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Setting FIRES to Stem Cell Research

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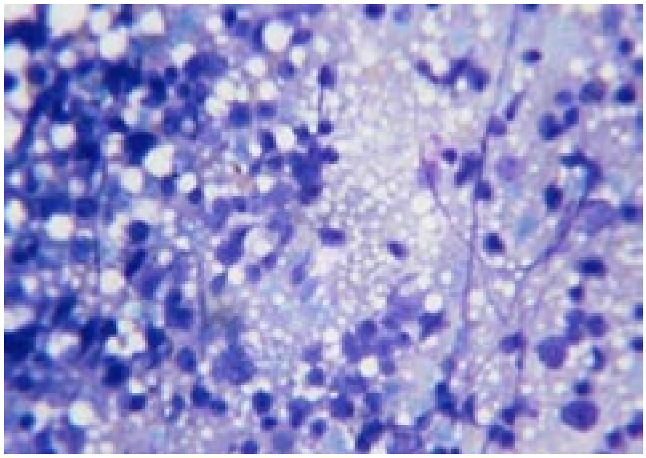

In 1999, I taught my first lesson on stem cell research with middle grade students. Even though the field was then brand new, my goal was to inform students about both the science and the ethical implications of this cutting-edge research so that they would be able to make their own judgments about stem cell research in the future.

Now, six years later, stem cell research is at the forefront of our public media, particularly in my home state of California. The National Science Education Standards recommend we teach students about cells and current cell research; however, we must not only teach the content involved, but also provide students with a mechanism for making decisions on their own about advances in science and technology. To give students a schema for evaluating issues in science, I have relied over the years on a strategy for classifying points in text that I learned several years ago while teaching in Florida's Miami-Dade County Public Schools (DCPSOIL 1992). The strategy is represented by the acronym FIRES, which stands for Facts, Incidents, Reasons, Examples, and Statistics.

In this article, I will present up-to-date information on stem cell research in the form of a synopsis on the subject that I compiled from multiple sources, and illustrate the FIRES strategy using this information and other relevant sources.

The lesson

The goal of this lesson is to present the basic scientific knowledge about stem cells, the promise of stem cell research to medicine, and the ethical considerations and arguments involved. In the lesson, students are introduced to the FIRES strategy and given an opportunity to evaluate stem cell information from multiple sources using this technique.

One of the challenges of discussing stem cell research is that the field is constantly evolving and the most current information changes almost daily. Few science texts contain stem cell information, and those that do are generally written at a reading level above that of a typical middle grade student. Thus, the first step for me in preparing this lesson was to compile the most current information, decide which key points I wanted to teach students, and deliver the information in a way that would be appropriate for middle grade students. Additionally, I had to be mindful of refraining from taking any particular position on stem cell research, presenting only the facts so that students could make their own informed and educated conclusions.

The next section presents my compiled notes, from which I prepared a PowerPoint presentation to share the key points and examples with my students.

What is a stem cell?

Cells are the building blocks of every tissue and organ in your body. If you were to examine different body tissues, such as skin and blood, you would see that the cells are quite different in structure and chemical composition, even though both types contain the same DNA. DNA, essentially, can be considered the instruction manual for the whole body, with every cell containing a complete copy of the manual; however, only certain segments of the DNA (chapters, so to speak) are "read" or used by each different type of cell. This is understandable, as the different tissues and organs in the body have different functions, and cells must be specialized—in structure and chemical composition—to perform these functions. To further the current metaphor, we don't read an entire instruction manual to troubleshoot a single problem; we go directly to the chapter we need, read the applicable pages, and use them. Cells function in much the same way with the reading (or translation) of their DNA. Stem cells are a special type of cell that is not specialized or devoted to a particular tissue or

Note: All information in this article was verified to be accurate as of April 2005.

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function; they are a more general, nonspecific type of cell. It is from these stem cells that the specialized cells develop through a process called *differentiation*.

