Structure and Function

Synopsis

Students choose some biological object, examine its structure, and identify or speculate on one particular function. Next they create a blueprint of the object, focusing on the particular function. Then they create an abstraction of the object, and finally, create a piece of art based on the object.

Objectives

This exercise teaches students to use observation skills more rigorously than they are probably accustomed to doing, and to use these observations to make hypotheses about the function of a biological object. After doing this exercise, students should be able to demonstrate the following abilities necessary to do scientific inquiry as described in the *NSES Content Standard A (Science as Inquiry)* for levels 5-8:

- develop descriptions, explanations, and predictions using evidence,
- recognize and analyze alternative explanations and predictions, and
- think critically and logically to develop the relationship between evidence and explanation.

In addition, students should be able to describe examples of the relationship between structure and function in living systems, particularly with regard to specialized tissues and organs, which is an objective of the *NSES Content Standard C (Life Science)* for levels 5-8.

Introduction

Virtually every structure in plants and animals has one or more functions: chloroplasts and leaves are specialized to perform photosynthesis, muscles contract, eyes see, roots anchor the plant and suck up water and dissolved nutrients from the soil. The same can be said for things made by humans: spark plugs spark, tires roll, pots hold liquids and solids, ribbons tie and decorate, nylon makes fishing line, tennis racquets, and non-iron shirts. (Interestingly, geological and astronomical structures are not usually thought of in this way. Why do you suppose this is so?).

In biology, the structure and its function have come to be the useful unit to study. The best units to illustrate the application of simple physical principles are structure-function units. We will start by looking at structures whose function we know and seeing just how the structure is suited to its function(s). The intent of the three exercises outlined below is to lead students stepwise from pure science to pure art. We hope that having three sequential exercises will reinforce the students' learning and remembering. However, it is possible that students will get tired of their objects. Eliminating *Exercise #2 or #3* is certainly an option.

Procedures

Exercise #1:

1. Students are asked to obtain a biological object from nature or a supermarket or anywhere they can

find it.

2. They are then asked to make a blueprint of the object with respect to a single function they know it to have. (It is not necessary that they read up on this topic, but it could be the centerpiece of a week-long study.) On a large piece of paper or posterboard, at least 20" on a side, they should draw an outline of the object. Then, they shoulde draw into the outline all the structural features they can see that pertain to the particular function they are focusing on. They may use color, collage, or any other medium to enhance the blueprint. They should label each functional part clearly.

3. We like our students to keep a science notebook. For this exercise, each student could write a short paragraph describing the structure he or she is focusing on, followed by a short explanation of its function. If you feel so inclined, you could have students do some library or textbook work to find out more information.

4. On the due date, each student should explain his or her blueprint and the structure-function unit to the class in 5 minutes.

Example: An orange or grapefruit. The function is to disseminate seeds. Bright color in the skin and tasty juice in the pulp cells attract animals that munch the orange and scatter the seeds.

Giving examples clarifies such assignments, but it also channels thinking. One must balance this so as not to inhibit students' imaginations by giving too many examples. On the other hand, if this example lures students into producing 15 blueprints of fruits, nuts and vegetables as seed dispersers, the diversity of images and ideas will promote both self confidence and collegiality among students.

Exercise #2 (Homework, 2-4days):

Students are asked to create a two- or three-dimensional *abstraction* of the natural object they have chosen. They may use any two- or three-dimensional media. They will make an 8-minute presentation to the class.

Before giving this assignment, ask students what an *abstraction* is, what it means to *abstract* something. Write ideas on the blackboard and invite discussion. A central idea to be developed is that most abstractions are *simplifications* of whatever is being abstracted. In biology, pictures and prose descriptions of structures are abstractions because they always leave something out. So do movies and videos (only sight and sound: no feel or smell). Graphs and charts are abstract presentations relating two or more features. Math formulas and equations are the ultimate scientific abstractions. They also leave out the most. The blueprint from exercise #1 was an abstraction.

Probably the greatest single discovery in physics was the formula for gravitation by Isaac Newton in the 18th Century:

$$G = kmm'/r^2$$

where m and m' are the masses of two bodies (e.g., the Earth and the Moon), r is the distance between their centers and k is a constant. It is said that he checked his formula by calculating the time it would take for the moon to go once around the earth. He calculated 28 days, and told his housekeeper, who was the only one present, "I got it pretty nearly." He knew that the sun's gravitational field also affects the motions of the Earth and the Moon and that he had left it out of his calculations.

For most students, especially science students, this may be the first time they have thought about abstraction, which is usually associated with art, in terms of science. A major message is that every conclusion, fact, or theory in science is incomplete--an abstraction. Each such conclusion is our best educated guess at the moment, and subsequent research is bound to cause a change in that conclusion, fact, or theory.

Exercise #3 (Homework 3-7 days):

This third exercise is intended to complete the transition from science to art. Start with a discussion by

students on what they think a work of art is. What might it be besides being an abstraction? Is a photograph a work of art or science? Can it be both? How about the great paintings of biblical themes on the walls of the great gothic cathedrals: in what ways are these more than works of art? Attack or defend the statement, "An art monument is a social document."

When a student creates his or her piece, the biological object may be central to the piece or it may disappear. Successful solutions we have seen have included poems, songs, dances, and skits as well as graphic and sculptural works.

Extensions

Library research is entirely appropriate at various points in the development of these lessons. Discussion can consider how many ways we can think about a biological structure. It can encompass any academic subject. The doors are really wide open.

Instructions for Students

Exercise #1:

1. Obtain a biological object from nature or a supermarket or anywhere you can find it.

2. Make a blueprint of your object with respect to a single function you know it to have. (It is not necessary to read up on this topic, but it wouldn't hurt.) On a large piece of paper or posterboard, at least 20" on a side, draw an outline of your object. Then, draw into the outline all the structural features you can see that pertain to the particular function you are focusing on. Use color, collage, or any other medium to enhance your blueprint. Label each functional part clearly.

3. In your science notebook, write a short paragraph describing, in words, the structure you are focusing on, followed by a short explanation of its function.

4. On the due date, you will explain your blueprint and your structure-function unit to the class in a 5 minute presentation.

Example: An orange or grapefruit. The function is to disseminate seeds. Bright color in the skin and tasty juice in the pulp cells attract animals that munch the orange and scatter the seeds.

Exercise #2 (Homework, 2-4days):

An *abstraction* is generally a simplification. You are probably familiar with this notion in art, but it also applies to science. Pictures, graphs, and mathematical formulas are all abstractions in that they always leave something out.

Sit and think about your natural object and any of its possible functions and come up with a visual image, a symbol if you like, of aspects of its structure and function. Create a two- or three-dimensional *abstraction* of your object. You may use any two- or three-dimensional media. As in *Exercise #1*, you will make an 8-minute presentation to the class.

Exercise #3 (Homework 3-7 days):

Create a work of art inspired by your biological object. Any media. Present it to the class in 8 minutes.

You may end up with a picture, like a painting--a work of art. Or a sculpture. Or a model. That is good. The results, when mounted on the wall or placed on a table, are guaranteed to fascinate and intrigue the class and the teacher.

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