Title: CSI Orlando: A-Who-Done-It Mystery Told by Insect Larvae

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Entomological Concept:

Forensic entomologists regularly aid criminal investigations by examining dead bodies. By knowing the species identity of the insect larvae present and developmental stage, it is possible to give a reliable estimate of the time of death for the individual. This is regularly used as evidence in court for including someone as a suspect or excluding others who could not have possibly been present when a crime was committed, and has important real-world implications.

Youth Activity:

The kids are briefed on the history of the "case" by the "criminal investigators" (entomology leaders) and given charge of a "crime scene." The latter is composed of chalked outlines of bodies on pavement, cement, or poster paper, each with its own unique fauna of "larvae" and surrounded by caution tape attached to traffic cones around the body outlines. The larvae are cut-up pipe cleaners of different colors (for different species) and of different developmental stages (e.g. sizes). The youth are equipped with a pair of gloves and forceps (it's important to be "sanitary"), as well as a ruler for measuring larvae. Youth will be split up into pairs, and each pair will be given a conversion table that translates the differently sized larvae into instars, and the different colors into species. The pairs will have to mark which species and stages are present and consult their chart to figure out the time of death for the individual. At the end of the activity when all the pairs have finished, they must report back to the criminal investigators for a debriefing and report their findings.

Supplies Needed (assuming a group of 20 kids at a time):

10 lightweight forceps
10 small flexible rulers in metric
10 clipboards for the table/conversion chart
10 pens or pencils
1 bag of pipe cleaners
1 box of size small nitrile gloves (kids seem to enjoy purple the most)
1 package of multicolored chalk
1 roll of caution tape
5 small traffic cones

Instructions for forensic entomology activity:

Rob Morrison and Alex Bryant

Preparation

1) Plan to chalk out an appropriate number of bodies so that students can be in groups of 2-3 per body. This number should be based on the expected number of students coming through in a given round of the activity.
2) Assign the bodies to one of 3 times of death (there may be more than one body assigned with the same time of death depending on the number of bodies needed). Having this number makes it easier to track the proper responses. Assign each body a unique body number of keep track of the appropriate time of death for that particular body. Generally, it's good to pick times of death that have unique "insect communities." In the past, I've picked 1 d, 6 d, 10 d, or 13 d after death, as there is less of a chance that children will confuse the answer with another answer.
3) For whatever "insect community" (e.g. pipe cleaners) is needed for each body, cut out 5-6 of each pipe cleaner color required. However, decide ahead of time where each crime took place (consulting the geographic guide on the worksheet), and whatever species (color) is most common in that county, make twice as many of that pipe cleaner for a body as all the others present. For example, if you have a body that died 6 d ago, you would need to cut out 5-6 purple, green, and yellow pipe cleaners of sizes indicated in the forensic entomology worksheet table, and if you wanted the students to think it is from Webster County (for example), you would have twice as many green pipe cleaners as the other colors. The reason that 5-6 are needed becomes clear below, but mostly revolves around each pair/group needing to take 3 "maggots" (pipe cleaners) of each "species" (color) to measure (need to be able to create an average! science needs replication).
4) The "insect community" for a given body can be put into the same plastic bag and assigned a body number corresponding to the ones created above.
5) On the day of the event, once the bodies are chalked out, a body number should be assigned to each (and denoted with a folded over piece of paper with the number on it). Again, each body number should have an associated "answer" (time of death) and "insect community" (plastic bag with pipe cleaners). Pour the appropriate bag of pipe cleaners into the appropriate body number and spread out the "maggots" to make it look more natural.

Guiding the Activity

1) The premise that you tell the students is that they've been deputized to be crime scene investigators. There has been a rash of murders lately, and their goal is to find out when and where the crimes happened using insects as indicators. Ask them if they accept the challenge.
2) Split people up into pairs/groups (you can number off for this).
3) Pass out the equipment, and emphasize as you are passing out gloves that it is important to be "sanitary" and to "not contaminate the evidence", so be sure to keep the gloves on and to use

the forceps to get the maggots. In addition, tell the students that they should NOT step into the body, as this would also affect the evidence (reemphasize this when the kids are out with the bodies).

4) In each pair, have the students decide who will be the "recorder" to take down all the information (it's good to make sure this is specifically assigned, or nothing gets recorded).
5) Tell the groups that each group needs to collect three maggots (pipe cleaners) of each species (color) that is present in the body, whatever those species happen to be. Not all species will be in all the bodies.
6) (It's good to have a helper with this activity for passing things out, and making sure everyone is doing what they are supposed to).
7) Assign each group a body number (make sure the students write this down on their recording sheet), and once everyone has all their equipment, a body number, gloves on, etc. then take them to the bodies and let them "dig in".
8) The bodies are typically roped off with caution tape to add to the "crime scene" vibe. They are allowed to go over the caution tape, but remind them not to step in the bodies.
9) The students need to complete two tasks at the bodies: 1) count the total numbers of each "species" of "maggot" in the body and record that on their worksheet (this will later give information about where the body came from), and 2) give students sufficient time to get three pipe cleaners of each species (this will tell students when the crime took place). When students are finished, tell them to line up to the side of the crime scene. Once everyone is done, you can "head back to the lab" to "crack these cases".
10) When you get back to the lab and have everyone seated by their partner, before they open their bags, it's good to communicate the main scientific points. There are two main points 1) the bigger the insect, the more time has passed because the development of insects depends on the temperature around them. Bigger insects = older body. 2) the insect community that colonizes a body will depend on where the body is located, because each area has a unique insect community. If we know what the insect community is like in specific areas, then we can trace where a body came from. By the end of the activity, the students should be able to identify when the crime happened, and where the crime happened (using the geographic guide in the worksheet).
11) Now, have students take out there maggots one at a time and measure them with the provided ruler in the correct units (this was rather hard in the past, and some times, depending on the age group, you would have to demonstrate how to use a ruler). Tell them to keep the maggots they've already measured in a separate pile from the ones they still need to measure, and as they measure each, record the measurement in the appropriate area of the worksheet.
12) Once they are done measuring all the maggots, demonstrate how to use the table, and tell them based on the sizes of their maggots and the colors presents, when they think their person died. This may require going around to different groups and helping them with this process (a helper is also good for this part of the activity).
13) After each group has found the time of death individually, have them try to figure out which county the crime was committed in. This will be based on which color is the most common that they counted when they were with the bodies originally (recorded on the right bottom of the

front page of the worksheet). Tell them to flip the worksheet over and give them information about which color is the most abundant in which county. Then, based on which color (species) was most common for their body, what county did they think their body was found in?

14) After everyone has these two bits of information, have each group go around and say which body number they had, when they thought their body died, and where they thought the crime happened. Congratulate them on solving the case!


INCHES
1
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5
6
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MATERIALS
METRIC 1
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CSI Orlando -- Forensic Entomologist Worksheet

Instructions: use ruler to measure the maggots found on the body, then look at the chart to match the time of death. All measurements are in millimeters.

Days After Death	Purple: *Musca Domestica*	Green: *Calliphora vomitoria*	Yellow: *Sarcophaga carnaria*	Blue: *Piophila nigriceps*
1			9-11mm	
2		9-11mm	12-16mm	
3		9-11mm	17-20mm	
4	6mm	12-16mm	21-25mm	
5	6mm	12-16mm	26-30mm	
6	7-11mm	17-20mm	31-35mm	
7	12-16mm	17-20mm	36-40mm	3mm
8	17-20mm	21-25mm	41-44mm	3mm
9	21-25mm	21-25mm	44-46mm	4-6mm
10	26-30mm	26-30mm	44-46mm	7-9mm
11	31-35mm	26-30mm		10-13mm
12		31-35mm		14-16mm
13		31-35mm		
14				
15				
16				
17				
18				

Your measurements for each pipe cleaner (3 of each):

	1	2	3
Purple:			
Green:			
Yellow:			
Blue:			

Total number of each pipe cleaner:

Purple:

Green:

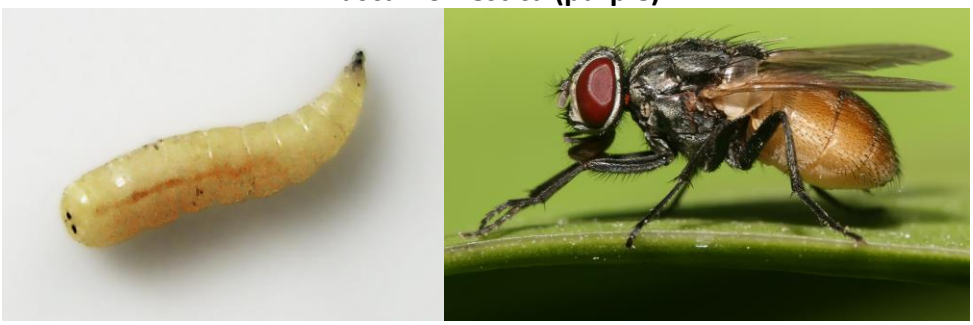
Yellow:

Blue:

Number of days since death:

County location of death:

Musca Domestica (purple)



Calliphora vomitoria (green)

Sarcophaga carnaria (yellow)

Piophila nigriceps (blue)

North Carolina Museum of Natural Sciences

June 25, 2005 to September 18, 2005

Teacher's Guide – Classroom Activities

Insects and Arthropods

Overview

The CSI Classroom Activities link the major scientific concepts of *CSI: Crime Scene Insects* to inquiry-based exercises for students. The unit begins with an introductory exercise to pique students' interest in the topic and leads to hands-on activities to explore the principles of insect biology and forensic science.

Features of ***CSI Classroom Activities***:

1. Adaptable to a broad range of grade levels **(Grades 3-8)**
2. Suitable before or after students visit *CSI: Crime Scene Insects*
3. Modular design so teachers can select those that best match students' interest and needs
4. Meet National Science Education Standards
5. Incorporate multidisciplinary approaches to learning including art, writing and math.
6. Offer suggestions for enrichment activities to permit advanced or individualized learning

CSI: Crime Scene Insects Classroom Activities

	Topic/Theme	CSI Activity	Description
Unit One	Insects & Arthropods	1.1 What's Your Insect IQ?	Pretest; teaser for Unit One
		1.2 Bugged by Bugs? Animal Symbols	Intro Activity on associations/reactions to bugs and how animals can become symbolic in cultures
		1.3 Build a Bug	Intro Art Activity; Insect Anatomy/Classification
		1.4 Surprise, This Dirt's Alive!	Insect Collection (soil samples) Berlese Funnel Lab with Observations

CSI Classroom Activity 1.1

Part 1. What's your "Insect IQ?"
Part 2. Check Out These Insect Facts!

Overview

Launch your students into the Crime Scene Insects Activity Series by asking them to take this quick and fun self-quiz. The survey "What's your Insect IQ?" in Part 1 tests their basic knowledge of **entomology**, the study of insects, and lets students rate themselves on their level of "expertise." Not to worry though, this is a quiz where the points don't count; it's only to stimulate interest in studying insects.

In Part 2 "Check out These Insect Facts", students consider some of the more amazing skills and structures of six-legged critters and other **arthropods**. It's an introduction to the **specialized adaptations** and record-breaking feats that are only possible in the insect world.

Both lessons serve as excellent pre-visit activities for the *CSI: Crime Scene Insects* exhibit where students see how insect anatomy and life cycle provide surprisingly vital clues in various types of crime scene investigations.

Estimated Time: 30-45 minutes depending on the level of discussion

Grade Level: **Grades 3-8**. Delete or modify questions and facts according to grade level

Materials

1. "What's Your Insect IQ?" Test
2. Insect Fact Sheet

Procedure

1. Review the Insect IQ test questions; select ten you think are appropriate for your class.
2. Have students take the Insect IQ test and check their own answers. Use the test to start a discussion about insects and how much students may or may not already know.
   HINT: Students might also take a "pretest", discuss, and then do a "post-test" before determining their ranking.
3. Have students read and comment on the Insect Facts to promote additional interest, discussion and positive attitudes about insects.
4. Announce that they are soon to become amateur "CSIs," that is, Crime Scene INSECT Investigators! Their "training" will include a visit to the *CSI: Crime Scene Insects* exhibit along with the unique experiments from the CSI Activities Series.

