

15 Stem Cell Research

TALK IT OVER • 1 CLASS SESSION

OVERVIEW

Students read about current scientific research on and the social controversy over embryonic stem cells. On a KWL literacy strategy student sheet, they record their initial ideas and what they have learned from the reading.

KEY CONTENT

1. Stem cells produce a variety of types of specialized cells.
2. The process by which stem cells produce specialized descendent cells is called differentiation.
3. An embryonic stem cell has the potential to produce any type of specialized cells, while stem cells from developed organisms can produce a limited set of specialized cell types.

KEY PROCESS SKILLS

1. Students distinguish scientific questions from ethical questions in medical research.

MATERIALS AND ADVANCE PREPARATION

For each student

Student Sheet 15.1, “KWL: Stem Cells”

TEACHING SUMMARY

Getting Started

- Review the role of stem cells in the development of specialized cells.

Doing the Activity

- (LITERACY) Using the KWL literacy strategy, students discuss in their groups what they know and want to know about stem cells and stem cell research.
- (LITERACY) Students read about stem cells and stem cell research, and complete their KWLs according to what they learned.

Follow-up

- The class discusses the types of questions that science can and cannot answer about stem cells.

BACKGROUND INFORMATION

In 1998, biologist James Thomson and his group of research scientists at the University of Wisconsin were the first to isolate and reproduce human embryonic stem cells. Scientists are working towards a complete understanding of embryonic stem cells and their role in normal human development, and they think that embryonic stem cells may be harnessed to create better treatments for such diseases as Parkinson’s disease, heart disease, Type I diabetes, and rheumatoid arthritis, or reverse damage from spinal cord injuries.

Experimenting with embryonic stem cells currently requires destroying the embryos from which they are derived. This is so controversial in the United States that in 2001, President George W. Bush ordered that no federal funds could be used to develop or conduct research on new embryonic stem cell lines. Research on existing cell lines was allowed with federal funds as long as the embryonic cells were derived from embryos that were created for reproductive purposes and were no longer needed. The policy also required informed consent for the donation of the embryo and that donation must not have involved financial inducements. On March 9, 2009, U.S. President Barack Obama issued an Executive Order titled “Removing Barriers to Responsible Scientific Research Involving Human Stem Cells.” The purpose of the order was to remove barriers to scientifically worthy and responsible use of embryonic stem cells. The National Institutes of Health’s Stem Cell Information website provides updates on the status of national guidelines and policies for stem cell research.

REFERENCES

National Institutes of Health. 2009. *Stem Cell Information*. Retrieved October 2009 from <http://stemcells.nih.gov/>

GETTING STARTED

1 Review the function of stem cells in producing the many types of specialized cells in the body. Emphasize to students that the simulation they conducted in the last activity showed that embryonic stem cells pass through a number of stages along the pathway to complete differentiation. Explain that each time it divides, a stem cell might become two more stem cells or one or both of its offspring might enter the next stage of differentiation.

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Stem Cell Research

1 **B**ECAUSE OF THEIR ability to differentiate into multiple cell types, stem cells hold the potential to treat a variety of human diseases. In fact, several stem cell-based treatments are already in widespread use, including bone marrow transplantation and umbilical-cord-blood stem cell therapy. One area of stem cell research, however, has generated a major social controversy. This is research performed with human embryonic stem cells.

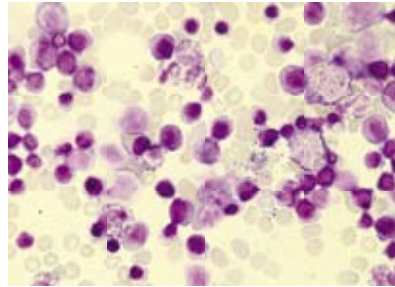
In this activity, you will explore current scientific knowledge and social issues related to stem cell research.

Challenge

► What are the current scientific understandings and social debates about stem cell research?

MATERIALS

FOR EACH STUDENT
Student Sheet 15.1, "KWL: Stem Cells"



Bone marrow cells from a healthy donor, such as the stained cells shown here, can be transplanted into a patient with a disease such as leukemia.

