# The Molecular and Biochemical Basis of an Organism

## Unit-3

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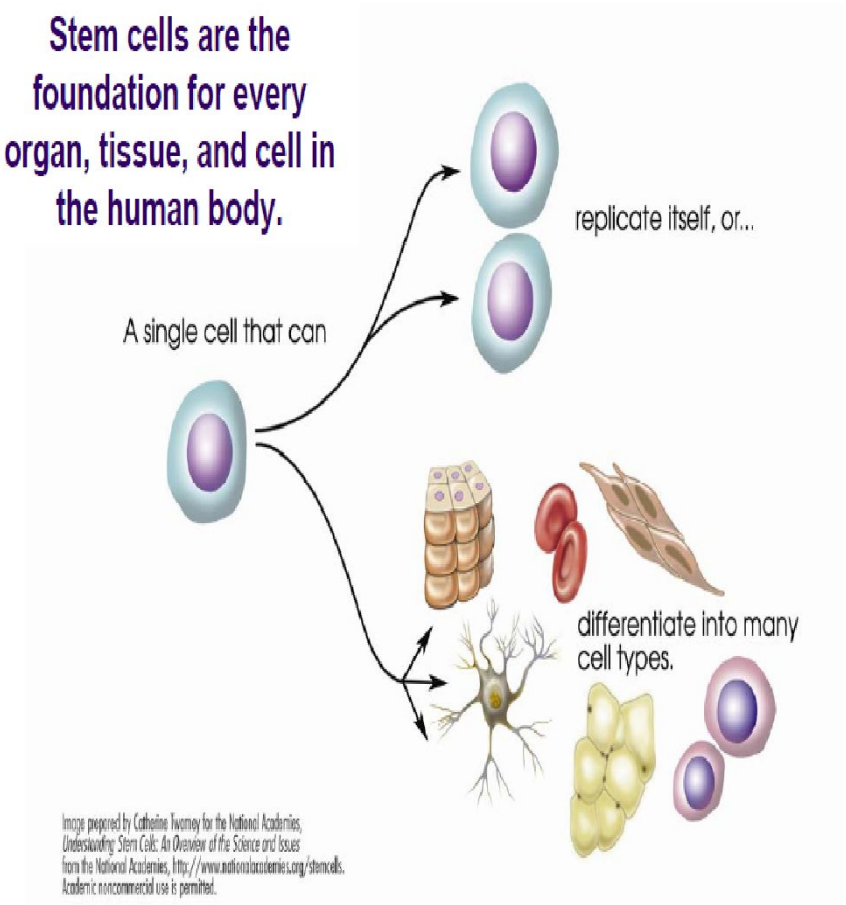
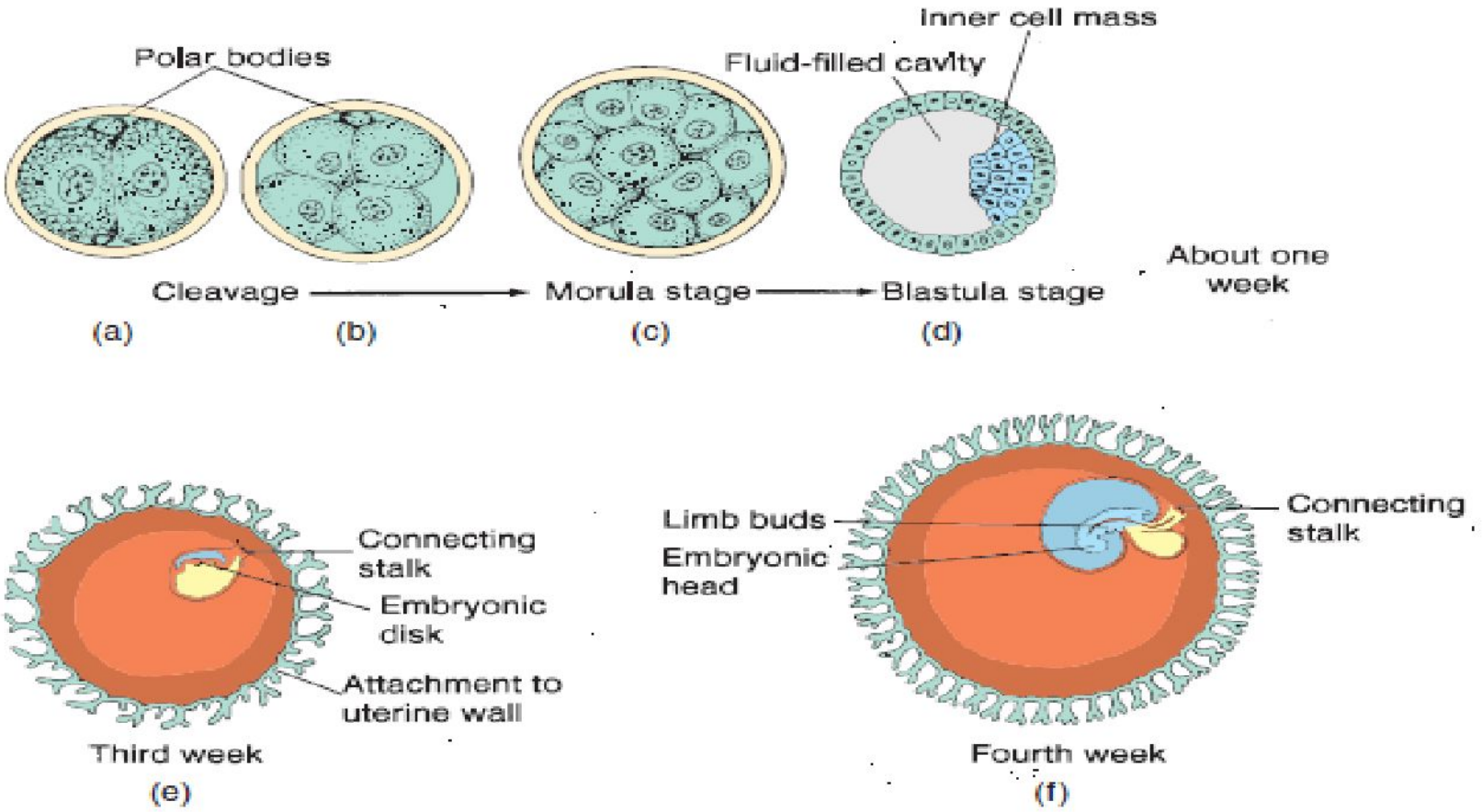
# Cell Differentiation



