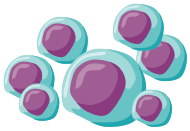
Cell Specialization



Why do we look so complex?

If we know we are made up off billions of cells...
And each cell contains the same DNA...

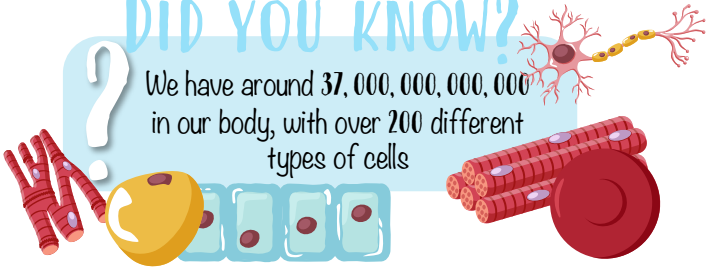
Cell Specialization

Cells develop into distinct cells types with specific functions allowing the organism to be uniquely adapted to perform tasks efficiently.

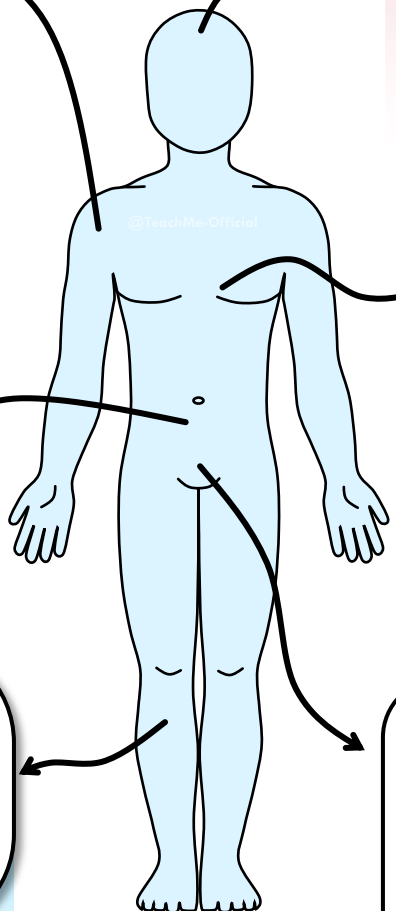
You can think of different cells each being a different instrument in a band, each have a soecific role which contributes to the overall task at hand: the concert.

Did you know?

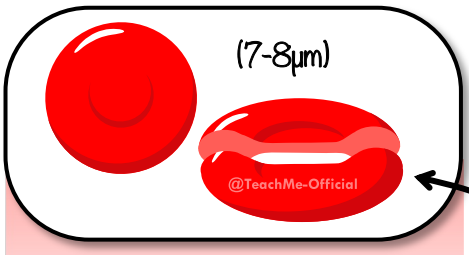
We have around 37,000,000,000,000 in our body, with over 200 different types of cells



Some examples of cells

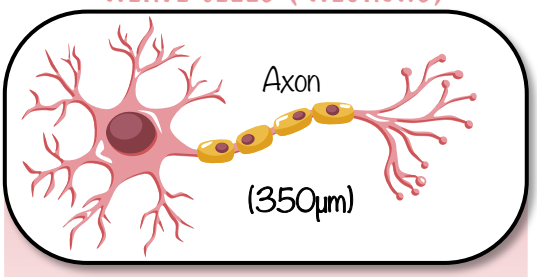


Erythrocyte (RBC)



Hemoglobin - Carry oxygen
Biconcave shape - efficient
Lacks organelles - More space for oxygen
Small & flexible - Pass tiny capillaries

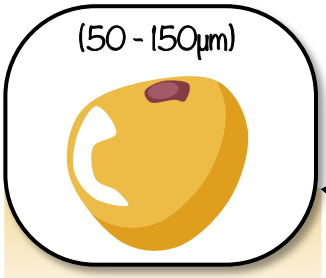
Nerve cells (Neurons)



Carry signals over long distances

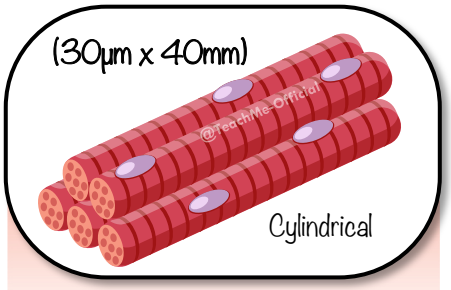
Different Type = Different Function
Motor – Carry signal from brain/spinal cord to muscle (to contract)
Sensory – Carry signals towards the brain (sensation)

