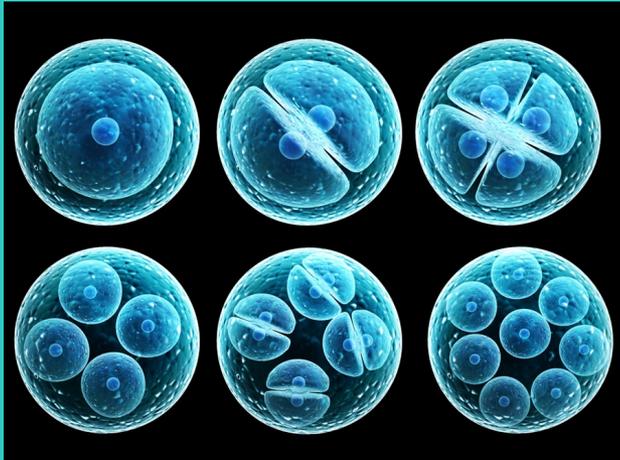
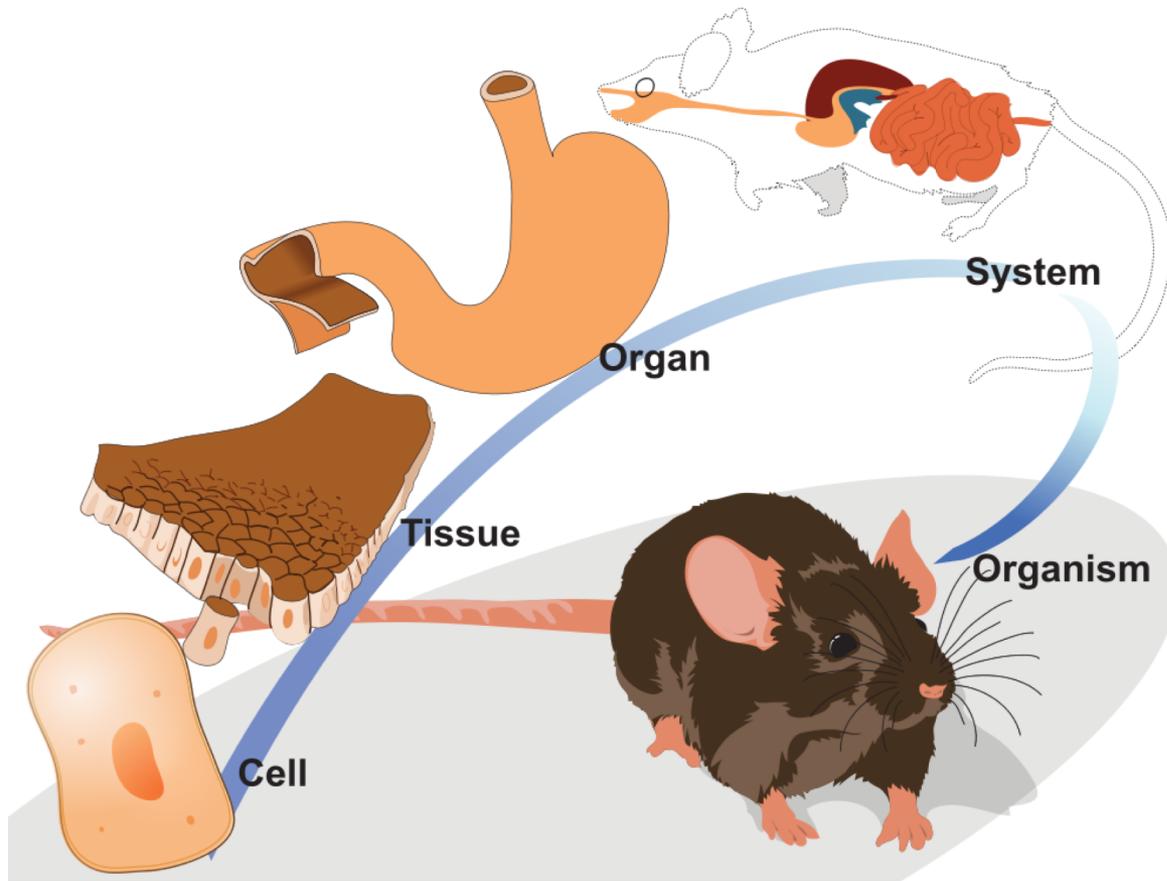


Introducing *STEM CELLS*



Teachers in Residence Programme
Colm Caomhánach and Róisín Ní Bhraíain

How animals are 'organised'



Cells

Cells are the smallest building blocks that make up the body

As a cell gets older it can lose the ability to change or **regenerate**



There are 3 types of cells:

- **Young Cells**
- **Teenage Cells**
- **Grown Up Cells**

As a cell gets older it gets more defined and is "stuck" as a certain type of cell



Stem cells are special because:

1) They can copy themselves.

(Not all cells can do this!)

2) They can make other types of cells.

Our body uses stem cells to replace damaged or dead cells.