From this point forward, for simplicity, I will speak exclusively of human stem cells and human biology, although stem cells are present in every animal, and nonhuman animal stem cells have been vital to the development of human stem cell research.

Where do stem cells come from?

There are two sources for human stem cells. Stem cells first develop inside a newly fertilized human embryo, one that is between three and five days post-fertilization. The term *embryo* is used by scientists and doctors to refer to the egg once it has been fertilized; however, in common language usage the word *embryo* generally evokes mental images of a tiny humanlike form implanted inside a female's uterus—and large enough to be visible to the naked eye if removed. In actuality, the three-to five-day-old human embryo is in a stage of development called a *blastocyst*; it is a microscopic, spherical, hollow mass of about 150 cells that have not yet implanted in the uterus. The blastocyst is more similar in appearance to a microscopic golf ball than the human body form into which it has the potential to develop. The stem cells develop on the inside of this microscopic ball, and typically number about 30 cells at this early stage of development. Over time, these embryonic stem cells will give rise to the 200 different cell types found in the tissues and organs of the human body. The stem cells that are obtained from embryos are referred to as *human embryonic stem cells*.

Limited numbers of undifferentiated stem cells are also found in the specialized tissues of children and adults, and are thought to have the function of repairing damaged tissues. As of this time, the origin of these stem cells, called *adult stem cells* is unknown. (Note: The term *adult* is a bit misleading. It refers to the stem cell type, not to an adult human; in fact, adult stem cells can be found in humans of any age.) These adult stem cells are typically further along the path of differentiation than those found in embryos, meaning they can give rise to only a few of the types of cells in the body, rather than to all 200 types, as can embryonic stem cells (this is referred to as being *pluripotent* instead of *totipotent*). Additionally, adult stem cells are limited in number in the human body, and are more difficult to grow and reproduce in the laboratory than human embryonic stem cells. Adult stem cells are most frequently obtained from human bone marrow, circulating blood, and umbilical cord blood.

What is unique about stem cells?

There are three unique characteristics of stem cells:

- They are unspecialized. All other cells of the body have a specific function.
- They are capable of dividing and renewing themselves (replication) for long periods of time, unlike other cells that typically divide only once.
- Stem cells can give rise to any type of cell in the body through differentiation, a characteristic called plasticity. Additionally, stem cells can develop into specialized stem cells with more limited potential, such as hematopoietic stem cells (which give rise to all types of blood cells), bone stem cells (which give rise to bone, cartilage, fat, and connective tissue cells), neural stem cells (which form the three types of brain cells), and others. Scientists are at the beginning stages of understanding what causes cells to differentiate; it is generally attributed to chemical signals secreted by other cells, physical contact with other specialized cells, and certain molecules in the microenvironment.

From where are stem cells obtained for research?

Scientists obtain human embryonic stem cells for research from embryos created in laboratories that service infertility clinics for the purpose of in vitro fertilization. When a couple undergoes in vitro fertilization, multiple eggs are extracted from the woman's ovaries during a treatment cycle, fertilized in a petri dish, and monitored in the hope that one or more of these eggs will develop into an embryo. Between 24 and 60 hours post-fertilization (during the blastocyst stage of development), doctors typically insert a maximum of four of the early embryos into the woman's uterus, with the goal of at least one implantation culminating in a successful pregnancy. (If more than one embryo is successfully implanted and carried to term, the pregnancy results in a multiple birth.)

The embryos that successfully develop in the infertility laboratory, but are not used during treatment, are normally frozen. They may be used by the couple for later infertility treatment, discarded, or donated with the couple's consent for medical research or adoption. Over 400,000 frozen embryos such as these are currently stored in laboratories or infertility clinics in the United States.

Frozen human embryos that are donated for medical research and chosen for stem cell research projects have their stem cells extracted through a needle inserted in the inner mass of the blastocyst. The extracted stem cells are then grown (cultured) into larger cell colonies or cell lines. The first human embryonic stem cells were extracted and cultured in the United States in 1998.

