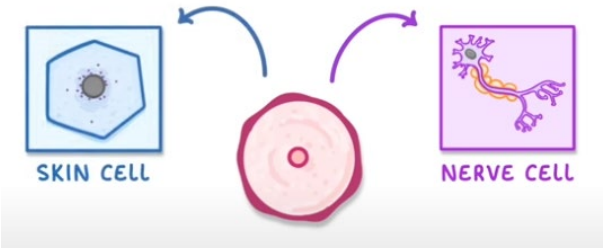
TABLE OF CONTENTS

STEM CELLS

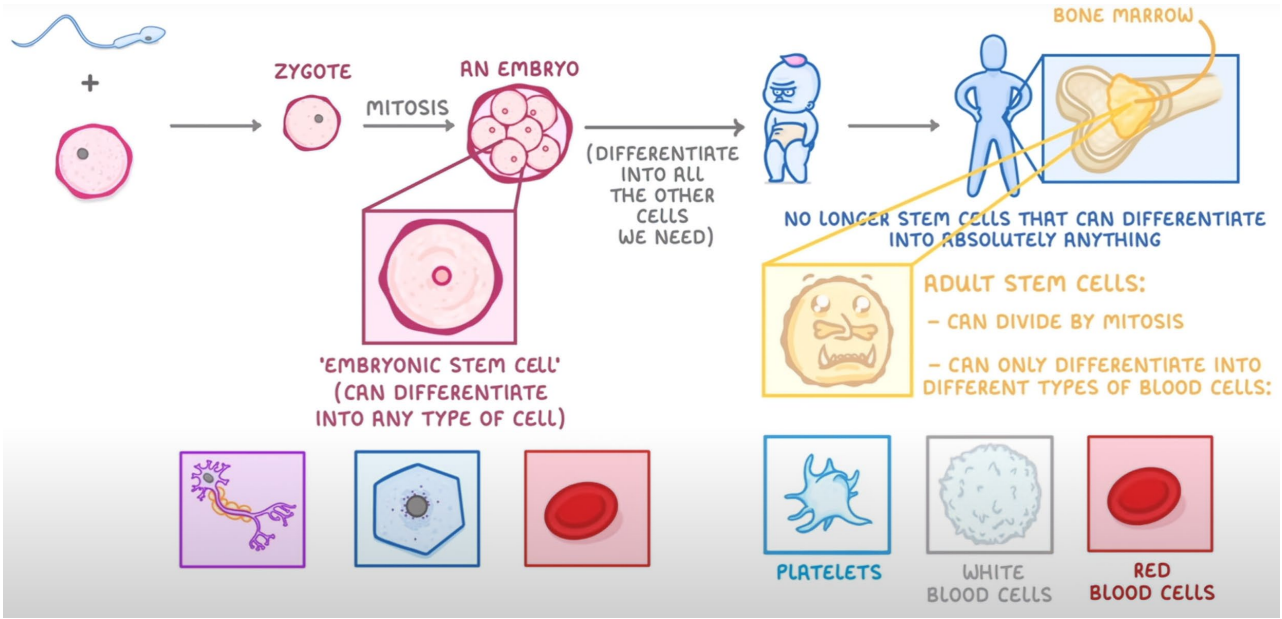
They are cells that can divide by mitosis to form more cells and **can differentiate into specialized cells**

So, a stem cell can turn into a skin cell, or a nerve cell, or any other type of cell



