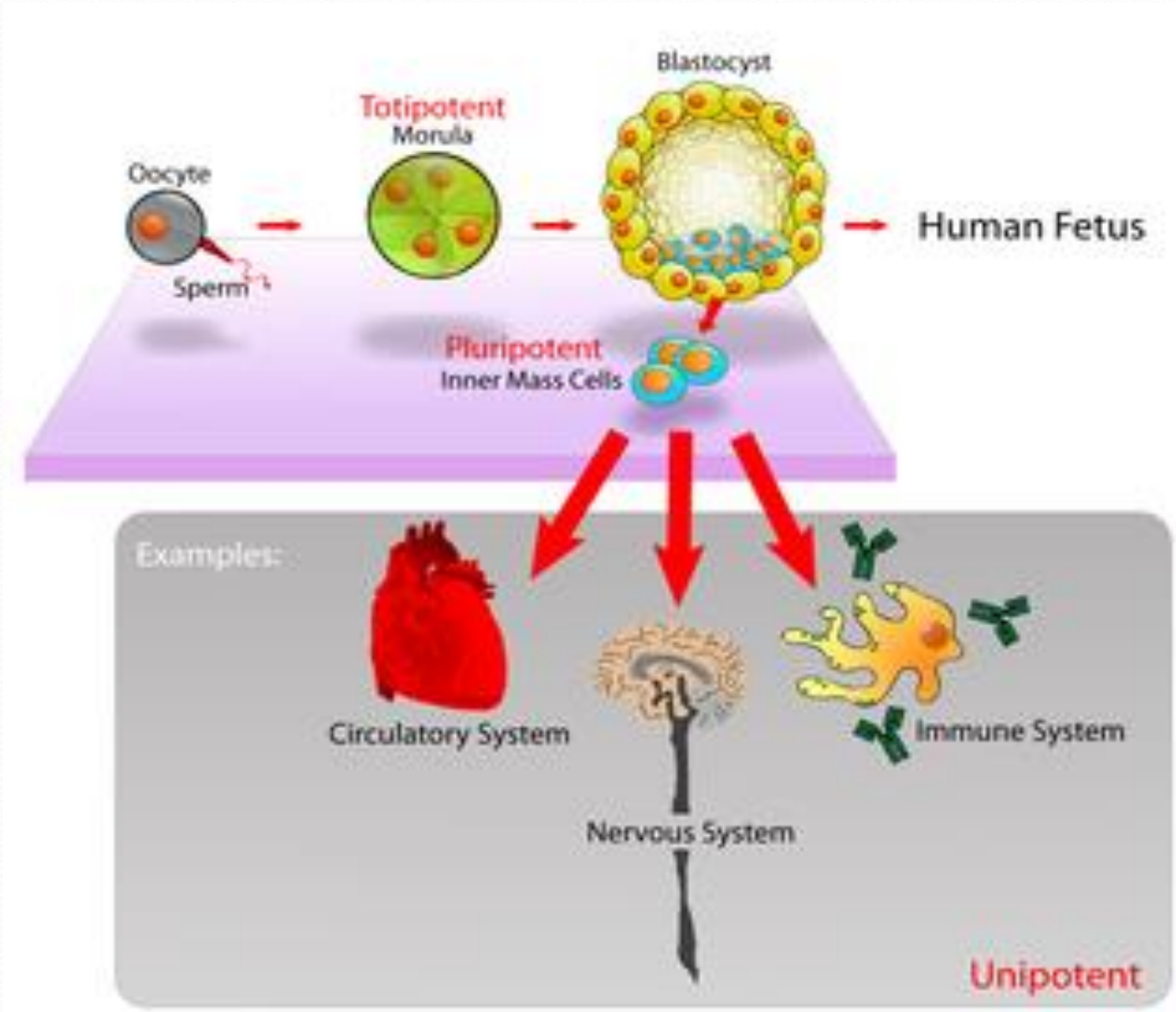

Blastocyst
Totipotent
Morula
Oocyte
Sperm
Human Fetus
Pluripotent
Inner Mass Cells
Examples:
Circulatory System
Nervous System
Immune System
Unipotent

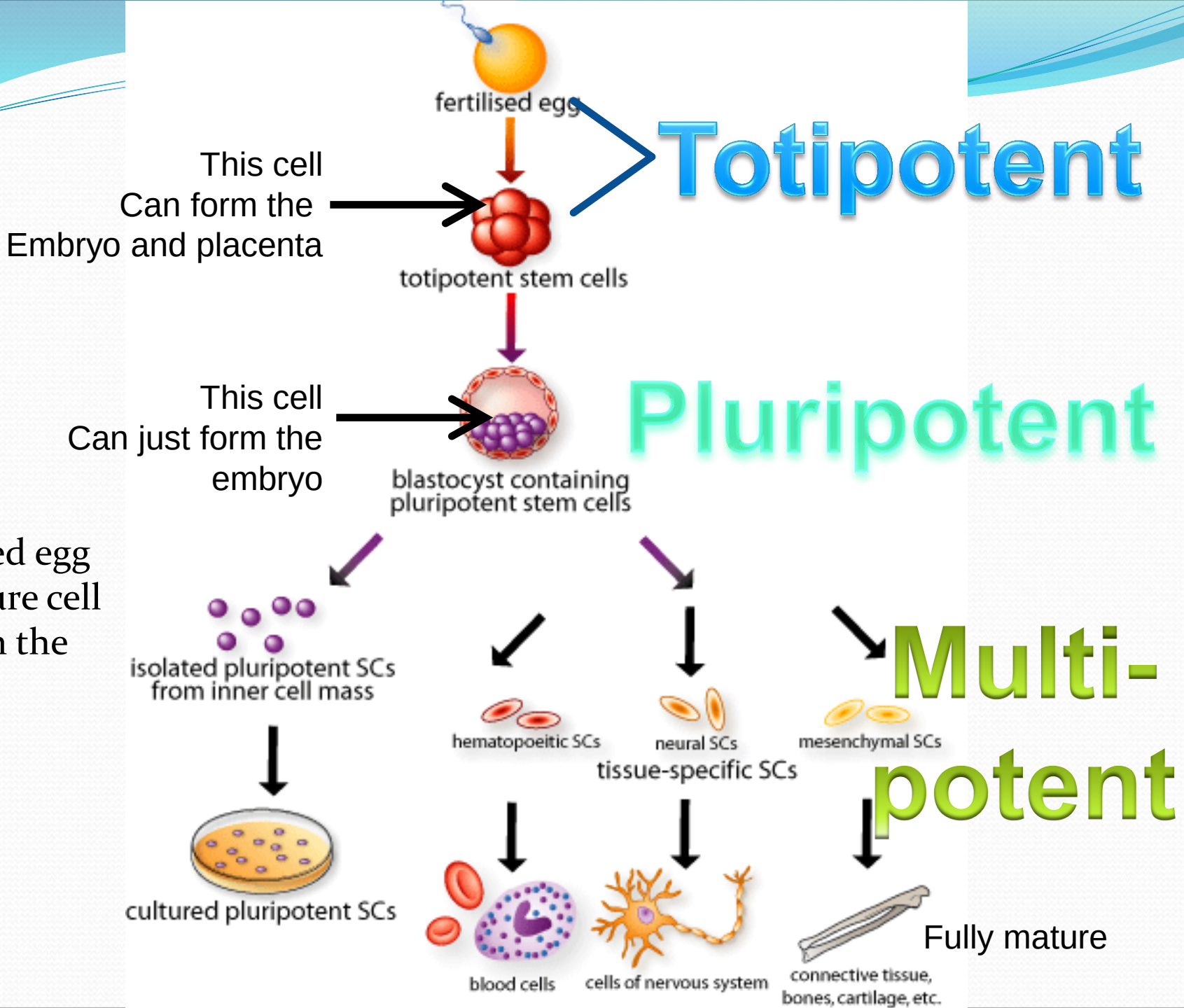
Stem Cells; Vary in their Developmental capacity

A **totipotent** cell can give rise to a new individual given appropriate maternal support

A **pluripotent** cell can give rise to all types of adult tissue cells.

