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Biomedical Engineering +
Leonard Gelfand Center

Stem Cells

What are stem cells and what is stem cell therapy?

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This educational resource for high school audiences was developed as a project by Carnegie Mellon student[s], Isabel Joyce and Cassandra Dodson, for the course *Biomedical Engineering Directed Study*, taught by Dr. Conrad Zapanta in spring 2022. Dr. Judith Hallinen served as a consultant.

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Sources for content and for images that are included in these slides can be found in the accompanying script and on the slides at the end of the file.

You can use the Stem Cell Vocabulary Worksheet to take notes throughout the presentation.

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Cell Review

Let’s do a quick review on what a cell is, before we delve into stem cells!

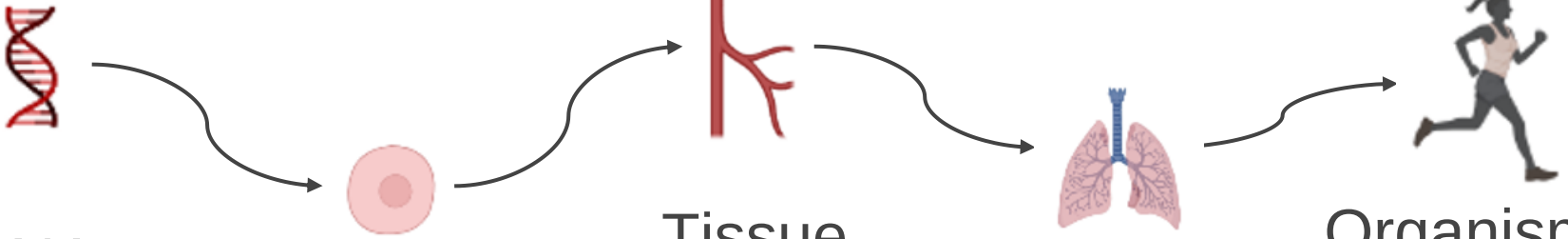
Mammalian Cell Review

Cell are the smallest unit of life.
Cells are composed of four main parts:

- Nucleus
- Membrane
- Organelles
- Cytoplasm

There are different types of cells with different functions, depending on the organ they live in!

Levels of Organization in the Body



DNA

Genetic information, stored in the nucleus of the cell.

Cell

Smallest unit of life in the body.

Tissue

Comprised of many cells, to form a functional unit.

Organ

Comprised of many tissues, to form a functional unit.

Organism

Comprised of many organs, to form a human!

01

What are stem cells?

Learn what stem cells are and how they differ from other cell types.

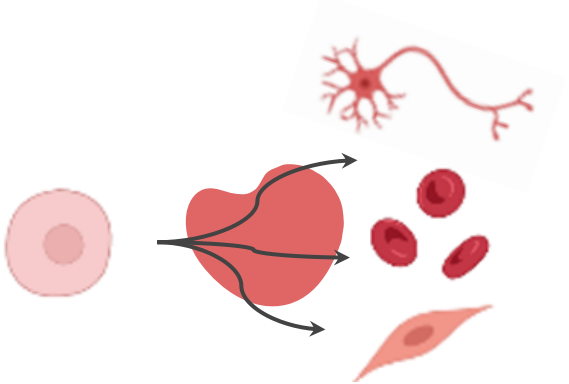
Imagine…

You are a high school senior, right about to graduate with plans to go to college. Whatever major you choose to study, you will develop your skills in that area. When you graduate, imagine you find a job related to your major. That job will have a specific role and contribution to society…

You're just like a stem cell!

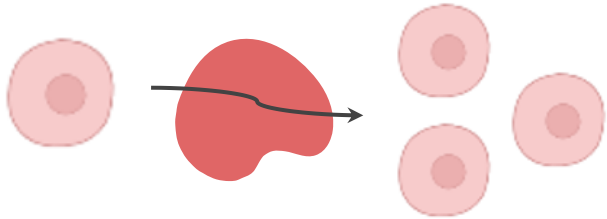
Stem cells start off as functionally non-specific, however they **differentiate** and grow into cells with specific functions and roles in the body.

What is the definition of a stem cell?



Differentiation

The ability of the stem cell to develop into many different types of cells in the body.



Self-Renewal

The ability of the stem cell to self-regenerate many times. This contributes to the stock of stem cells in the body.

