Teachers in Residence

Stem Cells

Secondary Level Lesson Plan

CÚRAM

Centre for Research in Medical Devices

A World Leading SFI Research Centre

Science Foundation Ireland SFI For what's next

Centre for Research in 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 device 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.

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 Introduction Lesson

Secondary School 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.
8.	**Limb**	Your limbs are your arms and legs.

STEMinator Card Game

Rules:

- Students get into pairs or groups of three and one set of cards is given to each pair or group.
- The dealer shuffles and deals all of the cards face down.
- The player to the dealer's left 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 all of the cards, including their own, and places them on the bottom of his/her pile.
- The winner of the hand gets to go again and chooses a category from the next card.
- If two or more cards share the top value then all 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	**Hematopoetic 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 osteocyte that has become trapped in a mature bone.

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.crm.ed.ac.uk/stem-cells-regenerative-medicine/what-are-stem-cells	Brief Overview of Stem Cells

Resources

- Teacher Lesson Plan
- PowerPoint to guide lesson
- Exit Ticket
- One set of cards per group of students

Methodologies

- Talk and discussion
- Active learning
- Guided and discovery learning
- Collaborative learning
- Free exploration of materials
- 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

Power Point Presentation – Stem Cells

Slide 1

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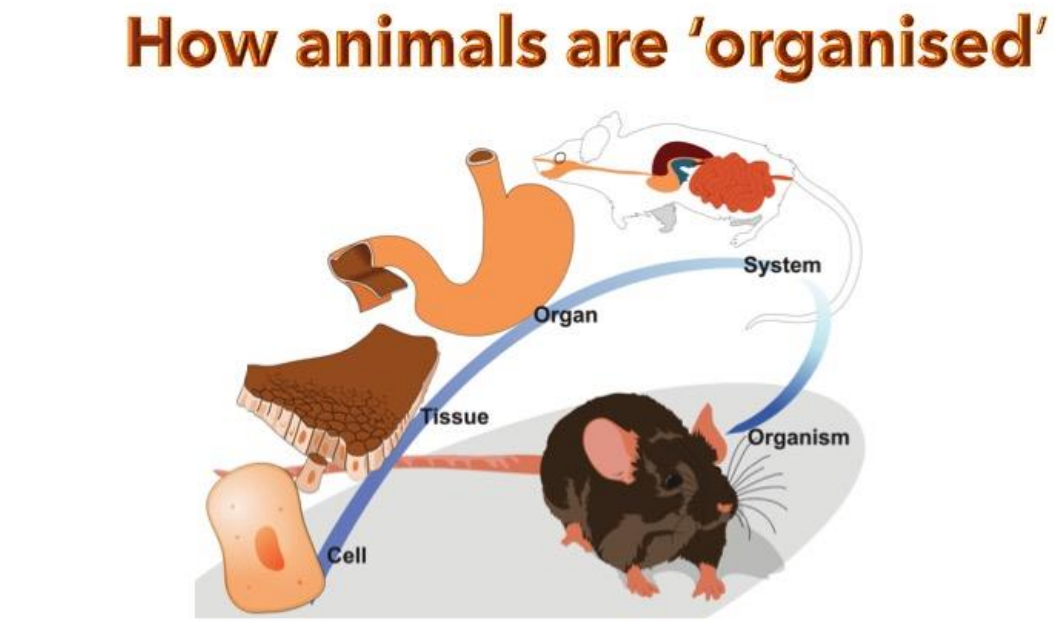
Teachers in Residence Programme
Colm Caomhánach and Róisín Ní Bhraiain

Slide 2



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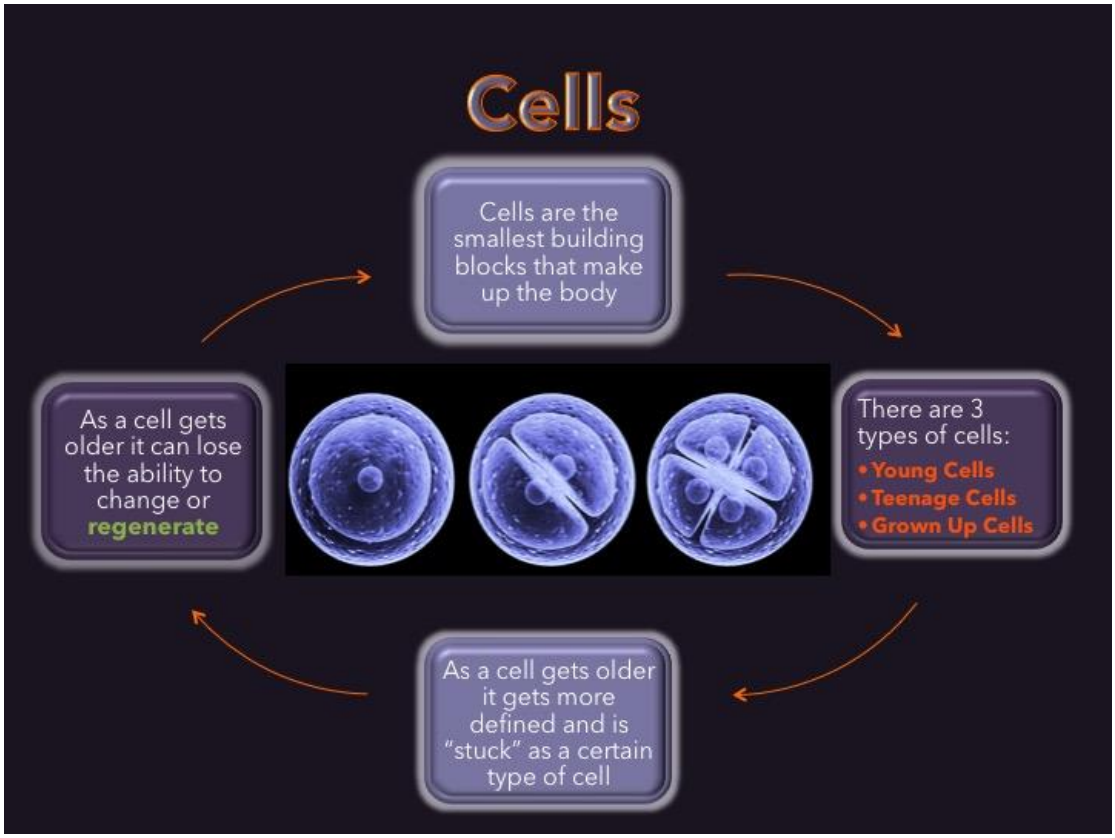