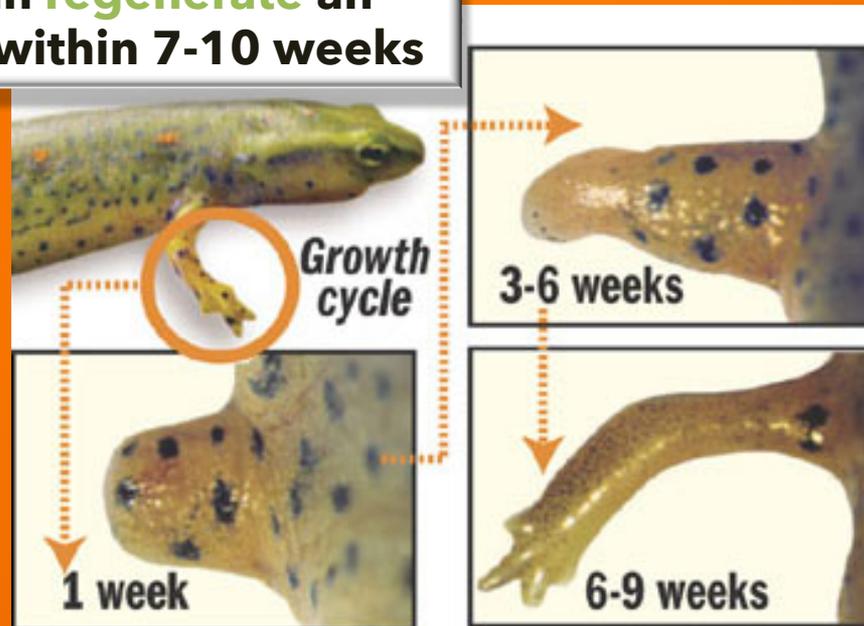
We hope that we can use them in the future to treat diseases.



Regeneration

Regeneration is the ability of an animal's cells to make new body parts when they are an adult

A newt can **regenerate** an entire limb within 7-10 weeks



For example, some animals can do more than just make new skin, they can grow new arms or even heads!

Stem Cells and Regeneration

When an animal is developing, most of the cells turn into a particular type

Cells become blood cells, heart cells, bone cells, etc.

During development, stem cells sometimes remain that do not turn into a type of cell

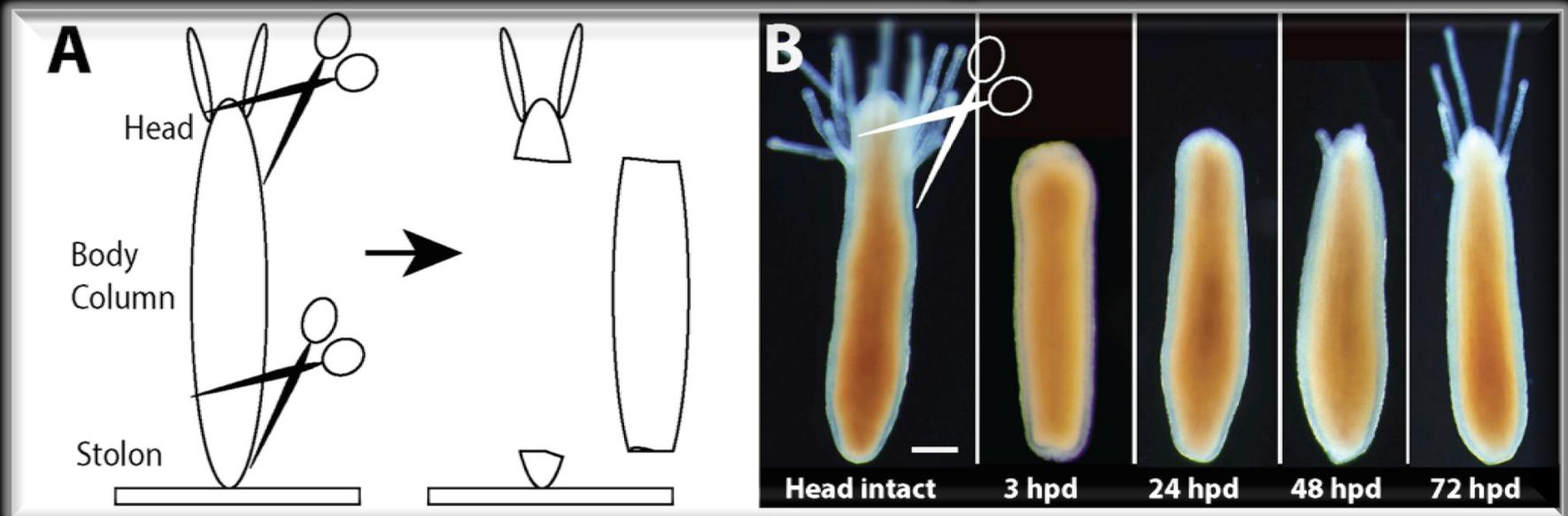
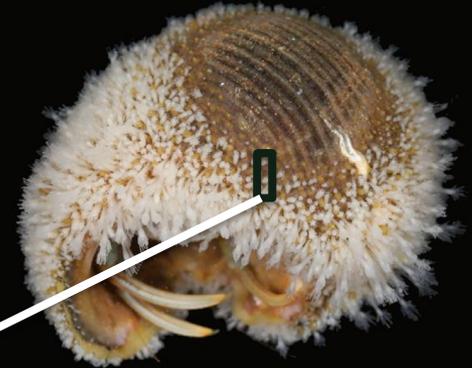
Some animals can use their stem cells to **regenerate** lost or damaged body parts

In order for animals to do this, their stem cells need to get the right signals from the rest of the body

Head Regeneration in Hydractinia

Hydractinia (also known as snail fur) is a small sea creature that lives on the shell of Hermit Crabs.

Hydractinia can **regenerate** its head within 72 hours of being cut off.

