on farms. Unless populations become very problematic no control is recommended. When they impede on a human environment control may be necessary, for example when they are seen in public places in relatively large numbers they create a nuisance and cause concern for human health.

A method of control to be considered first is sanitation for the prevention of invading vespids. Proper disposal of trash, cleaning, and maintaining the inside and outside of our homes and school will deter these insects from searching our areas for food.

Another very effective method of control is baiting. Sometimes it is difficult to locate the hive, or dangerous to destroy it, so injecting an insecticide into high protein baits such as tuna fish, salmon, beef, or poultry is very effective. The slow acting insecticide allows the workers to continuously visit the meat product and return to the hive, thus infiltrating the hive with the poison until the entire hive is eliminated.
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UC IPM Online – Yellowjackets and other social wasps:
http://www.ipm.ucdavis.edu/PMG/PESTNOTES/pn7450.html
Lesson 1 – Discovering Pests
Teacher Information Sheet: Gray Mold

Gray mold is a very common disease that is found on vegetables, fruits, ornamental plants, and agricultural crops. It is a common pathogen that thrives in greenhouse and grocery store environments. Gray mold is caused by the fungus *Botrytis cinerea*, and is called gray mold because of the gray, fuzzy sporulation that is found on decaying plant material. *Botrytis* commonly invades plant material that has been broken, cut, or somehow damaged, though it can also infect healthy material.

**Symptoms:** The symptoms of gray mold include spots and brown or tan lesions on stems and leaves, some plants may even produce cankers in response to the pathogen. Other symptoms include water-soaked lesions, and necrotic areas. Pictures of symptoms can be seen at the following websites:
- University of Guelph
  http://www.uoguelph.ca/~gbarron/MISCELLANEOUS/botrytis.htm
- University of Toronto
  http://www.botany.utoronto.ca/ResearchLabs/MallochLab/Malloch/Moulds/Botrytis.html

**Biology:** *Botrytis* overwinters in the soil in decaying plant debris. *Botrytis* does not generally infect the plant as the plant emerges. *Botrytis* can infect most any plant part under the right environmental conditions. The pathogen does not often infect seeds, but it can infect bulbs, corms, tubers, roots, petals, stems, leaves, and fruits. Cool and damp weather are optimal conditions for growth, sporulation, spore release and germination, and infection. Small conidia germinate on the plant surface, and then mycelia grow into plant tissues. Mycelia enter plant tissues through wounds. The pathogen produces enzymes which degrade plant tissue. *Botrytis* continues to grow by spreading more mycelium throughout the plant tissues. The mycelium then produces conidiophores, which produce balloon-like conidia. The gray branching conidiophores with conidia are easily seen on rotting fruit, such as strawberries. The presence of these conidia is a detectable sign of infection.
Control: Management for *Botrytis* is easy without the use of chemicals. If symptoms or signs of this pathogen are observed removal of the infected material is necessary. Prevention of *Botrytis* can be practiced by monitoring the environmental conditions, such as warm temperatures that will prevent moisture, and proper spacing of plants that allow for ample air flow for drying. Plants that are wounded can be protected with fungicides or removed from the environment.

Experiment: Study the development of *Botrytis* conidia by obtaining over ripe and mushy strawberries. Place them in a plastic bag for a few days. Observe the development of the mold as the strawberry breaks down, after a few days use a microscope to view spores or conidia.

Sources:
University of Guelph -
http://www.uoguelph.ca/~gbarron/MISCELLANEOUS/botrytis.htm

Ohio State University Extension Fact Sheet –
http://ohioline.osu.edu/hyg-fact/3000/3070.html


Lesson 1 – Discovering Pests  
Teacher Information Sheet: House Mouse

The house mouse is a common household pest. It originally arrived in North America on ships traveling from Central Asia, and has been able to adapt to a variety of environments. They are found around homes, commercial structures, in agricultural lands and in open fields. They are usually active at night and give off a distinct musky odor, which can assist in their detection. The house mouse has not been found to be a carrier of Hantavirus, though other mice have. Its relatives the deer mouse, and white-footed mouse have been documented as carriers of the virus.

**Pest Status:** The house mouse is considered a pest because it lives in close association with people, pets, and livestock and consumes and contaminates food and dwellings. It can cause considerable damage to structures and property. The house mouse has been documented as a carrier of disease causing pathogens such as *Salmonella*. They often emit a very pungent musty odor, and leave behind fecal pellets, which can be bothersome. They are very difficult to control because of their abundance, rapid adaptation and rapid reproductive rates.

**Food:** The house mouse is a “nibbler.” It prefers cereal and grain foods, but will eat almost any food available. They will also eat structural components such as wood materials and will chew through cable and telephone wires.

**Biology:** The house mouse is a small rodent with very large ears and small dark eyes. It weighs approximately ½ ounce, is usually light brown to gray in color. Adults are about 5-1/2 to 7-1/2 inches long, including a 3- to 4- inch tail. It has very keen senses of taste, hearing, smell, and touch. Females can have 5 to 10 litters of 5-6 young per year. Young are born 19 to 21 days after mating and reach reproductive maturity in 6 to 10 weeks. The life span of a mouse is 9 to 12 months.

**Shelter:** The house mouse is a very adaptable organism and will seek shelter almost anywhere. It creates its nest from fine shredded paper or other fibrous materials. It can create nests in home attics, in insulation materials, and between walls. The house mouse also can be found in open fields and in agricultural lands.
Behavior: The house mouse is most active at night, but can sometimes be seen during daylight hours. They are proficient climbers and can run up any vertical surface. They are capable of running horizontally along wire cables or ropes and can jump up to 12 inches from the ground up onto a flat surface. They can fit through openings that are slightly larger than \( \frac{1}{4} \) inch across.

Control: There are a variety of control options for the mouse pest problem. Preventative tactics are always the best option. Sanitation is the first option for preventing mice in the home. Remove mouse food and shelter sources when ever possible. Any dropped or left food items should be cleaned up and fibrous materials that could be a good source for a nest should be removed. Any holes, cracks, or gaps that are \( \frac{1}{4} \) inch or larger should be sealed. Steel wool is a good temporary option. Cracks or openings around pipes, vents, and utility cables should be sealed. Doors and windows should fit tightly. If a population already exists, traps are an option. Wood-based traps and live traps can be purchased at a local hardware store. Traps should be placed along walls, in dark corners, and places where there have been signs of mouse activity. Predators such as cats and dogs are also effective methods of keeping rodent populations down. A final option of rodent control is the use of baits. These usually consist of an attractant such as a food and a rodenticide, and can be purchased at hardware stores. These baits can be harmful to household pets and small children so product labels must be followed.

Sources:
University of California, UC IPM Online  
http://www.ipm.ucdavis.edu/PMG/PESTNOTES/pn7483.html

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, 1b
  C – Organisms and Their Environment, 2

Grade 4:
- I. Inquiry
  A – Process Skills 2ab – Classify, 4a – Communicate, 5a – Infer, 6a – Predict
  B – Inquiry 1e
- 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/cricket_color.pdf

Clemson University – Insect Communication Lessons by Dr. Joe Culin
Used with Permission
http://entweb.clemson.edu/buttrfly/Educatn/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/
Bellarmine, Anatomy drawing
http://cas.bellarmine.edu/tietjen/Laboratories/FlowerCommunities/insect_anatomy.htm

North Carolina State University

Discovery Channel Kids – All about insects

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 Univeristy – 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/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/

Bellarmine, Anatomy drawing
http://cas.bellarmine.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
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

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 groups’ 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:

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

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 though 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)

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:


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.

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.
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.

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?
________________________________________________________________________
________________________________________________________________________
________________________________________________________________________
________________________________________________________________________
________________________________________________________________________
________________________________________________________________________
Lesson 3 – Taking a Closer Look at Pests (monitoring)

Introduction
This lesson teaches students about monitoring (and scouting) pest populations. It also briefly introduces the concept of tolerance for pests. Students scout for their pest, in doing so they look for specific symptoms and signs. Monitoring is an essential component to any IPM program. It helps pest managers determine pest population density, and pest location. Knowing the biology, habitats, and habit is an important part to a monitoring program. With this information, pest managers can assess the pest life stage for virulence and potential resource damage. Information about pest habitat and habits make monitoring programs more efficient, providing pest managers with clues about to where to locate pests. Monitoring programs help pest managers determine injury and tolerance levels. If injury or tolerance levels increase during the monitoring program, the pest manager will then implement management tactics. Up to this point, the students should be familiar with symptoms and signs, but in this lesson they will be looking for them specifically. The students will also gain a better understanding of tolerance; what it is and what it means.

Appropriate SC Science Standards for the Following Outlined lessons

Grade 2:
- I. Inquiry
  A – Process Skills, 1a – Observe, 2a – Classify 4a – Communicate
  B – Inquiry, 1abd
- II. Life Science,
  A – Characteristics of Organisms, 1a, 2ab
  C – Organisms and their Environments, 1a

Grade 3:
- I. Inquiry,
  A – Process Skills, 1a – Observe, 2ab – Classify 4a – Communicate 6a – Predict
  B – Inquiry, 1abcd
- II. Life Science, A – Characteristics of Organisms, 1ab 2a
  B – Life Cycles of Organisms, 1a

Grade 4:
- I. Inquiry
  A – Process Skills, 1a – Observe, 2ab – Classify 4a – Communicate, 6a – Predict
  B – Inquiry, 1abde
- II. Life Science, A – Characteristics of Organisms, 1bc
  B – Organisms and Their Environment 1b, 2ab, 3abcd

Grade 5:
- I. Inquiry
  A – Process Skills, 1a – Observe, 2ab – Classify, 5ab – Infer, 6ab – Predict,
  B – Inquiry, 1abcdef

Grade 6:
- I. Inquiry
A – Abilities to do Scientific Inquiry, 1 – Identify process skills that can be used in scientific investigations a1, b1, d1, e1
   2 – Design and conduct a scientific investigation bcgh
   7 – Communicate scientific procedures and explanations, abd

Grade 7:

- I. Inquiry
  A – Abilities Necessary to do Scientific Inquiry
   1 – Identify process skills that can be used in scientific investigations, a1, 2; d1; e1
   2 – Design and conduct a scientific investigation bcgh
   4 – Develop descriptions, explanations, predictions, and models using evidence, b
   7 – Communicate scientific procedures and explanations abcd
- II. Life Science
  B – Regulation and Behavior, 1ab

Resources for the following Activities

Barbara Bromley
http://www.princetonol.com/groups/mg/monitoring.html

Virginia Cooperative Extension
http://www.ext.vt.edu/schoolipm/pages/establish.htm

University of California
http://www.ipm.ucdavis.edu/PMG/r280390211.html

Maryland Department of Agriculture – Action Thresholds in School IPM
http://schoolipm.ifas.ufl.edu/doc/MD_thres.pdf

University of Massachusetts – Setting thresholds for school IPM
http://www.umass.edu/umext/schoolipm/school_daycare/school_ipm_sch03a4.html

http://www.pested.msu.edu/CommunitySchoolIPM/Curriculum
Duration 3.5 hours for all of the following lessons

Objectives
Students will:
- Review what they have learned about pests so far.
- Use information about pests previously learned and put it into practice
- Scout the school for pests
- Use communication and interviewing skills
- Establish an IPM monitoring program using scouting skills
- Understand tolerance levels in relation to pests
- IPM objective – Through the establishment of a monitoring program make decisions about when management tactics may be necessary

Vocabulary
Pests
Symptoms
Signs
Scouting
Monitoring
Control
Tolerance

Discussion/Review
Take a few moments to review with your class what they have learned thus far. Ask them questions such as:
- What pests have we discovered in our school or at home? (Animals, insects, fungi, etc.)
- Where did we discover them? (Ask for specific details, e.g. in the dark closet, near a crack in the wall, close to moisture)
- What do we know about them? Such as: What are their eating habits? How do they grow? How do they communicate (if they are not insects)?

Begin to ask students more details about how they discovered their pests.
- Did they see any signs such as droppings, eggs, cast skins, or the pest itself?
- Did they see any symptoms such as chewed areas, holes, scratch marks or any other evidence of a pest?

Summary
This is a good opportunity for students to gain a better understanding of the difference between symptoms and signs. For review refer to teacher information sheet – symptoms and signs at the end of Lesson 1. Signs are biological evidence of the pest, something that must come from the pest, such as droppings, eggs, hair, whiskers, cast skins, or the pest itself. Symptoms are abiotic bits of evidence created by the pest such as chewed holes, burrowed or bored holes, or scratch marks.
Activity 1 – Scavenger Hunt part 2: Preparing to hunt
Be sure to obtain permission from the proper individuals before beginning this activity. Explain that you and your students will be scouting the school for pests and their symptoms and signs.

Have students refer to their worksheets from their first scavenger hunt and their notes from their interviews with the custodians and teachers. This will give them some background information for their scouting and monitoring activity. Students should work in groups to fill out the new worksheets that combine all of their pest information. Be sure to stay to the original pests, because adding new pests to your list could be confusing. After each group has filled in their charts, discuss the charts as a class making sure everyone has the same information. You may even choose to have students make one large classroom chart, on the board, overhead, or as a poster.

Materials
Paper for worksheets
Pencils
Overhead projector and sheets
Poster board
Markers

Activity 2 – The Hunt
Note: Make copies of the following worksheet for this activity. It will help students as they scout the school.

Working in groups, students should scout the school looking for pests and their symptoms and signs. Adult supervision is recommended for grades 2-4.

Before students begin scouting, be sure to review with them the difference between symptoms and signs. Remind them that they are not to collect or disturb any pests and that they are only observing. Tell them to take detailed notes, on their worksheets, because it will help them later. Students may then work in pairs (or small groups) scouting for their pests.

When students have finished hunting, ask them to return to the classroom and present to the class all of the information they found on one pest.
- Each group should present their findings for a different pest. Again you may choose to make a classroom chart of these findings.
- Ask your students how often they believe they should scout the pest infested areas (How many times per week, month, year) and why?
- Be sure they understand that regular scouting is necessary to monitor pest populations.

