life technologies™

An Introduction to Stem Cells

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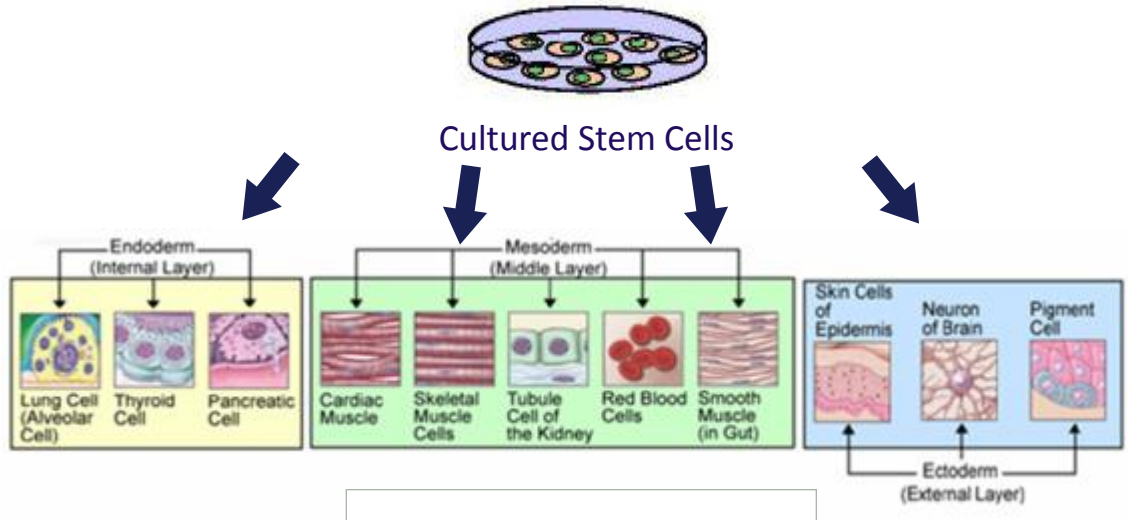
What are stem cells?

Watch a video about Induced Pluripotent Stem Cells

Stem cells differ from other kinds of cells in the body.

All stem cells—regardless of their source—have three general properties:

- they are capable of dividing and renewing themselves for long periods
- they are unspecialized
- they can give rise to specialized cell types



Basic Research

Drug Development

Cell Therapy

Types of Stem Cells

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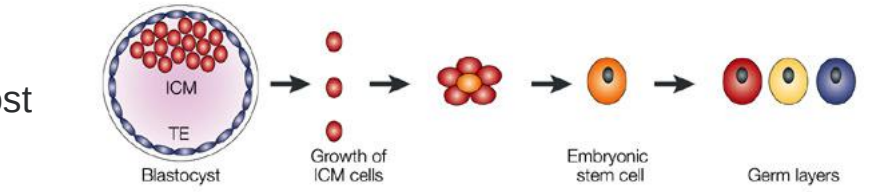
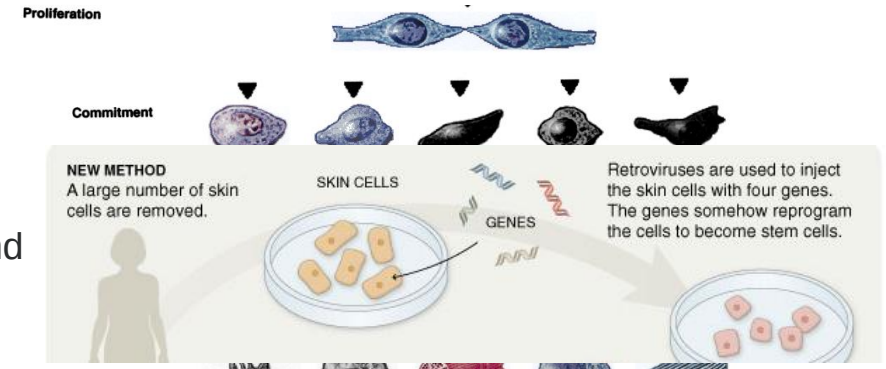
Embryonic Stem Cells (ESCs)