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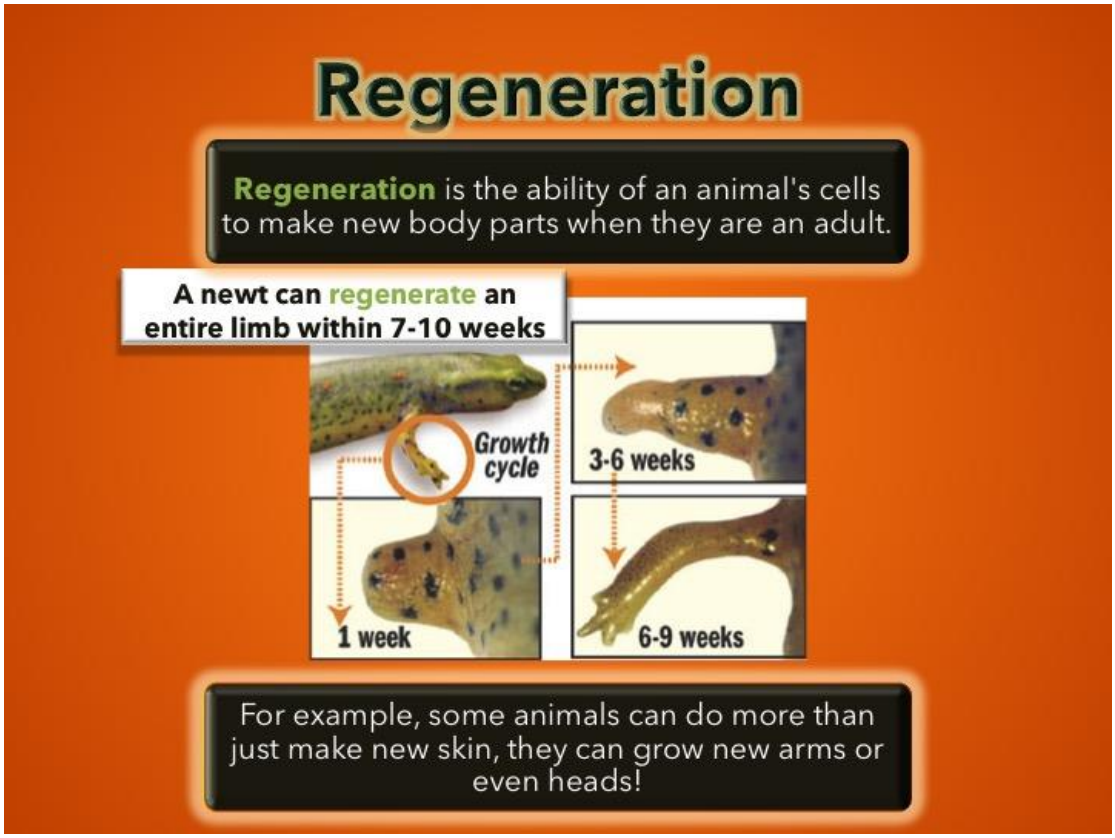


Slide 6

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.

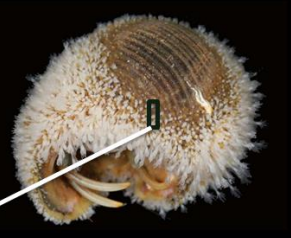
In order for animals to do this, their stem cells need to get the right signals from the rest of the body.

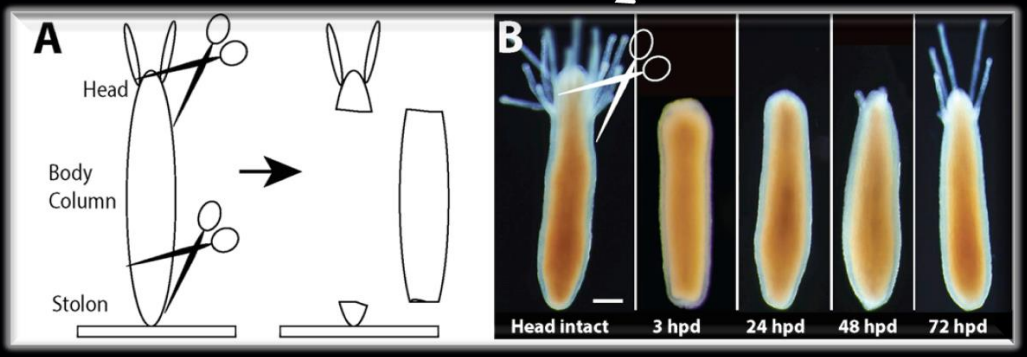
Slide 7

Head Regeneration in Hydractinia

Hydractinia (also know 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.





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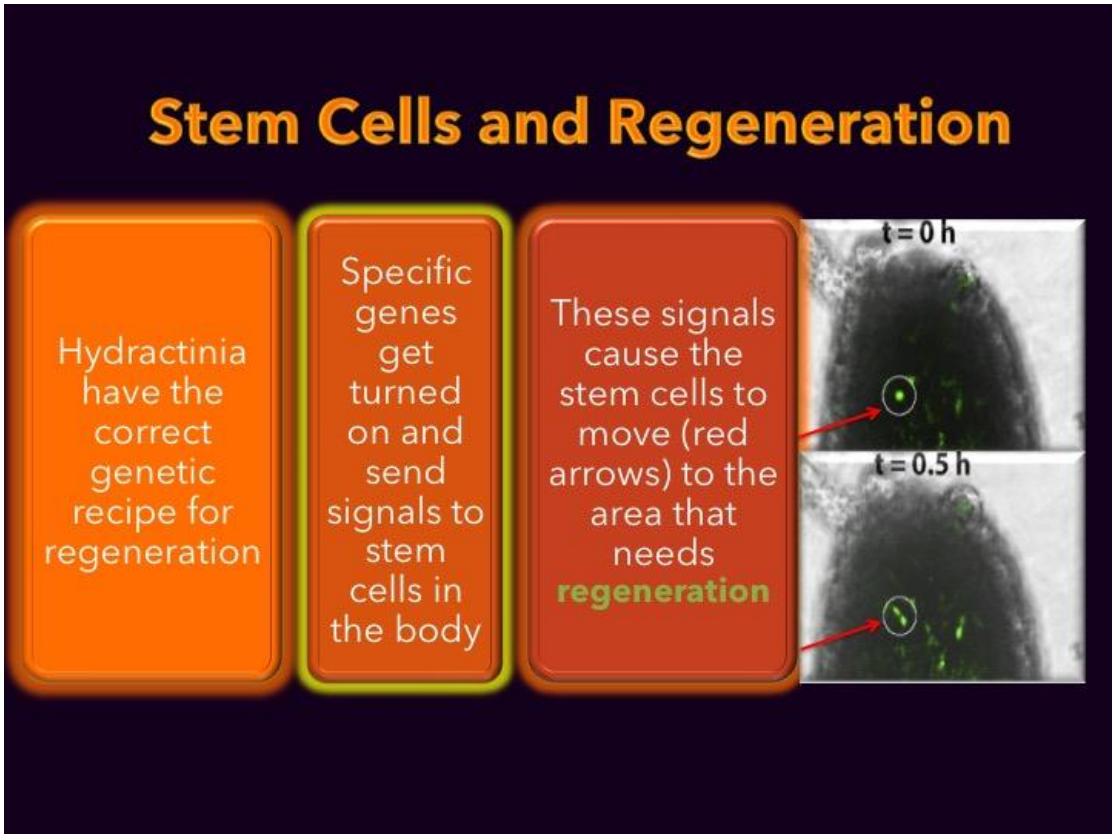