Assessment
Have students repeat this activity at home.
Follow-Up
Discuss with students their findings at home. Review the classroom chart from the previous day. Up to this point students have learned a great deal about the environment in which they fulfill some role every day. They have learned that they are not the only living organisms in their school or their home. They have discovered where these other organisms live, how they live, what they eat, how they develop, how they communicate, and perhaps some important role they fulfill in the environment.

Begin to talk with them about tolerance, or how many of a particular pest can you stand to see or live with before you feel that you need to manage the population. Ask them questions like, if they see one cockroach, would they kill it? How many cockroaches would they need to see before they investigated some management procedure?

Materials
Paper for worksheets
Pencils
Overhead projector and sheets
Poster board
Markers

Activity 3 – How many is too many?
In this activity your students will begin to understand what tolerance means, as far as pests populations are concerned, and begin to think about types of management tactics. Also encourage students to think about how and which management tactics they could use simultaneously.

For grades 2-4 arrange for adult volunteers to help your students with the interviews. Your students will interview each other in order to determine some pest threshold i.e. some level at which a pest population is no longer tolerable and must be managed. They will ask each other questions about how many is too many, and what have you done to manage this problem? They will ask each other why they choose those amounts. Students will also ask one another, how much control is necessary, i.e. how much impact is needed to manage the pest population? What management tactic is easiest, i.e. most efficient to use?

After they have interviewed each other, have a class discussion about their findings. Have the class determine what they think is a reasonable tolerance level for each pest before they should take some measure action to manage the pest population. Also have the class determine how much control is necessary for a pest population.

Enrichment
Contact your local University pest management extension specialist and ask him or her if they would be willing to visit your class for an interview. Have your class interview this person in the same manner as they previously interviewed the school officials and each other. Discuss with them any new information.
**Materials**

- Paper for interview sheets
- Pencils
- Black board
- Chalk
### Activity 1 – Lesson 3
**Scavenger Hunt part 2: Preparing to Hunt & The Hunt**

<table>
<thead>
<tr>
<th>School Pests (drawing or description)</th>
<th>Pest Habitat (where it was found)</th>
<th>Pest Evidence (Symptoms and signs)</th>
<th>Pest Numbers</th>
<th>Monitoring (how often and when)</th>
<th>Management (when, how, with what)</th>
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Activity 3 – Lesson 3  
Student Interview: How Many is Too Many?

Name of Interviewer ______________________________

Name of Person Interviewed ______________________________

Q: Recently you have been learning about pests in your school and home. Which pests have you discovered?

A: ______________________________________________________

_____________________________________________________________________

Q: What time of day did you discover these culprits?

A: ______________________________________________________

Q: What have you learned about these pests?

A: ______________________________________________________

_____________________________________________________________________

Q: Let’s focus on the pest that you find the most annoying. What interesting fact have you found out about it?

A: ______________________________________________________

_____________________________________________________________________

Q: Now that you know more about this irritating pest, do you still find it as disgusting? Is it more tolerable or less tolerable to you? Are you more able to live with it?

A: ______________________________________________________

_____________________________________________________________________

Q: When you discovered this particular pest, how many did you find? If you didn’t find the pest did you find any symptoms or signs of the pest? What were they?

A: ______________________________________________________

_____________________________________________________________________
Q: How often would you scout for this pest? Would you expect your findings to be the same every time you scouted? Why or why not?

A:________________________________________________________________________
________________________________________________________________________
________________________________________________________________________.

Q: How many of these pests do you think you could tolerate before you would have to take action? Why?

A:________________________________________________________________________
________________________________________________________________________.

Q: Now that you know something about the pest biology and its living habits, what kind of drastic measures would you take in order to manage this pest population? How much of a drastic measure would you use on your pest population? Why?

A:________________________________________________________________________
________________________________________________________________________.

Q: Which management tactic, do you think, would be the easiest to use?

A:________________________________________________________________________
________________________________________________________________________.

Q: If you could use more than one tactic which would you use? When? How? Why?

A:________________________________________________________________________
________________________________________________________________________.

Q: Thank you for your time. This has been a fun interview.
Lesson 4 – Making Decisions (management)

Introduction
This set of activities will guide your students through the decision making process. Making knowledge-based decisions for effective and environmentally safe management practices is a critical step in an IPM program. In this lesson students will use their knowledge about pest status, biology, habitat, habits, pest density (from scouting), and tolerance to make decisions about which management strategies to use on a pest population. It is likely that most of the students will think that pesticides are the only means of managing a pest population (especially if they have ever been visited by a pest control professional at their home or school). But these lessons will help them apply their knowledge to effectively manage pests without the use of pesticides. They will learn how to change certain components of the pest tetrahedron, and they will learn more about pesticides and their safety. This lesson also introduces students to a variety of management practices implemented in an IPM program.

Appropriate SC Science Standards for the Following Outlined lessons

Grade 2:
- I. Inquiry
  A – Process Skills, 2a – Classify, B – Inquiry, 1abd
- II. Life Science
  A – Characteristics of Organisms, 2ab
  B – Life Cycles of Organisms, 1abc
  C – Organisms and their Environments, 1a

Grade 3:
- I. Inquiry
  A – Process Skills, 2ab – Classify, 4a – Communicate
  B – Inquiry, 1abe
  C – Organisms and Their Environment, 1abaef

Grade 4:
- I. Inquiry
  A – Process Skills, 5a – Infer, 6a – Predict
  B – Inquiry, 1a
- II. Life Science, A – Characteristics of Organisms, c
  B – Organisms and Their Environment, 1b, 2ab, 3abcd

Grade 5:
- Inquiry,
  A – Process Skills, 2ab – Classify, 4a – Communicate, 5ab – Infer 6a, 7a – Hypothesize
  B – Inquiry, 1abcdef
- IV. Physical Science
  A – Properties of Matter, 1c, 2ef

Grade 6:
- I. Inquiry
  A – Abilities to do Scientific Inquiry
1 – Identify process skills that can be used in scientific investigations, d1, e1
2 – Design and conduct a scientific investigation, c
5 – Think critically and logically to make relationships between evidence and explanations
6 – Recognize and analyze alternative explanations and predictions, a

IV. Physical Science
A – Properties and changes of Properties in Matter, 3b

Grade 7:
• I. Inquiry
A – Abilities Necessary to do Scientific Inquiry
1 – Identify process skills that can be used in scientific investigations d1; e1
2 – Design and conduct a scientific investigation, c
5 – Think critically and logically to make relationships between evidence and explanations, a
6 – Recognize and analyze alternative explanations and predictions, a

• II. Life Science
B – Regulation and Behavior, 1a, 3b

• III. Earth Science
A – Structure of the Earth’s systems 4d

Resources for the following Activities

Integrated Plant Protection Center – reference to several links on control
http://www.ippc.orst.edu/cicp/Index.htm
http://www.ippc.orst.edu/cicp/tactics/category.htm – Database of IPM Resources: Control

Crop Life America Organization – Fact sheet about decision making

University of Georgia
http://interests.caes.uga.edu/gardening/gardenpacket/spring03/stories/spg03_20ipm.htm

U.S. EPA – Pesticides
http://www.epa.gov/pesticides/ipm/brochure/

Safer Pest Control Project
http://www.spcpweb.org/kidfs.pdf – Kid’s guide to pesticides
http://www.spcpweb.org/school_ipm.html

Australian Biological Control – goodbugs.org

Cornell University – North American biological control guide
http://www.nysaescornell.edu/ent/biocontrol/
**Duration** 2-3 hours for all of the following lessons

**Objectives**
Students will:
- Review information they have learned about their problem pests
- Review the pest tetrahedron
- Understand that management tactics to regulate a pest population below tolerable levels
- Learn about the different management methods practiced in an IPM program: cultural, biological, physical, chemical
- Learn to choose which control options are best for a given situation
- Think critically about the decision making process
- Understand the dangers, consequences, and safe use of pesticides
- Find pesticides in their environment and discuss them in class
- IPM objective – to learn about management practices implemented in an IPM program

**Vocabulary**
- Pest
- Pest tetrahedron
- Host
- Suitable environment
- Time
- Cultural control
- Biological control
- Predator
- Prey
- Habitat modification
- Pesticides

- Resistant plants
- Chemicals
- Prevention
- Insecticide
- Fungicide
- Rodenticide
- Physical controls
- Sanitation
Discussion/Review
If a University extension pest management professional visited your students begin this lesson by discussing what they learned from this person. Ask students about the different pests with which that person had experience. What pests were they? When were there too many of them i.e. how large was the population before it was necessary for that pest population to be managed? Also, what recommendations did pest manager give to manage the pest population, i.e. how was the pest population managed?

- You may find that your students may report that the pest manager managed mostly insects.
- They were called to manage the problem when pest populations were very high, or rather intolerable to the client.

If you were unable to have a pest management visitor, revisit your students’ problem pests. In the last exercise they determined tolerable levels for pest populations that they now know a great deal about. This is also a good opportunity for students to revisit the pest tetrahedron and their Team Problem Solvers. These materials will help them make educated pest management decisions.

Activity 1 - Brainstorming
Begin by drawing the pest tetrahedron on the board. Next to it list ‘management methods’ (italicized words below), under this category list ideas your students suggest for managing their pests.

Ask students several questions about pest management tactics; begin with general questions to see what kind of ideas they formulate. Ask more specific questions that will lead them to different methods of management. You may want to use examples to help phrase your questions. It is important in this activity that students understand that management should be thought of as a way to regulate populations below tolerable levels.

Example Questions and explanations:

- **Ask:** How many management methods can you think of?
  - **Expected Answer**: Chemicals, predators, cleaning
  - **Explanation**: Chemicals or *pesticides* are one important way that many of us manage unwanted pests, and we will talk about pesticides later. But, there are other very important ways for managing pest problems.

  - Predators that manage pests are called *beneficials* and they are a source of *biological control*. Spiders are beneficial arthropods.

  - Cleaning or *sanitation* is another very important way to manage pests. If you wish to avoid having mice or cockroaches in your house, then you will want to sweep your floors (especially under warm appliances) and wash your tables every day. If you wish to avoid mold on your shower wall, then you should clean your shower walls every week. Sanitation is a form of *prevention and cultural control*. 

84
• **Ask:** Often in the winter ladybird beetles try to get into our homes. While these little beetles are beneficial insects when they are outside, people often consider them a nuisance when they enter homes. What can we do to stop them from entering our living space?
  
  o **Expected Answer:** We can seal up cracks along windows and doors.
  o **Expected Answer:** Be sure all windows and doors are closed tightly.
  o **Explanation:** Sealing windows and doors is another type of cultural control, called *prevention*. Another way to rid the home of an annoying beetle population is to simply vacuum them up and dispose of the vacuum bag. This type of control is a form of *physical control*.

The class has not yet thoroughly explored pest management outside of school and home. However, this is a good time to introduce a few new ideas.

• **Ask:** How many students have been to a greenhouse or out in their mother’s garden? Often there are unwanted plants growing among the flowers, we refer to them as weeds. If they are unwanted, could we consider weeds pests?
  
  o **Expected answer:** Yes

• **How do we dispose of weeds, other than by pesticides (herbicides)?**
  
  o **Expected answer:** Pull them out.
  o **Explanation:** Yes, pulling weeds is a form of *cultural control*.

Physical, cultural, biological, and chemical controls must be practiced with a certain amount of effort. Discuss with students the most efficient way to manage a pest population. Is it more efficient to practice good, consistent cultural controls such as sanitization to keep pest populations low? Or is it more efficient to allow the pest population to grow and then try some form of control? Help the students to understand that it is more effective, and takes less effort, in the long run, to practice good physical and cultural controls that will keep pest populations below tolerable levels. Also help students understand that several management tactics can be practiced at the same time. It takes more effort, time, and money to reduce pest populations after they have become large.

**Materials**

- Black board
- Chalk
- Overhead projector
- Markers
- Paper
- Construction paper

85
Activity 2 – “What happens if…” game

Methods of play:

1. For grades 5-7: This game is played in a “around the world” fashion. The first student (challenger) in the front left corner desk stands next to the student behind him or her. Ask both students the question on a game card. The students must give an answer similar to answers listed on the game cards. The first student to raise his or her hand is allowed to answer the question. If the student standing is the first to raise his or her hand and to correctly answer the question they may challenge the next student who is sitting. If the student standing is incorrect they must sit down. The sitting student is then allowed to answer. If that student is correct they may stand next to and challenge the next student. If that student is incorrect, he or she must sit down, and the game will resume with the third and fourth students in line.

2. Grades 2-7: Divide students into 2 (3 or 4 students to a team depending on class size) teams, and play this game in a “Family Feud” fashion. In this game each team will choose a captain, and the captains will face-off. You will ask the question on the game card, and the first student (captain) to raise his or hand may answer. Then the other student may answer. The captain with the best answer wins the face-off, and his or her team has the first chance to try and get the other answers to the question. That team is allowed to work together to come up with answers to the question. They are allowed three tries. If they answer the question with all correct answers, they win that round and are awarded points (to be determined by the teacher). However, if the team fails to answer the question in three tries, i.e. they get three strikes, then the opposing team may steal the round. In order to steal the round, the opposing team must work together to figure out the best answer to the question. They are allowed one try. If they succeed, they win the round. If they fail, the first team wins the round. The next round begins with a face-off of the next two students from each team.

This game is designed to give the students an opportunity to think through a problem, individually or in teams, and come up with some solutions. It is similar to Team Problem Solvers, but it strictly targets different control methods. Use this game as a method to start class discussions.

Follow-Up

Review and discuss the different methods of control, with the exception of pesticides. Return to your brainstorm session and see how many more controls the students can list.

Materials

Teams of students
Game cards
Podium for game show host
Central desk or table for face-off
Black board
Chalk
Activity 3 – Implement
Have students return to their scouting groups. They should revisit their scouting worksheets, and determine a method to manage their school pests. The class has just brainstormed and discussed several management methods that do not involve the use of pesticides. The groups should draw pictures, or write short paragraphs about how they chose to control their pest population, and present to the class. Encourage students to consider any problems they may encounter with their management plan; could the tactics be reasonably implemented? With the help of the school custodial and administrative staff students should implement their controls.