Fat Cell (Adipocyte)



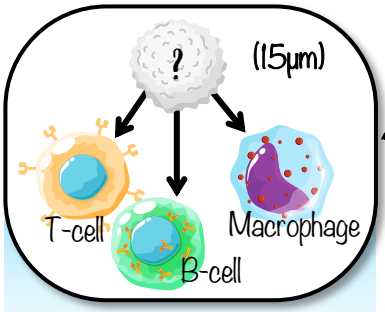
Lipid Storage

Striated Muscle Fibers (Skeletal)



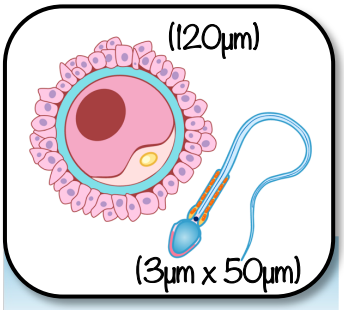
Contraction (movement)

Leukocyte (WBC)



Defense against infections

Egg and Sperm Cells



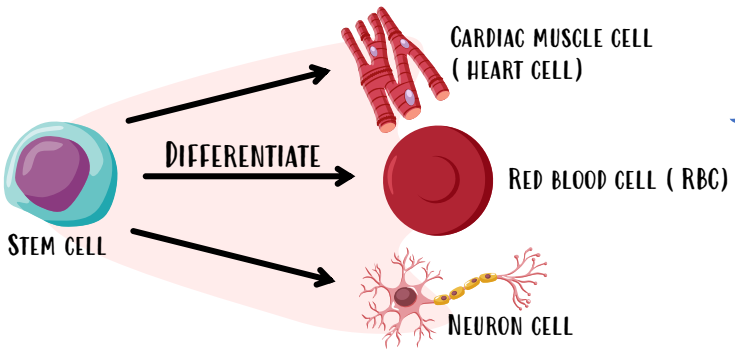
Carry genetic information

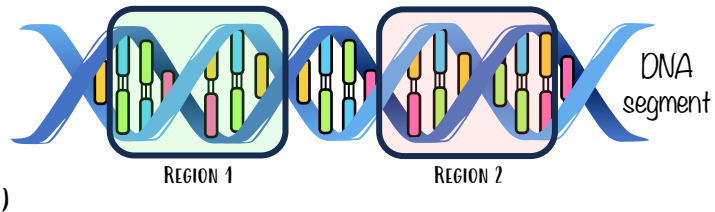
Cell Specialization

"If we know we are made up off billions of cells... And each cell contains the same DNA...Why do we have different cell types?"

Differentiation

Differentiation involves the expression (turn ON) of some genes from the organism's genome in the cell, but not others (turn OFF).



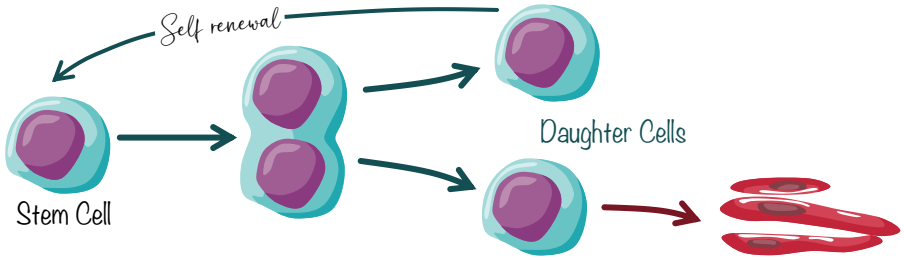


For example, a neuron cell could express (turn ON) **region 1** however, **not region 2**. A different kind of cell may express different regions.

Stem Cells

Cells that retain their ability to divide indefinitely (unlimited period) and differentiate.

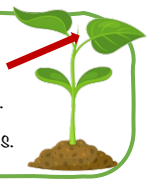
- Unspecialized
- Can differentiate
- Divide Repeatedly (self-renew)
- Large nucleus relative to cytoplasm



Plant Stem Cell

Meristematic tissue. Near root & stem tips.

Farmer use their cuttings to grow new plants.



