

ANAT 2341 Embryology

Lecture 18 - Stem Cells

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Dr Antonio Lee

*Neuromuscular & Regenerative Medicine Unit
School of Medical Sciences, UNSW*



Outline

- What are Stem Cells?
 - *Totipotency - Pluripotency - Multipotency*
- What are different sources of Stem Cells?
 - *Embryonic vs Adult*
 - *Pros and Cons for each type of stem cell?*
- What makes Stem Cells, “Stem Cells”?
 - *Self-Renewal & Differentiation*
- What can Stem Cells be used for?
 - *Therapeutic Applications for Stem Cells*

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Stem Cells in the News

Google news Stem Cells Search: the web pages from Australia Search Advanced Search

Web News Hide options Results 1 - 10 of about 1,410 for Stem Cells [definition] (0.18 seconds)

All results Images Videos News Blogs Updates Books Discussions Top Stories All news Images Blogs Any time Past hour Past 24 hours Past week Past month Sorted by relevance Sorted by date Reset options

Stem-cell, marrow donors rise
Seattle Times - 1 hour ago
Donating blood stem cells or bone marrow to assist patients fighting blood or immune disorders has never been easier, or more popular. ...
Be a bone marrow donor, help save a life - Rochester Democrat and Chronicle
Get a bone marrow transplant, stay - The Press Association
Aid, cloud puts lives of bone marrow patients at risk - BBC News
Daily Mail
all 33 news articles »

Stem cells may improve heart bypass results
Tehran Times - 10 hours ago
Patients who received bone marrow stem cell transplants during coronary bypass surgery (CABG) experienced "excellent long-term safety and survival," say ...

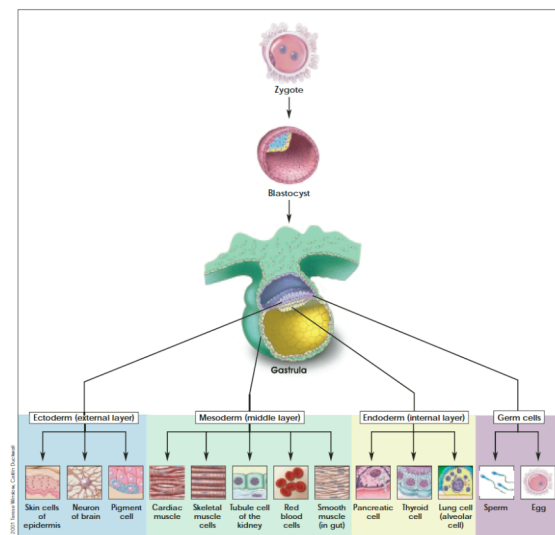
RSCRC scientists explore mysteries of human embryonic stem cells
News-Medical.net - 1 day ago
At Rutgers' Stem Cell Research Center scientists are exploring the mysteries of human embryonic stem cells and their potential use in treating diseases, ...
Our Turn: Should embryonic stem cell research continue? - Kalamazoo Gazette - MLINK.com
Asapio Hospital Group forays into stem cell research - MyNewsIn
Stem Cell Research Facilities At Emory To Be Expanded With The ... - Medical News Today (press release)
PS CANADA.net (press release) - Genetic Engineering News (press release) (blog)
all 24 news articles »

Stem cell therapy to help women regrow breasts post cancer
Times of India - 1 day ago
A new stem cell therapy developed by Melbourne scientists could help women regrow their breasts after cancer surgery. Doctors at the Bernard O'Brien ...

Marker indicating developmental potential of stem cells discovered
Sify - 1 day ago
(The more pluripotent, the more likely a stem cell will develop into the desired tissue, organ or being.) "We identified a genomic region encoding several ...
Novel Strategy For Generating Induced Pluripotent Stem Cells For ... - Medical News Today (press release)
all 28 news articles »

Researchers find breast cancer, hormone link
ABC Online - 11 Apr 2010
(AAP: Julian Smith, file photo) A key signal that triggers the growth of breast stem cells has been identified, helping scientists to better understand how ...
Breast cancer linked to stem cells - Australian Life Scientist
Study Establishes Link Between Increased Level of Hormones and ... - TopNews United States

What is a Stem Cell? - Pluripotency



1 Cell
(Zygote - fertilised egg)



6,000,000,000 cells
(230 different cell types)

Where does it all begin? - *Human*

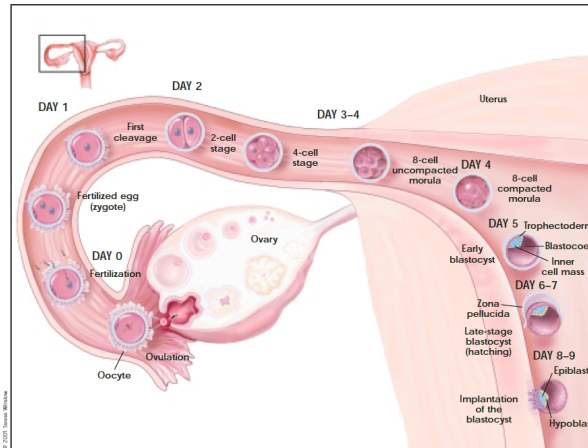


Figure A.2. Development of the Preimplantation Blastocyst in Humans.