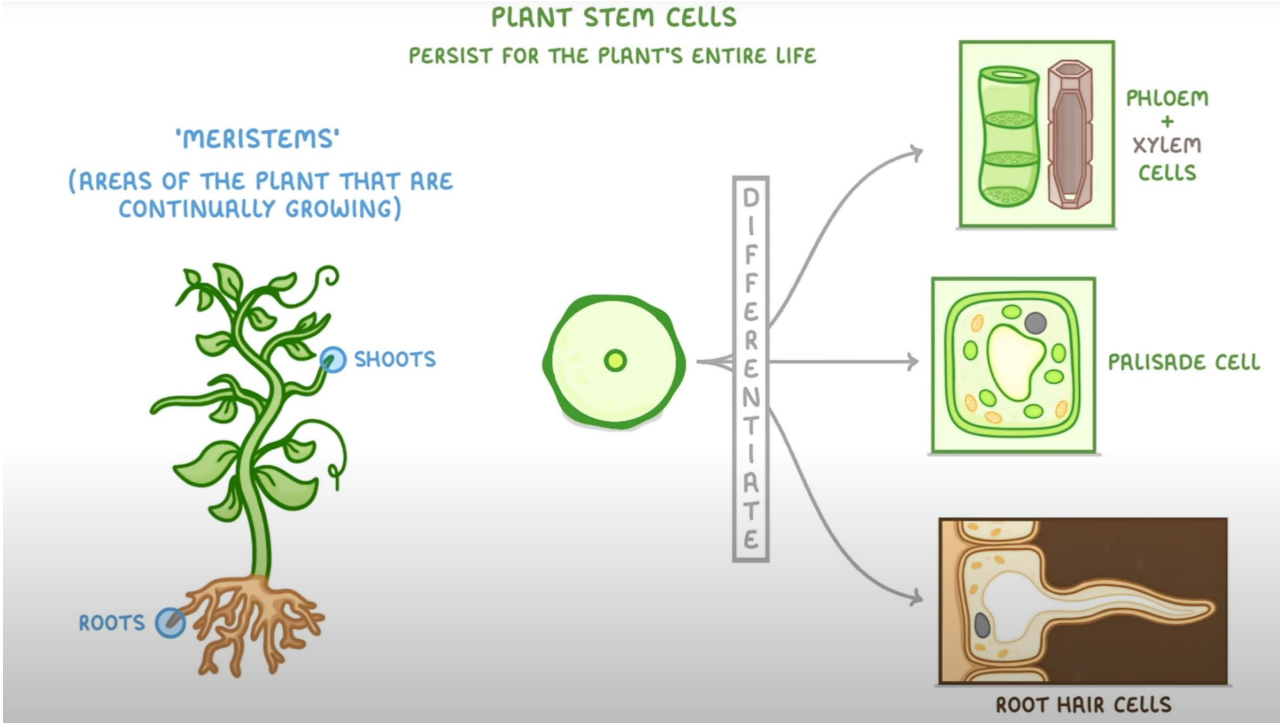
HUMAN LIFE

- When a sperm cell fertilizes and egg cell, it forms a new cell called a **zygote,** the zygote is its own organism now, independent of the mother.
- Over days, the zygote will divide using **mitosis**, over and over and over again, until forming a group of cells called an **embryo**, the cells forming the embryo are called **embryonic stem cells**
- **The embryonic stem cells** continue to divide and differentiate into different types of cells
- After **9 months**, we end up with a baby
- **When we have an adult**, stem cells can no longer differentiate into **absolutely anything**, we have new types of stem cells that can only differentiate into a narrow list of cells, these are called **adult (somatic) stem cells**, they exist in bones as **bone marrow**
- **Somatic/adult stem cells** divide and differentiate into different type of blood cells like **Red blood cells, white blood cells,** and **platelets**
- **Somatic stem cells** exist to replace damaged cells, not to make new tissue like **embryonic stem cells**



