Santa Cruz-Watsonville Inquiry-Based Learning in Environmental Sciences

An NSF GK-12 Project

Observing, Recording, & Inquiring

Scientific Drawing Module

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Field-tested with: the 10th-12th -grade students of Marine Biology, Environmental Science and Natural Resources Academy Watsonville High School, Watsonville, California, Fall 2010 and Winter 2011.

Concepts: Morphology, trait variation (within and among species)

Skills: Careful observation and generating scientific questions; recording scientific information through drawing and accompanying descriptive notes.

Module Type: Discussion and Activity

Duration: 75-minute class session

Key materials:

- Pencils and unlined paper
- Rulers
- Organisms to draw
- 3-page handout with background text and activity instructions (included here)

Helpful resources:

- Powerpoint slide show with sample scientific drawings (range of ability)
- Field guides, organismal texts, or internet access to research names of anatomical structures for correct labeling and follow-up on questions

Science Education Standards:

National: Science As Inquiry; Science and Technology

Overview: In this 1-day module, students learn about the importance of recording scientific information through detailed, realistic illustrations. Students gain experience through several approaches to scientific illustration, including detailed drawings of preserved specimens and quick sketches of moving animals. They also learn about trait variation through drawings that compare different individuals of the same species. The module aims to make recording scientific information and creating scientific artwork accessible to those without an extensive background in either science or art.

This project is an opportunity for students to:

- Develop their observational skills through creating detailed, realistic scientific illustrations
- Learn about the importance of recording scientific information
- Research the basic anatomy of a focal organism and develop questions based on their observations

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For more information, see: http://scwibles.ucsc.edu

Background for Teachers

This scientific drawing module helps students develop their observation skills, learn about the importance of recording scientific information, and gain confidence in creating scientific illustrations. In addition to gaining practice in creating detailed, realistic, scientific illustrations, they will learn to label key features of the organisms, study variation within and among species, and develop questions based on their observations of organisms' traits.

Science Education Standards Addressed:

National Science Education Content Standards A-G: Grades 9-12

A. Science as Inquiry (pp. 173-176)

Understandings about scientific inquiry (p 176)

- Scientists usually inquire about how physical, living, or designed systems function. Conceptual principles and knowledge guide scientific inquiries. Historical and current scientific knowledge influence the design and interpretation of investigations and the evaluation of proposed explanations made by other scientists.

E. Science and Technology (pp. 190- 193)

Understandings about science and technology (p 192)

- Creativity, imagination, and a good knowledge base are all required in the work of science and engineering.

NSES (http://www.nap.edu/catalog/4962.html)

Project Description

Materials:

- Pencils and unlined paper
- Rulers
- Organisms to draw (preserved specimens for Part I; living species can be used for Part 2)
- Lab handouts with background information to read and activity instructions (included in module Appendix)

Timeline:

1. Slideshow -5 minutes
2. Discussion- 5 minutes
3. Read Introduction to lab, "Using Drawing to Observe and Record Scientific Information," (page 1 of handout) and instructions for Methods, Part 1 of lab - 10 minutes
4. Students carry out methods in first part of lab- 30 minutes
5. Read instructions for Methods, Part 2 of lab in handout- 5 minutes
6. Students carry out methods in second part of the lab- 20 minutes

Procedure:

1. Slideshow -5 minutes

Instructor should prepare a Powerpoint presentation with examples of scientific illustrations. Include illustrations that demonstrate a range of skill, so they do not necessarily feel like they have to draw like a professional illustrator to make meaningful scientific drawings. While the instructor goes through the slides, have students write down words that they think describe scientific drawing.

2. Discussion- 5 minutes

Instructor can encourage a class discussion by posing the following questions to the class:

- *"What are the differences between scientific drawing and other artwork?"*

  Ask them about the adjectives that they brainstormed that describe scientific drawing (e.g., realistic, detailed, proportional, beautiful, informative).

  Discuss how the goal of scientific drawing is to represent what you see before you, including details that people wouldn't otherwise notice. While the drawing can be larger or small than life-sized, scientific drawing requires that everything remains proportional (so the head would still be the same size relative to the body even if the organism is overall magnified in the drawing).

  Discuss how a good scientific illustration should allow someone to identify the organism if they come across it while walking along the beach or taking a hike.

In other artwork, the artist does not necessarily represent what they see. While both scientific illustration and other types of art are valuable, scientific drawing has the purpose of helping you identify and observe.

- *"Where might you see a scientific illustration?"*

Textbooks, scientific journals, students' reports, personal journals, field guides. The instructor can bring in field guides for the students to look through.