Where does it all begin? - *Mouse*

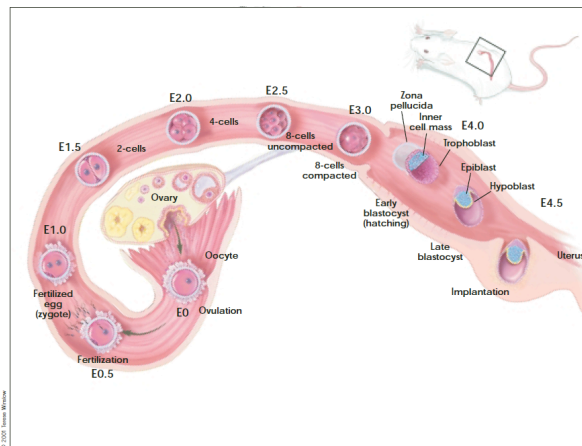
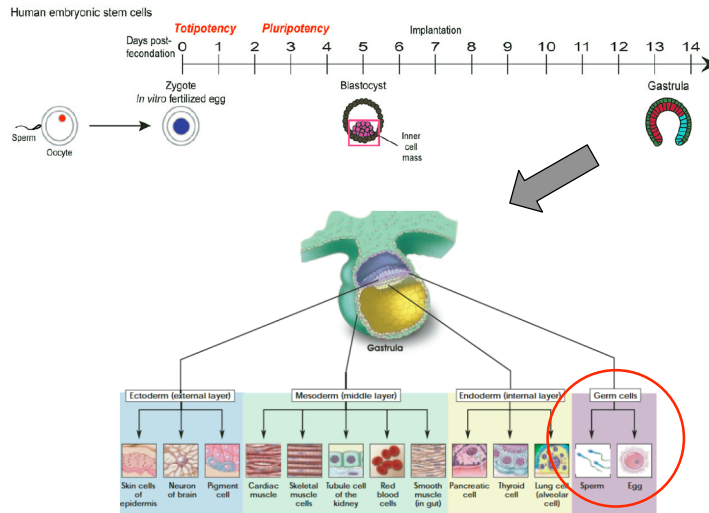


Figure A.3. Development of the Preimplantation Blastocyst in Mice from Embryonic Day 0 (E0) Through Day 5 (E5.0).

Totipotency vs Pluripotency



Development of Primordial Germ Cells

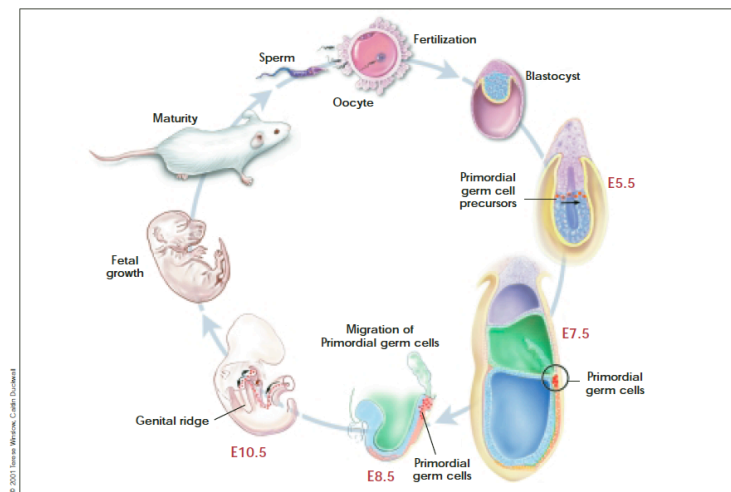


Figure A.5. Development of Mouse Embryonic Primordial Germ Cells.

What are Different Types of Stem Cells?

1. Embryonic Stem (ES) Cells
2. Embryonic Germ Cells
3. Adult Stem Cells
4. Umbilical Cord-Blood Stem Cells

Plus...