Part 1. What's Your Insect IQ?

Do you think you know insects? Well, take this quick quiz and see how you rate in your knowledge of these fascinating creatures.

1. Insects were on the Earth long before the time of
   a. dinosaurs b. VW Beetles c. birds d. all of these

2. An insect's body has how many sections (segments)?
   a. two b. three c. four d. six

3. All insects have how many total legs?
   a. two b. four c. six d. eight

4. Which of the following is NOT an insect?
   a. fly b. beetle c. dragonfly d. spider

5. "Insect" is Latin for
   a. bug b. small c. segmented d. crawls

6. Insects are a class of Arthropods, a word that means
   a. rigid toes b. stiff wing c. jointed feet d. athlete's feet

7. Many insects lay eggs that hatch into
   a. larva b. pupa c. maggots d. cocoons

8. Insects have special mouth parts that allow them to
   a. chew plants b. pierce skin c. eat other insects d. all of these

9. Insects do NOT have
   a. bones b. an exoskeleton c. jointed legs d. antennae

10. Insects have a hard outside layer (exoskeleton) made up of
    a. super glue b. bone c. cartilage d. chitin

11. The study of insects is called
    a. zoology b. insectology c. entomology d. astrology

12. Today, insects are being used to
    a. solve crimes b. clean wounds c. control crop pests d. all of these

13. The adult house fly lives about
    a. 17 minutes b. 17 hours c. 17 days d. 17 weeks

14. Insects breathe through special holes called
    a. lungettes b. eyelettes c. spiracles d. oxygen pores

15. Most insect species are in which group (order)?
    a. flies (Diptera) b. beetles (Coleoptera) c. ants/bees (Hymenoptera)
    d. butterflies/moths (Lepidoptera).

HOW DO YOU RATE? Add up your points out of 10 questions and find out your current level of insect expertise! For answers see next page.

TOTAL POINTS	EXPERT LEVEL	
Less than four	Neophyte	Not to worry, you are in for some great lessons on Insects.
Five to six	Larva	Not bad…clearly in a growth stage
Seven to eight	Pupa	Impressive…but don't think you can rest just yet
Nine to ten	Bug Brainiac	Highest level…congratulations, you're off to a great Start.

Discussion Questions

1. How do you rank as an "insect expert"?

2. Which answers were easiest? The hardest? The most surprising for you? Why?

ANSWERS to "What's Your Insect IQ"?

1. **d.** All of these. Insects evolved during the Silurian Period 438-408 million years ago, almost 200 million years before any dinosaurs roamed the Earth!

2. **b.** Insects have three major body parts or segments: head, thorax and abdomen. The variation within the class Insecta is enormous, however, with wings, antennae, mouthparts and legs being specially adapted to each insect's particular environment.

3. **c.** All insects have six legs, although each insect will have legs that are specialized for their environment (i.e. forelegs of a praying mantis are adapted to grab prey; hind legs of a grasshopper and flea are adapted for jumping; the legs of honeybees contain structures that collect and store pollen).

4. **d.** Spiders belong to the same phylum Arthropoda, but they are in the class Arachnida-- not the class Insecta. Arachnids have 1-2 body segments and eight legs; they include spiders, ticks, mites and scorpions. Besides Insecta and Arachnida, the other Arthropod classes include Crustacea (shrimp, crabs, lobsters, copepods), Diplopoda (millipedes) and Chilopoda (centipedes).

5. **c.** segmented.

6. **c.** jointed feet referring to the multiple joints found in each leg

7. **a.** The life cycle of most insects includes egg, larva (i.e. maggots/caterpillar), pupa (i.e. cocoon) and adult.

8. **d.** Depending on the insect species, the mouth parts will vary. There are different types of mouth parts that allow sucking, piercing, stinging, sponging, or chewing.

9. **a.** Classic features of insects, as well as other arthropods, include a rigid exoskeleton and jointed appendages. Various types of antennae are also present in all arthropods except the arachnids.

10. **d.** Chitin is the hard material that makes up the exoskeleton.

11. **c.** Entomology (*entoma*, G. "notched animals/insect"; logy, "the study of").

12. **d.** Despite the general association of insects with crop damage and the spread of diseases, insects have also played several beneficial roles for humans. Ladybugs are often used as natural predators of aphids to control their spread. Also in forensic entomology, police now use the age of fly larvae (maggots) or the presence of other insects to provide an estimate on the time of death at a crime scene. In the 1800s, certain types of maggots were used to clean open wounds since these fly larvae feed on only decaying tissues and leave the healthy areas alone.

13. **c.** The average housefly lives about 17 days. The process of development from egg, maggot, and pupae to adult takes about 24-25 days.

14. **c.** Spiracles are the openings in the abdomen that allow gases to enter and leave an insect's internal respiratory system.

15. **b.** Beetle species in the Insect order Coleoptera outnumber all the orders of insects.

Part 2. Check out These Insect Facts!

INSECT WORLD RECORDS

1. It is estimated that the total insects on Earth outweigh humans by a factor of 12, and that there are 300 million insects for each person alive!
2. Nearly a million different insect species have been described, more than the number of ALL other animal species put together!
3. The biggest insect that ever lived: an ancient dragonfly Meganeura, a predatory insect with a wing span of two feet. Try to swat that one!
4. Today's insects range in size from tiny beetles of 0.1 mm (.04 inches) long to tropical moths that have a wingspan of nearly 30 cm (8 inches).
5. Some flesh-eating flies can smell the scent of a rotting corpse up to 1.6 km (one mile) away.
6. Fleas can wait up to one year between meals. (When they bite humans, we don't feel the bite; instead, an itch is caused by the flea's saliva that sets off an allergic response at the skin site).

AMAZING FEATS BY SIX-LEGGED CREATURES

1. Insects, along with birds and bats, are the only living animals that fly (a few other animals can glide).
2. One locust swarm in Africa can measure 30 meters deep with a front 1500 meters long, and will consume every fragment of plant material in its path.
3. A housefly beats it wings more than 330 times per sec; a bee buzzes along at 200 beats per second. Most butterflies are more relaxed fliers, with wings that move less than 5 times per second.
4. During the mating season, male house flies can race around in short bursts that reach up to 145 km ph (90 mph)!
5. Human eyes have one light-gathering lens in the center of each eye. Dragonflies have almost 30,000 lenses per eye, helping them to detect the slightest movements around them.
6. Insects that feed on fresh blood smell the carbon dioxide that their prey breathes out. This helps them to track down their victims.
7. Houseflies cannot fly upside down, but they land easily on a ceiling by flying below it, raising their two front legs and grabbing hard, then swinging forward their four back legs in order to stick solidly upside down on the ceiling.

WHO WOULD HAVE THOUGHT?

1. Up to 80% of an insect’s brain is used to understand what its eyes see and what its antennae sense.
2. Most insects use their antennae to smell and detect scents, although some use antennae to taste.
3. Flies taste food with special hairs on their feet.
4. Crickets don't have ears; instead they “hear” through large swellings on their front legs.

5. A ladybug is no lady! One ladybug can eat up to about 50 aphids a day or about 5, 000 in a lifetime. If there is not enough food, ladybugs turn cannibal and start to eat their young. Oh, and there are both female AND male "lady" bugs.
6. Ladybugs use their bright color to deter birds from eating them but also send out smelly chemicals from their knee joints to further protect themselves.

Primary Source for the Interesting Insect Facts

1001 Facts About Insects, Lawrence Mound and Steve Brooks, DK Publishing, 2003.

Discussion Questions

1. What do you think was the most amazing, most funny, or most strange fact about insects?

2. Ask students if they ever heard of insects being used to help crime scene investigators? (If yes, have them describe what they know). Remind them that the *CSI: Crime Scene Insects* exhibit introduces the fascinating world of forensic entomology and shows how flies and beetles can become living evidence in solving various crimes.

CSI Activity 1.2

Part 1. Bugged by Bugs?
Part 2. So Why the Fly in the Portrait?

Overview

"Yuck! Bugs." If that's your students' reactions when introduced to a unit on insects, this activity is for them. **Part 1, "Bugged by Bugs?"** addresses the negative feelings and fear sometimes associated with insects. A guided classroom discussion promotes the idea that becoming more familiar with the small, six-legged creatures may counter misconceptions and even lead to a fascination with insects. The lesson prepares students for the upcoming classroom experiments where live insects are collected, raised and studied. It is also an excellent pre-visit activity for the *CSI: Crime Scene Insect Exhibit* since live beetles, flies and their larva are an important part of the displays.

Part 2 "So Why the Fly in the Portrait?" further explores the types of associations we make with insects and other animals. It begins with examining reasons for the curious insertion of a fly in a Renaissance painting showcased in *CSI Crime Scene Insects*. It ends with students considering other animal symbols or trademarks and how associations with the same animal can vary dramatically depending on one's cultural perspective.

Estimated time: One class period

Grade Level: **Grades 3-8**. Select or modify questions according to grade level.

Background and resources

For images of insects, use a large picture book or print images from web sites
HINT: search Google first selecting "images" and then searching by insect common names.

Materials

Compile 6-10 large photos or overheads of insect close-ups: include "good bugs" (ladybugs, butterflies), "bad bugs" (flies, grasshoppers, mosquitoes, beetles, bees), and "ugly bugs" (larvae such as caterpillars and maggots).

Print Renaissance portrait of "Madonna and Child" found at
http://www.getty.edu/art/collections/objects/oz619.html

Procedure

Part 1. "Bugged by Bugs?"

1. Start the discussion by showing the photos of insects that are usually associated with positive feelings (butterflies, ladybugs). Then show grasshoppers, beetles and flies to begin to bring up possible negative thoughts about insects (crop damage, disease). The last groups of photos should include some even less popular insects (mosquitoes, bees) larvae (caterpillars and maggots). Be sure flies, beetles and maggots are included in this exercise since they will be important in subsequent activities.

2. With each photo, solicit the students' immediate associations. Help them explore why they make their particular associations and why such small animals can invoke such strongly positive or negative feelings. Evaluate why some students may have completely opposite reactions.
3. Suggest that as we learn more about insects, perhaps our biases and negative impressions may be replaced, or at least tempered, by curiosity and an appreciation for the remarkable adaptations (and even beauty!) that insects demonstrate. Have any students who especially like insects share their reasons and experiences with insects.
4. Introduce the *CSI: Crime Scene Insect* Unit, and describe some of the upcoming activities including a visit to the *CSI: Crime Scene Insects* exhibit!

Extension Activities

1. "Can You Say Coleoptera?" Along with each photo, display the insect common name, genus, species, order, class and phylum to briefly introduce insect terminology and classifications. Ask students to try to pronounce some of the more interesting names and discuss their meaning (see **Glossary**).

2. "Phobia Focus". Have the students research the medical words for "fear of insects", "fear of spiders" and other animal phobias. They might also find out how common these conditions are and how they can be treated.

Part 2: So Why the Fly in the Portrait?

1. Show a reprint of the painting "Madonna and Child" as displayed in the exhibit. See material section.

2. Ask students to look at the painting and come up with an appropriate title.

3. Do they see anything interesting or surprising?

4. Challenge the students to find the fly in the portrait. (Look at the infant's right leg).

5. Ask the students to explore reasons why the painter would include something as unlikely as a fly in this portrait.

6. Why only a single fly and why only on the infant?

7. What associations do they make with flies?

8. Introduce the idea of flies being associated with decaying food or dead animals. Explain that during the Renaissance period, a fly painted on an individual's hand, leg or body indicated death for that person. A fly was often added to a painting after the subject had died or was used as a harbinger of death.

9. Ask students why people looking at the painting in the 1400s probably didn't have to have this symbolism explained to them, but today it isn't immediately obvious what the presence of a fly would indicate.

   HINT: With little refrigeration or preservation of meat (or corpses) at that time, people were very familiar with the sight of flies hovering around the carcass or body after death. Adult flies lay eggs on the decomposing tissue and the larvae that hatch from the fly eggs develop and feed off the decaying tissue. Fly larvae are also known as maggots.