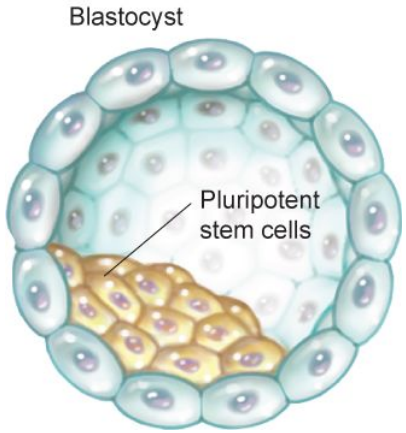

- **Differentiation** is the process by which cells become specialized and take on specific roles in an organism.
- During human development, a single cell (a fertilized egg) differentiates into every different kind of specialized cell type found in the body, including blood, muscle, and nerve cells.
- Cells that are undifferentiated are known as **stem cells.** Stem cells are found in embryos (embryonic stem cells) and in adults (adult stem cells).
- Every tissue of our body has an undifferentiated stem cell which helps in repair and regenration

# Cell Differentiation



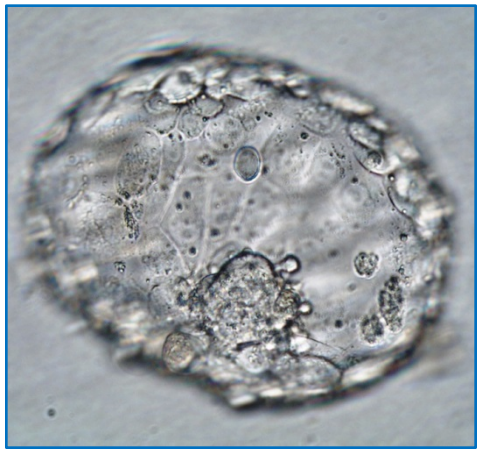
# Types of stem cells

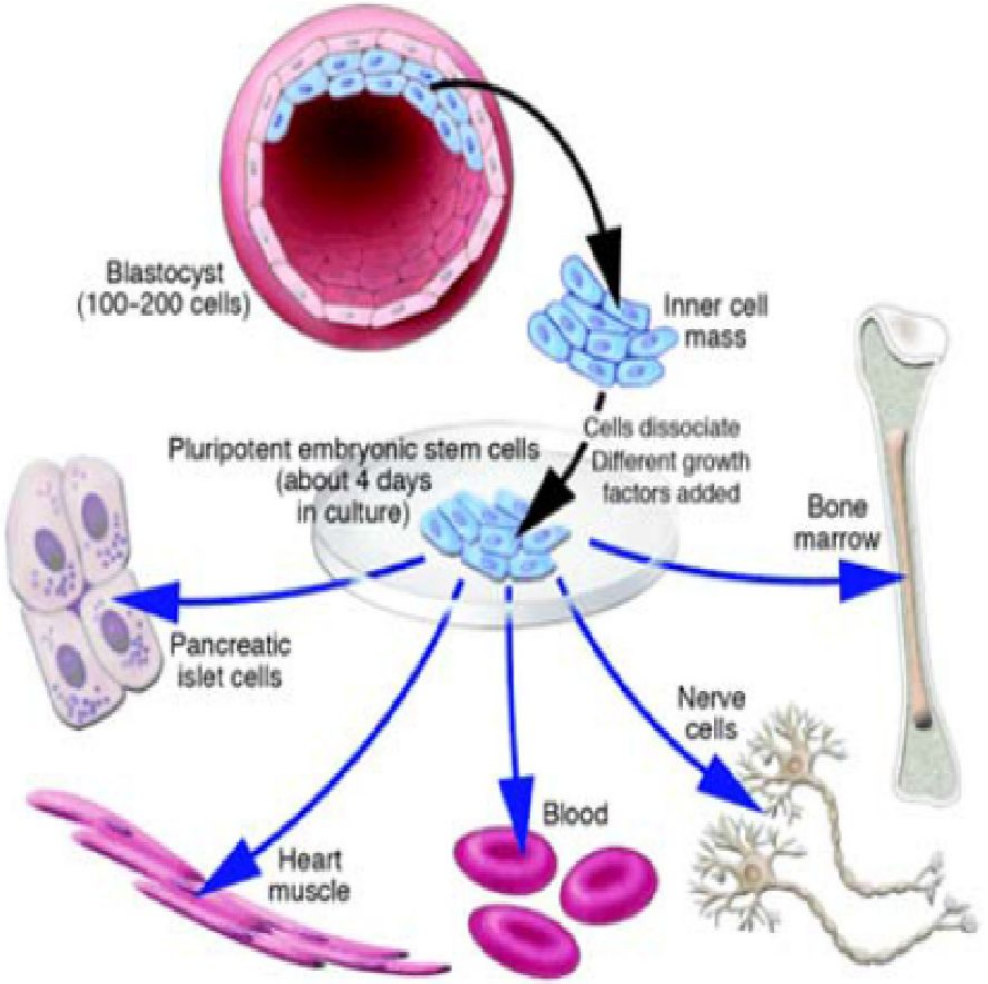
- ✔ In general, embryonic stem cells can be either totipotent or pluripotent. Adult stem cells are multipotent.
- ✔ Stem cells that have the ability to differentiate into every type of cell in the body are called **totipotent.**
- ✔ Stem cells that can differentiate into most, but not all type of cells are called **pluripotent.** Eg: Cells present within the blastocyst.
- ✔ Stem cells present in an adult organism that can differentiate into a limited number of cell types are called **multipotent. Eg:**
- ✔ Stem cells that can diifferentiate into only one cell type are called **Unipotent. Eg: Brain cells**



