Lesson Plan
Seeing the Cell as a System (9-12)

Estimated Time: 4–5 class periods.

Central Benchmarks

5C Cells (9-12)#2

Within the cell are specialized parts for the transport of materials, energy capture and release, protein building, waste disposal, information feedback, and even movement. In addition to these basic cellular functions common to all cells, most cells in multicellular organisms perform some special functions that others do not.

11A Systems (9-12)#1

A system usually has some properties that are different from those of its parts, but appear because of the interaction of those parts.

Objective

Students will be able to explain how the components of a cell operate as a system.

Advance Preparation

Students should have had many experiences using the microscope to observe different kinds of cells. They should know that the processes necessary for life take place within each cell.

List of Materials

For the class:

Bicycle

TRANSPARENCIES:

The Bicycle as a System

Questions to Ask About Systems

Paramecium

For each group of four students:

An item which may be considered a system, such as the classroom aquarium, the classroom pencil sharpener, a clock or watch, a plant, a student’s notebook, a balance, a mechanical toy, a model of the human eye, a hot plate, a flashlight, etc.

A microscope and slide-making equipment (deep well slides may be desirable)

Culture of paramecia

Prepared slides of human body cells

For each student:

HANDOUT:

The Bicycle as a System

Questions to Ask About Systems

Paramecium

It is important throughout this lesson that students focus on **functions** of parts of systems rather than on **names** of parts of systems. Students will need to name such cell parts as nucleus and cell membrane. However, it is not necessary for students to memorize the names of many cell organelles. For example, rather than learn the name endoplasmic reticulum, students should know that there are paths through a cell by which materials move.

Motivation
Presenter: *You have all heard the terms ecosystem, school system, sound system, solar system, and other kinds of systems. Let's explore today what we mean when we say something is a system.*

Have students work in pairs to develop a definition of "system." Have several responses shared. Focus on a definition that suggests that a system is something made of parts in which the parts interact.

Development

1. Looking at a bicycle as a system.
Display the bicycle.

Say: *Is this bicycle a system?*
Have students justify responses. (Some students may say that a rider is necessary to have a system. If students suggest this, ask someone to act as the rider during the following discussion.)

Continue: *Let's think of the bicycle as a system. What is the function of this system?* (Probable response: To transport someone.)

Show the TRANSPARENCY and distribute the HANDOUT: The Bicycle as a System.

Have students respond to the listed questions about the bicycle as a system. In addition to the sample answers, below, other answers also are acceptable if justified by students.

a. Identify at least six parts of the bicycle. If you don't know the name of a part, make up a name. Tell what function each part has. (Sample answer: The seat provides a place for the rider in the system.)

b. The seat is one part of the bicycle. Tell me three words or phrases that describe the seat. Do any of these words or phrases also describe the whole bicycle? (Possible answers: cloth-covered, uncomfortable, smaller in front than in back, etc. Most words that describe the seat do not also describe the whole bicycle.)

c. Could any part of this bicycle be made of a different material and still help the bicycle carry out its function? (Possible answer: The seat could be made of leather or plastic.)

d. Can any one part of the bicycle carry out the job of the whole bicycle? Explain your answer. (Possible answer: No one part can do the job of the whole bicycle. If you consider one part, such as the pedal, it is easy to see that that part cannot by itself transport anyone anywhere.)

e. What parts of the bicycle must work together if you want to ride around a corner? (Probable answer: handlebar, pedals, possibly the brake. Point out that the *interaction* of parts makes turning the corner possible.)

f. Can you take a part from another bicycle and use it to replace a part in this bicycle and still have the bicycle carry out its function? (Possible answer: Yes. For example, a wheel could be replaced by a wheel from another bicycle as long as the two wheels are the same size.)

g. Could some parts of the bicycle be arranged differently and the system still carry out its function? Explain your answer. (Possible answer: In some cases, yes. You might replace the left handlebar grip with the right handlebar grip. However, some parts cannot be rearranged.)

h. Can you identify any subsystems within the whole bicycle system? If so, describe one subsystem. (Possible answer: The pedal might be considered a subsystem. It in itself has parts that work together to perform the function of a pedal.)

i. Does the bicycle require symmetry among any of its parts? If so, describe the symmetry. (Possible answer: Radial symmetry is present in the wheels; bilateral symmetry is present in handlebars and pedals.)

j. What will happen to the bicycle if one part, such as a spoke, breaks? What if all the spokes on a wheel break? (Possible answer: The bicycle may still go if only one spoke breaks, at least for a while. It will not be able to transport someone if all the spokes break.)

k. Is it useful to think of a bicycle as a system? Justify your answer. (Possible answers: It helps you understand what each part does; knowing how the parts must work together may help you repair it, etc.)

2. Examples of systems.
Have students work in pairs to brainstorm a list of at least ten systems. Each pair should then share its list with another group. Have each group confirm that they agree that the items listed can be considered as systems.