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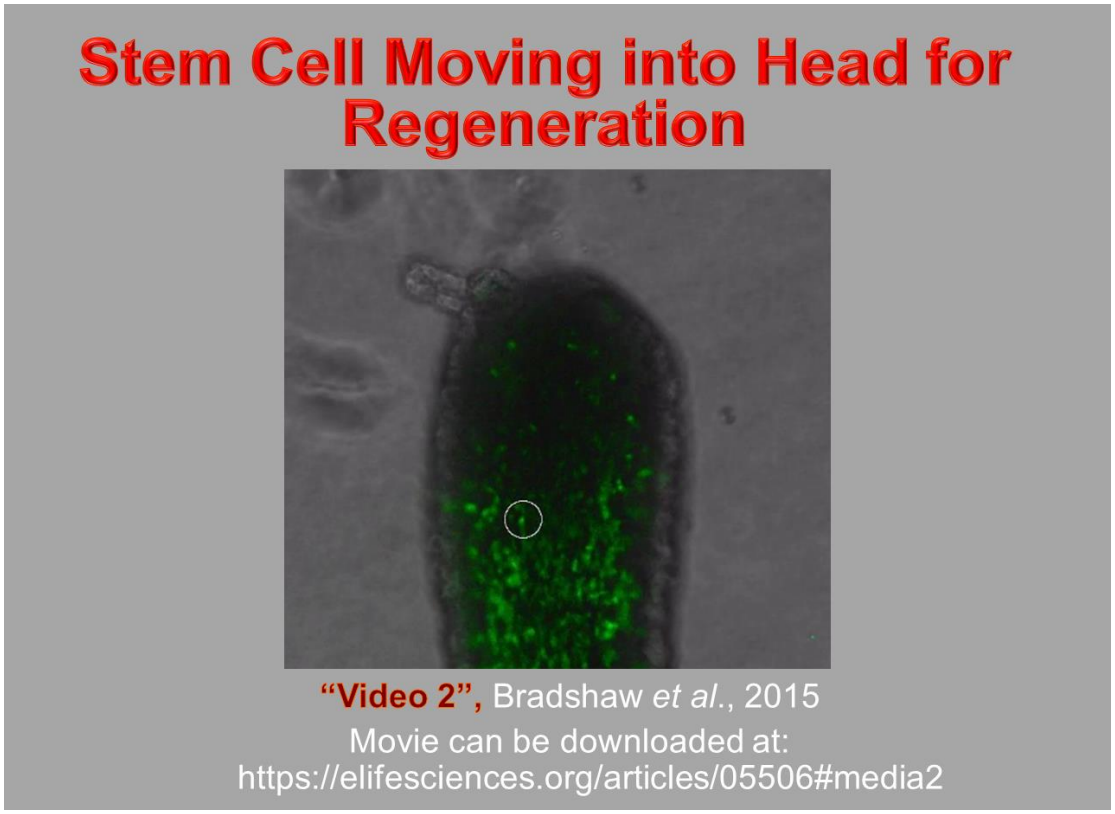

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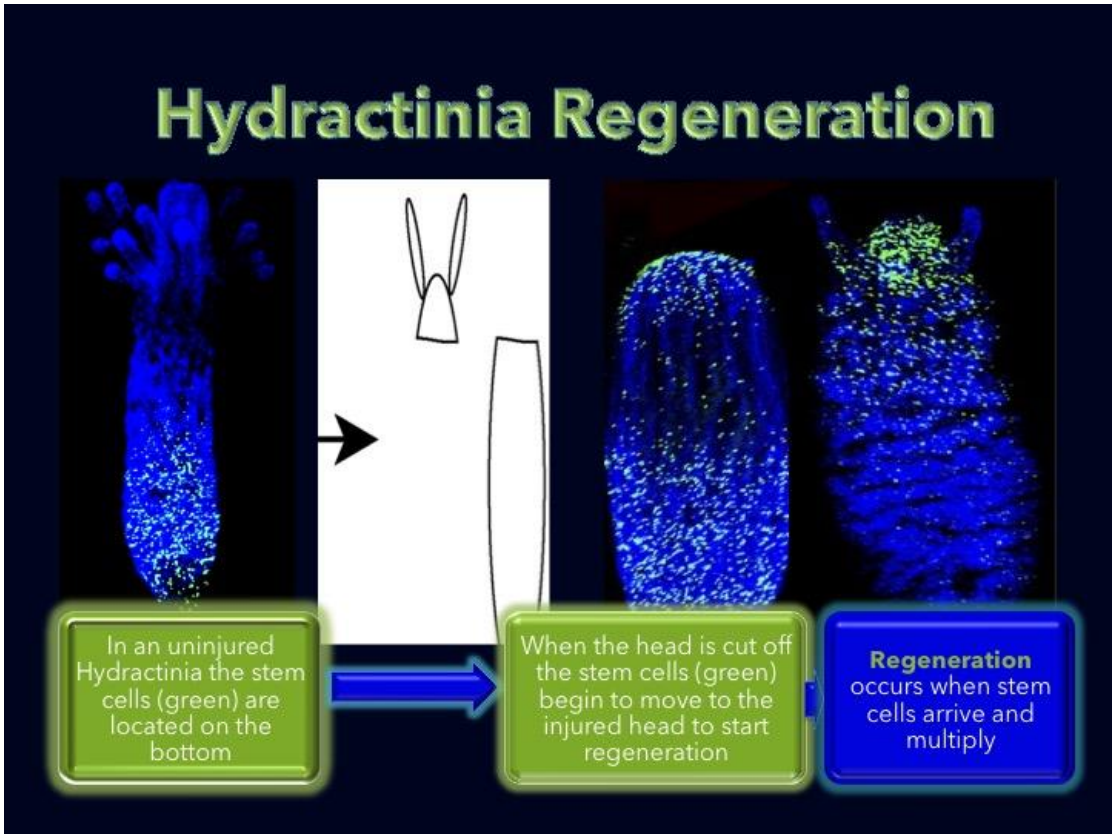