# Embryonic stem cells (ESCs)

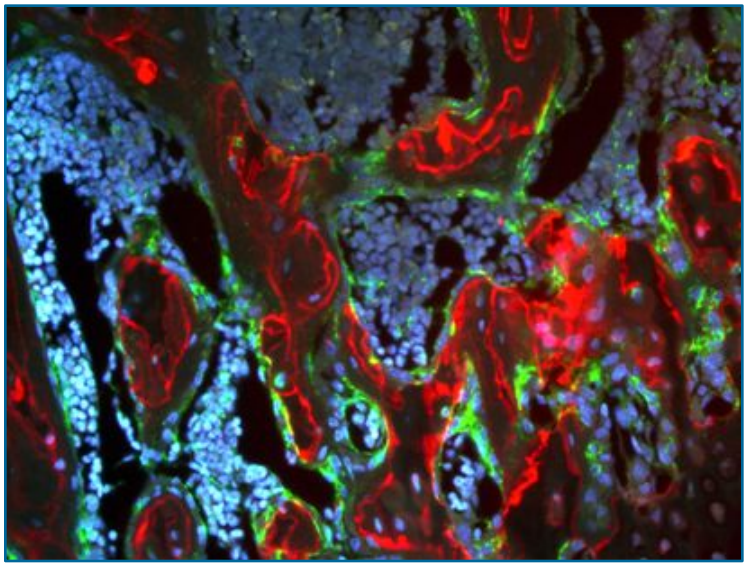
- derived from human embryos
- can be grown indefinitely in the laboratory in an undifferentiated state
- retain **pluripotent** state





# Tissue-specific stem cells

- often called “adult” or somatic stem cells
- involved in tissue homeostasis and repair
- generally multipotent
- difficult to isolate and grow in large numbers in the laboratory



Bone marrow

HSCs CD34+

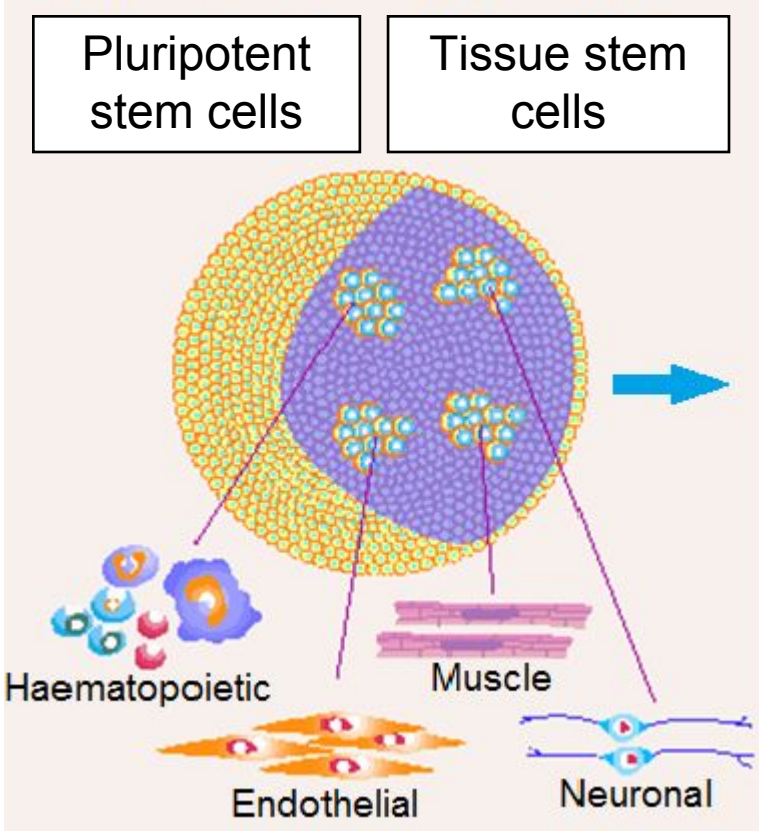
MSCs CD34-

# Differences Between ASC and ESC

| Embryonic | Adult |
| --- | --- |
| • FLEXIBLE | • LESS FLEXIBLE |
| • IMMORTAL | • MORTAL |
| • AVAILABLITY IS HIGH | • LIMITED QUANTITY |
| • IMMUNOGENIC | • NON IMMUNOGENIC |
| • TUMORIGENIC | • NON TUMORIGENIC |
| • ISOLATION LEADS TO DESTRUCTION OF EMBRYO | • RELATIVE EASE OF PROCUREMENT |

# What makes stem cells so valuable?

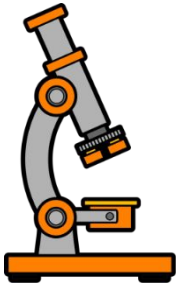
## Biology




## Applications

### Cell therapy

Transplantation of specific cells and precursors



### Research

Genetic, molecular and biologic control of tissue growth and development; *in vitro* and *in vivo* system for understanding function of genes and proteins

### New drugs

Early efficacy and toxicity screening system for drug and chemical development

No one stem cell type fits all applications
Research must continue using all types of stem cells

Image modified from Keller & Snodgrass, *Nat Med* 1999; 5(2): 151-152.

