

STEM CELLS

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Unit 5

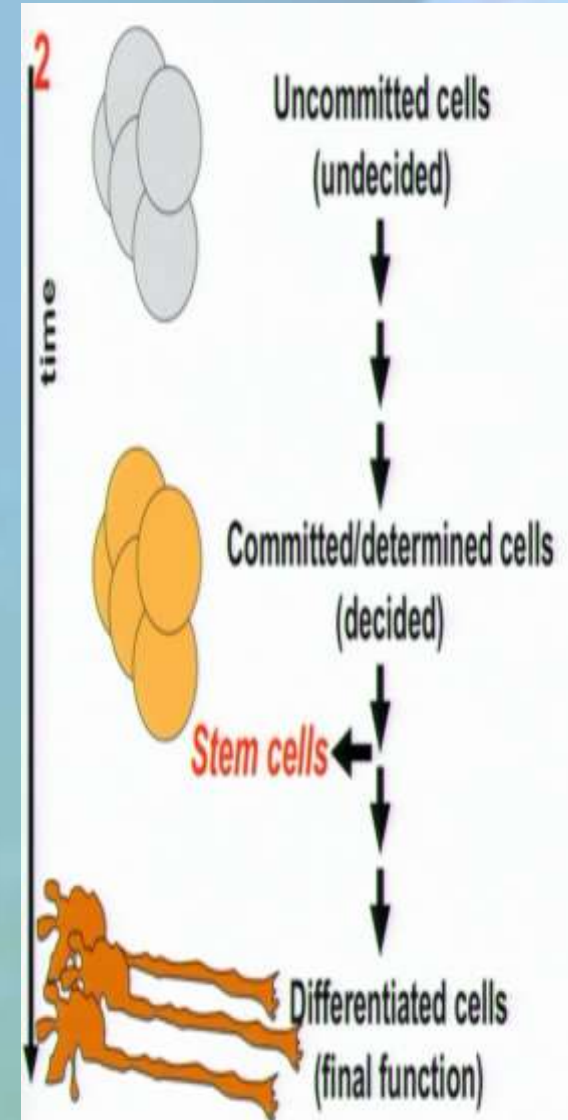
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What's Inside:

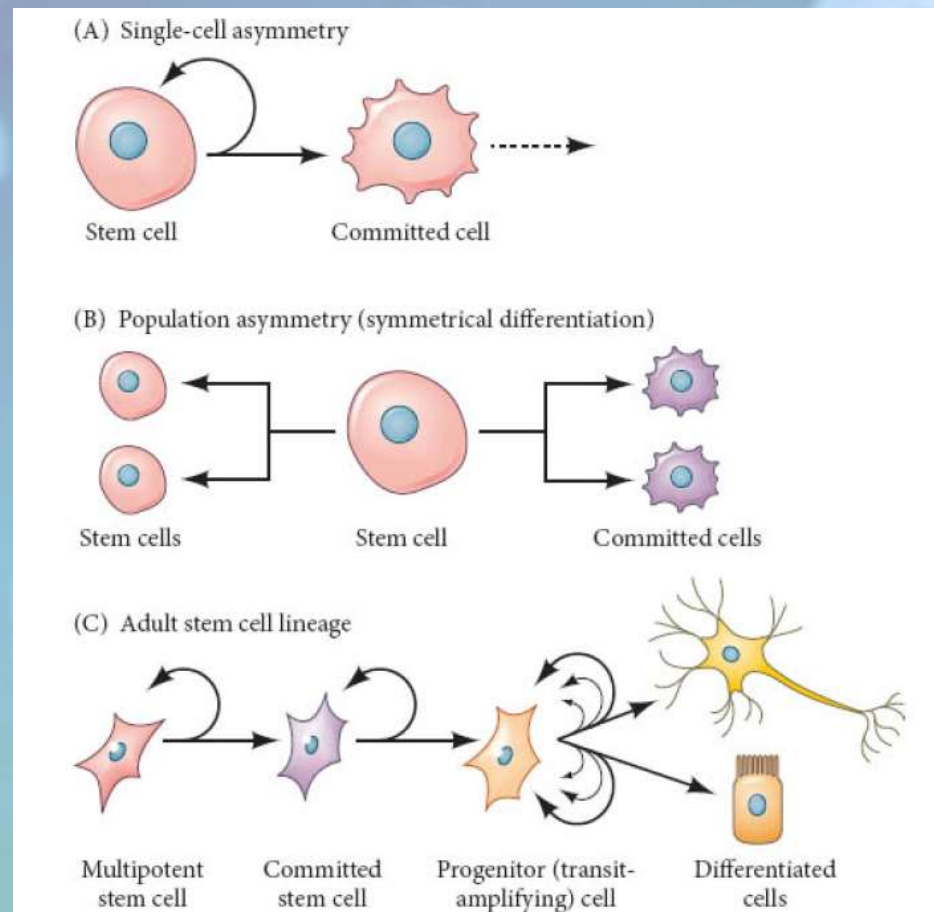
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Introduction