1. Somatic Cell Nuclear Transfer (SCNT)
2. Induced-Pluripotent Stem (iPS) Cells

1. Embryonic Stem (ES) Cells

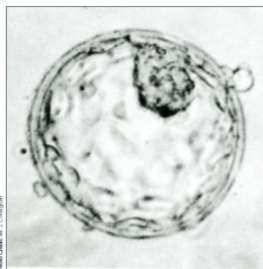
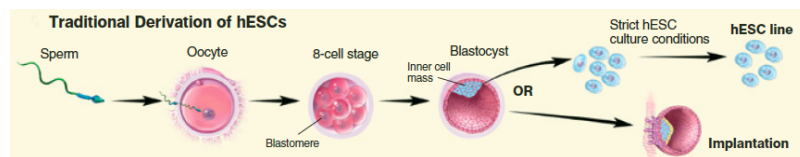
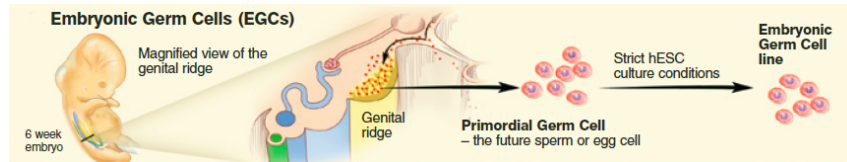


Figure 3.1. Human Blastocyst Showing Inner Cell Mass and Trophoblast.

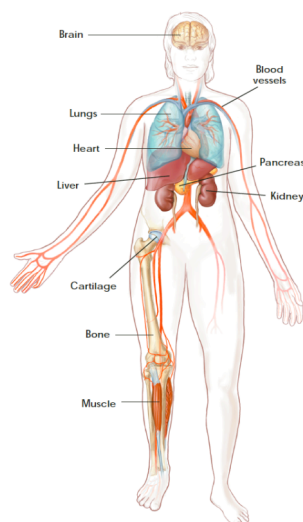
1. Pluripotent - can generate any cell type in the body.
2. From 5-7 day-old blastocyst - ICM.
3. Can be cultured as cell lines or frozen for future use.
4. In Australia, plenty of embryos are donated from IVF treatments.
5. Ethical issues?

2. Embryonic Germ Cells (EGCs)



1. Primordial germ cells (PGCs) destined to become gametes (oocytes / sperm cells)
2. From 5-7 week-old embryos developing into fetus.
3. EGC-lines share many properties with ES cells.
4. But *in vitro*, PGCs show spontaneous differentiation, thus limited in isolation of pure clonal lines.

3. Adult (Somatic) Stem Cells



1. More specialised than embryonic stem cells.
2. Found in the majority of tissues & organs (for ***maintenance & repair*** throughout life-span).
3. Have restricted ability to produce different cell types (multipotent *not* pluripotent).
4. Identification/isolation can be difficult.
5. Only small numbers may be present requiring expansion *ex vivo*.
6. More adult stem cell types are being discovered from variety of tissues with 'plasticity' - ability to form cell type of a completely different tissue.
7. Autologous (one's own) use can avoid immune-rejection problems in following transplantations.
8. Ethical issues?

3. Adult (Somatic) Stem Cells - Bone (Marrow)

Type	Microscopic Appearance	Diagram	Approx. % in adults ^[6] <small>See also: Blood values</small>	Diameter (µm) ^[6]	Main targets ^[2]	Nucleus ^[2]	Granules ^[2]	Lifetime ^[2]
Neutrophil			54–62% ^[2]	10–12	<ul style="list-style-type: none"> bacteria fungi 	multilobed	fine, faintly pink (H&E Stain)	6 hours–few days (days in spleen and other tissue)
Eosinophil			1–6%	10–12	<ul style="list-style-type: none"> larger parasites modulate allergic inflammatory responses 	bi-lobed	full of pink-orange (H&E Stain)	8–12 days (circulate for 4–5 hours)
Basophil			<1%	12–15	<ul style="list-style-type: none"> release histamine for inflammatory responses 	bi-lobed or tri-lobed	large blue	a few hours to a few days
Lymphocyte			25–33%	7–8	<ul style="list-style-type: none"> B cells: releases antibodies and assists activation of T cells T cells: <ul style="list-style-type: none"> Th (T helper) cells: activate and regulate T and B cells CD8+ cytotoxic T cells: virus-infected and tumor cells γδ T cells: Regulatory (suppressor) T cells: Returns the functioning of the immune system to normal operation after infection; prevents autoimmunity Natural killer cells: virus-infected and tumor cells. 	deeply staining, eccentric	NK cells and Cytotoxic (CD8+) T-cells ^[7]	weeks to years
Monocyte			2–10%	14–17	Monocytes migrate from the bloodstream to other tissues and differentiate into tissue resident macrophages or dendritic cells.	kidney shaped		hours to days
Macrophage			21 (human) ^[8]		Phagocytosis (engulfment and digestion) of cellular debris and pathogens, and stimulation of lymphocytes and other immune cells that respond to the pathogen.	none		activated: days immature: months to years
Dendritic cells					Main function is as an antigen-presenting cell (APC) that activates T lymphocytes.			similar to macrophages