If students are not able to implement their management measures, ask the custodian if he or she would practice the students’ management tactics, or ask the custodial staff what measures are being done to management pest populations. Ask the custodian to report his or her management plan to the class. Have students take detailed notes about the management practices being done to regulate particular pests.

Assessment:
Have students implement their management practices at home for the pests they have been learning about in their home environment. Be sure a parent is helping the student with this portion of their pest management project. Ask students to report back to the class, and have them turn in a paragraph about what management practices they decided to use and why.

Materials
Paper
Pencils
Materials for implementing controls

Activity 4 – Learning about Pesticides
This activity is only an introduction to pesticides, their use and consequences. For further information and enrichment about the dangers of pesticides, see the resources listed at the start of the lesson.

Begin this activity with a discussion of pesticides. Find out what your students know about pesticides. You may wish to use some of the following questions in your discussion. Make a list of pros and cons of pesticide use on the board for your students.

- What are pesticides?
- Where are pesticides found?
- What are pesticides used for?
- Who uses pesticides?
- Are pesticides helpful for managing pests?
- Are pesticides good for people and pets to be around?
- What kind of harm do pesticides cause?

Be sure to talk in depth about the dangers of pesticides, and about pesticides in the environment.
Parents should help their child with this exercise. Students must find a pesticide label and copy, or draw it. They must note: what kind of pesticide it is, e.g. insecticide, fungicide, rodenticide etc., the name of the pesticide, the signal word (i.e. Danger, Caution, Warning, etc.), precautionary statements, environmental hazards, directions for use and safety. You may also wish for students to draw the target pest on their label. Have them present their labels to the class.

Note: Signal word definitions:
Danger = slight taste to 1 teaspoon to kill an adult
Caution = slightly toxic to humans, an ounce to a pint to kill an adult
Warning = 1 teaspoon to 1 tablespoon to kill an adult

Suggestion: As an additional emphasis on the safety of chemicals and pesticides you may wish to contact your poison control center for additional information, or for a representative that would be willing to speak to your class about pesticides.

Materials
Black board
Chalk
Paper – white or construction
Markers
Crayons
Colored pencils
Lesson 4
Corresponding Activity - 1
Making Decisions
Teacher Information Sheet: Control Options

**Cultural:** Cultural methods involve manipulation of a resource (i.e. crop, kitchen, greenhouse, etc.) so that it becomes less suitable to the pest. Practices that make it more suitable for natural enemies and enhance the resource so that it is better able to withstand pest attack are cultural methods. Cultural controls affect the pest indirectly, are slow acting, and must be a continuous part of an IPM program. Cultural tactics include:

- Preventing invasion of a pest through: planting certified seed, sanitizing tools, equipment, and removing debris
- Changing the pest population dynamics so that populations remain low
- Controlling alternative hosts or habitats - removal, and monitoring of hosts that can serve as an alternate host for pests
- Rotations - alternating crops or plants that are non-hosts to previous pests will help reduce pest populations
- Planting and harvesting dates - adjusting planting and harvesting dates to avoid pest population outbreaks and gain an advantage over weed emergence to reduce pest populations.
- Crop density - planting the crop in such a way so that there is little competition with weeds
- Transplanting - planting seedlings that are already growing as opposed to seeds
- Soil maintenance - making sure that low spots are adequately drained to avoid heavy moisture, and ensuring that soil has proper nutrient availability for plants through fertilization
- Trap crops and intercropping - planting crops around the edge or within the crop that lures pests from the crop, and planting more than one crop in a field increases diversity of organisms including biological controls and reduces pests from increasing in population.

**Physical and mechanical:** This is the direct manipulation of the environment. It is a rapid eradication method of pest management. It creates an environmental stress that the pest cannot tolerate and its mode of action is to kill. There are three major approaches to physical and mechanical pest management:

- Environmental modification - changing temperature, water, and light availability
- Exclusion - using barriers or traps that stop pests from reaching their host
- Destruction of pests by direct physical means - physical removal (hand labor), cultivation, and shooting

**Biological:** This is the utilization of natural enemies (predators, parasites, and pathogens) to manage pest populations. These are predators of pests that invade our schools, homes, gardens, greenhouses, and crops. They regulate pest populations by establishing some level of natural population regulation. Most often biological controls are used in combination with some other form of management because they are not usually sufficient enough to manage pest populations independently. The advantages are that: with the use
of biological controls pests will reach harmful levels less rapidly, there are no pesticide residues, and biological controls can be effective in permanent ecosystems without causing harm. They can be used with other control tactics including selective pesticides that are safe for beneficials. There are several forms of biological control:

- **Classical** - this is implemented by regional and national agencies. Its purpose is to regulate the introduction of invasive species and is not usually used by individual growers, and pest managers. It involves the discovery and study of exotic animals and their predators. When an invasive species is discovered, regulatory agents eradicate the pest immediately. If an invasive species should enter an area unnoticed and is discovered later, the pest is correctly identified, quarantined, its country of origin and natural enemies are researched, and natural enemies reared in culture and released.
- **Inoculative** - this is the introduction and release of biological control agents. These predators may die out each year but have the ability to expand their population when conditions are conducive. These programs are regional and are implemented by local government agencies. They are most successful in perennial crops.
- **Augmentative** - this is the release of a biological control that is already living in the ecosystem but whose populations are not sufficient to manage pests. The individual pest manager can implement this program.
- **Inundative** - this is the mass release of a control agent that cannot reproduce and does not contain adequate population size without the help of humans. This program may be considered a biotic pesticide.
- **Conservation** - this includes maintaining the ecosystem in such a way it that benefits the beneficial population, and includes avoiding ecosystem disruption. This is implemented at both the regional and farm levels.

**Chemical:** Chemical control is the implementation of pesticides as a means of management. It may be part of a successful IPM program but must be used as a last alternative. Pesticides often affect non-target organisms, tend to become very costly, leave residues, can drift, and contaminate food, and water. They also are hazardous, and reliance upon them results in pest resistance, resurgence, and secondary pest outbreaks. When pesticides are relied upon, it becomes difficult to manage the pest population. Pesticides must be used very specifically to target only the pest organism. There are three classes of pesticides, the inorganic chemicals that are made from other elements than carbon, the synthetic organic chemicals that are made from carbon and other synthesized components, and the biopesticides that have some biological origin. Pesticides include insecticides, fungicides, rodenticides, bactericides, herbicides, nematicides, algicides, aracicides (spiders), and predacides (vertebrates). These divisions are based on the type of organism that they are intended to target.

Pesticides can work in several ways:

- **Contact** - kills the pest when it comes in contact with the pest or when the pest comes in contact with a surface that harbors the chemical.
- **Ingestion** - the pest must penetrate its host in order to consume the pesticide, essentially the pest eats the pesticide.
• Translocated pesticides - these are pesticides that are applied to the plant and the plant takes up the pesticide into its tissues, an example is a mobile herbicide. The pest then ingests the pesticide.

Sources:

Texas A&M University - Cultural controls
http://organiclifestyles.tamu.edu/pestdisease/cultural.html

Oklahoma State University – Physical or mechanical controls
http://www.okstate.edu/OSU_Ag/agedcm4h/pearl/hort/ornament/f-6432.pdf

Cornell University – Biological controls
http://www.nysaes.cornell.edu/ent/biocontrol/

EPA – Pesticides: Health and safety
http://www.epa.gov/pesticides/food/
Lesson 4
Corresponding Activity - 4
Pesticides
Teacher Information Sheet: Pesticides

Pesticides are commonly thought to be the easiest and most effective means of pest management. Sometimes pesticides are thought to be the only means of pest management. Indeed there are many advantages to using pesticides. Pesticides:

- Can manage some pests that other management strategies cannot.
- Are inexpensive
- Increase yield
- Require less energy put into a managed situation.
- Require less knowledge about pests and their biology
- Provide rapid action
- Decrease the amount of planning for the pest manager and grower
- Reduce the risk of toxins from microorganisms that can harm food

However, the benefits of immediate effects can often be a detriment to the future of the manageable situation. The use of pesticides and their long-term negative effects have a greater consequence than many people realize. The many disadvantages of pesticides include:

- Killing non-target, beneficial organisms that often regulate pest populations
- Currently older, environmentally toxic or those pesticides harmful to human health are being banned. Many of the remaining pesticides are very specific in their use but are more expensive. In the long run, the reliance on pesticides will become very costly (though they are currently economically efficient).
- The presence of residues and drift of pesticides in the environment. Many pesticides used in the past, and some that are currently used, do not break down rapidly in the environment. They persist in the soil, groundwater, and on plant materials.
- Food contamination. Some residues left on food can lead to long-term health problems in humans.
- Toxicity. Pesticides, by their very nature may be very toxic to humans and animals.
- Many hazards. People can increase their risk of exposure to pesticides through such means as mixing and application.
- Ecological pest problems. Reliance on pesticides increases resistance in pests. The pesticides select against the weaker individuals, thus allowing the pests with hardier physiological, morphological, and genetic characteristics to survive the pressure of the pesticide, creating population resistance. The use of pesticides can also cause pest resurgence. The pesticide initially kills pests but those that resisted pesticide pressure remain and continue to reproduce. Then the population grows more rapidly than before pesticide pressure. Pesticides can also cause secondary pest outbreaks. The chemical will kill the major or key pest, but then a lesser pest can become a substantial problem. The secondary pest may cause minor problems because of competition from the key pest, but when the key pest is removed the secondary pest thrives.
• Pesticide Treadmill. The reliance on pesticides can lead to their excessive use. If they are improperly used more applications at higher rates may be necessary, which leads to resistance, resurgence, and replacement (by secondary pests), which leads to more applications at higher rates and so on. Relief from pesticides never occurs.

Pesticides have several advantages and disadvantages, for their use in managing pest populations. They are easy, convenient, and effective. They remain an often necessary rescue or prevention method for many menacing pests, eliminating pests that are themselves a health or environmental threat. But pesticides are toxins and have potential to cause detrimental affects on human and environmental health. Historical pesticides created problems because they were environmentally persistent toxins. Today the problem of pesticides persisting in the environment has been solved through the development of newer, more environmentally safe pesticides. Despite improvements in pesticides, their use still has negative ecological effects. Therefore, it is necessary to develop sound IPM programs to reduce reliance on pesticides, and to promote environmental and ecological health.

Source:

EPA Pesticides
General information http://www.epa.gov/pesticides/
Health and safety http://www.epa.gov/pesticides/food/

PAN Pesticide database
http://www.pesticideinfo.org/Index.html

Northwest Coalition for Alternatives to Pesticides
http://www.pesticide.org/
Lesson 4  
Corresponding Activity – 2  
“What happens if….” game  
Control Options Game cards  
Resources:  
University of Illinois  

<table>
<thead>
<tr>
<th>Cockroaches in the kitchen</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sanitation – clean up crumbs, food, and water</td>
</tr>
<tr>
<td>Elimination – Seal up cracks and leaks</td>
</tr>
<tr>
<td>Prevention – cover trash cans and other garbage places</td>
</tr>
<tr>
<td>Physical control – traps and vacuuming</td>
</tr>
<tr>
<td>Chemical – Pesticides</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Beetles in the baking flour and cereal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prevention – buy small amounts, store in sealed containers, store in refrigerator</td>
</tr>
<tr>
<td>Sanitation – Clean up spilled flour, clean cabinets well, at least once a year</td>
</tr>
<tr>
<td>Physical – Discard materials with infestation</td>
</tr>
<tr>
<td>Chemical - pesticides</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Spiders crawling along the window</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cultural – sticky traps</td>
</tr>
<tr>
<td>Sanitation – cleaning and dusting unused areas</td>
</tr>
<tr>
<td>Physical – locate webs, and nests and destroy egg masses</td>
</tr>
<tr>
<td>Chemical – pesticides labeled for spiders</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Flies in the House</th>
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<tbody>
<tr>
<td>Exclusion – Install screens, and tighten doors and windows</td>
</tr>
<tr>
<td>Sanitation – Remove garbage from the home, keep covered</td>
</tr>
<tr>
<td>Physical – sticky traps and fly swatters</td>
</tr>
<tr>
<td>Chemical – pesticides</td>
</tr>
</tbody>
</table>
**Ants in your home**

Exclusion – caulk up or seal cracks, eliminate water leaks, tighten doors and windows
Cultural – trim bushes and hedges away from the house
Sanitation – remove food sources, clean up items stacked close to buildings that could encourage nests
Chemical – Pesticides

**Whiteflies in the greenhouse**

Prevention – Inspect regularly, keep infected plants out of the greenhouse
Biological control – predators such as green lace wings
Cultural – remove infested plants
Chemical - pesticides

**Aphids on trees around the house**

Do nothing
Prevention – avoid high nitrogen applications
Biological control – predators such as predatory wasps, and lady bugs
Chemical - horticultural oils, or insecticidal soaps

**Mice in the Home**

Sanitation – keep kitchens and food areas clean, stack food in cabinets neatly, put foods in protective containers
Prevention – in addition to sanitary techniques, keep stored materials away from walls and off floors
Physical – control population with traps
Chemical – rodenticides