- **STEM CELL:**
- A stem cell maintains the ability to divide to produce a copy of itself as well as generating progenitor cells capable of maturing into different cell types.



The stem cell concept.



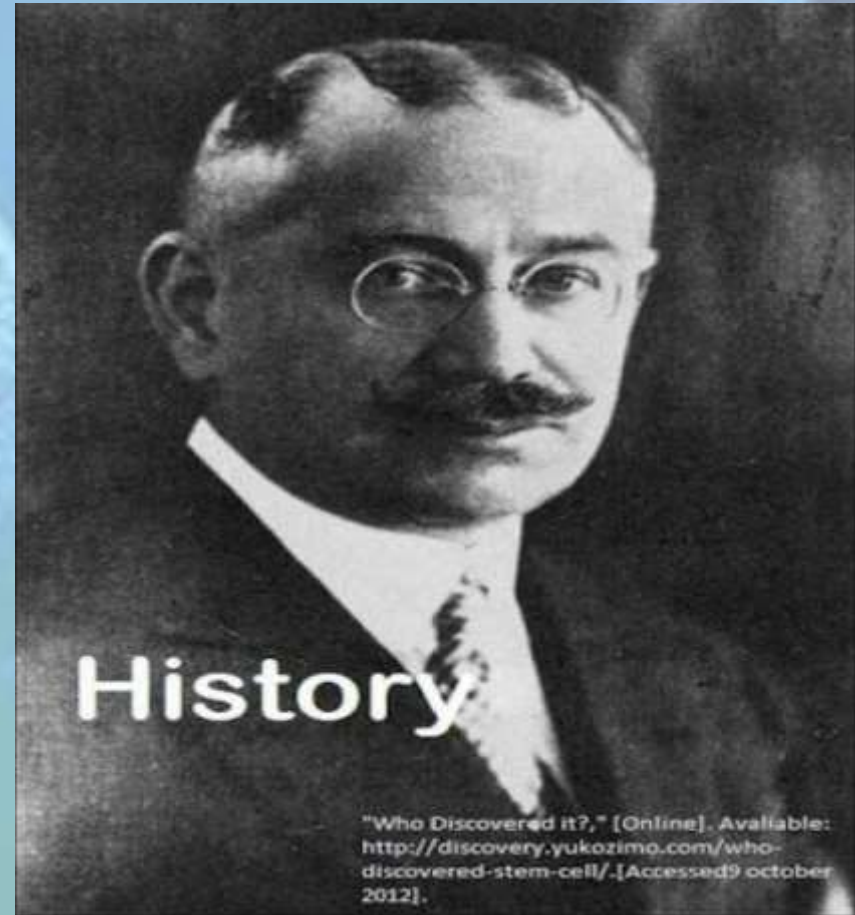
The stem cell concept. (A) The fundamental notion of a stem cell is that it can make more stem cells while also producing cells committed to undergoing differentiation. This process is called asymmetric cell division.