Google Image: https://www.yourgenome.org/facts/what-is-a-stem-cell

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02

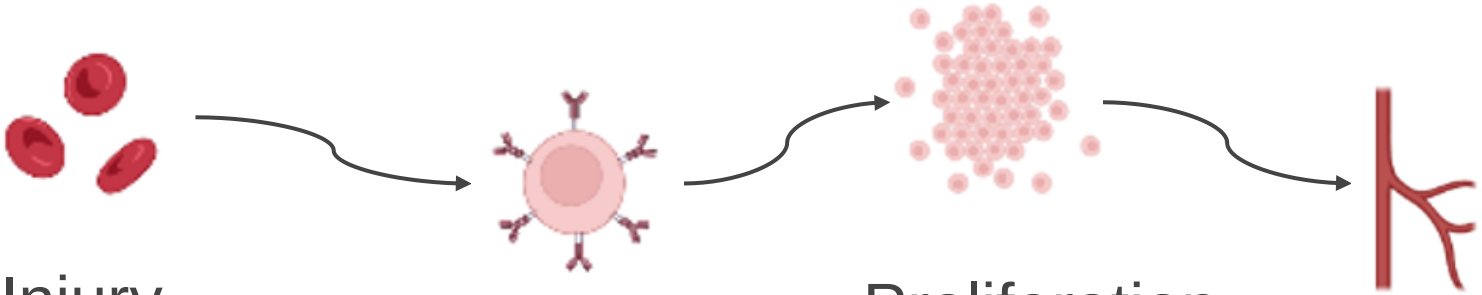
What do stem cells do?

Learn what role stem cells play in the body. What is their job?

Think…

Remember the last time you got a cut? What did your body do to repair the injury?

The Healing Process



Injury

Clot is formed to stop the bleeding.

Inflammatory

Immune cells fight any infection and get rid of debris.

Proliferation

New cells are formed and move to the site of healing.

Remodeling

New tissue continues to mature and increase strength.

In the proliferation phase, how were new skin and blood cells created?

Answer: stem cells!

What do stem cells do?

They create new functionally-specific cells!

Reminder that stem cells:

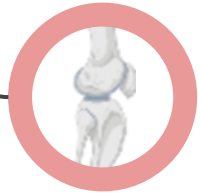
1) differentiate (become more specific) **AND**
2) self-renew

We see stem cells becoming fully differentiated cells in wound healing to **create new skin and blood cells**… can you think of any other situations in the body where you would need to generate new cells?

Other stem cell functions in the body:

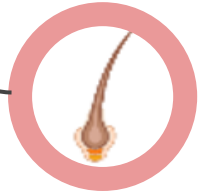
Broken Bone

Regrow bone cells after a broken bone.



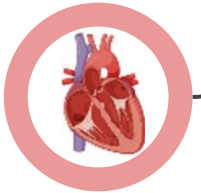
Hair Regrowth

Grow new hair cells daily.



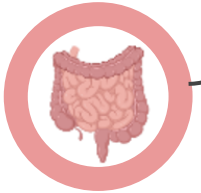
Heart Attack

Heart muscle regrowth after a heart attack.



Intestinal Lining

Damage to intestinal lining repaired frequently.



03

Types of stem cells?

Learn the different types of stem cells and why they're important.

Embryonic Stem Cells

What are they?

Embryonic stem cells are pluripotent cells that can differentiate into any cell of the human body

Where do we find these cells?

Embryonic stem cells are found in the blastocyst of a human embryo (4-7 days after fertilization)

Pros and Cons

Pros

- Easy to find/isolate
- Pluripotent
- Immortal

Cons

- Ethical concerns
- Potential of tumor formation

Adult Stem Cells

- These cells are multipotent and can be partially or fully differentiated
- Important in wound healing, maintaining cell populations, and renewing cells

Stem Cell Niche

- This is a specific region in the body where adult stem cells live and grow
- Adult stem cells are isolated from these regions for research, treatment, etc.

Pros and Cons

Pros

- Ethically sound method of stem cell use
- Multipotent

Cons

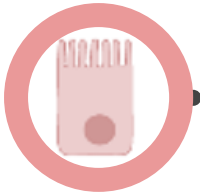
- Difficult to locate/isolate

Adult Stem Cell Types

Neural

- Become neurons & neural support cells
- Found in subventricular and subgranular zones

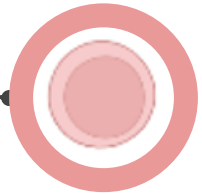
Epithelial



- Become skin, intestinal gland and vessel lining,
- Found in the niches of the skin, hair, etc.

Hematopoietic

- Various cells of the blood.
- Found in the bone marrow and umbilical cord blood



Mesenchymal

- Differentiate into cells of the cartilage, fat, muscle, etc.
- Found in bone marrow, adipose tissue, and umbilical cord blood

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Induced Pluripotent Stem Cells (iPS)

iPS cells are produced through transdifferentiation (reprogramming) of somatic cells

Where are they found?

iPS cells are taken from skin or blood cells

How are they reprogrammed?

Transcription factors are introduced into the cell to change gene expression

What cells can they become?