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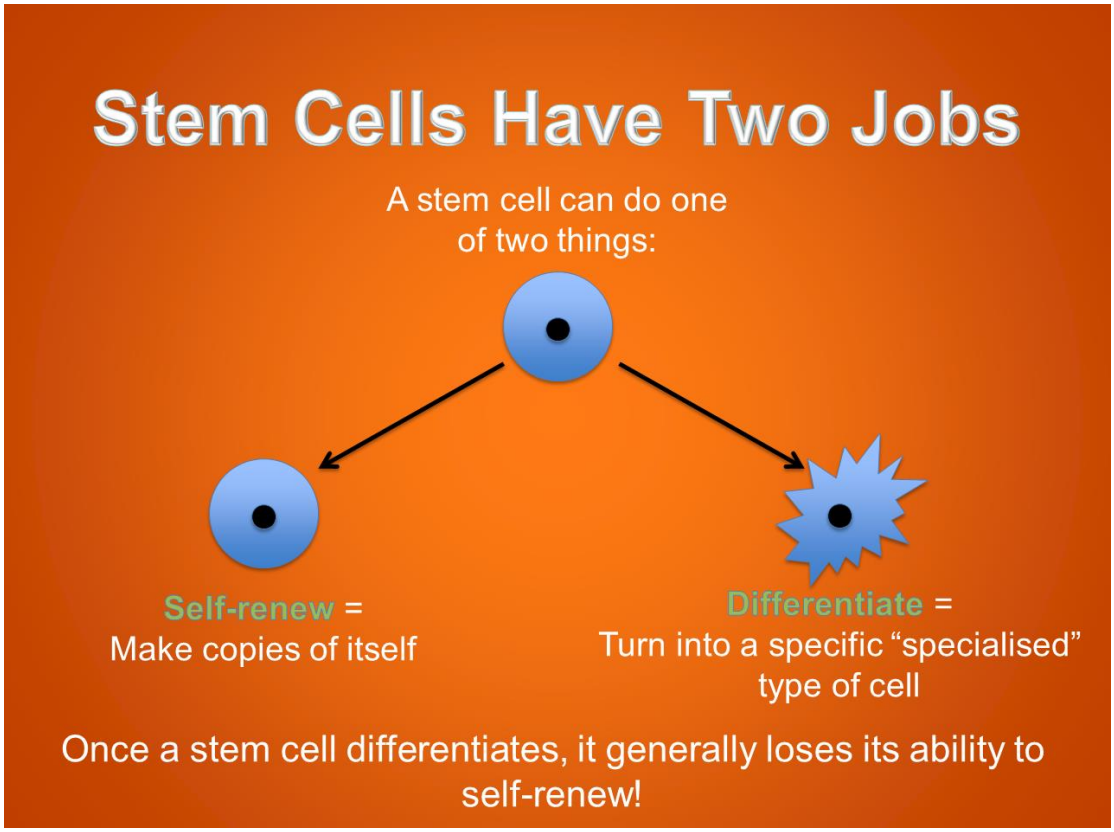
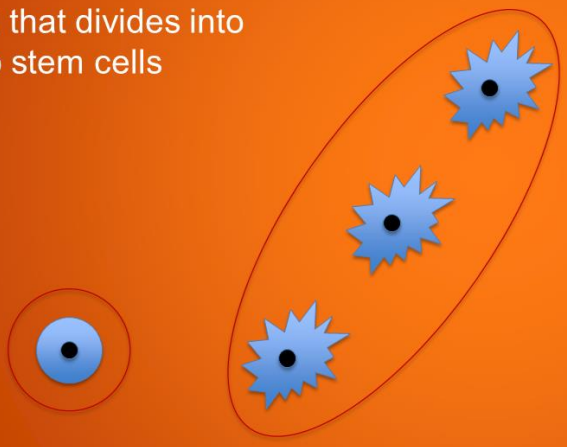


Slide 12

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

Slide 13

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 replaced

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

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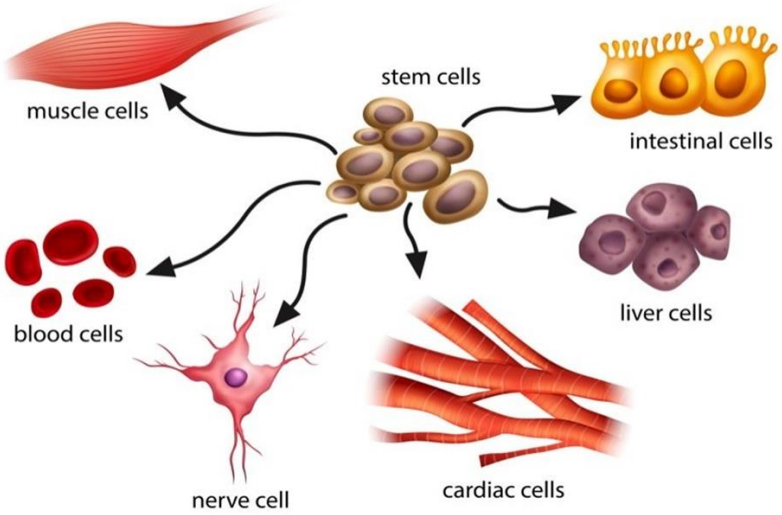
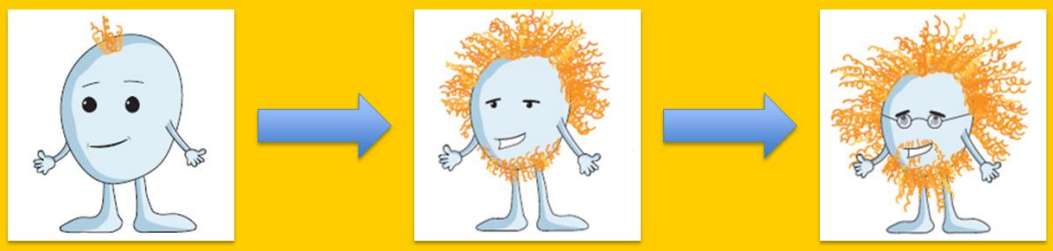
Stem cells are found all over the body and can turn into various differentiated cells