Adult stem cells may be obtained from various tissues in the human body, most commonly from bone marrow, peripheral blood, or umbilical cord blood. In contrast with human embryonic stem cell research, which is relatively new, blood stem cells—the most popular type of adult stem cell used in medicine—have been used to treat patients with certain blood diseases, such as serious types of anemia and leukemia, for the last 40 years.

Why is stem cell research controversial?

Here, it is important to distinguish between the two types of stem cells—embryonic and adult. Adult stem cell research is relatively free of controversy; adult stem cells are harvested from living persons, with their consent, without any harm to the donor.

Extracting human embryonic stem cells from embryos in the blastocyst stage destroys the blastocyst; therefore, it no longer has the characteristics of life. This is viewed by some persons as the equivalent of taking a human life, and is thereby judged to be unethical or immoral. To others, because these embryos have no potential to develop into human beings in their current state and would eventually be destroyed or become unusable for infertility treatment, the potential benefits yielded by human embryonic stem cell research justifies their use.

What are the current and proposed uses of stem cells in medicine and research?

It is estimated that 128 million Americans suffer from diseases and injuries that can be or have the potential to be treated with stem cell therapies. Stem cells are already used to treat over 70 diseases. They include many types of cancers (including but not limited to multiple forms of leukemia, breast cancer, non-Hodgkin's lymphoma, multiple myeloma, and renal cell carcinoma), varied forms of severe anemia, sickle cell disease, Hodgkin's disease, and multiple inherited metabolic and immune disorders.

Research into using stem cells to treat or cure Parkinson's disease, Alzheimer's disease, stroke, cystic fibrosis, retinitis pigmentosa, diabetes, and spinal cord injury, among others, is ongoing. It is proposed that stem cell research holds additional promise for treating severe burns, heart disease, multiple sclerosis, HIV/AIDS, osteoarthritis, osteoporosis, rheumatoid arthritis, and other conditions in which tissues must be replaced by providing a renewable cell/tissue source. Former First Lady Nancy Reagan (whose husband President Ronald Reagan suffered from Alzheimer's disease); Michael J. Fox (who has Parkinson's disease); the late Christopher Reeve (who lived the last 10 years of his life as a quadriplegic after a horseback riding accident); and Mary Tyler Moore (who has Type I diabetes and is the International Chairman of the Juvenile Diabetes Research Foundation) are public figures who have come out in support of stem cell research.

In addition to treating specific diseases and conditions, stem cells are also potentially highly useful for drug testing. By exposing stem cells to experimental drugs, it is hypothesized that scientists will be able to judge the effects of such drugs on many types of cells simultaneously, eliminating the exposure of animals or human beings to potential adverse effects.

What are the current federal regulations on funding for human embryonic stem cell research?

In 2000, the National Institutes of Health solicited the first applications for federally funded human embryonic stem cell research. Guidelines stated that the embryos used in such research must be derived from those created for use in infertility treatment, must be donated with the informed consent of the progenitors, and the clinics from which the embryos were obtained could not financially profit from their sale. In 2001, President George W. Bush restricted federal funding for human embryonic stem cell research to the 64 stem cell lines already created in laboratories. In doing so, President Bush also banned the use of federal funds for research using any human embryonic stem cell lines created after this date. The arguments used to justify this position at that time were, (1) since stem cell lines, theoretically, could replicate themselves indefinitely, the 64 lines already created provided enough material for future research; and (2) no federal dollars would be used in the future toward the destruction of human embryos.

Why do some people believe that the federal regulations must change?