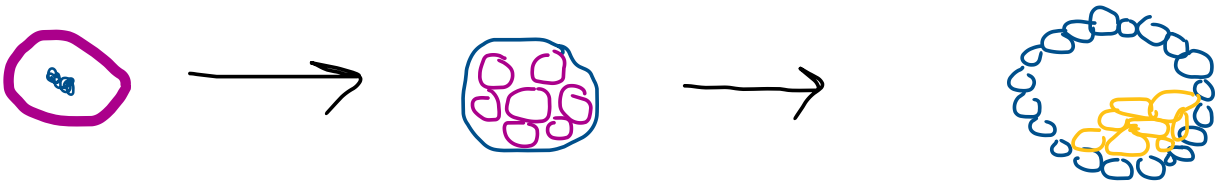
Plant stem cells

- They are found in plant tissue called **meristems** which are found in areas of the plant that are continuing to grow, aka **tips of roots and shoots**
- They differentiate into different types of cells that the plant needs, like
    - **palisade cells** that do photosynthesis
    - **Phloem + xylem cells** that move sugar and water
    - **Root hair cells** that absorb water
- Unlike **embryonic stem cells**, plant stem cells persist for the plant's entire life



HOW DO STEM CELLS START

- the zygote starts dividing with mitosis until it reaches the **blastocyst stage**, it's where a hollow ball of cells is formed, inside this hollow ball is a group of cells called the **inner cell mass (ICM)**



- **The ICM** is the thing that is going to become the embryo, it consist of a bunch of stem cells (embryonic), these stem cells will begin to specialize in different cell types, these stem cells are called **pluripotent stem cells**

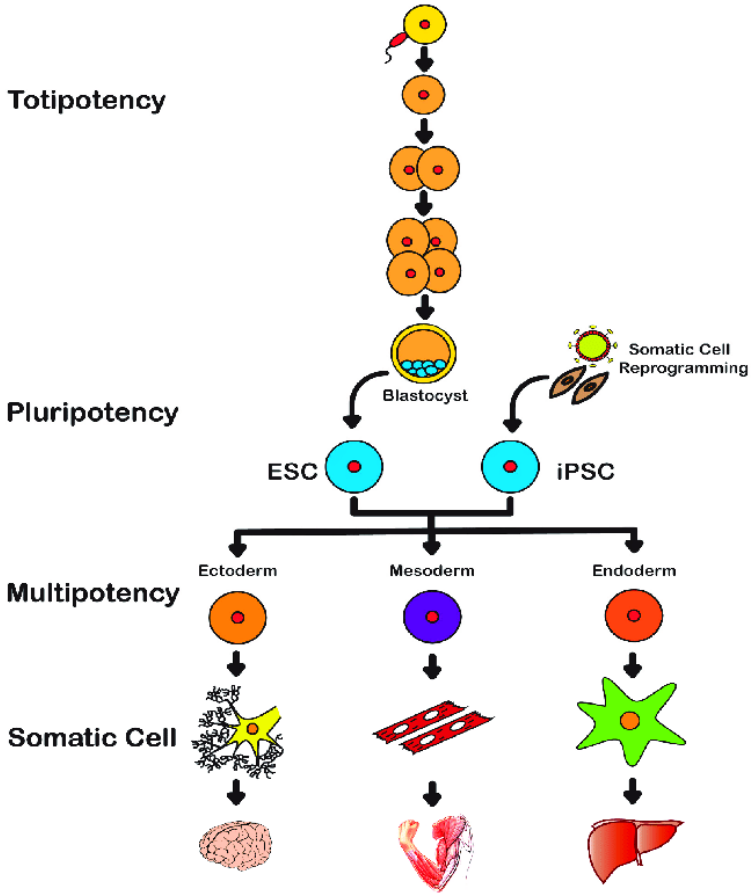
STEM CELLS BASED ON DIFFERENTIATION/POTENCY

TOTIPOTENT

- It's stem cells that are present in the early stages of the embryo (until the **morula**), it includes the **zygote** and **cells in the first few divisions**
- The totipotent stem cell has the biggest range out of the 4, as it can specialize in **embryonic** and **extraembryonic** cells
- **Toti** means "whole", referring to them being able to differentiate into every type

