ENTOMOLOGY

EXPLORATIONS

TGR FOUNDATION

HIGH SCHOOL

ENTOMOLOGY EXPLORATIONS

LESSON OVERVIEW

Did you know that there are over 1 million species of insects on Earth? Insects far outnumber humans and any other species of animal, and play important roles in ecosystems as pollinators, food sources and indicators of ecosystem health.

In this 3-part lesson, students will learn how insects are classified and techniques for collecting them. They will collect data about the species and numbers of insects around their school campus and use statistics to determine the Simpson's biodiversity index. Finally, they will be introduced to citizen science projects and experience how they can be powerful tools to help scientists and entomologists answer important scientific questions about insect populations around the world.

THIS LESSON FOCUSES ON

ENGINEERING DESIGN CYCLE	21ST CENTURY SKILLS
• **Defining the Problem**	• Collaboration
• **Designing Solutions**	• **Communication**
• Creating or Prototyping	• Critical Thinking
• Refine or Improve	• Creativity
• **Communicating Results**	

OBJECTIVES

Students will be able to:

- **Observe** and compare different insect and other arthropod specimens.
- **Identify** the taxonomic order that various species of insects belong to by analyzing the external structures of organisms.
- **Explain** how insect diversity is an important indicator for ecosystem health.
- **Safely** collect live insect specimens and classify these based on their physical characteristics.
- **Participate** in a citizen science project monitoring insect populations.
- **Practice** scientific inquiry in a project of their choosing that they will share with their scientific community of peers.

MATERIALS

- Insect Survey student capture sheet
- My Bug Catching Experience student capture sheet
- Teacher Resource Image: Insect Taxonomy
- Teacher Resource Image: General Insect Anatomy Diagram
- Insect catching equipment (may include nets, jars, magnifying glass, pillowcase,wire hanger, containers, forceps)

HAVE YOU EVER WONDERED...

How photos are sent from one device to another?
How many different kinds of insects are there in the world? Just step outside and look around you on any given day and chances are you'll see an insect. It's pretty incredible to learn that insects probably have the largest biomass of the all terrestrial animals. At any time, it is estimated that there are some 10 quintillion (10,000,000,000,000,000,000) individual insects alive. In the United States, the number of described species is approximately 91,000!

Why are insects important in an ecosystem? Most of us aren't too keen on the idea of finding an insect in our living rooms, or a bee flying around your picnic lunch, but insects play vital roles in ecosystems that other species depend on. Think about the average supermarket...what would it look like if there were no insect to pollinate plants? It is estimated that 86–90% of flowering plants require pollinators, such as insects, and that the global crop production from insect pollination totaled $217 billion dollars in 2008. Insects are important to everything in an ecosystem, including us, and it is important that we work to protect these insects from the challenges they face in an everchanging environment.

MAKE CONNECTIONS!

This section captures how this activity connects to different parts of our lives and frames the reason for learning.

HOW DOES THIS CONNECT TO STUDENTS?	HOW DOES THIS CONNECT TO CAREERS?	HOW DOES THIS CONNECT TO OUR WORLD?
Scientists have discovered that the populations of many species of bees in the United States are in rapid decline. By teaching students about the ecological importance of bees and other insects, and by introducing them to citizen science projects that they can be a part of, students will have the opportunity to use scientific inquiry to contribute to ongoing scientific studies on insects that live in their own backyards.	**Entomologists** in all branches of the military—Army, Navy, Air Force and Marines—protect troops from attack by insect pests, especially ones transmitting infectious diseases. **Molecular Geneticists** at agricultural companies develop disease-resistant crops and livestock. Some provide forensic analysis for law enforcement agencies. **Forensic Entomologists** focus on insects that colonize in human tissue in postmortem situations. Forensic entomology involves estimating the age of insects developing on human remains; specifically, it involves estimating the time of colonization or time when eggs or larvae are deposited on the remains and the time elapsed since insect activity began. **Formulation Chemists** design and develop new crop protection products. This includes developing fertilizers, soil conditioners and pest control methods. **Agronomists** advise farmers, research firms, government agencies and environmental organizations on soil and land management, nutrient and water needs, pest control and minimizing environmental impact.	Insects in their native habitats are key pieces to a healthy ecosystem. They function as pollinators and food sources for many other species. Insects can also decimate other species when they become invasive—when they are introduced into a new habitat by humans. It is important that students have an understanding of both of these aspects of the global impact of insects. Just as other species do, humans depend on insects for many of the food products we consume every day and the balance in natural areas that we enjoy.

