Santa Cruz-Watsonville Inquiry-Based Learning in Environmental Sciences
An NSF GK-12 Project

Observing Animals

Organizing and recording observations on the animals all around us

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Field-tested with: 10th grade students in Agriculture and Natural Resource Courses, ESNR Academy, Watsonville High School, Watsonville, CA (Fall, 2011)

Concepts: Recording observations, making scientific observations, organizing observations, insect biology, taxonomic grouping, insect external morphology.

Skills: Scientific illustration, microscope use, note-taking, drawing for accuracy.

Module Type: Classroom activity, with worksheets, discussion, and post-activity presentation.

Duration: 1 2-hour class period

Key materials:

- Class sets of all handouts:
  - animal observation worksheet
  - glossary worksheet
- Insect features presentation/ lecture (see template)
- Small six-specimen insect collections (one per group).
- Hand lenses/ magnifying glasses/ dissecting microscopes (one per group)

Science Education Standards:

National: Science As Inquiry; Life Science, Science in Personal and Social perspectives, History and Nature of Science, Investigation and Experimentation

California: Investigation and experimentation

Overview: This project encourages students to think about how they recognize and classify things they observe in nature, using local insects as a model. Students are asked to identify insects from their area and to think about how exactly they are able to tell them apart. They draw the insects, list any names they might know for them, and learn what defines them as insects. In the process, they learn the basics of insect biology and how to make meaningful scientific observations about the natural world.

Background for Teachers

Organizing the Insects around Us

One important aspect of being a scientist is being observant. Good scientists must also be able to quantify and organize their observations well in order to obtain the best possible insights from their observations. Most people (including high school students) know the names of common insects and may be able to tell them apart. Such skills are in fact the basis for the higher-level observations used by taxonomists (people who name and classify organisms) and entomologists (people who study insects). This module includes activities to link student's native conceptual skills to the scientific work done by these professionals by having them define, draw, and compare structures in insects they are likely already familiar with.

Insects are one of several classes of arthropods (literally "jointed-feet"), and Arthropoda is a phylum of animals whose most notable feature are the jointed exoskeletons that they all have. Though insects and many other arthropods are often just "bugs" to the casual observer, there are actually several criteria that unite and define insects. The criteria used to classify insects as a cohesive group are a result of their common evolutionary history. That is to say that all insects have a common ancestor that unites them.

In the present day, this shared evolutionary history provides a practical convenience in that we can group living insects together based on their shared characteristics. Specifically, there are six morphological characteristics that all insects have:

- Exoskeletons
- Three-part bodies (Head, Thorax, Abdomen)
- Legs with *joints*
- Three pairs of legs (six)
- Compound eyes
- One pair of antennae (two)

In addition, all insects undergo some type of metamorphosis. Metamorphosis is defined as a major change in body shape. In insects, there are two basic kinds: **Hemimetabolous** metamorphosis, or "incomplete" metamorphosis, where young insects look like smaller versions of adults without wings; and **Holometabolous** where young are worm-like in appearance (larvae), have a pupal stage, and emerge from pupae as adults with significantly different body shapes. Perhaps the most widely known example of this is the order Lepidoptera (butterflies and moths), where caterpillars are larvae, cocoons are pupae, and butterflies are the adults.

To do this exercise, teachers will need to do two things:

- Create small insect collections using local insects (4-6 insects for each collection, one collection for each group of insects).
- Create a slide-show or other presentation explaining the basic features of insects, following the template provided.

The insects used in the original activity (and recommended for future attempts) are the following:

- Ladybird beetle, aka ladybug (or any beetle)
- Grasshopper/cricket (or any orthopteran)
- Housefly (or any fly e.g., mosquito)
- Moth or butterfly
- Dragonfly or damselfly
- Bumble bee (or any wasp, bee, or ant)

These insects were chosen because they all represent distinct orders in the class Insecta and they are common insects that may be familiar to students.

Perhaps the most difficult part of this activity for teachers will be preparing the demo collections. The uninitiated teacher will have to purchase or create all the necessary supplies needed to pin and collect the insects, in addition to collecting the correct insects in sufficient numbers to generate one demo collection for each small group of students.