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**

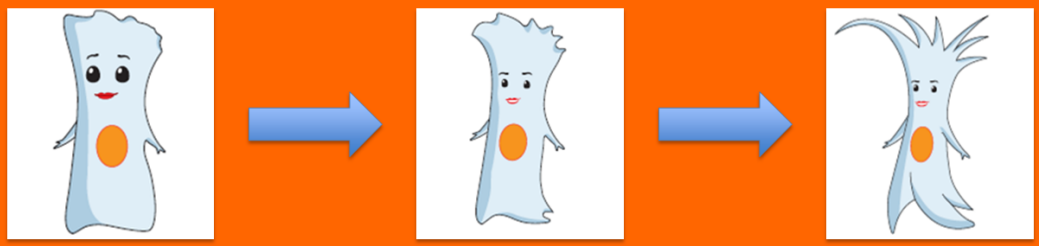
↑ Self-renewal
↓ Differentiation

↓ Self-renewal
↑ Differentiation

Slide 16

Tendon Lineage

Tendon = A band of tissue that connects muscle to bone



Mesenchymal Stem Cell → **Tenoblast** → **Tenocyte**

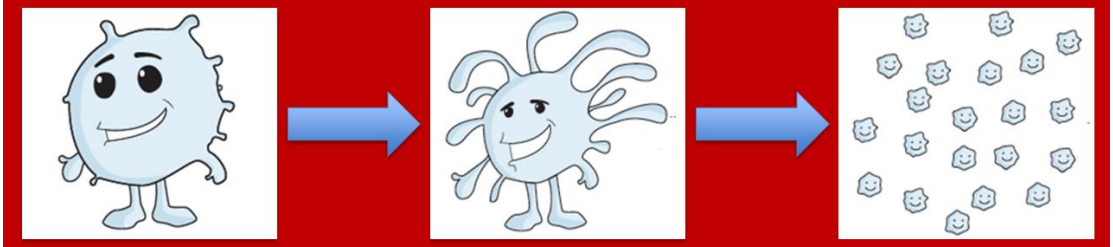
↑ **Self-renewal**
↓ **Differentiation**

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

Slide 17

Blood Cell Lineage

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



Hematopoetic Stem Cell → **Megakarocyte** → **Thrombocyte**

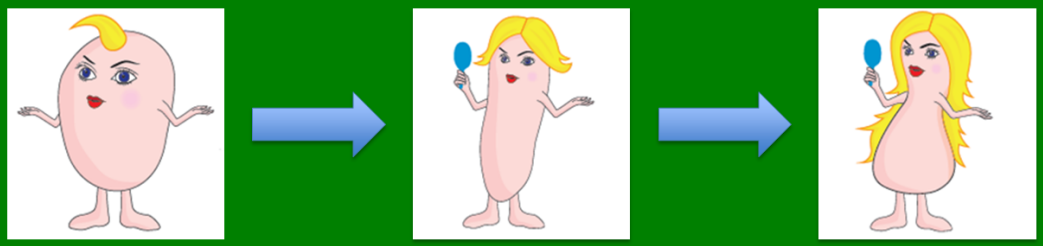
↑ **Self-renewal**
↓ **Differentiation**

↓ **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**

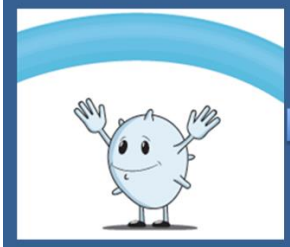
↑ **Self-renewal**
↓ **Differentiation**

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

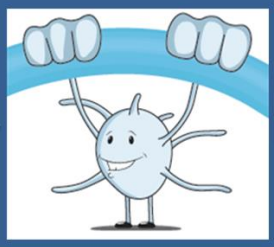
Slide 20

Myelin Sheath Lineage

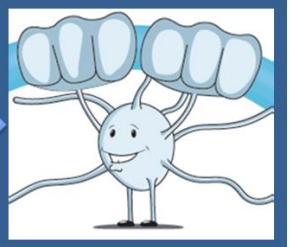
Myelin Sheath = An insulating layer surrounding the axon of neurons allowing signals to be transmitted quickly from the brain to the body



Neural Stem Cell



Glial Progenitor Cell



Oligodendrocyte

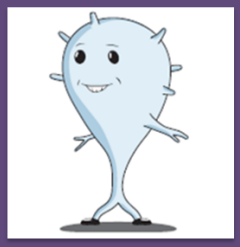
↑ Self-renewal
↓ Differentiation

↓ Self-renewal
↑ Differentiation

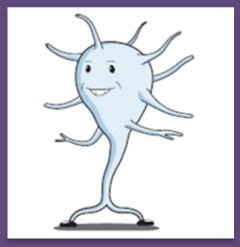
Slide 21

Neuron Lineage

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



Neuronal Stem Cell



Neurocyte

Neuron

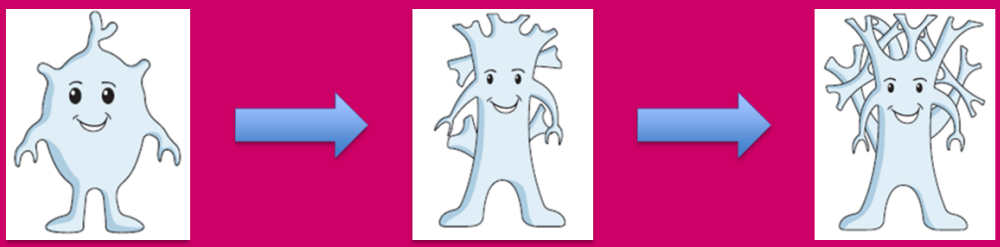
↑ Self-renewal
↓ Differentiation

↓ Self-renewal
↑ Differentiation

Slide 22

Bone Lineage

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



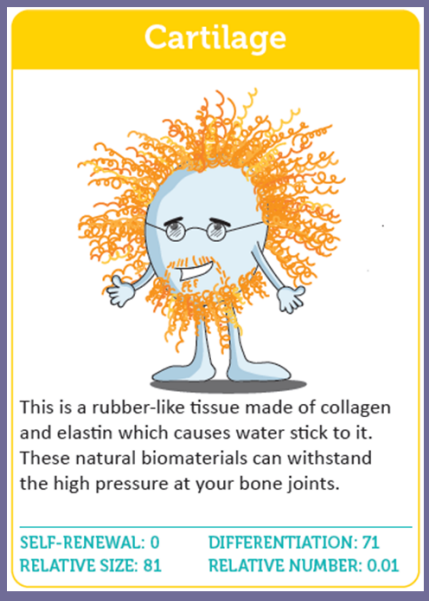
Transitory Osteoblast → **Osteoblast** → **Osteocyte**

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

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

Slide 23

Activity:



- 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

Slide 24

Slide 25

References:

1. Bradshaw *et al*., eLife 2015;4e05506
2. commons.wikimedia.org
3. pixabay.com
4. goo.gl/images/aFplMG
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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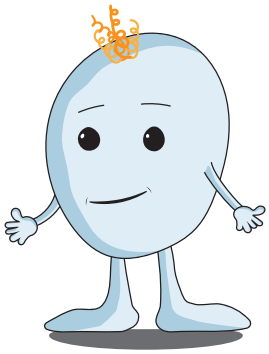
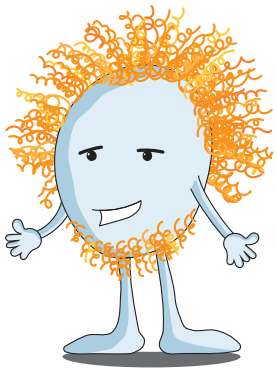
Transitory Chondrocyte



These cells have the ability to transform into chondrocytes.