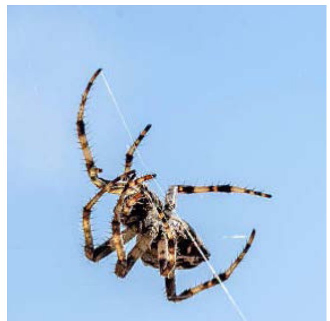
BLUEPRINT FOR DISCOVERY

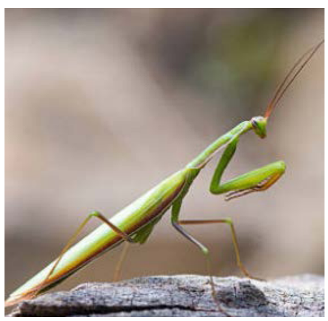
DAY 1

WHOLE GROUP (10–15 min):

1. Engage students by showing them the images below and having them answer “INSECT” or “NOT INSECT” (alternatively, you can create a slideshow or trivia game for students using online sites such as www.kahoot.com or www.quizizz.com)





*KEY: Images C, E, and G are not insects. All other images are insects.

2. Reveal to students which images are insects and which are not. Ask students what characteristics they think are used to classify an organism as a true insect. Record these as a list on the front board or overhead.

3. Play the following video clip to introduce students to the defining characteristics of an insect: Royal Entomological Society

   Add any new characteristics of insects that students think are important to the class list.

4. Show students the Teacher Resource Image: Insect Taxonomy. Explain that taxonomy is a field of study responsible for classifying organisms into groups on the basis of the characteristics they share. It is arranged as a hierarchy, where each group is larger and more inclusive as you move up the taxonomic levels. All insects are a part of the kingdom ANIMALIA and the phylum ARTHROPODA, but not all insects are in the ORDER Hymenoptera—only insects such as bees and ants are a part of this group, while flies are a in a different order, Diptera.

   In the next activity, students will be focusing on ORDERS of insects and looking at the unique characteristics that insects in each order have in common. Teachers should prepare 12 stations, one for each order, and display a preserved specimen or image at each. If insect specimens are available, place the insect on a petri dish for easy viewing at each station. This gives students a 360-degree view without having them touch the organism.

   a. Odonata: dragonfly, damselflies

   b. Orthoptera: grasshopper, locust, cricket

   c. Dermaptera: earwigs

   d. Blattodea: cockroaches

e. Isoptera: termites

f. Phthiraptera: lice

g. Hemiptera: cicadas, shield bug

h. Coleoptera: beetles

i. Siphonaptera: fleas

j. Diptera: flies

k. Lepidoptera: butterflies, moths

l. Hymenoptera

Teachers may also consider modifying this activity by having students look at virtual insect collections (http://entoplp.okstate.edu/4H-FFA/) to complete drawings on the Insect Survey student capture sheetDAY 2

SMALL GROUP (30 min):

1. Divide the class into 12 groups. Number each group from #1–12. Assign each group of students a collection of insects.

2. Distribute Insect Survey student capture sheet. Provide students 5 minutes per station, have each one draw one insect from each order and label important features and body parts. Teachers may want to display the Teacher Resource: General Insect Anatomy Diagram on the front board or have a copy at each station.

WHOLE GROUP (5 min):

3. When student groups have finished rotating between stations, have them return to their seats. Ask students to discuss and share their answers to follow-up questions:
   a. What are some common external anatomy features that each organism from Phylum Arthropoda share?
   b. Are all arthropods insects? Why or why not?

DAY 2
WHOLE GROUP (15–20 min):

1. Review the main body parts and features of arthropods and insects from the previous day with students.

2. Ask students how many different species of insects they think there are on Earth. (Scientists estimate that there are 1,000,000 known species of insects on Earth—and there are more that haven't been classified yet!)

3. Engage students by asking if they can define the term biodiversity. Break the word into "bio" and "diversity" to help students define the term.

   Optional: If students do not have background knowledge on biodiversity, show the following short video clip to introduce them to what biodiversity is and why it is important: https://www.youtube.com/watch?v=iR2AyybowPc&t=124s

   Explain to students that it is important to be able to determine the biodiversity of an area. It is not simply the total number of organisms that creates a healthy ecosystem, but also the number of different species in that ecosystem. Species fill niches, or play important roles, in their ecosystem. When species are not present in an ecosystem, it is similar to a factory without workers filling the jobs that need to be done, or a chain that is missing important links and falls apart.

