

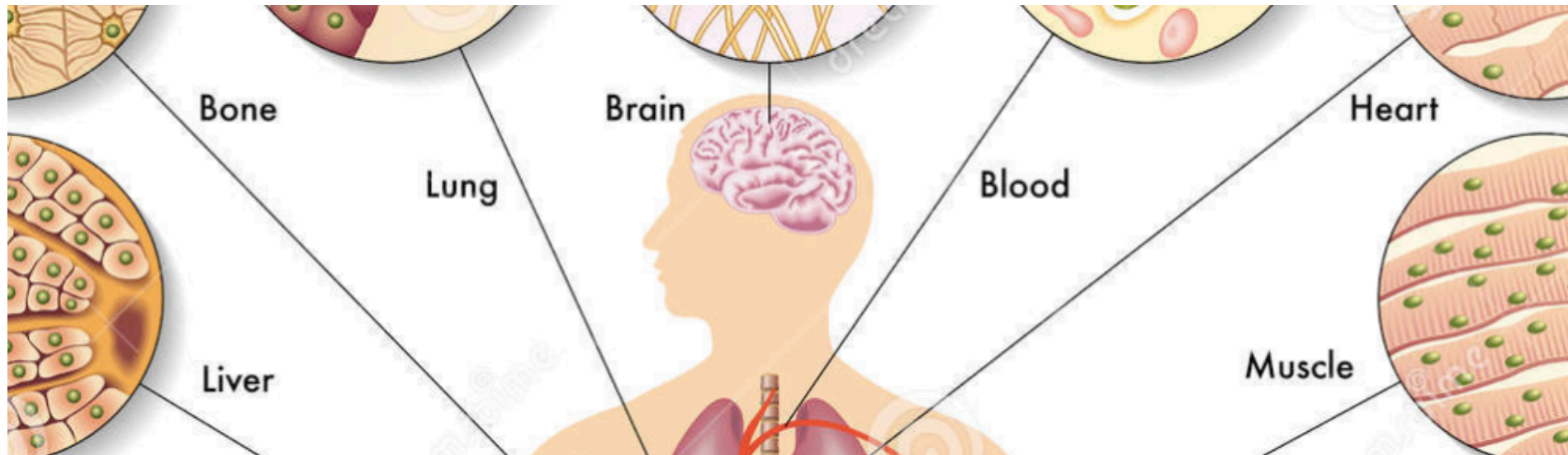
A microscopic image of a neural network. The background is black, with numerous green and red fluorescent structures. The green structures are long, thin, and branching, resembling axons or dendrites. The red structures are smaller, more rounded, and scattered throughout the network. The overall appearance is that of a complex, interconnected network of cells.

Lets regenerate!

The exciting life of a stem cell

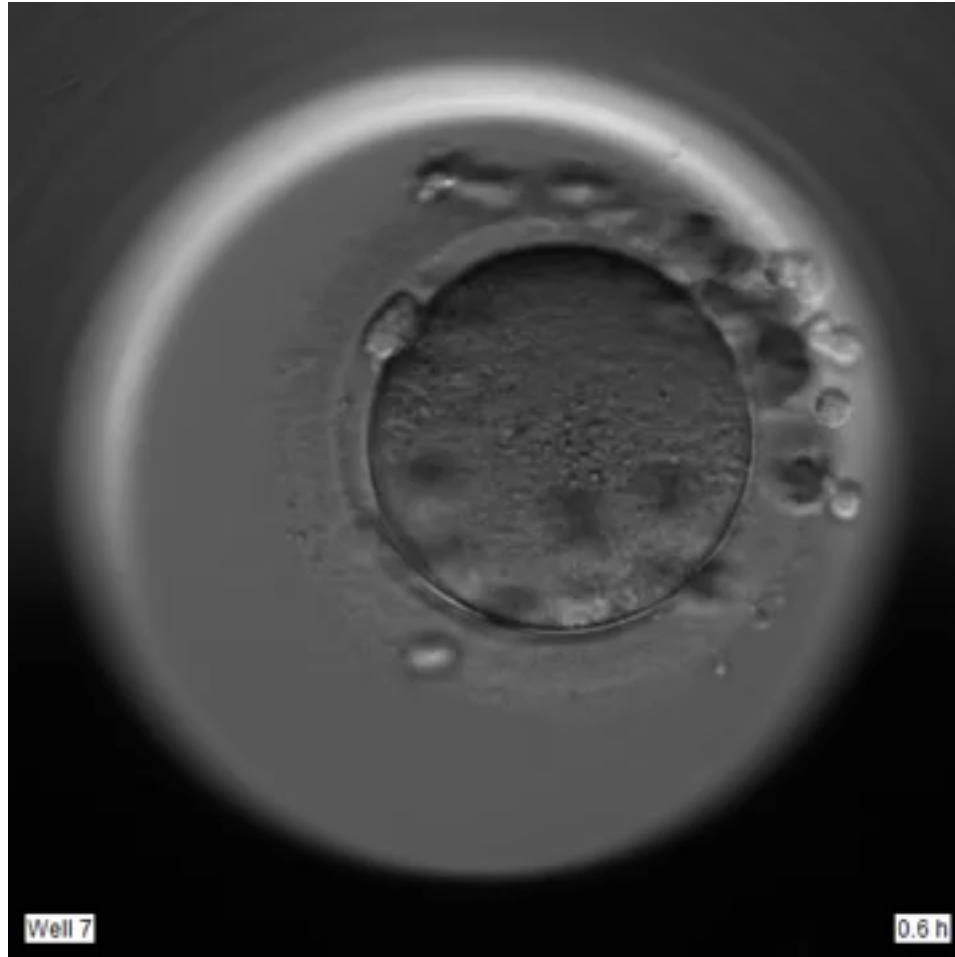
Deepa Subramanyam, PhD
National Centre for Cell Science, Pune

Our body is made up of different cells and organs...



.... how are these made?

The first few days of life



What are stem cells? What are the different types of stem cells?

Why should we study stem cells? What potential therapies could they provide?

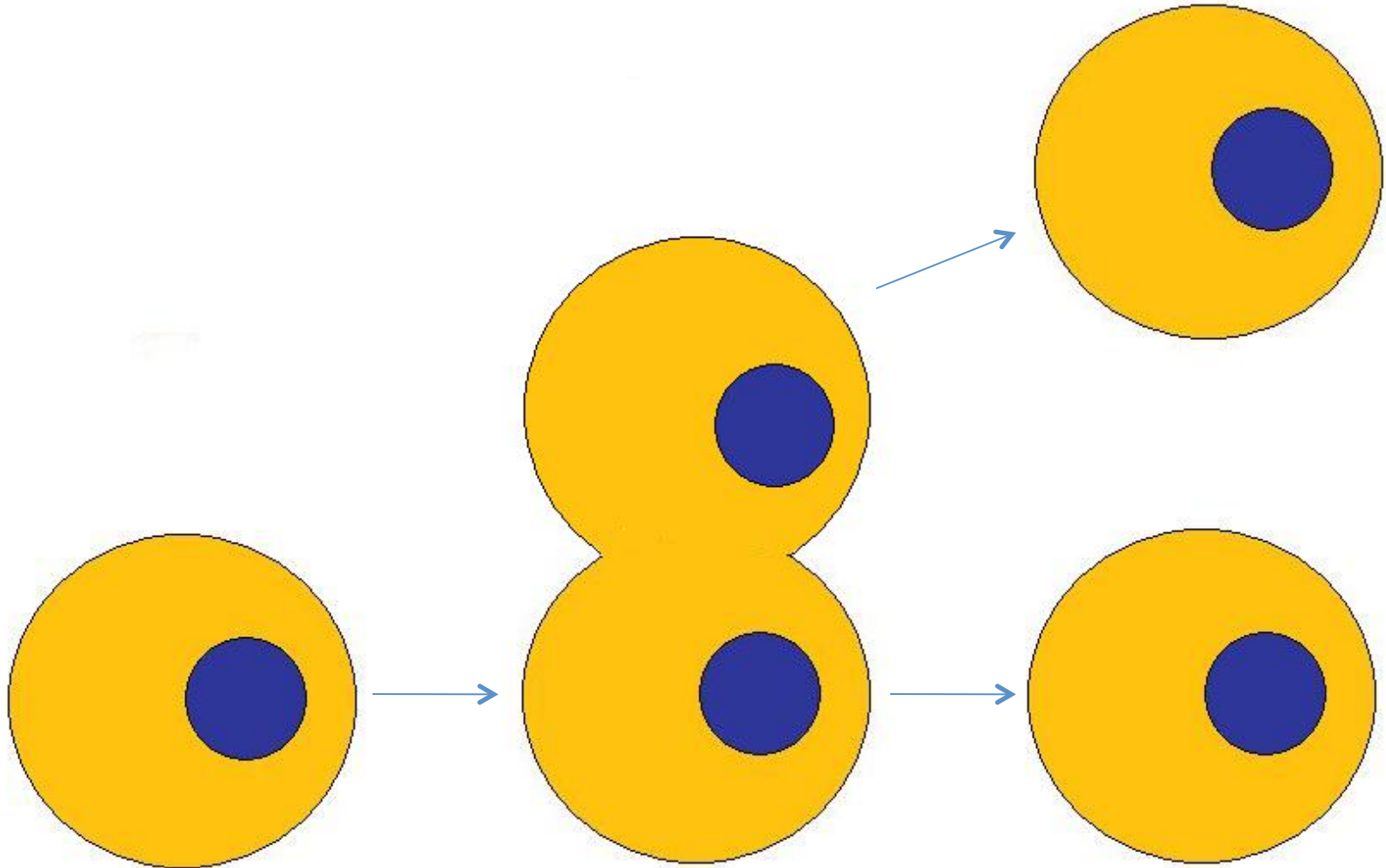
What are some of the challenges facing stem cell research?