A **multipotent** cell can give rise to several types of mature cell

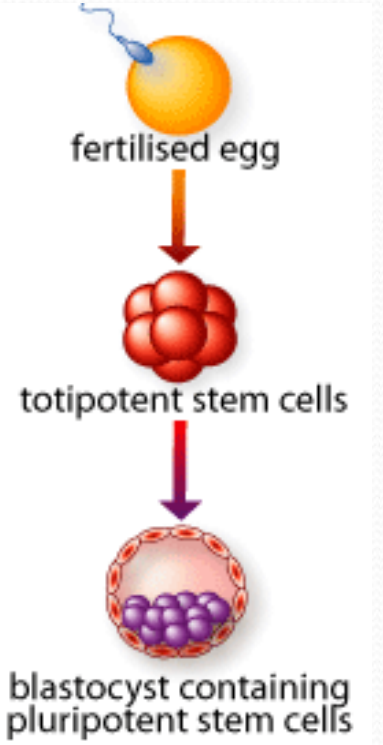
from fertilized egg to mature cell types in the body.



Each cell in the 8-cell embryo, here in red, can generate every cell in the embryo **as well as** the placenta and extra-embryonic tissues. These cells are called **TOTIPOTENT** stem cells.

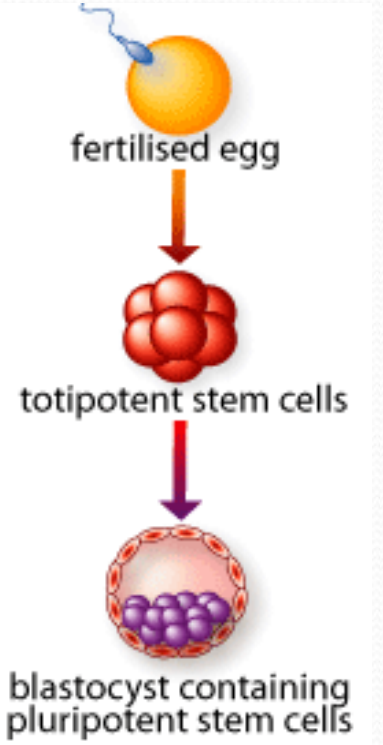
Why are they called totipotent?

Because each cell can potentially make all necessary tissues for development.



Pre-implantation genetic diagnosis doesn't destroy the embryo. Scientists are attempting to adapt this pre-implantation genetic diagnosis procedure and use it to create a stem cell line from one single TOTIPOTENT cell, without destroying the embryo.

- The embryonic stem cells inside the blastocyst can generate every cell in the body **except** placenta and extra-embryonic tissues. These are called PLURIPOTENT stem cells
- they can differentiate into all the 200+ cell types in the body, but they do not form the placenta.
- Pluripotent stem cells can be isolated and grown in culture, or left to develop into more specialized cells in the body.



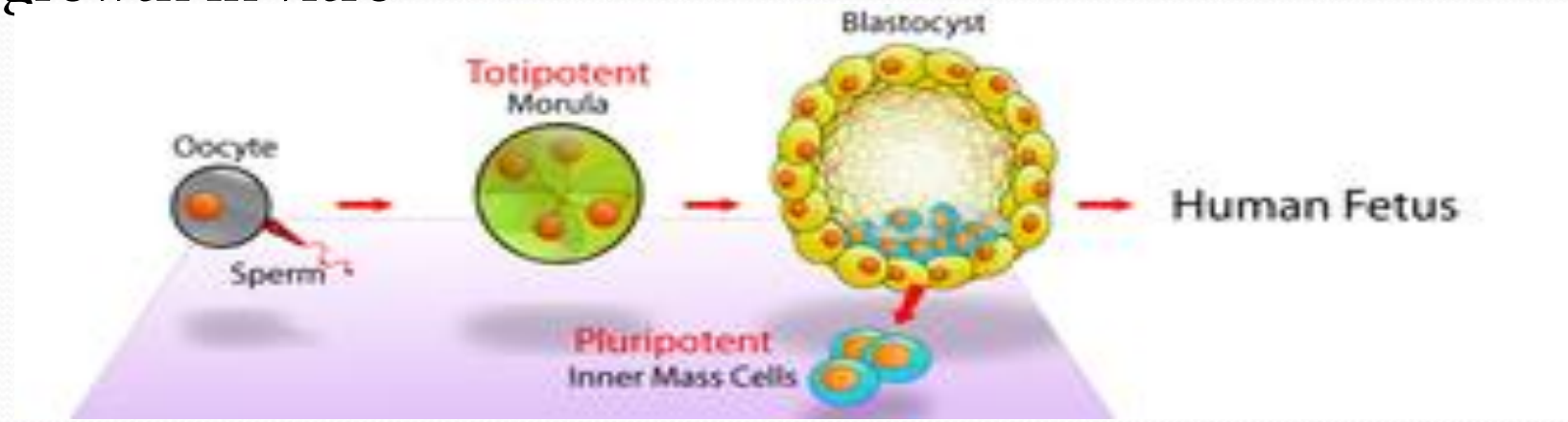
types of stem cells?

Embryonic stem cells;

ES cells are derived from five day old spare human embryos before specialized tissues of the body begin to form.

May be grown indefinitely in culture in the primitive embryonic state

Retain the property of pluripotency during extended growth in vitro



Cell types derived from human ES cells in vitro;

- Nerve cell, astrocyte, oligodendrocyte
- Hematopoietic stem cells
- Insulin producing cells
- Cardiomyocytes
- Hepatocytes
- Endothelial cells

Embryonic stem cells have important applications in

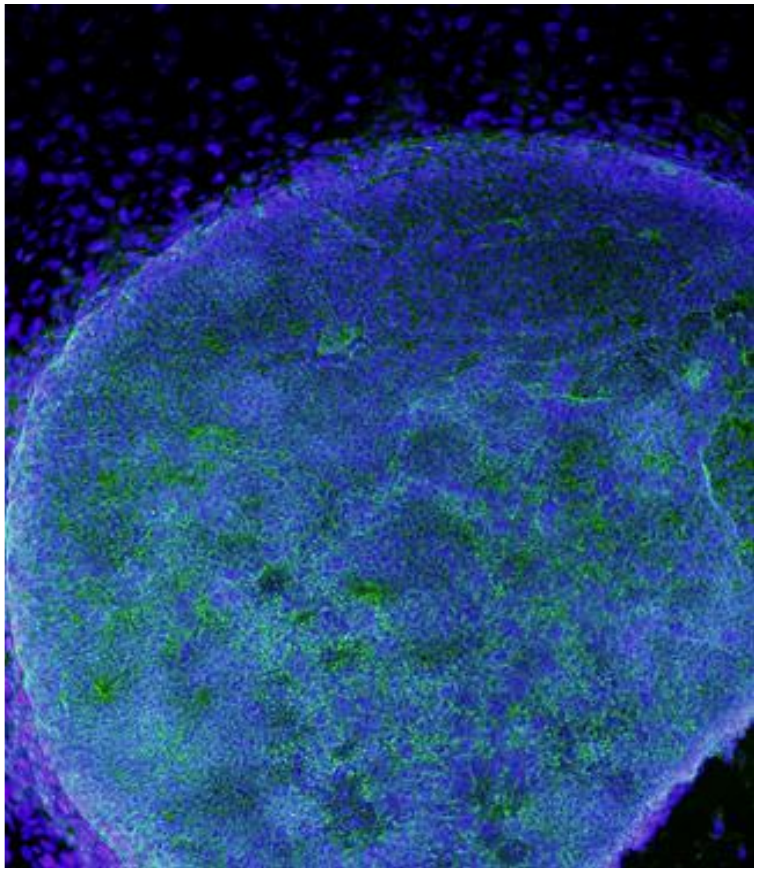
- biomedical research
- Basic studies of early human development and its disorders-birth defects, childhood cancers
- Functional genomics in human cells
- Discovery of novel factors controlling tissue regeneration and repair
- In vitro models for drug discovery and toxicology
- Source of tissue for transplantation medicine

Successful treatment of animal models of disease with mouse ES derived cells

- Severe immune deficiency
- Diabetes
- Parkinson's disease
- Spinal injury
- Demyelination
- Myocardial infarction

Scientists can label embryonic stem cells using antibodies attached to fluorescent molecules.