# Stem Cell Applications

- Tissue repair - nerve, heart, muscle, organ, skin, etc.
- Cancers
- Autoimmune diseases
  Eg: diabetes, rheumatoid arthritis, Multiple sclerosis, etc.

# Stem Cell Applications

**Tissue Repair:**
Regenerate spinal cord, heart tissue or any other major tissue in the body.

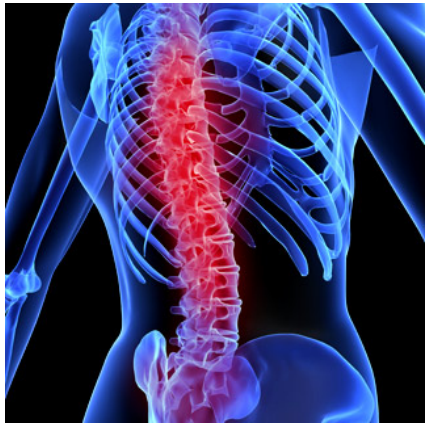
**Heart Disease:**Adult bone marrow stem cells injected into the hearts are believed to improve cardiac function in victims of heart failure or heart attack

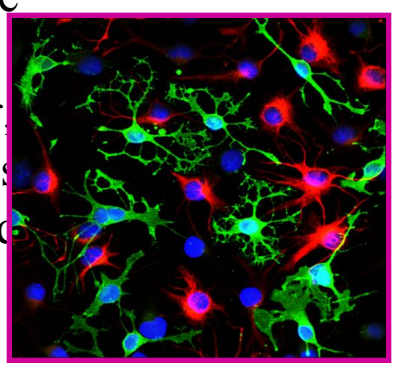
**Cancer:** Injections of stem cells have also reduces leukemia and many forms of cancers

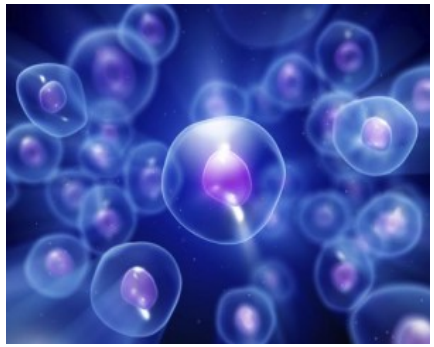
**Rheumatoid Arthritis:** Adult Stem Cells may be helpful in jumpstarting repair of eroded cartilage.

**Type I Diabetes:** Pancreatic cells fails to produce insulin. Embryonic Stems Cells might be trained to become pancreatic islets cells needed to secrete insulin.

**Parkinsons Disease:** Stem cells could, however, be genetically modified so as to deliver substances to the PD brain, to stop cells from dying and stimulate the function of existing cells.