**Scale on house plants**

Prevention – carefully inspect plants before bringing into the house
Physical – hand remove any scale
Monitor – use double sided sticky tape on either side of the scale, watch for crawlers (babies) and
Chemical – apply an insecticidal soap or horticultural oil
<table>
<thead>
<tr>
<th><strong>Bulging Galls on oak trees in the school yard</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Do nothing – no harm is being done</td>
</tr>
<tr>
<td>Monitor for galls</td>
</tr>
<tr>
<td>Hand remove</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>S-shaped (serpentine) mines on the school holly bush</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Monitor carefully</td>
</tr>
<tr>
<td>Do nothing</td>
</tr>
<tr>
<td>Keep isolated if possible</td>
</tr>
<tr>
<td>Chemical – pesticides</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Mealybugs on house plants</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Physical – hand remove</td>
</tr>
<tr>
<td>Cultural – prune off plant parts</td>
</tr>
<tr>
<td>Remove with alcohol swab</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Woollybear caterpillar in the flower garden</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Do nothing</td>
</tr>
<tr>
<td>Hand remove</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Green – striped maple worm in the maple tree outside</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Cultural – prune off webbing with caterpillars and burn</td>
</tr>
<tr>
<td>Do nothing if late in the year</td>
</tr>
<tr>
<td>Chemical – pesticides</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Southern Pine beetle in the backyard pine tree</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Physical – cut down trees and burn</td>
</tr>
<tr>
<td>Monitor – remove bark and check for s-shaped mines at right angles</td>
</tr>
<tr>
<td>Cultural – keep trees well watered and fertilized, promote resistance</td>
</tr>
</tbody>
</table>
Rotting roots on the petunias in the front yard flower bed

Prevention – use resistant plants
Cultural – clean tools before and after use
Cultural – remove infected plants

Mold on the Underside (downy mildew) of flowerbed plants

Monitor – watch for infection, pull out infected plants
Cultural – space plants for proper ventilation
Prevention – use resistant plants
Cultural – avoid over watering

Mold in the bathroom shower

Dry shower walls when finished
Wipe clean regularly
Clean often with soapy water
Use anti-bacterial cleaning agents

Lady beetles crawling on the living room ceiling

Do nothing
Vacuum and dispose of bag in outside trash
Chemical - insecticide

Brown and red angular spots on strawberry leaves (caused by bacteria)

Remove diseased plants
Clean tools before and after use
Check for adequate fertility
Chemical – pesticides

Rabbits eating vegetables in the garden

Exclusion - Put up a barrier, fence
Set traps
Chemicals – baits with rodenticides
Gray fuzzy mold on Mother’s favorite lilies

Prevention – use resistant plants
Cultural – plant with enough spacing to allow air flow
Cultural – avoid over watering
Monitor often
Lesson 5 The Big Picture – IPM Discovered (evaluate & educate)

Introduction
Throughout the previous lessons students discovered the steps used in an integrated pest management plan, though they have not been formally introduced to the concept. They have independently discovered some organisms that can be considered pests, where these pests are found, what their habitats are, and how they live their lives. The students have learned the ideas of how to scout, monitor, make control decisions. This segment of lessons will put the concept of IPM into focus for the students.

Appropriate SC Science Standards for the Following Outlined lessons

Grade 2:
- I. Inquiry
  A – Process Skills, 1a – Observe, 2a – Classify, 4a – Communicate
  B – Inquiry, 1abd
- II. Life Science,
  A – Characteristics of Organisms, 1a, 2ab
  C – Organisms and their Environments, 1a

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

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

Grade 5:
- I. Inquiry
  A – Process Skills, 1a – Observe, 2ab – Classify, 4a – Communicate, 6a - 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, a1, b1, d1, e1
  2 – Design and conduct a scientific investigation, bcgh
Grade 7:
- I. Inquiry
  - Abilities Necessary to do Scientific Inquiry
    1 – Identify process skills that can be used in scientific investigations, 1, 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
  - Regulation and Behavior, 1ab, 3b

Resources for the following Activities

University of Florida
http://ipm.ifas.ufl.edu/

IPM institute of North America – IPM Super Sleuth
www.ipminstitute.org

Iowa State University
http://www.ipm.iastate.edu/ipm/

New York State Department of Law
http://www.oag.state.ny.us/environment/ipm3fold.html

Bio-Integral Resource Center
http://www.birc.org/

Michigan State University – Exploring Urban Integrated Pest Management
www.pested.msu.edu

Pennsylvania Schools IPM
http://paipm.cas.psu.edu/schools/SchoolEduc.htm
Duration 4 hours for all of the following lessons

Objectives
Students will:
- Learn the terms Integrated, Pest, and Management
- Learn the concept of Integrated Pest Management (IPM)
- Relate the steps of an IPM program to the activities they have done
- Evaluate their control practices
- Educate their peers and adults about IPM and preventative pest measures

Vocabulary
Integrated
Pest
Management
Evaluate
Educate
Prevention
Environment

Activity 1 – Discovering IPM
For grades 2-4 have students work in groups
For grades 5-7 have students work independently or in groups

Write Integrated Pest Management on your black board. Underline the letters I, P, and M. Divide your class into three groups. Give each group a word, either integrated, pest, or management. Ask each group to take a three-step approach in order to figure out what their group’s word means.
1. Have each group member write their meaning of their word.
2. Allow each group to interview other classmates or teachers about the meaning of their word.
3. Have each group look up the meaning of their word in the dictionary.

Ask each group to present their word to the class. After each group has presented their word, lead a class discussion about these words. Talk about each word and its meaning individually and then talk with the class about what IPM means when all of the words are put together in the phrase. Help students make the connection between the concept of IPM and what they have already practiced. Discuss the steps of an IPM program and see if they can match their activities with the steps. Have students work in their scouting groups again to complete the worksheet that will help them make the connections between the activities they have performed and the steps of an IPM program.

Steps in a successful IPM program:
1. Observe the pest or problem
2. Identify the pest and learn about its biology
3. Develop a monitoring program - scout and monitor for symptoms, signs, and quantities of pest populations
4. Make decisions about management options
5. Implement management strategies
6. Evaluate the management practices and educate about the pest and preventative measures

Once the students have completed their worksheets, ask them if there is anything left to do in their school and home IPM program. The students should realize they have not completed the last step of their program.

Materials
Paper
Pencils
Blackboard
Chalk
Paper/copies for worksheets
Dictionaries

Activity 2 – Evaluate
Ask students to reform their scouting groups. They will now re-scout their area of the school for their pest and fill out their scouting worksheet again. This time they will make specific notes about the management practices that were used and try to determine if these practices are working. Questions they should be thinking about:

- Are there symptoms and signs of the pest?
- Are there any pests? How many?
- Are there more or less symptoms and signs than previously observed?

Once students return from their scouting mission, ask them to compare their first scouting mission with the second. Talk about the differences they found. Have them present their findings to the class. Items they should tell the class:

- Explain again what management measure they used and why.
- Have them explain if they feel it worked or not and why.
- How could this pest problem be prevented?

Assessment
Have the students repeat this procedure for their pests found at home. They should return to school with notes about what they found.

Follow-up
Review with your students all of the steps of an IPM program be sure to match their activities with the IPM steps they have taken both in school and at home. Ask them why they think they have also done IPM at home. Help them understand that school and home are two different environments, but that people and pests are a part of both. Pests can be in similar environments, therefore it is important for us to take care of all of our surroundings.
**Materials**
- Paper for worksheets
- Paper
- Pencils
- Blackboard
- Chalk

**Activity 3 – Educate**
Students should, once again, return to their scouting groups and begin preparing presentations. Assign each group a different pest, either one they have been studying at school or one they have been studying at home. Half of the class should talk about school pests, and the other about home pests. Allow your students class time to work on their presentations. They can present with posters, overheads, a puppet show, or any other creative measures.

Invite parents, administrative, custodial, and teaching staff to your class for a student taught IPM lesson. Allow your students to explain to your audience:
- What does IPM mean?
- What are the steps in IPM?
- How they have used IPM.
- What pests did they find?
- What did they learn about these pests?
- What kind of management options they used other than pesticides, and why?
- How they decided which options to use.
- Did their management tactics work?
- What everybody can do to prevent pest problems.
- Have the class explain what they have learned about IPM both in school and at home.

**Activity 4 – Super Sleuth**
The IPM Institute of North America (http://www.ipminstitute.org) has put together a variety of games and puzzles that address the concept and steps of and IPM program. At this point these games would help to cement your students’ understanding of IPM. However, you may choose to use these helpful games and puzzles at any point during your IPM program.

**Materials**
- Paper
- Pencils
- Construction paper
- Markers
- Colored pencils
- Scissors
- Glue
- Overhead and transparencies
Lesson 5 -Activity 1
Discovering IPM

Integrated Means: ___________________________________________________________
_________________________________________________________________________

A Pest Is: __________________________________________________________________
_________________________________________________________________________

Management Means: _________________________________________________________
_________________________________________________________________________

Integrated Pest Management (IPM) is ___________________________________________
_________________________________________________________________________

Steps in a successful IPM program are:
1. Observe the pest or problem
2. Identify the pest and learn about its biology
3. Scout and Monitor for symptoms and signs of the pest
4. Make decisions about control
4. Implement control options
5. Evaluate the control practices and educate about the pest and preventative measures

What have you done that is associated with each step? (the way we have practiced these steps is…)

1. _______________________________________________________________________

2. _______________________________________________________________________

3. _______________________________________________________________________

4. _______________________________________________________________________

5. _______________________________________________________________________

6. _______________________________________________________________________
Lesson 5 - Activity 2
Evaluate

<table>
<thead>
<tr>
<th>School Pests (drawing or description)</th>
<th>Pest Habitat (where it was found)</th>
<th>Pest Evidence (Symptoms and signs)</th>
<th>Pest Numbers</th>
<th>Monitoring (how often and when)</th>
<th>Management (when, how, with what)</th>
</tr>
</thead>
<tbody>
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</tbody>
</table>
Integrated Pest Management (IPM) is a form of applied ecology. It uses, influences, and impacts the relationships of an ecosystem through biotic and abiotic means. IPM is a knowledge-based system that relies on correct and adequate information for decision making about management practices in both the present and future. Integrated Pest management integrates several compatible tactics for controlling pest populations through environmentally conscience and economical methods.

IPM does integrate the use of pesticides. They are often part of a successful program. However, the use of pesticides should be very specific for the situation that is being managed. Pesticides should only be used when necessary, and should target the major pest populations. Pesticides should not be harmful to beneficial organisms, and must be used in accordance with the label. It is necessary that individuals incorporating pesticides in their pest management program are knowledgeable about their use and safety. A successful IPM program uses additional methods to control pest problems and uses only those pesticides that are compatible with other management strategies. IPM programs aim to reduce the use and reliance on pesticides, and this program includes a series of steps.

Step One: Organisms in the situation are correctly identified. Then determine if the organism is a major pest, a minor pest, or a beneficial organism. If it is minor pest, it may not be necessary to take further action. Likewise, if it is a beneficial organism, no action is necessary.

Step Two: Learn more about the pest. Identify the pest as the cause of a problem; research the pest and its biology. Know its life cycle and developmental habits, its behavioral and feeding habits, and understand its distribution, and potential damage to the resource.

Step Three: Establish a monitoring program. This is done through scouting and monitoring procedures. Determine the levels at which pest populations will cause severe loss either through yield, aesthetics, or monetary value.

Step Four: Make decisions about tactics that can be implemented in the situation. Which tactics are most available, effective, efficient, and cost beneficial to the situation? It is important at this step to think about how management strategies will influence the ecosystem to be managed. Examine all of the alternatives and choose the best option(s).

Step Five: Implement the tactics chosen to manage the pest situation. Then continue to monitor the pest population with respect to the chosen tactic. Are the tactics working? Or does the situation need to be reevaluated and new tactics implemented? Was a decision really necessary? Was the population high enough to cause severe problems?
Step Six: Continue to evaluate the monitoring program and chosen management tactics. Consider if changes are needed in the monitoring program or management tactics. Then educate individuals about IPM programs that were implemented. This can be considered a preventative measure to ensure against pests in the future. Taking preventative measures against pests can be the easiest and most effective pest management tactic.

Sources:

University of California IPM online
http://www.ipm.ucdavis.edu/

Cooperative State Research, Education, and Extension Service
http://www.csrees.usda.gov/

IPM Institute
http://www.ipminstitute.org

Integrated Plant Protection Center – Directory of IPM Resources
http://www.ippc.orst.edu/DIR/
IPM Modules

Introduction: The following modules are designed to reinforce and practice IPM in several settings. There are several ways to use the modules.

1. They can be practiced following the home and school IPM discovery lessons. The students will be familiar with the components of an IPM program, and through the use of the modules they will be allowed to explore and practice IPM in different settings.
2. The modules can be used as an alternative to the home and school IPM lessons. You may choose to follow the home and school IPM discovery lessons as a guide to teach the process of IPM in one or more of the settings provided.
3. The modules can be used in addition to the home and school discovery IPM lessons; thus as the students learn IPM in the school and home, they can also learn and practice IPM in one or more of the module environments.

It is suggested that a field trip to a facility that manages ornamental plants, a commercial greenhouse, golf course or other turf management facility or to a sustainable, organic or commercial farm that practices a sound IPM program accompany the modules. In addition to a field trip, the modules should be reinforced with an interview with a knowledgeable IPM manager associated with the subject of the module.

For grades 2-5, it is recommended that these modules are introduced to students only as field trips and interviews with managers.
**IPM Modules: Greenhouses**

**Note:** IPM learned and practiced in this module should be successfully reinforced with a field trip to a local greenhouse, or if possible in the school agriculture greenhouse. Additionally, an interview with a knowledgeable greenhouse manager will help students understand IPM more completely.