Since President Bush's restriction of federally funded research to the 64 human embryonic cell lines in existence in 2001, the majority of those cell lines have either ceased to replicate, or the cells produced have been found to be unsuitable for research. Thus, the number of available cell lines for federally funded human embryonic stem cell research has been reduced from 64 to the current 22, a number some say is insufficient for large-scale research. It is also suggested that the 22 lines are not genetically diverse enough to produce stem cells that would provide a "match" for all persons in need of stem cell therapy. Additionally, in January 2005, University of California, San Diego, researchers confirmed the suspicion that the 22 federally approved stem cell lines have been compromised by the method that has been used to grow them and may pose a risk if they are used on human subjects. The human stem cells in the 22 approved lines have been exposed to mouse and calf cells to help them grow in the laboratory. The animal cells contain sialic acid, which human cells do not have, and which human cells recognize as an invader substance that our immune system should attack. Therefore, it is inadvisable for the federally approved stem cell lines to be used to test therapies in humans. Just one month later in February 2005, demonstrating the rapid advances with stem cell research, Japanese scientists reported success with a technique for growing human embryonic stem cells without exposing them to animal cells; however, this does not remove the problem with the existing federally-approved lines.

Other persons advocate that the United States needs to repeal the restrictions on human embryonic stem cell research simply to remain scientifically competitive with the rest of the world, and to provide its citizenry with the most advanced medical treatments available at the lowest cost. Most other countries at the forefront of stem cell research—particularly the United Kingdom, Japan, Singapore, and South Korea—have more open policies toward human embryonic stem cell research, even though some (like the United Kingdom) still require that the embryos used were not created for the sole purpose of research, and have been donated with the progenitors' consent.

While a federal ban on human embryonic stem cell research from newly developed cell lines exists, private research using such new stem cell lines is underway at many private laboratories. Additionally, some states (such as California through the passage of Proposition 71) have developed public initiatives to create funding at the state level for unrestricted human embryonic stem cell research not eligible for federal funding.

Where can I find more information?

As stem cell research is rapidly progressing, the best method for obtaining current information is through the internet. Below are some websites that I would recommend you review.

- Stem Cell Basics, prepared by the National Institutes of Health, available at *http://stemcells.nih.gov/info/basics*
- Frequently Asked Questions, prepared by the National Institutes of Health, available at *http://stemcells.nih.gov/info/faqs.asp*
- Frequently Asked Questions, prepared by the International Society for Stem Cell Research, available at *www.isscr.org/science/faq.htm#1*
- FAQ about Stem Cell Therapy, prepared by the Stem Cell Research Foundation, available at *www.stemcellresearchfoundation.org/About/FAQ.htm#1*

Using the FIRES strategy with stem cell research

To help students make sense of all of the varied viewpoints regarding human stem cell research, I suggest using the FIRES strategy after you have presented your information and given students an opportunity to do research and read some of the literature on stem cells. Often students' greatest difficulty with evaluating large amounts of complex information lies in categorizing it, and then weighing each point's credibility and importance. "Where to begin?" can be a daunting question.

The FIRES strategy provides just such a place for students to begin, by sorting the information into one of the acronym's categories: Facts, Incidents, Reasons, Examples, or Statistics. These categories are obviously artificially imposed, and sometimes do overlap (particularly in the Incidents and Examples categories), but the basic strategy gets students started and on their way to analyzing the relative importance of similar types of data.

In my classroom, we used the FIRES strategy not only to organize points from other people's writing, but also for students to organize their own writing points when tackling writing assignments such as essays, compare-and-contrast, or persuasive writing. In fact, the phrase "Set FIRES to it!" became my way of telling students how to approach a problem and make a decision about it.

