Teachers in Residence

Stem Cells

Secondary Level Lesson Plan

curam

SFI Research Centre for Medical Devices

SFI Research Centre for Medical Devices

TEACHERS IN RESIDENCE

"Breaking Barriers"

THE PHILOSOPHY BEHIND OUR LESSON PLANS

Teachers participating in CÚRAM's Teachers in Residence programme have developed a 'learning module' on MedTech in Ireland that links with multiple streams and themes in the primary and junior cycle curricula. The primary and secondary lesson plans were created **by teachers for teachers** and are accessible online to use in classrooms all over the world.

During their residencies, teachers developed the contents of the lesson plans by working directly with CÚRAM researchers, while learning about the medical devices research being carried out at CÚRAM. Primary teachers were paired with secondary teachers to create plans covering five major themes: biomaterials, heart, brain, musculoskeletal system and stem cells. The partnership between the primary and secondary teachers ensured that the materials created follow a natural progression from one age group to the next.

The lesson plans were further designed and formatted by a Visual Artist who used various teaching methodologies to suit the multiple intelligences and range of learning styles and abilities present in classrooms. By using a range of teaching approaches we hope to engage all children at all levels whatever their natural talents or interests may be.

All presentations, lesson plan booklets and optional resources are free to download at: http://www.curamdevices.ie/curam/public-engagement/teachers-in-residence/. We hope that you and your students find these resources an enjoyable way to learn about our research centre and the MedTech industry!

Sincerely,

Dr. Sarah Gundy

Programme Manager-Teachers in Residence

Stem Cells Lesson Plan

Junior Cycle Science Curriculum Links

Strand One: The Nature of Science

Element:

Understanding about Science

Students should be able to:

1. *Appreciate* how scientists work and how scientific ideas are modified over time.

Element:

Investigating in Science

Students should be able to:

3. *Design, plan* and *conduct* investigations; *explain* how reliability, accuracy, precision, fairness, safety, ethics and selection of suitable equipment have been considered.

Element:

Science in Society

Students should be able to:

10. *Appreciate* the role of science in society; and its personal, social and global importance; and how society influences scientific research.

Strand Five: Biological world

Element:

Building Blocks

Students should be able to:

1. *Investigate* the structures of animal and plant cells and relate them to their functions.

Element:

Systems and Interactions

6. *Evaluate* how human health is affected by: inherited factors and environmental factors including nutrition; lifestyle choices.

Element:

Sustainability

Students should be able to:

9. *Discuss* medical, ethical, and societal issues.

Learning Outcomes

Children should be enabled to:

1. Know what a stem cell is.
2. Understand the differences between various types of stem cells.
3. Recognise why stem cell research is important.
4. Understand the use of stem cells and why scientists are so interested in them.
5. Understand the advantages and disadvantages associated with stem cell use, and the current limitations.

Keywords and Definitions

	Keyword	Definition
1.	**Cell**	The smallest part of an animal or plant that is able to function independently. Every animal or plant is made up of trillions of cells.
2.	**Stem Cell**	A type of cell that can copy themselves (self-renew) and make other types of cells (differentiate).
3.	**Self-renewal**	Process of creating more cells of the same cell type through cell division.
4.	**Cell Division**	The splitting of a cell into two new cells with the same genetic material.
5.	**Differentiate**	Process of cells obtaining more specialised features to perform specific functions.
6.	**Regeneration**	Regrowth by an animal or plant of an organ, tissue, or part that has been lost or damaged.
7.	**Gene**	A section of DNA that controls what a cell does.

Learning Activities

Children will:

- Understand that some animals/organisms can regenerate.
- Engage in talk and discussion on stem cells and regeneration.
- Participate in a group activity to learn about different types of cells and how the more differentiated a cell is, the lower its self-renewing power.
- Engage in talk and discussion on the different types of cells involved in various lineages and what they specialise in.
- Evaluate their work by filling in the Exit Ticket.

Extra Info / Files

	Web Address	Brief Description
1.	www.youtube.com/watch?v=evH0I7Coc54	Video on stem cells
2.	www.eurostemcell.org	Stem cell resources
3.	www.yourgenome.org/facts/what-is-a-stem-cell	Website with helpful background information for teachers

Resources Provided

- Teacher Lesson Plan
- PowerPoint to guide lesson
- STEMinator cards for photocopying
- Exit Ticket

Materials Needed

- One deck of STEMinator cards per group of students. **Note:** Please ensure that you print out the cards on double sided paper and that there is a front and back to each card.

STEMinator Card Game Instructions

"Guess Who" Style Rules:

- Students get into pairs and one set of cards is given to each pair.
- The cards are laid out facing up in front of each pair of students.
- One pair chooses a stem cell card without showing it to anyone else.
- The pair read out loud to the class the description on their chosen stem cell card.
- The class tries to guess what stem cell the pair has chosen by looking at the cards laid out in front of them, and by listening to the description read out loud.
- The pair that guesses the correct stem cell first gets to choose the next card to read out loud to the class.

"Top Trumps" Style Rules:

- Students get into pairs and one deck of cards is given to each pair.
- The dealer shuffles and deals an equal number of cards to each person face down.

- The player who did not deal starts by reading out the value from a category from the top card (Self-renewal, Differentiation, Relative Size, or Relative Number)
- The player with the highest value wins and collects the cards, including his/her own, and places them on the bottom of his/her pile.
- The winner of the hand gets to go first and chooses a category from the next card.
- If two cards share the highest value, then both of the cards are placed in the middle and the same player chooses again from the next card. The winner of the hand takes the cards in the middle as well.
- The person with all of the cards at the end is the winner.

Categories:

Self-renewal = The ability of the cell to proliferate or self-renew.

Relative Size = The size of the cell compared to other cells in the body.

Differentiation = How specialised or differentiated the cell is (or the degree of specialisation).

Relative Number = The number of cells in the body compared to other cell types.

Cells on the Cards:

Lineage Group	Cell Name	Characteristics
Cartilage	**Transitory Chondrocyte**	This type of cell gives rise to more a mature chondrocyte, called an articular chondrocyte.
Cartilage	**Articular Chondrocyte**	Cells that maintain and produce the components that make up cartilage.
Cartilage	**Cartilage**	A rubber-like tissue made of collagen and elastin that covers and protects the ends of bones at joints.
Tendon	**Mesenchymal Stem Cell**	A type of stem cell that is able to differentiate into a wide variety of cell types.
Tendon	**Tenoblast**	A spindle-shaped, immature tendon cell that gives rise to a tenocyte.
Tendon	**Tenocyte**	A mature tendon cell that attaches to collagen fibres in a tendon.
Blood Cell	**Hematopoietic Stem Cell**	A stem cell located in bone marrow that gives rise to blood cells.
Blood Cell	**Megakarocyte**	A large cell found in the bone marrow that produces thrombocytes.
Blood Cell	**Thrombocyte (Platelet)**	A cell found in the blood involved in clotting to stop bleeding.

Skin	**Epidermal Stem Cell**	A cell that is responsible for everyday regeneration of the different layers of the epidermis in the skin.
Skin	**Keratinocyte (Young)**	This cell type is located in the inner layer of the skin's epidermis.
Skin	**Keratinocyte (Old)**	This type of cell forms a protective barrier in the outer layer of the skin's epidermis.
Muscle	**Myoblast**	These cells combine and develop into myoblast tubes to form muscles.
Muscle	**Myoblast (Tube)**	These cells are formed when myoblasts stick together and form a tube structure.
Muscle	**Muscle**	This tissue responsible for movement throughout the body from walking to pumping blood.
Myelin Sheath	**Neural Stem Cell**	A type of cell located in the brain that can generate both neurons and glial cells.
Myelin Sheath	**Glial Progenitor Cell**	This cell type gives rise to oligodendrocytes.
Myelin Sheath	**Oligodendrocyte**	A type of cell that insulates neurons which allows the nervous system to react quicker.

Neuron	**Neuronal Stem Cell**	A cell that makes only neurons in the developing brain.
Neuron	**Neurocyte**	A cell that can develop into neurons in the brain.
Neuron	**Neuron**	A cell that receives and transmits information in the brain.
Bone	**Transitory Osteoblast**	This cell moves into developing and growing bones.
Bone	**Osteoblast**	This cell produces proteins and minerals to form bone.
Bone	**Osteocyte**	An osteoblast that has become trapped in a mature bone.

Teachers' Tips

- The cards are easier to work with if printed out on thicker paper.
- Sometimes the students end up creating their own games using the cards. "Snap" style is a popular version!

Methodologies

- Talk and discussion
- Active learning
- Guided and discovery learning
- Collaborative learning
- Investigative approach

Assessment

- Self-assessment – Exit Ticket
- Teacher observation – discussion while playing STEMinator card game
- Teacher questioning –talk and discussion

Linkage and Integration

- **Maths** – problem solving
- **STEM** – I.T. / Engineering
- **Art** – construction
- **S.P.H.E** – working together co-operatively
- **English** – oral language through talk and discussion and presenting their work

Differentiation By:

- Teaching style
- Support
- Task

PowerPoint Presentation – Stem Cells

Slide 1

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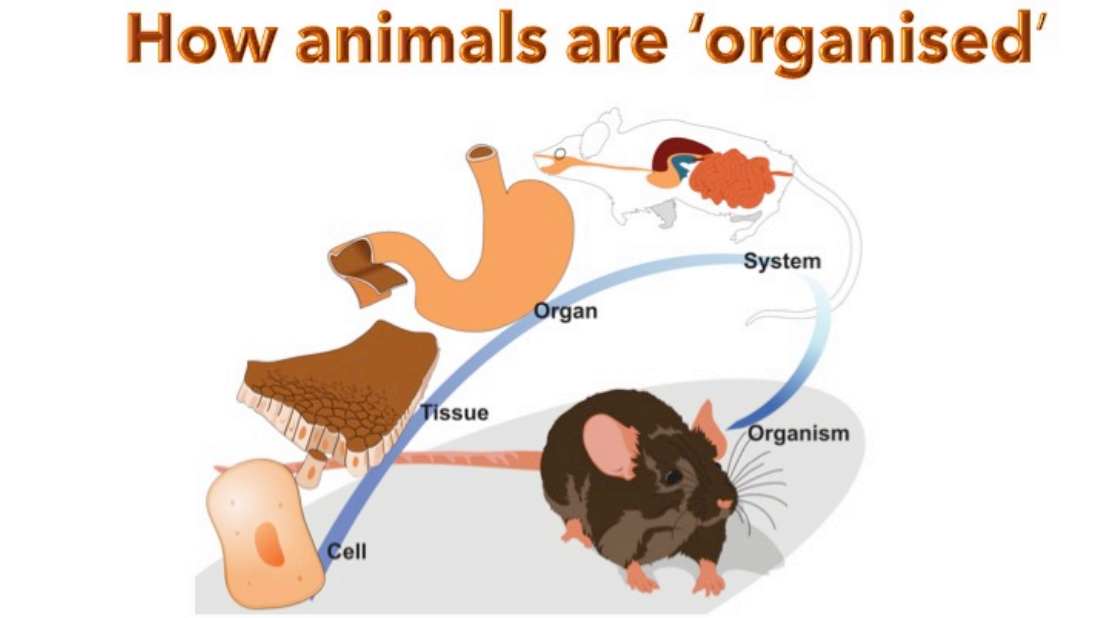
SFI Research Centre for Medical Devices

