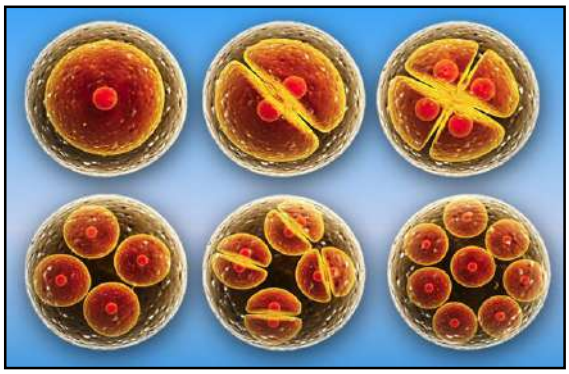
STEM CELL SCIENCE

(1) Stem cells have been a hot area of research for over the last three decades and researchers have been making very interesting medical advances recently. Let's look at the fundamentals of stem cell science before we get into the newest research. There are three different types of stem cells: embryonic stem cells, adult stem cells and induced-pluripotent stem cells (IPSCs), though all share common traits. First, all can divide for long periods of time. Second, stem cells are not specialized, meaning that they have not become a specific type of cell yet (e.g. neurons and skeletal muscle cells are specific and specialized cells). Third, they have plasticity, so they are capable of becoming more than one cell type.

(2) Embryonic stem cells were first isolated in human embryos in 1998. Stem cells are used in the research of diseases, like cancer and birth defects, as well as drug research and medical treatments where stem cells can be used to make new tissues. However, obtaining these stem cells is the most controversial part of stem cell research as they are harvested from embryos which are destroyed in the process.

(3) Embryos are obtained by using the unused embryos from IVF (*in vitro* fertilization) treatments. IVF helps infertile couples have a child. In this process, several eggs are harvested from a woman and mixed with the sperm taken from her partner. If fertilization results and produces embryos, often only one or two embryos are transplanted back into the woman's uterus. The couple can consent for the unneeded and leftover embryos to be either destroyed or used for stem cell research. Those against human embryonic stem cell research argue that using and destroying embryos shows a lack of respect for the value and dignity of life. For those who are for human embryonic stem cell research, they argue that the embryos were going to be discarded so they would never have become human beings. They also argue that embryos do not have the rights of personhood. Using adult stem cells would seem like the solution to this ethical dilemma, as they can be obtained from a consenting adult without the need for embryos. If so, why not just use adult stem cells? It is because adult stem cells are much less plastic than embryonic stem cells.



(4) Embryonic stem cells obtained from early embryos are totipotent, which literally means "totally powerful". They have the ability to become any cell type in the body and any one of these cells, in isolation, can form an entire human. Four days after fertilization the cells divide into a blastocyst with two cell layers. The surrounding layer forms the placenta and the inner layer are the stem cells that form the tissues of the fetus. At this point, stem cells are no longer totipotent. Though they can still form any and all the tissues of the body, they have lost the ability to form an entire individual if removed from the embryo, thus instead of being totipotent, they are now considered pluripotent. As an embryo continues to develop, the pluripotent stem cells increasingly lose their plasticity.

(5) As adult stem cells are even less plastic than pluripotent stem cells, they are called multipotent stem cells. This means they only have the ability to become a small and limited selection of related cell types. A good example are the multipotent stem cells found in your bone marrow, called a hemocytoblasts. These divide throughout your lifetime to make white and red blood cells. The purpose of adult stem cells is to maintain and repair existing adult tissues. Adult stem cell research bypasses the controversy over destroying embryos, but it also limits research because the plasticity of adult stem cells is reduced.

(6) A third type of stem cell was developed in 2006 to help overcome the embryo controversy and supply more stem cells for researchers. These are induced-pluripotent stem cells (IPSCs). They come from specialized adult somatic cells (not gametes), which are

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reprogrammed, "induced", to act and behave like pluripotent embryonic stem cells. When stem cells begin to specialize, certain genes turn off so that only the genes needed for a specific cell type stay active. The IPSCs are reprogrammed by reactivating the genes that have been switched off.

(7) In addition to skipping over the moral dilemma of using embryos, IPSCs also allow for the custom tailoring of stem cell therapies to individual patients. This removes the risk of immune system rejection. For example, if your liver is damaged and you need a new liver, you would have to get a liver transplant. This means you will have to wait for a liver donor whose cells are a match for yours so that your immune system doesn't reject the transplanted organ. However, if healthy cells of your own body are harvested and turned into IPSCs, these IPSCs in turn can be made into liver cells that form liver tissue that can be transplanted back into you. You will not need to wait for a compatible donor and you will not reject transplanted tissue from our own cells. Though using IPSCs for tissue regeneration is just beginning, there is hope that this type of treatment will become a common reality in the near future.

(8) Another benefit is for drug testing. Many drugs tested on non-human animals harm and kill them. This is often considered a cruel but necessary step in early drug testing, however, testing on human tissues made from IPSCs is a very good alternative. The response of human cells provides more accurate results than using non-human animals and no one is harmed.

Article Questions

1) What are three characteristics of a stem cell?

2) What is the ethical controversy over using human embryonic stem cells for research?

3) How are most embryos obtained?

4) What is the difference between a totipotent stem cell and a pluripotent stem cell?

5) What is the difference between a pluripotent stem cell and a multipotent stem cell?

6) What does IPSCs stand for and what are they?

7) Name two potential uses of using IPSCs?