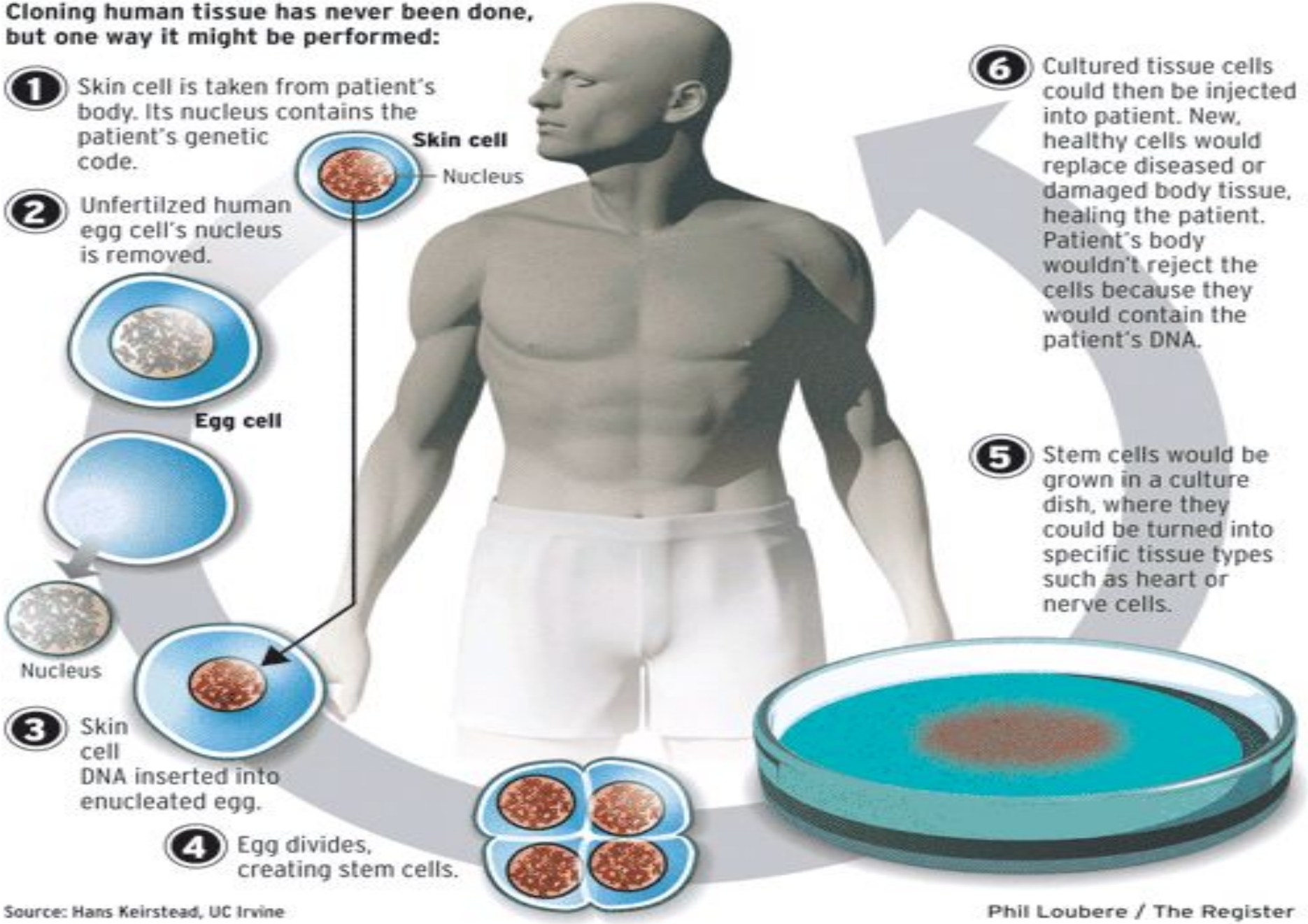






# How therapeutic cloning could work

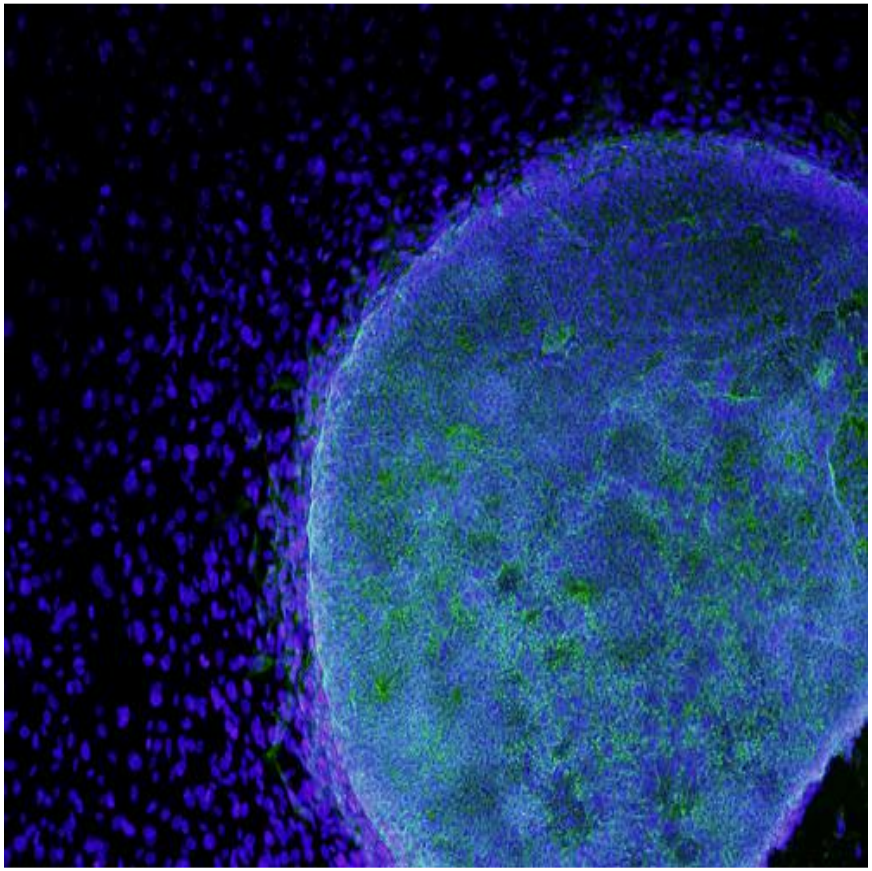
**Cloning human tissue has never been done, but one way it might be