DOING THE ACTIVITY

2 (LITERACY) Distribute copies of Student Sheet 15.1, “KWL: Stem Cells.” The letters KWL refer to the three sections of the reading strategy that ask, “What do I Know? What do I Want to know? What did I Learn?” KWLs help students process and apply what they have read. For more information on this strategy, refer to Teacher Resources III: Literacy. Encourage students to listen and respond to each other’s ideas about stem cells, based on their current perceptions, and to ask thoughtful questions about what more they want to know about stem cells. It is likely that many students have heard something about stem cell research in the news.

3 (LITERACY) You might assign this short reading for homework. After students have read the text, ask them to complete the “Learned” column on Student Sheet 15.1, “KWL: Stem Cells.” A sample KWL is shown at right.

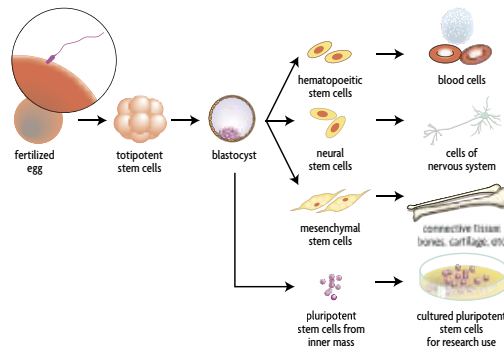
Procedure

- 2**
- In your group, discuss each of the questions below. Record on Student Sheet 15.1, “KWL: Stem Cells,” what you Know and Want to know about each of the questions.
 - What is a stem cell?
 - What kinds of human stem cells are there?
 - Why might stem cells be useful in treating certain diseases?
 - What is the debate about stem cell research and stem cell therapy?
 - Read the information below about stem cells, and then complete the Learned column of your KWL.

Reading

Several Types of Stem Cells

In the previous activity, you learned that stem cells often differentiate through multiple cell cycles to produce a variety of types of specialized cells. A human fertilized egg, or zygote, can produce cells that differentiate into every kind of specialized human cell. This means the zygote is **totipotent**, totally capable. When the zygote first begins dividing, its cells form a hollow ball, called a blastocyst. The inner cells of this blastocyst will form most types of human cells, and are called **pluripotent embryonic stem cells**.



Sample Student Response, KWL: Stem Cells

Know	Want to know	Learned
<ul style="list-style-type: none"> • Blood is produced from blood-forming stem cells (Activity 13). • Stem cells can differentiate into more than one kind of specialized cell (Activity 14). 	<ul style="list-style-type: none"> • Why can't scientists just use adult stem cells to treat diseases? • What kinds of diseases are treated with stem cells? • At what stage of an embryo's development are stem cells taken from human embryos? 	<ul style="list-style-type: none"> • There are several types of stem cells. • Stem cells vary in the kinds of cells they produce, from totally potent, to pluripotent, to multipotent. • Because embryonic stem cells are totipotent—they can produce any kind of cell—they might be more useful in treating many diseases. • Adult stem cells are usually multipotent, and can only produce certain cell types. • Embryonic stem cells are obtained from early-stage embryos in which the cells have not begun to differentiate. • Getting stem cells from an embryo destroys the embryo. That's why embryonic stem cell research is controversial. • Stem cells are most likely to work at treating or curing non-infectious diseases that affect one kind of cell.

SCIENCE & GLOBAL ISSUES/BIOLOGY • CELL BIOLOGY

Unlike embryonic stem cells, the stem cells in a human adult—or a child or infant—can differentiate into only a limited number of kinds of cells and are usually found within the tissues that they will renew. Stem cells found in our bone marrow, for example, can form many types of blood cells, but not muscle or nervous tissue cells. These **multipotent stem cells** have a multiple, but limited, potential.

Stem Cell Therapy Today

A frequently used stem cell therapy, bone marrow transplantation, involves injecting blood stem cells from a healthy donor into the bone marrow of a recipient with a blood disease, such as leukemia. Leukemias are a group of cancers that cause an overproduction of white blood cells. The recipient is first treated with radiation and chemotherapy to kill all of the unhealthy bone marrow and blood cells before receiving blood-forming cells from the donor. These cells may be obtained from the donor's bone marrow or circulating blood. There are a number of risks to this procedure, including an immune system attack on the donor cells.