3. Adult (Somatic) Stem Cells - Plasticity?

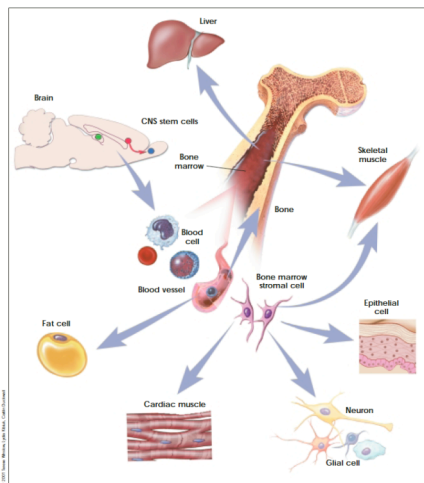


Figure 4.2. Preliminary Evidence of Plasticity Among Nonhuman Adult Stem Cells.

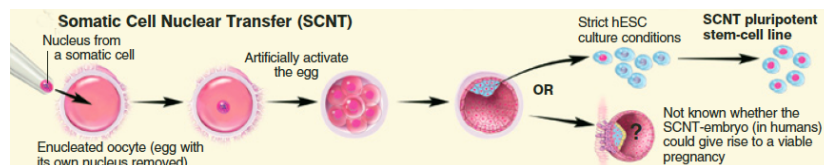
1. Neural Stem Cells for Blood.
2. Bone-Marrow Stem Cells for Liver, Skin and Neurons.
3. Blood Vessel Stem Cells for Fat and Muscles.

4. Umbilical Cord Blood Stem Cells



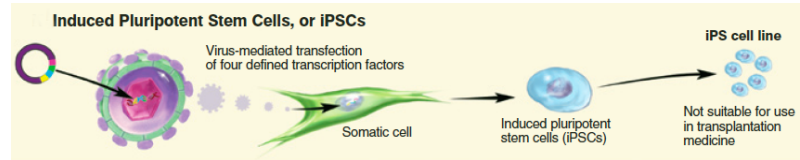
1. Adult Stem Cells collected from a newborn baby shortly after birth.
2. Can generate all blood cell types including immune system.
3. Potential to generate other tissue types is currently being explored.
4. Can be stored (at cord-blood bank) for future use: matched-siblings, matched but unrelated-individual or autologous-use.
5. 'Saviour Siblings' - using donor baby's cord blood to treat a matched ill sibling.
6. Ethical issues?

5. Somatic Cell Nuclear Transfer (SCNT) - Therapeutic Cloning



1. Nucleus of oocyte is removed and replaced with foreign nucleus from any somatic cell that is 'reprogrammed' in the environment of the egg.
2. Artificial activation of egg and 5-7 days in culture allows development of ES cell-like, SCNT pluripotent stem-cell line.
3. Allows patient-specific cell therapies avoiding immune-rejections following transplantation.
4. Normal Zygote (fertilised egg) vs SCNT-derived egg - 'Dolly' died prematurely with signs of arthritis and lung infection.
5. Reproductive Cloning - *Prohibition of Human Cloning for Reproduction and the Regulation of Human Embryo Research Amendment Act 2006* (Australia).
6. Ethical issues?

6. Induced Pluripotent Stem Cells (iPSCs)



1. Mature somatic cells were genetically engineered by virus to achieve pluripotent, ES-like state (Nov 2007).
2. Forced expression of genes (including Oct3/4 and SOX family) in adult mouse/human cells led to a 'reprogramming' into pluripotent status.
3. Rapid development of strategies for gene delivery (non-integrating viruses, chemicals and small molecules) to prevent permanent / harmful changes.
4. Allows patient-specific cell therapies avoiding immune-rejections following transplantation.
5. Possible clinical use may be distant due to concerns on 'genetic stability'.
6. Ethical issues?

Embryonic vs Adult Stem Cells - Pros & Cons

Embryonic Stem (ES) Cells

Advantages	Disadvantages
<ul style="list-style-type: none"> • Pluripotency - ability to differentiate into any cell type. • Immortal - one cell can supply endless amounts of cells. • Easily available - human embryos from fertility clinics. 	<ul style="list-style-type: none"> • Unstable - difficult to control differentiation into specific cell type. • Immunogenic - potential immune-rejection when transplanted into patients. • Teratomas - tumor composed of tissues from 3 embryonic germ layers. • Ethical Controversy - unethical for those who believes that life begins at conception.