All Stem Cells Can...

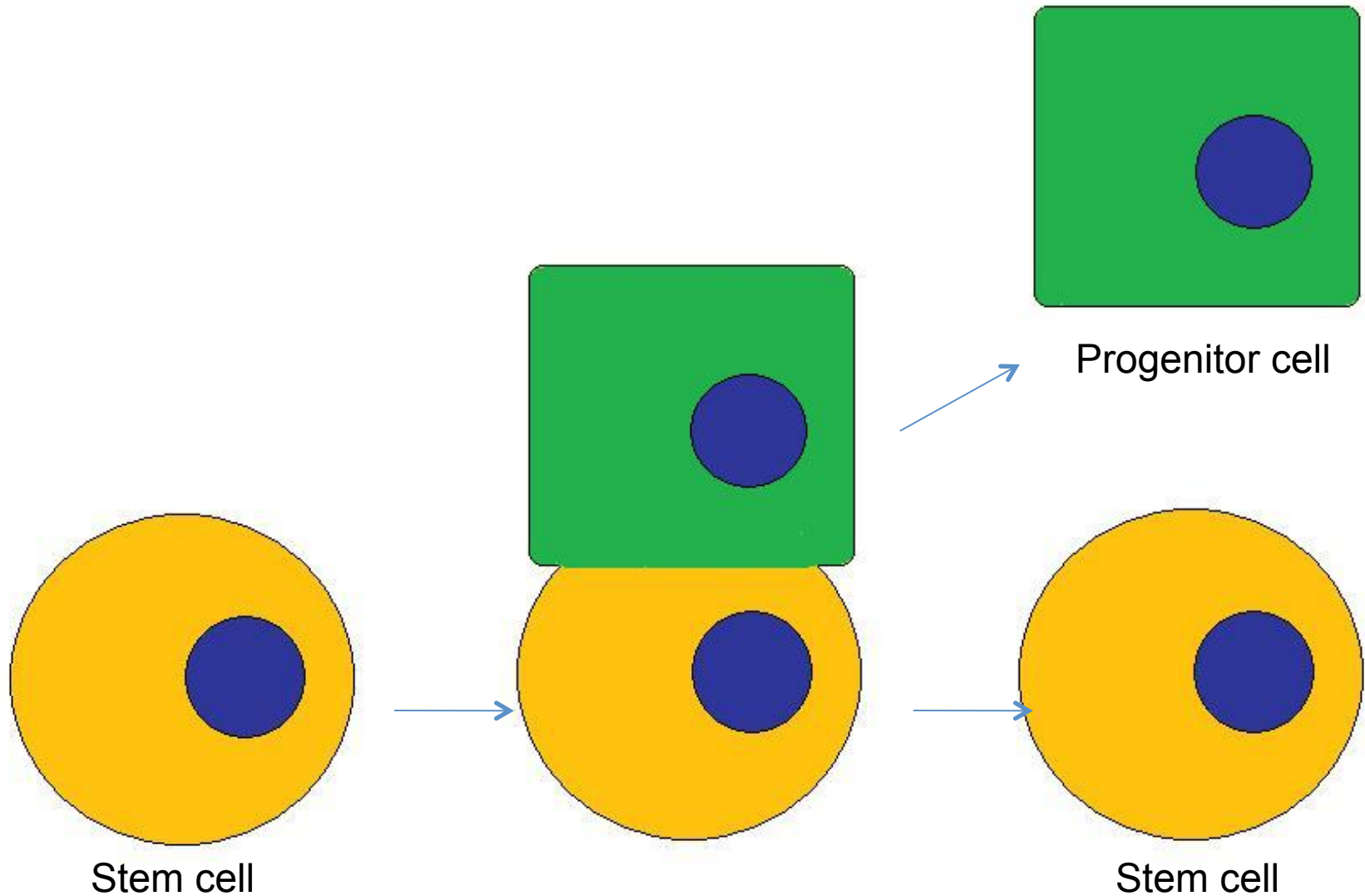
1. Self-Renew

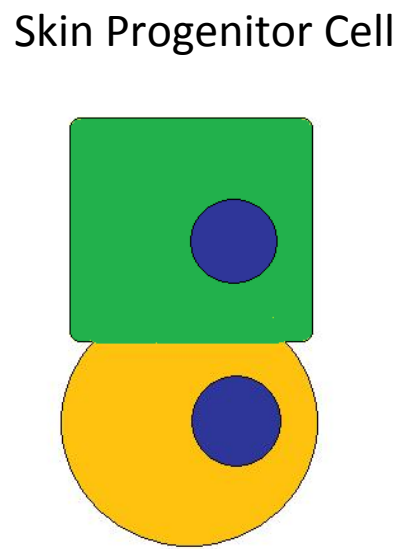
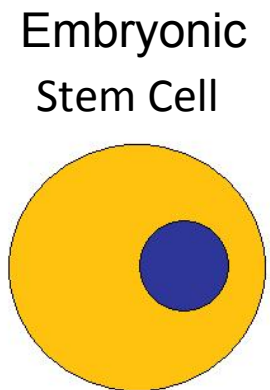
2. Differentiate

Self-Renewal (symmetric cell division)

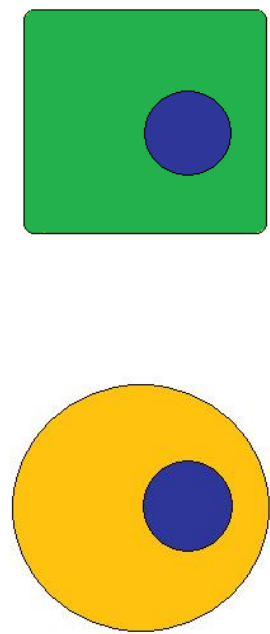


Differentiation (asymmetric cell division)



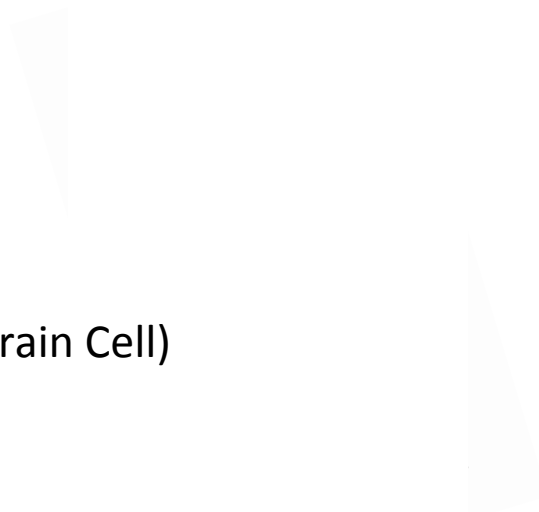


Skin Cell



Neural Progenitor Cell

Neuron (Brain Cell)