- Derived from the blastocyst of a 5 day-old embryo
- Are pluripotent, i.e., they can differentiate into almost any cell type in the body (primary-like cells)
- Can renew themselves indefinitely



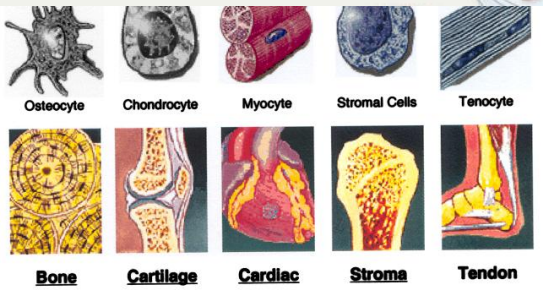


Induced Pluripotent Stem Cells (iPSCs)

- Generated from reprogrammed somatic cells
- Similar or equivalent to ESCs, i.e., pluripotent and the ability to renew themselves indefinitely

Adult Stem Cells (e.g. MSCs, NSCs, ADSCs)

- Isolated from adult tissues, organs or blood, cord blood, etc.
- Are multipotent – i.e., can give rise to a number of related cell types
- Can renew themselves a number of times but not indefinitely



Embryonic Stem Cells

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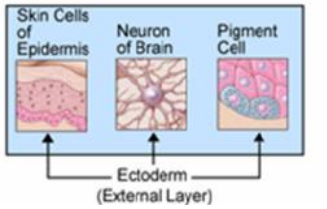
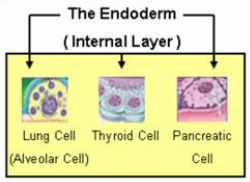
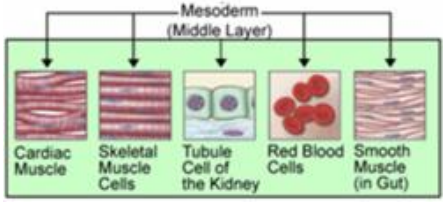
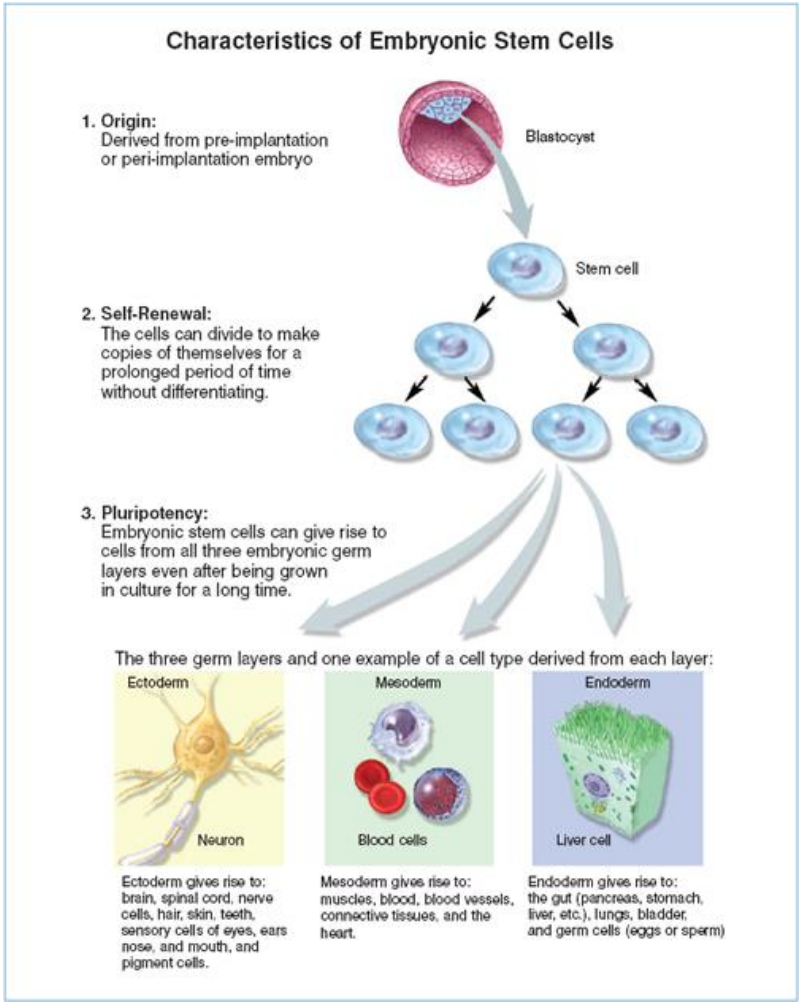
- **Embryonic stem cells (ESCs)** are pluripotent stem cells derived from the inner cell mass of the blastocyst, an early-stage embryo
- ESCs are able to differentiate into all derivatives of the three primary germ layers which include each of the more than 220 cell types in the adult body:







- Because of their pluripotency, ESCs have broad applications in basic research, drug discovery and cell therapy.
- On January 23, 2009, Phase I clinical trials, led by Geron, for transplantation of oligodendrocytes derived from human ES cells into spinal cord-injured individuals received approval from the FDA, marking it the world's first human ES cell human trial.



Induced Pluripotent Stem Cells

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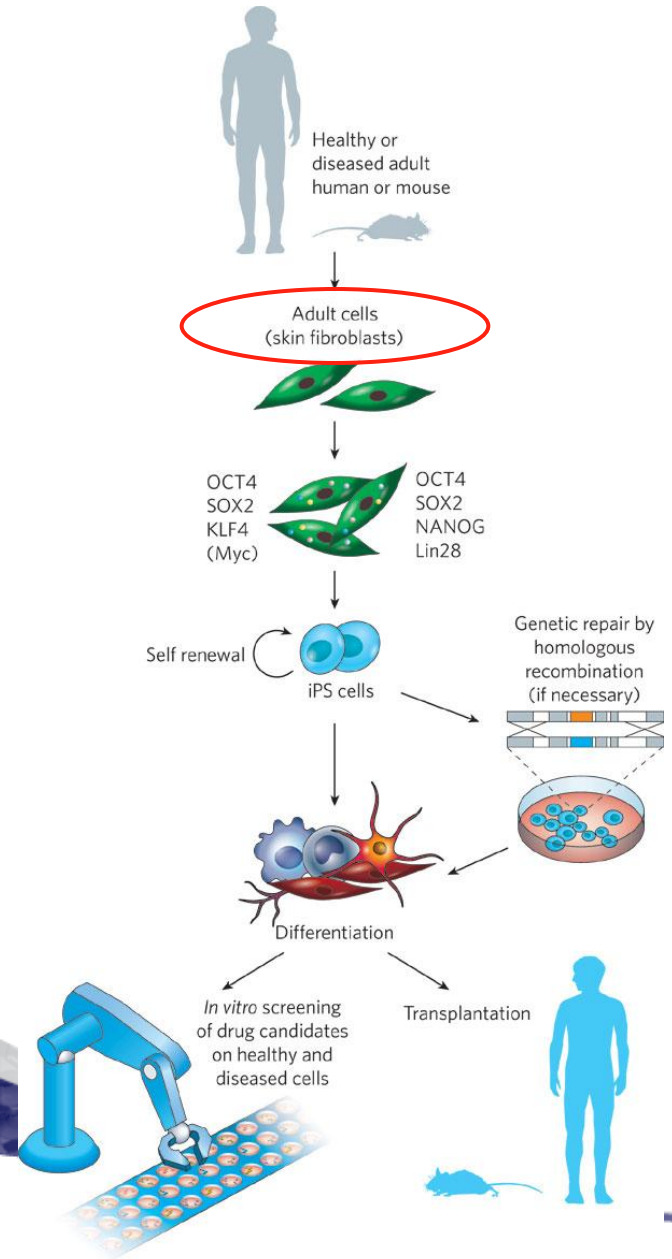

- **Induced pluripotent stem cells (iPSCs)** are adult cells that have been genetically reprogrammed to an **embryonic stem cell–like state** by being forced to express genes and factors important for maintaining the defining properties of embryonic stem cells

- iPSCs were first generated by Shinya Yamanaka at Kyoto University, Japan in 2006.
- Yamanaka used genes that had been identified as particularly important in **embryonic stem cells** (ESCs), and used retroviruses to transduce mouse fibroblasts with a selection of those genes.
- Eventually, four key pluripotency genes essential for the production of pluripotent stem cells were isolated; **Oct-3/4, SOX2, c-Myc, and Klf4**.