**Resources**
Integrated Pest Management (IPM) for school Greenhouses – Manual 2003
Maryland Cooperative Extension, University of Maryland
Ed Crow, Maryland Department of Agriculture: CrowEA@MDA.STATE.MD.US

University of Vermont – Greenhouse IPM
http://www.uvm.edu/~entlab/?Page=greenhouseipm.html

University of Massachusetts – Greenhouse project
http://www.umass.edu/umext/ipm/ipm_projects/greenhouse.html

Growing Lifestyle – Greenhouse IPM
http://www.growinglifestyle.com/j/4002/

Rutgers University – Greenhouse Notes

**Objectives**
The Students will:
- Become familiar with the greenhouse environment
- Compare symptoms of healthy and unhealthy greenhouse plants
- Discover pest and disease symptoms that occur in a greenhouse
- Learn which pests are common in greenhouses, why they are pests, and which IPM tactics are employed to manage them
- Research key pest biology, damage caused, host plants, monitoring and management practices
- Participate in an IPM program designed by the students

**Vocabulary**

<table>
<thead>
<tr>
<th>Insects</th>
<th>Pythium root rots</th>
<th>Sticky cards</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aphids</td>
<td>Phytophthora root rots</td>
<td>Cultural control</td>
</tr>
<tr>
<td>Fungus Gnats</td>
<td>Rhizoctonia root rots</td>
<td>Insecticides</td>
</tr>
<tr>
<td>Mealybugs</td>
<td>Powdery mildew</td>
<td>Fungicides</td>
</tr>
<tr>
<td>Scale</td>
<td>Leaf spot (bacterial disease)</td>
<td>Miticides</td>
</tr>
<tr>
<td>Shore flies</td>
<td>Tomato Spotted Wilt</td>
<td>Pesticides</td>
</tr>
<tr>
<td>Spider mites</td>
<td>Virus</td>
<td>Diseases</td>
</tr>
<tr>
<td>Thrips</td>
<td>Tobacco mosaic virus</td>
<td>Soil Sample</td>
</tr>
<tr>
<td>Whiteflies</td>
<td>Frass</td>
<td></td>
</tr>
</tbody>
</table>
Activity

Step One, Discussion:
Talk with the students about experiences they may have had in a greenhouse.
- Have they ever visited a greenhouse?
- What did it look like?
- What kinds of plants were there?
- Did they see any pests, insects or diseases?
- What kind of watering system did the greenhouse use?
- How large was the greenhouse?
- What was under the benches, rocks, soil, etc?
- What kind of shade was in or near the greenhouse?
- What kind of access was there to the greenhouse, several doors, one door, windows, etc?

Step Two, The greenhouse:
If the school has a greenhouse, visit it in this next step. If it is not possible to visit a school greenhouse, arrange for a field trip to a local commercial greenhouse. When inside the greenhouse have students take detailed notes about their findings. Caution students to respect the greenhouse, and to be careful not to damage any plants and equipment. They will need hand lenses, rulers, pencils, and paper. They should make notes about:
- Plants in the greenhouse
- Plants that look healthy, height, color, leaf shape
- Plants that look unhealthy, height, color, leaf shape
- Did they observe any insects, insect waste (frass) looks like black specks, cast skins (on the underside of leaves and along stems)
- Wilted or weakened plants
- Soil conditions, too wet, too dry, moist
- Lighting conditions in the greenhouse
- Temperature in the greenhouse
- Discolored leaves and stems
- Malformed leaves and stems (rosetting)
- Leaves and stems with yellow, brown, or black spots
- Chewed leaves
- Leaves with speckled yellow spots
- Leaves with a windowpane appearance

Step Three, Professional Greenhouse
This step may be easiest to accomplish while at a commercial greenhouse. However, if the class has not visited the greenhouse, or is not able to, ask a greenhouse manager to visit the class. You may choose to have the greenhouse manager present the IPM program he or she uses to the class, or have the class interview the greenhouse manager about the IPM program he or she uses. Points that should be addressed during the visit with the greenhouse manager are:
• What pest prevention techniques are used?
• What insects are common to greenhouses?
• Are these insects pests or beneficial?
• How are pest insects monitored?
• How are pest insects managed?
• What diseases are common in greenhouses?
• How are diseases monitored?
• How are diseases managed?
• What weeds are problems in greenhouses?
• How are they monitored?
• How are they managed?
• Are biological controls used?
• Are cultural controls used?
• Are physical and mechanical controls used?

Step Four, Greenhouse IPM discovery
Working in pairs students should use a variety of materials such as Internet resources, extension information, books and manuals to research the variety of pests that can occur in a greenhouse. Students must discover and report to the class:

- Name of a Pest
- Pest Host
- Pest Biology
- Pest Damage
- Monitoring/scouting methods
- At least one method for managing pest populations

Students may choose to investigate a major pest of their interest or a pest mentioned by the greenhouse manager. If students wish to investigate a pest of interest, encourage them first to decide on a plant they have interest in, then research the key pests for that plant. Groups of students should research insects and diseases respectively. Below is an abbreviated list of common greenhouse pests.

**Insects**: Aphids, Fungus Gnats, Mealybugs, Scale, Shore flies, Spider mites, Thrips, whiteflies

**Diseases**: Botrytis, Pythium and Phytophthora root rots, Rhizoctonia root rots, Powdery mildew, Leaf spot (bacterial disease), Tomato Spotted Wilt Virus, Tobacco mosaic virus

Step Five, Greenhouse IPM in practice:
Now that your students are much more familiar with a specific pest, allow them to revisit the commercial greenhouse or school greenhouse and begin looking for their specific pest. **Note: If students perform this step in a commercial greenhouse, permission must be obtained first, and scouting should be done with the supervision of greenhouse personnel.** Students should implement the scouting and monitoring techniques they researched. They should take detailed notes about pests that they find (location, number, and damage severity). Students should collect samples to bring back to the classroom for further identification.
Once they have returned to the classroom, they must use the information they have researched (pictures, descriptions, etc.) to correctly identify their pest. Students should also use **microscopes and slides, hand lenses, and rulers** to aid in pest identification.

After students have verified their pest, they should be allowed to scout the area once again to make more notes about pest abundance, host plant, and pest location on host plant, life stage of pest, and pest quantities. They should then present a scouting report to the class. The scouting report should include if they found their pest, pest density (numbers of pests), pest life stage, pest location, and on which plant the pest found. The scouting report should also include if management tactics are necessary. What they recommend for management? Are there any other tactics that can be incorporated? How often is treatment necessary?

If students have access to the school greenhouse and are able to continue a full IPM program they should gain information about previous pest problems, management methods, and end of the year disinfecting procedures. This background information is necessary to predict potential pest problems that could occur during the students’ time in the greenhouse. The students should research greenhouse monitoring programs that include scouting and sampling methods; this information will help students determine pest population densities and life histories. Allow the students to continue the greenhouse IPM program throughout the school year.

**Step Six, Take Action:**
This step may not be available to all teachers. However, if it is possible allow the students to implement their management methods (if necessary). Have the students continue scouting and making notes at regular intervals about pest densities, life cycles, and whether or not management practices are effective at managing pest populations. Periodically discuss their findings and have them report to the class. It may be necessary to re-evaluate and change management tactics.

**Materials**

<table>
<thead>
<tr>
<th>Slides</th>
<th>Bags for sampling</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rulers</td>
<td>Rulers</td>
</tr>
<tr>
<td>Hand lenses</td>
<td>Microscopes</td>
</tr>
<tr>
<td>Pencil</td>
<td>Thermometers</td>
</tr>
<tr>
<td>Paper</td>
<td>Tweezers</td>
</tr>
<tr>
<td>Sticky cards (for monitoring pest densities, may not be needed)</td>
<td>Transportation for field trip</td>
</tr>
<tr>
<td>Flags</td>
<td></td>
</tr>
<tr>
<td>Gloves</td>
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</tbody>
</table>
IPM Modules: Turfgrass

Note: IPM learned and practiced in this module should be successfully reinforced with a field trip to a local golf course, athletic field, cemetery, or other facility where turf maintenance is important. Additionally, an interview with a trained and qualified turf management person will help the students understand IPM more completely. Turfgrass IPM presents a particular problem in which pesticides play a predominant role as an integral strategy. It is important in this module to become familiar with proper and safe use of pesticides as the students interact with turfgrass professionals.

Resources
University of California – UC IPM Online
http://www.ipm.ucdavis.edu/index.html

Maryland Cooperative Extension
http://www.agnr.umd.edu/users/hgic/pubs/online/hg63.pdf

IPM Report Card for School grounds – a self assessment tool

Alabama IPM – Turf and Landscape IPM
http://www.aces.edu/department/ipm/turfipm.htm

Michigan State University – Turf Library, IPM Monitoring article

Guelph Turf grass Institute
http://www.uoguelph.ca/GTI/linkfram.htm?http://www.uoguelph.ca/GTI/links/reldx10

Objectives
The students will:
• Observe local school area for turf pests
• Be introduced to professional turf IPM
• Research insect, disease, and weed pests of turf
• Learn pest name, host, damage, monitoring methods, and be able to provide management recommendations
• Scout and monitor for a specific turf pest
• Collect and identify pests
• Evaluate management methods
• Present pest information
Vocabulary

<table>
<thead>
<tr>
<th>Vocabulary</th>
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</tr>
</thead>
<tbody>
<tr>
<td>Turf grass</td>
<td>Cutworms</td>
<td>Clover</td>
</tr>
<tr>
<td>Golf course</td>
<td>Chinch bugs</td>
<td>Resistant variety</td>
</tr>
<tr>
<td>Lawn</td>
<td>White grubs</td>
<td>Drench test</td>
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<tr>
<td>Lawn insects</td>
<td>Dollar spot</td>
<td>Root zone</td>
</tr>
<tr>
<td>Landscape pests</td>
<td>Leaf spot</td>
<td>Blade</td>
</tr>
<tr>
<td>Pathogens</td>
<td>Rhizoctonia blight</td>
<td>Leaf</td>
</tr>
<tr>
<td>Disease</td>
<td>Crabgrass</td>
<td>Nematode</td>
</tr>
<tr>
<td>Weeds</td>
<td>Spurge</td>
<td>Prevention</td>
</tr>
<tr>
<td>Armyworms</td>
<td>Dandelion</td>
<td>Cultural controls</td>
</tr>
</tbody>
</table>

Activity

Step One, Discussion:
Ask students:
• What their lawn looks like in the springtime. Help them to visualize a healthy green lawn with very little problems.
• If they have ever been to a golf course, baseball game or football game.
• What does the grass look like? Is it very green?
• Does it have of unwanted plants or weeds?
• Are there brown patches or dead looking patches?

Step Two, The schoolyard:
Take the students around the school yard assist them in identifying the difference between healthy grass and damaged grass. Damaged grass may be considered as thinned areas, and brown or yellow patches, etc. This observation requires hand lenses. Have students work in pairs, taking notes about healthy long, green blades in patches, and thin brown or yellow patches of grass, blades of grass with yellow blotches, brown spots, or black speckled areas. If they are having trouble, inform them that they should be looking for:
• chewed blades of grass
• brown thin spots
• grass with few roots
• spots on the blades
• yellowish patches
• odd weeds that stand out

Step Three, the professional lawn:
Taking students on a field trip to see a professional lawn and talking with a knowledgeable turf management professional or having a professional visit the class will emphasize the importance of IPM in turfgrass management. Another or alternative person that should meet with students is a turf extension specialist. Have the professional address his or her IPM program and how he or she implements it, what pests do they monitor for and how, and what management tactics do they employ and how. Or have, if possible, students interview the person (see IPM lesson 1 – Discovering IPM). Note: ask the turf management person to emphasize and define tactics and methods used in turf
IPM, such as soap flushes, ELISA kits, or floatation methods. Ask the turf professionals to explain how and which pesticides are safely and effectively incorporated into the IPM program.

- What pest prevention techniques are used?
- What pest insects are common to turf?
- How are pest insects monitored?
- How are insects managed?
- What diseases are common in turf?
- How are diseases monitored?
- How are diseases managed?
- What weeds are problems in turf?
- How are they monitored?
- How are they managed?
- What other IPM strategies are used?

**Step Four, Turf IPM discovery:**
Working in groups, students should research more about the pest problems of turf. Allow groups to study insect, disease, or weed pests. This is to ensure a variety of pests are covered. Encourage your students to find pesticides that are used in turf IPM programs. Students may use Internet resources, extension information, and information provided by the turf management person. Students must discover and then present to the class:

- Name of the Pest
- Pest Host
- Pest Biology
- Pest Damage
- Monitoring methods
- At least one management method used to manage the pest or disease
- If student choose a pesticide:
  - What pesticide is used in turf IPM?
  - For what is the pesticide used?
  - How is the pesticide used?
  - When is the pesticide used?
  - What are the safety concerns associated with the pesticide?

You may choose to have your students investigate pests they find interesting (that they may have found in the schoolyard) or pests mentioned by the management professional. However, if you were unable to visit with a turf management professional, below is an abbreviated list of common pests your students could investigate.

*Insects*: armyworms, cutworms, chinch bugs, white grubs
*Diseases*: Dollar spot, leaf spot, Rhizoctonia blight
*Weeds*: Crabgrass, spurge, dandelion, clover

**Step Five, Turf IPM in practice:**
Now that your students are more familiar with a specific pest, allow them to go out into the schoolyard, baseball or football field and begin looking for their specific pest. They
should implement the scouting and monitoring techniques they have researched. Be sure they take detailed notes about what they find (location, number, and damage type and damage severity). Have them collect samples to bring back to the classroom for further identification.

Once they have returned to the classroom, students must use the information they have researched (pictures, descriptions, etc.) to correctly identify their pest. Students should also use **microscopes and slides, hand lenses, and rulers** to aid in pest identification.

After students have verified their pest, they should be allowed to scout the area once again to make more notes about pest quantities, life stage, location, damage caused, and location on host plants. Then they should present a scouting report to the class. Their scouting report should include if they found their pest, how many of their pests were present, what life stage was their pest in, and what was the location of their pest. The students’ scouting report should also include if management tactics are necessary and their recommends.

**Step Six, Take Action:**
Implementing management measures for turfgrass is considerably different than in other situations (such as greenhouse or urban IPM). Therefore, this step may not be available to all teachers. However, if it is possible allow students to observe management practices at a golf course, athletic facility or some other turfgrass environment. Students should write a short essay about which management practices they would implement for their pest and why. Allow the students to continue scouting and making notes at regular intervals about pest densities, life stages, and lawn conditions. Discuss with students their management plan and have them report their management plan and findings to the class.