Stem Cell Types

- **Embryonic** – pluripotent: can form almost any cell type in the human body
- **Tissue-Specific (Adult)** – multipotent: can form only limited types of cells (blood, brain, liver, etc.)
- **Induced Pluripotent** – engineered by scientists to act like embryonic stem cells

In Vitro Development

Day 1



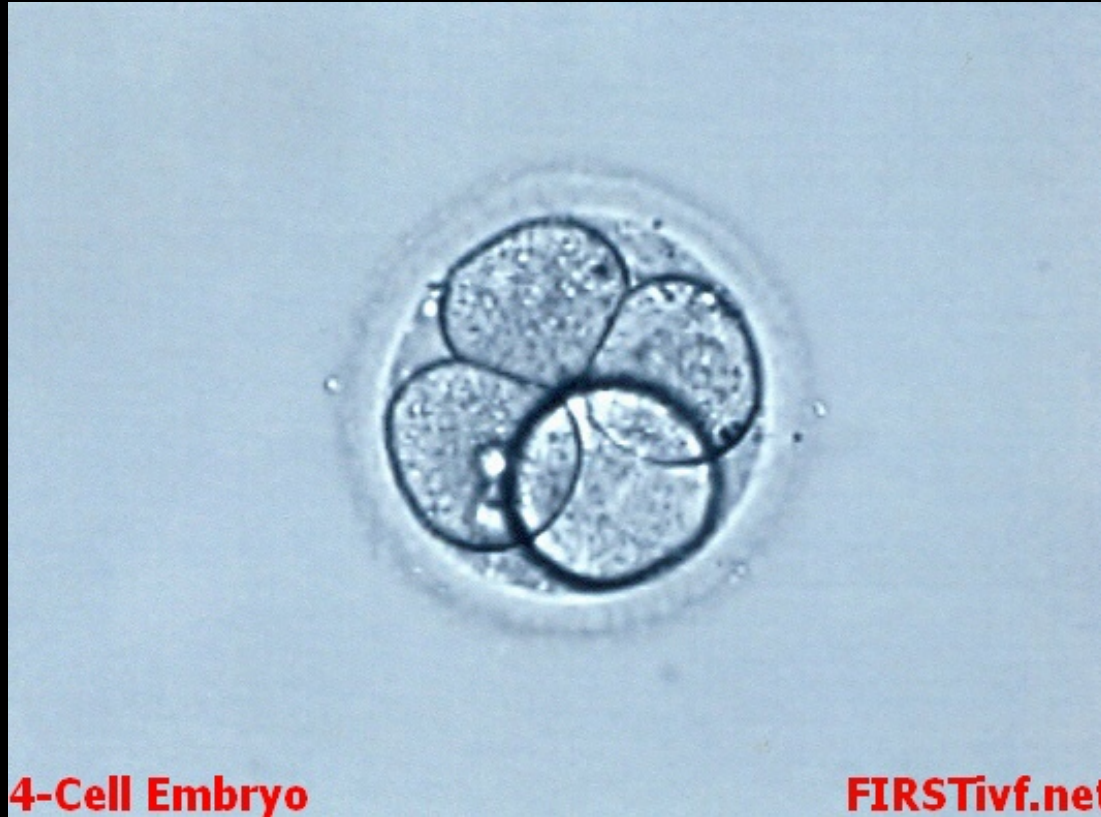
In Vitro Development

Day 2



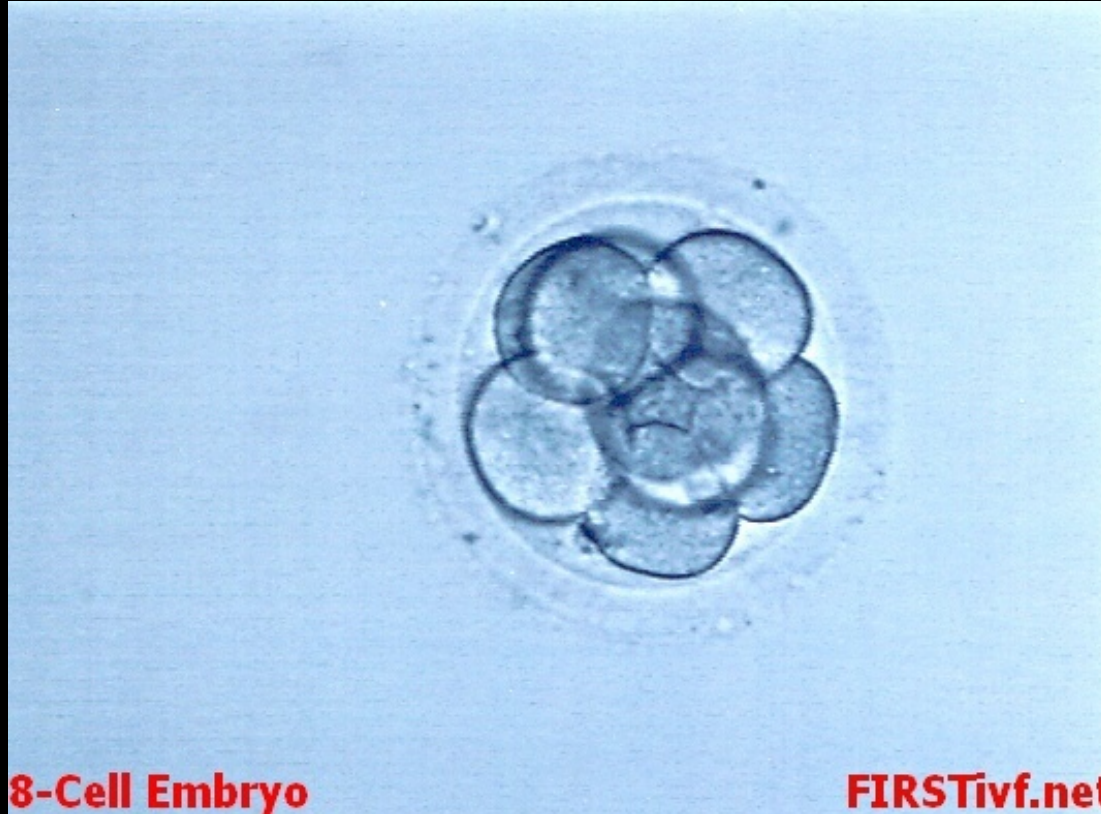
In Vitro Development