Discussion Questions

1. List and discuss other animals have are used as symbols or are associated with human traits (lions/courage; owl/wisdom; fox/sly). Class groups can compete to see how many each group can come up with in a given time.
2. How many sports teams can students list that are named after animals? What attributes do these animals portray for the team? If you had to name a team after an insect, which one would you choose and why?
3. What trademarks have been linked to animals? How about animals associated with brand names or logos? (cars/Mustang, US Post Office/eagle, Disneyland/Mickey Mouse)

Extension Activities

1. "Advanced Research-1." Research the associations other cultures had with flies or other insects. For example, compare the significance that flies had in ancient cultures (i.e.

Babylonians, Phoenicians, Egyptians), mythology (Greek/Roman/Native American) or literature (*Lord of the Flies*). Explain how different cultures could have different/similar beliefs about the same insect.

2. "Advanced Research-2." Research your official state/county animal. Find out or suggest a reason for its selection to represent your area. When was it selected? Were there alternatives considered? Is there an official insect for your state? For your school? If not, which insect would you choose for your state and school and why?

3. "Insect Ads." Review common phrase that describe attributes of animals. (i.e. "as slow as a turtle," "as strong as an ox," "as happy as a clam"). Challenge students to come up with a slogan that would go along with a fly, a beetle or a maggot. Have them create a mini "billboard" using their phrase as an "advertisement" for this animal. Students can include their own drawings or use images cut out from magazines and newspapers in their ads.

CSI Activity 1.3

Build a Bug

Part 1. Build Your Insect
Part 2. Research Your Insect
Part 3. Resources: Insect Images on the Web

Overview

This lesson uses an art project to introduce insect anatomy and classification. In Part 1, students observe a series of enlarged photos (or mounted specimens, if available) of various common insects to examine and record details of insects' basic body segments, eyes, appendages, wings and sensory structures. Students use their recorded observations to create a 3-D model of an insect of choice.

In Part 2, students research their "chosen insect" to discover and report on additional details about its habitat, life cycle and environmental impact. A comparison of all the constructed insect models, along with the insect reports, allows the students to develop a classification scheme to describe the major groups of insects and other members of the arthropod phylum.

Estimated time: Minimum of 2-4 class periods. The time will vary depending on the expected detail of the insect models, completeness of the reports and whether the students work individually or in small groups.

Grade level: **Grades 3-8**, depending on the complexity of the insect models and reports. Discussion questions and optional extension activities can be deleted or modified as needed.

Materials

1. Large, close-up color photos of 10-12 adult insects.

   Be sure to obtain representatives from the major insect orders. Try to get multiple views of each insect, if possible, in order to show the details of the head, wings, legs and abdomen. You might include a spider which is an arthropod but not an insect, just to stimulate a bit of controversy. For Web resources see Part3. Resources: Insect Images on the Web.

   Option: have the students or each group select an insect and locate appropriate photos and information doing a Web search.)

2. Classification Key for Classes of Arthropods
3. Major Orders of Insects
4. Balloons of various sizes and shapes (round, elongated)
5. Paper strips in various colors
6. White glue for dipping the paper strips in order to adhere to balloons
7. Wax paper
8. Cookie sheets (or counter space for drying the models)

9. For legs: pipe cleaners, coat hangers, wire
10. For wings: sections of panty hose or cellophane stretched over wire shapes
11. For eyes: wads of paper
12. Paints and paint brushes
13. Colored markers
14. Glitter, sequins, buttons
15. String or nylon thread to hang each insect model

Procedure

This activity can be done by individual students or in small groups.

Part 1. Building your insect

1. Obtain and look carefully at large, close-up photos of various insects. Select an insect that appeals to you--one that you would like to build a model of and research more details about.
2. Record as many observations as you can about your insect while looking at the photos. Make notes about all parts of the body including the major sections (segments), legs, wings, antennae, eyes and any other notable features. Describe each part or structure carefully including shape, color, relative size, texture etc.
3. Using the materials supplied in class, or other materials that you have decided to bring from home, build a three-dimensional model of your insect. The basic body can be constructed by covering balloons with paper dipped in glue. A few layers of paper should be good enough. You might use balloons of different sizes to represent the different segments of your insect.
4. Decide if you need additional features of your insect that need to be constructed with the glued-paper and apply those if necessary.
5. Place each covered balloon on a cookie sheet lined with wax paper to dry. After it is dry, pop the balloon inside using a small needle or pin.
6. After the paper dries, glue the segments together.
7. Construct and attach wings, legs, and antennae to the appropriate segments of your insect.
8. Decide if your insect will look authentic, or if it will be more of a “fanciful” representation of the insect.
9. Paint, color and decorate your insect according to your decision. The only requirement is that the anatomy of the insect be correct. The colors are up to you.
10. When the insect is completed and dry, attach a thread or string to it so that it can be displayed in class.
11. Construct and attach a label card identifying your insect and its creators (you!) You should use common and scientific names for your insect, and if you like, you can give it your own personal “pet” name as well.

Part 2. Researching your insect.

1. Obtain as much information about how your insect lives, survives and behaves using web searches, the library, and books from home.

2. Put together a written report describing your insect. Include: common name(s), classification (kingdom, phylum, class, order, genus and species), habitat and life cycle. Also see if you can find out how it uses its specialized sensory organs to see, taste, hear and touch. Determine what types of food it eats and what predators eat your insect. Describe any unusual activities, abilities or specialized structures of your insect.
3. After you complete the report, "introduce" your insect to the class and present your findings.

Discussion

1. Looking at all the models of insects built in class, describe the basic features of an insect's anatomy. (What segments/parts do they all have in common? What variations do you see between the insect models?)

2. Organize some classification scheme that would include and group every insect represented in the class collection of insect models.

   HINT: Before showing the students a scientific classification chart, encourage them to come up with their own groupings based on whatever criteria they think makes sense. These can be nonscientific and even funny criteria but should be based on some observations.

3. Examine the classification charts for Arthropods and Insects. Look up the meaning of the scientific names, and list a few examples of each class and order. State briefly how the other arthropods are different from insects.

4. Explain why all insects are not technically true "bugs" and why spiders are not really insects.

5. Why do scientists bother to classify organisms? Why do they use scientific genus and species names instead of common names?

Extension Activities

1. A real insect's "skin" is not made of paper and glue. Find out what the exoskeleton of insects is composed of. Since the exoskeleton can't stretch, describe what happens to the exoskeleton as insects grow.
2. Determine the actual length/size of the insect you researched (in cm). Measure the size of your model and calculate how much larger your insect model is compared to the real animal. Attach a sticker to your insect indicating the magnification size of your model relative to the real insect.
3. Why can't a live insect ever be the size of your model? Research this.
   HINT: exoskeleton would weigh it down; too much heat build up from increased volume; too much weight for its legs/wings; circulatory system couldn't support its nutritional needs; where would it possibly get enough food to survive?

Source: "Build a Bug" was adapted from activities described in *The Everything Kids' Big Book* by Kathi Wagner, Adams Media Corporation, 2003.

CSI Activity 1.3

Part 3. Resources Insect Images on the Web

General Resources

http://www.rlephoto.com/
Photographer Randy Emmitt's site has excellent shots with multiple views of North Carolina insects.

http://www.hiltonpond.org/ThisWeekIndex2004.html
Hilton Pond is a great source of information and photographs on Piedmont natural history including insects.

http://animaldiversity.ummz.umich.edu/site/index.html
Animal Diversity Web site at the University of Michigan has many images.

Other Insect close-ups

http://www.wildlife.state.nh.us/Kids/Wildtimes_issues/Wildtimes_issue9.pdf
http://www.carolinabutterflysociety.org/nottke/index.htm
http://www.1000plus.com/Hbirds/
http://www.insects.org/entophiles/

Resources by Group

Beetle

- **Eastern Eyed Click Beetle**

http://www.rlephoto.com/beetles01/Alanus_oculatus/0590_alanus_oculatus_ws.htm
http://www.hiltonpond.org/ThisWeek010515.html
http://animaldiversity.ummz.umich.edu/site/resources/Grzimek_insects/Coleoptera/Alaus_oculatus.jpg/view.html

- **Tiger Beetle**

http://www.rlephoto.com/beetles01/Cicindela_sexguttata/index.htm

- **Carrion Beetle**

http://animaldiversity.ummz.umich.edu/site/resources/Grzimek_insects/Coleoptera/Nicrophorus_americanus.jpg/view.html

Bug (True)

- **Wheel Bug**

http://www.rlephoto.com/bugs/bug_wheel/index.htm
http://www.hiltonpond.org/ThisWeek030901.html

Butterfly

- **Appalachian Swallowtail**

http://www.rlephoto.com/butterflies/swallowtail_A_tiger/index.htm

Butterfly cont.

- Gulf Fritillary

http://www.rlephoto.com/butterflies/fritillary_gulf/index.htm

- Monarch

http://www.rlephoto.com/butterflies/monarch/index.htm

Damselfly

- Seepage Dancer

http://www.rlephoto.com/odes/damsels/dancer_seepage/index.htm

- Ebony Jewelwing

http://www.rlephoto.com/odes/damsels/jewelwing_ebony/index.htm

Dragonfly

- Halloween Pennant:

http://www.rlephoto.com/odes/pennant_hal/index.htm

- Eastern Pondhawk:

http://www.rlephoto.com/odes/pondhawk_e/index.htm

Grasshopper

http://www.fotosearch.com/ITS140/itf040014/
http://www.fotosearch.com/ITS140/itf040026/
http://pdphoto.org/PictureDetail.php?mat=pdef&pg=5711

Praying Mantis

- Chinese Mantid

http://www.rlephoto.com/bugs/mantis_praying/index.htm
http://www.1000plus.com/Hbirds/010922%20DSBG%20Praying%20Mantis%20.JPG
http://www.fotosearch.com/ITS140/itf040039/
http://animaldiversity.ummz.umich.edu/site/resources/Grzimek_insects/Mantodea/Tenodera_aridifolia_sinensi.jpg/view.html

CSI Activity 1.4
Surprise, This Dirt's Alive!

Objective

Here's an easy laboratory exercise that lets students discover the amazing diversity of insects and other arthropods living in seemingly lifeless soil. It involves setting up a simple **Berlese funnel** to remove, collect and preserve the small soil organisms taken from various sites around the school yard. These organisms then become specimens that students observe, compare and classify to better understand Arthropods and insects.

When students visit the *CSI: Crime Scene Insect* exhibit they will see a similar type of apparatus displayed as part of a crime scene investigator's experimental tools. In fact, **forensic entomologists** depend upon the same technique described here to collect their own critical insect evidence from soils at a crime scene!

Estimated time: (3-4 class periods)

Day 1	Collect soil samples and set up funnel(s)
Day 1-3	Organisms appear in the bottom collecting jar
Day 2-4	Insect observations and identification

Grade level: **Grades 3-8**. Discussion questions can be deleted or modified accordingly.

Materials for funnel

1. Plastic funnel with at least a 15-20 cm (6-8 inch) diameter. Purchase from auto supply or hardware stores.
2. Galvanized screen--coarse mesh, 3-6 mm inch (1/8 to 1/4)
3. Tin snips to cut the screen
4. Cheesecloth (approximately 18-24 inches square)
5. Clear, wide-mouth jar to hold the funnel; funnel should not touch the bottom of the jar
6. Small vial, larger than the mouth of the funnel to collect the insects as they leave the soil
7. Lamp with a 40-watt bulb

Option: Purchase a premade Berlese funnel from Carolina supply (# 65-4148) or smaller re-useable units from BioQuip Products (#2845). See resource list for contact information.