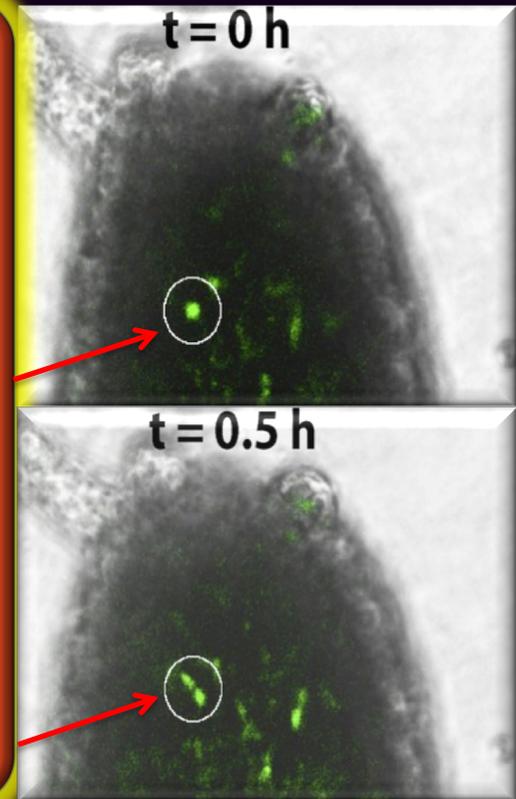


Stem Cells and Regeneration

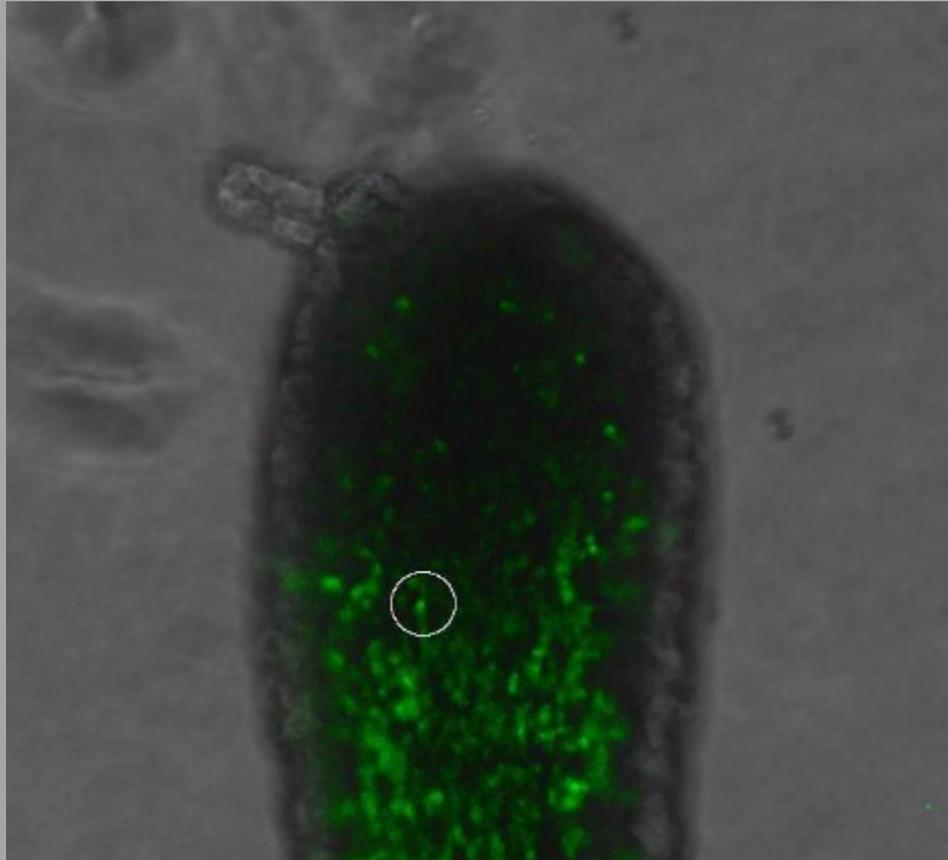
Hydractinia have the correct genetic recipe for regeneration

Specific genes get turned on and send signals to stem cells in the body

These signals cause the stem cells to move (red arrows) to the area that needs **regeneration**



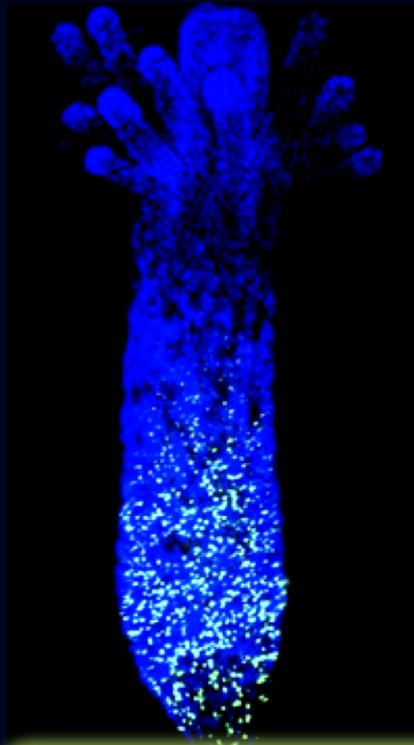
Stem Cell Moving into Head for Regeneration