Day 2



In Vitro Development

Day 3



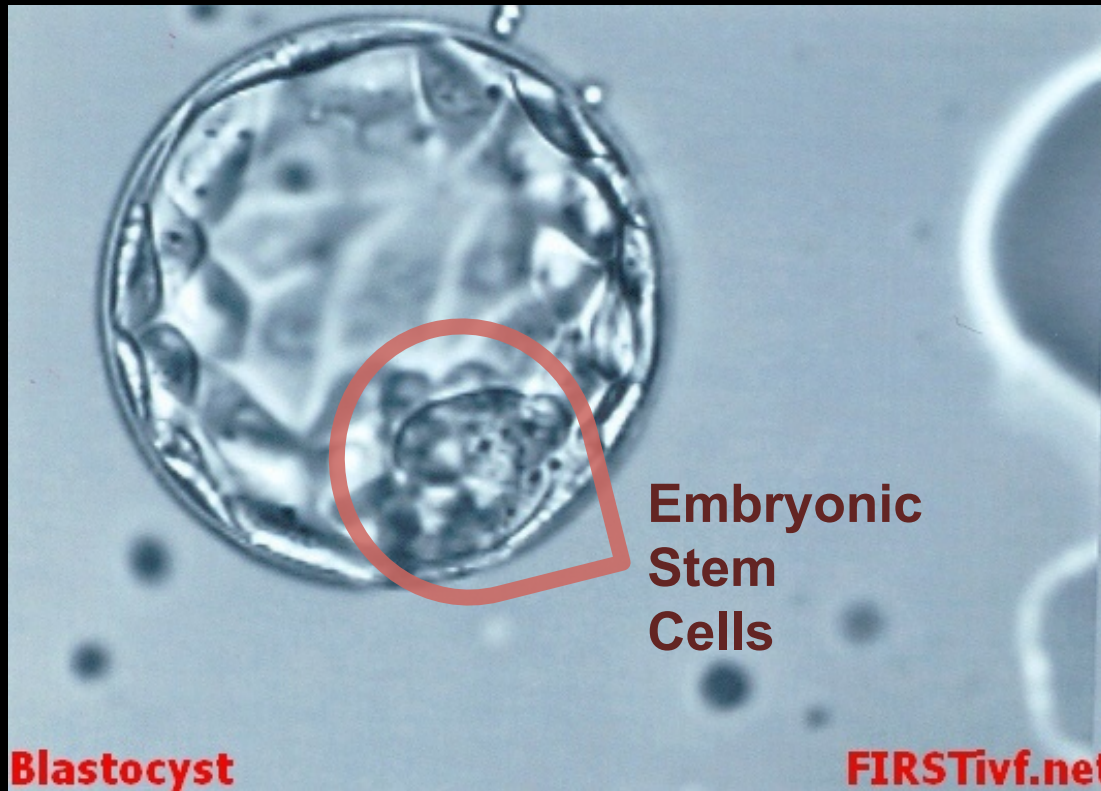
In Vitro Development

Day 4

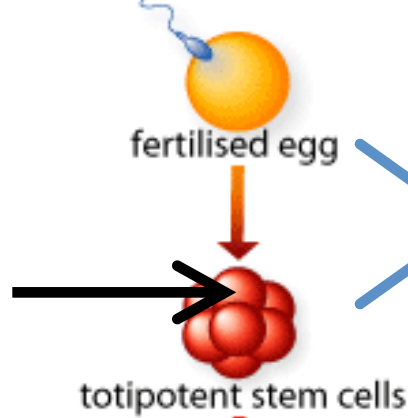


In Vitro Development

Day 5

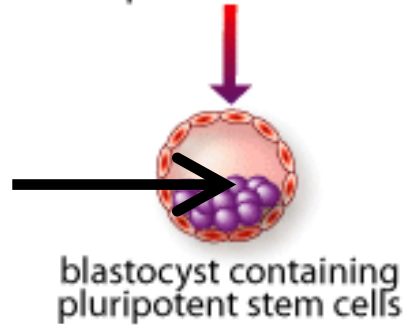


This cell can form all of the cells in the human body



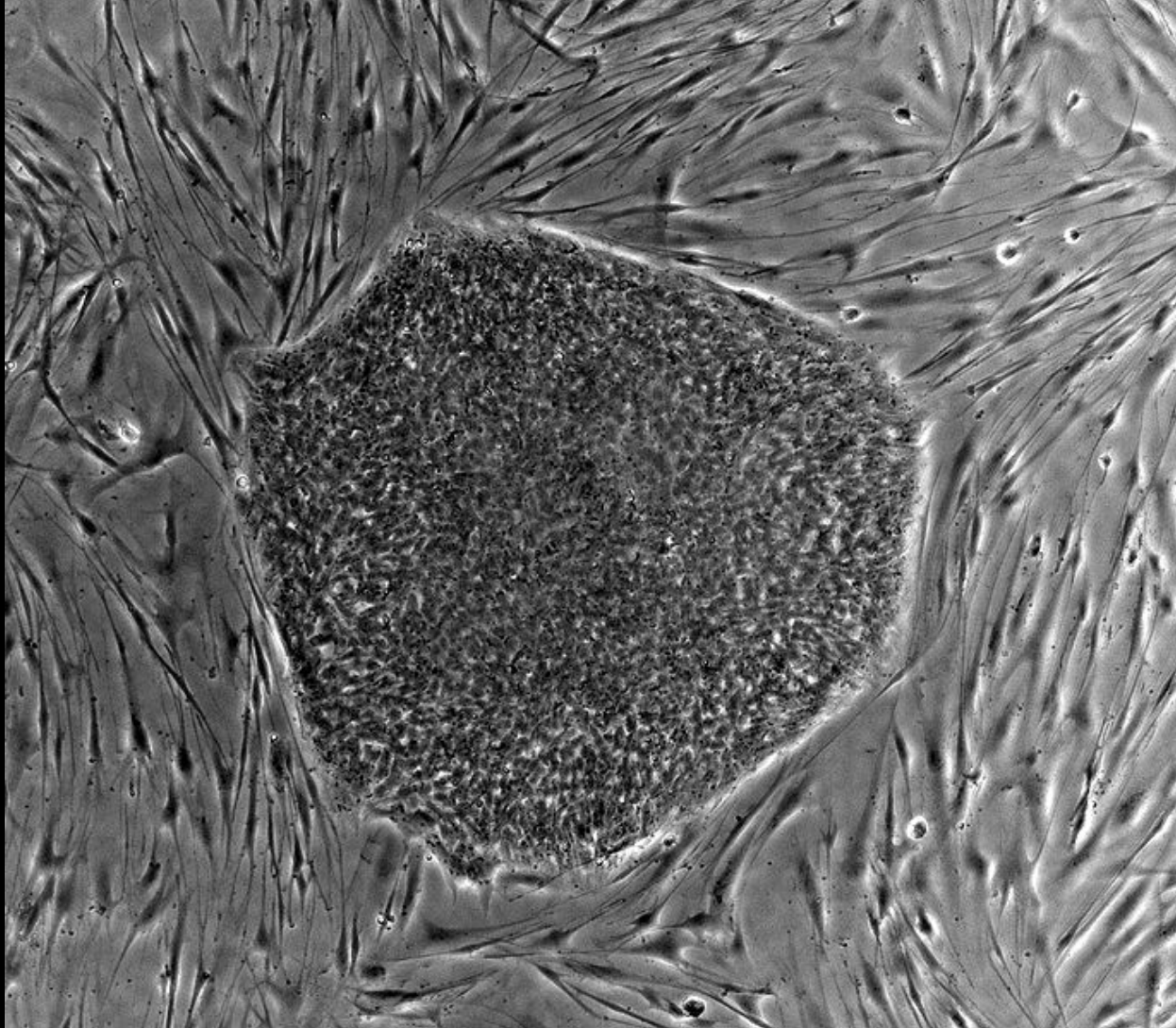
Totipotent

This cell can form almost every cell type in the human body

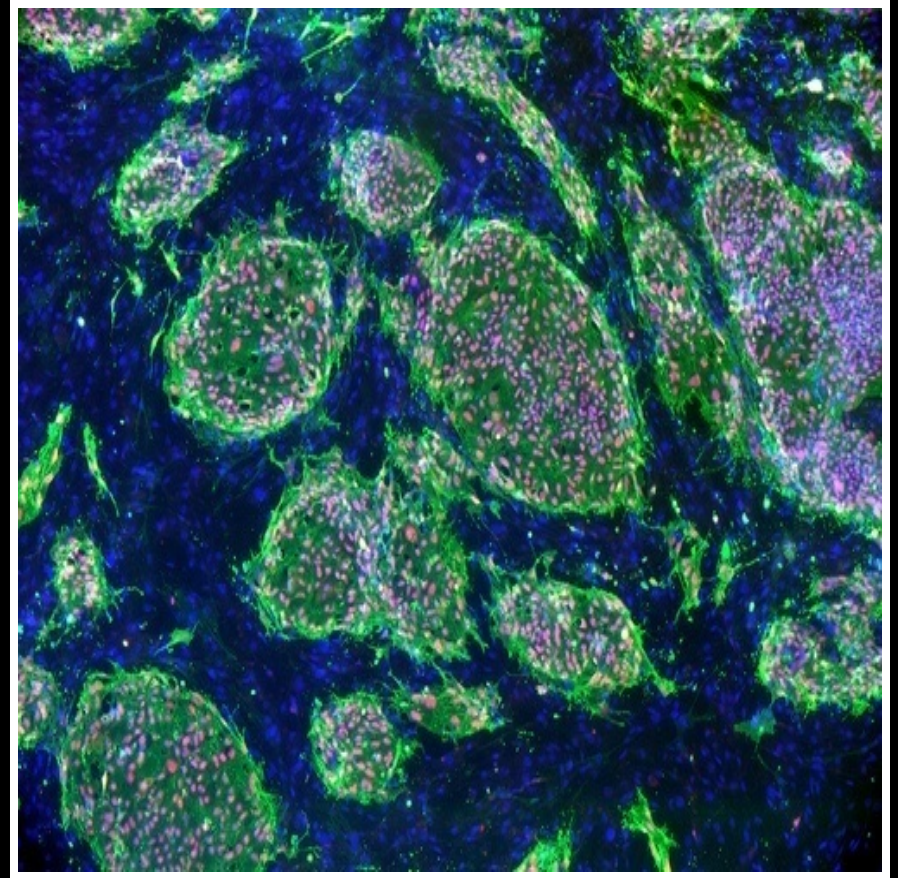