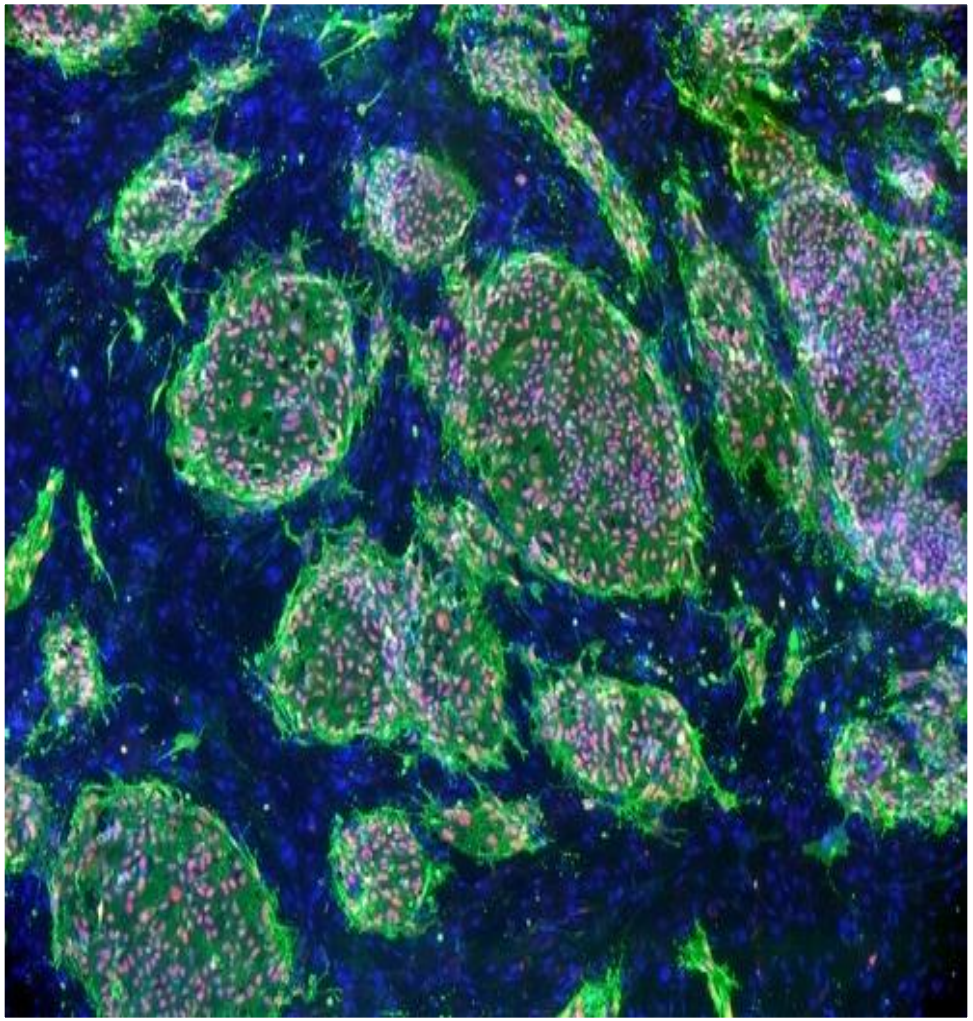
The smaller blue dots in the green area label the nuclei of the embryonic stem cells, and the **blue dots** outside the colony label **fibroblast feeder** cells. fluorescent labeling is important as it can show which cells are stem cells and which are not.



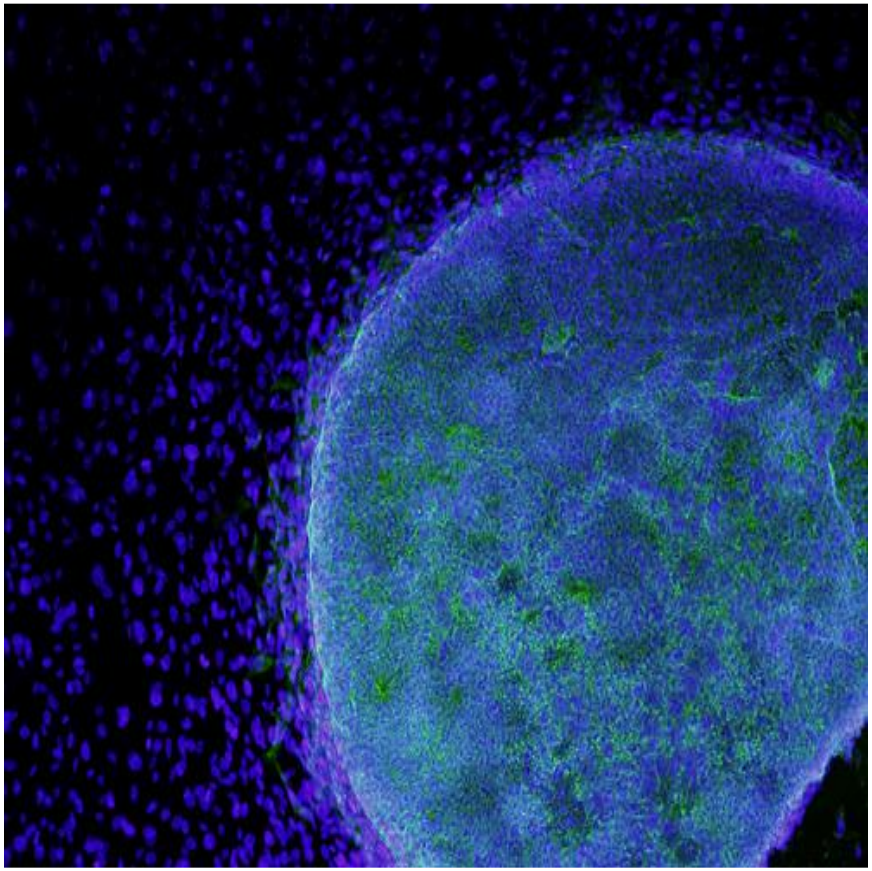
Fluorescent imaging of embryonic stem cell colonies.

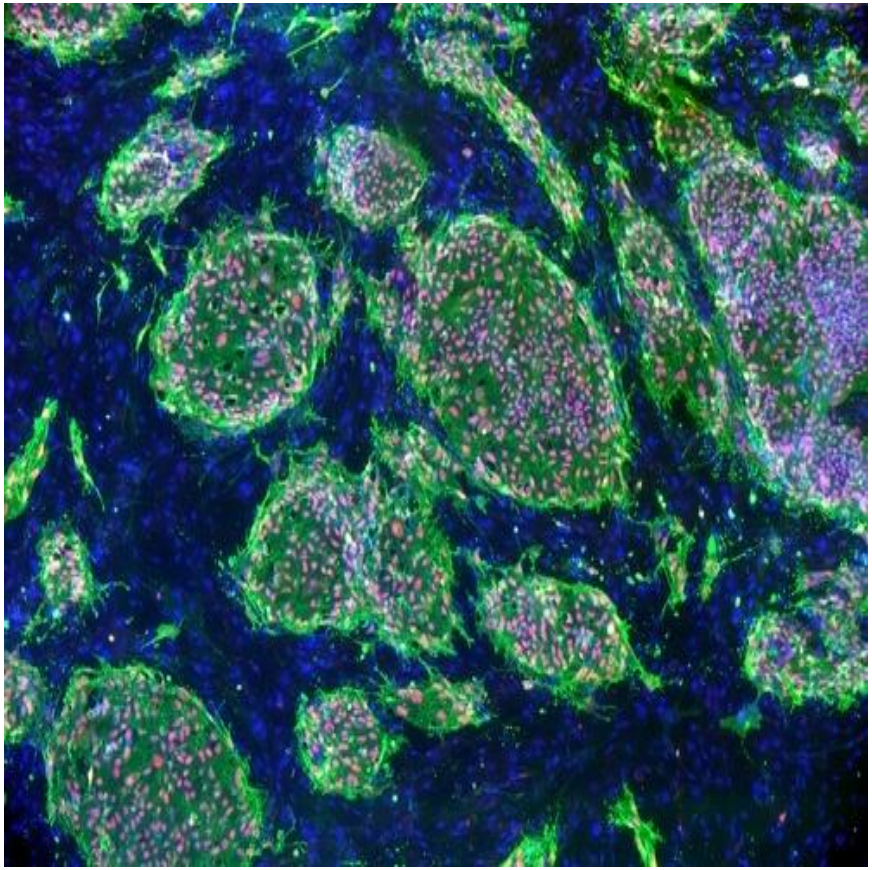
Scientists can label embryonic stem cells using antibodies attached to fluorescent molecules.