An easier option, and the option we used for this project, is to contact the natural history museum or entomology department of a local university. Often undergraduates donate their collections after finishing an entomology course, and in our experience, universities are very willing to lend these collections. These collections typically have plenty of the common insects you will need for our purposes. In our case we borrowed six of each of the following:

- Houseflies (*Musca domestica*)
- Ladybird beetles AKA ladybugs (family Coccinellidae)
- Grasshoppers (subfamily Oedipodinae)
- Common buckeyes (*Junonia coenia*) (butterfly)
- Bumblebees (genus *Bombus*)
- Green darners (dragonflies, family Aeshnidae)

Science Education Standards Addressed

This module focuses on recognizing and recording the features and taxonomic names of insects, and addresses NSES standards A. Science As Inquiry (p176), C. Life Science: organization in living systems (pp.181-187), G. History and Nature of Science: Science

as a human endeavor (pp. 200-201), Nature of scientific knowledge (p201), and the following SCSCPS content standards:

Biology-Life Sciences; Investigation and Experimentation (p61)

a. Select and use appropriate tools and technology (such as computer-linked probes, spreadsheets, and graphing calculators) to perform tests, collect data, analyze relationships, and display data.

k. Recognize the cumulative nature of scientific evidence.

(NSES (http://www.nap.edu/catalog/4962.html;
SCSCPS (http://www.cde.ca.gov/be/st/ss/documents/sciencestnd.pdf)

Common Student Misconceptions/Notes to Teachers

Students often have strong feelings about insects, but these can be rapidly replaced by fascination with something as simple as a hand lens or dissecting microscope. One great way to jump-start student interest is to get them to compare structures among the different insects. For instance, using a brush-footed butterfly (family Nymphalidae, very common), remind students that all insects have 6 feet and ask them how many they see. Hopefully they will notice the reduced vestigial forelimbs that characterize this family.

Students often think insects are harmful or dangerous, but most are not. For example, in our classes, many students were convinced that Jerusalem crickets (Order: Orthoptera Family: Stenopelmatidae Genus: *Stenopelmatus)* were venomous and that it was dangerous to handle them.

Students often think spiders are insects.

Emphasize the fragility of pinned specimens to students, especially if the collections are borrowed!! Demonstrate good technique for removing pins, replacing pins and passing pins to each other.

Project Description

In this project students will extend their own innate knowledge for categorizing things into a tool for organizing scientific observations in the natural world using insects as a model. Students will become familiar with basic external anatomy of insects and what characteristics are typically used to identify insects.

This activity can be done on its own, but was originally intended as part one of a three-part module on collecting and identifying insects. Thus it can also be used as a

precursor to modules in which students also learn how to use dichotomous keys and how to make one themselves, how to collect their own insects and prepare them for identification, and finally, how to use the taxonomic information they discover to prepare reports on the general biology of a particular insect species.

Materials

- 1 prepared specimen collection for each group of students (2-4 students per group recommended):
  - Insect collection boxes
  - Insect pins
  - Six unique common insects for each group of students (ideally each group will get the same six insects)
  - Paper labels A-F to anonymously label the pinned insects
- Hand lenses/ magnifying glasses/ dissecting microscopes (one per group)
- Animal observation worksheet (1 per student)
- Insect features presentation presentation, "What Is An Insect?" (see attached template)
- Glossary worksheet (1 per student)

Preparation

-Prepare demo insect collections. The details and nuances of collecting and preparing an insect collection are beyond the scope of this module, but there are many resources available on the Internet. I recommend "how to start a proper insect collection" at http://bugguide.net/node/view/36900 Otherwise, as suggested before, contact a local university about obtaining pre-prepared specimens.
The goal is to create X number of identical collections where X = the number of student groups you intend to do this activity at once. Once you have the collections, hide the actual taxonomic information and put a letter code on each pin. There is a template sheet of letters included in this module.

-Prepare brief lecture on insect morphology using presentation template provided, "What Is an Insect?". Please contact the author, Joe Sapp, for a sample presentation, which is not included here for copyright reasons. Plentiful photos and illustrations are available on the Internet to populate the template, which can be used in your classroom.

-Print copies of the "Glossary worksheet" and the "Animal Observation Worksheet" for each student in the class.