How are iPSCs created?

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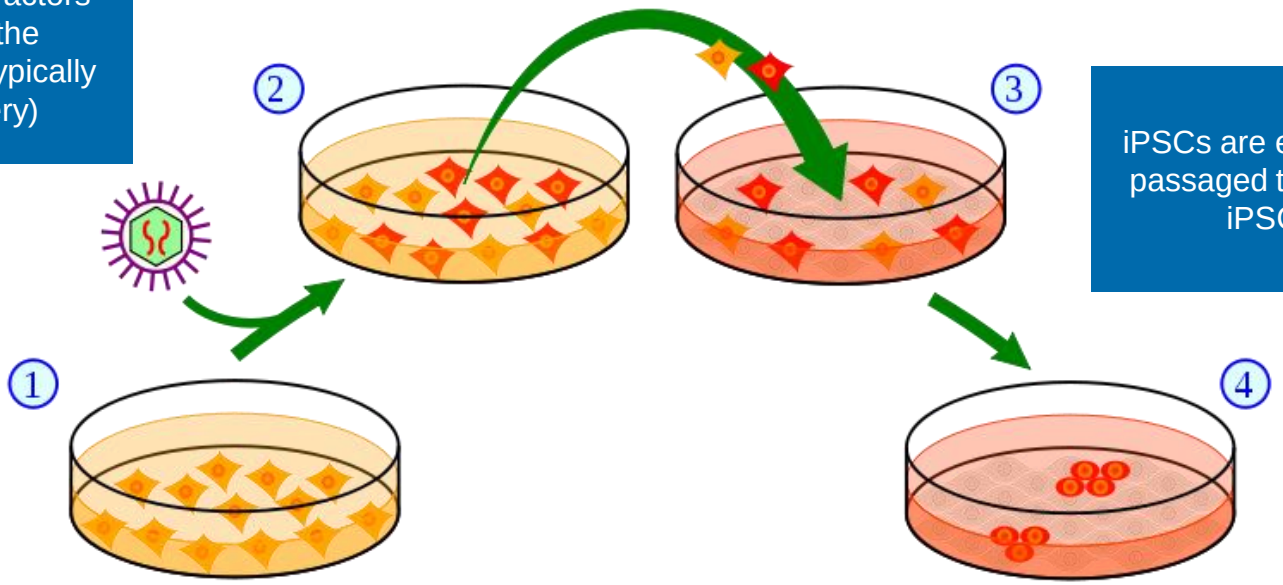

Why are iPSCs important?

