

Alternatives to Embryonic Stem Cells

Fact Sheet 9 - January 2003

GLOSSARY

AUTOLOGOUS cells are those derived or transferred from the same individual's body.

BLASTOCYSTS are hollow, fluid-filled balls of cells which develop from the zygote 5-6 days after fertilisation and consist of 30 to 150 cells.

DIFFERENTIATION is the process by which cells or tissues develop a more specialised function.

EGG CELLS are the female reproductive cell.

A **GENOME** consists of all the DNA contained in an organism or a cell. It includes both the chromosomes within the nucleus and the DNA in mitochondria.

IMMUNOLOGICAL REJECTION occurs when transplanted cells or tissues stimulate an immune response in the recipient, resulting in the body rejecting the transplant.

The **INNER CELL MASS** is a cluster of cells inside the blastocyst.

MESENCHYMAL CELLS are those derived from the embryonic mesoderm, from which connective tissue, bone, cartilage, and the circulatory and lymphatic systems develop.

SOMATIC CELLS are all body cells except the reproductive cells.

SPERM CELLS are the male reproductive cell.

STEM CELL LINES are stem cells from one source that are grown and maintained in petri dishes in a laboratory.

VECTORS are agents, such as viruses, which carry a modified or foreign gene. When used in gene therapy, a vector delivers a specific gene to a target cell.

INTRODUCTION

Although embryonic stem cells (ESCs) could potentially provide treatments for many different diseases, their use is controversial as it involves the destruction of human embryos (see fact sheet on ESCs). A number of different sources of stem cells have been suggested as alternatives to the use of ESCs in medical research and clinical therapies.

Adult stem cells (ASCs) are **AUTOLOGOUS** stem cells. They are unspecialised cells found in certain areas of the adult human body such as bone marrow and the brain. These cells are indefinitely self-renewable and have the potential to develop into specialised cell types.

Multipotent adult progenitor cells (MAPCs) can be isolated from **MESENCHYMAL CELLS** from bone marrow. Like ASCs, MAPCs are autologous and appear to be able to renew themselves indefinitely. These cells are also capable of **DIFFERENTIATING** into cells that make up a variety of tissues such as the brain, liver and skin.

Parthenotes are embryos created by the process of parthenogenesis. Parthenogenesis involves taking an immature **EGG CELL** from a female donor and treating it with chemicals that stimulate the egg to start dividing, as though it had been fertilised by a **SPERM CELL** (see note 1). The egg cell continues to divide until it forms a **BLASTOCYST**. The **INNER CELL MASS** can be harvested from the blastocyst and used to create a **STEM CELL LINE** that will be genetically identical to the original egg donor. Potentially, the blastocyst could be implanted in a woman, rather than used to harvest stem cells. In this case, the child born would have the same **GENOME** as the egg donor and would therefore be her clone.

APPLICATIONS

ASCs, MPACs and Parthenotes are likely to have similar clinical applications to ESCs. These cells could be used to create **tissues and organs for transplantation**, in **cell therapies for degenerative diseases**, as **VECTORS** for **gene therapy**, and in **toxicology testing** of new drugs. The advantage of using these alternatives is that unlike ESCs, they would be **immunologically compatible** with the patient. Consequently there would be no risk of **IMMUNOLOGICAL REJECTION** of organs, tissues or cells.

RISKS AND LIMITATIONS

The **cell extraction processes** used to isolate ASCs and MAPCs present some health risks to the patient. ASCs and MAPCs are located in tissues such as brain or bone marrow and therefore extraction of these cells is an invasive and occasionally painful process.

The **quantity of ASCs and MAPCs** in mature human tissues is relatively low. Consequently cell lines must be grown for a considerable time in the laboratory before enough cells are available for therapeutic use.

As yet, **no human parthenotes** have been successfully created. Whether parthenogenesis can be used to create stem cells remains to be seen. Even if the technique is successful, it is not known whether the cells produced would be suitable for clinical applications.