Embryonic stem cells like to grow in little colonies spaced out over the dish instead of in one big layer



Fluorescent imaging of embryonic stem cell colonies.





Adult stem cells or tissue-specific stem cells;

have restricted lineages. **Adult stem cells** show up when the three distinct layers form in the **14-day-old embryo**, and are present in the fetus, baby, child, and adult just means they've gone further down their lineage pathway than the initial stem cells in the embryo.

They are called **MULTIPOTENT** stem cells because they will only become mature cells from the tissue in which they reside.

Adult stem cells are present throughout your life and replace fully mature damaged and dying cells.

- **An adult stem cell** ;
- is an **undifferentiated** cell found among differentiated cells in a tissue or organ, can renew itself, and can differentiate to yield the major specialized cell types of the tissue or organ .
- The stem cells that appear in the 14 day old embryo are also called adult stem cells. At this point these cells CANNOT naturally turn back into pluripotent cells.

the tests used for identifying adult stem cells

One or more of the following methods are normally used for the identification of adult stem cells:

Labeling the cells in a living tissue with molecular markers and then determining the specialized cell types they generate .

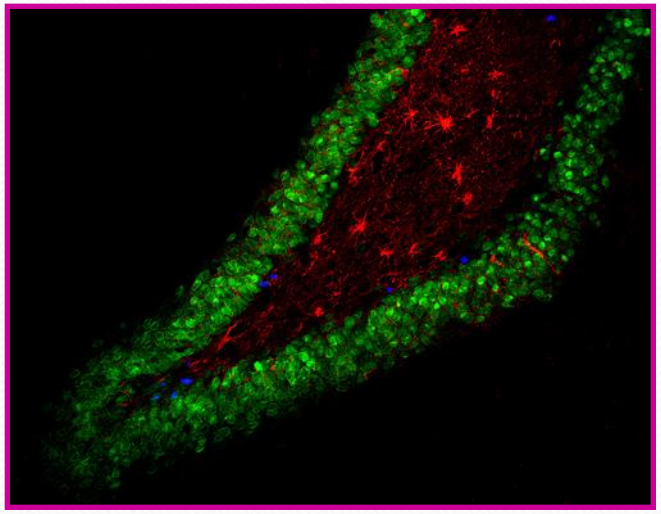
Removing the cells from a living animal, labeling them in cell culture, and transplanting them back into another animal

Isolating the cells, growing them in cell culture, and manipulating them, often by adding growth factors or introducing new **genes**, to determine what differentiated cells types they can become.

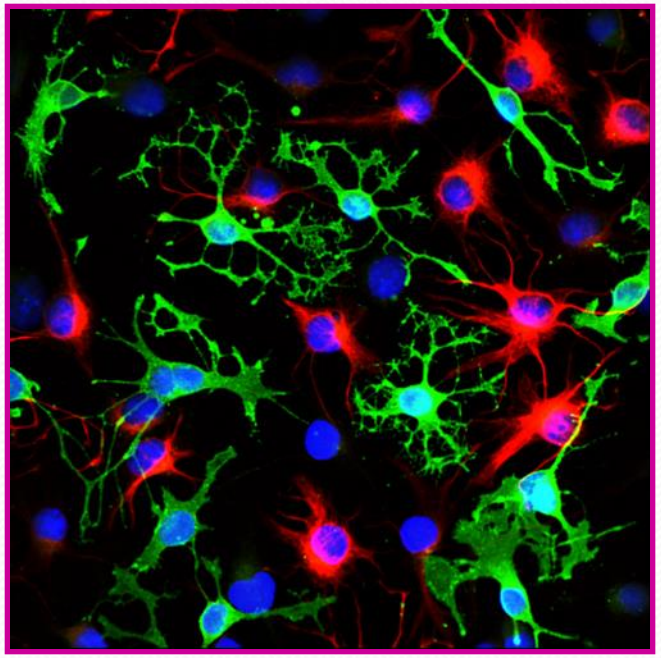
- **Adult stem cells** ;
- are found all over your body. Here are a **few examples** of places in the body with stem cells.

- Recently scientists discovered that in two specific parts of your brain, **neural stem cells** divide and differentiate to become neurons and glial cells, which support the growth of neurons. Without neural stem cells in the hippocampus, you would probably not be able to learn or remember.

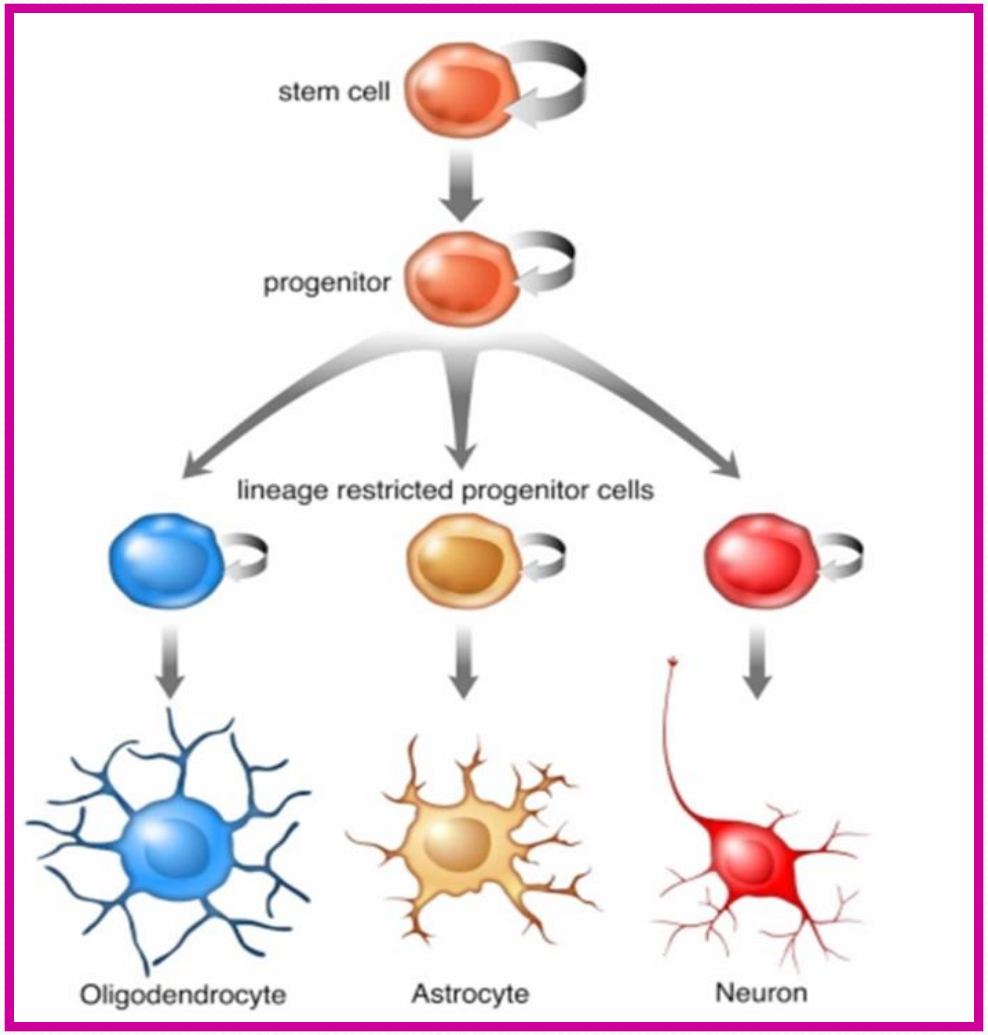
The picture is a cross-section of the rat hippocampus, and neural stem cells are the blue dots, which divide and differentiate to form mature neurons (green) and astrocytes (red).