PLURIPOTENT

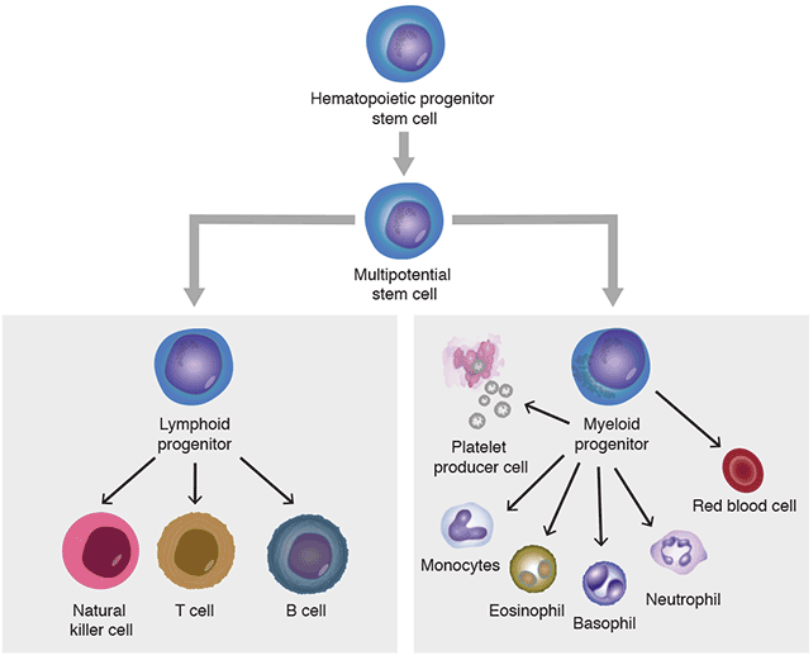
- It's stem cells that are present in the **blastocyst stage**, they are the **inner cell mass (ICM)** and they are the ones who will begin making the body
- The pluripotent stem cells have the 2nd biggest range, as they can differentiate into **200+ different cell types**, but they can't specialize in **extraembryonic** cells necessary for embryonic development
- They can differentiate into **ectoderm** and **mesoderm** and **endoderm** cells, which can also specialize in different things too
- **Pluri** means "several", referring to them being able to differentiate into many several types



- As you can see, there is a middle phase called iPSCs and ESCs
    - **Embryonic Stem Cells (ESCs):**
        - **Source:** Derived from the inner cell mass of the blastocyst, which is a very early stage of embryonic development, and they are Found in embryos at about 4-5 days of development.
    - **Induced Pluripotent Stem Cells (iPSCs):**
        - **Source:** Generated by reprogramming adult somatic cells (e.g., skin cells) to induce a pluripotent state, they were first created in the laboratory by introducing specific genes (often called Yamanaka factors) into adult cells, resetting their developmental clock to a pluripotent state.

MULTIPOTENT (ADULT/SOMATIC)

- They are cells that appear in the later stage of life, unlike pluripotent stem cells, they can differentiate into a **narrow** range of cells.
- They have two types
    - **Hematopoietic stem cells (HSCs)** exist in bone marrow and give rise to red blood cells, white blood cells, and platelets
    - **Mesenchymal stem cells (MSCs)** are found in various tissues such as **bone marrow, adipose tissue,** and **umbilical cord**, they can differentiate into **bone cells (osteocytes), cartilage cells (chondrocytes),** and **fat cells (adipocytes),** among others.
- **HSCs** can be divided into either
    - **Lymphoid progenitors** -> which are immune cells
    - **Myeloid progenitors** -> which consits of immune and blood cells



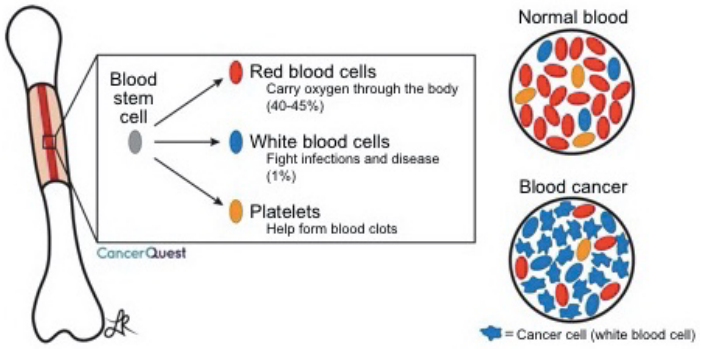
There is also a type called **unipotent** which you don't have to study but you can save it in your brain 😊