Additional materials

1. Rulers
2. Spoons or trowels to collect soil
3. Plastic bags
4. Newspaper
5. Marking pen

6. Rubbing alcohol (70%)
7. Glycerin
8. Hand lens (10X) or dissection microscope
9. Insect Orders Chart (see reference section of *1001 Facts about Insects*; L. Mound & S. Brooks, DK Publishers; or a similar entomology text for insect classification groups)
10. Web Resource on Insect Orders:

http://www.backyardnature.net/insects.htm
http://www.amnh.org/learn/biodiversity_counts/ident_help/Text_Keys/text_keys_index.htm

Procedure

Adapted from "Collecting Microarthropods" by Steve Binkley; Carolina Biological Life Science Activity. See http://www.carolina.com/life_science/microarthropods.asp)

1. To make each Berlese funnel, cut the 3-6 mm mesh screen into a round disc that will fit snugly about 2/3 the way down into the throat of the funnel.

   HINT: If there is a small screen already inside the funnel, remove it since the mesh is generally too fine for this experiment.

2. Set the funnel, with the screen disc in place, into a wide-mouth jar. Be sure there are a few inches of space between the end of the funnel and the bottom of jar. Alternatively, you can support the funnel with a ring stand.

3. Line the mouth of the funnel with a single layer of cheesecloth and press it down so that it lies on top of the screen. The cheesecloth should be large enough to also drape over the funnel's top rim.

4. Collect soil samples from designated areas. Depending on the size of your funnel, a soil sample that is approximately 15 cm (5.9 inches) square by 4 cm (1.6 inches) deep is a good starting point. If the class is doing this in groups, have each group take samples from different spots.

   HINT: Moist soils around bushes or trees should yield more live organisms than dry sandy soils. Areas with rotting leaves or logs are other potentially rich sites.

5. Place the collected soil in the plastic bag. Label it with date, student(s) name and a description of the collection site including whether it was in shade, partial/direct sun, was moist/dry and its color/texture.

6. If the sample is damp, let it dry on newspaper in a shoe box at room temperature for 24-48 hours before placing it into the Berlese funnel. Be sure to check for any animals that might be crawling around or away from the soil in the meantime.

7. Place the soil sample into the funnel on top of the cheesecloth and screen. It is not necessary to remove any leaves or small twigs (there may be specimens on them).

8. Pour 70% alcohol into the small vial, and place it under the funnel's stem.

   HINT: You can add a few drops of glycerin per 100 ml of alcohol to keep it from evaporating if the experiment runs over the weekend.
9. Turn on the lamp. Place it about 5 -7.5 cm (2-3 inches) above the soil sample.

10. Make daily observations and records of the adult and immature specimens that appear in the alcohol.

    HINT: The animals could start to appear within a couple of hours, even minutes.

Observations

During the 2-3 days of collection time, have the students complete an expanded chart formatted like the one below. For help in identifying their organisms, see the Insect Orders Chart and Web resources above.

SOIL ANIMAL OBSERVATION AND CLASSIFICATION CHART

Sketch of Organism Length (mm)	No. found	Body Segments (No,)	Pairs of Legs (No.)	Pairs of Legs per Segment	Pairs of Wings (No.)	Common Name	Arthropod Class (and Order)
1							
2							
3							
4							

NOTE: The types of insects and arthropods will vary somewhat depending on the habitat. Arthropods in the class Insecta that frequently appear include ants (Hymenoptera) pill bugs (Isoptera), beetles (Coleoptera), cockroaches (Blattodea), earwigs (Dermaptera), springtails (Collembola), and various immature insects that are frequently difficult to identify. Earthworms and non-insect arthropods like mites (Arachnida), spiders (Arachnida) centipedes (Chilopoda) and millipeds (Diplopoda) may also be present.

Discussion Questions

1. What were the most common and least common specimens in your soil sample? How do your findings compare with those of other groups?
2. What might be some of the factors that influenced the types and numbers of insects/arthropods that were found in the different soil samples? (moisture, food sources, light exposure)
3. What do you think caused the insects/arthropods to leave the soil? How would you set up an experiment to test your idea?
   HINT: Could set up a series of funnels to test the independent affect of light (no heat), heat (no light), constant moisture (no drying), drying without heat, etc.)

Extension Activities

1. “Classroom Insect Zoo.” Have the class spend a day or two collecting insects form other sites around the school or around their homes. Ask them to bring in the animals for observation and classification. This activity can be offered to multiple classes to generate a friendly competition to see who gets the most or most varied types of insects. Winners can be awarded small “SuperFly” trophies.

2. “Taxonomy Poems.” Challenge students to compose short limericks or funny poems incorporating some of the scientific names they are learning. For example:

“The Lady Bug” by Yvette H., grade 4, Ms. Jenkins' class,

> A lady who loved the garden Opera,
> Belonged to the Order Coleoptera.
> During intermission she quickly ate
> All her many small green aphid dates
> And alone she left, at half past eight.

CSI: Crime Scene Insects™

Teacher's Guide
Part 1

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CSI: Crime Scene Insects Teacher's Guide
Table of Contents

PART ONE

PART TWO

I. INTRODUCTION

About the Exhibit

CSI: Crime Scene Insects explores the science behind one of the most fascinating areas of criminal investigation—forensic entomology. This field employs the use of insects such as flies, maggots and beetles to reveal critical details of a crime scene.

Exhibit Highlights include:

1. Time line of forensic entomology from 13th-Century China to present day
2. Insect models and computer interactives
3. Stroboscopic sculpture "The Fly Wheel" that animates the fly life cycle
4. Hundreds of insect specimens displayed individually or as "Insect Art"
5. Live displays of insect life cycles and skeleton decomposers
6. Field and lab equipment used by forensic investigators
7. Realistic simulated crime scenes with life-size figures
8. "Can you solve the crime?" case studies

Your students will leave the exhibit with a much greater appreciation for both the science behind criminal investigations and the important role insects play in solving those mysteries. So, round up your usual suspects and come join us soon to follow the evidence and investigate the science at *CSI: Crime Scene Insects*!

CSI Teacher's Guide Goals

The *CSI: Crime Scene Insects* Teacher's Guide provides:

1. Useful background for the teacher on the exhibit and forensic entomology
2. Classroom activities that can be used before or after a visit to the exhibit
3. Science activities and lab exercises that meet National Science Education Standards and incorporate multidisciplinary approaches to learning
4. Suggestions for extension classroom activities to promote further exploration into science topics related to insects, life cycles, and forensics
5. A concise resource for additional information, web sites and publications related to forensic entomology.

Helpful Hints Before The Visit

Preparation is a key element to making your museum field trip a valuable and enjoyable learning experience. Here are some quick tips to get you started:

1. Remember to schedule your classroom's visit with the museum in advance to arrive on times and days most appropriate for larger groups.
2. If possible, visit the exhibit before you take your students. You might invite some of the chaperones to come along as well. You can use this pre-visit as an opportunity to develop leading questions, check lists, or task sheets related to the exhibit that are specially adapted to your classroom interests and needs.
3. Before your visit, introduce the concept of forensic entomology to your students and briefly discuss some of the information provided in this Introduction and in the next section on Exhibit Details and Content. You can also look at the **CSI: Classroom Activities** in Unit One to see if any of these might be useful to do before the students visit the exhibit.
4. Select interested chaperones and provide them with background information on the exhibit. Museums typically recommend one adult per five students. Inform chaperones of their group leader responsibilities and encourage them to assist students with inquiry-based interactions while taking in the exhibit.

5. Prior to the visit, you might assign groups of students to specific topics or themes presented in *CSI: Crime Scene Insects*. Each group can become the "experts" in that area and report back to the class their detailed observations and comments after the visit to the exhibit.
6. Providing students with a check list of specimens to find, vocabulary to define, or basic questions to answer when they arrive at the museum can be a helpful way to keep students on track and engaged during their visit. Review the Key Content Points, Common Misconceptions and the Appendix of this Guide for suggestions.
7. At the museum, encourage students to discuss what they are experiencing and observing. Although each group may focus on one topic or area, allow ample time for your students to fully explore the entire exhibit.
8. Inform the students and chaperones about their tasks, departure and arrival times, lunch breaks, museum rules, and bathroom locations.

Special Notes and Suggestions

- **Helping students to positively react to exhibits of live termites and maggots, or beetles devouring flesh from skeletons.**

Remind your students that knowledge generally replaces fear or avoidance with curiosity and appreciation. Not everyone immediately warms up to insects or insect larvae, but after taking the time to investigate such an animal, a visitor is more likely to overcome any initial adverse reaction and can often gain an interest in the creature's biology. Pointing out the positive role of maggots and carrion beetles as major decomposers in our world might help visitors balance an initial lack of appreciation for these insects. Seeing a maggot as just an immature form of a fly and as a stage in the fly's incredible metamorphosis may help to remove some initial negative feelings.

- **Dealing with sensitive issues such as death and murder.**

While the writers in this exhibit specially selected cases that do not show excessive blood or violence, it is important to be sensitive to the age and maturity level of your students and to approach the displays and topics with appropriate discretion. When dealing with the issue of decomposition, it would be helpful to point out that death and decay are a natural part of the life cycle of all organisms. When violent deaths are depicted in the exhibit, point out that the purpose of forensic entomology is to aid law enforcement personnel in apprehending and convicting dangerous criminals. The ultimate goal is to prevent further tragedies. Nothing presented in this exhibit is done for sensationalistic reasons. Every element was carefully selected to provide accurate visual representations and to reinforce scientific themes.

II. EXHIBIT DESIGN AND CONTENT

Scientific Curator

The exhibit's curator is M. Lee Goff, Ph.D., one of the best possible advisors for an exhibit on the science and methods of forensic entomology. Dr. Goff is a professor and department chair at Chaminade University, a founding member and past president of the American Board of Forensic Entomology, and an FBI Academy instructor. He is a much-in-demand speaker on forensic entomology, and has also authored the recently published Harvard University Press book, A Fly for the Prosecution: *How Insect Evidence Helps Solve Crimes* and serves as a technical consultant for the hit television show “CSI: Crime Scene Investigations.”

Exhibit Design and Production

CSI: Crime Scene Insects was designed by Belzberg Architects based in Santa Monica, California. Their primary goal was to give visitors a feel for the work and science of forensic investigators. The exhibit components (or walls) are large and imposing. They are made of stacked plywood, which is meant to resemble the layers of dirt that an investigator may have to dig through to unearth evidence. There is also a puzzle-like quality to the design, which is meant to replicate the process an investigator goes through to solve a crime—this is often described as piecing together a puzzle. Finally, you will see that many of the

displays are designed to be viewed from more then just one side. Again, this is meant to mimic the work of an investigator who must examine all sides of a crime scene to find evidence.

We're Green! This exhibit was built with Earth-friendly products whenever possible. The plywood is from farm-raised sources, not forested. The tops of the benches are made from pressed sunflower seed husks and shells. All paints and lacquers are non-polluting, and the majority of the building materials are recycled or environmentally friendly. The entire exhibit was constructed with a commitment to seek alternative building methods that employ the three "R's"—Reduce, Reuse and Recycle.

The producer of *CSI: Crime Scene Insects* is ExhibitQ, an emerging museum exhibit company based in Long Beach, California, dedicated to providing science and cultural exhibits for museums, science centers, zoos, aquariums and libraries. Starting with the idea that science should and can be presented artistically, ExhibitQ gathered an eclectic and talented team to develop this exhibit. The exhibit team consists of more than 20 professionals including artisans and scientists, writers and engineers all interacting to produce a new type of science exhibit that is informative, accurate and aesthetically appealing.