Reprogrammed iPS cells are pluripotent and can differentiate into any cell type

Pros and Cons

Pros

- Pluripotent
- Immortal
- Easy to create

Cons

- Teratoma formation

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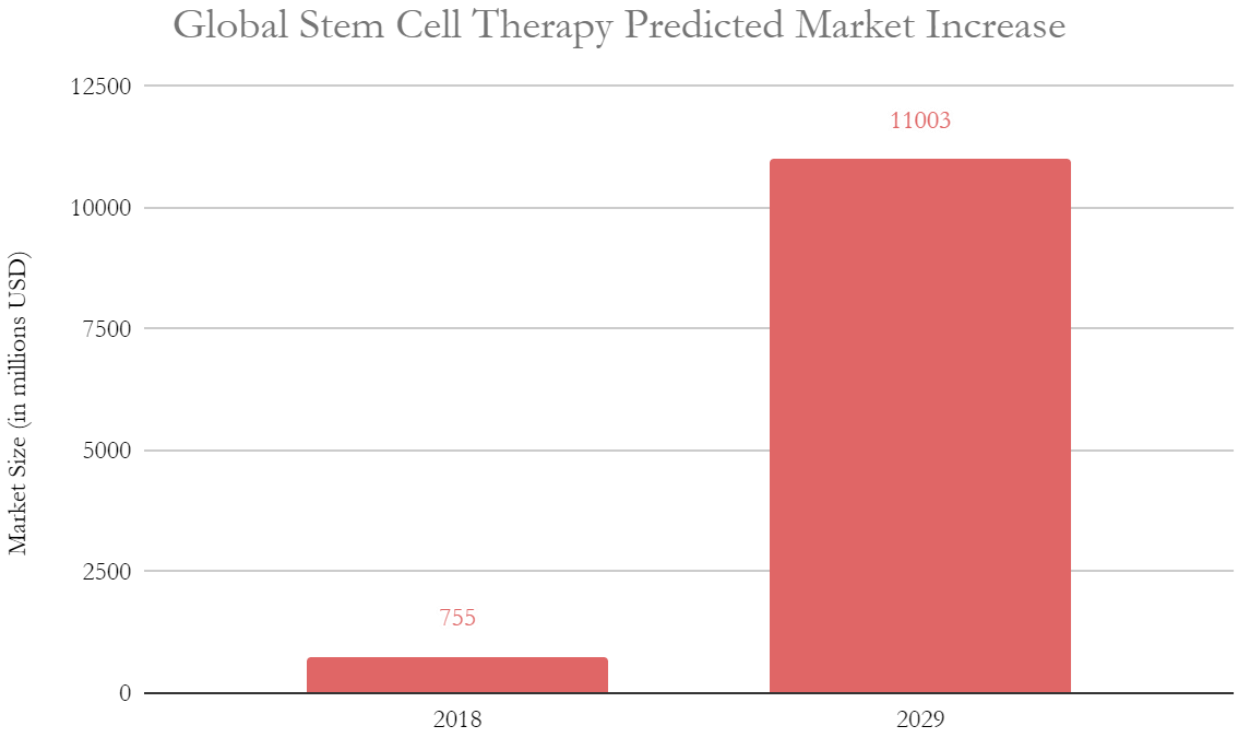
04

Why do we care in medicine?

Learn the current research. How can we leverage the functionality of stem cells in therapies?



The stem cell therapy market is growing!

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What do stem cells do in the body?

Answer: create new cells to maintain functionality of cells in tissues

For example:
creating new bone cells after a broken bone.

Can you think of any ways stem cells can be used as therapies?

Stem Cell Therapies

Alzheimer's

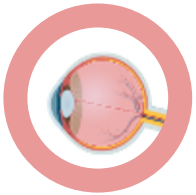
Replace diseased neural cells with new neurons.

Diabetes

Replace insulin pancreas cells.

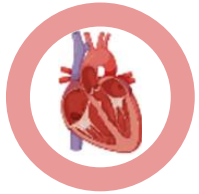
Blindness

Replace dead retinal cells with new cells.



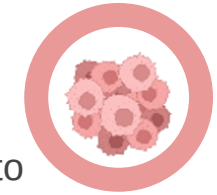
Heart Attack

Regrow heart muscle cells.



Cancer

Utilize regenerative ability to study cancer growth.



Vascular Grafts

Creation of medical devices with stem cells reduces inflammatory response.

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The Alzheimer's Brain

Alzheimer's involves the **degeneration of neurons**, which causes memory loss.

Over **6 million** people are living with Alzheimer's dementia.

Notice the **loss in mass** of the Alzheimer's brain?

Stem cell therapy offers potential cures to Alzheimer's, by **regrowing the neurons!**

Thanks for using this Stem Cell Presentation!

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References

Note: details about references can be found in the associated Instructor Slide Guide!

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