The first time you introduce the FIRES strategy, I have found it best to have students come up with a problem with points that are easily classified, and then to go through a group discussion of how to apply FIRES to that problem. For example, when I recently introduced this strategy to a group of sixth graders who live in a desert region in California, I told them we were going to learn a way to organize complex information, and asked them to give me a real problem that they were having with school. One of the students raised his hand and said, "The school bus gets so hot during the summer months that we're miserable on even a short ride" (this region participates in a year-round school calendar, hence the use of buses in the summer). Then I introduced the FIRES categories and asked students to give me facts, incidents, reasons, examples, and statistics related to the problem, writing all of their contributions on the board in the corresponding categories. Within 15 minutes, we had numerous points for the topic, and students were able to see how points can stand with and against each other and make better conclusions about which points are strongest. To take the idea further, students then had to write a letter to the district superintendent in an attempt to persuade him to take action to resolve the problem, and they used the points organized with FIRES to form the paragraphs for the body of the letter. The next week, students began to apply the FIRES strategy to science issues, and we always had the bus discussion to come back to for a schema to help make the idea concrete.

FIGURE 1 **FIRES and stem cell research**

Category	Points
Facts	Stem cells come from either adult humans or 3–5-day-old embryo • Embryonic stem cells have the potential to develop into any kind of cell in the body • Adult stem cells have limited potential to develop into only some cell types • In the U.S., human embryonic stem cells are obtained from in vitro fertilized embryos donated with progenitors' consent • Human embryos from which stem cells are extracted will not develop into human beings without being implanted into a woman • Stem cells grown by being exposed to animal cells may be attacked by human immunosystems
Incidents	1998—The first human embryonic stem cells were cultured in the U.S. • 2000—U.S. NIH solicits first applications for federally funded stem cell research • 2001—U.S. President G.W. Bush restricts funding to 64 existing stem cell lines, to prevent federally funded destruction of additional human embryos • 2004—number of federally approved cell lines stands at 22 due to problems • January 2005—researchers confirm that the federally approved stem cell lines are contaminated with animal compounds • February 2005—Japanese researchers report stem cells grown without animal compounds
Reasons	Stem cell research is promising due to the number of diseases it has the potential to treat or cure • Stem cells also have the potential to serve for drug testing without exposing live animals or humans • Stem cell research is opposed by some because extracting the stem cells from the embryo destroys the embryo, which may be viewed as taking a human life
Examples	Stem cells are used to treat cancers, severe anemia, sickle cell disease, Hodgkin's disease, and many inherited disorders • Stem cells may help treat or cure Parkinson's disease, Alzheimer's, stroke, cystic fibrosis, retinitis pigmentosa, diabetes, neurological impairments, and many other disorders • While federal funding is not permitted on nonapproved cell lines, private laboratories and some U.S. states (e.g., California) have established funding • Much stem cell research is going on worldwide • Stem cell research is supported by many famous persons
Statistics	128 million Americans suffer from diseases and injuries that stem cells may treat • Stem cells are already used to treat over 70 diseases

Human stem cell research, like many complex issues, can be approached with the same activities. Using the information presented earlier in the article, I have broken out major points in the following table using FIRES. Note that some points can overlap, but the general strategy is clear. As a culminating activity for this topic, students write a position paper on stem cell research, or engage in an in-class debate about the topic.

Closing thoughts

As with any sensitive subject discussed in class, stem cell research—particularly human embryonic stem cell research—must be approached in a deliberate manner that welcomes all opinions and supports people's feelings, experiences, and ethical and religious views. Students should be encouraged to respect varied points of view, and to consider all opinions before making their own decisions about the subject. I hope that the information in this article will assist you in building a factually accurate and emotionally supportive environment in which to hold your discussions.

Reference

Dade County Public Schools Office of Instructional Leadership (DCPSOIL). 1992. *Developing support in writing using FIRES! Middle school POW/R pack: Improving writing skills*, 9–10. Miami, FL: Author.

Resources

In addition to the websites listed above and in the text, information for this article was obtained from the following:

Researchers Eye New Stem Cell Source—*http://afgen.com/clon48.html*

Stem Cells and the Future of Regenerative Medicine—*www.nap.edu/books/0309076307/html*

Stem Cell Research Moves Forward—*http://chronicle.com/prm/weekly/v51/i06/06a02201.htm*

California Stem Cell Research and Cures Initiative—*www.curesforcalifornia.com*

Acknowledgment

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