Teachers in Residence Programme
Colm Caomhánach and Róisín Ní Bhraiain

Slide 2



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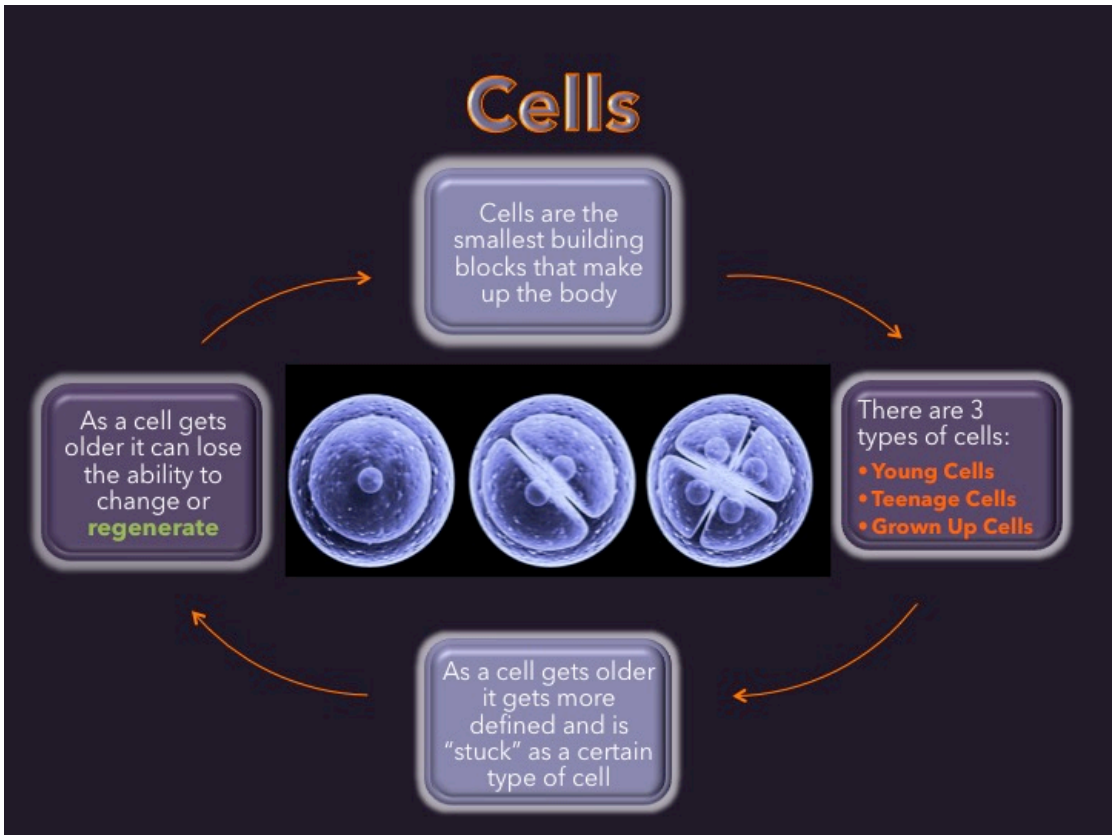

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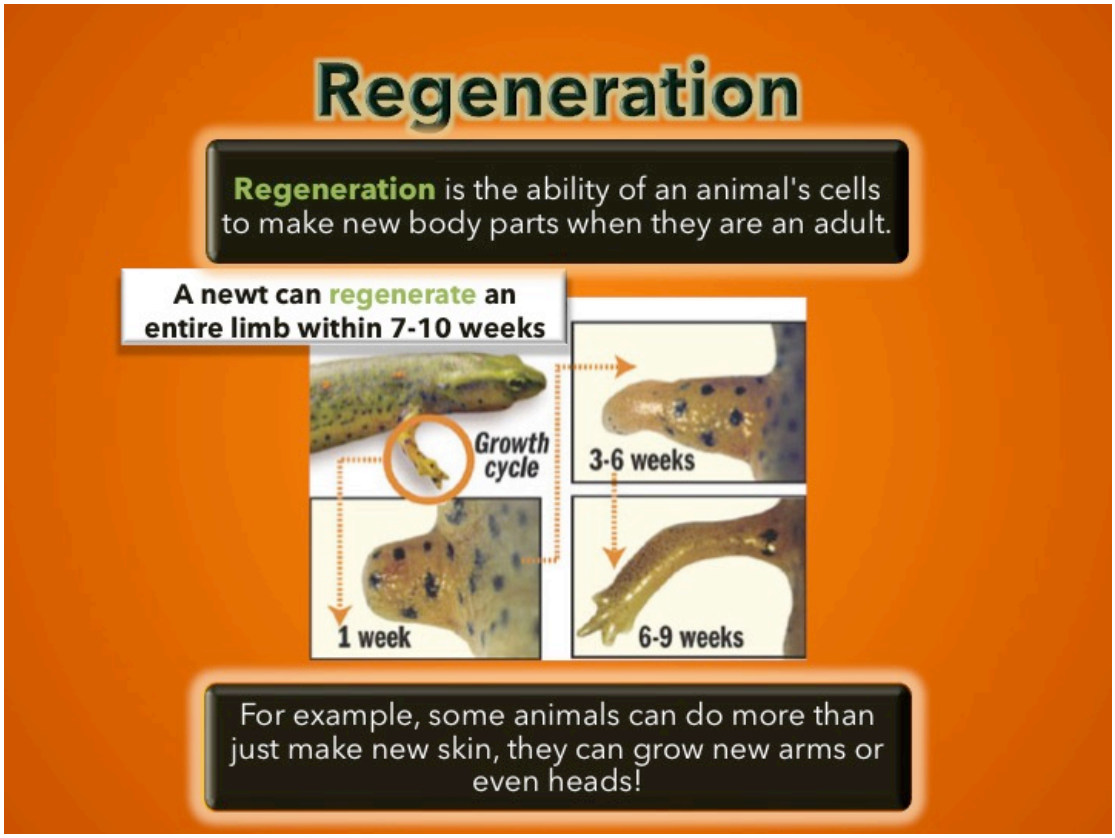

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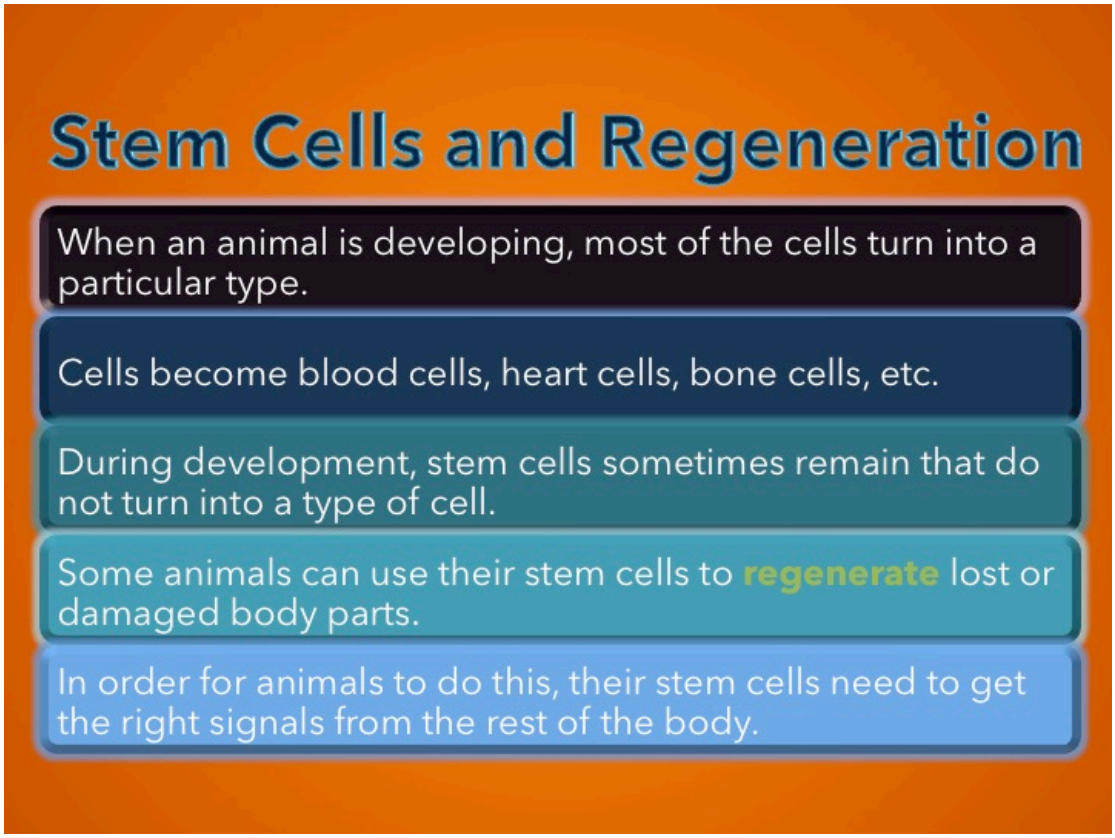