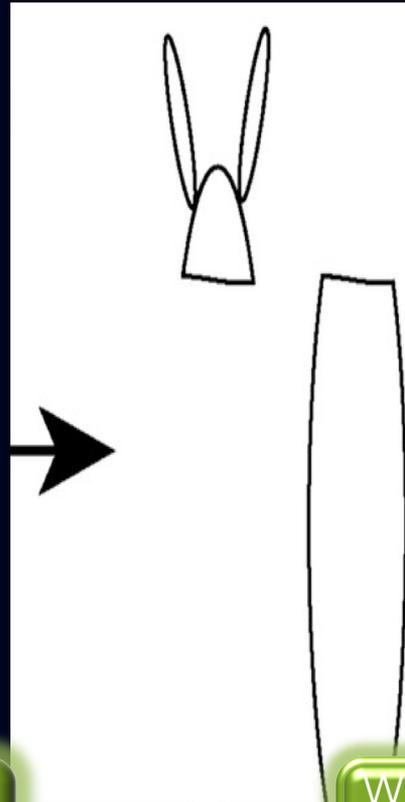
"Video 2", Bradshaw *et al.*, 2015

Movie can be downloaded at:
<https://elifesciences.org/articles/05506#media2>

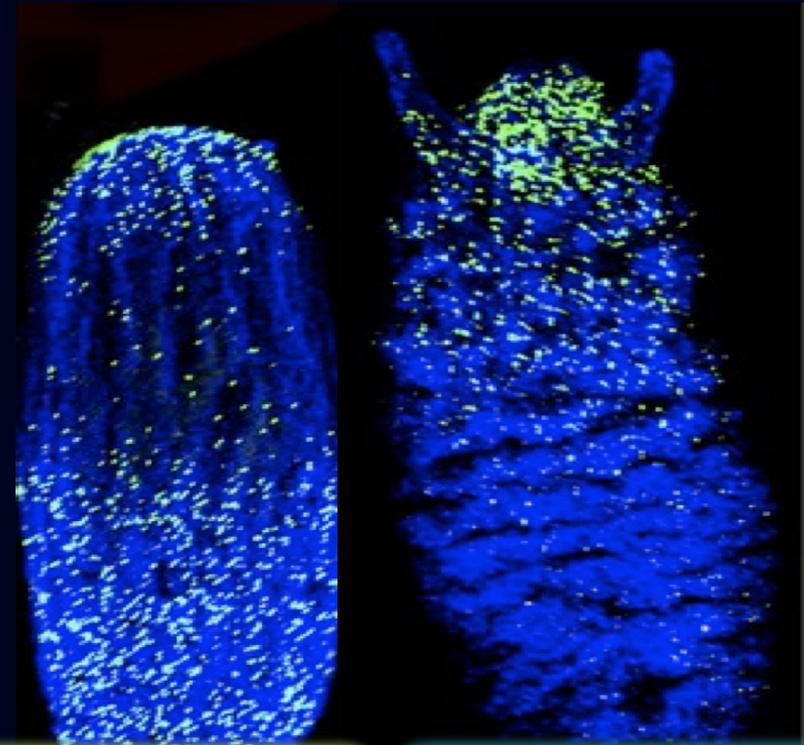
Hydractinia Regeneration



In an uninjured Hydractinia the stem cells (green) are located on the bottom



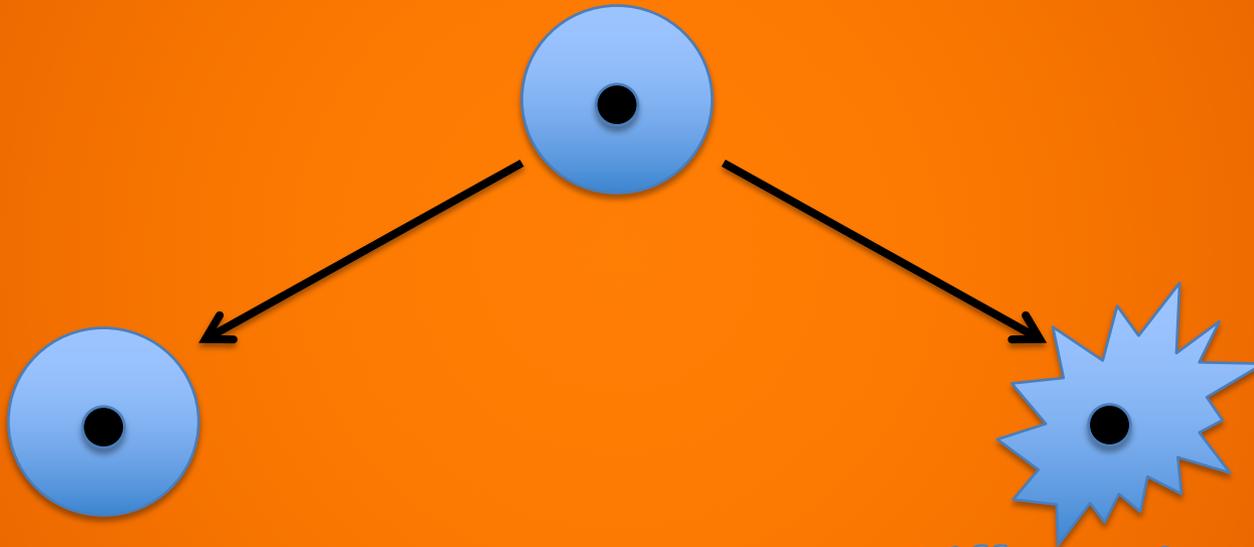
When the head is cut off the stem cells (green) begin to move to the injured head to start regeneration



Regeneration occurs when stem cells arrive and multiply

Stem Cells Have Two Jobs

A stem cell can do one of two things:



Self-renew =

Make copies of itself

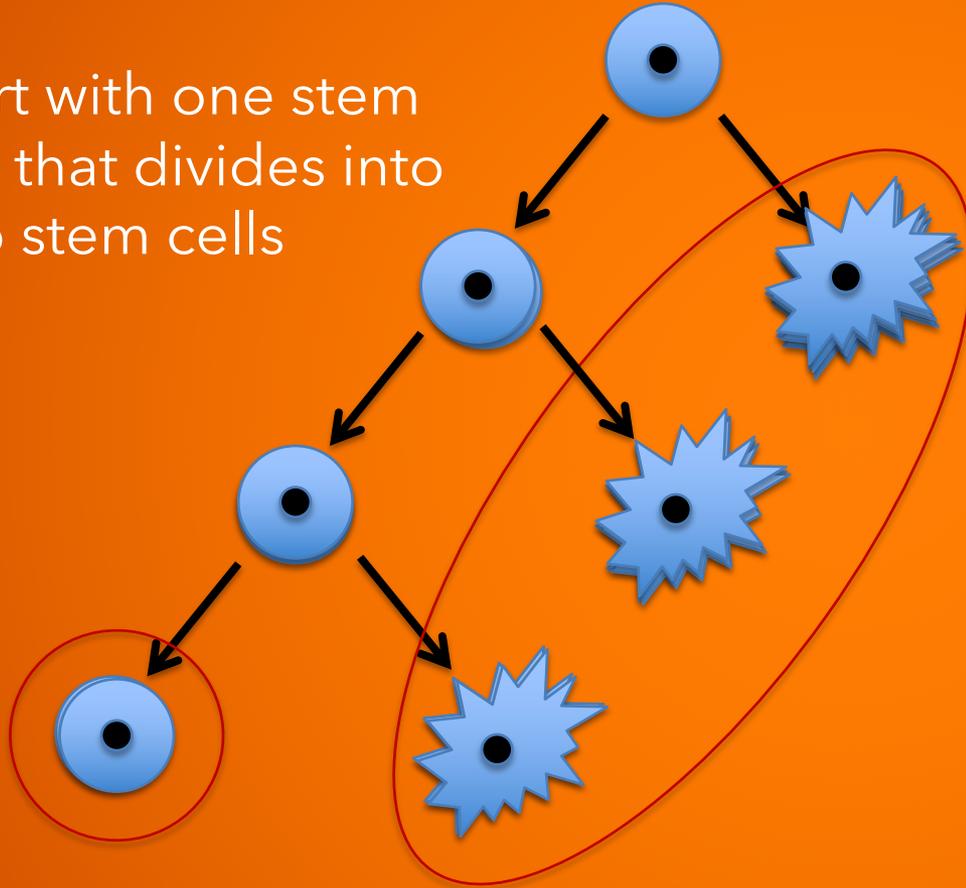
Differentiate =

Turn into a specific
"specialised" type of cell

Once a stem cell differentiates, it generally loses its ability to self-renew!

Why are Two Jobs Necessary?

Start with one stem cell that divides into two stem cells



Self-renewing cells -
Make sure stem cells
do not run out

Differentiated cells -
Replace dead or
damaged cells

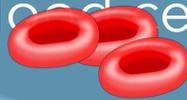
After three divisions, finish with one **self-renewing** cell and
three **differentiated** cells

Example: Blood Cells

Blood stem cells are found in your bone marrow in the middle of your bones



Blood stem cells can differentiate into more specialised cells such as **red** blood cells