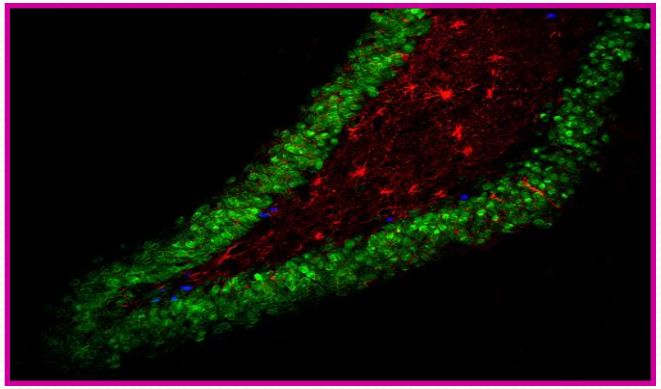


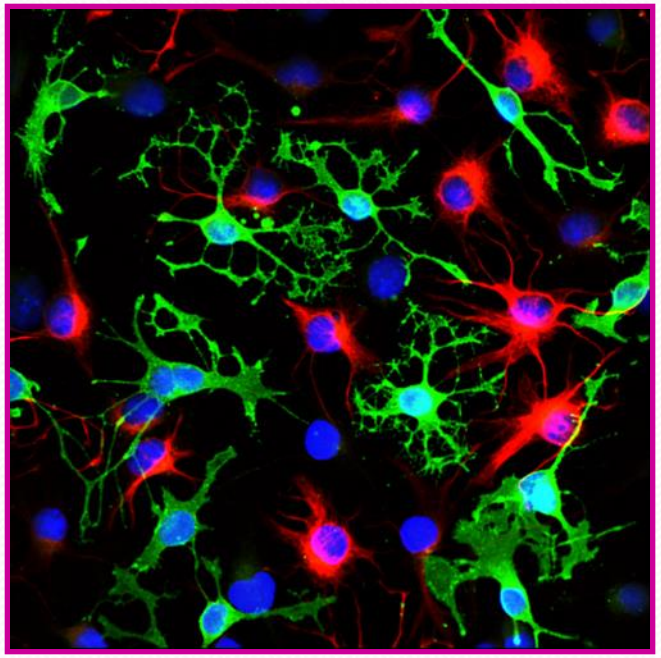
The picture is of cultured neural stem cells (just plain blue dots), and
derived from those stem cells, neurons (blue dots surrounded by red) and oligodendrocytes (blue dots surrounded by green).



Stem cells in the adult brain:



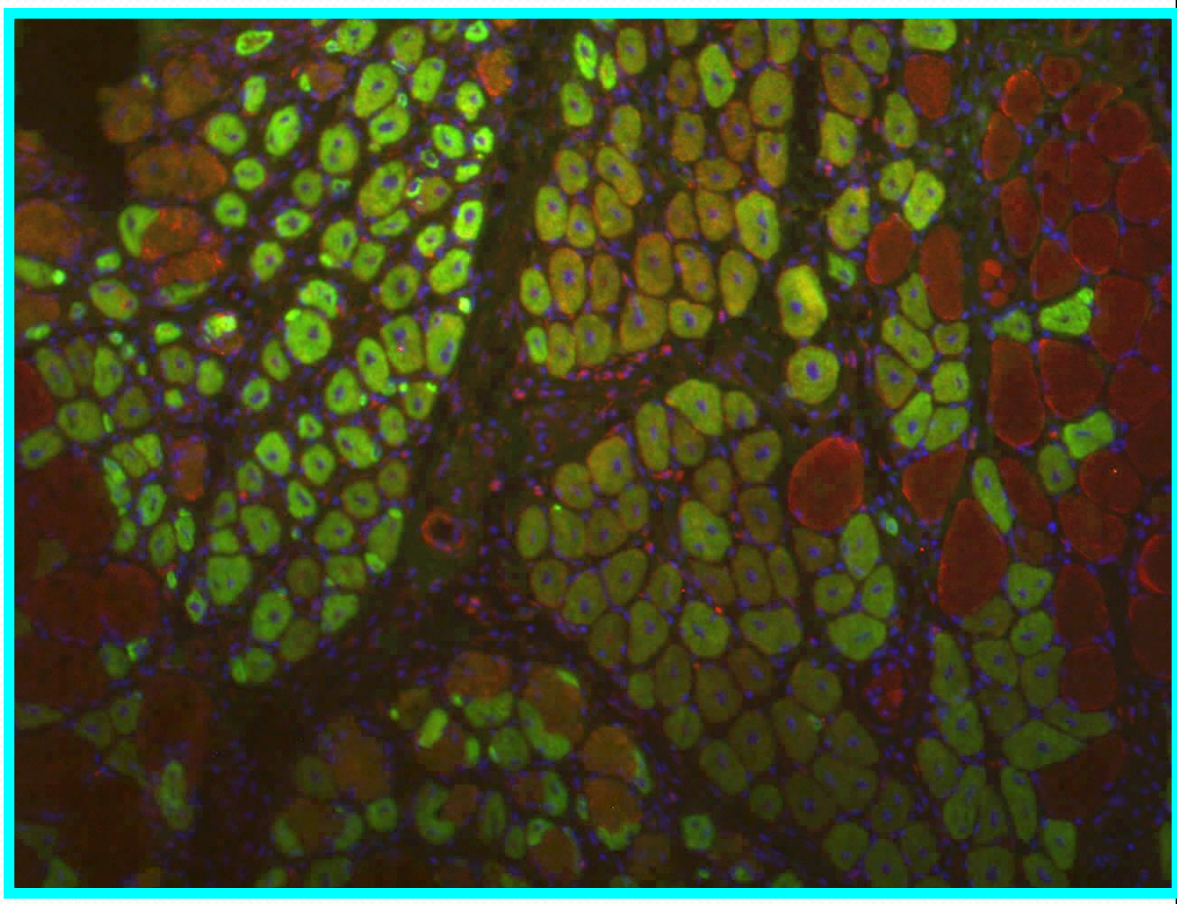


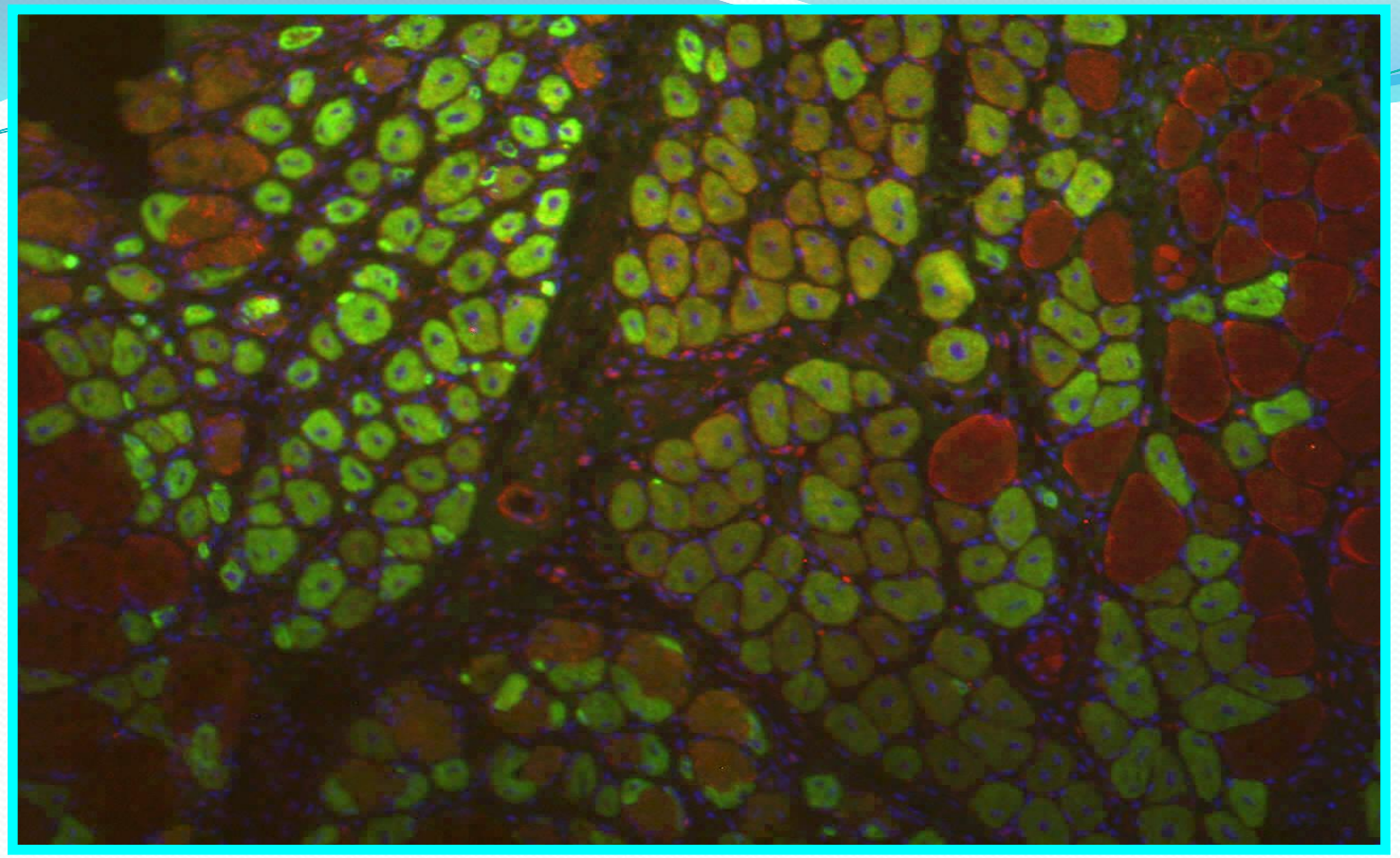


- **In skeletal muscle**, muscle stem cells are activated immediately after an injury to help replace damaged muscle.
- The big red circles are healthy muscle fibers, the green cells are newly-regenerated muscle fibers, and the **tiny pink** dots are muscle stem cells, also called **satellite cells** because they hang around the sides of muscle fibers. The tiny pink dots eventually turn into the green cells which add together to form the red muscle fibers. the concepts of regeneration after injury and after exercise are similar.

Stem cells in mature skeletal muscle:

- a picture of mouse muscle that has been injured by injection of snake venom, but the concepts of regeneration after injury and after exercise are similar.)

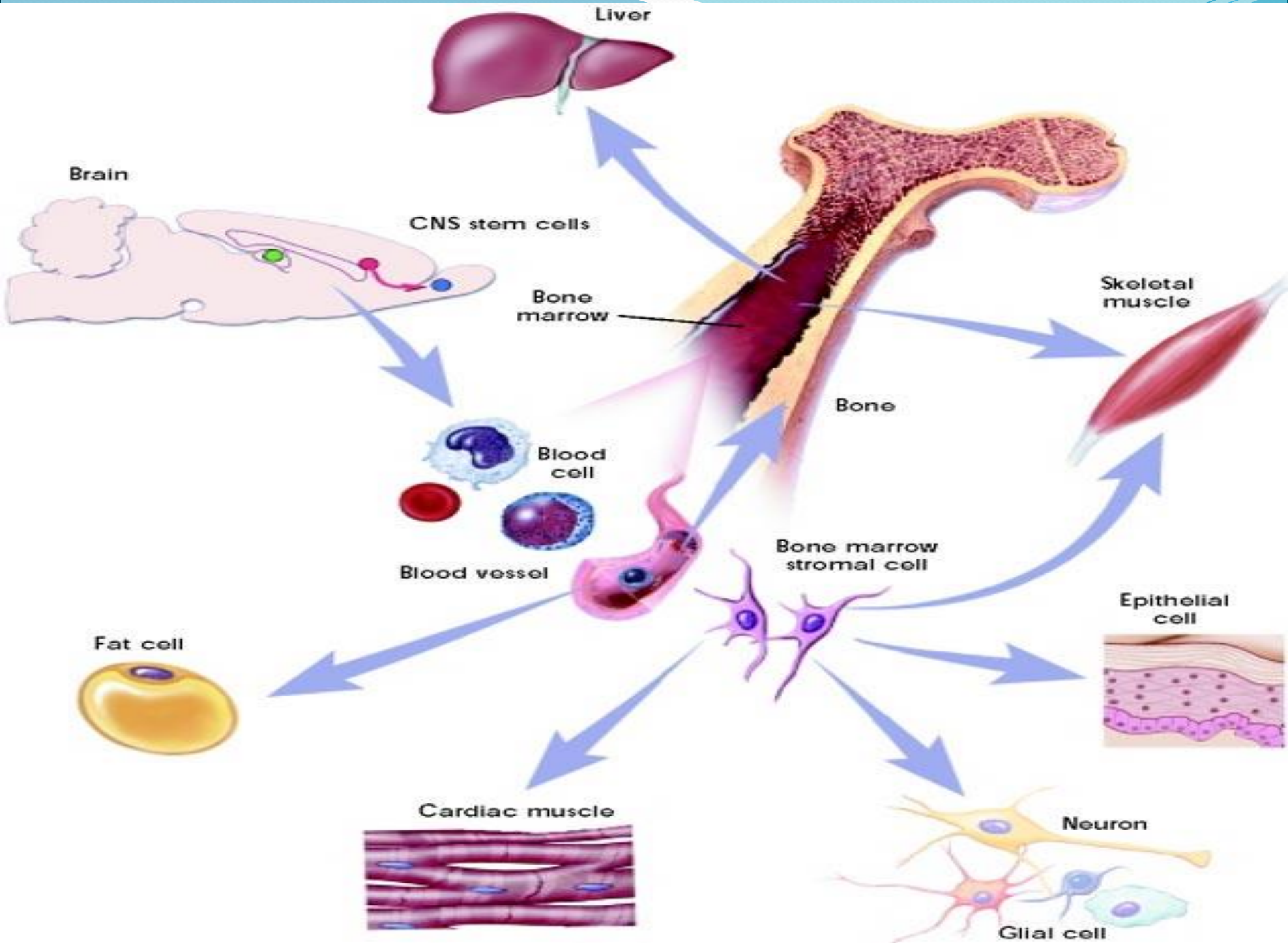




The big red circles are healthy muscle fibers, the green cells are newly-regenerated muscle fibers, and **the tiny pink dots are muscle stem cells**, also called **satellite cells** because they hang around the sides of muscle fibers. The tiny pink dots eventually turn into the green cells which add together to form the red muscle fibers.

Adult stem cells

- Although they are more difficult to obtain in pure form than embryonic stem cells,
- They do have therapeutic potential.
- A well-established adult stem cell therapy is a bone marrow transplant, which is usually a mix of several types of cells including adult stem cells.
- Bone marrow transplants have been practiced for 40 years as a treatment for diseases of the blood and certain types of cancer like leukemia.


Liver
Brain
CNS stem cells
Bone marrow
Skeletal muscle
Bone
Blood cell
Blood vessel
Bone marrow stromal cell
Epithelial cell
Fat cell
Cardiac muscle
Neuron
Glial cell

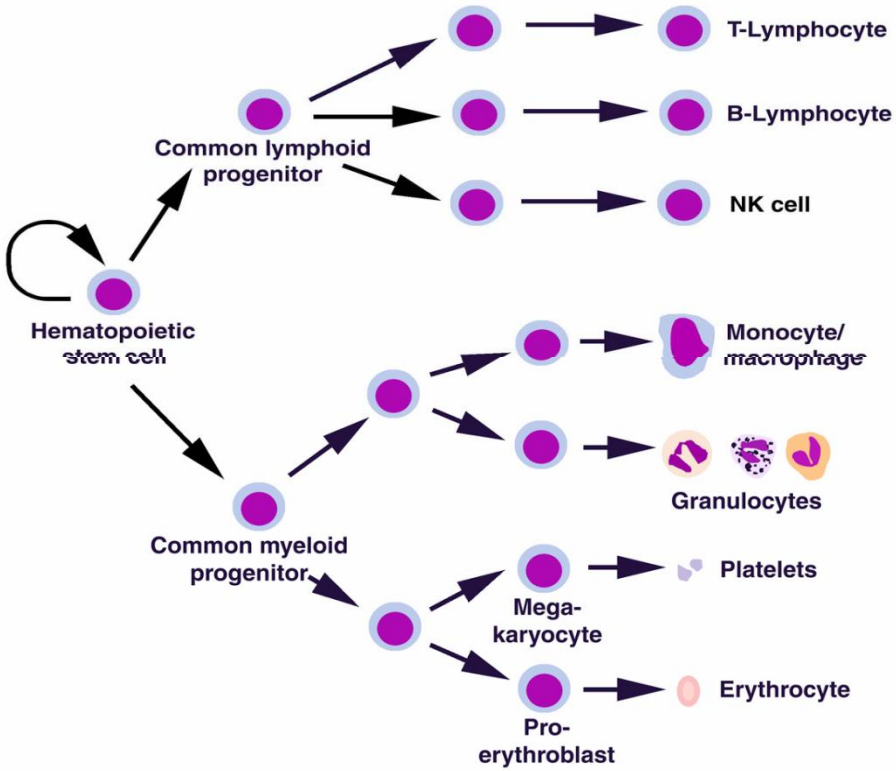
Hematopoietic stem cells

Bone Marrow Stem Cells;

Include hematopoietic stem cells & mesenchymal s. c.