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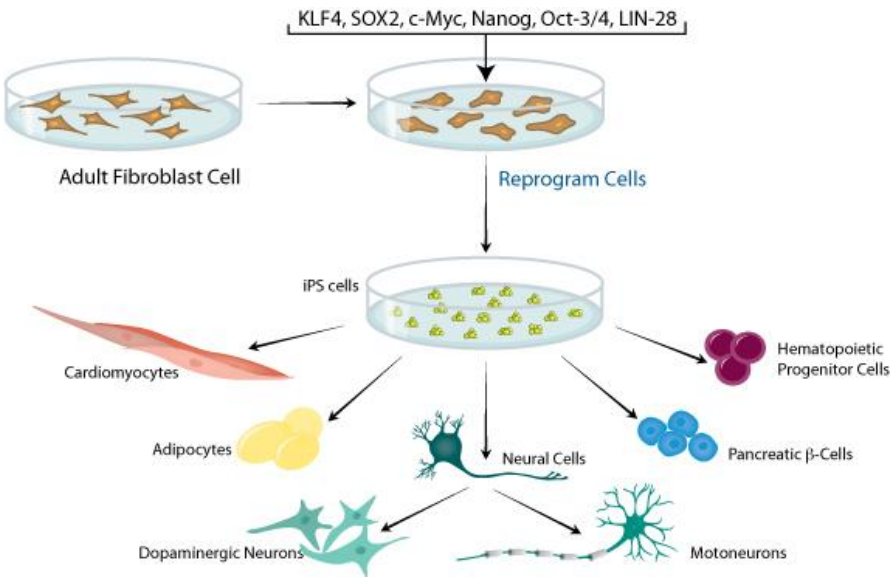
- **iPS cell research allows**
  - both wild-type and disease-specific pluripotent cells to be derived from accessible tissue sources
- **iPS cells will help researchers**
  - create genetic models for disease
  - understand molecular controls influencing cell development
- **iPS cells hold the promise of**
  - reducing drug development times
  - improving drug safety
  - bringing us closer to Personalized Medicine and targeted therapies



Mesenchymal Stem Cells

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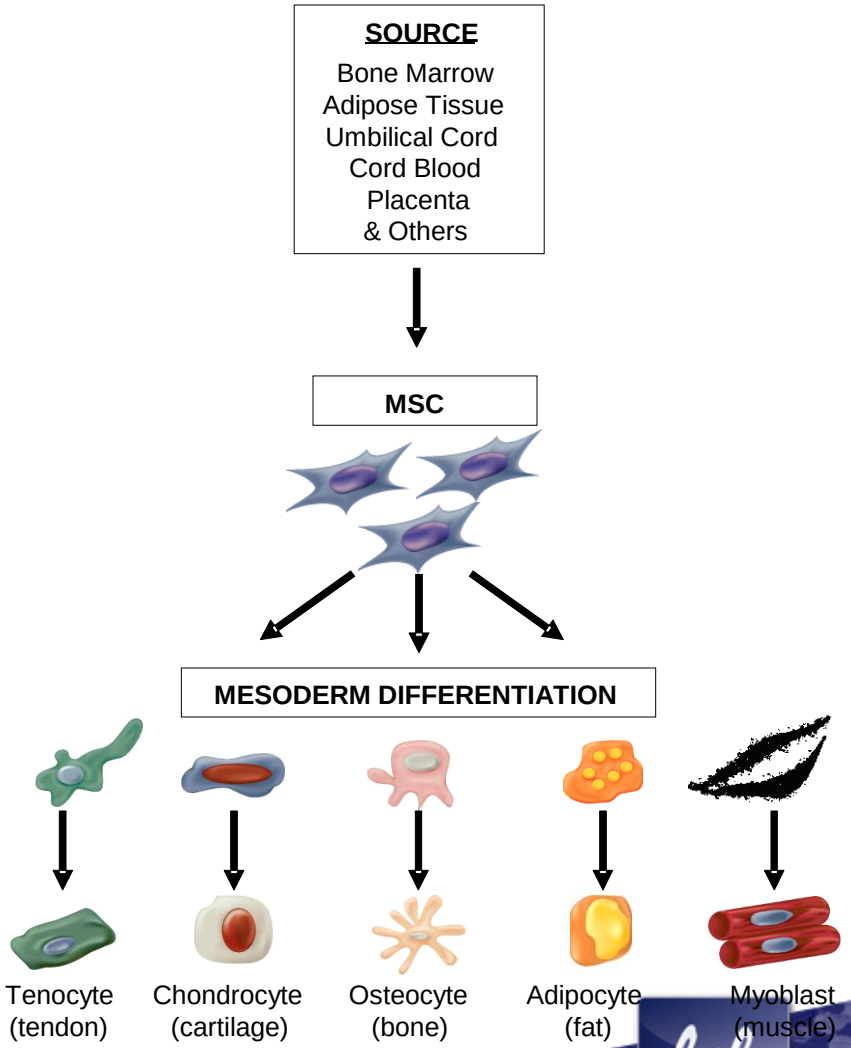
- **Mesenchymal stem cells (MSCs)**, also called bone marrow stromal cells, are **multipotent** stem cells that differentiate into a variety of cell types, including:
  - **osteoblasts** (bone cells)
  - **chondrocytes** (cartilage cells)
  - **adipocytes** (fat cells).
- Human MSCs are of interest in **clinical applications** due to:
  - Capacity for homing and engraftment
  - Wide-range differentiation potential
  - Immunosuppressive attributes
- Potential MSC Therapies:
  - Graft versus Host Disease
  - Crohn's Disease
  - Bone Defects/ Genetic Disease
  - HSC Transplantation
  - Cardiac repair
  - Trachea repair