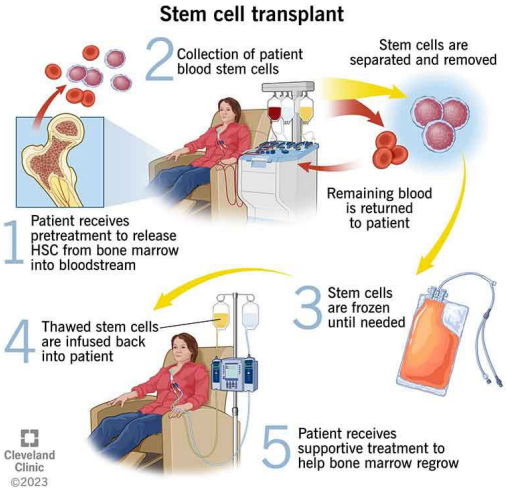
- They are just cells that divide into a single type, that's the reason they're called **uni** meaning "one"
- Example of them are sperm cells and muscle cells

STEM CELLS & LUEKEMIA (BLOOD CANCER) TREATMENT

This is how we can treat a leukemia patient

- Destroy all blood cells in the patient (to get rid of the unhealthy ones)
- Then replace them with new healthy stem cells which are ready to grow and give you a whole set of **healthy blood cells**





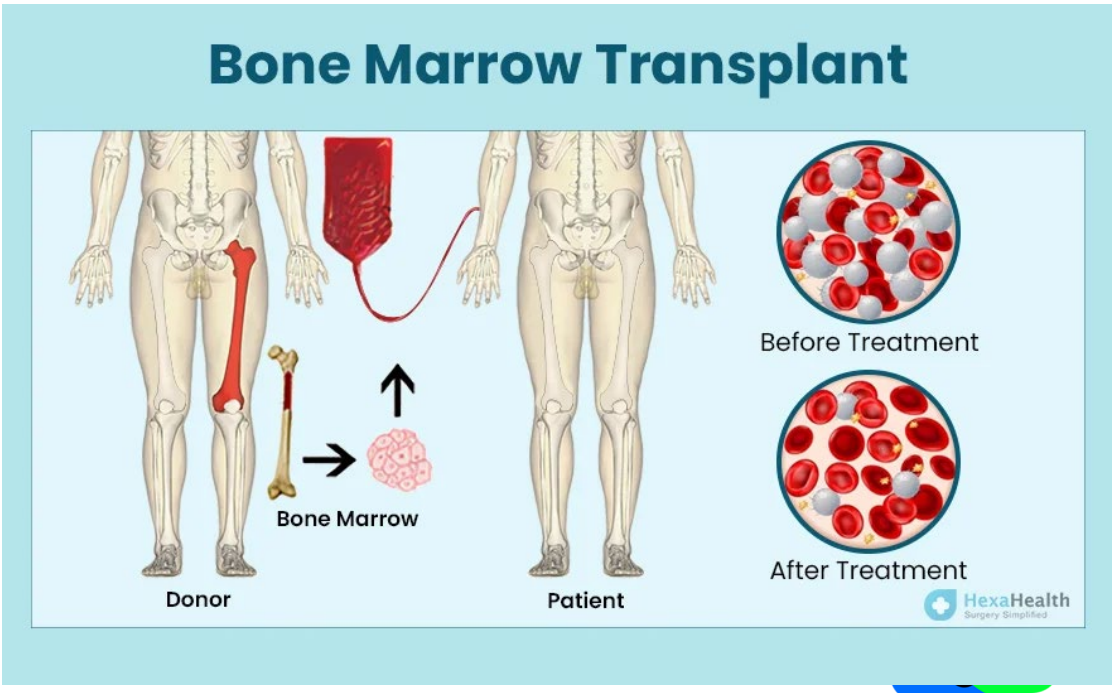
BONE MARROW TRANSPLANT

It's the same as we said earlier

Firstly, we remove the infected bone marrow and any stem cells in the blood

secondly, we take the bone marrow from the donor after checking it has a similar **type** to the patient