• Isolated from human, mouse and rat & give rise to mesoderm, neuro-ectoderm and endoderm

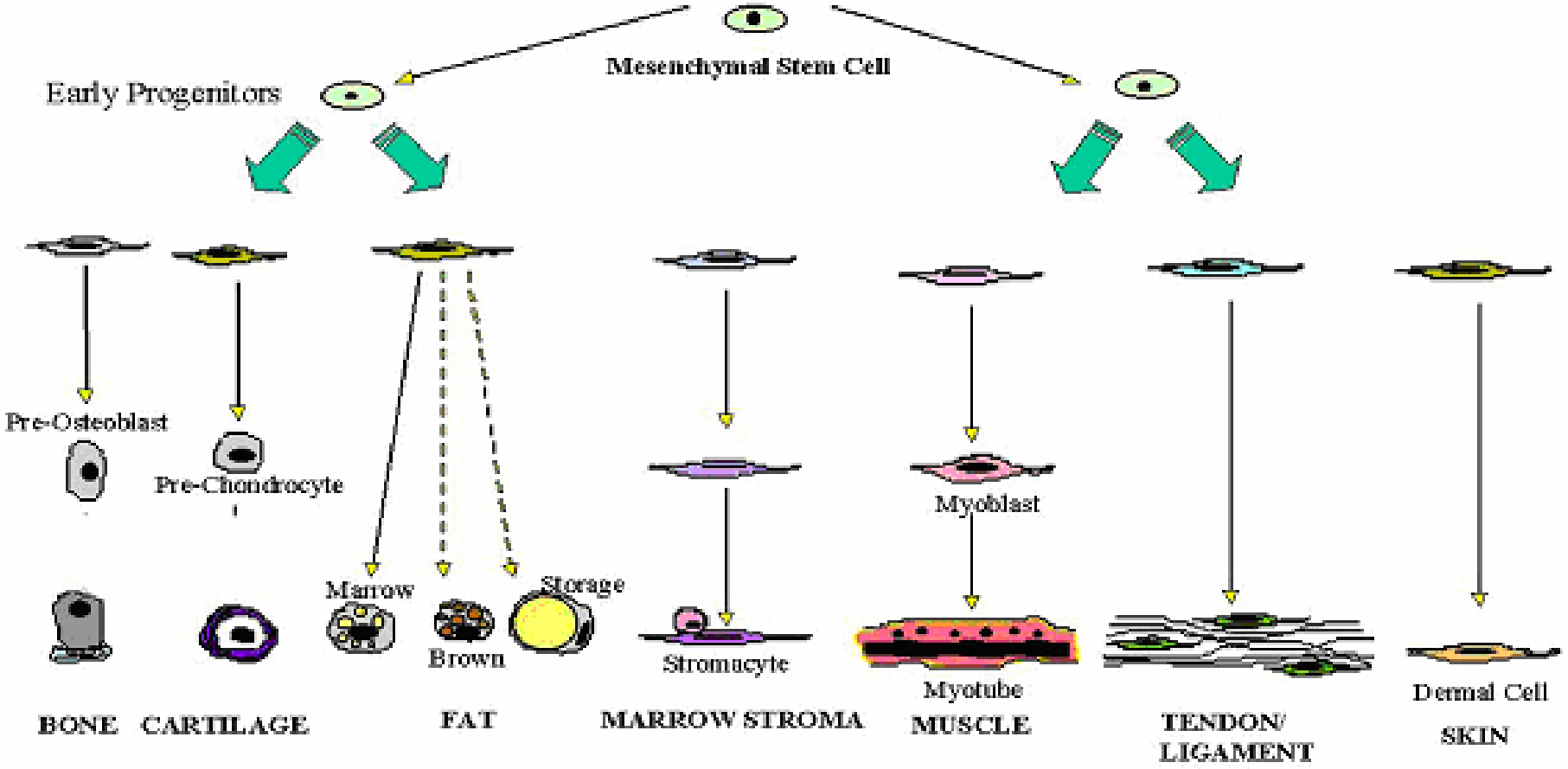
mesenchymal stem cells) give rise to connective tissue cells



Cord Blood Stem Cells

• from umbilical cord
• Grow in vitro without differentiating.
• Give rise to mesoderm, neuro-ectoderm and endoderm.
• In vivo: differentiation into neural cells, bone and cartilage, blood, myocardial cells and Purkinje fibers, hepatic cells.