Umbilical cord stem cells are also used to treat leukemia. Like an adult's stem cells, they are multipotent, but they are less likely than fully developed stem cells to cause an immune response in the recipient.

The Potential of Stem Cells for the Future

Many diseases are caused by a problem with one particular cell type. These are the diseases that are current or potential targets for stem cell therapy. One possible target for adult stem cell therapy is diabetes. In Type-1 diabetes, the afflicted person's immune system attacks cells in the pancreas that produce insulin, the protein hormone necessary for metabolizing sugars. One approach to treating this disease is to kill the person's immune cells with radiation or chemotherapy, and then provide adult stem cells that will restore a healthy immune system. A group of scientists has reported promising results from trying this treatment on a small number of diabetes patients. This treatment is highly experimental, and even if the results hold up over time, there are risks involved.

Embryonic stem cells can become any type of specialized cells. They are also easier to obtain than some types of adult stem cells, most of which are not easily located and isolated. For these reasons, embryonic stem cells might allow more rapid development of effective treatments.

One area of potential is treating neurological diseases, such as Parkinson's disease. In Parkinson's, the nerve cells in the brain that make the chemical dopamine stop functioning, and the person loses the ability to move properly and might eventually develop mental impairments. If these cells could be replaced in some way, it might relieve the symptoms or cure the disease. Because stable adult nerve cell lines are difficult to produce, using pluripotent embryonic stem cells might allow researchers to find cures more quickly.

FOLLOW-UP

4 Continue the class discussion using the Analysis Questions as prompts. Discuss the types of questions about stem cells that science can and cannot answer. Scientific inquiry can answer questions about the isolation and properties of stem cells at each stage of development, and can investigate stem cells' effectiveness in treating diseases. This information may help an individual understand and form an opinion about stem cell research. Ethical questions enter into decisions about whether or not particular types of stem cells or methods for obtaining them should be used in research or medical procedures.

SAMPLE RESPONSES

1. Scientists can answer questions about the potential of stem cells at different stages and investigate whether stem cells can be used to reduce the symptoms of or cure certain diseases.
2. The types of questions that involve ethical considerations include: Where do the stem cells come from? How were they obtained? These questions apply especially to embryonic stem cells.
3. Stem cell treatments will not kill microbes. Stem cells are useful for treating diseases that involve a problem with a particular type of cell in the person with the disease. In the future, it might be possible to use stem cells to reverse damage that an infection caused. But right now the targets of stem cell treatment are diseases that involve breakdown of human cells from genetic or environmental factors, aging, cancer, and other noninfectious disease mechanisms.

The Stem Cell Debate

Working with stem cells from developed humans is not generally a controversial area of scientific research, but it is more complicated than starting with an embryonic stem cell that might be steered in any direction to re-create specialized cells. In contrast, embryonic stem cell research involves getting an early-stage embryo from a fertility clinic and isolating individual cells. This destroys the embryo. Although the cells of those embryos have not yet begun to differentiate into the specialized cells that will turn into a functioning human being, some people object to destroying any embryo because of its potential to develop into a human being. Another method being researched for creating embryonic stem cells is to take a human egg, remove its nucleus, and insert an adult cell nucleus from the person to be treated. This produces an embryonic stem cell with the same genetic makeup as the recipient, lowering the chance of an immune reaction to the stem cells. However, the same ethical considerations apply.

4 Analysis

1. What kinds of questions can scientists answer about stem cells?
2. What kinds of questions about stem cell research involve ethical considerations?
3. Why do you think scientists are not pursuing stem cell research and treatments to reduce deaths from infectious diseases?

KEY VOCABULARY

multipotent stem cells	totipotent
pluripotent embryonic stem cells	stem cell

REVISIT THE CHALLENGE

Much of the current scientific research on stem cells revolves around the different types of stem cells and their potential to differentiate into specific cell types. Because those embryonic stem cells that are in the earliest stages of the embryo's development have the potential to form all types of specialized cells, scientists think they provide a faster route to inventing therapies for diseases. People's qualms about stem cell research are related to destroying a human embryo to obtain its stem cells.