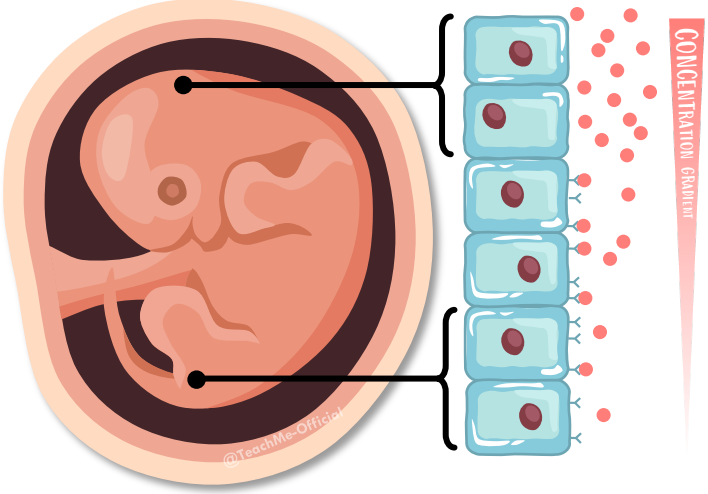
How is differentiation controlled?

It all starts in the embryo, where **signal molecules** are released to control which genes get expressed.

(think of them like instruction messages)

Morphogens

Signal molecules that control cell differentiation (in embryo)

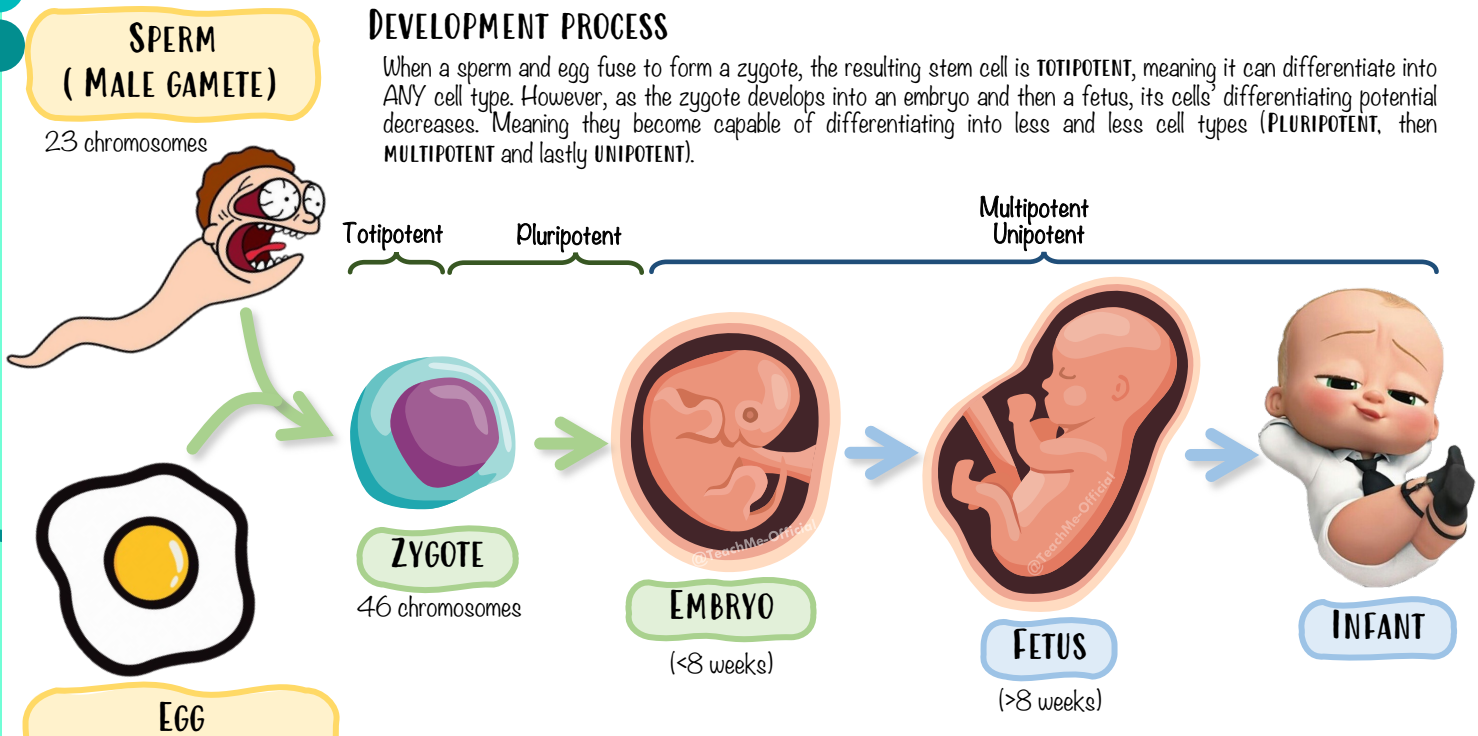


- The morphogens occur in gradients in different regions of the early embryo.
- The gradient of the signaling molecule results in different genes being expressed in different parts of the embryo.
- The concentration of the signal molecules controls the regional development of the first cells into head and tail structures.
- As the embryo develops, other signaling molecules become factors in differentiation.