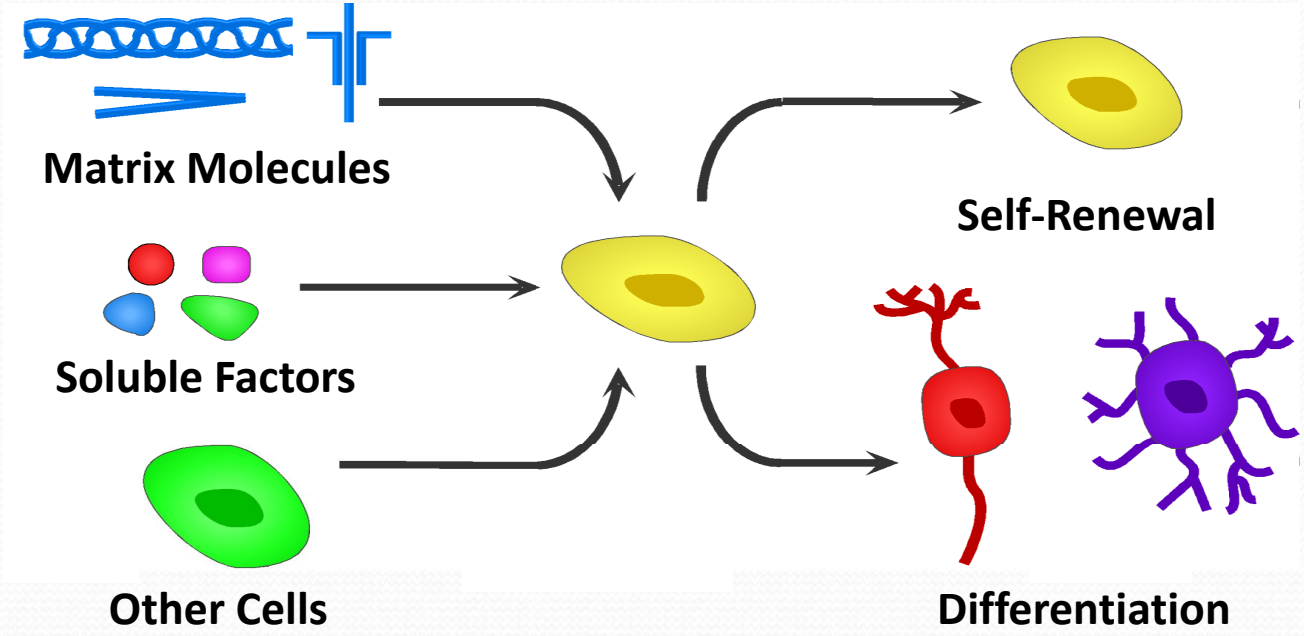
Mesengenic Lineage

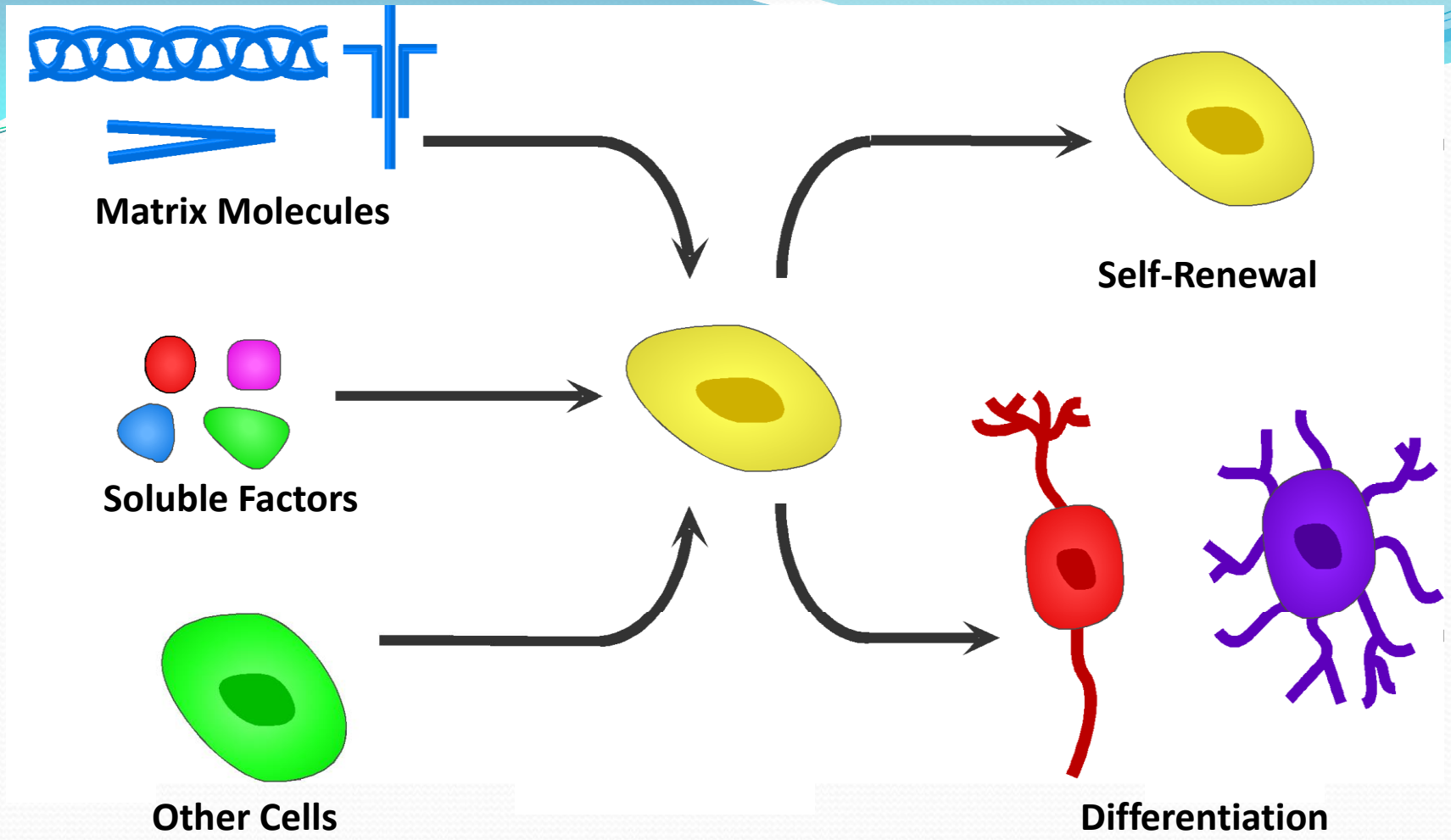


- Sometimes instead of receiving stem cells from a donor, the patient can receive their own stem cells.
- Umbilical cord, is a rich source of hematopoietic stem cells.
- The umbilical cord is usually thrown away after a baby is born, but some people choose to “bank” the umbilical cord blood cells in case the child needs to use those stem cells later on.
- Hematopoietic stem cells from umbilical cord do not have the same immune-rejection issues as hematopoietic stem cells from bone marrow, which makes them ideal for therapies.

Signals to Stem Cells

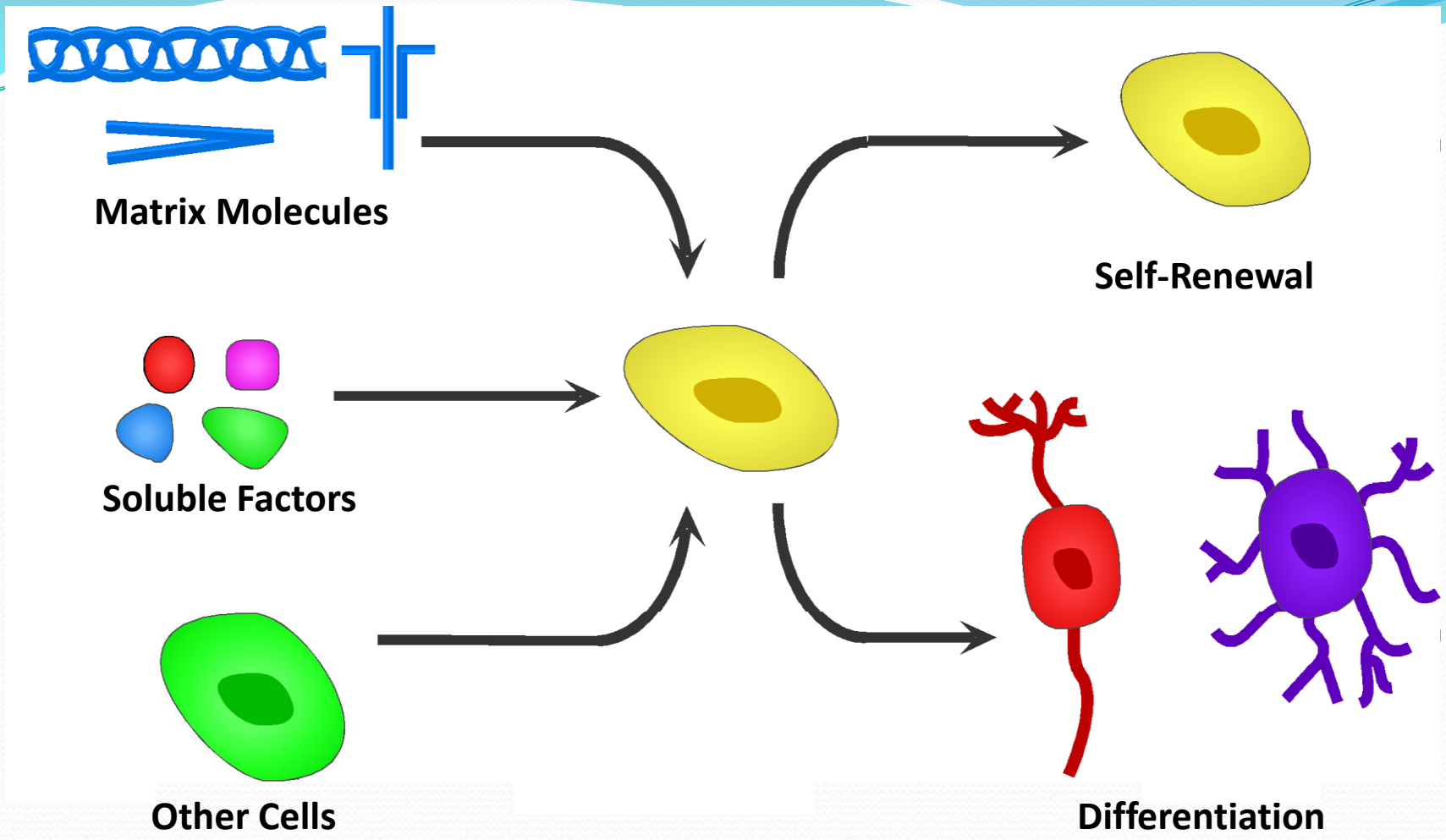
- Cells stick and respond to molecules embedded in their extracellular environment (top left).
- They also respond to chemicals or molecules floating around in the liquid surrounding them (middle left).
- Cells can feel and communicate with each other (bottom left), and also can respond to forces.





Little, et al. *Chemical Reviews* (2008).

if it touches a bunch of muscle cells It might differentiate into a muscle fiber. How do you think that same stem cell would respond to culture with a bunch of neurons? It'll turn into a neuron.



Little, et al. *Chemical Reviews* (2008).

Here, this stem cell is going to make a decision to self-renew or differentiate based on the individual components and combinations of these factors in the extracellular environment

Factors known to affect stem cells

- Low stress levels
- Regular exercise
- Enriching experiences
- Learning new information
- Healthy diets: rich in antioxidants