(B) A population of stem cells can also be maintained through population asymmetry. Here a stem cell is shown to have the ability to divide symmetrically to produce *either* two stem cells (thus increasing the stem cell pool by one) *or* two committed cells (thus decreasing the pool by one). This is called symmetrical renewing or symmetrical differentiating.

(C) In many organs, stem cell lineages pass from a multipotent stem cell (capable of forming numerous types of cells) to a committed stem cell that makes one or very few types of cells to a progenitor cell (also known as a transit-amplifying cell) that can proliferate for multiple rounds of divisions but is transient in its life and is committed to becoming a particular type of differentiated cell.

Glorious Journey of Stem Cells

- **Mid 1800-** discovered that some cells could generate other cells.
- **Early 1900-** first real stem cell discovered by finding the generation of blood cells.
- **1908-**the term stem cell was proposed by Russian Histologist Alexander Maksimov.
- **1968-** Bone Marrow Transplant.



**ALEXANDER
MAKSIMOV**

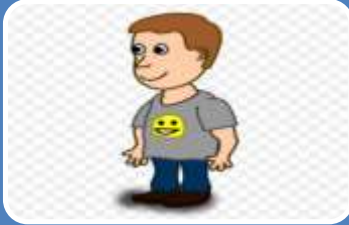
Continued....

- 2010- Induced Pluripotent Stem Cells (iPSC) introduced.
- 2012- **Shinya Yamanaka** and **Sir John.B.Gurdon** discovered that mature cells can be reprogrammed to become pluripotent.
- 27 October 2016-new way for cardiac repair therapies
- 2 May 2017-a method to grow inner ear tissue from human stem cell developed.



The Nobel
Prize
in
Physiology
or
Medicine
2012

Sources of Stem Cells



1. AUTOLOGOUS:

Cell's from a) patient's own body
b) his /her cord blood cells



2. ALLOGENIC:

Cells from donors body

a) FAMILIAL- ALLOGENIC: from relatives

b) UNRELATED- ALLOGENIC: from completely unrelated donor



3. XENOGENIC:

Cells from different species.