4. Ask students what roles they think insects play in an ecosystem? Answers should include that they act as important pollinators for flowering plants, provide an important food source for animals, they help to aerate soil, among other things.

   *Teachers can have students explore the following webpage to learn more about why insects are important in ecosystems: https://extension.entm.purdue.edu/radicalbugs/index.php?page=importance_of_insects

5. Explain to students that data can be collected on the number of different species and the total number of plants or animals, such as insects, in an ecosystem. This information determines an area's biodiversity index, a value that represents the overall health of the ecosystem. The biodiversity index of different areas can then be compared to determine which have a higher or lower biodiversity. If there is a low biodiversity index, solutions are explored to help increase the biodiversity of an area to improve the ecosystem.

6. Insects can be important indicator species—species whose presence gives us information about the health of an ecosystem. Insects are often used to indicate the water quality in streams and rivers. For example, an insect called a stonefly requires very clean water to live in. If you find a stonefly in an aquatic ecosystem, you can infer that the water must be relatively clean.

   *Video link about stoneflies as indicators.

7. Explain to students that they will record and compare the habitats of different insects on the school campus and determine the biodiversity index based on the data they collect.

8. Demonstrate some examples of bug catching techniques to students:
   a. Swooping mechanism
   - Sweep nets are used to sweep the grass and fields for insects or to catch insects in bushes or trees. Use a wire coat hanger and form into a round loop, thread the wire through an old pillowcase and tape the ends with duct tape.

   b. Use tweezers or forceps to pick up insects and place them in a container.
   c. A variety of other insect collecting techniques are available depending on the intended species targeted.

9. Explain to students that they should use insect field guides to try to identify the order that each insect they capture is a part of, and record the number of individual insects they collect. Field guides may be available at the school or community library. Casual or citizen field guides are available online for more commonly found insect species. Some apps are available for purchase.

SMALL GROUPS (30–40 min):

1. Have students form groups. Groups should create a data table that will allow them to record the order of each bug they collect and the total number of insects collected for each order.

   Note to Teacher: This activity works better with students divided into small groups of 3 or 4. Assign each student in the group a number. Students should take turns catching insects. While one student is catching insects, the other students may work to identify previously captured insects.

2. In an outdoor area, walk around the perimeter. Have students investigate the best places to find insects (under rocks, tree bark, bushes, etc.).

3. Give student groups 20 minutes in each area to catch insects. (Teacher can determine the number of areas students will be allowed to collect in based on time and success capturing insects.) Students should identify the order of each insect they collect and add it to their data table.

   *Students should release all insects in the place they found them when finished with the insect collection portion of this lesson.

4. When students return back to class, ask them to complete the analysis questions on My Bug Catching Experience student capture sheet.

5. Have students share their answers with the class if time allows. Students will use the data they collected in their data table in the next day's activity.

DAY 3
SMALL GROUPS (15 min):

1. Ask students to get their data from the previous day's insect collection and return to their group members. Today they will be calculating the biodiversity index for the insects in the ecosystem around the school campus. At this point, it may be helpful to clarify the difference between biodiversity and biomass with students. Biodiversity is the variety of living organisms on Earth and in ecosystems. Biomass is the amount of living matter in an ecosystem.

2. Project the formula for the Simpson's Diversity Index and the variables on the front screen or write it on the front board.

   SIMPSON'S INDEX OF DIVERSITY FORMULA:

   $$D=1-\left(\frac{\sum n(n-1)}{N(N-1)}\right)$$

   D = DIVERSITY
   N = TOTAL NUMBER OF ALL INDIVIDUALS PRESENT (all species/orders combined)
   n = NUMBER OF INDIVIDUALS OF A PARTICULAR SPECIES
   Σ= THE SUM OF
   0 = LOW DIVERSITY
   1 = HIGH DIVERSITY
   Therefore, the closer to 1, the higher the diversity is.
   *Helpful tutorial on calculating Simpson's Diversity Index.

3. Ask students to work with their insect collection groups to use their data and the Simpson's Index of Diversity formula to calculate the diversity value. If students do not have much data, this can be done with class data to get a larger sample size.