3. Analyzing a system.
Organize the class into small groups of three or four students. Give or assign to each group an item that can be considered a system (see the List of Materials).

Show the TRANSPARENCY and distribute the HANDOUT: Questions to Ask About Systems. Have students work in their groups to answer the questions. Answers will vary according to the system being analyzed.

Have each group share its answers with another group. If there are differences of opinion, have these discussed by the whole class.

4. Looking at a one-celled organism as a system.

Say: *Let's analyze a one-celled organism as a system*.

Show the TRANSPARENCY and distribute the HANDOUT: Paramecium.

Continue: *We have looked at paramecia with the microscope many times. Now let's look at a paramecium as a system and analyze this system using the same questions we used to analyze the items on which you have just worked.* Tell students they may examine live paramecia cultures and use printed reference materials as they complete their systems analysis of a paramecium.

Have students write answers on large charts. Post these around the room. Have a whole-class discussion of the responses. Answers other than the examples below are acceptable if students justify them. Be sure the following points are made:

a. When the parts are working together the paramecium is kept alive.
b. Materials such as food and water must enter the organism from outside.
c. Waste materials must leave the organism.
d. Be sure the functions described include transporting materials, capturing and releasing energy, building proteins, waste disposal, information feedback, and movement.
e. Except for "made of protoplasm," most words or phrases do not describe the whole organism as well as they describe a particular part.
f. No.
g. No. Each part has a specialized function. Only when they all work together does the organism live.
h. Students may reason that, since organ transplants can sometimes succeed in humans, transplants of cell parts might also be possible in paramecia.
i. Among possible answers: The cilia and the oral groove must work together to help the paramecium obtain food. The beating of the cilia not only helps the paramecium move, but also sweeps food into the oral gullet. Some parts can and do move to different places in the paramecium and still carry out their functions.
j. The cell membrane may be considered a boundary for the paramecium. Some may say that the boundary must include enough of the surrounding medium to provide food and a watery environment for the paramecium.
k. Systems within the system of the paramecium can be identified. For example, an atom can be considered a system.
l. Students may mention the symmetry seen in mitosis as the paramecium is dividing by binary fission.
m. If one of the parts of the paramecium wears out, it may not be able to move (cilia) or get rid of water (contractile vacuole) or divide (nucleus).
n. If this system stops working, the paramecium would be dead.
o. If the paramecium contains excess water, it will respond by emitting water through a contractile vacuole.
p. The paramecium might respond to the presence of food by moving toward it or it might change its direction when it strikes a barrier.
q. Thinking of the paramecium as a system helps you understand how each part contributes to the functioning of the whole thing.
r. Perhaps, but the model might not be able to simulate all of the functions.

s. Answers will vary.

Emphasize that the property of being alive belongs to the whole cell, the paramecium, and results from the interaction of its parts, rather than being a property of the separate parts. You may wish to use the following line of questioning:

- Are the cilia of the paramecium alive? (No.)
- Is the part that squeezes out extra water (the contractile vacuole) alive? (No.)
- Is the macronucleus alive? (No.)
- Is the whole paramecium alive? (Yes. But each of the parts by itself is not alive.)
- What makes the whole paramecium alive? (When the parts all interact, the paramecium is alive.)

5. Looking at a cell of a multicellular organism as a system.
Say: *Now let's work in our groups to analyze a single cell from a multicellular organism as a system*.

Tell students they may choose any kind of cell they wish from the human body. They are to think of a single cell of this type and analyze its activities using the same questions with which they analyzed the activities of the paramecium.

Ask groups to share their answers to the first question before continuing. Make sure students understand the functions of a specialized cell. The cell will carry out a specialized process; a nerve cell, for example, will carry stimuli. The cell will also complete general life processes common to all cells, including transporting materials, capturing and releasing energy, building proteins, disposing of waste, providing information feedback, and sometimes moving.

Tell students they may examine prepared slides of human body cells and use printed reference materials as they complete their analysis.

Again have students write answers on large charts. Post these around the room. Have a whole-class discussion of the responses. Answers to the questions will vary somewhat according to the cell type chosen.

Defer discussion of question (k) (What is the boundary of this system?) to the end of the class discussion. Begin the discussion of this question by asking whether the single cell the students have analyzed is alive. Help students reason that, if it is carrying out life processes, it cannot be dead. However, it cannot sustain itself independently, either. Ask students at what organizational level in the human body life becomes a property of the system: the cell, tissue, organ, organ system, or whole organism.

Discuss how it might be useful to consider any of these levels as a system.

Summary
Have one or two students describe the activities completed in this lesson.

Evaluation

- Have each student complete a journal entry listing at least five generalizations about systems.

- Have students compare the functions that occur inside a cell with the functions that occur in a factory where some item is manufactured. Have students use graphics in presenting their comparison.

Extensions

- Have students investigate feedback and control in the regulation of body temperature in humans.

- Have students research regeneration, as in starfish or worms.

- Have students research genetic engineering.