**Materials**

<table>
<thead>
<tr>
<th>Materials</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Hand lenses</td>
<td>Scissors</td>
</tr>
<tr>
<td>Microscopes</td>
<td>Forceps (tweezers)</td>
</tr>
<tr>
<td>Microscope slides</td>
<td>Probes</td>
</tr>
<tr>
<td>Pencils</td>
<td>Internet resources</td>
</tr>
<tr>
<td>Paper</td>
<td>Transportation for a field trip</td>
</tr>
<tr>
<td>Rulers</td>
<td>Guest speaker</td>
</tr>
<tr>
<td>Collecting materials: jars, bags, etc</td>
<td></td>
</tr>
</tbody>
</table>
IPM Modules: Agriculture

Note: IPM learned and practiced in this module should be reinforced with a field trip to a local farm specializing in vegetable, fruit, or field crops, and if possible, should be practiced in the school garden. Additionally, an interview with a knowledgeable farmer or IPM manager, who administers a successful IPM program, will help students understand IPM. This module was designed in a very general sense, giving examples only for common crops. It may be necessary to alter the module to accommodate region specific crops. The resources listed below will aid in gathering information.

Resources
Penn State IPM – Field Crop Manual
http://www.cas.psu.edu/docs/CASDEPT/IPM/FldCrop/default.html

University of Missouri – Columbia IPM
http://ipm.missouri.edu/fieldcrops.htm

Database of IPM Resources (DIR) – Vegetable IPM links
http://www.ippc.orst.edu/cicp/Vegetable/vegindex.htm

Illinois Extension – Fruit and Vegetable IPM
http://www.aces.uiuc.edu/ipm/fruits/fruits.html

Board of Regents, University of Wisconsin System – IPM
http://ipcm.wisc.edu/green/Pest_management.htm

Minnesota Department of Agriculture – Fruit and Vegetable IPM
http://www.mda.state.mn.us/ipm/fandvipm.html

University of Minnesota – Radcliffe’s IPM world textbook
http://ipmworld.umn.edu/textbook.htm

North Carolina State University – pests of tomato
http://ipm.ncsu.edu/AG295/html/tomato_key.htm

Cornell University vegetable MD online
http://vegetablemdonline.ppath.cornell.edu/factsheets/Tomato_List.htm

For further resources the terms: vegetable IPM, field crop IPM, Livestock IPM, and Fruit crop IPM, give rise to a variety of links in www.google.com searches.
Objectives
Students will:
- Learn about pests and diseases in gardens, on farms, and other large agricultural production systems
- Observe pests that occur in these systems
- Research pest biology, monitoring techniques, damage caused, and management techniques
- Implement IPM in a school garden
- Use microscopy to identify the pests

Vocabulary

<table>
<thead>
<tr>
<th>Fruit</th>
<th>Cast Skins</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vegetable</td>
<td>Malformed</td>
</tr>
<tr>
<td>Field Crop</td>
<td>Discolored areas</td>
</tr>
<tr>
<td>Community garden</td>
<td>Chewed areas</td>
</tr>
<tr>
<td>Livestock</td>
<td>Windowpane appearance</td>
</tr>
<tr>
<td>Sweep net</td>
<td>Speckled yellow spots (stippling)</td>
</tr>
<tr>
<td>Insects</td>
<td>Row crop</td>
</tr>
<tr>
<td>Diseases</td>
<td>Direct Damage</td>
</tr>
<tr>
<td>Frass</td>
<td>Indirect damage</td>
</tr>
</tbody>
</table>

Activity

Step One, Discussion:
This could be a wonderful opportunity for students to learn more about their family farms (if applicable) and/or gardens. Perhaps a family farmer would be willing to participate in this module. Discuss with students their experiences with farming or gardening.
- Have they ever helped in a family vegetable garden?
- Do they help on the family farm?
- What fruits, vegetables, or field crops do they grow?
- Have they ever noticed any insect pests?
- What kind were they?
- What type of damage did they cause?
- Have they ever observed any diseases?
- What did the plant look like?
- Did it change color?
- Did it have yellow or brown spots?
- Was the garden or field large or small?
- What was around the garden or field, trees, homes, roads, etc?

Step Two, The garden or farm:
If the school has a garden, visit it in this next step. If it is not possible to use the school garden, make arrangements to visit a local community garden or commercial farm. At
the garden or farm, have the students take detailed notes about their findings. They will need **hand lenses, rulers, pencils, and paper**. They should make notes about:

- Plants in the garden or farm
- Plants that look healthy, height, color, leaf shape
- Plants that look unhealthy, height, color, leaf shape
- Areas that have wilted, damaged, or unhealthy looking plants
- Under leaves and along stems for insects
- Did they observe any insects, insect waste (frass) looks like black specks
- Presence of shed or cast skins
- Soil conditions, too wet, too dry, moist
- Shaded areas and low spots
- Discolored leaves and stems
- Malformed leaves and stems
- Leaves and stems with yellow, brown, or black spots
- Chewed leaves
- Leaves with speckled yellow spots
- Leaves with a windowpane appearance
- Entrance/exits areas of the garden or farm
- Cultivation equipment used
- Previous pesticide applications
- Plants previously grown in the area
- Pests of plants previously grown in the area
- Surrounding area, neighboring farms, roads, etc.

**Step Three, Community garden or commercial farm**

This step may be easiest to accomplish while at garden or commercial farm. However, if the class has not visited the garden or farm, or is not able to, ask a University extension agent knowledgeable in IPM or a farmer with a successful IPM program to visit the class. You may choose to have the IPM agent/manager or farmer present an IPM program to the class, or have the class interview the IPM agent/manager or farmer about an IPM program in practice. Points that should be addressed during the visit include:

- What pest prevention techniques are used?
- What insect pests are common to gardens and crops?
- How are insects monitored?
- How are insects managed?
- What diseases are common in gardens and crops?
- How are diseases monitored?
- How are diseases managed?
- What weeds are problems in gardens and crops?
- How are they monitored?
- How are they managed?
- Are biological controls used?
- Are natural enemies conserved (protected) or enhanced (provided with food, water, shelter, etc.)?
• Are cultural controls used?
• Are physical and mechanical controls used?
• When are pesticides necessary?
• What kinds of pesticides are used?

**Step Four, Garden and Field Crop IPM discovery**

Working in pairs, students should use a variety of materials such as Internet resources, extension information, books and manuals to research the variety of pests that can occur in a garden or field. Students must discover and report to the class:

- Name of the Pest
- Pest Host
- Pest Biology
- Pest Damage
- Monitoring/scouting methods
- At least one method for managing pests

Students may choose to investigate pests interesting to them or pests mentioned by the IPM manager or grower. Groups of students should research the life histories, major problems caused (yield loss and economic loss), and monitoring and scouting programs for insects or diseases. Below is an abbreviated list of common pests of some crops. Students may need to research the pests and diseases of the crop or garden plants with which they are working. It is recommended to do a Google search (http://www.google.com) with key words such as: corn pests, corn diseases, lettuce pests, lettuce diseases, carrot pests, carrot diseases, etc.

**Soybean:**
- Insects – Seedcorn maggot, Green cloverworm, Two Spotted Spider Mite, Wooly bear caterpillar, grasshoppers, corn earworm, stinkbugs, Mexican bean beetle, Velvetbean caterpillar
- Diseases – Brown Stem Rot, Phytophthora Stem and root rot, soybean cyst nematode

**Peach:**
- Insects – Oriental Fruit Moth, Plum Curculio, Tarnished Plant bug, stink bug, Japanese beetle, Western Flower Thrips
- Diseases – Apple Scab, Fire blight, Peach leaf curl, Crown Gall of Peach, Powdery Mildew, Rhizopus

**Potato:**
- Insects – Armyworm, Aster leafhopper, Cabbage Looper, Colorado Potato Beetle, Green Peach Aphid, Potato Aphid, Potato Flea beetle, Tarnished Plant bug, White grub
- Diseases – Bacterial ring rot, Bacterial soft rot, Early blight, Late blight, Fusarium Wilt, Leaf roll, Rhizoctonia canker

**Tomato:**
- Insects – Tobacco budworm, tomato pinworm, blister beetles, cabbage looper, flea beetles, hornworms, aphids, whiteflies, stink bugs
- Diseases – Tomato anthracnose, bacterial canker, bacterial speck, bacterial spot, blossom end rot of tomato, *Botrytis* gray mold

Weeds:
- Yellow Nutsedge, Barnyardgrass, Yellow Foxtail, Giant Foxtail, Green foxtail, Fall Panicum, Large Crabgrass, Wild buckwheat, Smartweed, Pigweed, Velvetleaf, Morningglory

Step Five, Garden and Crop IPM in practice:
Now that your students are much more familiar with specific pests, allow them to revisit the community garden, school garden, or field crop and begin looking for their specific pest. **Note:** If students perform this step in a community garden or in a grower’s field, permission must first be obtained, and scouting should be done with the supervision of a professional crop scout. Students should implement the scouting and monitoring techniques they have just researched. Be sure they take detailed notes about what they find (location, number, and damage severity). Have them collect samples to bring back to the classroom for further identification.

Once students have returned to the classroom, they must use the information they have researched (pictures, descriptions, etc.) to confirm they have found their pest. Students should also confirm their findings by using microscopes, and slides, hand lenses, and rulers.

If students are practicing IPM in a school garden and after they have verified their pest, they should be allowed to scout the area once again to make more notes about pest abundance (numbers), pest life stage, pest location on the host, host plant health, and weather conditions. They should then present a scouting report to the class. Their scouting report should include if they found their pest, how many of their pest did they find? Were there any other pests? What were they? What was the life stage of their pest? Do they think management measures are necessary? What would they recommend? How often should this management measure be used? Why did they choose this management tactic? If students are unable to re-scout the area, they should speculate about what they might find if they could scout the area again. Then students should write a report answering the afore stated questions about pests and management tactics.

If the students have access to the school garden and are able to continue their IPM program they should set up and use the sampling devices they have research for their pest such as, pheromone, pitfall, light traps, sweep nets or other traps. They may choose to take plant tissue (to test for viruses) and soil samples (to determine nutrient needs). Students should also obtain information about previous pest problems, management tactics, and end of the year/post harvest procedures, to help them predict pest problems that may occur during the time period students are working in the garden or on the farm. The students should continue the garden IPM program throughout the school year.
Step Six, Take Action:
This step may not be available to all teachers. However, if it is possible students should implement their management tactics (if it is necessary). Students should continue scouting and making notes at regular intervals. Periodically discuss their findings and have students report them to the class. It may be necessary to re-evaluate and change management strategies.

Materials
Transportation for field trip
Pencil
Paper
Rulers
Hand lenses
Old shoes
Sweep nets
Flags for denoting troubled areas
Bags for sampling
Microscopes
Microscope slides
IPM Module: Pesticides in the Environment

Note: This module should be used as a reinforcement tool for promoting IPM as a necessary program. This module should be taught with the home and school IPM lessons and with all of the modules. It may also be taught independent of the other lessons as an environmental science lesson. It is designed to enhance environmental awareness, the use of pesticides, their dangers, and effects on the environment. It may be best incorporated with Lesson 4 – Decision making.

Resources
Extension Toxicology Network - Movement of pesticides
http://extoxnet.orst.edu/tibs/movement.htm

Environmental Protection Agency
http://www.epa.gov/pesticides/

EPA - Environmental Affects of Pesticides
http://www.epa.gov/pesticides/ecosystem/index.htm

EPA - Endangered Species Coloring book
http://www.epa.gov/espp/coloring/

EPA - Information about Pesticides for kids, students, and teachers
http://www.epa.gov/pesticides/kids/

EPA - Learn about chemicals around the house
http://www.epa.gov/kidshometour/

Objectives
Students will:
- Reinforce their knowledge of pesticides
- Learn about pesticides in and around the home
- Learn about types of pesticides
- Understand the effects of pesticides on the environment
- Understand the movement of pesticides in the environment
- Create a pesticide life cycle using inquiry, art, and writing skills

Vocabulary
Pesticides
Drift
Environment
Pesticide movement
Residue
Safety
Pesticide selection
Persistence
Crop emergence
Insect breeding
Crop canopy
Backpack sprayer
Pesticide efficacy
Crop dusting
Runoff
Pesticide safety
Poison
Poison control
Activity

Step One, Discussion

Revisit Activity 4 of Lesson 4. Remind students of the discussion that took place about their knowledge of pesticides. It might be useful to re-ask some of the questions and create a pesticide desirable/undesirable (pro/con) list on the board. Help them remember what they discovered when they found pesticides labels at home. You may wish to use some of the following questions in your discussion.

- What are pesticides?
- Where are pesticides found?
- What are pesticides used for?
- Who uses pesticides?
- What good do pesticides do?
- Are pesticides safe for people and pets to be around? Why or why not?
- What kind of harm do pesticides cause?

Be sure to talk in depth about the dangers of pesticides, and about pesticides in the environment.

Step Two: EPA Pesticides around the home:

Use the EPA website: EPA - Learn about chemicals around the house [http://www.epa.gov/kidshometour/](http://www.epa.gov/kidshometour/) to help students learn more about varieties and uses of pesticides. This is a very good interactive and informative tool. It is a pesticide scavenger hunt for students. This website gives detailed information about various chemicals that can exist in and around the home. It also gives important information about pesticide safety and poison control.

If the classroom is equipped for the entire class to participate in this activity you may wish to do so. However, if the classroom is not equipped for entire class internet use, have the students work in small groups of 2-3 and tour the EPA home searching and learning about pesticides.
Step Three, The Life Cycle of the Pesticide:

Use the Extension Toxicology Network - Movement of pesticides in the environment [http://extoxnet.orst.edu/tibs/movement.htm](http://extoxnet.orst.edu/tibs/movement.htm) for background information prior to this lesson. It explains the movement of pesticides in the environment. Explain to students that there are many outcomes of a pesticide in the environment.

When pesticides are applied to a resource (crop, garden, flower bed, house plant, pet, etc.), depending on the chemical nature of the pesticide and the conditions in which it was applied, the pesticide can have many fates. Those pesticides that remain in the environment for long periods of time are said to be persistent.

- Pesticides that are moved off-site through wind, water, or other means are known as pesticide drift.
- Pesticides can be taken up by plant through their roots and into their stems and leaves are translocated.
- Pesticides can be adsorbed into the soil (clinging onto soil particles).
- Pesticides can move through soil and into ground water.
- Pesticides can linger in the environment; this is called residue.
- Pesticides can be degraded by sunlight.