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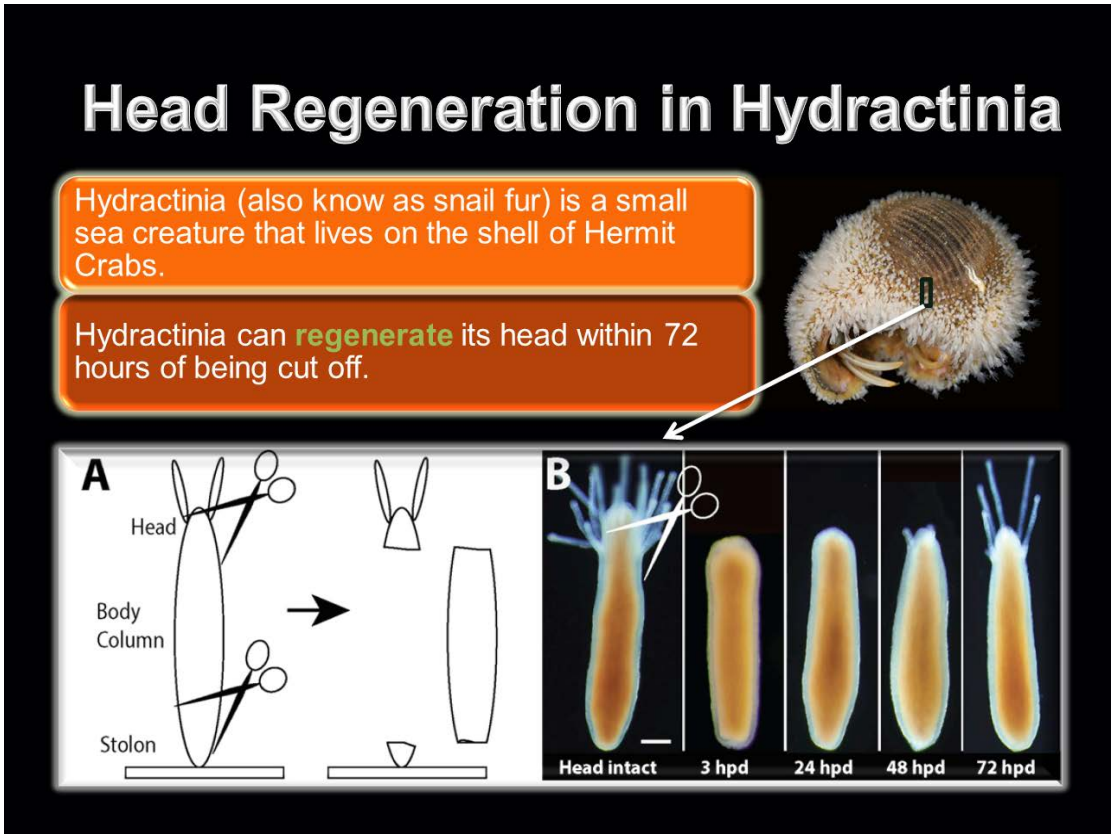

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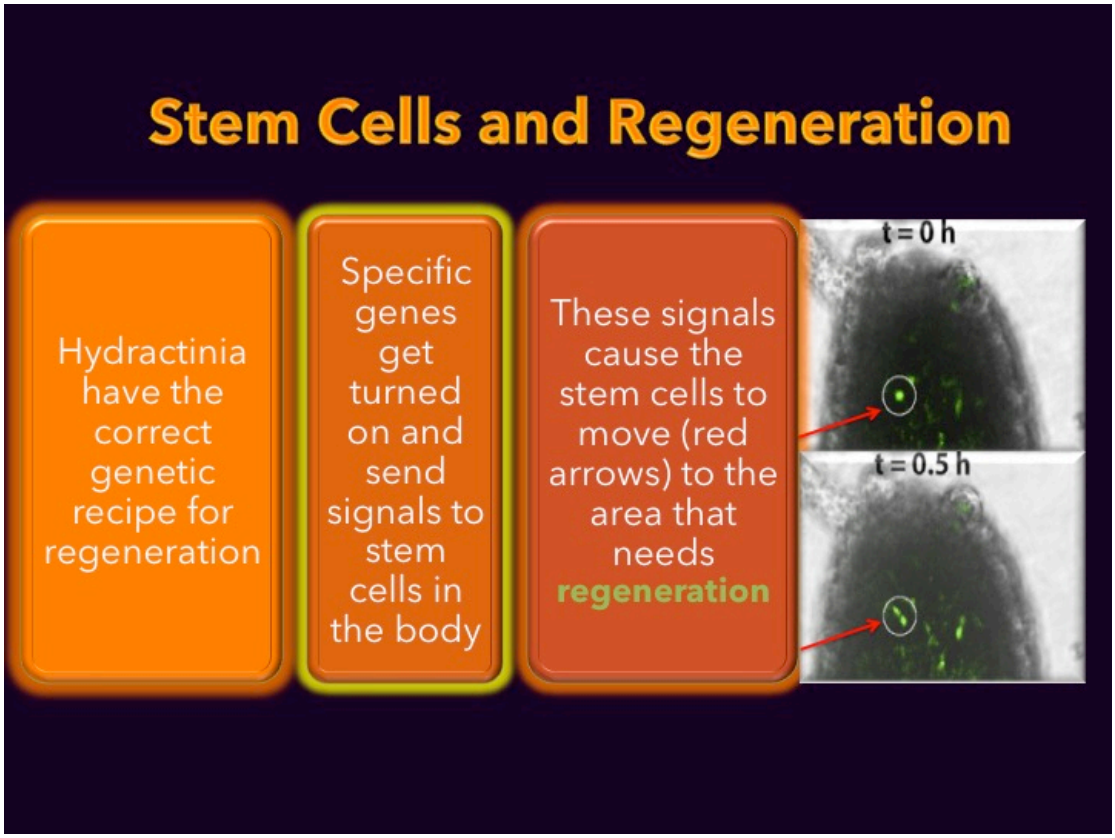

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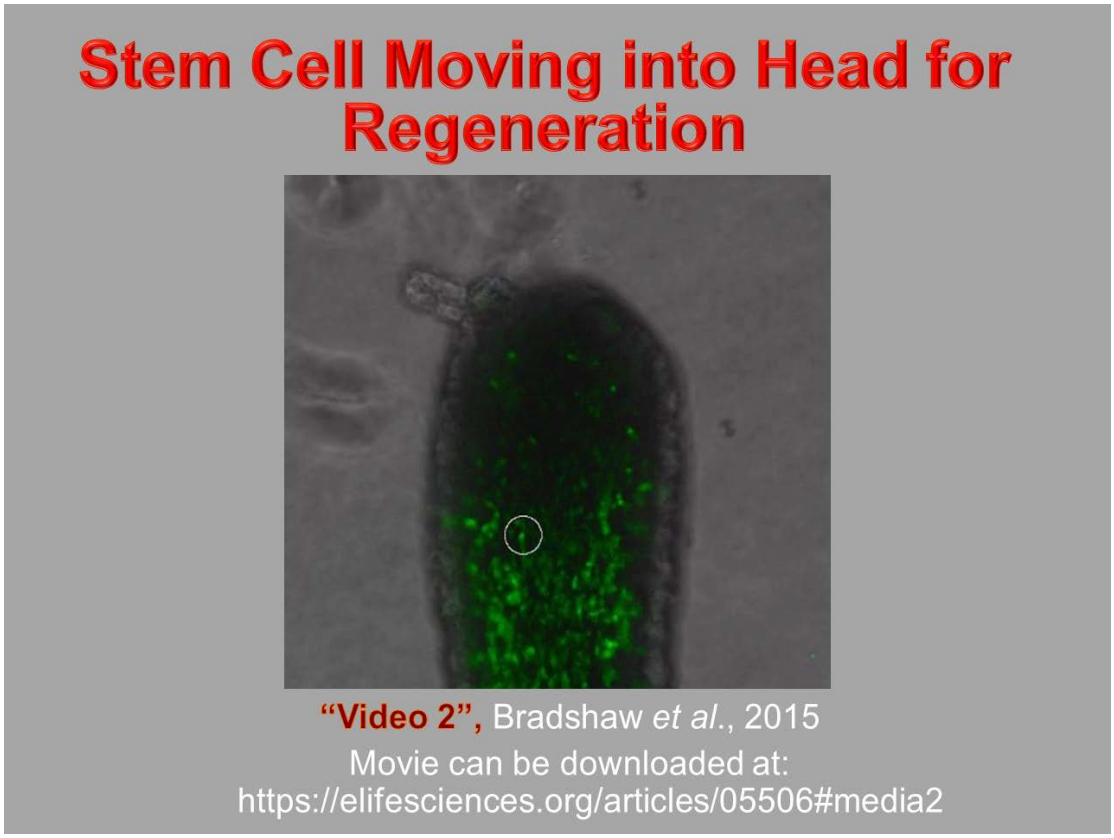

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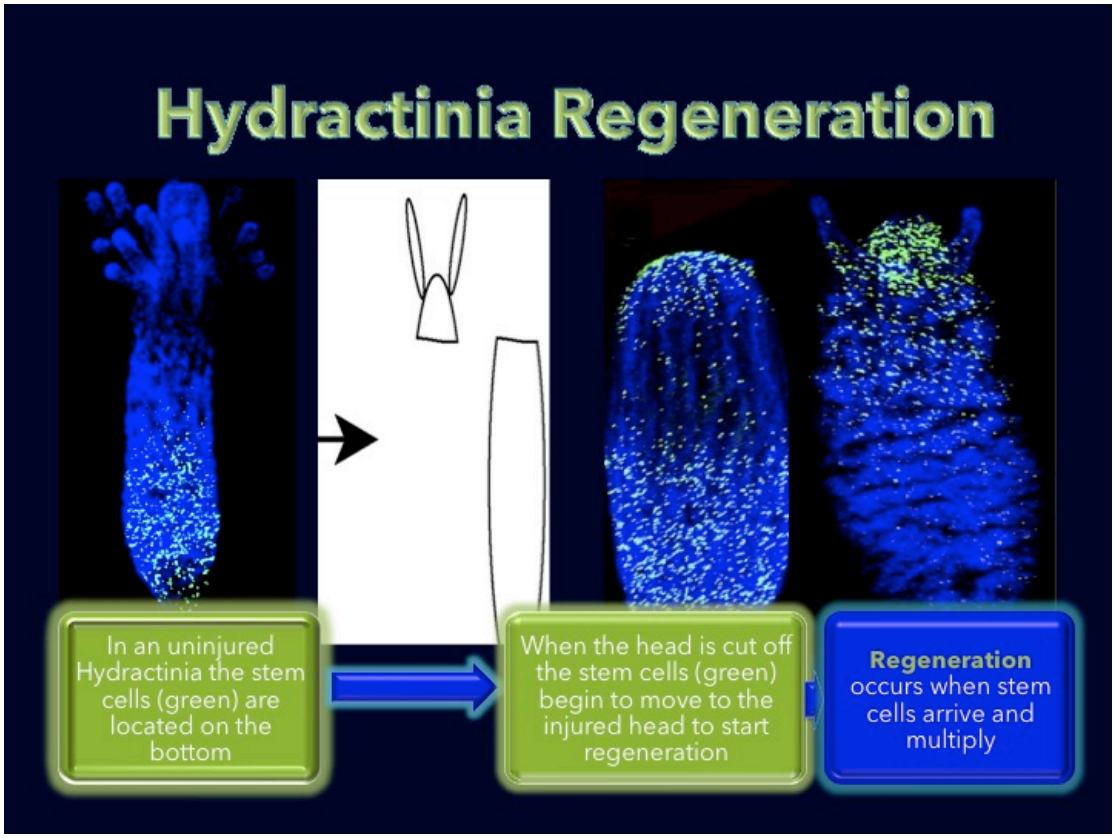