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

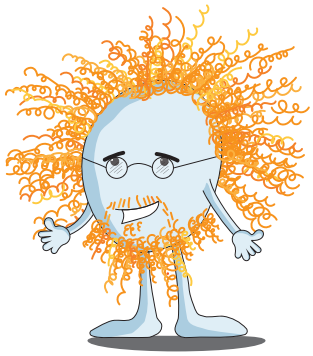
Articular Chondrocyte



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

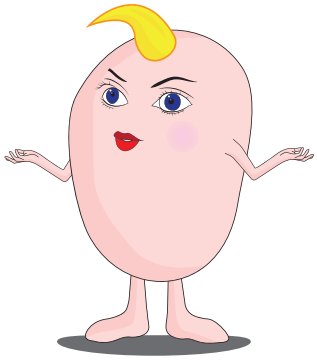
Cartilage



This is a rubber-like tissue made of collagen and elastin which causes water 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

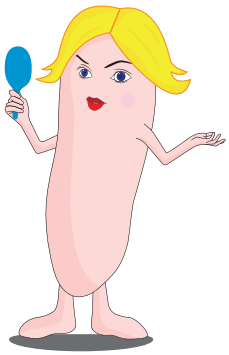
Epidermal Stem Cell



Epidermal stem 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

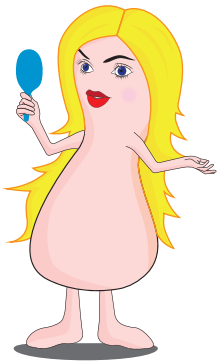
Keratinocyte (Young)



Keratinocytes 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

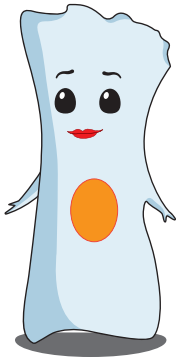
Keratinocyte (Old)



Old and dead keratinocytes 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

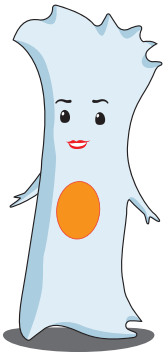
Mesenchymal Stem Cell



Mesenchymal stem cells (MSCs) can differentiate into a variety of cell types including bone, cartilage and muscles cells. Scientists are differentiating MSCs into tenocytes to repair tendons.

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

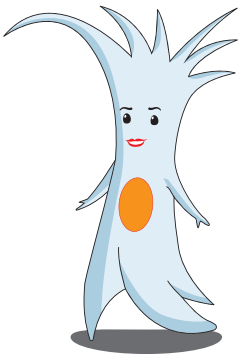
Tenoblast



Tenoblasts 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)



Tenocytes 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

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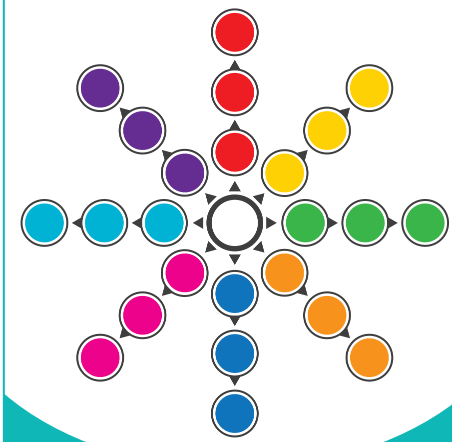

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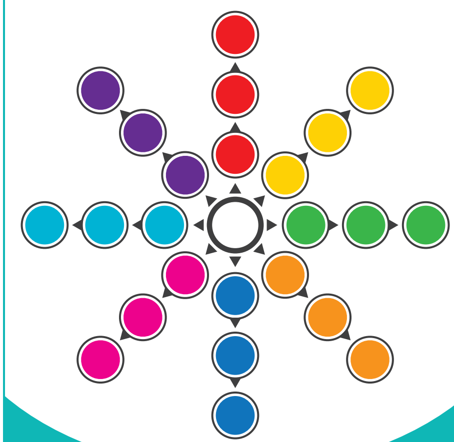

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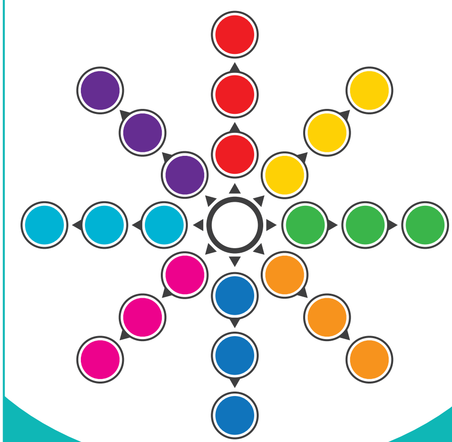

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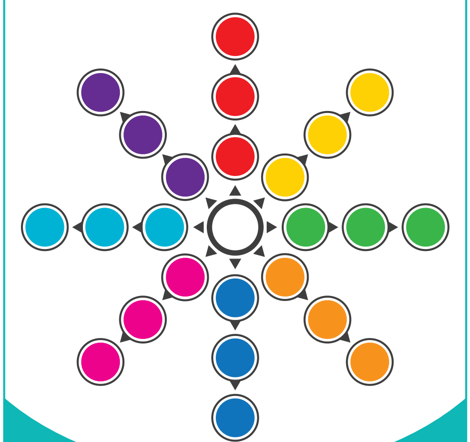

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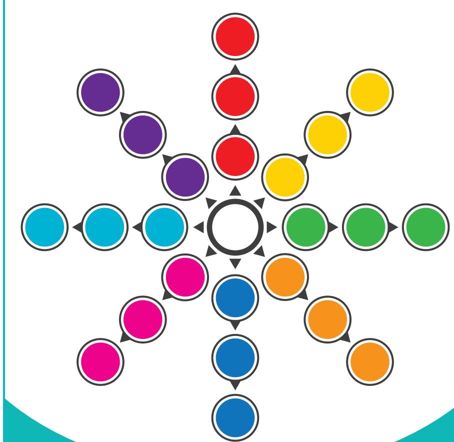