Allow your students to choose a brief situation from the list below, or create situations of your own. *For Grades 6 & 7*: students should research a pesticide that could be used in their chosen pest situation. They should find and read the label for pesticide formulation (liquid, powder, granule), directions for use, environmental hazards, rates (amount to be applied), and time of application. *For grades 2-7*: ask them to create a life cycle for a pesticide. What do they think happens to the pesticide when it is applied? Where does it go? Who or what is affected by it? They may choose to draw the life cycle, or create a story about it. Use the subsequent Environmental Protection Agency reports to help students understand that pesticides do not stay in one place after they are applied. It may even be useful to discuss the EPA situation with your students.
**Pesticide Situations:**

- A potato grower applies a powder pesticide, on a windy day, with an airplane. This is known as crop dusting.
- Mosquitoes are pestering vacationers. Pesticide applicators apply the pesticide to the pond that is the environment for mosquito breeding.
- Pesticides are applied to the ground before a corn crop emerges. The crop is near a wooded area.
- Pesticides are applied to orchard fruits through backpack sprayers.
- Liquid pesticides are applied to a crop of cranberries. Cranberries grow in bogs (low wetland areas).
- Powder pesticides are applied to a crop canopy.
- Mouse poison is hidden in the corner of a home.

**Teacher Information, Ideas of possible outcomes of listed situations.**

- Pesticide is carried on wind currents – drifts to nearby water source – water is taken in by fish – fish are eaten by birds – birds die. Or pesticide is carried by wind currents – drifts to homeowner’s garden that does not use chemicals and has small children – children eat vegetables – become sick.
- Pesticide is in water – taken in by plankton – plankton eaten by small fish – smaller fish eaten by larger fish – larger fish eaten by birds – ingestion of pesticide by birds affects bird reproductive processes and eggs fail to hatch.
- Crop emerges – plants have taken in pesticide – deer population eats plants along the edge of the forest and crop – fawns become sick and die.
- Pesticides drift onto neighboring plants – fruits are harvested and sold to grocery stores – consumers purchase fruit and intake fruit without washing – later in life consumer gets cancer from pesticide residues.
- Pesticides for cranberries leeks through the soil into the ground water – water is pumped by a city – water filtration systems are inadequate on a particular day – and pesticides are pumped into a city through water.
- Powder pesticides applied – remain in the soil, are degraded by microbes, are degraded by sunlight before absorption into the soil.
- Household pet eats the mouse poison and becomes very ill.

**Step Four: Pesticide Safety**

In this exercise, students will learn the importance of pesticide safety. Gather a variety of pesticides to bring to class for discussion. Pesticides for home and garden use can be found at a local hardware store or garden center. Discuss with students the importance of reading the label. Pesticides must be used in accordance with the label.

Choose one pesticide and ask the students to write down the best answer as you ask the following questions. After asking the questions, arrange the students into groups of three, and have them discuss their answers, choosing the best from the group. Then conduct a class discussion about the pesticide. Inform students that all of this information can be found on the pesticide label. Read the labels to the class to help the students formulate correct answers.
• What pest does this pesticide control?
• Is this pesticide used indoors or outdoors?
• Who may use this pesticide?
• When should this pesticide be used?
• What protective clothing should be worn when using this pesticide?
• How should the person using this pesticide clean up?
• What other animals or plants could this pesticide harm?
• How does the person using this pesticide know how much to use?
• Where does the person learn how to use this pesticide?
• What could happen if this pesticide is incorrectly used?
• How would someone know if the pesticide harmed the person?
• Who should be called for help?

Following discussion about labels and pesticide safety, arrange for a guest speaker from the poison control center and/or school nurse. Ask this person to provide information about:

• How to contact the poison control center.
• What information is needed when reporting poisoning?
• What are the symptoms and signs of human poisoning?
STATE OF CALIFORNIA
DEPARTMENT OF FISH AND GAME

PESTICIDE LABORATORY REPORT
1701 Nimbus Road, Suite F
Rancho Cordova, California 95670

Lab No: P- 2360
Date Received: February 27, 2003
E.P. No. L- 103-03
Sample: 2 grass carp, 1 flathead catfish, 1 largemouth bass
Index: N400
PICA: H1893

To: Warden Carol Sassie
P.O. Box 1673
Brawley, CA 92227
Report Date: April 3, 2003

Remarks
A fish kill was reported in the Lavender Canal east of Highway I 11, Imperial County, on February 19, 2003. Staff from the Imperial County Agricultural Commissioner's office responded to the report and documented the fish kill. A Notice of Intent had been filed for aerial application of a tank mix containing the insecticides cyfluthrin and chlorpyrifos for the agricultural field adjacent to the site of the kill. The kill was estimated at close to 400 fish and consisted of approximately 320 Flathead Catfish Pylodictis olivaris, 60 Grass Carp Ctenopharyngodon idella, and 20 Largemouth Bass Micropterus dolomieu. Water samples were collected and submitted to the California Department of Food and Agriculture (CDFA) Pesticide Chemistry Laboratory for analysis. Dead fish were collected from the canal and submitted to the Department of Fish And Game (DFG) Pesticide Investigations Unit for necropsy and pesticide residue analysis.

RESULTS OF EXAMINATION
The samples received consisted of one largemouth bass, one flathead catfish and two grass carp. The fish appeared to be in good condition. There were no observable external signs of autolysis. A small amount of bleeding from the gills was observed in the catfish. There were no observable ectoparasites present on any of the fish. Internal examination indicated blood tinged fluids in the abdominal cavities of both grass carp. Gill samples were collected from all four fish and submitted to the DFG Water Pollution Control Laboratory (WPCL) for pesticide residue analysis. The results of the analysis of the water and tissue samples are presented in Table 1.

Table 1. Sample Analysis Results, Lavender Canal Fish Kill (conc. in parts per billion, ppb)

<table>
<thead>
<tr>
<th>Sample</th>
<th>Cyfluthrin</th>
<th>Chlorpyrifos</th>
</tr>
</thead>
<tbody>
<tr>
<td>Upstream Water Sample</td>
<td>N. D.</td>
<td>0.08</td>
</tr>
<tr>
<td>Kill_Site_Water Sample</td>
<td>0.33</td>
<td>11.7</td>
</tr>
<tr>
<td>Bass Gills</td>
<td>390</td>
<td>2.100</td>
</tr>
<tr>
<td>Catfish Gills</td>
<td>240</td>
<td>660</td>
</tr>
<tr>
<td>Grass Ca Gills</td>
<td>220</td>
<td>830</td>
</tr>
<tr>
<td>Grass Carp Gills</td>
<td>270</td>
<td>770</td>
</tr>
</tbody>
</table>
Data supplied to the California Department of Pesticide Regulation in support of product registration indicated that the LC50 values for bluegill sunfish *Lepomis macrochirus* were 0.998 ppb for cyfluthrin and 5.8 ppb for chlorpyrifos.

**Conclusion**

The concentrations of both cyfluthrin and chlorpyrifos in the water sample from the site of the fish kill were near or exceeded the LC50 concentrations for these compounds. The presence of elevated levels of both compounds in the gill tissues of all four fish analyzed indicates that these fish were exposed to both compounds. Based on the results of these analyses, it is highly likely that the fish kill in the Lavender Canal was due to exposure to cyfluthrin and chlorpyrifos. The absence of any other applications of these compounds in the area at the time of the fish kill indicates that the source of the compounds was overspray from the reported aerial application.

Chemical analysis of water samples was performed by the CDFA Pesticide Chemistry Laboratory. Tissue analyses were performed by Abdou Mekebri, chemist, DFG WPCL.

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**PESTICIDE INVESTIGATIONS UNIT**
**OFFICE OF SPILL PREVENTION AND RESPONSE**

By
Robert C. Hosea
Principal Investigator

Approved
Brian Finlayson, Chief
Pesticide Investigations Unit

Chemical analysis: $3,600.00
Assessment and report: $575.00
Total Cost of investigation: $4,175.00

cc:
Mr. Robert Powell
Imperial County Department of Agriculture
150 South 9th Street
El Centro, CA 92243-2850
Pesticide Registration Branch
1001 I Street
P.O. Box 4015
Sacramento, CA 95812-4015

Mr. F. Nicholas Mastrota
EIIS Database Manager
Environmental Fate and Effects Division
Office of Pesticide Programs
U.S. Environmental Protection Agency
Washington, D.C. 20460

Mr. Dan Weerasekera
California Department of Pesticide Regulation
Enforcement Branch, Southern Region
130 Chaparral Court, #130
Anaheim, CA 92808
Nick-
I am trying to find out the answer to question 1. As far as question 2. No the pilot did not follow buffer restrictions as the County Ag Comm. staff documented that it was an overspray case. I didn't mention it in my report as the data didn't directly apply to the dead fish but there were detectable residues on vegetation on both sides of the canal. The CAC staffer Robert Powell has that information. -Bob

Hi Bob,
Thank you for sending me the report on the Feb fish kill in the Lavender Canal (Lab No. P-2360). I have a couple of questions about it.
1. Do you know on what crop the tank mixture of cyfluthrin and chlorpyrifos was sprayed?
2. Were label restrictions, such as buffer zones, followed in the application?

Thanks.

Nick Mastrota

Legality = "Misuse (Accidental)"
Nicholas Mastrota

To: Norman Spurling/DC/USEPA/US@EPA

04/29/2003 09:04 AM

cc:

Subject: Imperial County fish kill

Norman,

I just got this additional information about a fish kill in California caused by a mixture of chlorpyrifos and cyfluthrin. I just mailed the incident report to you yesterday. I will mail a hardcopy of this note to you today along with a couple of other items I have found.

Nick ------ Forwarded by Nicholas Mastrota/DC/USEPA/US on 04/29/03 09:00 AM ------

Bob Hosea
<bhosea@OSPR.DFG.CA.GOV>

To: Nicholas Mastrota/DC/USEPA/US@EPA

04/28/03 11:55 AM

cc: Nicholas Mastrota/DC/USEPA/US@EPA

Subject: Imperial County fish kill

Nick-
The crop associated with the fish kill in the Lavender Canal was alfalfa.

-Bob
CASE HISTORY: This fox was found convulsing on the ground next to a pond by a Kingwood Golf Resort employee in the morning of January 15, 2003. It later began walking in large circles when disturbed, and then collapsed. The fox was euthanized by Chris Moore of the Georgia Department of Natural Resources (GADNR). The fox was submitted to SCWDS by Jay Cantrell of the GADNR on January 16, 2003.

FINAL DIAGNOSIS: Parathion (organophosphate) toxicity suspect

COMMENTS: Toxicologic results demonstrate high levels of parathion (35 ppm) with possible intoxication. There is no information in the literature on parathion toxicity for foxes. However, oral LD60 concentrations reported for dogs are 3-5 ppm (Extoxnet; http://ace.orst.edu/cgi-bin/mfs/01/pips/parathio.htm), suggesting that this fox ingested a toxic dose of parathion. There was no gross, histologic, or microbiologic evidence of an infectious process. Mr. Cantrell was e-mailed results on March 3, 2003.

WILD ANIMAL IMPLICATIONS: Parathion is a broad spectrum, organophosphate pesticide used to control many insects and mites. Wild birds and mammals are susceptible to the toxic effects of parathion and other organophosphates. Parathion is highly toxic by all routes of exposure (transdermal, ingestion, and inhalation). Parathion primarily affects the nervous system. Clinical signs of mammals normally include excessive salivation and defecation, as well as prostration, tremors, or convulsions.

PUBLIC HEALTH IMPLICATIONS: Humans are susceptible to effects of organophosphate pesticides and should follow manufacturer's instructions to avoid exposure.

LIVESTOCK IMPLICATIONS: Domestic livestock and pets are susceptible to organophosphate toxicity.
GROSS FINDINGS: This fox presents in adequate nutritional condition with loose, vet feces on the perianal region and hind limbs. The kidneys are diffusely pale yellow. There is severe hemorrhage in the lungs and thoracic cavity (euthanasia artifact). There are fragments of mammal tissues in the stomach (hair, bones), loose ingests in the intestines, and soft, pale, loose feces in the colon. There are no gross lesions apparent in the spleen, reproductive tract, adrenal glands, and brain.

MICROSCOPIC FINDINGS: W03-09 Multifocally, there are large numbers of clear vacuoles in the cytoplasm of proximal renal tubules. In some tubules, the vacuoles are so large as to compress the renal tubular nucleus. There are small amounts of hemorrhage randomly scattered in the cerebrum. There is multifocal, mild meningeal hemorrhage. There is mild peribiliary fibrosis and biliary epithelial hyperplasia and cytoplasmic vacuolation of the biliary tubular epithelium. There is diffuse, severe pulmonary hemorrhage. There are few cross sections of adult nematodes in a large bronchus with intrauterine capillarid eggs. Multifocally, there are moderate numbers of eosinophils and few lymphocytes and neutrophils in the intestinal lamina propria. There are no histologic lesions apparent in the testis, adrenals, and spleen.

MORPHOLOGIC DIAGNOSIS:
Fatty change of proximal renal tubules

MICROBIOLOGIC RESULTS: There was heavy growth of Proteus sp. (interpreted as a contaminant) from the lung and intestines anti heavy growth of Clostridium perfringens (interpreted as post mortem overgrowth) from intestinal cultures. Brain tissue was negative for rabies, canine distemper virus, and infectious canine hepatitis virus by fluorescent antibody testing.

TOXICOLOGIC RESULTS: Fresh tissues were submitted to the University of Pennsylvania, New Bolton Center Laboratory of Toxicology in Kennett Square, Pennsylvania. A complete metal screen yielded no significant findings. Organic chemical screens of gastrointestinal contents yielded 35 ppm of parathion (an organophosphate). These screens are capable of detecting a large number of compounds including pesticides, strychnine, metaldehyde, a number of therapeutic and illicit drugs, euthanasia agents, and environmental contaminants.
Glossary

Abdomen
- The end part of an insect's body, which contains the digestive and reproductive organs.