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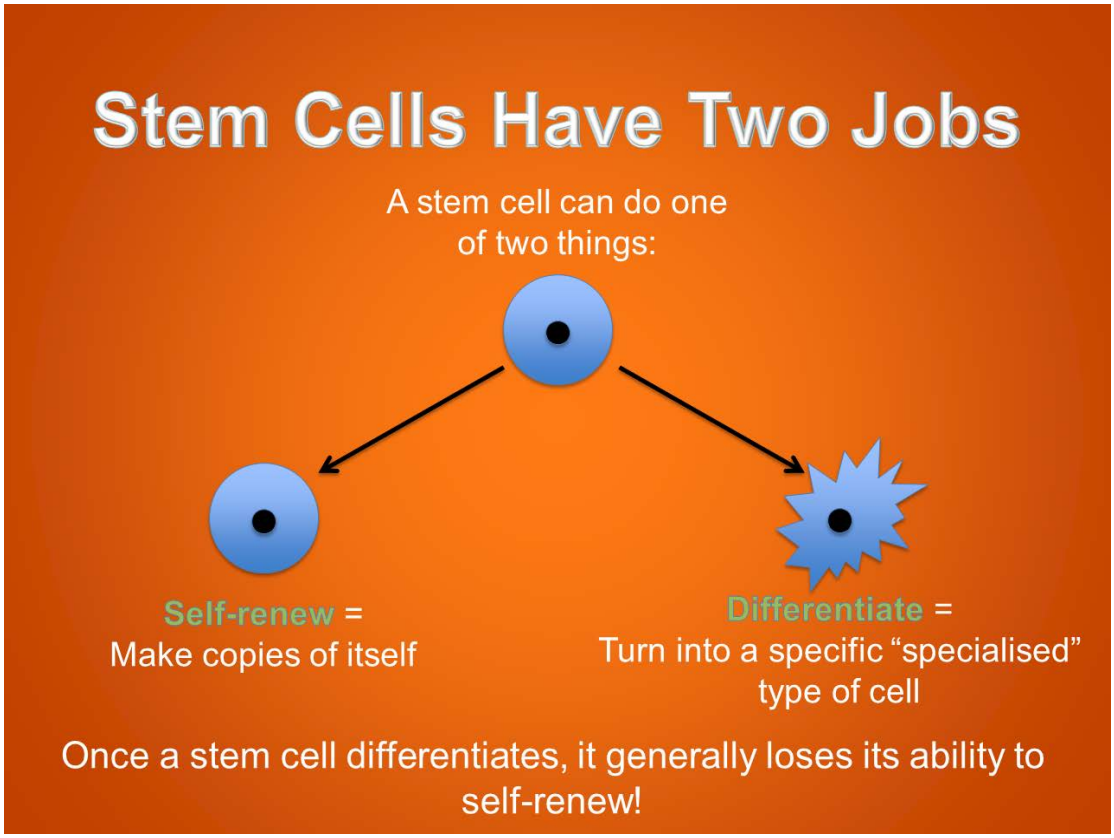

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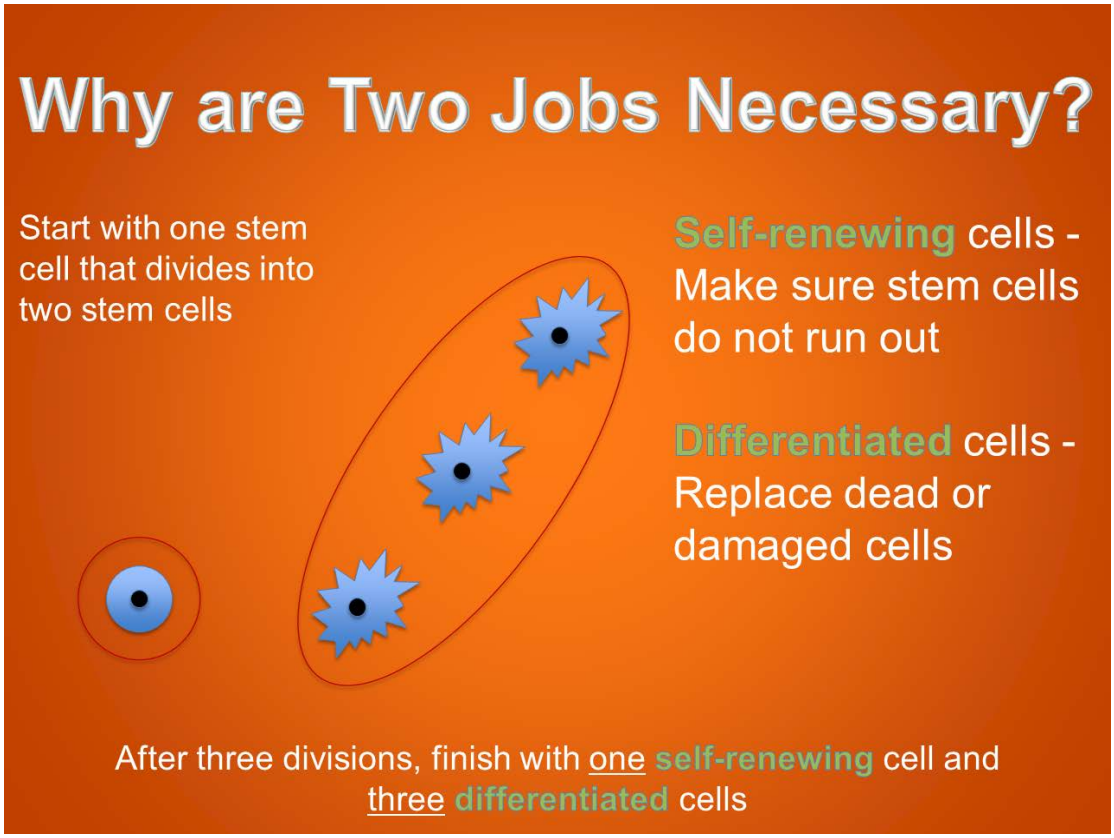

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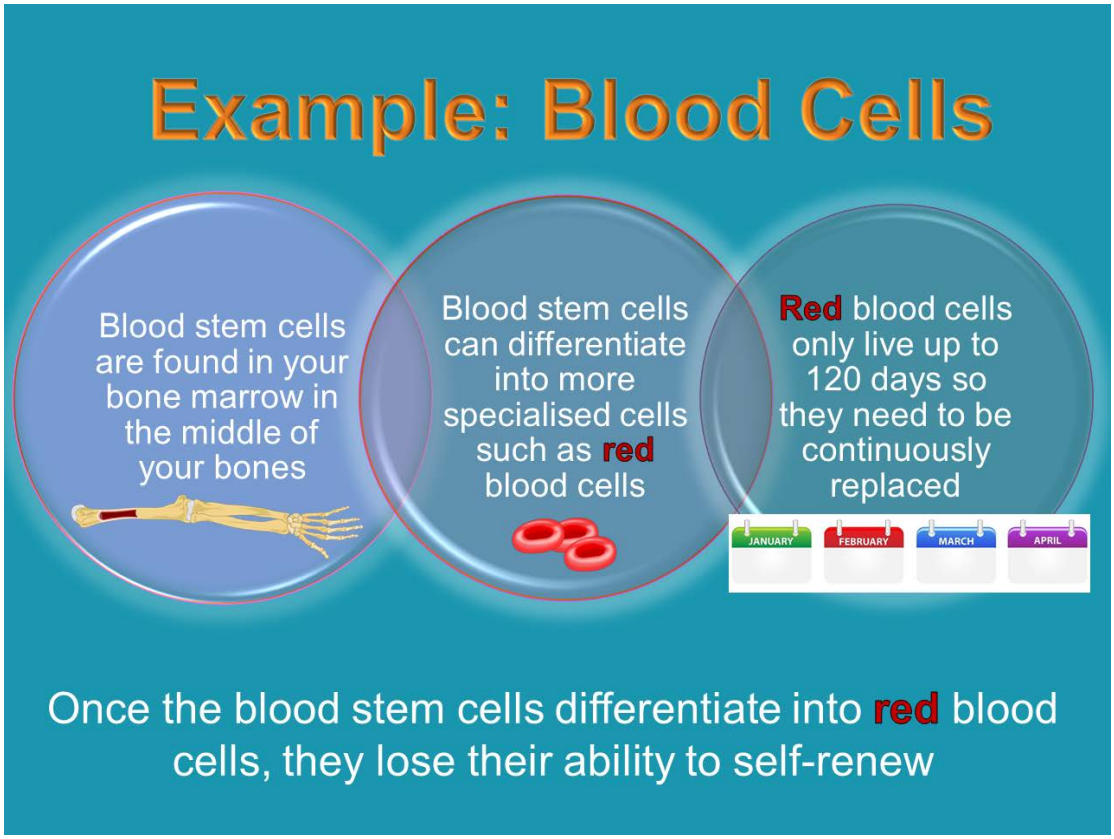
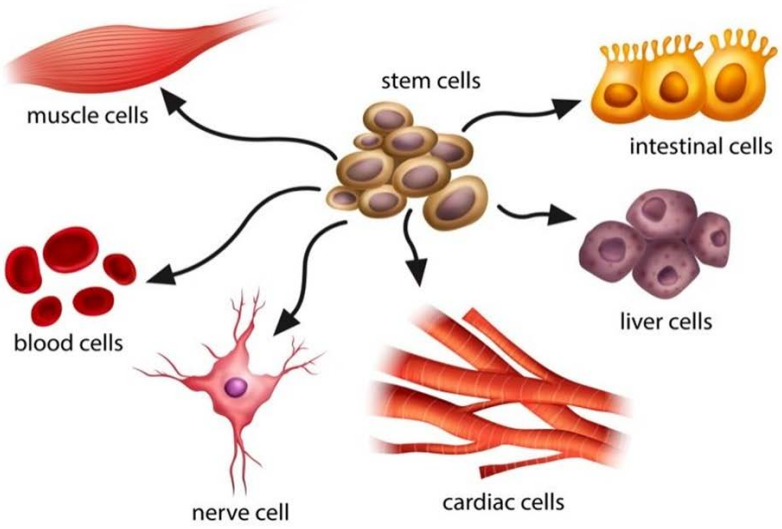