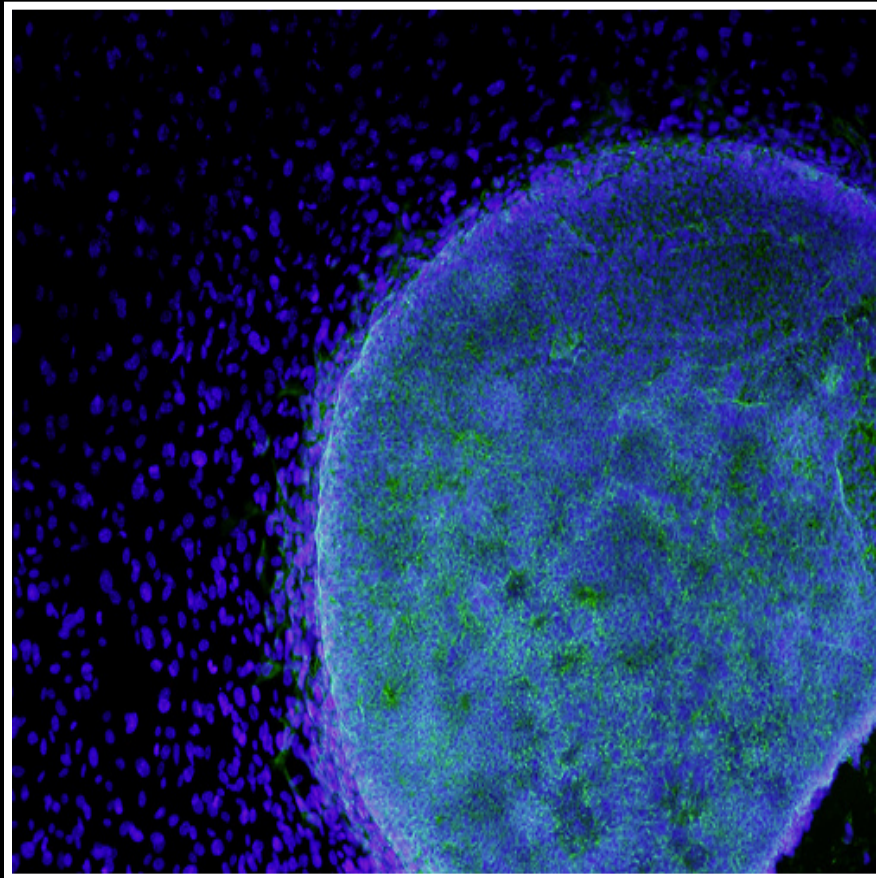


Pluripotent

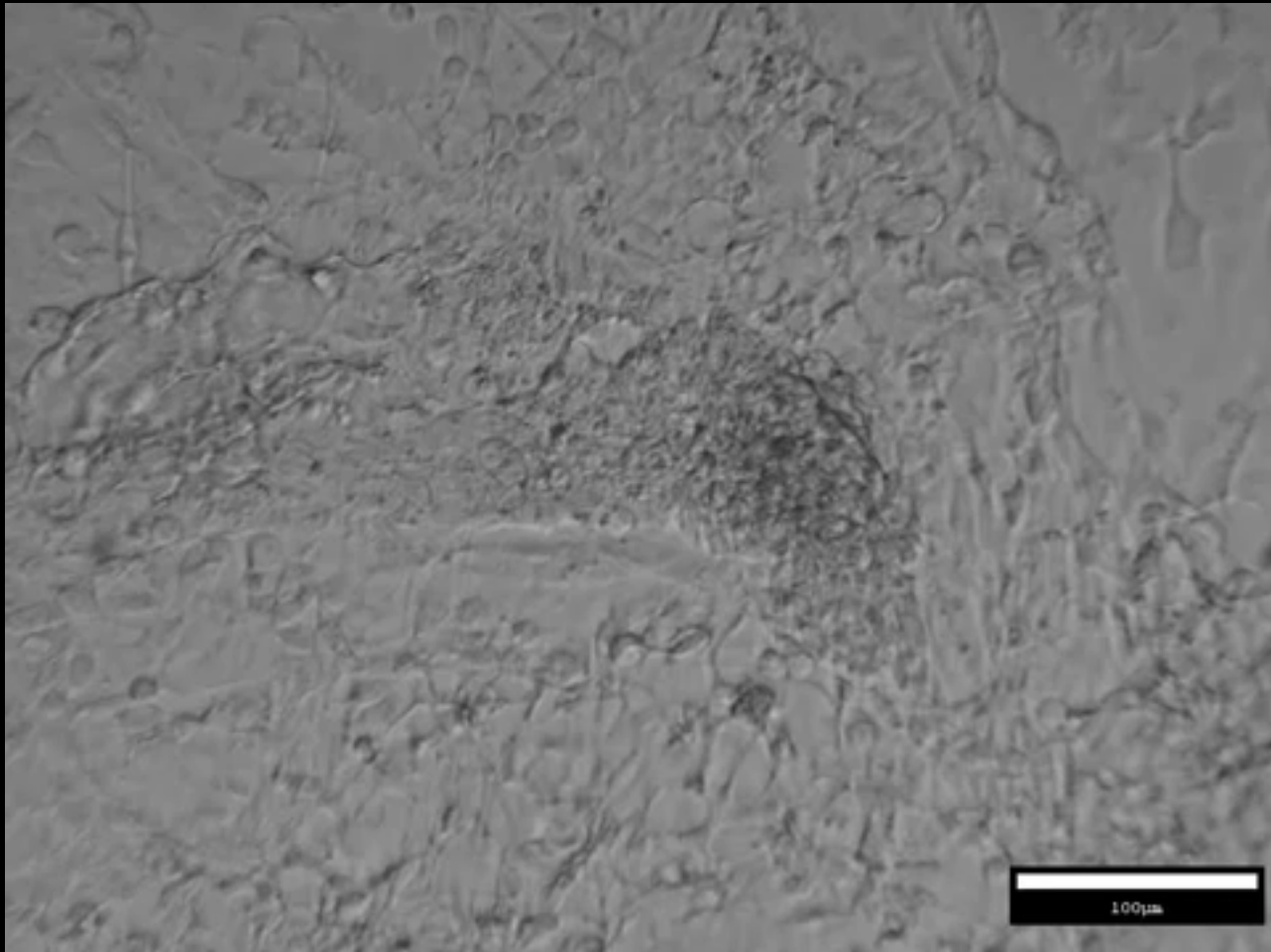
Human embryonic stem cells in culture



Fluorescent imaging of human embryonic stem cell colonies



Embryonic Stem-Cell Derived Heart Muscle Cells



Stem Cell Types

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Adult stem cells are present in each organ for maintenance and repair



What Diseases Do Stem Cells Treat? Have the Potential to Treat?