Antennae
- Two long thin growths on the heads of insects, crustaceans etc. They are often called feelers. Animals might use their antennae to feel, smell, taste and even to hear.

Aphids
- Small, soft-bodied, translucent insects, color green, red, brown or black, which suck plant juices. Found on shoots, under leaves and on flower buds. Can stunt or deform leaves or flowers. Sticky residue ("honeydew") usually present, which attracts ants.

Armyworms
– Defoliating caterpillar common to agricultural crops

Auditory communication
- Communication that relies on hearing

Backpack sprayer
- spray unit with plastic containers on a backpack frame. Used by individual operator to apply chemicals, such as herbicides.

Blade
- Especially a leaf of grass or the broad portion of a leaf as distinct from the petiole

Botrytis
- *Botrytis cinerea*, a mold or fungus that attacks grapes or strawberries in humid climate conditions

Carnivore
- A carnivore is an animal that eats meat

Cast Skins
– Discarded exoskeleton as a result of molting

Chewed areas
– Portions of plant tissues that have been eaten (or defoliated) by insects

Chinch bugs
– Small insect of Turfgrass, common to St. Augustine grass

Clover
- a plant of the genus *Trifolium*
Community
- A characteristic group of plants and animals living and interacting with one another in a specific region under similar environmental conditions

Community garden
- Common garden area where individuals share plots to grow fruits, vegetables, or flowers. Usually located within city limits

Complete metamorphosis
- Developmental process of an insect in which each life stage is different from the previous

Compound Eye
- The eye of most insects and some crustaceans, which is composed of many light-sensitive elements, each having its own refractive system and each forming a portion of an image.

Consumer
- An organism (herbivores) that obtains nutrients and energy by eating other organisms (plants)

Control
- A relation of constraint of one entity by another. A method used to decrease pest populations below tolerable levels

Crabgrass
- Grasses with creeping stems that root freely; a pest in lawns

Crop canopy
- The uppermost layer of an agricultural or ornamental resource (crop)

Crop dusting
- The process of applying pesticides to a crop through aerial applications (by airplane)

Crop emergence
- The point at which plants of a crop break the soil surface

Cultural control
- Using non-chemical methods to control a crop pest, including mechanical cultivation for weed control, crop rotation to avoid buildup of disease, and plant variety or hybrid selection for resistance to nematodes. Includes altering the resource to make a situation unfavorable to pests
**Cutworms** – Defoliating caterpillars of agricultural crops

**Dandelion**
- any of several herbs of the genus *Taraxacum* having long tap roots and deeply notched leaves and bright yellow flowers followed by fluffy seed balls

**Decomposer**
- Any of various organisms that feed on and break down organic substances

**Direct Damage**
- Damage to a resource caused usually immediately and precisely by a pest

**Discolored areas** – Chlorotic or necrotic regions on the leaves of plants. Plants exhibit a color other than normal due to some environmental pressure

**Disease**
- a state in which a function or part of the plant is no longer in a healthy condition. A pathogen or deficiency that has caused physiological dysfunction

**Dollar spot**
- Common disease of Turfgrass

**Drench test** – Applying copious amounts of water to determine soil water potential. Applying excessive amounts of pesticide to a soil substrate to manage pests

**Drift**
- a force that moves something along. Pesticides carried by wind, water, or some other environmental factor away from the target area

**Ecology**
- The study of the relationships between living organisms and their environment.

**Ecosystem**
- The system of interactions between living organisms and their environment.

**Energy**
- The gaining of life supporting nutrition from eating or through sunlight. The capacity to do work.

**Environment**
- The sum total of all the external conditions that affect an organism, community, material, or energy.

**Field Crop**
- Agricultural commodities grown on large tracts of land. Common examples: potatoes, cotton, corn, alfalfa, soybeans
**Frass**
– Insect feces, looks like small black specks

**Fruit**
- The ripened reproductive body of a seed plant.

**Fungicides**
– Pesticides intended to manage fungi

**Fungus Gnats**
– Common mosquito-like pests of greenhouses

**Golf course**
- course consisting of a large landscaped area for playing golf

**Gradual Metamorphosis**
– Insect developmental process in which each life stage resembles the previous. All life stages resemble the adult

**Habitat**
- The place or environment where a plant or animal naturally or normally lives and grows.

**Head**
- a dense clusters of flowers or foliage

**Herbivore**
- Animal that eats plants.

**Host**
– resource that provides some nutritional value for pests. Usually a plant

**Indirect damage**
– Damage to a resource that is not immediate and usually is not seen

**Insect breeding**
– The process by which insects reproduce, either sexually, asexually, or through cloning

**Insecticides**
- Substances used to manage insects and prevent infestation.

**Insects**
- Member of the class Insecta in the phylum Arthropoda. Members have three body regions and three pairs of legs.
**Labial palps**  
– Structures located near the labium; modified suction structures

**Labium** - The second maxilla; the lower lip; a compound structure which forms the floor of the mouth in mandibulate insects.

**Labrum**  
- The upper lip, which covers the base of the mandible and forms the roof of the mouth.

**Landscape pests**  
– Insects or diseases detrimental to landscaped areas

**Lawn**  
- A field of cultivated and mowed grass.

**Lawn insects** – Arthropods that are either beneficial or detrimental to and reside in lawns

**Leaf**  
- An organ found in most vascular plants; it consists of a flat lamina (blade) and a petiole (stalk). Many flowering plants have additionally a pair of small stipules near the base of the petiole.

**Leaf spot**  
- A bacterial disease causing necrotic lesions on leaves

**Legs**  
- Appendages used for mobility

**Livestock**  
- Animals raised to provide food and dairy products

**Malformed**  
– Disfigured, curled, cupped or otherwise abnormal leaves or other plant parts

**Mandibles**  
- The second set of mouthparts in insects; in layman's terms: the jaws; used by ants for chewing, biting and manipulating objects.

**Maxillae**  
– Insect mouthparts used to manipulate food

**Maxillary palps**  
– sensory organs of the maxillae

**Mealybugs**  
– Cotton-like insects that feed on plant juices. Common in homes and greenhouses
Miticides
– Pesticides designed for managing mites

Monitoring
- A planned, systematic, and ongoing process to gather and organize data, and aggregate results in order to evaluate performance. A critical step in an IPM program

Morphology
- The study of form and structure of animals and plants and their fossil remains. A developmental process.

Nematode
- Nematodes are invertebrates comprising the parasitic roundworms. They are characterized by a smooth narrow cylindrical unsegmented body tapered at both ends.

Niche
- The status of an organism within its environment and community affecting its survival as a species.

Olfactory communication
– Communication through smell

Omnivore
- An organism that eats a diversity of food types, including animals and plants.

Pathogens
- Any virus, microorganism, or other substance that causes disease; an infecting agent.

Persistence
- Stability of chemical compounds in the environment. Persistence is an important negative criterion in the ecological assessment of chemicals.

Pest
- Any form of plant or animal life, or any pathogenic agent, injurious or potentially injurious to plants, plant products, or that is injurious or a nuisance to the well-being of man.

Pesticide efficacy
– Amount of effect a pesticide produces. Its potency

Pesticide movement
– The mobility of a pesticide through the environment, on wind, in water, adsorbance in soil, through food chains

Pesticide safety
– Proper use and handling of pesticides according to the label
**Pesticide selection**
– Choice of pesticide for a particular situation with consideration of safety for humans, animals, beneficial organisms and necessity and cost

**Pesticides**
- Chemicals that kill or inhibit the growth of organisms that people consider undesirable.

**Phytophthora** root rots
– Fungus that causes root death

**Poison**
- Any substance that causes injury or illness or death of a living organism

**Poison control center**
– Organization educates about the safe handling of toxins

**Population**
- A group of organisms of the same species populating a given area.

**Powdery mildew**
- Fungal disease of grape vines which, unlike most fungal diseases, thrives in dry climates. Appears as a white powder on the upper surface of leaves

**Predator**
- An animal that hunts and kills other animals for food.

**Prevention**
– Actions taken to prohibit pests

**Prey**
- Animal hunted or caught for food.

**Producer**
- Any organism which brings energy into an ecosystem from inorganic sources.

**Pythium** root rots – Fungus that causes root death

**Residue**
- Trace of a pesticide and its metabolites remaining in or on any commodity, animal, plant or environmental component. The term may be applied to contaminants of natural, industrial or environmental origin, but particularly in relation to crops at harvest time.

**Resistant variety**
– Organisms that have a high tolerance for, or the ability to withstand pest infestations

**Rhizoctonia blight**
– Fungal pathogen that causes necrotic lesions on leaves and stems
**Rhizoctonia** root rots  
– Fungus that causes root death

**Root zone**  
- The portion of a soil profile in which plant roots occur.

**Row crop**  
– Agricultural commodities grown parallel in fields, common examples are potatoes, and corn

**Runoff**  
- That part of precipitation, snow melt, or irrigation water that drains or flows off the land into streams or other surface waters. This precipitation can carry pesticides

**Safety**  
- Freedom from danger; a property of a device or process which limits the risk of accident below some specified acceptable level.

**Scale**  
– Insect that feed on plant phloem, immobile, and protected by an outer covering

**Scouting**  
– Important in a monitoring program, observing for pests, pest densities, pest locations, and other detriments

**Shore flies**  
– Insect similar to Fungus gnats, common in green houses

**Signs**  
– The biological evidence left by pests, fecal material, cast skins, eggs

**Soil Sample**  
– Method of removing a portion of soil for testing

**Speckled yellow spots**  
– Stippling caused by an insect. Insects with piercing-sucking mouthparts cause this damage

**Spider mites**  
– Small arachnids that are common pests to greenhouses

**Spiracles**  
– Small breathing holes located on the insect body for respiration.

**Spurge**  
- Any of numerous plants of the genus *Euphorbia*; having milky often poisonous juice.
Sticky cards
- Index cards lubricated with adhesive, used for monitoring insect populations

Sweep net
- Net used to sample insect populations in a field

Symptoms
- Physical evidence left by a pest, chewed leaves, stippling, windowpane appearance, wilting, etc

Thorax
- The middle segment of an insect. Includes the legs and wings if present

Thrips
- Thrips are very small insect pests that attack a number of different plants species, ranging from onions to pears.

Time
- The fourth element to the pest tetrahedron

Tobacco mosaic virus
- Virus transmitted by Thrips, causes severe plant death

Tolerance
- The ability to experience exposure to potentially harmful amounts of a substance or pest population without showing an adverse effect.

Tomato Spotted Wilt Virus
- Virus transmitted by Thrips, causes severe plant death

Turfgrass
- Manicured greens for athletic fields, golf courses, and cemeteries

Vegetable
- Edible seeds, roots, stems, leaves, bulbs, tubers or nonsweet fruits of any of numerous herbaceous plant

Weeds
- A plant growing in a place where it is not desirable

White grubs
- The larval stage of insects, usually beetles that develop below the soil surface

Whiteflies
- Small winged arthropods, common greenhouse pests
**Windowpane appearance**
- The epidermal layer of leaves has been eaten by insects usually in round or square shapes. Looks like small windows in leaves

**Wings**
- Appendages used for flight. Insects with wings have either one or two pair.
Web Resources


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


<http://www.antcolony.org/>

<http://www.uky.edu/Agriculture/Entomology/entfacts/trees/ef411.htm>


Minnesota Department of Agriculture. **Fruit and Vegetable IPM.** Minnesota Department of Agriculture. Apr. 2004<br>http://www.mda.state.mn.us/ipm/fandvipm.html


<http://www.stevetrash.com/booking/lessons/lesson1.htm>


<http://www.cis.yale.edu/ynhti/curriculum/units/1992/5/92.05.10.x.html#e>

<http://www.cis.yale.edu/ynhti/curriculum/units/1992/5/92.05.10.x.html#s>

<http://www.cis.yale.edu/ynhti/curriculum/units/1992/5/92.05.10.x.html>

<http://www.cis.yale.edu/ynhti/curriculum/units/1980/5/80.05.12.x.html>


**Additional Resources**


King, Donnie, R. et al. 4-H Manual 142 Grade levels 4-6 IPM level B Clemson University Cooperative Extension Service March 1987


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Inquiry Learning to IPM: A message from the Author

Inquiry-based learning is related to the process of discovery. It includes a multiple of learning styles and focuses on presenting a student with a question about a concept and allowing them to learn and answer their own question. It is interactive and inventive.

Prior to writing Discovering IPM: An Inquiry Approach to Learning Integrated Pest Management, I was fortunate to participate in the National Science Foundation’s GK-12 program through Clemson University. This program taught me about learning and teaching from the perspective of a teacher, and it introduced me to the concept of inquiry-based learning. The experience opened my eyes to the respectable profession of teaching and the challenges therein.

Throughout my fellowship year, I served as a science advisor in a middle school classroom, where I aided in teaching lessons, provided additional resources for teachers, designed and taught lessons, participated in school events and parent-teacher conferences, and attended national and state teaching conventions. While in the classroom, I observed students generally respond to lecture instruction with difficulty. Students are bored, and have difficulty formulating concepts mentally. Through a hands-on inquiry approach to math and science, students became more interested in concepts, and enjoyed learning. Inquiry lessons targeted individuals who needed to see or touch the concept being taught and allowed teacher freedom from explanation.

Through experiencing the inquiry-based concept and guided inquiry approaches to teaching, I discovered this is a milestone in education. Through inquiry, students became interested learning and remembered concepts more readily. As a result of this inquiry-based inspiration I decided to write an integrated pest management curriculum with an inquiry approach. Integrated pest management is a concept for people interested in learning and interested in solving problems. It in itself is inquiry. When faced with a pest problem one must discover, through a process, the solution to the problem. When students are faced with a new concept or question, they must engage themselves in a process of questions to find out more about the concept or to answer the question. Simply lecturing students on what IPM is, and why it is important to learn and use it, defeats the essence of the concept of IPM. It is important to discover what IPM is, why it is important, how to use it, and how to use it properly. This can be done through inquiry.