Key Content Points of the Exhibit

CSI: Crime Scene Insects is presented in multiple sections, each presenting one or two major concepts related to forensic entomology. The key content points of the exhibit are highlighted below.

a. Forensic entomology links the study of insects to the science of crime investigations.
In forensic entomology, usually a crime has been committed, most often a murder, and insects on and around the victim's body become the evidence. To a trained investigator, insects can provide surprisingly precise clues concerning the time of wounds and of the death, whether or not drugs or toxins were involved, and whether the body was moved.

b. The natural succession of insects and the timing of their life cycles offer useful clues at a crime scene.
All insects go through one of several types of characteristic metamorphosis during their development from egg or immature form to adult. The precise sequence of insect species on a corpse and the timing of their developmental stages have been carefully documented by forensic entomologists. So under specified environmental conditions, it is possible to predict within hours the exact order of insects that will appear at a carcass or corpse as well as when the insects will lay eggs, when their larvae will hatch and how quickly they will develop into new adults. Knowing these time frames, investigators can literally "tell time" at a crime scene based, in part, on which insect species is present on a decaying body or in the surrounding soil and how far along the insects are in their developmental stages.

c. Flies and beetles, in particular, are important in forensic entomology.
While there are hundreds of insect species that can visit a decomposing body, generally flies and beetles are the fist to arrive on the scene. It's these two insect groups that emerge as major "key witnesses" and sources of information to a forensic investigator. Many of the forensically important flies and beetles are exhibited as live or preserved specimens in *CSI: Crime Scene Insects* including green bottle flies, blow flies, common house flies, rove beetles, hide beetles, checkered beetles, scarabs and carrion beetles. Some of the other types of insects or arthopods that have less significant roles in forensic entomology are also represented in the exhibit.

d. Maggots also play a key role as evidence at a crime scene.
Admittedly, maggots are not the most popular animal form, but they do provide some of the most accessible and useful information to a forensic investigator. These wiggling masses are actually fly larvae that have hatched from eggs deposited on decaying flesh by female flies; so, contrary to some myths, maggots do not spontaneously spring out of dead tissue. Maggots of each fly species relevant to forensics have been well studied by entomologists. These different fly larvae each show a predictable timetable for their growth and formation of pupae, the "cocoon" state that eventually emerges as a new adult fly. Taking samples of maggots from a corpse, determining their species and measuring their size and other structural

features helps investigators determine how long the maggots (and a body) have been present at a particular site.

e. Insect decomposers are more than just evidence.
In the natural and necessary process of decay in our world, animal and plant tissues are broken down and recycled. Many insects and/or their larvae consume dead or decaying materials as part of their natural life cycle and depend on decaying flesh for food sources. Their contribution as part of the Earth's natural "clean up crew" to eliminating the huge continuous biomass of dead plants and animals is critical to maintaining healthy environments and preventing the spread of disease.

Some Common Misconceptions

a. Forensic entomology only deals with murders and violent crimes.
Forensic entomologists are also called in to investigate cases related to neglect of patients or children when open bedsores or wounds are present and may be infested with insect larvae. The field can also involve investigations of insect damage to food (stored product entomology) or to buildings (structural entomology).

b. Simply knowing a species of fly or beetle on a corpse is enough information to make an estimate of time of death.
Calculating an estimate of a victim's time of death using insect data requires sampling multiple insect types, larvae and pupae from the body as well as capturing insects from the surrounding soil and environment. In addition, environmental conditions must be considered since they greatly influence the rate of insect's development. Temperature and weather conditions, in particular, are key factors.

c. Crimes are solved solely on the basis of evidence from insects.
While information from the analysis of insects on or near a corpse can be valuable in a criminal case, multiple lines of evidence are typically compiled including witness testimonies, DNA comparisons, fingerprints and other available physical evidence. Insects are only part of the picture.

d. All maggots are harmful to the animals they feed on.
Some species of maggots only feed on dying or decaying tissues in wounds and do not interfere with any surrounding healthy areas. In fact, these species of maggots have been used as an unconventional treatment for patients with antibiotic resistant skin infections to clean out necrotic (dead) cells in the wounds in order to promote healing.

e. The idea of using insects as evidence has only recently emerged since the creation of a current popular television show based on crime scene investigations.
One of the first recorded cases of forensic entomology is from China in 1235 where a murder was solved by identifying the killer's weapon from the presence of flies feeding on bits of tissue and blood still clinging to it. There had been only a few sporadic reports of using insects to estimate time of death in Western culture up until the mid-1980s when more entomologists and forensic investigators began to accept the reliability of entomological evidence from a corpse. The American Board of Forensic Entomology was formed in 1996.

III. APPENDIX

How Animals Are Classified

Classification Group	Humans	Skin Beetle	House Fly	Black Blow Fly
KINGDOM	Animalia	Animalia	Animalia	Animalia
PHYLUM	Chordata	Arthropoda	Arthropoda	Arthropoda
CLASS	Mammalia	Insecta	Insecta	Insecta
ORDER	Primates	Coleoptera	Diptera	Diptera
FAMILY	Hominidae	Dermestidae	Muscidae	Calliphoridae
GENUS	*Homo*	*Dermestes*	*Musca*	*Phormia*
SPECIES	*sapiens*	*maculatus*	*domestica*	*regina*

Major Classes of the **Phylum Arthropoda**

Characteristics of Arthropods: Segmented bodies with jointed exoskeletons of chitin; jointed appendages; respiration by body surface, gills, or trachae; marine, freshwater and terrestrial

Class	Examples	Species Number	Characteristics
Insecta	Flies, beetles, ants, termites, butterflies	~700,000	3 body parts; antennae, mouthparts for chewing, sucking or sponging; 3 pairs of legs; usually 2 pairs of wings; breathe via tracheae; most terrestrial
Arachnida	Spiders, scorpions, ticks	~57,000	1 or 2 body parts; modified mouth parts; 4 pairs of walking legs; mostly terrestrial
Crustacea	Shrimp, lobster, crabs, barnacles, copepods, ostracods	~25,000	2 or 3 body parts; antennae; hewing mouthparts; 3 or more pairs of legs, mostly marine
Diplopoda	Millipedes	~7,000	Multiple body segments with distinct head; antennae; chewing mouthparts; 2 pairs of legs per segment; breathe via tracheae; terrestrial; feed on plants (dead or living)
Chilopoda	Centipedes	~2,000	Multiple body segments with distinct head; large antennae; chewing mouth parts; 1 pair of legs per segment; terrestrial; feed on insects

NOTE: species numbers are likely underestimates, but are helpful to show relative differences between the classes

Major Orders of Insects with Incomplete Metamorphosis

ORDER	SPECIES	CHARACTERISTICS
Collembola	Springtails	Primitive wingless insects; largely in soil;
Thysanura	Silverfish	Primitive wingless insects; in caves and damp houses
Ephemeroptera	Mayflies	Larvae in fresh water, adults live only days
Odonata	Dragonflies, Damselflies	Generally large insects found worldwide; carnivorous or herbivores; larvae predators in fresh water
Plecoptera	Stoneflies	Adults usually live near river banks, larvae in fresh water
Blattodea	Cockroaches	Omnivorous (eat both plants and animals); often scavengers; found worldwide;
Isoptera	Termites ("white ants")	Social insects living in vast colonies, with one queen to lay all the eggs; most feed on wood;
Mantodea	Mantids	Predatory insects with large eyes and grasping front legs; mostly in tropics
Dermaptera	Earwigs	Omnivorous insects with fan-shaped hind wings and pincers on tail
Orthoptera	Grasshoppers	Grass-feeding insects with jumping back legs
Phasmatodea	Walking Sticks Leaf-insects	Leaf-feeding insects with camouflaged, flattened or slender bodies; look like leaves or sticks of plants
Psocoptera	Book lice	Small chewing insects, feed on tree bark, book bindings, also found in food
Phthiraptera	Parasitic lice	Parasites of birds and mammals, live on skin; feed on feathers, skin or blood; wingless
Hemiptera	True Bugs	Piercing or sucking mouthparts; feed on plants, insects or mammals
Thysanoptera	Thrips	Tiny insects with fringed wings; herbivorous with sucking mouthparts
Megaloptera	Alderflies Dobsonflies	Larvae are aquatic and carnivorous; adults have long antennae, 2 pairs of large wings
Neuroptera	Lacewings Ant-lions	Predatores as larvae, adults are carnivorous or herbivorous

Source: Adapted from *1001 Facts About Insects*, Laurence Mound & Steve Brooks, DK Publishers, 2003

Major Orders of Insects with Complete Metamorphosis

ORDER	SPECIES	CHARACTERISTICS
Coleoptera	Beetles	Very varied species; hard front pair of wings covering a second pair; found worldwide
Mecoptera	Scorpion flies	Small predators with biting mouthparts; in woodlands, caterpillar-like larvae
Siphonaptera	Fleas	Wingless with jumping hind legs; parasites of birds and mammals; feed on blood; piercing and sucking mouthparts
Diptera	True Flies	Two-winged flies; adults feed on plants/animals, rotting vegetation; found worldwide in all habitats; larvae (maggots) are legless and wormlike
Trichoptera	Caddisflies	Larvae in fresh water, have a protective case around their body; adults feed on flowers if at all
Lepidoptera	Butterflies Moths	Larvae (caterpillars) feed mainly on plants; colorful adults drink nectar, some adult species feed very little
Hymenoptera	Wasps, Ants, Bees	Mainly carnivorous insects, some herbivorous; some species live in highly ordered societies

Source: Adapted from *1001 Facts About Insects*, Laurence Mound & Steve Brooks, DK Publishers, 2003

Carrion Insects: Diptera and Coleoptera

Flies (Diptera) and beetles (Coleoptera) make up the two most common orders of insects found on carrion. Carrion insects are those that feed on or are associated with decomposing animal tissues. To properly identify the insect species found on carrion often requires a microscope since many distinguishing characteristics are too small to be seen by eye. In addition, immature larval forms of carrion insects are often present on the dead animal. Determining the species of insect from its larval stage is very difficult and often requires rearing the larvae in the lab until they develop into more easily identifiable adults.

Order Diptera

This order consists of true flies; the adults have one pair of wings and one pair of halteres, small knobbed structures used for balance and equilibrium. The larvae are called maggots; they lack legs and appear wormlike. Diptera have complete metamorphosis (egg, larva, pupa, adult) and all stages are found on carrion.

Major Families of **Diptera** Found on or Near Carrion

FAMILY	EXAMPLES AND CHARACTERISTICS
Calliphoridae	Blow flies, Greenbottle flies; often the most abundant larvae on carrion (early stage of decomposition)
Sarcophagidae	Flesh flies; large flies that lay live larvae instead of eggs; may be present shortly after death (early stage of decomposition)
Muscidae	House flies and stable flies; Dump flies which are sometimes found during late stages of decomposition
Piophilidae	Cheese Skippers (maggots tend to curl and flick, or "skip"). Associated with late stage of decomposition

Order Coleoptera

This order is the largest in the class Insecta and consists of beetles. Adults have two pairs of wings, but the front pair are hard, thickened elytra that protect the flight wings folded underneath. Coleoptera have complete metamorphosis, but it is unlikely that one would find eggs or pupae on carrion.

Major Families of **Coleoptera** Found on or Near Carrion

FAMILY	EXAMPLES AND CHARACTERISTICS
Staphylinidae	Rove Beetles; predators of fly larvae; can be present within hours after death as well as months later (early to late stage decomposition)
Silphidae	Carrion Beetles; adults and larvae feed on fly larvae; (early stage of decomposition)
Histeridae	Clown Beetles; predators of fly eggs, fly/beetle larvae; often found under the remains (early stage of decomposition)
Dermestidae	Skin Beetles; feed on dried skin and tissues (late stage of decomposition)
Scarabidae	Hide Beetles; some of the last arrivals at a corpse (late stage)
Cleridae	Ham Beetles, Checkered Beetles; predators of flies and beetles; feed also on dried tissue (late stage)

Glossary

Adventive species. Insects or arthopods that are not decomposers but use the body or corpse as an extension of their normal habitat.
Abdomen. The third body division of an insect.
Ametabolous metamorphosis. Development without change or metamorphosis. The immature form is similar to the adult insect. (Ex. springtails and silverfish).
Antennae. (sing., antenna). Pair of segmented appendages located on the head and usually sensory in function - the "feelers."
Arthropoda. "Jointed leg." A phylum of animals with segmented body, exoskeleton, and jointed legs.
Arthropods. Animals belonging to the phylum Arthropoda.

Berlese Funnel. A device used by entomologists to separate insects from a sample of moist soil, humus, compost, or leaf litter.

Carrion. The dead and rotting flesh of an animal.
Chitin. The light yet tough material that makes up an insect's exoskeleton and wings.
Coleoptera. Order of insects having stiff anterior pair of wings (elytra) that cover membraneous wings underneath. The mouth parts form two pairs of jaws (mandibles and maxill[ae]) that are adapted for chewing. Most Coleoptera are known as beetles and weevils.
Compound eye. An eye consisting of many individual elements facets that produces multiple images and allows vision in many directions.
Corpse. The dead body of a human being.