Currently Treat

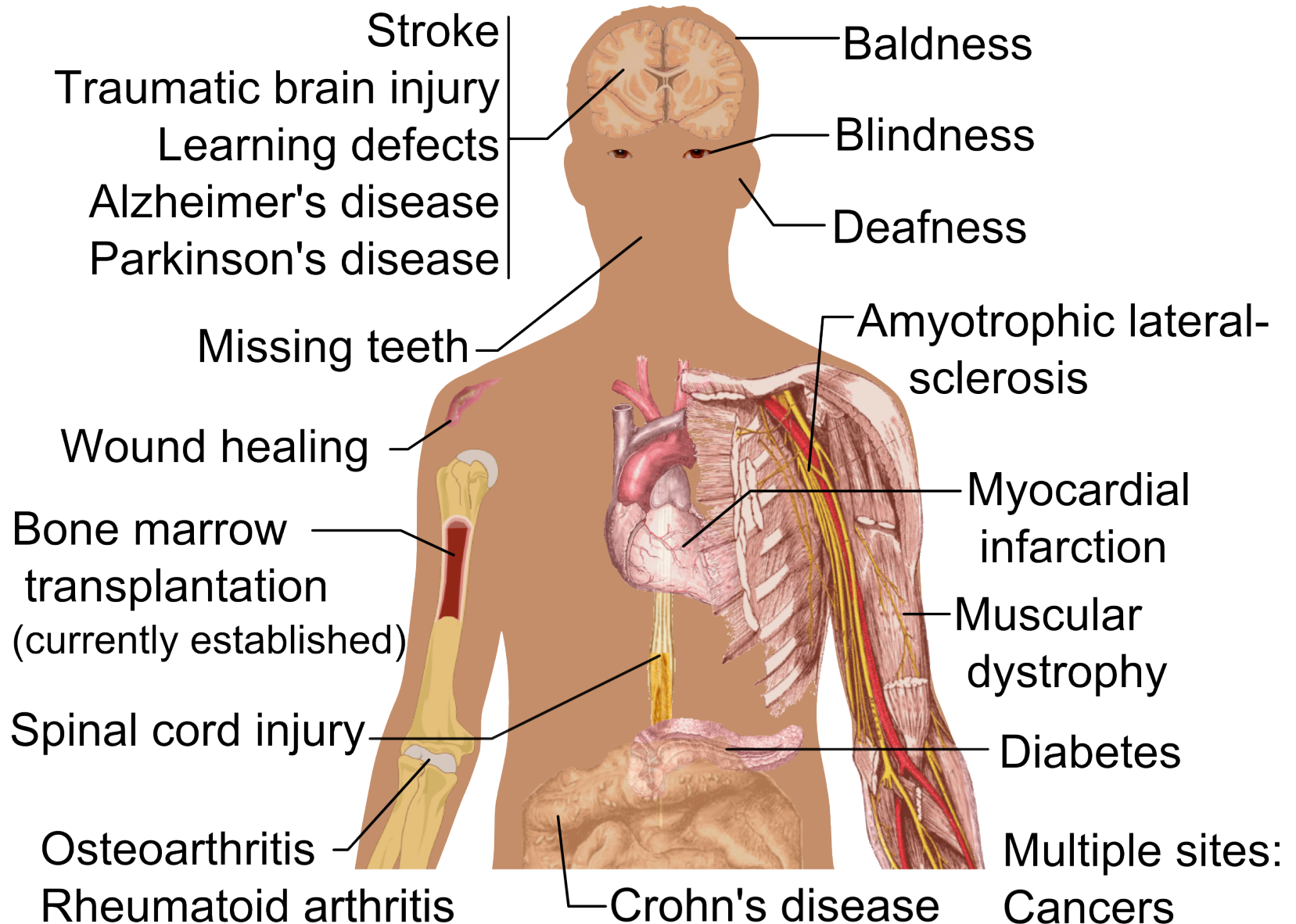
- Blood Diseases (including immune system disorders)
- Genetic metabolic disorders (*very limited/experimental*)
- Tissue/organ replacement (*very limited/experimental*)

Potential to Treat

- Heart Disease
- Neurological Diseases (Parkinson's, Alzheimer's, Huntington's & others)
- Stroke
- Type 1 Diabetes
- Macular Degeneration (a common cause of blindness)
- Cancer
- HIV/AIDS
- Spinal Cord Injury
- Multiple Sclerosis
- ALS (Lou Gehrig's Disease)
- Liver Disease

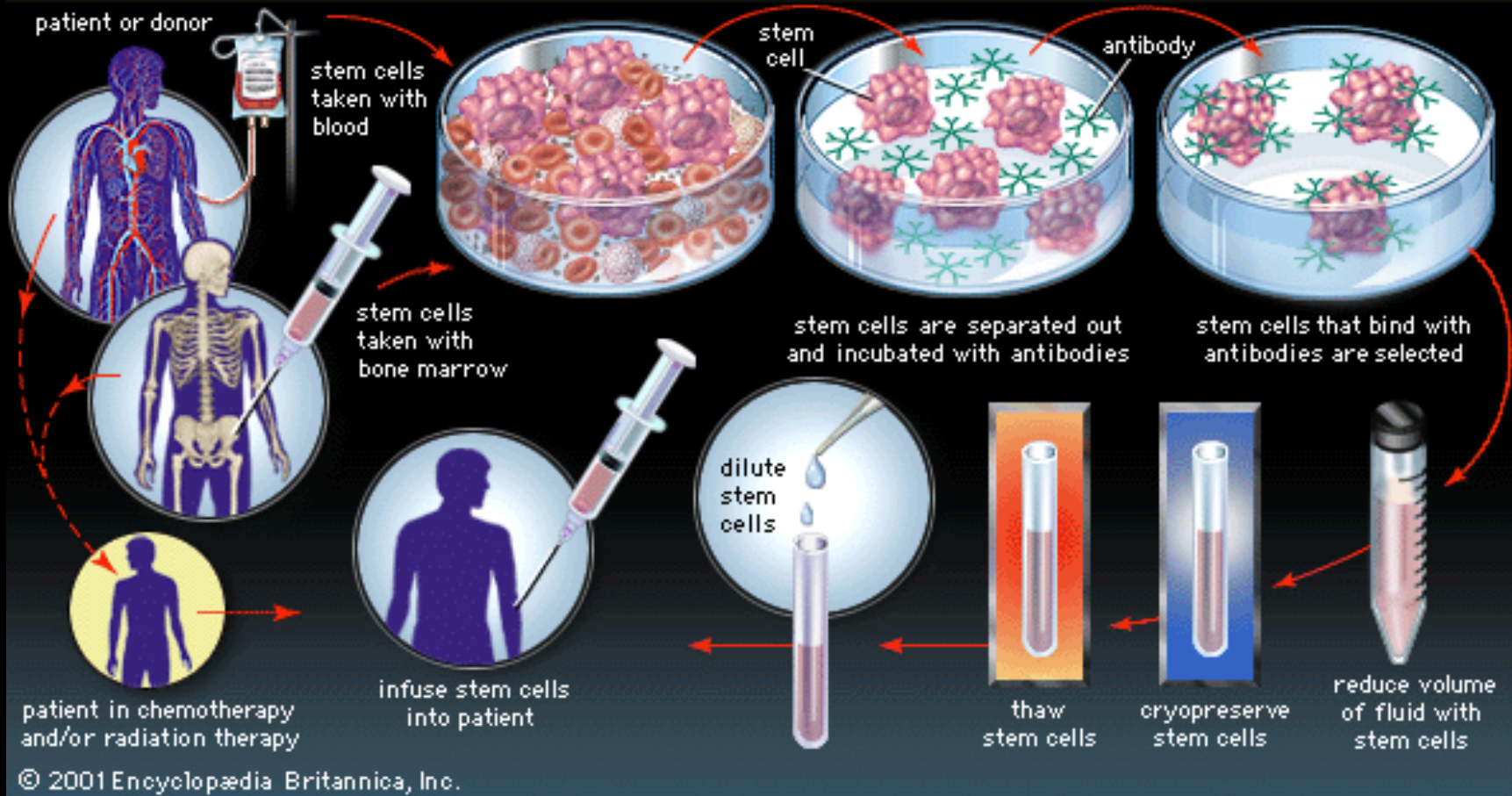
...and
more!

What can we do with stem cells?