Types of Stem Cells

A. Classification based on the basis of potency

1. TOTIPOTENT STEM CELLS:

All fates possible. e.g. zygote

2. PLURIPOTENT STEM CELLS:

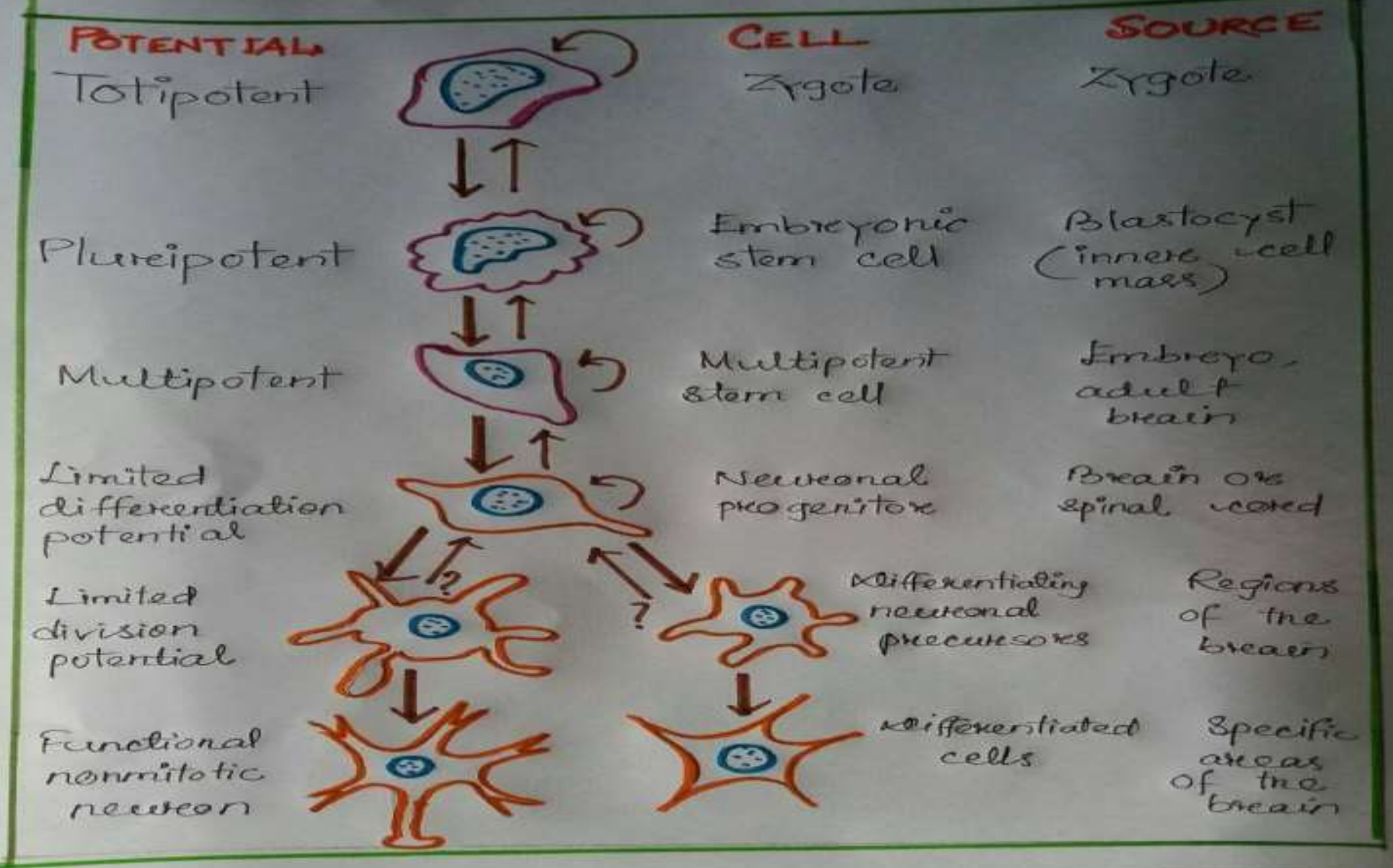
All cell types possible except trophoblast
e.g. Embryonic stem cells

3. MULTIPOTENT STEM CELLS:

A small subset of cells possible.
e.g. mammary stem cells .

4. UNIPOTENT STEM CELLS:

Generation of only a particular cell e.g. spermatogonia



Diagrammatic representation of an example of the maturational series of stem cells, a differentiation of neurons is illustrated here.

(Gilbert, S. F. (2014). Developmental biology. Tenth. Sunderland, MA)