Diptera. Order of insects with one pair of wings, the second ones modified to halteres. Includes flies and mosquitoes.

Ecdysis. "Stripping." Molting process of insects; shedding of exoskeleton.
Ectoparasite. Any parasite that lives on the outside of animals (Ex. lice, mosquitoes).
Elytra. The two stiff anterior wings of a beetle which protect the posterior membranous functional wings.
Entomologist. "Entomo = notched (animals)." A scientist who studies insects.
Entomology. The scientific study of insects.
Entomotoxicology. The use of carrion-feeding insects to identify drugs and toxins present in corpse tissues.
Exoskeleton. The outside "skin" of an insect or arthopod, made from tough chitin.

Forensics. The use of science and technology to investigate and establish facts in criminal or civil courts of law.
Forensic Entomology. The application of insect biology as reliable evidence in criminal or civil cases.
Haltere. One of the club-shaped 'balancers'' found on each side of the metathorax among the true flies (Diptera). They are the much-modified hind wings.
Holometabolous. Complete metamorphosis involving egg, larva, pupa and adult. Includes flies, beetles, butterflies, wasps.
Hygrothermograph. An instrument that measures and records temperature and relative humidity changes.

Incomplete Metamorphosis. See Paurometabolous.
Instar. Stages of an insect or arthropod between molts.

Larva. (Larvae pl.) An immature insect form that is markedly different from the adult: caterpillars and fly maggots are good examples. Larvae is plural.

Maggot. A fly larva; a larva without legs and without well-developed head.
Mandible. The jaw of an insect. It may be sharply toothed and used for biting, as in grasshoppers and wasps, or it may be drawn out to form a slender needle as in mosquitoes. Mandibles are completely absent in most flies, butterflies and moths.

Maxilla. (plural maxillae) One of the two components of the insect mouth-parts lying just behind the jaws. They assist with the detection and manipulation of food and are often drawn out into tubular structures for sucking up liquids.
Metamorphosis. The changes that take place during an insect's life as it turns from a young animal to an adult (incomplete metamorphosis) or from egg, larva, pupa, adult (complete metamorphosis).
Molt. Shedding the outer covering of the body - the exoskeleton.
Muscoid flies. Flies (Diptera)that belong to the Family Muscidae (Ex. Houseflies). **Myiasis.** When maggots (fly larvae) feed on living tissue and not decaying tissue.

Necrophagous. "Death, feeding." Species that feed on carrion or corpses, includes some flies and beetles.
Nymph. Young stages insects that undergo an incomplete metamorphosis. The nymph is usually quite similar to the adult except that its wings are not fully developed.

Ocellus. (Plural Ocelli) One of the simple eyes of insects, usually occurring in a group of three on the top of the head, although one or more may be absent from many insects.
Omnivorous. "All, feeding." Species that feed on corpses and are also predators of other insects present on a corpse (Ex. wasps, ants, and some types of beetles).

Paurometabolous. Incomplete or "gradual metamorphosis". The eggs hatch into an immature form that resembles the adult , but is smaller and without wings (Ex. cockroaches, grasshoppers, praying mantis).
Postmortem Interval (PMI). The time since death of a victim.
Predator species. One that feeds on other insects or arthopods (Ex. Spiders, wasps, and some types of beetles that prey on fly larvae, eggs and pupae).

Pupa. (pl., pupae). The third stage in the life history of flies, butterflies and other insects undergoing a complete metamorphosis. The pupa is a non-feeding and usually immobile.
Pupate. To turn into and exist as a pupa.

Redi, Francisco. An Italian physician and naturalist who demonstrated in the 1600s that flies did not arise as a result of "spontaneous generation" from rotting meat. He showed that meat, shielded from egg-laying flies by cloth, never developed maggots.
Rigor mortis. "Stiffness, death." Muscular stiffening following death.

Spiracle. One of the breathing pores - openings of the tracheal system - through which diffusion of gases takes place. In maggots, the number of spiracles present helps entomologists determine the age of the larvae.
Succession. The natural change and replacement of insects on corpses that happens in a fairly predictable sequence and can be used in estimating time of death.

Thorax. The middle segment of the three major divisions of an insect body. The legs and wings (if present) are always attached to the thorax.
Trachea. (Plural tracheae). One of the internal minute tubes that permeate the insect body and carry gases to and from the various organs etc. They open to the air at the spiracles.

IV. RESOURCES and SUPPLIES

Books and Publications

A Fly for the Prosecution: How Insect Evidence Helps Solve Crimes, M. Lee Goff, Harvard University Press: 2000

*Photographic Atlas of Entomology and Guide to Insect Identification***,** James L. Castner, Feline Press: 2000

Forensic Entomology: Utility of Arthropods in Legal Investigations, Jason H. Byrd, James L. Castner H., CRC Press: 2000

Forensic Insect Identification Cards (laminated), Jason H. Byrd, James L. Castner, Feline Press: 2000

*Entomology and the Law: Flies as Forensic Indicators***,** Bernard Greenberg, John Charles Kunich, Cambridge University Press: 2002

The Practical Entomologist (An introductory guide to observing and understanding the world of insects), Rick Imes, Simon and Schuster/Fireside Publication, 1992.

Encyclopedia of Insects, (The newly published consummate guide to everything and anything insect related. Includes a chapter on forensic entomology by Dr. Goff.) Vincent Resh & Ring Cerde, Academic Press, 2003.

1001 Facts About Insects, (Excellent photographs and interesting facts about insect behavior and environments; reference section is especially helpful in this backpack size book.) Laurence Mound and Steve Brooks, DK Publishing (Backpack Book Series), 2003.

Bugs, (Children's book with beautiful close up photographs of insects.) Penelope York, DK Publishing (Eye Wonder Series), 2002.

Web sites

http://www.aafs.org
The web site for the American Academy of Forensic Sciences includes a Resource/Forensic section that provides additional links to forensic publications and organizations.

www.missouri.edu/~agwww/entomology/
Official page of the American Board of Forensic Entomology.

http://www.Tncrimlaw.com/forensic/
Provided by the Tennessee Criminal Law Defense Resources, this site provides definitions and web site links for many fields within the broad umbrella of forensic investigations.

http://www.fbi.gov/hq/lab/handbook/intro.htm
This is a link to the FBI's Handbook of Forensic Services. This handbook provides guidance and procedures for safe and efficient methods of collecting and preserving evidence and to describe the forensic examinations performed by the FBI Laboratory.

http://www.deathonline.net/decomposition/index.htm
Describes the natural biological process that occurs after death. Body changes, insect interaction, decomposition, and forensic evidence. **Please note**: this site contains graphic images and descriptions.

http://www.uky.edu/Agriculture/Entomology/ythfacts/entyouth.htm
This University of Kentucky Entomology Department site is designed for teachers and young students. Basic insect information, resources and related activities are found here.

www.ent.iastate.edu/List/
Entomology index of internet resources, Iowa State University; VanDyk, J.K. and Bjostad, L.B.

Web sites/Videos

http://www.deathonline.net/decomposition/decomposition/index.htm
An extension to the cite noted above; contains a movie clip showing an animal at various points of decomposition. (**Please note**: this site contains graphic images that may not be appropriate for some young children.)

Scientific Supply Companies

1. BioQuip Products, Inc. 2321 Gladwick St. Rancho Dominguez, CA 90220. 310 667-8800. Supplies for entomology; insect models and videos.
2. Science Kit and Boreal Laboratories. 800 828-7777 www.sciencekit.com
3. Dermestid Skeletal Preparation Kit and other Forensic Kits.
4. The Science Store. 800 522.8281 www.science-store.com
5. Skeleton and skull models.
6. Combined Scientific Supplies PO Box 1446 Ft. Davis, TX 79734. 915 426-3851. www.wirelessfrontier.net. Insect specimens, preserved and ready for mounting.
7. Carolina Biological Supply Co. 800 334-5551 www.carolina.com
8. Insect specimens-live; Forensic Activity: Skeleton Sleuth Kit
9. Ward's Biological Supply 800 962-2660 www.wardsci.com live insect specimens.

CSI: CRIME SCENE INSECTS™

Teacher's Guide

Part 2: Classroom Units and Activities
Unit 1: Insects and Arthropods

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Overview

The CSI Classroom Activities link the major scientific concepts of *CSI: Crime Scene Insects* to inquiry-based exercises for students. The unit begins with an introductory exercise to pique students' interest in the topic and leads to hands-on activities to explore the principles of insect biology and forensic science.

Features of ***CSI Classroom Activities***:

1. Suitable before or after students visit *CSI: Crime Scene Insects*
2. Modular design so teachers can select those that best match students' interest and needs
3. Adaptable to a broad range of grade levels (Grades 3-8)
4. Meet National Science Education Standards
5. Incorporate multidisciplinary approaches to learning including art, writing and math.
6. Offer suggestions for enrichment activities to permit advanced or individualized learning

CSI: Crime Scene Insects Classroom Activities

	Topic/Theme	CSI Activity	Description
Unit One	Insects & Arthropods	1.1 What's Your Insect IQ?	Pretest; teaser for Unit One
		1.2 Bugged by Bugs? Animal Symbols	Intro Activity on associations/reactions to bugs and how animals can become symbolic in cultures
		1.3 Build a Bug	Intro Art Activity; Insect Anatomy/Classification
		1.4 Surprise, This Dirt's Alive!	Insect Collection (soil samples) Berlese Funnel Lab with Observations

CSI Classroom Activity 1.1

Part 1. What's your "Insect IQ?"
Part 2. Check Out These Insect Facts!

Overview

Launch your students into the Crime Scene Insects Activity Series by asking them to take this quick and fun self-quiz. The survey "What's your Insect IQ?" in Part 1 tests their basic knowledge of **entomology**, the study of insects, and lets students rate themselves on their level of "expertise." Not to worry though, this is a quiz where the points don't count; it's only to stimulate interest in studying insects.

In Part 2 "Check out These Insect Facts", students consider some of the more amazing skills and structures of six-legged critters and other **arthropods**. It's an introduction to the **specialized adaptations** and record-breaking feats that are only possible in the insect world.

Both lessons serve as excellent pre-visit activities for the *CSI: Crime Scene Insects* exhibit where students see how insect anatomy and life cycle provide surprisingly vital clues in various types of crime scene investigations.

Estimated Time: 30-45 minutes depending on the level of discussion

Grade Level: Grades 3-8. Delete or modify questions and facts according to grade level

Materials

1. "What's Your Insect IQ?" Test
2. Insect Fact Sheet

Procedure

1. Review the Insect IQ test questions; select ten you think are appropriate for your class.
2. Have students take the Insect IQ test and check their own answers. Use the test to start a discussion about insects and how much students may or may not already know.
   HINT: Students might also take a "pretest", discuss, and then do a "post-test" before determining their ranking.
3. Have students read and comment on the Insect Facts to promote additional interest, discussion and positive attitudes about insects.
4. Announce that they are soon to become amateur "CSIs," that is, Crime Scene INSECT Investigators! Their "training" will include a visit to the *CSI: Crime Scene Insects* exhibit along with the unique experiments from the CSI Activities Series.

Part 1. What's Your Insect IQ?

Do you think you know insects? Well, take this quick quiz and see how you rate in your knowledge of these fascinating creatures.