Slide 14

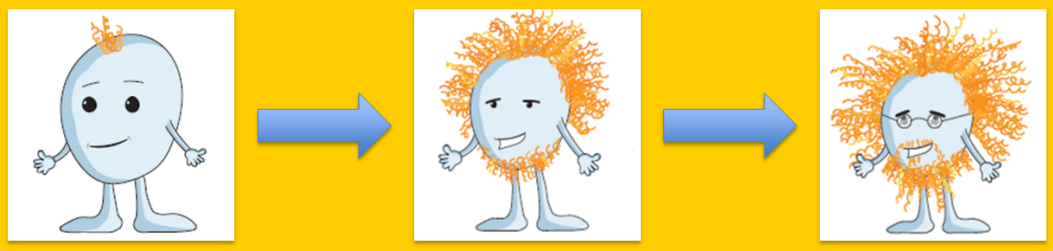
Stem cells are found all over the body and can turn into various differentiated cells



Slide 15

Cartilage Lineage

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



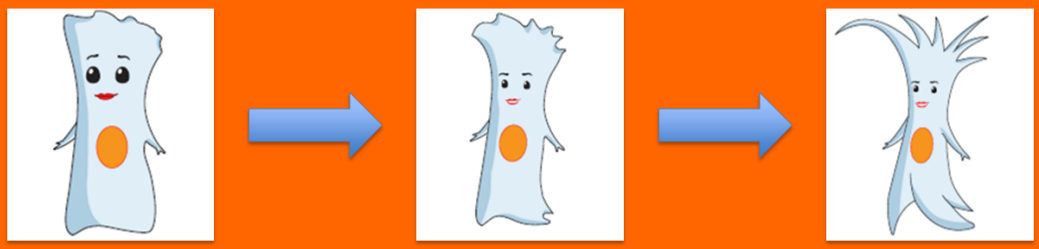
Transitory Chondrocyte → **Articular Chondrocyte** → **Cartilage**

↑ Self-renewal	↓ Self-renewal
↓ Differentiation	↑ Differentiation

Slide 16

Tendon Lineage

Tendon = A band of tissue that connects muscle to bone



Mesenchymal Stem Cell → Tenoblast → Tenocyte

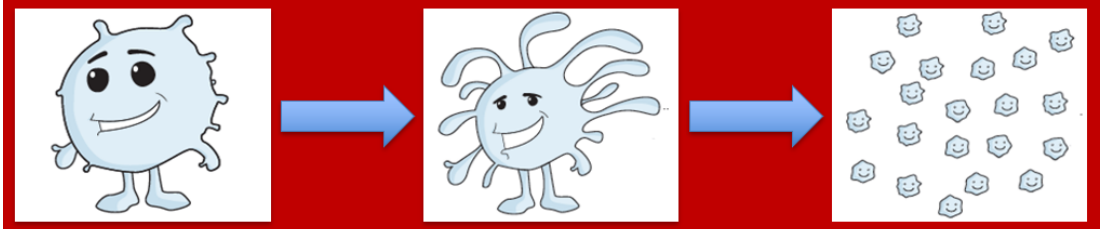
↑ Self-renewal
↓ Differentiation

↓ Self-renewal
↑ Differentiation

Slide 17

Blood Cell Lineage

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



Hematopoietic Stem Cell → Megakarocyte → Thrombocyte

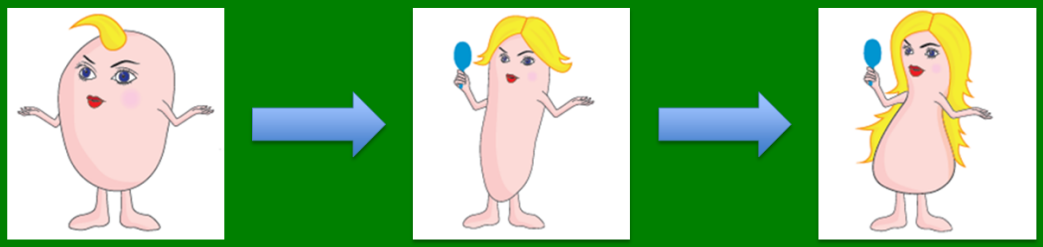
↑ Self-renewal
↓ Differentiation

↓ Self-renewal
↑ Differentiation

Slide 18

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

Slide 19

Muscle Lineage

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

Myoblast

Myoblast (Tube)

Muscle

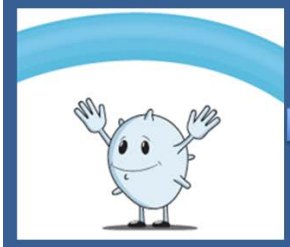
↑ Self-renewal
↓ Differentiation

↓ Self-renewal
↑ Differentiation

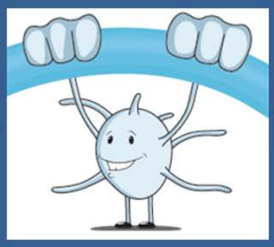
Slide 20

Myelin Sheath Lineage

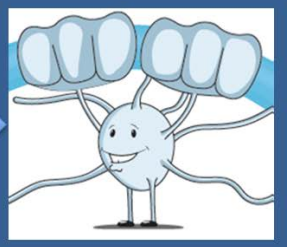
Myelin Sheath = An insulating layer surrounding the axon of neurons allowing signals to be transmitted quickly from the brain to the body



Neural Stem Cell



Glial Progenitor Cell



Oligodendrocyte

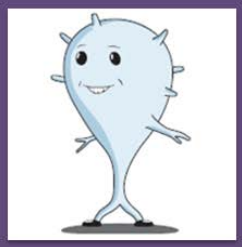
↑ Self-renewal
↓ Differentiation

↓ Self-renewal
↑ Differentiation

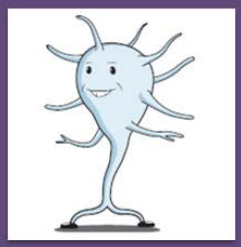
Slide 21

Neuron Lineage

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



Neuronal Stem Cell



Neurocyte

Neuron

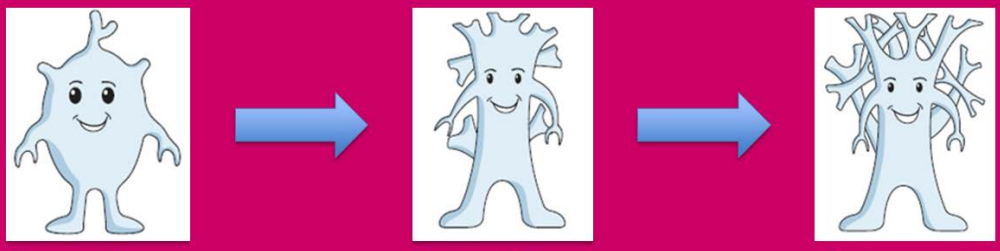
↑ Self-renewal
↓ Differentiation

↓ Self-renewal
↑ Differentiation

Slide 22

Bone Lineage

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



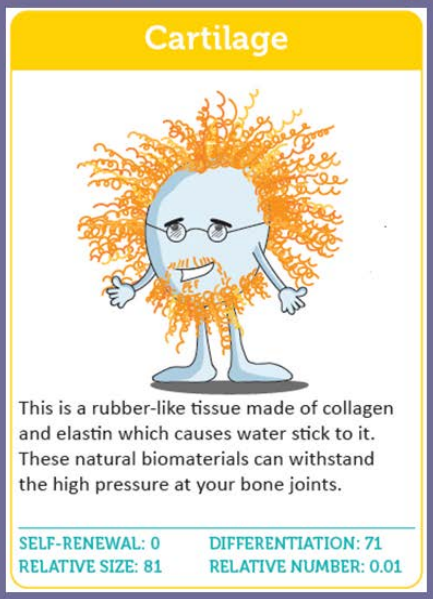
Transitory Osteoblast → **Osteoblast** → **Osteocyte**

↑ **Self-renewal**
↓ **Differentiation**

↓ **Self-renewal**
↑ **Differentiation**

Slide 23

Activity 1: "Guess Who" Style



1. Get into pairs
2. Layout all of the cards out face up
3. One pair chooses a card without showing it to anyone
4. The pair read out the description on their chosen card
5. The class tries to guess what stem cell the pair have chosen

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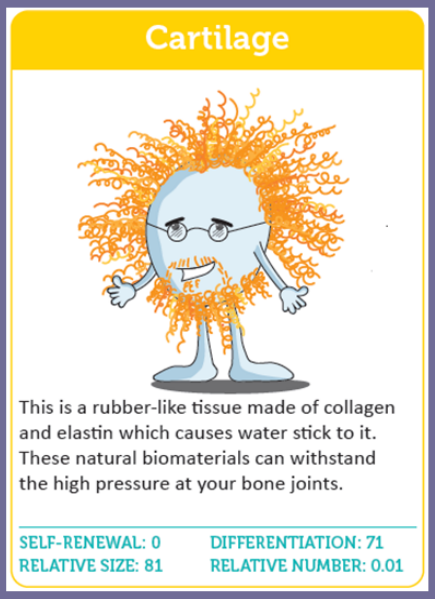
Activity 2: "Top Trumps" Style