Hematopoietic Stem Cells

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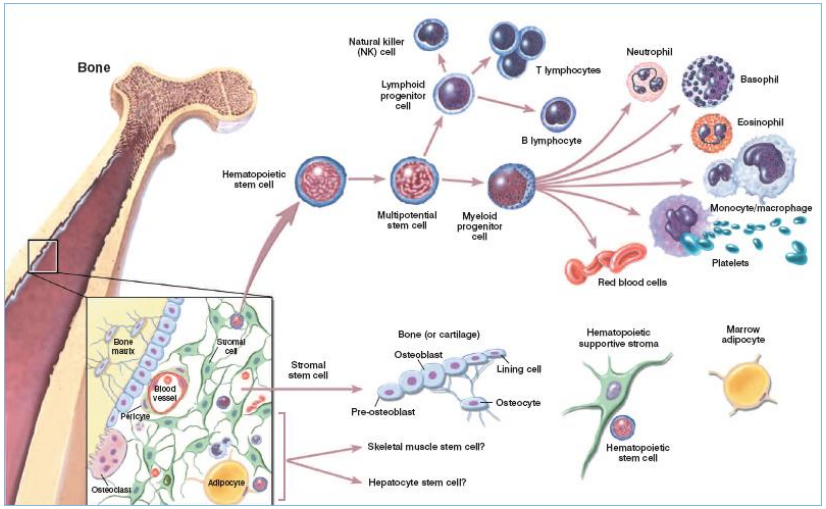
- **Hematopoietic stem cells (HSCs)** are **multipotent** stem cells that give rise to all the blood cell types from the:
  - **myeloid lineage** (monocytes and macrophages, neutrophils, basophils, eosinophils, erythrocytes, megakaryocytes/platelets, dendritic cells)
  - and **lymphoid lineage** (T-cells, B-cells, NK-cells).
- The average human requires approximately one hundred billion new hematopoietic cells each day
- The continued production of these cells depends directly on the presence of HSCs, the ultimate, and only, source of all these cells
- HSC transplants are now routinely used to treat patients with cancers and other disorders of the blood and immune systems.



Neural Stem Cells

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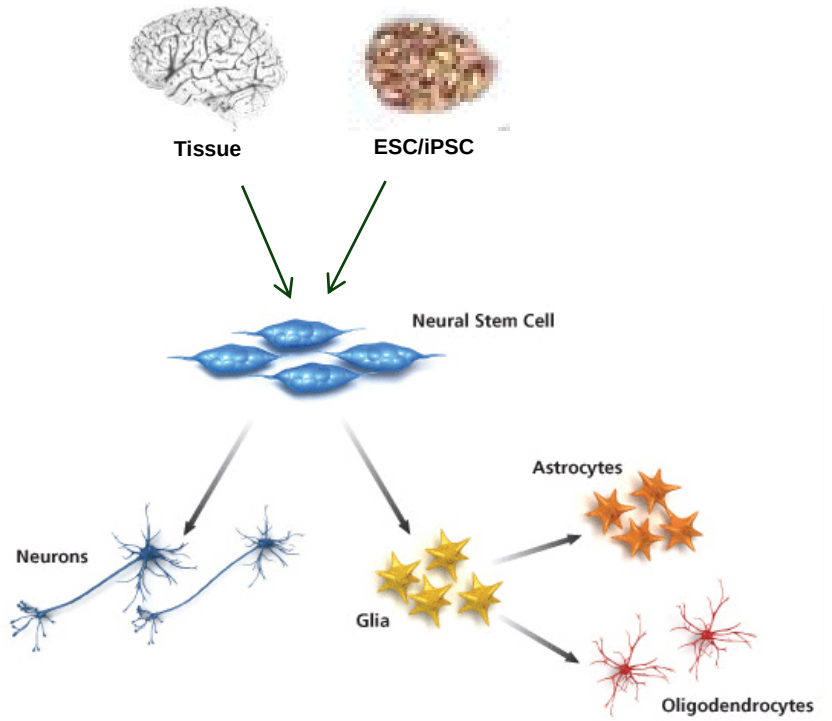
- **Neural Stem Cells (NSCs)** are **multipotent** stem cells that that generate the main phenotypes of the nervous system
  - Neurons
  - Astrocytes
  - Oligodendrocytes
- NSCs are derived from brain tissue or differentiated from pluripotent stem cells
- NSC research is currently focused on methods to repair damage from degenerative diseases such as Parkinson's Disease and amyotrophic lateral sclerosis (ALS, also known as Lou Gehrig's disease), as well as from brain and spinal cord injuries resulting from stroke or trauma:



