Stem Cells

UNDIFFERENTIATED CELLS WITH POTENTIAL

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What Are Stem Cells and How Do They Relate to Development?

- Stem cells are immature cells that have the potential to differentiate into specialized cells which have a distinct function.
- There are 2 types of human stem cells:
  a. those associated with the embryo (or embryonic)
  b. those associated with the adult (or somatic)
Classification of Embryonic Stem Cells

- **Totipotent**
  - Oocyte
  - Morula

- **Pluripotent**
  - Inner Mass Cells

- **Unipotent**
  - Circulatory System
  - Nervous System
  - Immune System

*Examples:*

- Heart
- Brain
- Immune Cells

*Images:


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a) Zygote (fertilization)
b) 2-Cell Embryo
c) 4-Cell Embryo
d) 8-Cell Embryo
e) 16-to 32-Cell Embryo
f) Morula
g) Blastocyst – Can Implant in Uterus

Development of the Zygote into a Blastocyst

Inner Cell Mass (Forms the Fetus)
Trophectoderm (Forms the Placenta)

Photos: Dr. Shoukhrat Mitalipov, PhD, ONPRC
Each Blastomere (Cell from a 2- to 8-Cell Embryo) Can Become an Individual (Blastocyst)

Photos: Don Wolf, PhD, ONPRC
Blastocyst Splitting Into Two Potential Individuals – Development Is Less Successful

Photos: Don Wolf, PhD, ONPRC
Embryonic Stem Cells Can Incorporate Into Host Embryos

Photos & Graphics: Dr. Don Wolf, PhD, ONPRC
Adult Stem Cells

- Adult stem cells include:
  i) hematopoietic stem cells which give rise to all of the types of blood
  ii) mesenchymal stem cells which give rise to osteocytes, chondrocytes, adipocytes, and other connective tissue
  iii) neural stem cells which give rise to neurons, astrocytes, and oligodendrocytes
  iv) epithelial stem cells which give rise to cells lining the digestive tract such as absorptive cells, goblet cells, Paneth cells, and enteroendocrine cells
  v) skin stem cells which occur in the basal layer of the epidermis and at the base of the hair follicles and give rise to new epidermal layers of skin.

- Also included in the category of adult stem cells are cord blood stem cells in the umbilical cord of a baby which give rise to platelets, red and white blood cells, and mesenchymal cells.
In 1968, human adult stem cells were used in the first successful bone marrow transplant.

The process includes irradiating the bone marrow to destroy the faulty stem cells (often causing cancer) and replacing them with normal bone marrow stem cells from a healthy and immune compatible donor.

Today, bone marrow is transplanted routinely to treat a variety of blood and bone marrow diseases, blood cancers, and immune disorders.
Multipotent and Oligopotent Somatic Stem Cells

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The Scientific Challenges of Human Stem Cells

Basic Research Phase

Building Scientific Capacity
- Creating Career Development Pathways
- Training Courses
- Establishing Infrastructure
  - novel cell culture methods
  - expanding cell lines
  - cell sorting methods

Proving Long Term Stability of Cells
- Characterization of Embryonic Stem Cells
- Genetic Stability

Understanding Cell Cycle Control
- Regulation/Control of Cell Division

Understanding Cell Specialization
- Growth Factors
- Gene Regulation

Evaluating Cell-Host Interactions
- Immunology
- Transplantation Biology

This diagram illustrates the range of stem cell potency, based upon the cells’ state of differentiation. The more potent a cell, the less differentiated it is. The most differentiated cells are specialized cells, which have assumed only one fate from the more than 260 different types of specialized adult cells. Also illustrated is the deprogramming of specialized cells using “stemness” genes (Oct3/4, Sox2, and Klf4) to take them back to a pluripotent state, known as induced pluripotent stem cells.
The Goal of Stem Cell Research

Tissue Scaffolding

- Growth factor
- Mechanical stimulus
- Implantation
- Biopsy
- Cell isolation
- Cell proliferation
- Cell cultivation
- Scaffold
- Tissue development

http://en.wikipedia.org/wiki/Tissue_engineering  http://creativecommons.org/licenses/by/3.0/deed.en  No changes were made.
Other Potential Uses of Stem Cells

- Traumatic Brain Injury
- Stroke
- Alzheimer’s Disease
- Parkinson’s Disease
- Multiple Sclerosis (MS)
- Deafness
- Spinal Cord Injury
- Myocardial Infarction
- Liver Disease
- Diabetes
- Crohn’s Disease
- Muscular Dystrophy (MD)
- Amyotrophic Lateral Sclerosis (ALS)
- Bone Marrow Transplant
- Osteoporosis
- Osteoarthritis
- Rheumatoid Arthritis (RA)