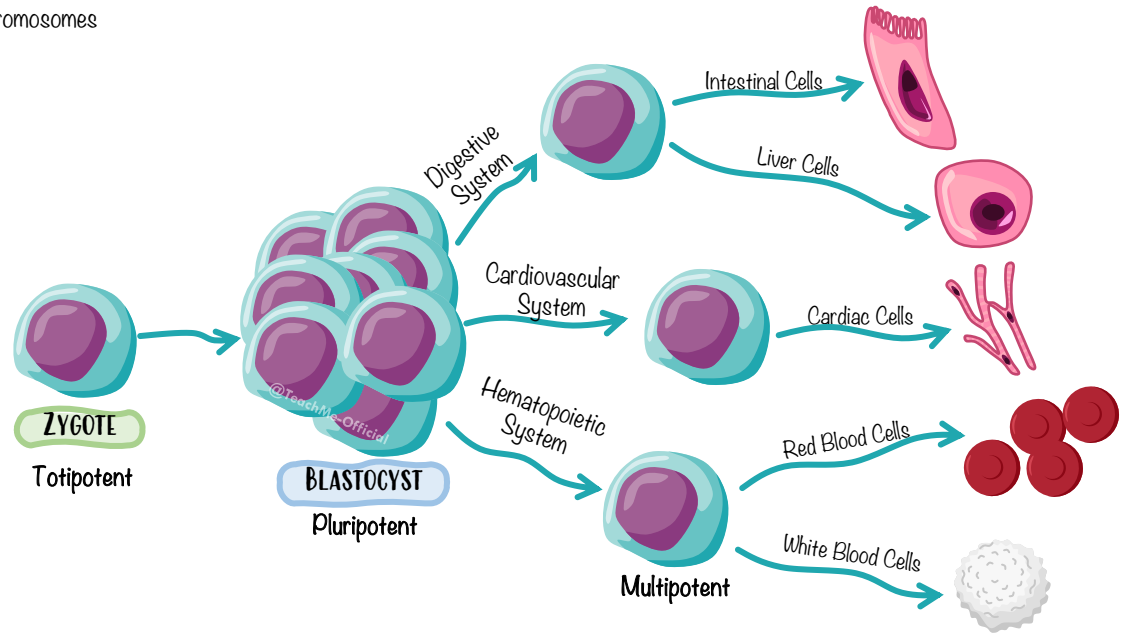
Cell Specialization

Development Process

When a sperm and egg fuse to form a zygote, the resulting stem cell is **totipotent**, meaning it can differentiate into ANY cell type. However, as the zygote develops into an embryo and then a fetus, its cells' differentiating potential decreases. Meaning they become capable of differentiating into less and less cell types (**pluripotent**, then **multipotent** and lastly **unipotent**).



Stem cells are found both in zygotes and in fully grown adults – they just have different abilities.



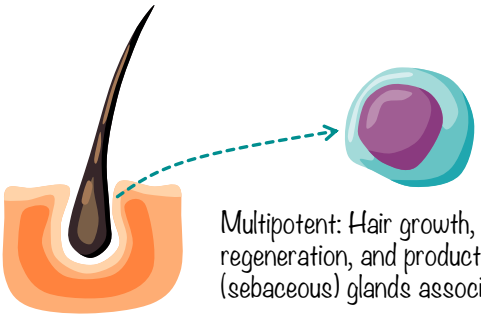
Stem Cell	Description
Totipotent	Capable of continued division and the ability to become ANY kind of cell. They only exist in the VERY EARLY stages (first 5 days) of embryo development. They can form a complete organism.
Pluripotent	They come from totipotent cells. They exist in EARLY stages of embryo development. They can become ALMOST any cell type. They cannot form a complete organism.
Multipotent	Only forms a limited number of cell types. For example, bone marrow stem cells can become any kind of blood cell. But not others. They occur later in the development process and remain throughout life.
Unipotent	Only forms a single cell type. For example, there are certain stem cells that can only become sperm cells, nothing else. They occur later in the development process and remain throughout life.

Cell Specialization

Stem Cell Niche

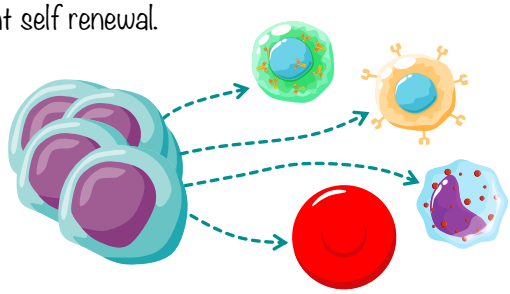
Where to find Stem Cells?