- Get into pairs
- Shuffle then deal half the cards to each player face down
- A player reads out the value from a category from the top card
- The player with the highest value wins and gets all of the cards, and places them on the bottom of his/her pile
- The person with all of the cards at the end is the winner

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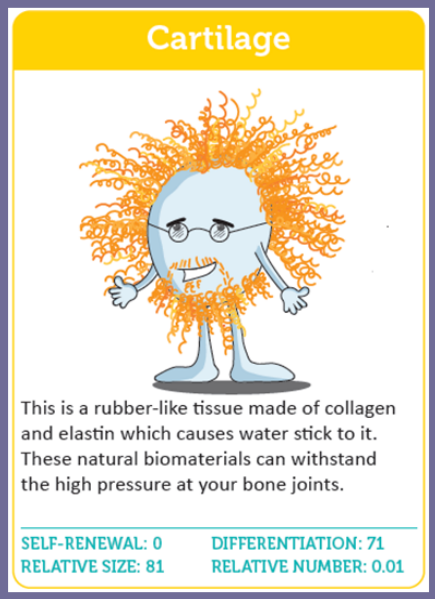
Activity 2: "Top Trumps" Style



- There are 6 groups of cards
- Each group contains 3 steps of differentiation
- Take note of the different types of cells and what they specialise in
- Notice how the **higher** differentiated a cell is, the **lower** its self-renewing power
- Notice how the **lower** differentiated a cell is, the **higher** its self-renewing power

Slide 26

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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Thanks also to all the participating teachers who very kindly shared ideas and resources.

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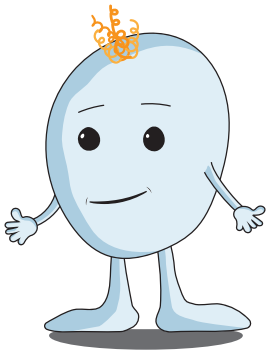
Slide 28

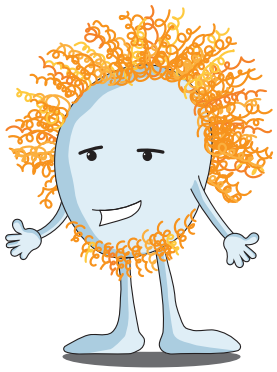
Transitory Chondrocyte



These cells have the ability to transform into chondrocytes.

SELF-RENEWAL: 93
DIFFERENTIATION: 18
RELATIVE SIZE: 29
RELATIVE NUMBER: 0.004

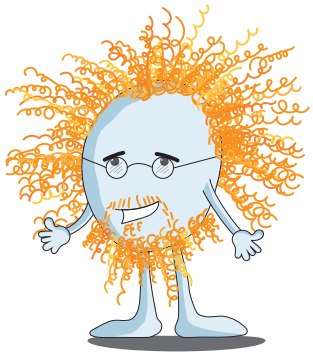
Articular Chondrocyte



Water sticks to these cells a lot which makes the tissue slippery. These cells cannot move anymore and do not repair tissues very well.

SELF-RENEWAL: 67
DIFFERENTIATION: 23
RELATIVE SIZE: 81
RELATIVE NUMBER: 0.008

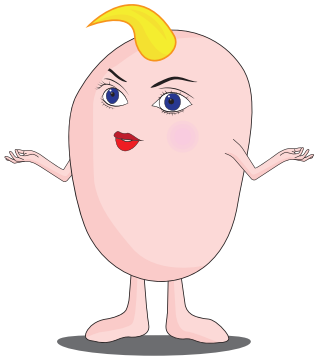
Cartilage



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

SELF-RENEWAL: 0
DIFFERENTIATION: 71
RELATIVE SIZE: 81
RELATIVE NUMBER: 0.01

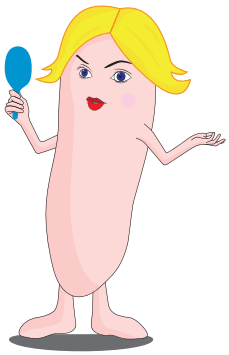
Epidermal Stem Cell



These cells can create the tissue where all the other skin cells are living and can heal the damage in your skin.

SELF-RENEWAL: 100
DIFFERENTIATION: 10
RELATIVE SIZE: 37
RELATIVE NUMBER: 6.2

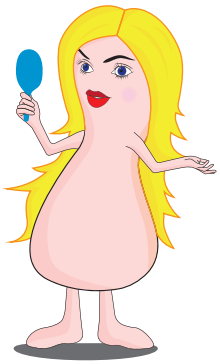
Keratinocyte (Young)



These cells play a fundamental role in making new skin. Did you know that your entire skin is replaced every 4 weeks?

SELF-RENEWAL: 79
DIFFERENTIATION: 36
RELATIVE SIZE: 32
RELATIVE NUMBER: 7

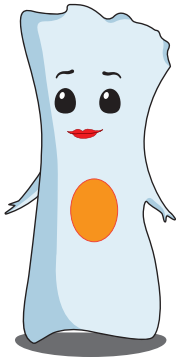
Keratinocyte (Old)



When these cells are old, they make up the outer layers of our skin. Skin protects us from the environment and harmful things.

SELF-RENEWAL: 0
DIFFERENTIATION: 44
RELATIVE SIZE: 29
RELATIVE NUMBER: 55

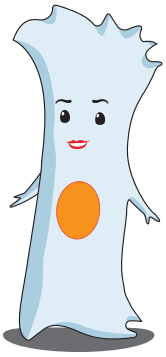
Mesenchymal Stem Cell



These cells can differentiate into a variety of cell types including bone, cartilage and muscle cells. Scientists are differentiating these cells into tenocytes to repair tendons.

SELF-RENEWAL: 96
DIFFERENTIATION: 43
RELATIVE SIZE: 34
RELATIVE NUMBER: 40

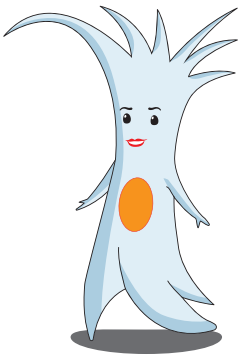
Tenoblast



These cells occur in clusters and are involved in the synthesis of collagen.

SELF-RENEWAL: 70
DIFFERENTIATION: 63
RELATIVE SIZE: 65
RELATIVE NUMBER: 0.003

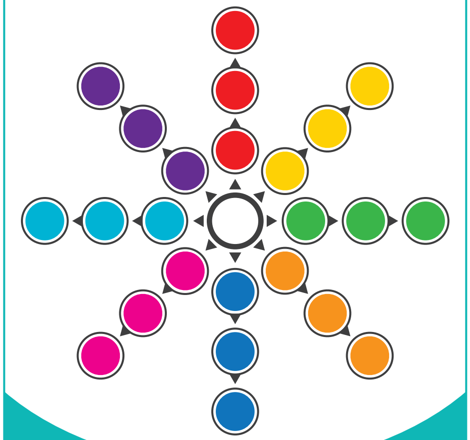
Tenocyte (Tendon)



These cells are found throughout a tendon usually attached to collagen fibres. Because of their poor growth ability, healing tendons remains a great challenge!

SELF-RENEWAL: 0
DIFFERENTIATION: 88
RELATIVE SIZE: 72
RELATIVE NUMBER: 0.009

STEMinator



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STEMinator

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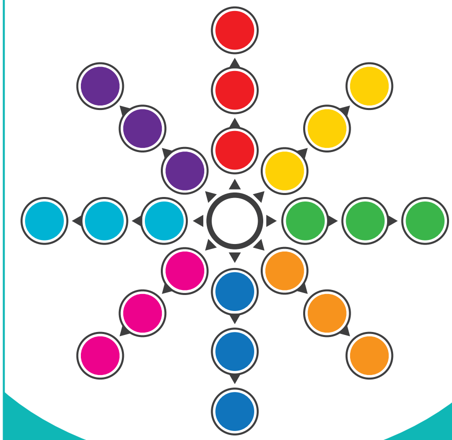
STEMinator



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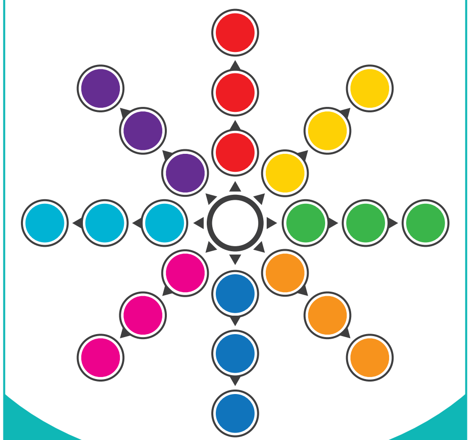

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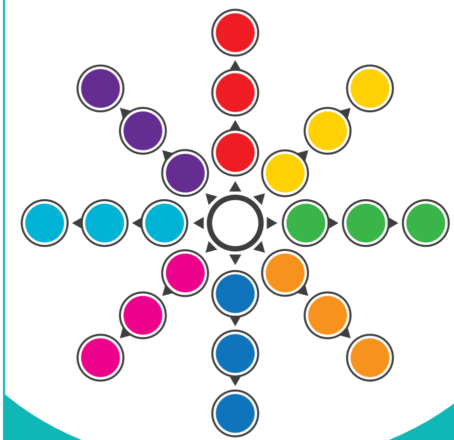

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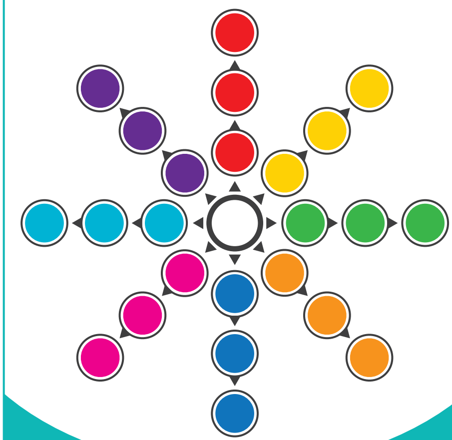