Cancer Stem Cells

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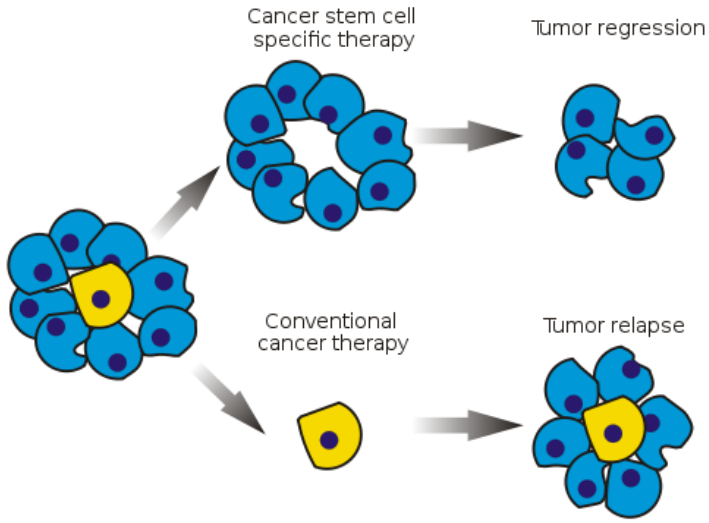
- **Cancer stem cells (CSCs)** are cancer cells (found within tumors or hematological cancers) that possess characteristics associated with normal stem cells, specifically the ability to give rise to all cell types found in a particular cancer sample.
- Current CSC theory states that if current treatments of cancer do not properly destroy enough CSCs, the tumor will reappear.
- This includes the possibility that treatment by, for example, chemotherapy, will leave only chemotherapy-resistant CSCs and the ensuing tumor will most likely also be resistant to chemotherapy.
- CSCs have recently been identified in several solid tumors, including cancers of the:
  - Brain
  - Breast
  - Colon
  - Ovary
  - Pancreas
  - Prostate
  - Melanoma
  - Multiple Myeloma



Summary

Watch a video about Induced Pluripotent Stem Cells

All stem cells—regardless of their source—have three general properties:

1. they are capable of dividing and renewing themselves for long periods
2. they are unspecialized
3. they can give rise to specialized cell types

There are two main types of stem cells:

1. Pluripotent Stem Cells
   - Embryonic Stem Cells (ESCs)
   - Induced Pluriptoent Stem Cells (iPSCs)
2. Adult or Multipotent Stem Cells
   - Mesenchymal Stem Cells (MSCs)
   - Neural Stem Cells (NSCs)
   - Hematopoietic Stem Cells (HSCs)
   - Cancer Stem Cells (CSCs)

Stem Cells have applications in:

- Basic Research
- Drug Discovery
- Cell Therapy

To learn more about Stem Cells, join the Life Technologies **Stem Cell Research Network**