4. Compare the diversity index of the various groups to see if they are similar, or if doing class data, have students check to see if they have calculated the Simpson's Diversity Index correctly. Ask students what this tells them about the ecosystem near the school campus.

5. Have students come back to their desks for the next activity.

WHOLE GROUP (40–45 min)

1. Engage students by asking if they have ever heard of citizen science. Ask students to share their ideas of what citizen science might be.

2. Ask students to go to the following link on their device, or project and read the short article to students about the decline of bees: http://time.com/4688417/north-american-bee-population-extinction/

3. Explain to the class that to come to this conclusion, scientists needed to collect massive amounts of data that help them determine the populations of species of bees in North America and to have evidence to support their conclusion. How can this be achieved? (Ask them to think about the growing role of technology in scientific research and data collection. Do they ever observe bees? Assuming they do, how could they help these scientists collect the data that they need?)

   Display or share the Fast Fact about citizen science with students:

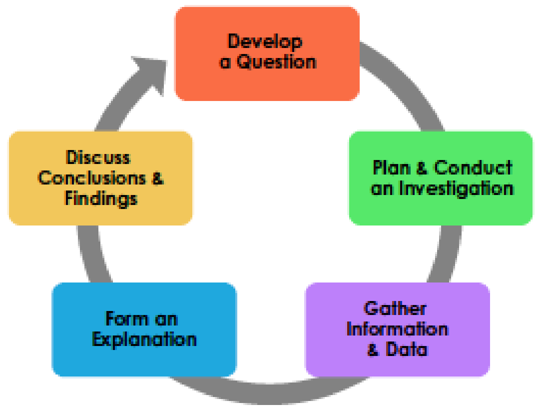
FAST FACTS
Citizen science is the involvement of the public in scientific research—whether community-driven research or global investigations. Citizen science mobilizes the public to participate in the scientific process to address problems. This can include identifying research questions, collecting and analyzing data, making new discoveries, and developing technologies and applications.

4. Explain to students that as a capstone to this lesson, they will explore citizen science opportunities and select an insect of study. They will design and carry out an inquiry-based investigation based on their citizen science project.

5. Present the following links to students:
   https://entomologytoday.org/tag/citizen-science/
   https://scistarter.com/
   http://pbskids.org/scigirls/citizen-science

They should take some time to look at some of the available citizen science projects pertaining to insects and choose one citizen science project to participate in.
*Students may have to create an account or sign up for their chosen study.

CYCLE OF SCIENTIFIC INQUIRY



6. Display the Cycle of Scientific Inquiry for students.
7. Ask students to create a document (on paper or on a device) that includes a section for each of the headings from the Cycle of Scientific Inquiry. They should begin with the QUESTION SECTION. In this section, students should also add a place to write their HYPOTHESIS/PREDICTION, which is where they will write what they think the answer to their question is. This should be followed by a section where they describe their INVESTIGATION/EXPERIMENT. What steps are they following to answer their question. This should mention their use of their citizen science platform/study and how data is collected (by observation? by fieldwork?). The next section should be their DATA section. This will include a data table and any data they can collect from their chosen citizen science project.

   After the DATA section, students should create a section title CONCLUSION or EXPLANATION. In this section, students should explain what their data shows them. They should determine if their hypothesis was correct based on the data, and what further questions this conclusion leads them to.

   Example activities could include:

   - students differentiate between the six species of crickets and katydids and map occurrence in a select region
   - understand the diversity of insects and microbes on cucurbit plants (melons, squash, cucumbers)
   - protect berries from invasive Spotted Wing Drosophila
   - use tree leaves and aquatic insects to determine stream health

8. Give students time either in or out of class (determined by the teacher) to collect data and complete the cycle of Scientific Inquiry but adding to their document.
9. Have students create slide presentations to share their findings with the class or demonstrate how they submitted their data.

TAKE ACTION!

As an extension to this activity, students could research the impact that invasive species of insects have had on ecosystems. (Examples include the emerald ash borer, the Asian lady beetle and the Africanized honey bee.) Students could then create a wanted poster, infographic, or a logo and campaign slogan that could help inform the public about the dangers of invasive species on native plants and animals.

NATIONAL STANDARDS

Next Generation Science Standards

MIDDLE SCHOOL

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
Using Mathematics and Computational Thinking Use mathematical representations to support scientific conclusions and design solutions.	**LS2.C: Ecosystem Dynamics, Functioning, and Resilience** Biodiversity describes the variety of species found in Earth's terrestrial and oceanic ecosystems. The completeness or integrity of an ecosystem's biodiversity is often used as a measure of its health.	**Stability and Change** Small changes in one part of a system might cause large changes in another part.

