

## Teacher Information

### Pre-Lesson Instructions

1. Look over the list of cell parts, and decide which ones you would like to teach in your classroom. Certain cell parts are essential and must be included in the mobile; these parts are shaded in the Cell Parts Table.
2. Make copies of the Student Sheets. Each student will need a copy.
3. Gather all needed materials.

### Background Information

Researchers have been growing living cells for more than a century, generally using a similar technique to when they first began. Cells are cultured by being placed in a container, such as a Petri dish, containing a liquid medium with the nutrients they need to grow. This tried-and-true technique has been instrumental in many scientific discoveries over the years. A new advanced method of cell culturing is being developed by NASA.

The new NASA method involves the use of a bioreactor. The bioreactor was originally intended to simulate, in space, a terrestrial environment—the inside of a living organism. However, researchers discovered it can also be used on Earth to simulate a space environment—micro-gravity. Cells cultured in a rotating bioreactor essentially exist in a state of free fall. Because of the circulation of the rotating medium fluid, the cells are constantly falling downwards but are simultaneously being lifted by the rotational currents. This state of free fall closely mimics the free fall that exists on orbiting spacecraft. As a result, bioreactors can be used on Earth in a fashion similar to use in space, allowing scientists to culture three-dimensional tissue systems that would be impossible to grow using conventional methods.

In this lesson, students will learn more about the structure of the cell. By compare the inner workings of a cell to the structure of a city, students will gain a better understanding of what goes on inside of a cell. They will then use this knowledge to create a cell mobile. See the final pages of the Teacher Sheets for more information about the different parts of the cell.

## Guidelines

1. Read the NASA explores 5-8 article, "Mending A Broken Heart." Discuss the article as a class, and answer any questions the students may have.
2. Have students name large parts of a city. What makes up a city? Write all suggestions on the board.
3. Give clues and descriptions about each part of the cell that you chose (see descriptions in the table below). Have students guess the part of the city that matches the same purpose or activity. As an example, use the relationship of a city to a cell by stating, "The cell body provides the location for all cell parts to live and for many activities of working parts, deliveries of products, and factories that make products."
4. Explain that the students are going to be making mobiles to represent the cell and how it acts like a city.
5. Distribute the Student Sheets, and go over the procedure as a class. Answer any questions the students may have about the activity.
6. Allow time for students to complete their cell city mobiles.

<b>Cell Part</b>	<b>City Analogy</b>	<b>Clues And Descriptions</b>
Cell Body	"City"	Provides the location for cell parts to live and for many activities of working parts, deliveries of products, and factories that make products.
Cell Membrane	"City Limits/Wall"	Provides the boundaries for activities that go on within the cell.
Chromosomes	"City Plans"	The plans for how the cells are built and how products are made.
Cytoplasm	"Community"	The part of the cell outside of the nucleus.
Cytoskeleton	"Roads"	Provides paths for parts of the cell to move

Golgi Apparatus	"Postal Service"	Packages up things made in the cell, and ships them out.
Lysosome	"Wrecking Ball"	Breaks down old or damaged parts of the cell.
Mitochondrion	"Power Plant"	Creates and stores energy/power for the cell.
Nucleus	"City Hall"	Control centre for the cell. Gives directions for construction within the cell. Holds the blue prints for building.
Nucleolus	"Mayor"	Figure for the cell, and the most noticeable part of the nucleus.
Nuclear Envelope	"City Hall Walls"	Surrounds the nucleus.
Ribosome	"Workers"	Makes all kinds of things to use in the cell and to send out of the cell. Works inside of larger buildings or free within the city.
Rough Endoplasmic Reticulum	"Factory"	Workers here make all kinds of things for use in the city and out of the city.
Smooth Endoplasmic Reticulum	"Pharmaceutical Plant"	Hormones, steroids, and medications are made here.