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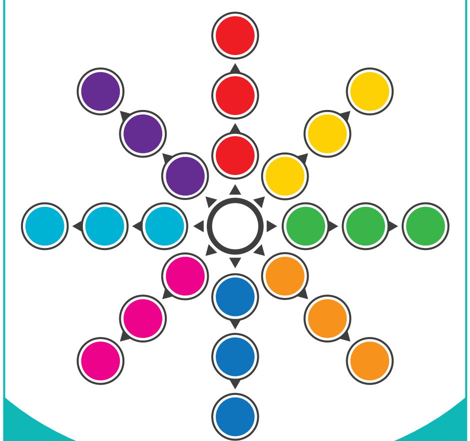

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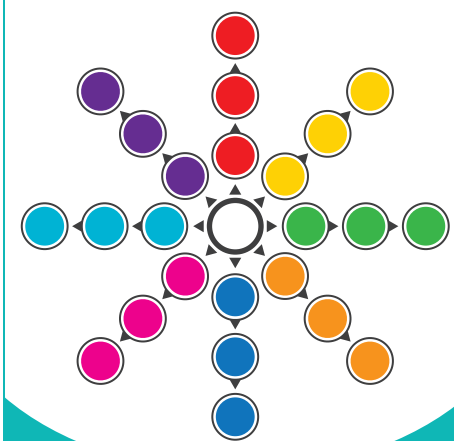

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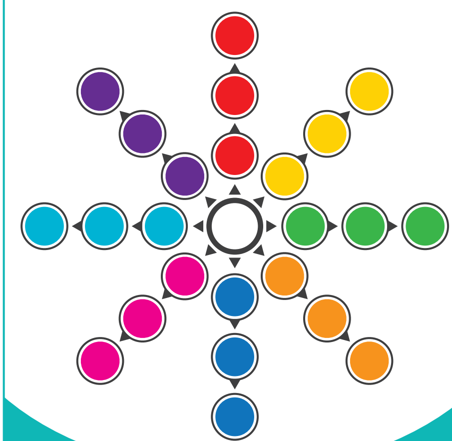

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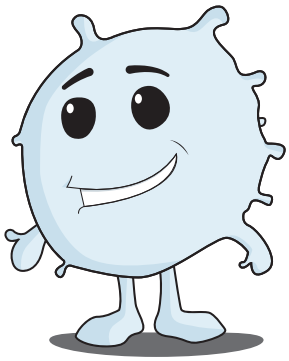
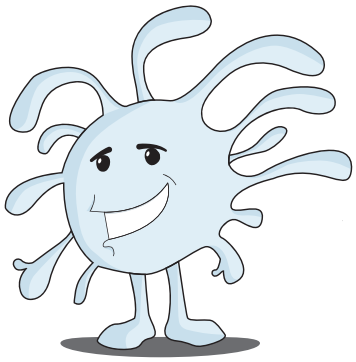
Hematopoietic Stem Cell



These cells give rise to all the other types of blood cells. They are all born in the bone marrow.

SELF-RENEWAL: 98
DIFFERENTIATION: 13
RELATIVE SIZE: 27
RELATIVE NUMBER: 0.02

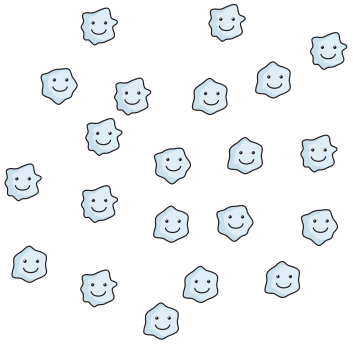
Megakarocyte



These cells are 10 times bigger than red blood cells. They have a mega sized nucleus. That is how they got their name!

SELF-RENEWAL: 75
DIFFERENTIATION: 39
RELATIVE SIZE: 82
RELATIVE NUMBER: 0.1

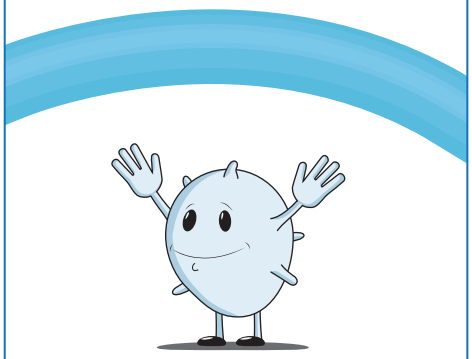
Thrombocyte (Platelet)



These cells emerge when a mature megakaryocyte explodes. Each explosion makes 2000 – 5000 of this type of cell. They are a special task force to stop bleeding.

SELF-RENEWAL: 0
DIFFERENTIATION: 64
RELATIVE SIZE: 1
RELATIVE NUMBER: 39

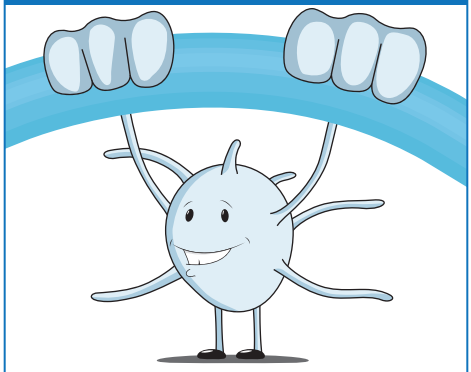
Neural Stem Cell



These cells make different cell types in the young brain such as glia cells. They are located only in specific areas within the brain.

SELF-RENEWAL: 80
DIFFERENTIATION: 14
RELATIVE SIZE: 25
RELATIVE NUMBER: 0.005

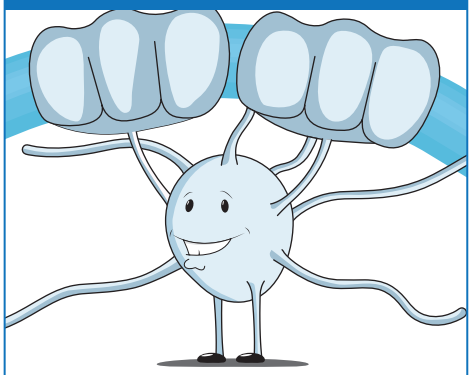
Glial Progenitor Cell



These cells are evenly distributed thoughout all areas in the brain. They have a lot of branches that start reaching out towards the neurons.

SELF-RENEWAL: 48
DIFFERENTIATION: 25
RELATIVE SIZE: 80
RELATIVE NUMBER: 0.81

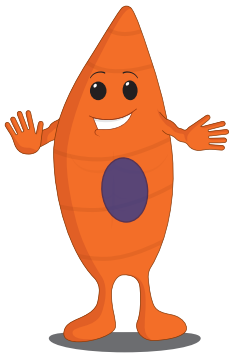
Oligodendrocyte



These cells provide support and insulation for all neurons. They wrap their flattened branches like huge hands around every neuron.

SELF-RENEWAL: 0
DIFFERENTIATION: 92
RELATIVE SIZE: 89
RELATIVE NUMBER: 81

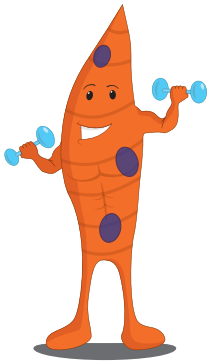
Myoblast



These cells can develop into skeletal, heart or intestine muscle depending on the signals sent by their environment.

SELF-RENEWAL: 90
DIFFERENTIATION: 17
RELATIVE SIZE: 24
RELATIVE NUMBER: 1.9

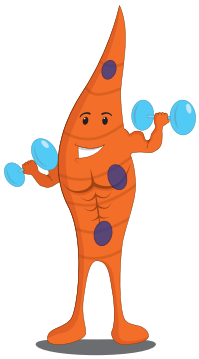
Myoblast (Tube)



When these cells start to stick together they form a tube, and this helps to repair damaged muscles.

SELF-RENEWAL: 62
DIFFERENTIATION: 19
RELATIVE SIZE: 64
RELATIVE NUMBER: 2.4

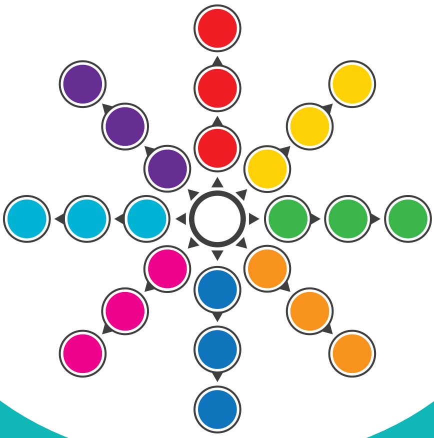
Muscle



These cells are responsible for the movement of our bodies. They make it possible for us to walk and our hearts to pump blood.

SELF-RENEWAL: 0
DIFFERENTIATION: 88
RELATIVE SIZE: 100
RELATIVE NUMBER: 2.7

STEMinator



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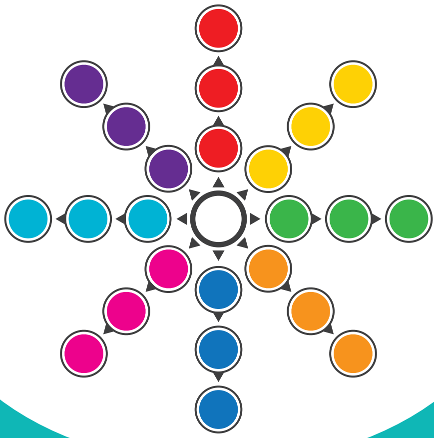

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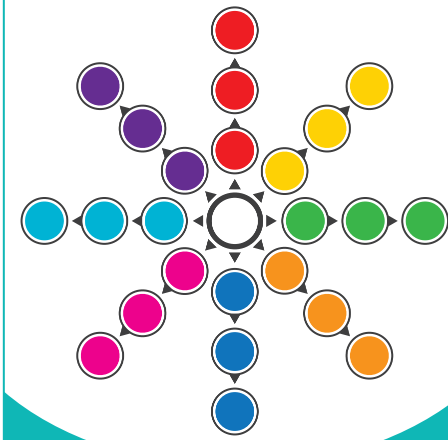