Bone Marrow (Hematopoietic Stem Cell) Transplant

Example of a tissue-specific stem cell therapy



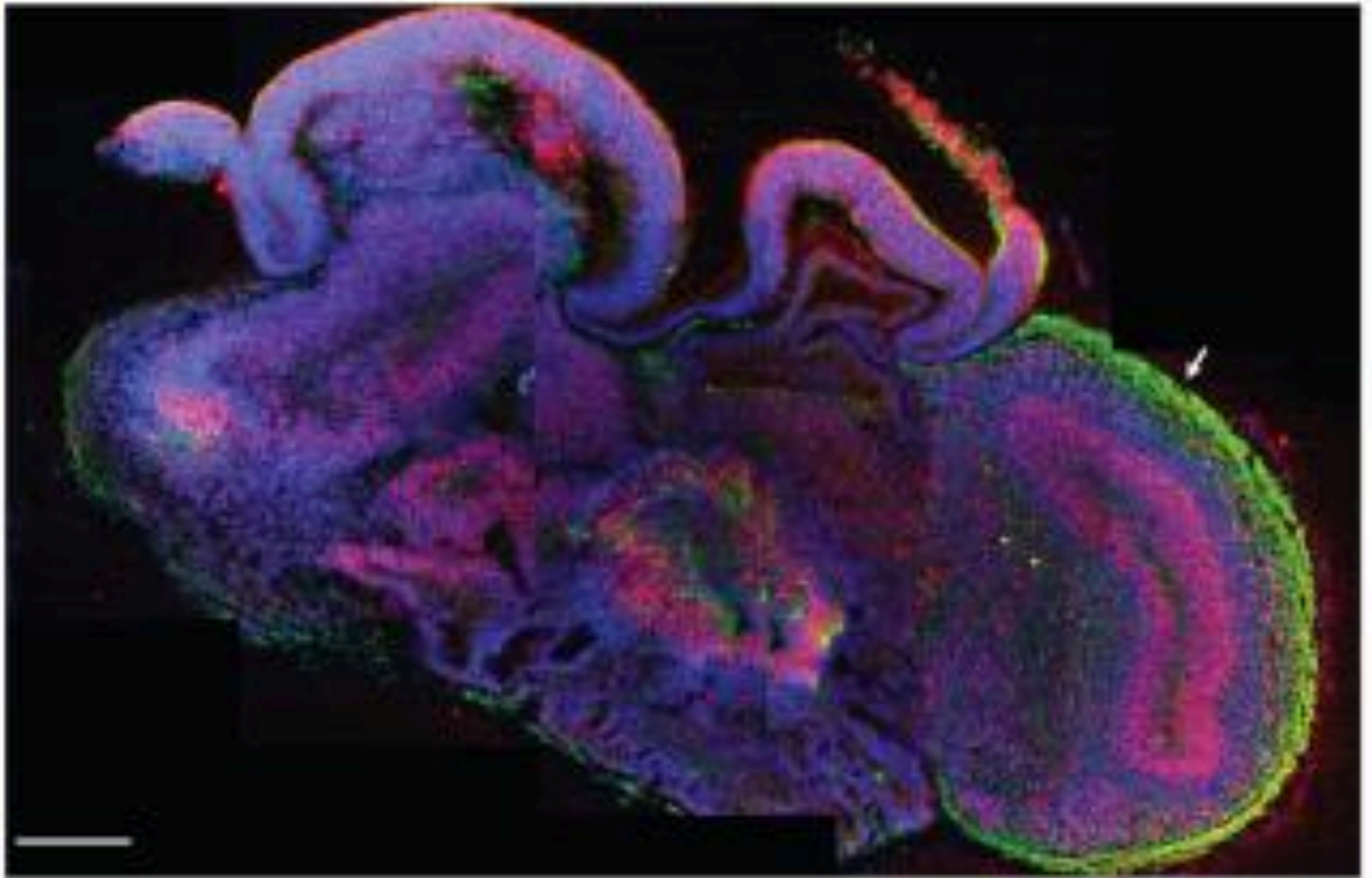
Making mini-organs from adult stem cells



Making mini-brains from stem cells

C

Sox2 Tuj1 Hoechst



Tissue-specific (adult) stem cells are
powerful and promising!

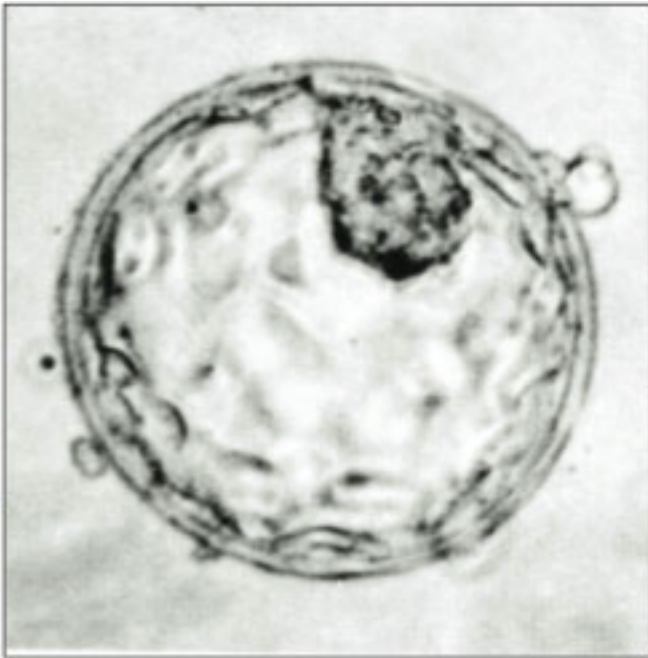
*Why do researchers study embryonic
stem cells?*

- Tissue-specific stem cells are limited in their differentiation potential (blood → blood)
- Stem cells from some tissues are inaccessible
- Some tissue-specific stem cells don't self-renew well
- Some tissues may not have stem cells!

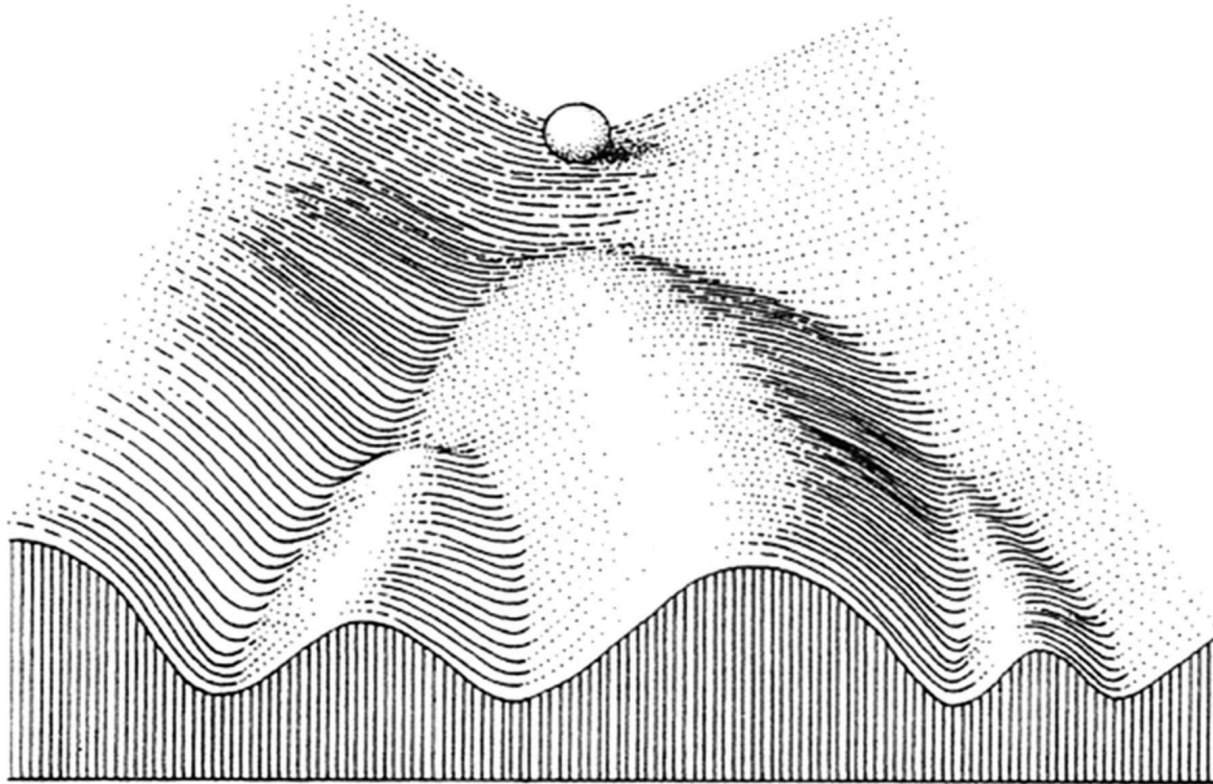
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But what about stem cells for myself?