1. Insects were on the Earth long before the time of
   a. dinosaurs b. VW Beetles c. birds d. all of these

2. An insect's body has how many sections (segments)?
   a. two b. three c. four d. six

3. All insects have how many total legs?
   a. two b. four c. six d. eight

4. Which of the following is NOT an insect?
   a. fly b. beetle c. dragonfly d. spider

5. "Insect" is Latin for
   a. bug b. small c. segmented d. crawls

6. Insects are a class of Arthropods, a word that means
   a. rigid toes b. stiff wing c. jointed feet d. athlete's feet

7. Many insects lay eggs that hatch into
   a. larva b. pupa c. maggots d. cocoons

8. Insects have special mouth parts that allow them to
   a. chew plants b. pierce skin c. eat other insects d. all of these

9. Insects do NOT have
   a. bones b. an exoskeleton c. jointed legs d. antennae

10. Insects have a hard outside layer (exoskeleton) made up of
    a. super glue b. bone c. cartilage d. chitin

11. The study of insects is called
    a. zoology b. insectology c. entomology d. astrology

12. Today, insects are being used to
    a. solve crimes b. clean wounds c. control crop pests d. all of these

13. The life span of a house fly is about
    a. 15 minutes b. 15 hours c. 15 days d. 15 weeks

14. Insects breathe through special holes called
    a. lungettes b. eyelettes c. spiracles d. oxygen pores

15. Most insect species are in which group (order)?
    a. flies (Diptera) b. beetles (Coleoptera) c. ants/bees (Hymenoptera)
    d. butterflies/moths (Lepidoptera).

HOW DO YOU RATE? Add up your points out of 10 questions and find out your current level of insect expertise!

TOTAL POINTS	EXPERT LEVEL	
Less than four	Neophyte	Not to worry, you are in for some great lessons on insects
Five to six	Larva	Not bad…clearly in a growth stage
Seven to eight	Pupa	Impressive…but don't think you can rest just yet
Nine to ten	Bug Brainiac	Highest level…congratulations, you're off to a great start

Discussion Questions

1. How do you rank as an "insect expert"?

2. Which answers were easiest? The hardest? The most surprising for you? Why?

ANSWERS to "What's Your Insect IQ"?

1. **d.** all of these. Insects evolved during the Silurian Period 438-408 million years ago, almost 200 million years before any dinosaurs roamed the Earth!

2. **b.** Insects have three major body parts or segments: head, thorax and abdomen. The variation within the class Insecta is enormous, however, with wings, antennae, mouthparts and legs being specially adapted to each insect's particular environment.

3. **c.** All insects have six legs, although each insect will have legs that are specialized for their environment (i.e. forelegs of a praying mantis are adapted to grab prey; hind legs of a grasshopper and flea are adapted for jumping; the legs of honeybees contain structures that collect and store pollen).

4. **d.** Spiders below to the same phylum Arthopoda, but they are in the class Arachnida-- not the class Insecta. Arachnids have 1-2 body segments and eight legs; they include spiders, ticks, mites and scorpions. Besides Insecta and Arachnida, the other Arthopod classes include Crustacea (shrimp, crabs, lobsters, copepods), Diplopoda (millipedes) and Chilopoda (centipedes).

5. **c.** segmented.

6. **c.** jointed feet referring to the multiple joints found in each leg

7. **a.** The life cycle of most insects includes egg, larva (i.e. maggots/caterpillar), pupa (i.e. cocoon) and adult.

8. **d.** Depending on the insect species, the mouth parts will vary. There are different types of mouth parts that allow sucking, piercing, stinging, sponging, or chewing.

9. **a.** Classic features of insects, as well as other arthropods, include a rigid exoskeleton and jointed appendages. Various types of antennae are also present in all arthropods except the arachnids.

10. **d.** Chitin is the hard material that makes up the exoskeleton.

11. **c.** Entomology (*entoma*, G. "notched animals/insect"; logy, "the study of").

12. **d.** Despite the general association of insects with crop damage and the spread of diseases, insects have also played several beneficial roles for humans. Ladybugs are often used as natural predators of aphids to control their spread. Also in forensic entomology, police now use the age of fly larvae (maggots) or the presence of other insects to provide an estimate on the time of death at a crime scene. In the 1800s, certain types of maggots were used to clean open wounds since these fly larvae feed on only decaying tissues and leave the healthy areas alone.

13. **c.** The average housefly lives about 17 days. The process of development from egg, maggot, pupae to adult takes about 24-25 days.

14. **c.** Spiracles are the openings in the abdomen that allow gases to enter and leave an insect's internal respiratory system.

15. **b.** Beetle species in the Insect order Coleoptera outnumber all the orders of insects.

Part 2. Check out These Insect Facts!

INSECT WORLD RECORDS

1. It is estimated that the total insects on Earth outweigh humans by a factor of 12, and that there are 300 million insects for each person alive!
2. Nearly a million different insect species have been described, more than the number of ALL other animal species put together!
3. The biggest insect that ever lived: an ancient dragonfly Meganeura, a predatory insect with a wing span of two feet. Try to swat that one!
4. Today's insects range in size from tiny beetles of 0.1 mm long to tropical moths that have a wingspan of nearly 8 inches (30 cm).
5. Some flesh-eating flies can smell the scent of a rotting corpse up to one mile (1.6 km) away.
6. Fleas can wait up to one year between meals. (When they bite humans, we don't feel the bite; instead, an itch is caused by the flea's saliva that sets off an allergic response at the skin site).

AMAZING FEATS BY SIX-LEGGED CREATURES

1. Insects, along with birds and bats, are the only living animals that fly (a few other animals can glide).
2. One locust swarm in Africa can measure 30 meters deep with a front 1500 meters long, and will consume every fragment of plant material in its path.
3. A housefly beats it wings more than 330 times per sec; a bee buzzes along at 200 beats per second. Most butterflies are more relaxed fliers, with wings that move less than 5 times per second.
4. During the mating season, male house flies can race around in short bursts that reach up to 90 mph (145 kmph)!
5. Human eyes have one light-gathering lens in the center of each eye. Dragonflies have almost 30,000 lenses per eye, helping them to detect the slightest movements around them.
6. Insects that feed on fresh blood smell the carbon dioxide that their prey breathes out. This helps them to track down their victims.
7. Houseflies cannot fly upside down, but they land easily on a ceiling by flying below it, raising their two front legs and grabbing hard, then swinging forward their four back legs in order to stick solidly upside down on the ceiling.

WHO WOULD HAVE THOUGHT?

1. Up to 80% of an insect’s brain is used to understand what its eyes see and what its antennae sense.
2. Most insects use their antennae to smell and detect scents, although some use antennae to taste.
3. Flies taste food with special hairs on their feet.
4. Crickets don't have ears; instead they “hear” through large swellings on their front legs.

5. A ladybug is no lady! One ladybug can eat up to about 50 aphids a day or about 5, 000 in a lifetime. If there is not enough food, ladybugs turn cannibal and start to eat their young. Oh, and there are both female AND male "lady" bugs.
6. Ladybugs use their bright color to deter birds from eating them but also send out smelly chemicals from their knee joints to further protect themselves.

Primary Source for the Interesting Insect Facts

1001 Facts About Insects, Laurence Mound and Steve Brooks, DK Publishing, 2003.

Discussion Questions

1. What do you think was the most amazing, most funny, or most strange fact about insects?

2. Ask students if they ever heard of insects being used to help crime scene investigators? (If yes, have them describe what they know). Remind them that the *CSI: Crime Scene Insects* exhibit introduces the fascinating world of forensic entomology and shows how flies and beetles can become living evidence in solving various crimes.

CSI Activity 1.2

Part 1. Bugged by Bugs?
Part 2. So Why the Fly in the Portrait?

Overview

"Yuck! Bugs." If that's your students' reactions when introduced to a unit on insects, this activity is for them. Part 1, "Bugged by Bugs?" addresses the negative feelings and fear sometimes associated with insects. A guided classroom discussion promotes the idea that becoming more familiar with the small, six-legged creatures may counter misconceptions and even lead to a fascination with insects. The lesson prepares students for the upcoming classroom experiments where live insects are collected, raised and studied. It is also an excellent pre-visit activity for the *CSI: Crime Scene Insect Exhibit* since live beetles, flies and their larva are an important part of the displays.

Part 2 "So Why the Fly in the Portrait?" further explores the types of associations we make with insects and other animals. It begins with examining reasons for the curious insertion of a fly in a Renaissance painting showcased in *CSI Crime Scene Insects*. It ends with students considering other animal symbols or trademarks and how associations with the same animal can vary dramatically depending on one's cultural perspective.

Estimated time: One class period

Grade Level: Grades 3-8. Select or modify questions according to grade level.

Background and resources

For images of insects, use a large picture book or print images from web sites
HINT: search Google first selecting "images" and then searching by insect common names.

Materials

Compile 6-10 large photos or overheads of insect close-ups: include "good bugs" (ladybugs, butterflies), "bad bugs" (flies, grasshoppers, mosquitoes, beetles, bees), and "ugly bugs" (larvae such as caterpillars and maggots).

Renaissance portrait "Madonna and Child."

Procedure

Part 1. "Bugged by Bugs?"

1. Start the discussion by showing the photos of insects that are usually associated with positive feelings (butterflies, ladybugs). Then show grasshoppers, beetles and flies to begin to bring up possible negative thoughts about insects (crop damage, disease). The last groups of photos should include some even less popular insects (mosquitoes, bees) larvae (caterpillars and maggots). Be sure flies, beetles and maggots are included in this exercise since they will be important in subsequent activities.

2. With each photo, solicit the students' immediate associations. Help them explore why they make their particular associations and why such small animals can invoke such strongly positive or negative feelings. Evaluate why some students may have completely opposite reactions.
3. Suggest that as we learn more about insects, perhaps our biases and negative impressions may be replaced, or at least tempered, by curiosity and an appreciation for the remarkable adaptations (and even beauty!) that insects demonstrate. Have any students who especially like insects share their reasons and experiences with insects.
4. Introduce the *CSI: Crime Scene Insect* Unit, and describe some of the upcoming activities including a visit to the *CSI: Crime Scene Insects* exhibit!

Extension Activities

1. "Can You Say Coleoptera?" Along with each photo, display the insect common name, genus, species, order, class and phylum to briefly introduce insect terminology and classifications. Ask students to try to pronounce some of the more interesting names and discuss their meaning (see **Glossary**).

2. "Phobia Focus". Have the students research the medical words for "fear of insects", "fear of spiders" and other animal phobias. They might also find out how common these conditions are and how they can be treated.

Part 2: So Why the Fly in the Portrait?

1. Show a reprint of the painting "Madonna with Child" as displayed in the exhibit.

2. Ask students to look at the painting and come up with an appropriate title.

3. Do they see anything interesting or surprising?

4. Challenge the students to find the fly in the portrait. (Look at the infant's right leg).

5. Ask the students to explore reasons why the painter would include something as unlikely as a fly in this portrait.

6. Why only a single fly and why only on the infant?

7. What associations do they make with flies?

8. Introduce the idea of flies being associated with decaying food or dead animals. Explain that during the Renaissance period, a fly painted on an individual's hand, leg or body indicated death for that person. A fly was often added to a painting after the subject had died or was used as a harbinger of death.

9. Ask students why people looking at the painting in the 1400s probably didn't have to have this symbolism explained to them, but today it isn't immediately obvious what the presence of a fly would indicate.

   HINT: With little refrigeration or preservation of meat (or corpses) at that time, people were very familiar with the sight of flies hovering around the carcass or body after death. Adult flies lay eggs on the decomposing tissue and the larvae that hatch from the fly eggs develop and feed off the decaying tissue. Fly larvae are also known as maggots.

Discussion Questions

1. List and discuss other animals have are used as symbols or are associated with human traits (lions/courage; owl/wisdom; fox/sly). Class groups can compete to see how many each group can come up with in a given time.
2. How many sports teams can students list that are named after animals? What attributes do these animals portray for the team? If you had to name a team after an insect, which one would you choose and why?
3. What trademarks have been linked to animals? How about animals associated with brand names or logos? (cars/Mustang, US Post Office/eagle, Disneyland/Mickey Mouse)

Extension Activities

1. "Advanced Research-1." Research the associations other cultures had with flies or other insects. For example, compare the significance that flies had in ancient cultures (i.e. Babylonians, Phoenicians, Egyptians), mythology (Greek/Roman/Native American) or

literature (*Lord of the Flies*). Explain how different cultures could have different/similar beliefs about the same insect.

2. "Advanced Research-2." Research your official state/county animal. Find out or suggest a reason for its selection to represent your area. When was it selected? Were there alternatives considered? Is there an official insect for your state? For your school? If not, which insect would you choose for your state and school and why?