lastly, the patient is left to be monitored if ~~any~~ problems arise



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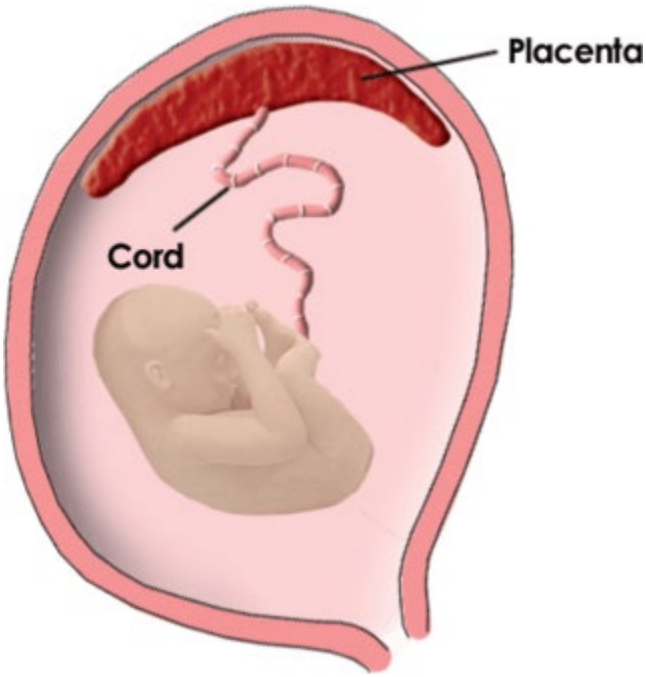
STEM CELLS AND CORD-BLOOD TRANSPLANT

First of all, let's talk about **human leukocyte antigens (HLAs)**, they are proteins that exist on the surface of **white** **blood cells** and **platelets** and **other immune cells (T cells, B cells, natural killer (NK) cells, and antigen-presenting cells (such as macrophages and dendritic cells).**

HLAs are used by the immune system to distinguish **the good body cells** and **the bad invader cells**.

The stem cells forming the **cells mentioned above** are called **hematopoietic stem cells (HSCs)** which exist in the **umbilical cord blood**



a **cord-blood transplant** is we take umbilical cord blood from the cord of a **pregnant mother** and use the **HSCs** in it to treat several diseases

it's divided into a few steps

Collection of cord blood

- Here, the remaining cord blood is taken after the baby is born and stored in a cord blood bank

Donor Matching

- Unlike bone marrow transplants, cord-blood transplants are more flexible, as instead of searching for the **exact blood type**, we search for an exact or similar **HLA** type, as **HLAs** do not require the same type to be able to be transplanted

Conditioning Treatment

- The patient will have to undergo a training regimen, which involves chemo/radio therapy to remove all the infected blood/immune cells

Transplantation

- Where the cord-blood will be transplanted into the patient, and the **HSC**s will begin to go the bone marrow

Engraftment

- Where the transplanted **HSCs** will begin to grow and specialize and divide

Recovery/follow-up

- The patient will be monitored to check for any infections or **graft-versus-host disease (GVHD)**
- This stage takes weeks/month to end

DIABETES & STEM CELLS

type 1 diabetes is where the **immune system** attacks the insulin, this can be fixed by replacing the **immune system's cells** with good cells

1. We get **stem cells** from a donor that have the similar/same type as the patient's stem cells
2. We remove all bad immune/stem cells from the patient
3. We insert the new immune stem cells
4. We monitor the patient for any infections or **GVHD**

THE STEM CELL DEBATE

It's the consideration of the **ethics** of the research about **embryonic stem cells** using **human embryos**