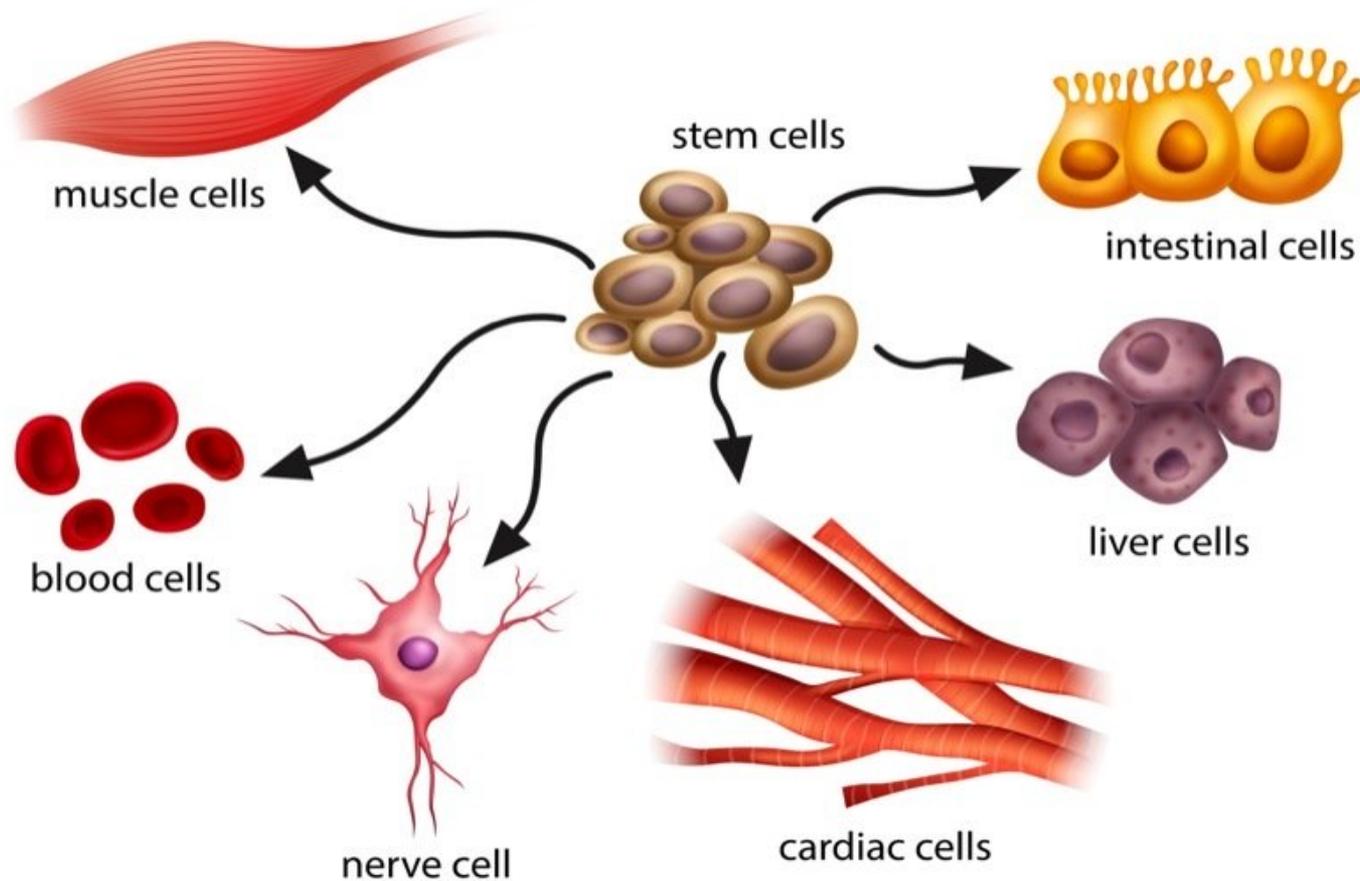


Red blood cells only live up to 120 days so they need to be continuously



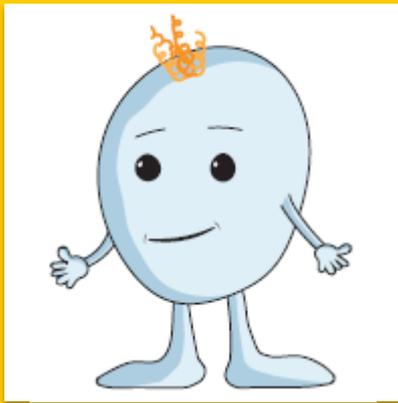
Once the blood stem cells differentiate into **red** blood cells, they lose their ability to self-renew

Stem cells are found all over the body and can turn into various differentiated cells

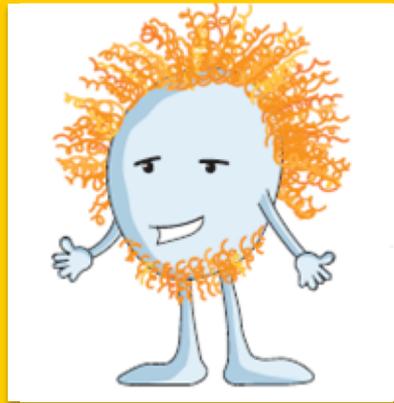


Cartilage Lineage

Cartilage = A rubber-like tissue made of collagen and elastin that covers and protects the ends of bones at joints



**Transitory
Chondrocyt
e**



**Articular
Chondrocyte**



Cartilage

↑ Self-renewal

↓ Differentiation

↓ Self-renewal

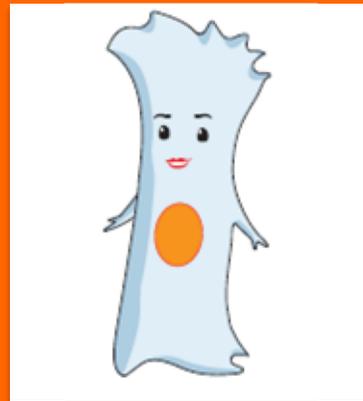
↑ Differentiation

Tendon Lineage

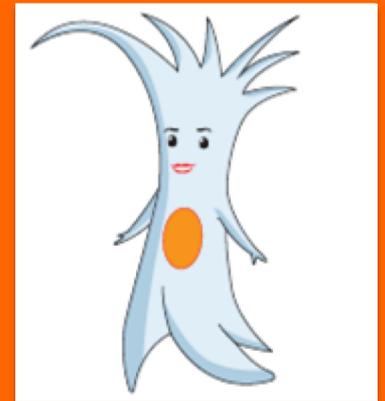
Tendon = A band of tissue that connects muscle to bone



**Mesenchymal
Stem Cell**



Tenoblast



Tenocyte

↑ **Self-renewal**

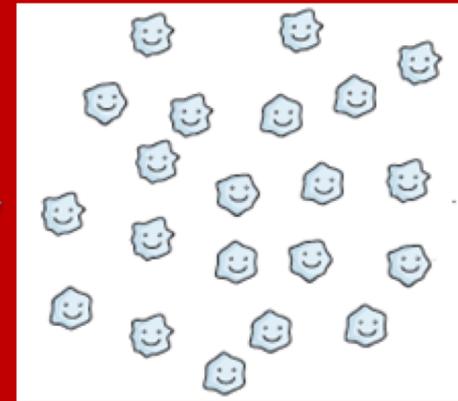
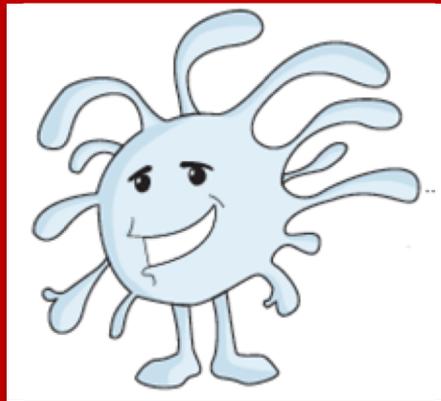
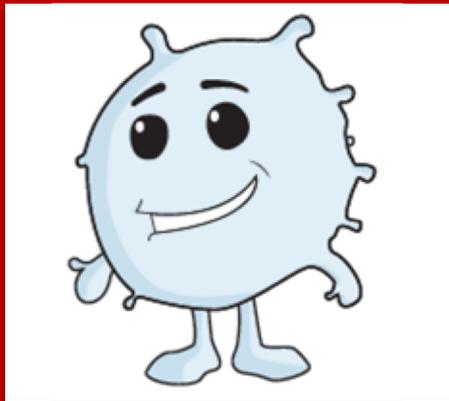
↓
Differentiation

↓ **Self-renewal**

↑
Differentiation

Blood Cell Lineage

Thrombocyte (Platelet) = A cell found in the blood involved in clotting to stop bleeding