3. "Insect Ads." Review common phrase that are describe attributes of animals. (i.e. "as slow as a turtle," "as strong as an ox," "as happy as a clam"). Challenge students to come up with a slogan that would go along with a fly, a beetle or a maggot. Have them create a mini "billboard" using their phrase as an "advertisement" for this animal. Students can include their own drawings or use images cut out from magazines and newspapers in their ads.

CSI Activity 1.3
Build a Bug

Overview

This lesson uses an art project to introduce insect anatomy and classification. In Part 1, students observe a series of enlarged photos (or mounted specimens, if available) of various common insects to examine and record details of insects' basic body segments, eyes, appendages, wings and sensory structures. Students use their recorded observations to create a 3-D model of an insect of choice.

In Part 2, students research their "chosen insect" to discover and report on additional details about its habitat, life cycle and environmental impact. A comparison of all the constructed insect models, along with the insect reports, allows the students to develop a classification scheme to describe the major groups of insects and other members of the arthropod phylum.

Estimated time: Minimum of 2-4 class periods. The time will vary depending on the expected detail of the insect models, completeness of the reports and whether the students work individually or in small groups.

Grade level: Grades 3-8, depending on the complexity of the insect models and reports. Discussion questions and optional extension activities can be deleted or modified as needed.

Materials

1. Large, close-up color photos of 10-12 adult insects.

   Be sure to obtain representatives from the major insect orders. Try to get multiple views of each insect, if possible, in order to show the details of the head, wings, legs and abdomen. You might include a spider which is an arthropod but not an insect, just to stimulate a bit of controversy.

Option: have the students or each group select an insect and locate appropriate photos and information doing a Web search.)

2. Classification Key for Classes of Arthropods
3. Major Orders of Insects
4. Balloons of various sizes and shapes (round, elongated)
5. Paper strips in various colors
6. White glue for dipping the paper strips in order to adhere to balloons
7. Wax paper
8. Cookie sheets (or counter space for drying the models)
9. For legs: pipe cleaners, coat hangers, wire
10. For wings: sections of panty hose or cellophane stretched over wire shapes
11. For eyes: wads of paper
12. Paints and paint brushes

13. Colored markers
14. Glitter, sequins, buttons
15. String or nylon thread to hang each insect model

Procedure

This activity can be done by individual students or in small groups.

Part 1. Building your insect

1. Obtain and look carefully at large, close-up photos of various insects. Select an insect that appeals to you--one that you would like to build a model of and research more details about.
2. Record as many observations as you can about your insect while looking at the photos. Make notes about all parts of the body including the major sections (segments), legs, wings, antennae, eyes and any other notable features. Describe each part or structure carefully including shape, color, relative size, texture etc.
3. Using the materials supplied in class, or other materials that you have decided to bring from home, build a three-dimensional model of your insect. The basic body can be constructed by covering balloons with paper dipped in glue. A few layers of paper should be good enough. You might use balloons of different sizes to represent the different segments of your insect.
4. Decide if you need additional features of your insect that need to be constructed with the glued-paper and apply those if necessary.
5. Place each covered balloon on a cookie sheet lined with wax paper to dry. After it is dry, pop the balloon inside using a small needle or pin.
6. After the paper dries, glue the segments together.
7. Construct and attach wings, legs, antennae to the appropriate segments of your insect.
8. Decide if your insect will look authentic, or if it will be more of a “fanciful” representation of the insect.
9. Paint, color and decorate your insect according to your decision. The only requirement is that the anatomy of the insect be correct. The colors are up to you.
10. When the insect is completed and dry, attach a thread or string to it so that it can be displayed in class.
11. Construct and attach a label card identifying your insect and its creators (you!) You should use common and scientific names for your insect, and if you like, you can give it your own personal “pet” name as well.

Part 2. Researching your insect.

1. Obtain as much information about how your insect lives, survives and behaves using web searches, the library, books from home.
2. Put together a written report describing your insect. Include: common name(s), classification (kingdom, phylum, class, order, genus and species), habitat and life cycle. Also see if you can find out how it uses its specialized sensory organs to see, taste, hear and touch. Determine what types of food it eats and what predators eat your insect. Describe any unusual activities, abilities or specialized structures of your insect.

3. After you complete the report, “introduce” your insect to the class and present your findings.

Discussion

1. Looking at all the models of insects built in class, describe the basic features of an insect's anatomy. (What segments/parts do they all have in common? What variations do you see between the insect models?)

2. Organize some classification scheme that would include and group every insect represented in the class collection of insect models.

   HINT: Before showing the students a scientific classification chart, encourage them to come up with their own groupings based on whatever criteria they think makes sense. These can be nonscientific and even funny criteria but should be based on some observations.

3. Examine the classification charts for Arthropods and Insects. Look up the meaning of the scientific names, and list a few examples of each class and order. State briefly how the other arthropods are different from insects.

4. Explain why all insects are not technically true “bugs” and why spiders are not really insects.

5. Why do scientists bother to classify organisms? Why do they use scientific genus and species names instead of common names?

Extension Activities

1. A real insect’s “skin” is not made of paper and glue. Find out what the exoskeleton of insects is composed of. Since the exoskeleton can't stretch, describe what happens to the exoskeleton as insects grow.
2. Determine the actual length/size of the insect you researched (in cm). Measure the size of your model and calculate how much larger your insect model is compared to the real animal. Attach a sticker to your insect indicating the magnification size of your model relative to the real insect.
3. Why can’t a live insect ever be the size of your model? Research this.
   HINT: exoskeleton would weigh it down; too much heat build up from increased volume; too much weight for its legs/wings; circulatory system couldn't support its nutritional needs; Where would it possibly get enough food to survive?

Source: “Build a Bug” was adapted from activities described in *The Everything Kids’ Big Book* by Kathi Wagner, Adams Media Corporation, 2003.

CSI Activity 1.4
Surprise, This Dirt's Alive!

Objective

Here's an easy laboratory exercise that lets students discover the amazing diversity of insects and other arthropods living in seemingly lifeless soil. It involves setting up a simple **Berlese funnel** to remove, collect and preserve the small soil organisms taken from various sites around the school yard. These organisms then become specimens that students observe, compare and classify to better understand Arthropods and insects.

When students visit the *CSI: Crime Scene Insect* exhibit they will see a similar type of apparatus displayed as part of a crime scene investigator's experimental tools. In fact, **forensic entomologists** depend upon the same technique described here to collect their own critical insect evidence from soils at a crime scene!

Estimated time: (3-4 class periods)

Day 1	Collect soil samples and set up funnel(s)
Day 1-3	Organisms appear in the bottom collecting jar
Day 2-4	Insect observations and identification

Grade level: Grades 3-8. Discussion questions can be deleted or modified accordingly.

Materials for funnel

1. Plastic funnel with at least a 6-8 inch (15-20 cm diameter (from auto supply or hardware stores)
2. Galvanized screen--coarse mesh, 1/8 to 1/4 inch (3-6 mm
3. Tin snips to cut the screen
4. Cheesecloth (approximately 18-24 inches square)
5. Clear, wide-mouth jar to hold the funnel; funnel should not touch the bottom of the jar
6. Small vial, larger than the mouth of the funnel to collect the insects as they leave the soil
7. Lamp with a 40-watt bulb

Option: Purchase a premade Berlese funnel from Carolina supply (# 65-4148) or smaller re-useable units from BioQuip Products (#2845)

Additional materials

1. Rulers
2. Spoons or trowels to collect soil
3. Plastic bags
4. Newspaper
5. Marking pen

6. Rubbing alcohol (70%)
7. Glycerine
8. Hand lens (10X) or dissection microscope
9. Insect Orders Chart (see reference section of *1001 Facts about Insects*; L. Mound & S. Brooks, DK Publishers; or a similar entomology text for insect classification groups)

Procedure

Adapted from "Collecting Microarthropods" by Steve Binkley; Carolina Biological Life Science Activity. See http://www.carolina.com/life_science/microarthropods.asp)

1. To make each Berlese funnel, cut the 3-6 mm mesh screen into a round disc that will fit snugly about 2/3 the way down into the throat of the funnel.

   HINT: If there is a small screen already inside the funnel, remove it since the mesh is generally too fine for this experiment.

2. Set the funnel, with the screen disc in place, into a wide-mouth jar. Be sure there are a few inches of space between the end of the funnel and the bottom of jar. Alternatively, you can support the funnel with a ring stand.

3. Line the mouth of the funnel with a single layer of cheesecloth and press it down so that it lies on top of the screen. The cheesecloth should be large enough to also drape over the funnel's top rim.

4. Collect soil samples from designated areas. Depending on the size of your funnel, a soil sample that is approximately 15 cm square by 4 cm deep is a good starting point. If the class is doing this in groups, have each group take samples from different spots.

   HINT: Moist soils around bushes or trees should yield more live organisms than dry sandy soils. Areas with rotting leaves or logs are another potentially rich site.

5. Place the collected soil in the plastic bag. Label it with date, student(s) name and a description of the collection site including whether it was in shade, partial/direct sun, was moist/dry and its color/texture.

6. If the sample is damp, let it dry on newspaper in a shoe box at room temperature for 24-48 hours before placing it into the Berlese funnel. Be sure to check for any animals that might be crawling around or away from the soil in the meantime.

7. Place the soil sample into the funnel on top of the cheescloth and screen. It is not necessary to remove any leaves or small twigs (there may be specimens on them).

8. Pour 70% alcohol into the small vial, and place it under the funnel's stem.

   HINT: You can add a few drops of glycerine per 100 ml of alcohol to keep it from evaporating if the experiment runs over the weekend.

9. Turn on the lamp. Place it about 2-3 inches (5 -7.5 cm) above the soil sample.

10. Make daily observations and records of the adult and immature specimens that appear in the alcohol.

    HINT: The animals could start to appear within a couple of hours, even minutes.

Observations

During the 2-3 days of collection time, have the students complete an expanded chart formatted like the one below. For help in identifying their organisms, see the Insect Orders Chart or check out www.edc.org/CCT/AMNH/handbk/InsectCard/artho.html.

SOIL ANIMAL OBSERVATION AND CLASSIFICATION CHART

Sketch of Organism Length (mm)	No. found	Body Segments (No,)	Pairs of Legs (No.)	Pairs of Legs per Segment	Pairs of Wings (No.)	Common Name	Arthropod Class (and Order)
1							
2							
3							
4							

NOTE: The types of insects and arthropods will vary somewhat depending on the habitat. Arthopods in the class Insecta that frequently appear include ants (Hymenoptera) pill bugs (Isoptera), beetles (Coleoptera), cockroaches (Blattodea), earwigs (Dermaptera), springtails (Collembola), and various immature insects that are frequently difficult to identify. Earthworms and non-insect arthropods like mites (Arachnida), spiders (Arachnida) centipedes (Chilopoda) and millipeds (Diplopoda) may also be present.

Discussion Questions

1. What were the most common and least common specimens in your soil sample? How do your findings compare with those of other groups?
2. What might be some of the factors that influenced the types and numbers of insects/arthropods that were found in the different soil samples? (moisture, food sources, light exposure)
3. What do you think caused the insects/arthropods to leave the soil? How would you set up an experiment to test your idea?
   HINT: Could set up a series of funnels to test the independent affect of light (no heat), heat (no light), constant moisture (no drying), drying without heat, etc.)

Extension Activities

1. “Classroom Insect Zoo.” Have the class spend a day or two collecting insects form other sites around the school or around their homes. Ask them to bring in the animals for observation and classification. This activity can be offered to multiple classes to generate a friendly competition to see who gets the most or most varied types of insects. Winners can be awarded small “SuperFly” trophies.

2. “Taxonomy Poems.” Challenge students to compose short limericks or funny poems incorporating some of the scientific names they are learning. For example:

“The Lady Bug” by Yvette H., grade 4, Ms. Jenkins' class,

A lady who loved the garden Opera,
Belonged to the Order Coleoptera.
During intermission she quickly ate
All her many small green aphid dates
And alone she left, at half past eight.