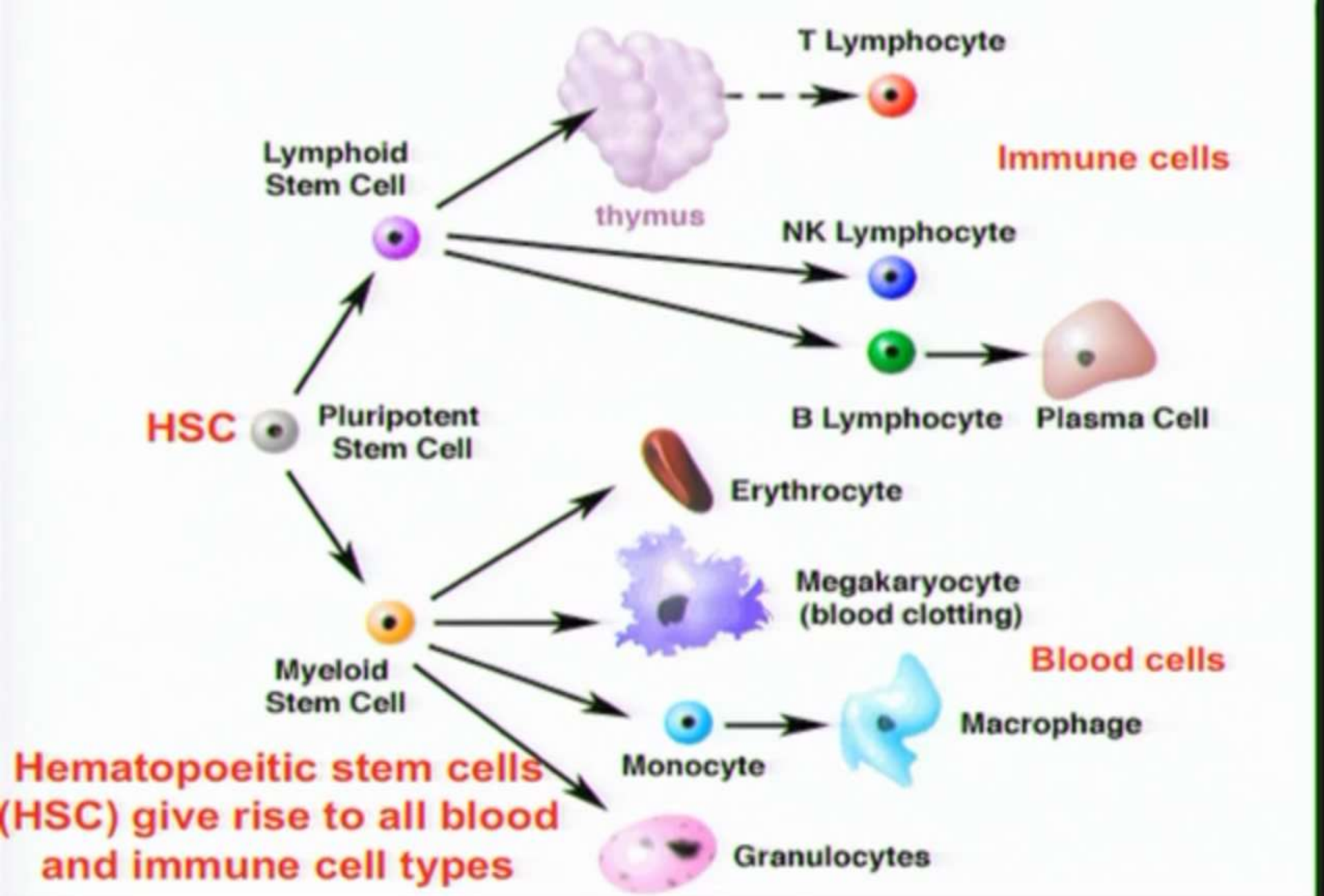
B. Classification based on Origin:

1. Embryonic Stem cells

- Derived from ICM of mammalian blastocyst or from fetal gamete progenitor (germ) cells
- form a complete organisms.

2. Adult Stem Cells

- Found in the tissues of organ after organ maturation
- Can form only a subset of cell types.



(Source: MIT Open Courseware)

Potential uses of Stem cells



(Source: NeuroscienceNews.com)

- Embryonic stem cells (ESCs) and induced pluripotent stem cells (iPSCs) are being used to study **human cell development and diseases**. The use of stem cells to study patient-specific cell differentiation of the rare blood disorder Fanconi anemia or disorders of the nervous system like autism and ALS have already started to provide novel insight into disease mechanisms.

Pluripotent stem cells can also be used in regenerative medicine to rebuild tissues and to make structures called organoids, which seem to possess many of the multicellular hallmarks of human organs. Organoids are being used to study human organogenesis and patient-specific disease progression on the tissue level, all in vitro.

CHALLENGES:

1. Ethical Issue.

2. Rejection by the body.

3. Difficulty in performing transplantation

4. Often, source may lead to mutation.

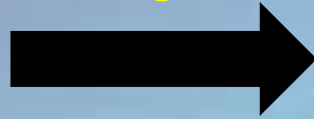
5. Expensive

It leads to the introduction of iPSCs...