Niche exist in the **SKIN**. Stem cells are found in the bottom rounded area of a hair follicle.



Multipotent: Hair growth, skin and hair follicle regeneration, and production of oil-producing (sebaceous) glands associating with hair follicles.

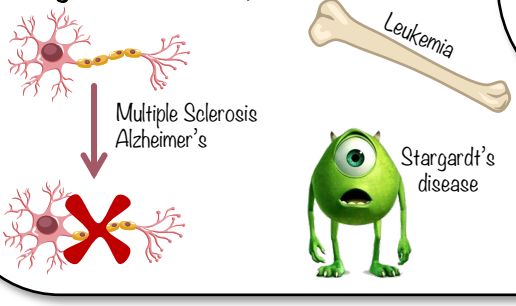
In the **BONE**, there is a stem cell niche. These cells take part in differentiation (into white blood cells **WBC** and red blood cells **RBC**), & constant self renewal.



Other locations in the body may also contain stem cells

Advantages

Treating some diseases;



Disadvantages

EMBRYONIC Stem Cell

More potential BUT ethical Issues (Death of an embryo)

ADULT Stem Cell

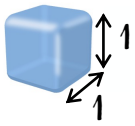
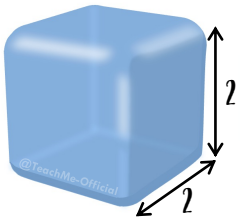
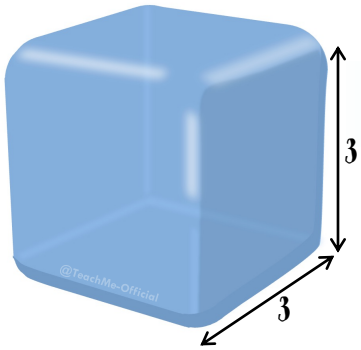
Less potential, lack of ethical issues

Cell Specialization

Surface Area to Volume Ratio

Why do our cells not continue growing indefinitely?

"As a cell **INCREASES**, the surface area to volume ratio **DECREASES**."

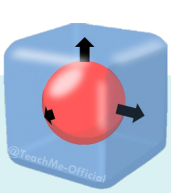
	Surface Area	Volume	Ratio
	6	1	6:1
	24	8	3:1
	54	27	2:1

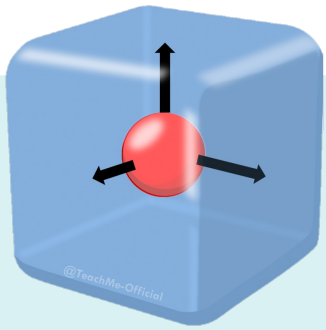
**The numbers and ratios are just for reference to understand the concept*

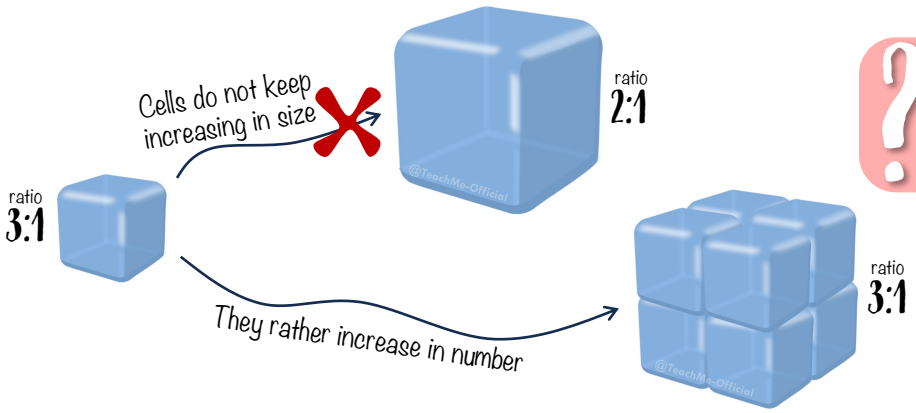
Why do our cells not continue growing indefinitely?

Increasing the cell size means the surface area to volume ratio decreases. Molecules need a farther distances to travel – causes them to become **LESS EFFICIENT** at releasing waste products and heat out of the cell as well as bringing in nutrients for the cell.

For example; mitotic spindles do not work as well when the cell is too large.







Fun Fact!

Larger organisms do not have **LARGER** cells – they have **MORE** cells!

notes