Hematopoietic Stem Cell

Megakaryocyte

Thrombocyte

↑ **Self-renewal**

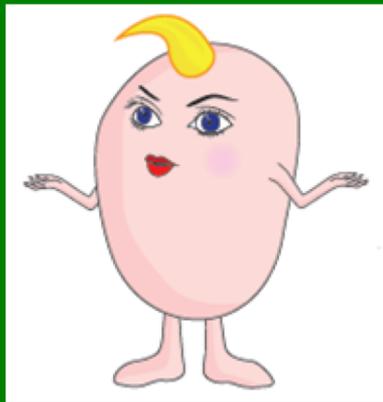
↓ **Differentiation**

↓ **Self-renewal**

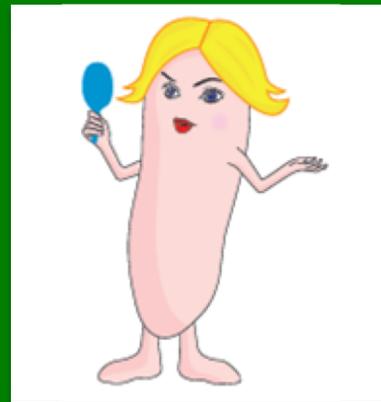
↑ **Differentiation**

Skin Lineage

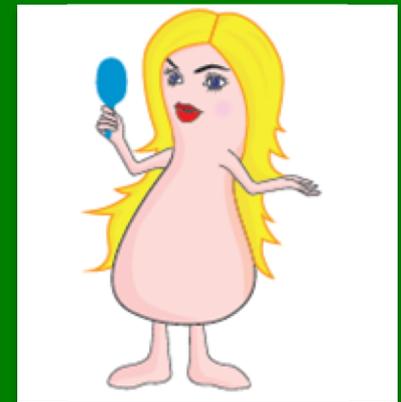
Skin = The outer protective covering of the body which has up to seven layers of tissue, including the epidermis



**Epidermal
Stem Cell**



**Keratinocyte
(Young)**



**Keratinocyte
(Old)**

↑ Self-renewal

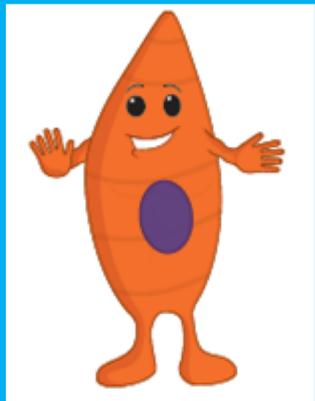
↓ Differentiation

↓ Self-renewal

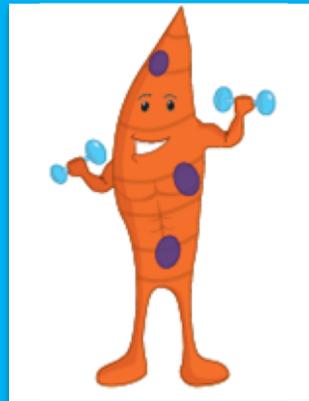
↑ Differentiation

Muscle Lineage

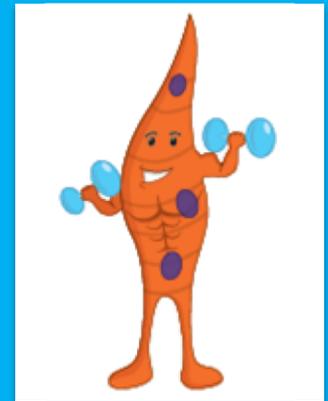
Muscle = The tissue responsible for movement throughout the body from walking to pumping blood



Myoblast



**Myoblast
(Tube)**



Muscle

↑ **Self-renewal**

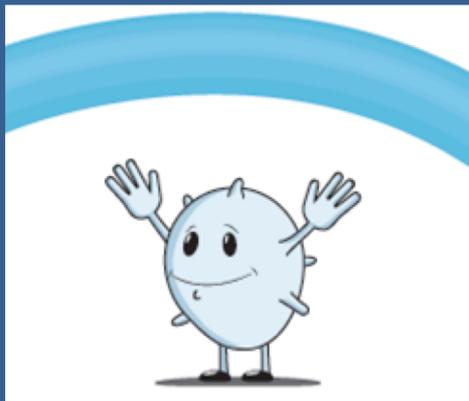
↓
Differentiation

↓ **Self-renewal**

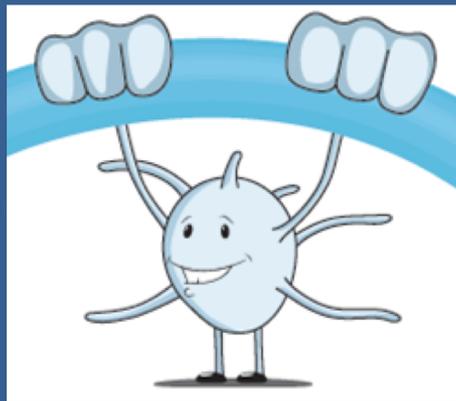
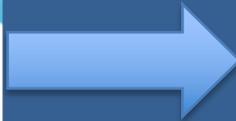
↑
Differentiation

Myelin Sheath Lineage

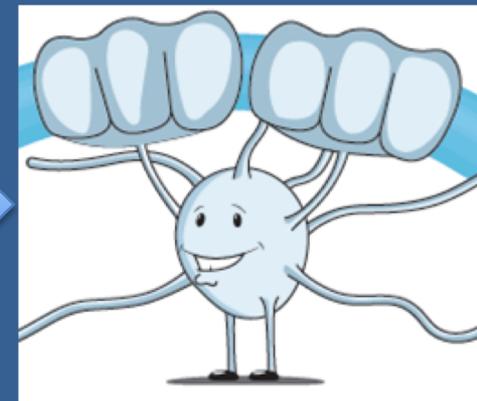
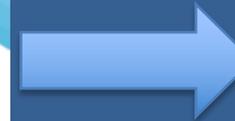
Myelin Sheath = An insulating layer surrounding the axon of neurons allowing signals to be transmitted quickly from the brain to the body