HIGH SCHOOL

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
Using Mathematics and Computational Thinking Use mathematical and/or computational representations of phenomena or design solutions to support explanations.	**LS2.C: Ecosystem Dynamics, Functioning, and Resilience** A complex set of interactions within an ecosystem can keep its numbers and types of organisms relatively constant over long periods of time under stable conditions. If a modest biological or physical disturbance to an ecosystem occurs, it may return to its more or less original status a(i.e., the ecosystem is resilient), as opposed to becoming a very different ecosystem. Extreme fluctuations in conditions or the size of any population, however, can challenge the functioning of ecosystems in terms of resources and habitat availability.	**Cause and Effect** Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects.

Common Core State Standards: Math

CCSS.MATH.CONTENT.7.EE.B.4
Use variables to represent quantities in a real-world or mathematical problem, and construct simple equations and inequalities to solve problems by reasoning about the quantities.

CCSS.MATH.CONTENT.HSA.REI.A.1
Explain each step in solving a simple equation as following from the equality of numbers asserted at the previous step, starting from the assumption that the original equation has a solution. Construct a viable argument to justify a solution method.

RECOMMENDED LINKS:

http://entoplp.okstate.edu/4H-FFA/

http://blogs.discovermagazine.com/citizen-science-salon/2015/05/07/like-bugs-insects-here-are-six-citizen-scienceprojects-for-you/#.WgJlxxNSx-U

http://www.ourhabitatgarden.org/act/insects.html

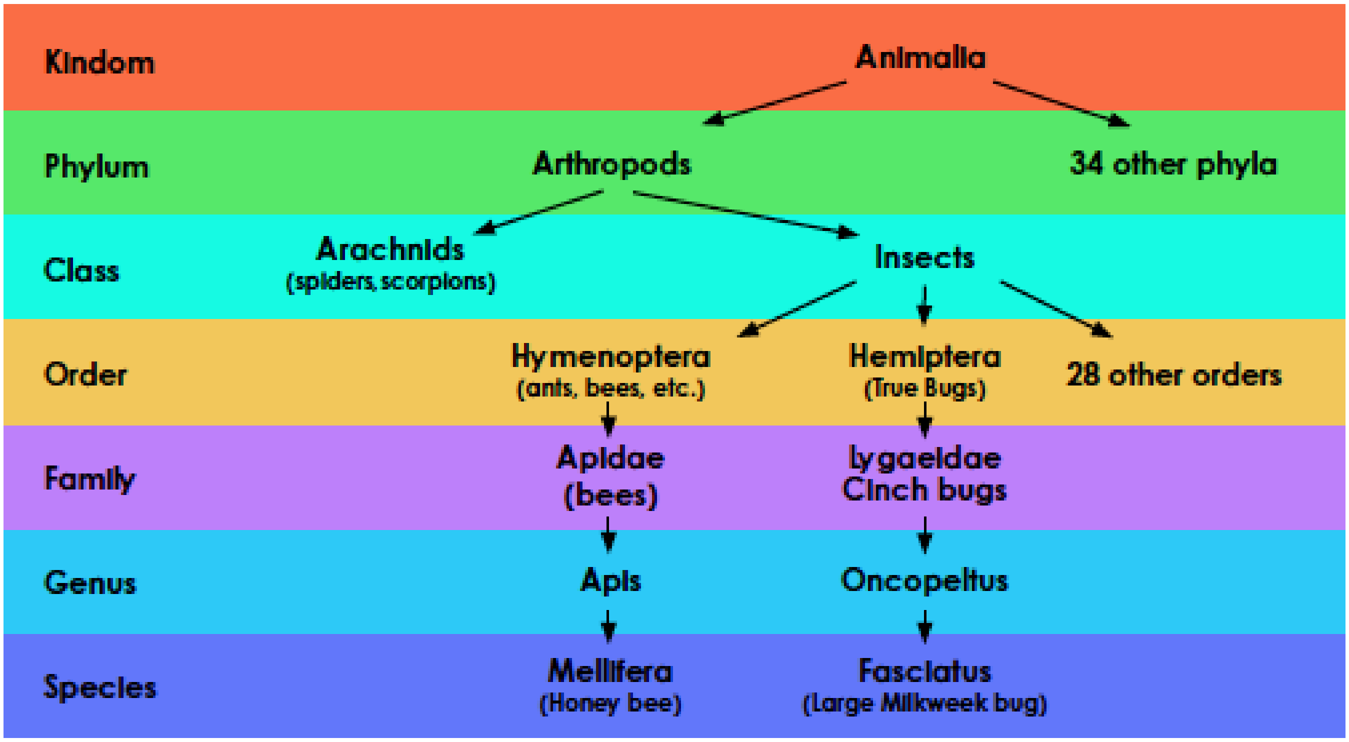
https://entomologytoday.org/2013/11/04/using-citizen-science-to-track-insects-across-the-u-s/