The **plasticity** of ASCs and MAPCs is currently unclear. The potential for ASCs to develop into specialised cell types was thought to be limited by the ASC's tissue of origin. However, recent research has suggested that ASCs from one type of tissue may have the capacity to develop into a number of different cell types. MAPCs appear to be able to differentiate into a broad range of cell types but this research has not been confirmed.

The **cell differentiation factors** that determine which cell types are formed by stem cells are not well understood in humans. Significant research into this area is needed before the production of tissues and organs for transplantation using ASCs, MAPCs or parthenotes is possible.

Organ construction presents similar obstacles to transplantation. Organs derived from ASC, MAPC or parthenote cell lines will be grown outside the human body and will therefore require some type of scaffolding during development. This has yet to be achieved with animal or human cells.

ETHICAL AND POLICY ISSUES

ASC and MAPC collection does not involve the **destruction of embryos** and consequently it is viewed as a less ethically contentious procedure than collecting ESCs. It has been suggested that parthenogenesis also side-steps the ethical objections to ESC research because it does not involve the destruction of an embryo. However, others have argued that parthenotes share enough characteristics with embryos created via the fertilisation of an egg by sperm that they should be accorded the same status as 'normal' embryos (see OPPE factsheet on ESCs for more information).

Reproductive cloning could be achieved via parthenogenesis. Many people view this as an ethically unacceptable use of the technology, and the social consensus is that all forms of reproductive cloning should be universally prohibited. However, it has been argued that such a prohibition would infringe upon peoples' religious and reproductive freedoms. Additionally, whether governments should interfere with the reproductive choices of their citizens is also a contested issue.

Resource allocation may become an issue if ASCs, MAPCs or parthenotes become commonly used in medical procedures or are made generally available to the public. The use of ASCs, MAPCs or parthenotes is likely to be expensive, as production of these cells requires significant time and labour. Whether the public health system, private insurers or patients themselves will have to cover these costs is unknown. If these sources of stem cells are commercialised, costs are likely to be even higher in the short to medium term. Thus the availability of stem cell related therapies may be limited by their cost and what funding is made available to cover these costs.

REGULATION

In **Australia**, the use of ASCs or MAPCs in research or clinical is only subject to regulations governing the general use of human tissue. The creation of parthenotes is likely to be prohibited by the *Prohibition of Human Cloning Bill 2002* (Cth), which was recently passed by both Houses of Parliament.

Legislation in the **United Kingdom** would permit the use of ASCs and MAPCs in clinical treatments. The production and use of parthenotes would also be permitted by this legislation, provided that parthenogenetic embryos were used for therapeutic purposes only and were not implanted in a woman and brought to term.

European countries are all likely to permit the use of ASCs and MAPCs for medical treatments. However, whether the use of parthenote-derived stem cells would be permissible is unclear. The European Convention on Human Rights and Biomedicine prohibits the creation of human beings that are genetically identical to another. Signatories to this convention include **France, Italy and The Netherlands**. The European Parliament is currently seeking a ban on all forms of cloning and has determined that ASC research should be a research priority for the European Union.

United States legislation would permit the use of ASCs and MAPCs in research and clinical therapies, but legislation that will determine whether or not parthenotes can be used is currently being debated. President Bush has advocated a ban on all forms of cloning.

NOTES

1. Mature egg and sperm cells only have half the genetic material of a SOMATIC CELL and therefore could not be used for parthenogenesis. However, egg cells halve their genetic material very close to maturity and consequently it is possible to collect immature egg cells that still contain an woman's entire genome.

FURTHER READING

- Bruce, D.M. (2002) Stem cells, embryos and cloning - unravelling the ethics of a knotty debate. *Journal of Molecular Biology* 319, 917-925
- Reyes, M. and Verfaillie, C.M. (2001) Characterization of Multipotent Adult Progenitor Cells, a Subpopulation of Mesenchymal Stem Cells. *Annals of the New York Academy of Sciences* 938, 231-233; discussion 233-235
- Trounson, A. (2002) The genesis of embryonic stem cells. *Nature Biotechnology* 20, 237-238

See also: Office of Public Policy and Ethics fact sheets on Cloning and Embryonic Stem Cells.

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