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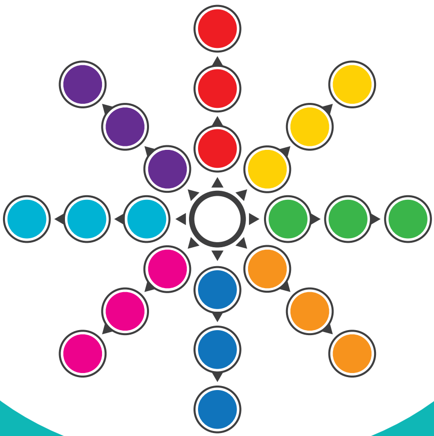

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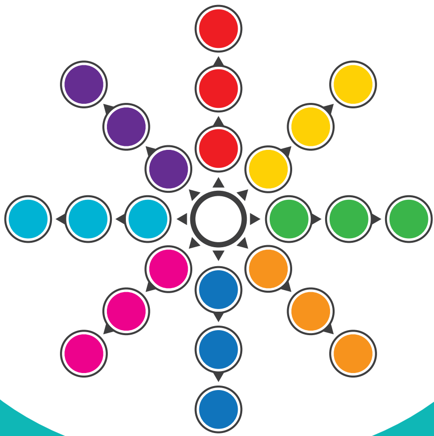

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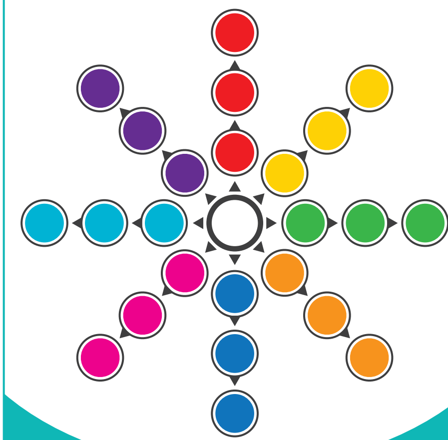

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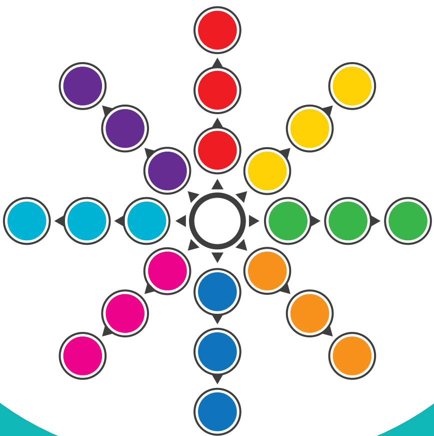

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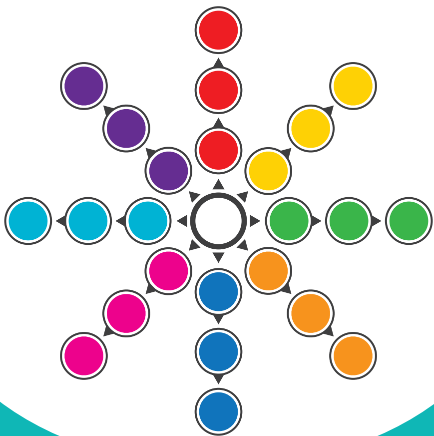

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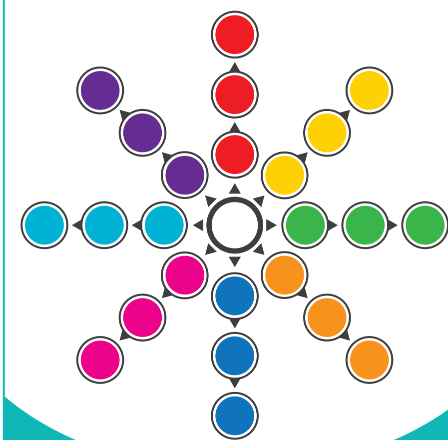
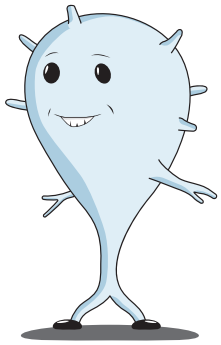


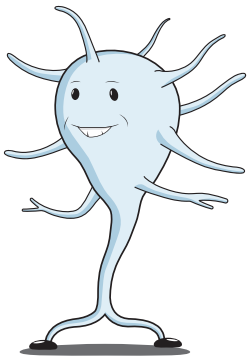
Neuronal Stem Cell



These cells can make all neuronal cell types in the developing brain. We can find them in specific areas throughout the whole young brain.

SELF-RENEWAL: 78 DIFFERENTIATION: 12
RELATIVE SIZE: 31 RELATIVE NUMBER: 0.04

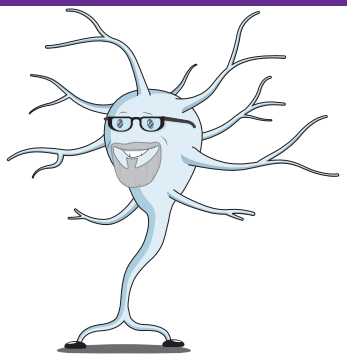
Neurocyte



These cells can develop into neurons (nerves) in all parts of the brain.

SELF-RENEWAL: 50 DIFFERENTIATION: 21
RELATIVE SIZE: 33 RELATIVE NUMBER: 0.3

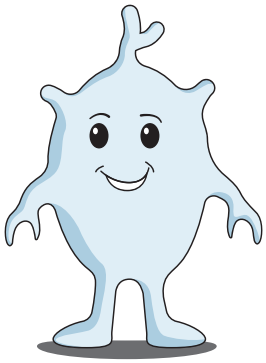
Neuron



These cells transmit the information from our eyes, nose and hands to the brain and allow us to understand what we see, smell or touch. They also transmit the information to your muscles to let you move!

SELF-RENEWAL: 0 DIFFERENTIATION: 100
RELATIVE SIZE: 92 RELATIVE NUMBER: 3.2

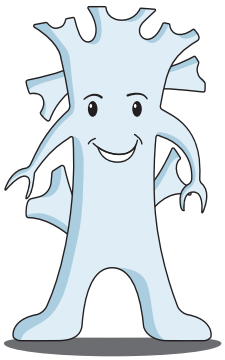
Transitory Osteoblast



These cells move into the growing, developing, or fractured/broken bones.

SELF-RENEWAL: 87 DIFFERENTIATION: 35
RELATIVE SIZE: 26 RELATIVE NUMBER: 0.03

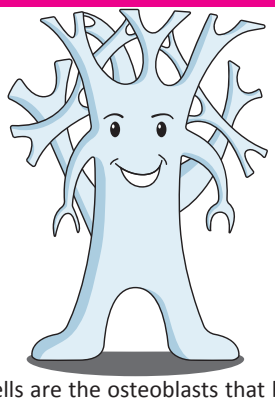
Osteoblast



These cells are the major cellular component of bone. They produce and secrete proteins and minerals into the matrix that surrounds them, forming bone tissue.

SELF-RENEWAL: 58 DIFFERENTIATION: 58
RELATIVE SIZE: 75 RELATIVE NUMBER: 0.05

Osteocyte



These cells are the osteoblasts that become trapped in the bone that they make. They can live as long as you, and do not have any self-renewing ability.

SELF-RENEWAL: 0 DIFFERENTIATION: 98
RELATIVE SIZE: 80 RELATIVE NUMBER: 0.06

STEMinator

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3-2-1 Exit Ticket *Name*_____

3 Things I Learned From This Lesson:

1._____

2._____

3.

2 Questions I Still Have:

1._____

2._____

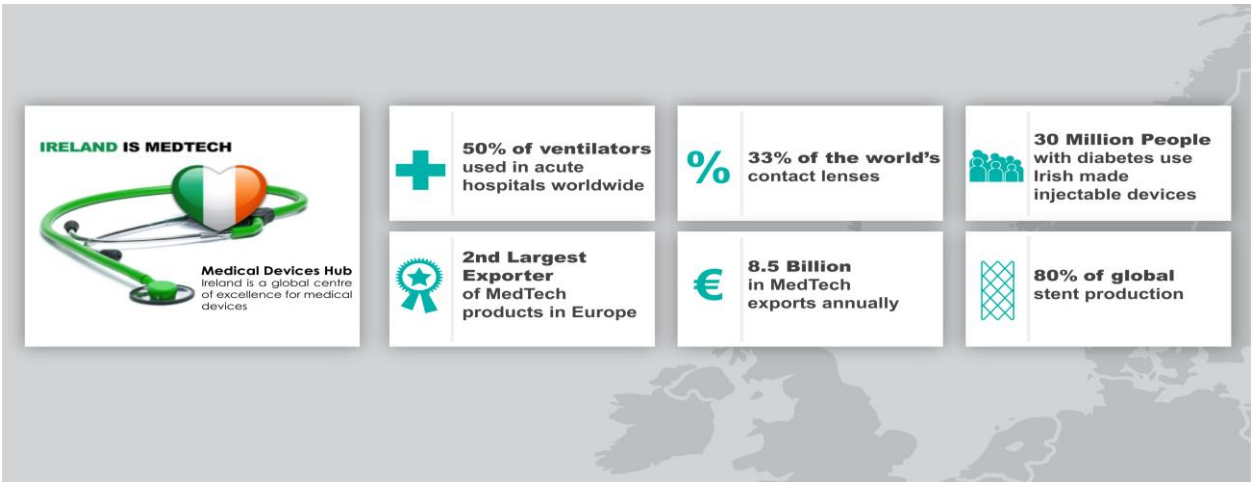
1 Idea That Stuck With You:

1._____

FACTS ABOUT MEDTECH IN IRELAND

- Ireland is the second largest exporter of MedTech products in Europe.
- Ireland's MedTech sector employs 29,000 people across 450 companies.
- Ireland has the highest number of people working in the MedTech industry than in any other European country, per head of population.
- 18 of the world's top 25 MedTech companies have a base in Ireland.
- Galway employs one third of the country's MedTech employees.

The Centre for Cell Manufacturing Ireland (CCMI) is the first ever facility in Ireland to be granted a licence from the Irish Medicines Board to manufacture culture-expanded stem cells for human use. The CCMI is a custom built facility based in the Regenerative Medicine Institute (REMEDI) at the National University of Ireland Galway that supplies stem cells for use in clinical trials. Clinical trials are used to test the safety and effectiveness of treatments for diseases. Stem cells that are manufactured at CCMI are being tested to treat conditions such as critical limb ischemia, osteoarthritis in the knee and diabetic kidney disease.



Source: IDA Ireland, 2017

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