performed:**

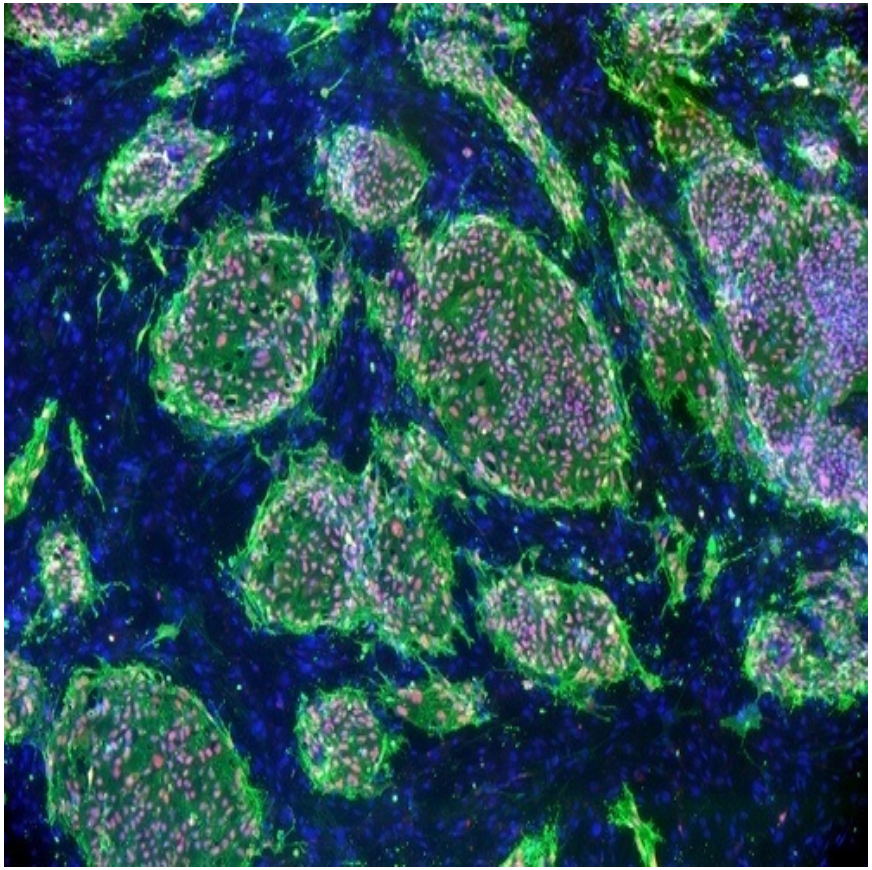



Source: Hans Keirstead, UC Irvine

Phil Loubere / The Register

# Thank you





Fluorescent imaging of human embryonic stem cell colonies