- *"Who do you think does scientific illustrations?"*

For publications, sometimes artists with training in sciences do the illustrations; other times the scientists do the illustrations themselves. But there is a long tradition and great value to scientists recording their observations in the field by drawing. Scientific drawing is one way to be better observers, to record what we have seen, and communicate to others.

3. Read Introduction and Instructions for the first part of lab- 10 minutes

Discuss how to keep correct proportions in scientific illustrations. Demonstrate how to measure an organism and then draw it within a rectangle to help preserve proportions. The rectangle, for example, can be twice as big as the organism and divided up into different sections for the head and body (see worksheet for instructions).

Ask the students how they would indicate scale on the drawing. Then demonstrate how they can either draw a scale line or indicate how much the drawing is magnified on the paper.

Then let them know they have half an hour to do the first section of the worksheet.

4. Students carry out methods in first part of lab- 30 minutes
5. Read Instructions for second part of lab- 5 minutes
6. Students carry out methods in second part of the lab- 20 minutes

Assessment Methods:

The teacher can evaluate the final product. See rubric under Assessment Materials in Appendices for a suggested evaluation approach.

Teachers' Notes for Assessing Students Drawing

(inspired by John Muir Laws' curriculum; see http://www.johnmuirlaws.com/cnps-curriculum)

Emphasize that the goal of scientific drawing is not to produce pretty pictures but to accurately observe and record data. If the focus is on drawing pretty pictures, then the inner critic can make drawing intimidating. If instead the goal is to comprehensively, clearly, and accurately observe and record observations, then the pressure of producing art is lifted and the student can instead focus on making and recording observations.

Avoid saying to a student, or writing on their scientific illustration, "That looks great!" It might indicate to them that you were insincere when you stated that the activity was not to produce pretty pictures. Positive reinforcement should be given in a way that advances the curriculum, particularly with feedback that highlights the students' observations and recordings. Keep the emphasis on the accuracy and completeness of students' illustrative and written recording of their observations. Comment on points such as their inclusion of date, location, time, and weather information, size or scale information, color notes, multiple views of the same subject, or observations on the behavior or interactions with other species.

Do say or write on their drawing:

"Your written observations describing this crab are very clear."

"I see that you measured the fish's head and kept the proportions accurate in your illustrations."

"It's very helpful that you included a scale."

"You captured very well the patterns of this shell in your illustration. Maybe you can add some notes on coloration?"

Appendices

1. Glossary

Field guide- an illustrated book for the identification of animals and plants in nature

Morphology- the branch of biology that deals with the form and structure of organisms, including aspects of their appearance (shape, color, pattern)

Taxonomy- the branch of science concerned with the classification of organisms; it is focused on identifying, grouping, and naming organisms according to how related they are or evolutionary relationships.

2. Lab Handout Using Drawing to Observe and Record Scientific Information, 3 pp (see next page for printable handout)

3. Assessment Rubric (see page 10)

Using Drawing to Observe and Record Scientific Information

Materials: Unlined paper, a sharp pencil, a ruler, subjects to draw.

Introduction: Species have different **morphologies** (how they look) and we can often learn about the function of morphological characteristics by studying their form. People who look casually at the world often do not see the details that are in front of them. For example, while you might recognize the familiar robin, have you looked closely enough to notice the ring around the robin's eye? A scientist must look closely and recognize subtle differences between species and individuals. Even if you do notice these details, they can slip easily from the mind.

When you draw, you are inspired to notice the distinguishing features of that subject. The purpose of a scientific illustration is to improve your observational skills and record information that you can then consult in the future. Scientific illustrations can also help someone else locate and identify a specific type of animal or plant. In **field guides** (books that help people identify plants or animals), scientific illustrations can be more helpful than photographs when it comes to showing the key features of an organism.

Everyone can create informative scientific illustrations, even if they don't think they can draw. While drawing is a skill that can be improved with practice, what is most important for scientific illustrations is that you are making accurate and detailed drawings and improving your knowledge of the subject.

Each scientific discipline has a traditional way of representing specimens. The angle of the drawing typically depends on the scientific discipline or the preferences of the illustrator or scientist. For example, for **taxonomic** illustrations (illustrations that describe and group species based on their features and origin), animals are often drawn facing left. If the illustration is going to be published, then the illustrator might be asked not to use shading or coloring. Instead they might indicate a darker area or pattern on a species by the stippling technique (a technique that uses a series of small dots to create the effect of shading or patterns). Sometimes all that is required for a scientific illustration is a general body form, and too much surface detail might be distracting. In other cases, a certain part of the subject might need to be intricately detailed. Today you are the illustrator and you decide your preference. What is most important is that you construct scaled and appropriately labeled drawings to communicate scientific knowledge about the organism.