Neural Stem Cell



Glial Progenitor Cell



Oligodendrocyte

↑ **Self-renewal**

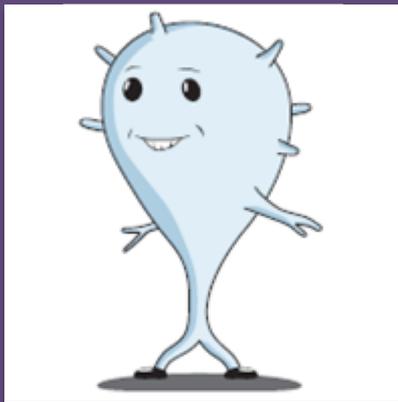
↓ **Differentiation**

↓ **Self-renewal**

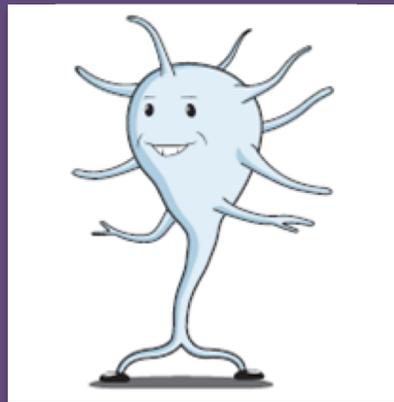
↑ **Differentiation**

Neuron Lineage

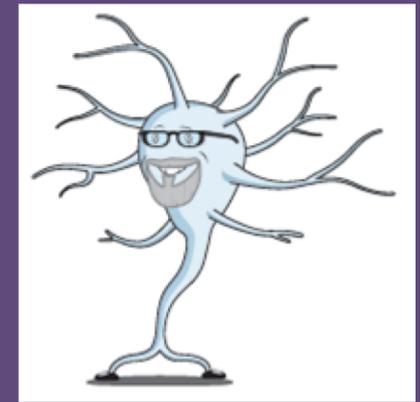
Neuron = A cell that receives and transmits information in the brain.



**Neuronal
Stem Cell**



Neurocyte



Neuron

↑ **Self-renewal**

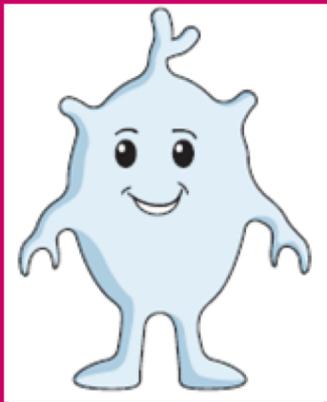
↓
Differentiation

↓ **Self-renewal**

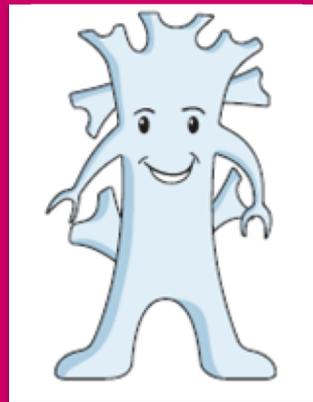
↑
Differentiation

Bone Lineage

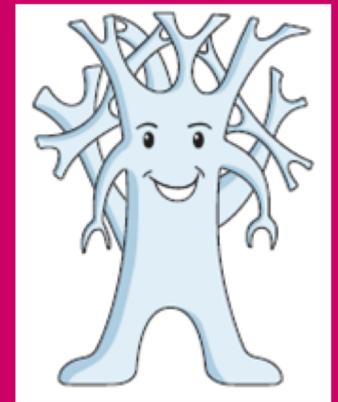
Bone = A living tissue containing blood vessels and cells which allow it to grow and repair itself



**Transitory
Osteoblast**



Osteoblast



Osteocyte

↑ **Self-renewal**

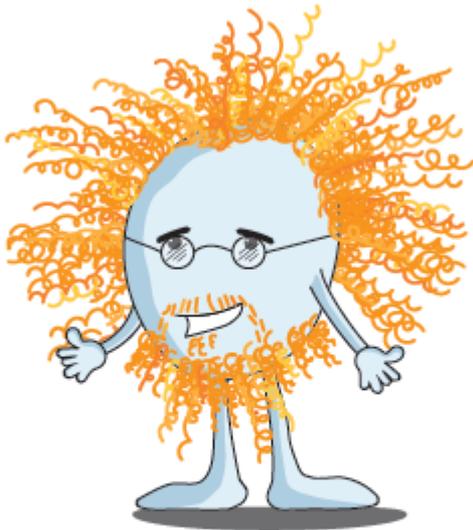
↓
Differentiation

↓ **Self-renewal**

↑
Differentiation

Activity:

Cartilage



This is a rubber-like tissue made of collagen and elastin which causes water stick to it. These natural biomaterials can withstand the high pressure at your bone joints.

SELF-RENEWAL: 0
RELATIVE SIZE: 81

DIFFERENTIATION: 71
RELATIVE NUMBER: 0.01

Assemble into groups of two

Play the "STEMinator" card game in Top Trumps style

Six groups, each group contains three steps of differentiation

Take note of the different types of cells and what they specialise in

Notice how the more differentiated a cell is the lower its self-renewing power

cúirdeam

Centre for Research in Medical Devices

References:

1. Bradshaw *et al.*, eLife 2015;4e05506
2. commons.wikimedia.org
3. pixabay.com
4. goo.gl/images/aFpIMG
5. goo.gl/images/CbYRk5
6. try.stem-kine.com/lf-1/

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