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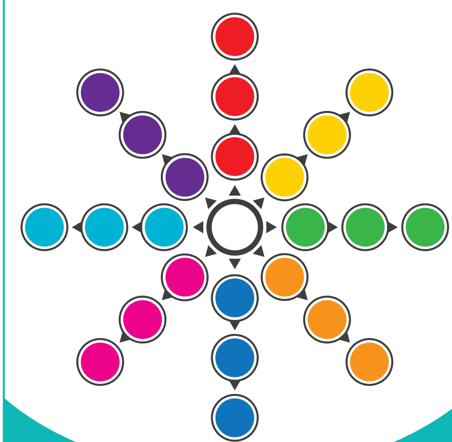

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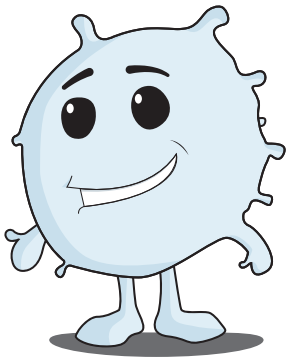
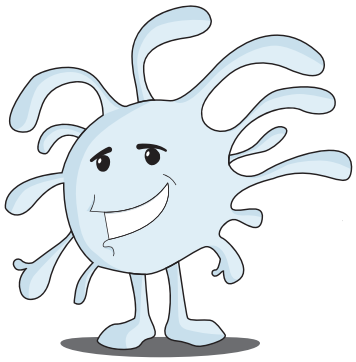
Hematopoetic Stem Cell



Blood stem cells give rise to all the other type of blood cells. They are all born in the bone marrow.

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

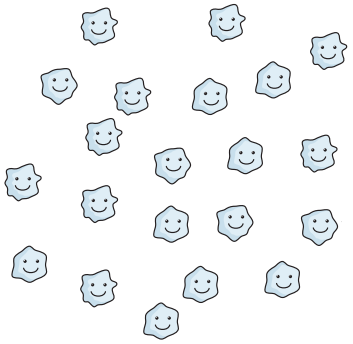
Megakarocyte



Megakaryocyte 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

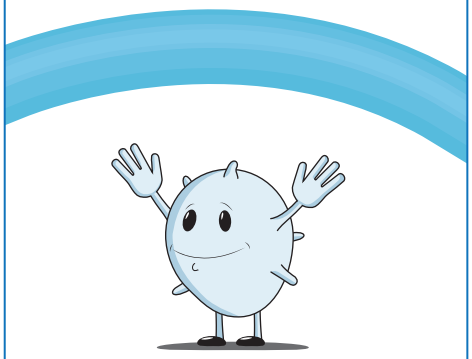
Thrombocyte (Platelet)



Platelets emerge when a mature megakaryocyte explodes. Each explosion makes 2000 – 5000 platelets. They are the special task force to stop any bleeding.

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

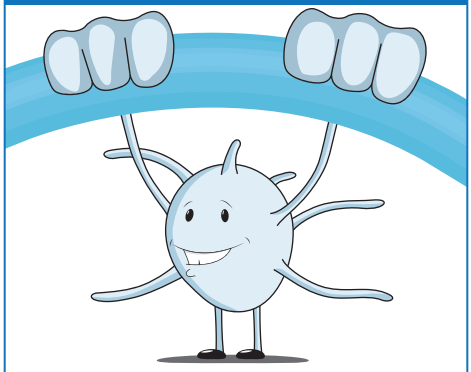
Neural Stem Cell



Neural stem 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

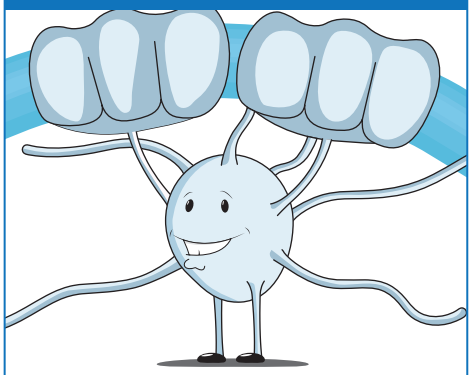
Glial Progenitor Cell



Glial progenitor 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

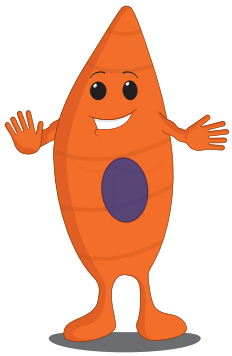
Oligodendrocyte



Oligodendrocytes 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

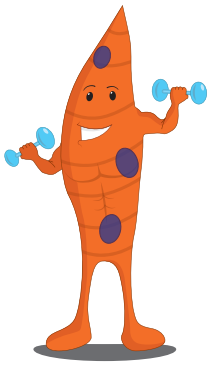
Myoblast



Myoblasts 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

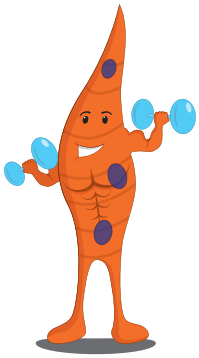
Myoblast (Tube)



When myoblasts 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



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

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

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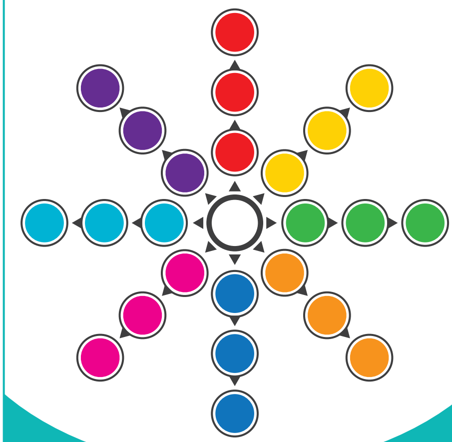

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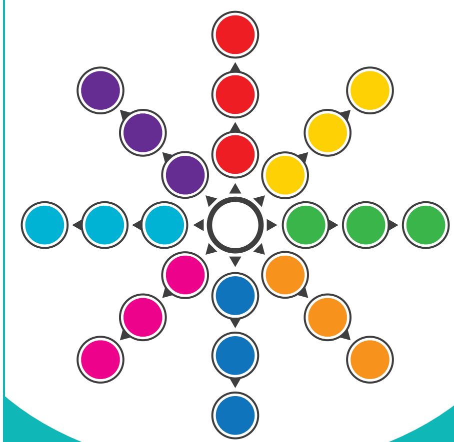

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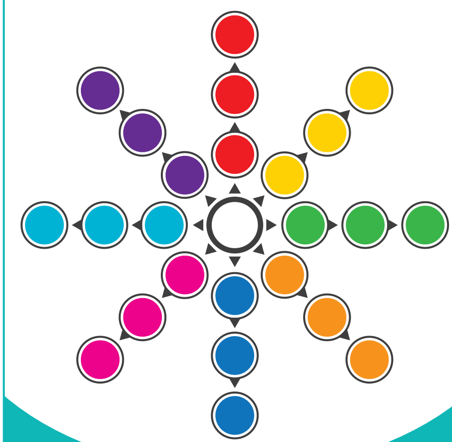