### Discussion/Wrap - up

- If desired, the following optional items can be added to the students' cell city mobile to represent the cell parts that are not included.
  - Glue small pompoms to the rough endoplasmic reticulum (rough ER) factory.
  - Staple aluminum foil to the mobile to represent the cell membrane and the nuclear envelope
  - Feed accordion-folded paper strips through slits in the nucleus to represent chromosomes.
  - Tape or staple strips of green or blue plastic wrap to the mobile to represent cytoplasm.

- Have students share their cell city mobiles with the class. Discuss each student's arrangement of the cell parts.

### Extensions

Have students learn more about the cell and the work being done by NASA's Biological Sciences Office by visiting the Web sites listed in the Related Links section. These pages include on-line games that students can play to learn more about the cell and how NASA is helping scientists learn more about cell structure.



## **Mending a Broken Heart**

What becomes of the broken-hearted? Thanks in part to some NASA research, they may be patched. Scientists have grown heart tissue outside of a body that beats like a human heart. The tissue was grown in a special device called a bioreactor, originally developed for use in space flight.

Researchers have been growing living cells for more than a century, generally using a similar technique to when they first began. Cells are cultured by being placed in a container, such as a Petri dish, containing a liquid medium with the nutrients they need to grow. This tried-and-true technique has been instrumental in many scientific discoveries over the years, but it has a major limitation. It produces essentially two-dimensional cultures of cells. As a result, it is useful only for studying distinct types of cells, not complex systems of cells. In a body, cells grow according to a particular structure. Heart cells, for example, grow according to the shape of heart. Lung cells grow into a lung shape. That structure helps the cells differentiate and specialize. Cells know what they are supposed to do based on where they are. When cells in a flat culture try to form those structures, they essentially collapse. Bottom cells are crushed by the weight of higher cells. Since they can't form structures, the cells don't specialize. They can't form systems.

In the 1970s, researchers at NASA's Johnson Space Centre came up with a solution to this situation. Since the problem was, basically, gravity, weightlessness should be the answer. They theorized that cells grown in a micro-gravity environment would not suffer the same limitations as cultured cells on Earth. They should be able to grow into complex structures just as they do inside a body. They developed a device called a bioreactor, which essentially consists of a rotating cylinder. Cells are placed in the cylinder in a culturing fluid. The rotation keeps the fluid circulating and prevents the cell cultures from settling. A framework can be placed in the cylinder to give the cells a structure into which to grow. That system has been used successfully for cellular research on several space flights, both on the Space Shuttle and the Russian Mir space station. In addition, a new bioreactor is being developed for the International Space Station. The bioreactor used in space is essentially a complete simulated organism. In addition to the rotating cylinder, it has systems that mimic the

functions of lungs, a heart, a digestive system, and a waste system. These all work together to keep the cultured cells alive.

While NASA initially began researching the bioreactor for space-based applications, scientists soon realized that it has uses on Earth as well. The bioreactor was originally intended to simulate, in space, a terrestrial environment—the inside of a living organism. However, researchers discovered it can also be used on Earth to simulate a space environment—micro-gravity. Cells cultured in a rotating bioreactor essentially exist in a state of free fall. Because of the circulation of the rotating medium fluid, the cells are constantly falling downwards but are simultaneously being lifted by the rotational currents. This state of free fall closely mimics the free fall that exists on orbiting spacecraft. As a result, bioreactors can be used on Earth in a fashion similar to use in space, allowing scientists to culture three-dimensional tissue systems that would be impossible to grow using conventional methods.

Earthbound scientists have already used a bioreactor to create working heart tissue. They did this by placing heart tissues into a bioreactor with a scaffold that aided them in coalescing into the proper shape. The cells joined together and began exchanging the signals that caused them to beat together like a human heart. Someday, a similar system could possibly be used to grow an entire heart that could be transplanted into a human body. Cartilage, liver, prostate, and kidney tissues have also been grown in bioreactors.

The day when replacement organs can be specially grown for transplant is still a long way off. However, thanks in part to NASA's bioreactor technology, the heart of progress is definitely beating.