Timeline

Time needed: 2 hours

What are these animals?
1. Intro talk (5 minutes)
2. Student activity: Animal Observation Worksheet (1 hour 5 minutes).
3. Classroom sharing of observations (20 minutes)

What is an insect? (20 minutes total)
1. Brainstorming review
2. interactive presentation ("What is an Insect?") & filling out glossary

Procedure

What are these animals?

1. Intro talk. (*Note that this activity tries to avoid using the term "insect" in order to see if students know it and know what it means. Thus, the specimens are simply referred to as "animals" at first.*)

   Tell students, "A big part of science is simple observing and organizing the information in the world around us. In this unit, we're going to teach ourselves how to do this. Before we begin, I am curious to see how much you already know about the subject. To do this, we're going to break into small groups and examine some ***animal*** specimens. I want each person to fill out the worksheet on their own. Remember, there are no wrong answers here, but it is important that everyone participates and completes their OWN worksheet. When you are done, we are going to organize and share our observations so we can compare what we observed with what the scientific community knows about these ***animals***." (5 minutes)

2. Activity: Observation and Worksheet.
   a. Break students into groups of no more than four to work on the Intro animal observation worksheet. Hand out work sheet, insect demo collections, and magnifying glasses. (5 minutes)
   b. Walk through the worksheet with the students (10 minutes)
   c. Each student completes worksheet. (50 minutes)

   Teacher and any assistants float between student groups and facilitate completion of the worksheet. It may be especially important to prompt and guide students who are stuck on question 3 and 4 with examples of insect characteristics and differences.

3. Classroom Sharing of Observations

   a. Teacher tallies student responses (10 minutes). Make a chart on the board with several columns: Animal #, Names, Characteristics, illustration
   b. Teacher draws first insect (to break the ice/lower the bar). Teacher records all the different names students have for each insect, adds some of his/her own, and lists the scientific name. Teacher records list of characteristics for each insect. Encourage students to replicate chart in their notebooks.
   c. Once chart is complete, teacher circles the shared characteristics between the organisms.
   d. Teacher leads quick class discussion to the last part of question #1: hopefully most students identified the group as "insects" or "bugs". Other answers are fine and are a nice spring board into a discussion about the utility of and/or problems with common names versus scientific names. (Common names are never wrong, which can be good or bad. Scientific names can be hard to learn but are the universal standard and as such are the keys to all the information that is known about an organism.)

What is an insect? (20 minutes total)

1. Brainstorming Review.

   The Teacher poses this simple question to the class, possibly writing it on the board:

   "What is an insect?"

   Teacher facilitates discussion with students and asks several follow up questions as necessary:

   "What do we know about them already?" (write facts on board)

   "How many different kinds of insects can we name?" (write names on board)

   "How do we tell them apart from each other?"

   Ask students what body parts insects have. Try to get a list that includes:

   i. Legs (how many?)
   ii. Wings (how many?)
   iii. Eyes (how many? What kinds?)
   iv. Body parts: head, thorax (middle), abdomen, (end)
   v. Antennae (how many?)

2. Power Point & Glossary.

Hand out Glossary.

Using the Power Point presentation "What Is an Insect?" created from the template provided, Teacher leads discussion on what insects are. Prompt students to use the presentation to fill out their glossary worksheets as all the terms in the glossary will be used during the presentation.

Starting Point For Inquiry: The inquiry in this activity comes from connecting existing student skills and knowledge with specific scientific facts and techniques. Students are guided to start with their background knowledge of insects and their observational skills (including drawing) and connect them to scientific names and the characteristics that define class Insecta.

Analyzing and Presenting Final Results:

Students are both asked to share their results with the class on the board and to record these combined results in their lab notebooks. They also fill out two worksheets (glossary and animal observation worksheet) that can be reviewed by the teacher or by their peers.

Assessment Methods

There are many opportunities for pre- and post activity assessment built into this activity. The pre-assessments include asking the students to name insects "in their own words" using any common names they may know (in any language!), the entire animal observation worksheet, the class-generated compiled table on their observations, and the introductory discussions on what is an insect. Post assessment is done through the "introduction to insects" presentation which is interactive and mostly composed of questions that assess student understanding.

Appendices

1) **Animal observation worksheet**
2) **Glossary worksheet**
3) **Anonymous labels for insect collection**
4) **Template presentation (separate Powerpoint file)**