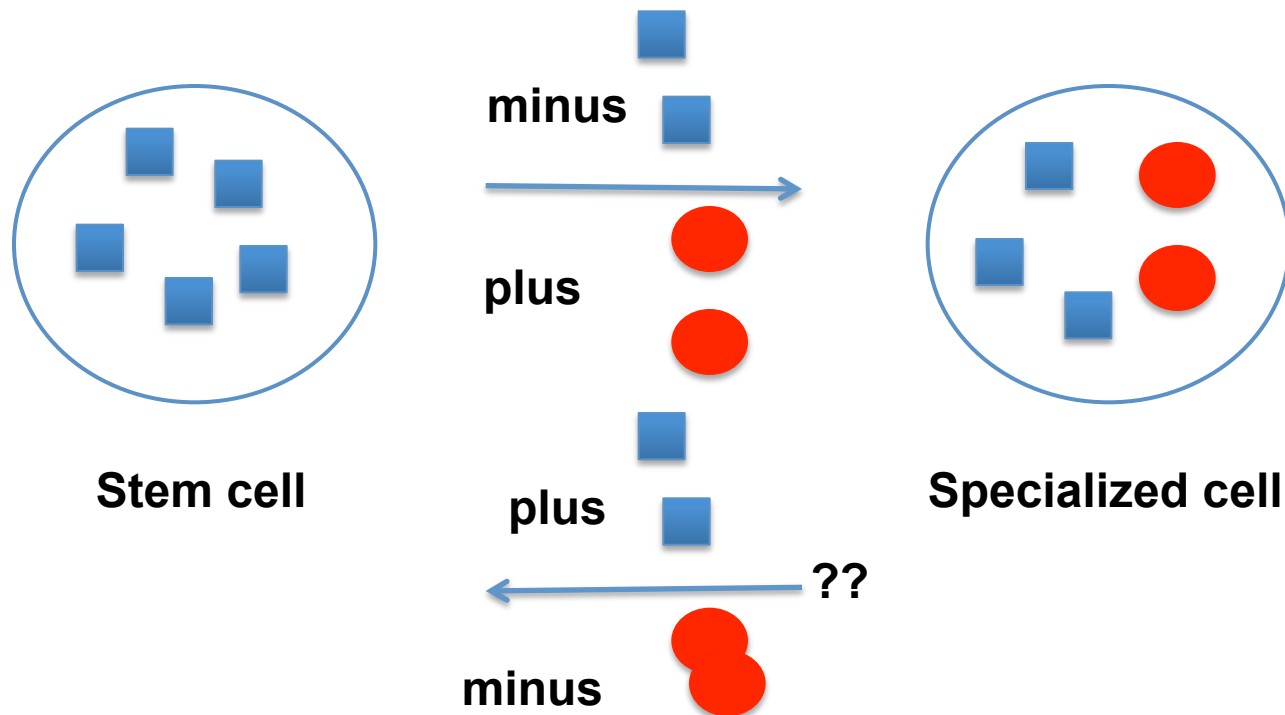


We can imagine a ball rolling down a hill, but back upwards?



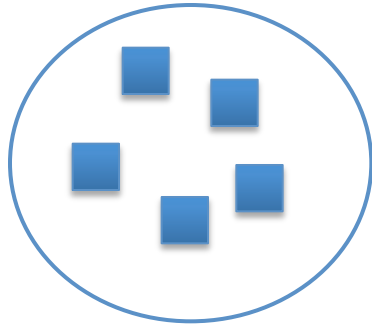
Is it possible to take a cell that is already performing a specific function and take it back to a state where it does not have a fixed role – aka stem cell state?

But how can we get stem cells from ourselves? Is there a magic solution?



Is this reversible? Can we subtract and add specific components to get back a stem cell?

Yes! Now I can make stem cells from my own body cells by addition and subtraction



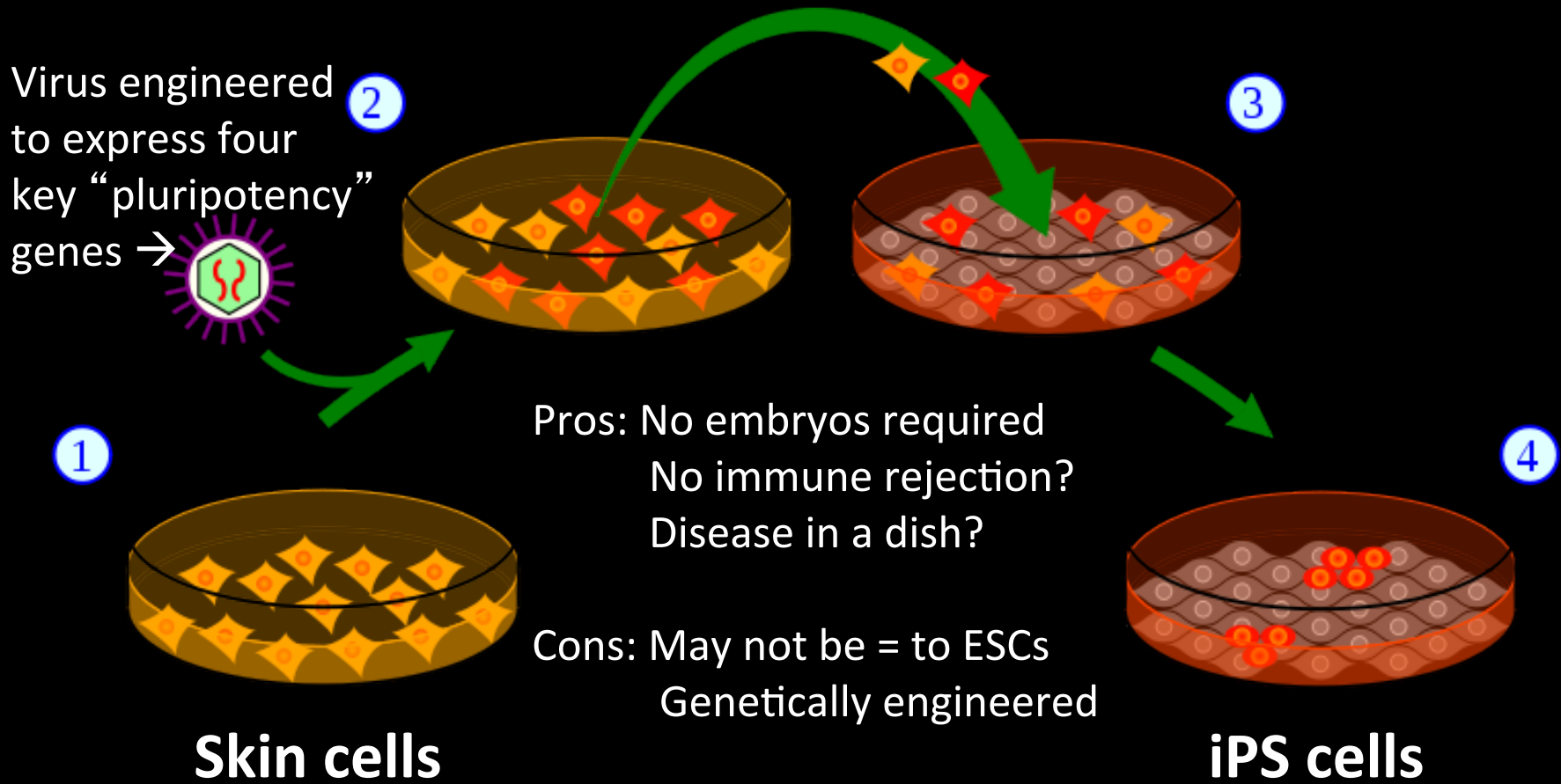
Stem cell



Reprogramming!

Induced Pluripotent Stem (iPS) Cells

Genetically engineering new stem cells



What are some of the challenges facing embryonic stem cell research?

- Differentiation of stem cells into mature, functional cells
- Potential for tumor formation
- Immune rejection

2 Nobel prizes – one for stem cells and one for reprogramming.

Physiology or Medicine 2007



Photo: U. Montan
Mario R. Capecchi
Prize share: 1/3



Photo: U. Montan
Sir Martin J. Evans
Prize share: 1/3



Photo: U. Montan
Oliver Smithies
Prize share: 1/3

The Nobel Prize in Physiology or Medicine 2007 was awarded jointly to Mario R. Capecchi, Sir Martin J. Evans and Oliver Smithies *"for their discoveries of principles for introducing specific gene modifications in mice by the use of embryonic stem cells"*.

The Nobel Prize in Physiology or Medicine 2012



Photo: U. Montan
Sir John B. Gurdon
Prize share: 1/2



Photo: U. Montan
Shinya Yamanaka
Prize share: 1/2

Summary

- Stem cells are of three types: embryonic, adult and induced pluripotent.
- Embryonic stem cells are derived from the embryo and can give rise to all cell types in the body.
- Adult stem cells are present in each organ and can give rise to cell types present in that specific organ.
- Induced pluripotent stem cells can be made for each individual and are the future of regenerative medicine.

A word of caution...

- Scientists are still in the process of understanding the behaviour of stem cells.
- Improper use of stem cells in unapproved therapies can result in serious consequences and can be dangerous.
- Almost all stem cell therapies are still NOT approved, even though there are numerous advertisements proclaiming successful use of stem cells to treat various diseases/disorders.



Thank you!