We will practice several ways of drawing. The most successful scientific illustrators are ones who emphasize practice and concentration. Make sure to keep all your sketches.

Methods Part I (25 minutes in total)

Observation

1. Chose a specimen that you would like to draw that is either in the plastic molds or jars (avoid a live, moving animal). Spend about three minutes, with your pencils down, observing the organism. Look at it close up, at arm's length, from different angles. What might the organism share with related species? What might be unique to this species? Is the organism bilaterally symmetrical (i.e., the organism can be divided into two halves that are mirror images of each other)? What do you think the species eats? How do you think it eats it? Write down at least one question that results from your observations.

Contour Drawing

Now you will make several contour drawings to warm up and become familiar with your subject.

2. Move your eyes over the subject slowly and use your pencil to draw what your eye is seeing. Do not look at your paper as you are drawing. Remember to use your pencil to make large drawing motions, rather than small writing motions.

Detailed Drawing

Now you will spend about 10 minutes drawing your subject as closely and accurately as possible.

3. Place the subject in an area that minimizes the movement of your head when glancing from the subject back to your paper. This helps keep your angle of view similar throughout the whole drawing process.

4. Draw big! Your diagram should be at least ½ page in size. Leave space to add captions and labels.

5. Using your ruler and a pencil, lightly draw a rectangle that you will fit your subject into. For example, if your subject is 50mm long and you would like to enlarge it by a factor of 3, then mark off 150mm on your piece of paper. If your subject is 30mm wide, then mark off 90mm. If the animal is bilaterally symmetrical, you can then add a line to bisect the rectangle you just drew.

6. Now draw an outline of the main structures within the rectangle that you just drew. Try to capture the basic shape, posture, proportions and distances between lines rather than focusing on the details.

7. Now you can start to add details to your drawing. Remember to count important structures and make sure that your drawing has the same number of structures.

8. Include a scale bar or the degree of magnification in your drawing.

9. On the back of your paper write your name, date, location, and the species identity.

10. Remember to include written observations. For example, add notes on coloration or distinguishing features.

11. Label the structures on your subject, using your ruler to draw the lines to different structures. You can check with your instructor or do some independent research in books or on the internet on basic anatomy and terminology.

Methods Part II (15 minutes)

For Part II, you can chose to do either a gesture drawing of something that is moving (i.e., in the classroom tank) or compare and draw individuals of the same species

a) Gesture Drawing.
Sometimes you will need to be able to find an overall shape and draw quickly. Gesture drawings are quick impressions of what you have seen. They are important when sketching in the field, particularly of an animal that is moving fast. Move the pencil quickly, loosely, and lightly to help get down the basic shape. Do not erase lines you have drawn, but accent the lines that you like (i.e., draw them darker). Don't worry about details or even finishing a drawing. Try this with the animal in several positions. Write notes on the side of the page with your observations.

b) Comparing Individuals of the same Species. Due to environmental and genetic factors, two individuals rarely look exactly alike. We are used to noticing differences in appearance between individual humans. Just as people vary, there is also variability within other species; we just have to train our eyes to see these differences. For this exercise find two individuals of the same species and draw a quick sketch of them side-by-side, trying to keep proportions accurate. What appears to be common across individuals and should be captured in a scientific illustration that represents that species? What characteristics might vary among individuals of the same species? You will have to look carefully, because these differences are likely very subtle. Write notes on the side of the page with your observations.

Assessment

Name:
Date:

Contour Drawing

____ Sketches (1 point)

Detailed Drawing

____Likeness of object (2 point)

____Notes and descriptions (1 point)

____Detail of interesting part (1 point)

____Color or notes about color (1 point)

____Identified species sketched (1 point)

____ Inclusion of a question (1)

____Inclusion of scale or indicate magnification (1 point)

____Inclusion of information, such as date and location, on back of the paper (1 point)

____Label parts (1 point)- *extra credit*

Total points received: _____

Total points possible: 10

Adapted from a rubric developed by Lorie Topinka, Assistant Director of Education at the California Academy of Sciences.

Reference List

Laws, J.M. (2011). *Opening the World Through Nature Journaling: California Native Plant Society Curriculum* http://www.johnmuirlaws.com/cnps-curriculum

Nature Watch (2002). *Scientific Diagram.* http://www.naturewatch.ca/english/wormwatch/resources/drawing.html

MaKarrell, R. (2007). *Introduction to Scientific Illustration Lesson Plan for 7th grade Life Science.*

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Hodges, E.R.S**.** (2003). *The guild handbook of scientific illustration.* (Wiley).