https://www.epa.gov/citizen-science/what-citizen-science

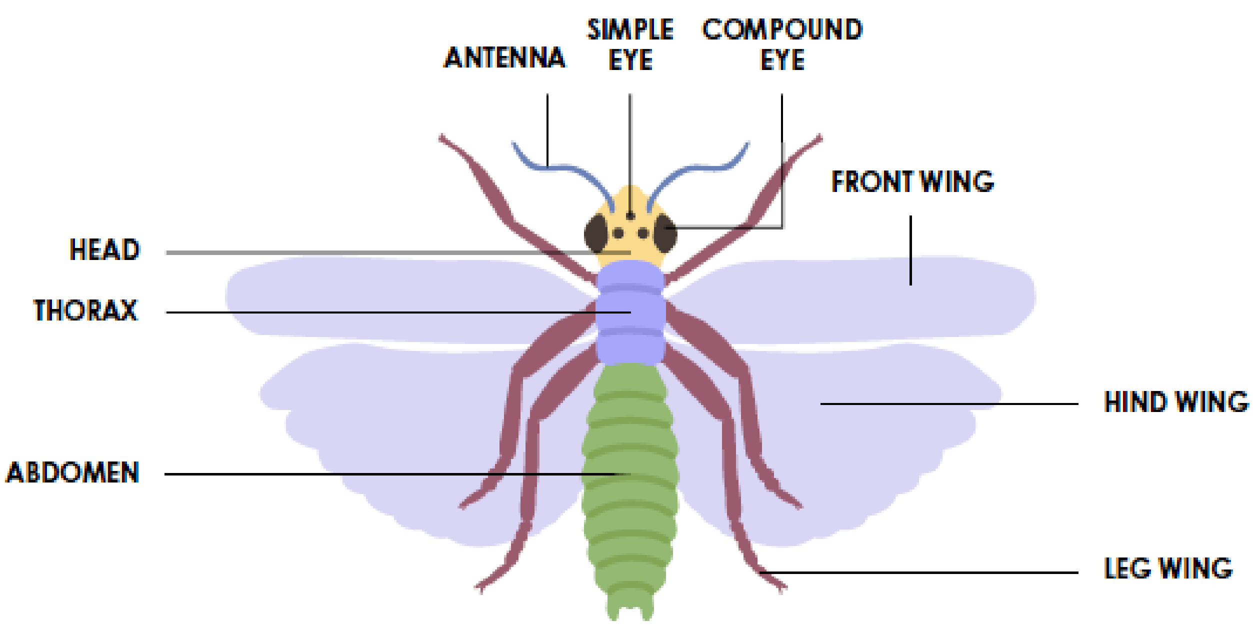
https://www.si.edu/spotlight/buginfo/bugnos

https://www.epa.gov/sites/production/files/2016-08/documents/vicki_wojcik_6-23-16.pdf

TEACHER RESOURCE IMAGE: INSECT TAXONOMY



TEACHER RESOURCE IMAGE: GENERAL INSECT ANATOMY DIAGRAM



INSECT SURVEY STUDENT CAPTURE SHEET

1. Odonata	2. Orthoptera
3. Dermaptera	4. Blattodea
5. Isoptera	6. Phthiraptera
7. Hemiptera	8. Coleoptera
9. Siphonaptera	10. Diptera
11. Lepidoptera	12. Hymonoptera

MY BUG CATCHING EXPERIENCE STUDENT CAPTURE SHEET

What were some of the techniques used in catching bugs?
Describe the environment:
What would be the best time of activity and temperature to catch bugs?
What types of bugs did you catch?
How was your overall experience?