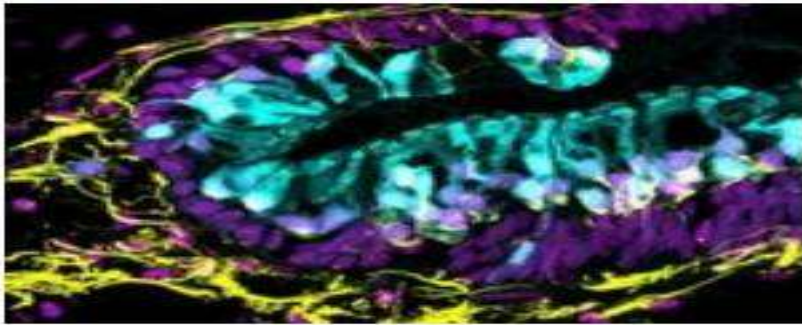
Induced Pluripotent Stem Cells (iPSCs)

Adult Stem Cells



Embryonic-like Stem Cells

- Founder: **Kazutoshi Takahashi and Shinya Yamanaka** of Kyoto University in mouse body.
- Obtained by reprogramming somatic cells of a patient through the introduction of certain transcription factors (**Oct4, Nanog, and Sox2**).
- Possess potential value for discovery of new drugs and establishment of stem cell therapy protocol.
- May prevent immune rejection and do not raise bioethical issue.
- Highly encouraging results have been achieved from skin fibroblast differentiated to insulin- secreting pancreatic cells.
- Embryonic and induced pluripotent stem cells can be maintained in culture indefinitely and, when exposed to certain combinations of factors and/or constrained by the physical growth substrate, can be coaxed to differentiate into potentially any cell type of the body.



**Human Inner Ear
Organs Grown**



**Success in 3-D
Bioprinting of
Cartilage**



**Stem Cells Edited to
Fight Arthritis**



**Identical Twins, Not-
So-Identical Stem
Cells**

Quick Summary

- ✓ A relatively undifferentiated cell which on division produces-
 - A) One cell retaining undifferentiated character
 - B) a second cell undergoing one or more paths of differentiation.
- ✓ Stem cell potential refers to the range of cell types a stem cell can produce. A totipotent stem cell can generate all cell types of both embryonic and extraembryonic lineages. Pluripotent and multipotent stem cells produce restricted lineages of just the embryo and of only select tissues or organs, respectively.
- ✓ Adult stem cells reside in microenvironments called stem cell **niches**. Most organs and tissues possess stem cell niches, such as the germ cell, hematopoietic, gut epithelial, and ventricular-subventricular niches.
- ✓ The niche employs a variety of mechanisms of **cell-to-cell communication** to regulate the quiescent, proliferative, and differentiative states of the resident stem cell.
- ✓ Mesenchymal stem cells can be found in a variety of tissues, including connective tissue, muscle, cornea, dental pulp, bone, and more. They play dual roles as supportive stromal cells and multipotent stem cells.

Conclusion

- ✓ **Stem cells have enormous potentiality.**
- ✓ **But, the question lies in whether we can exploit the ability of stem cell for whatever treatment or objectives we wish to accomplish?**
- ✓ **Further work on stem cell is required for the welfare of whole mankind.**

Quick Quiz

- 1. Name two scientists related to the field of Stem Cell Biology.**
- 2. Write True or False: Stem cells retain the ability to divide while also generating differentiating progeny.**
- 3. Choose the correct option:**
 - a) Self Renewal is NOT the property of Stem Cell.**
 - b) It has the power to produce many different undifferentiated cells.**
 - c) Embryonic stem cells are pluripotent.**
- 4. -----Stem Cell are capable of forming either myeloid progenitor cell or lymphoid progenitor cell. (Fill in the Blank).**
- 5. Define stem cell.**
- 6. What are the applications and challenges of stem cells.**
- 7. 'Potency decides a stem cell'-Explain.**

Further Readings and References

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THANK YOU.....