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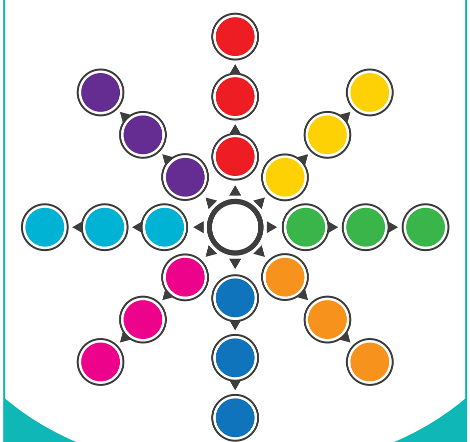

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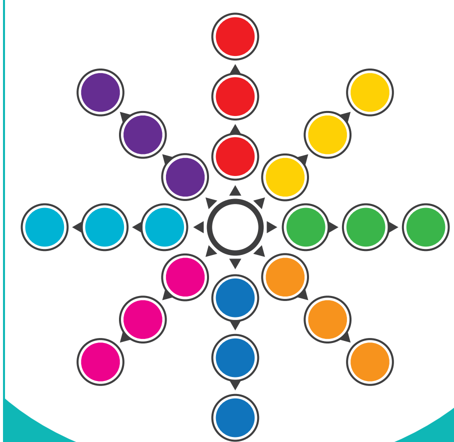

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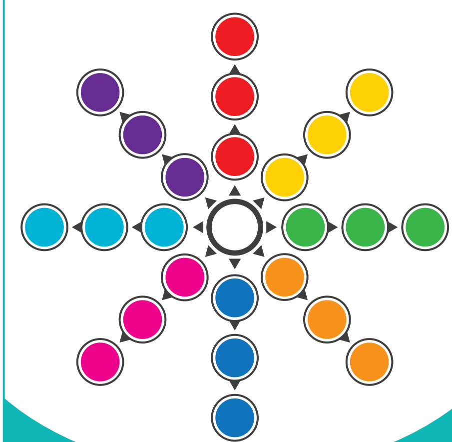

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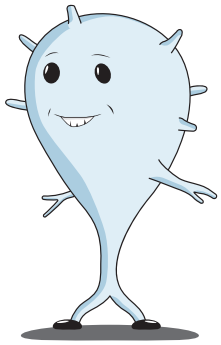
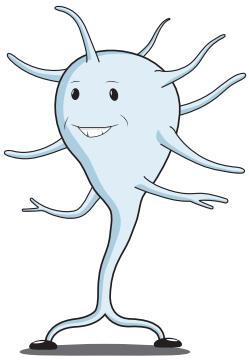
Neuronal Stem Cell



Neuronal stem 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

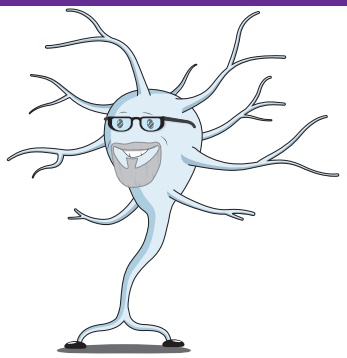
Neurocyte



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

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

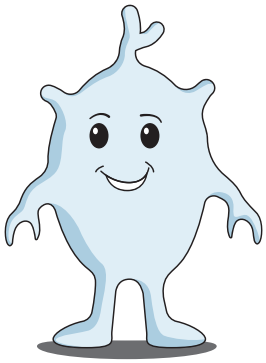
Neuron



Neurons 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

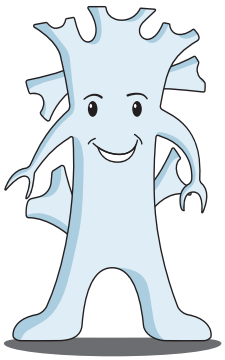
Transitory Osteoblast



Transitory osteoblasts move into the developing, growing or fracture bones.

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

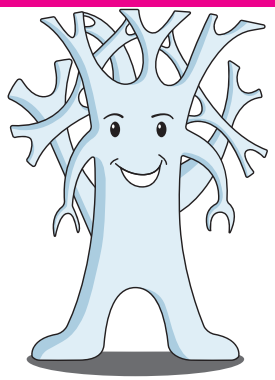
Osteoblast



Mature osteoblasts 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



Osteocytes 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

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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._____

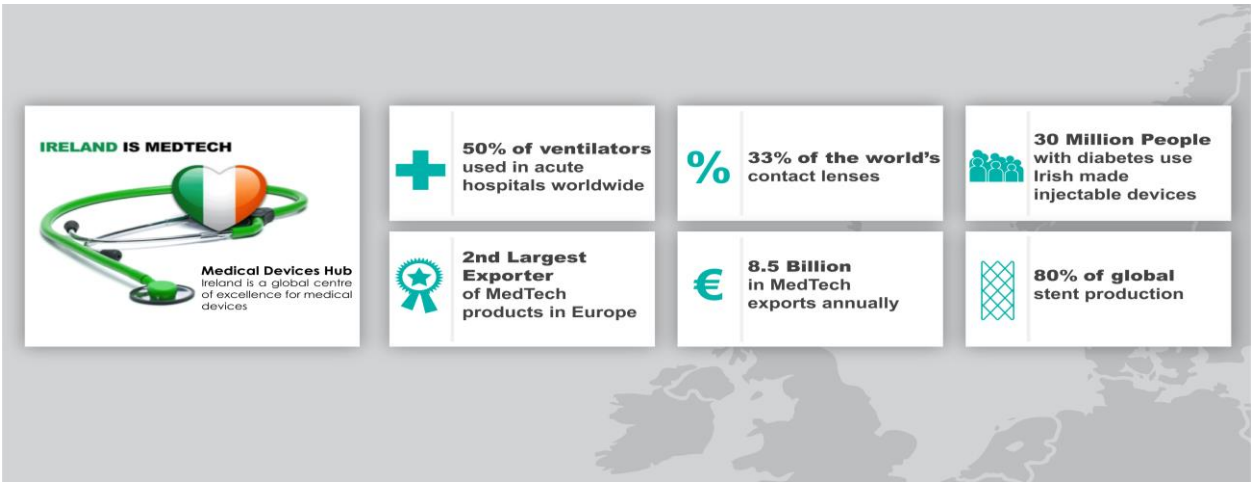
1 Idea that stuck with you:

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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