

Chapter 1

What are these things called stem cells?

This chapter contains a number of ways to introduce the concept of stem cells, what they are, how cells differentiate, why stem cells are so important and what makes them so special. The activities can be used as standalone activities, or as part of a unit of work. Each task introduces the concept of stem cells and also aims to develop a series of key skills. Mix and match the tasks to formulate a lesson plan. Alternatively, spread a few activities around the room in stations and have students move from station to station for a period of time.

Background teacher information

Stem cells play a critical role in normal growth and development by providing new cells for growth, and for replacing and repairing used and damaged tissues. They give rise to all the different cell types in the body. Stem cells differ from other cells as they are 'unspecialised' and have the potential to change into specialised cell types. Stem cells are also unique in that they are capable of self renewal (that is, they can reproduce by themselves). This chapter introduces the concept of 'potency' and stem cells. Pluripotent stem cells have the ability to become any cell type in the body, and multipotent stem cells can usually only become the cell type from which they originate (e.g. nerve stem cells become nerve cells). The different types of stem cells will be discussed further in chapter 2: The different types of stem cells.

Purpose

This chapter aims to provide a basic overview of the three main qualities of stem cells: they are unspecialised, they can be induced to specialise and they can self renew and grow in culture. Later chapters of this kit further explore the similarities and differences between the pluripotent stem cells (e.g. embryonic stem cells) and tissue stem cells (e.g. adult stem cells) in more detail.

List of activities

Activity 1.1 Introducing... stem cells!

A list of strategies to help introduce the concept of stem cells. Aimed at all levels of ability from year 10 to year 12. Can be used in Science, English, ethics and Philosophy.

Activity 1.2 Tuning in – stem cell word splash

Use the 'Stem cell word splash' page in a variety of different activities to inspire thinking and discussion on all things 'stem cell'. This activity can also be used as a revision tool at the end of a teaching unit.

Activity 1.3 What are stem cells?

What are stem cells? An informative worksheet and reading comprehension task.



Activity 1.1

Introducing... stem cells!

Purpose

Below are six strategies designed to introduce the concept of stem cells. Use one or a few activities at the start of the topic to get students thinking and discussing stem cells.

Class time required

10–30 minutes, depending on task.

Resources required

Specified in each section below.

Student knowledge outcomes

- To brainstorm and recall what students already know about stem cells.
- To become familiar with the concept that stem cells give rise to other cells in the body.

Student skills outcome

Applying previous knowledge and understanding, communication skills and group work, thinking skills and problem solving.

Prior knowledge

None required.

Common misconceptions

- Stem cells are only found in the stems of plants.
- Humans are the only living things with stem cells.
Fact: Stem cells are found in the tissues of all plants and animals.
- Stem cells are artificially synthesised cells that are only made in the laboratory.
Fact: Stem cells are the main growth and repair cells in the body and they are functioning right now in all of us. Once stem cells have been obtained from the body they can, in the right conditions, be grown in a laboratory.

Further Resources

Introductory information about stem cells for teachers:

- The Australian Stem Cell Centre: http://www.stemcellcentre.edu.au/For_The_Public.aspx
- The Stem Cell Channel: <http://www.stemcellchannel.com.au>
- Stem Cell School: <http://www.stemcellschool.org>
- California Institute for Regenerative Medicine website (CIRM): http://www.cirm.ca.gov/Stem_Cell_Basics
- CIRM Education Portal: http://www.cirm.ca.gov/Stem_Cell_Education_Portal
- Northwest Association for Biomedical Research (NWABR) website: <http://www.nwabr.org/education/stemcell.html>

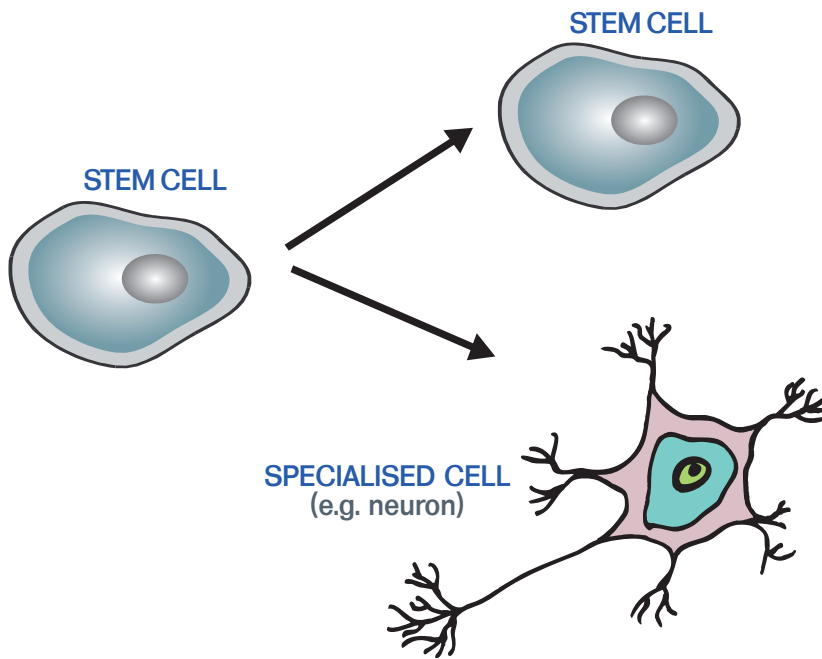
References

Bennet, B, Rolheiser-Bennet, C and Stevahn, L. (1991) *Cooperative learning: Where heart meets mind.* Educational Connections, Toronto, Canada.

Activity 1.1	Task	Educational rational/aim/key skills and resources
Brainstorm	<p>Write the words 'stem cells' on the board. Ask students for the first words or phrases that come into their mind when they think about stem cells. Write all ideas on the board.</p> <p>This can be done as a whole group, in smaller groups or individually. More specific aspects of stem cell research and uses of stem cells could be used for the smaller group brainstorming. Examples of words/phrases include: embryonic stem cells, ART (assisted reproductive technology), embryos, adult stem cells, when does life begin?, stem cells could cure diseases, etc.</p> <p>To break students up into small groups, divide the total number of students by four. For example if there were 28 students, make seven groups. Number students individually within the groups from one to seven. Ask all the number threes, for example, to work in a group together. This divides the students up in a varied way.</p>	<p>This activity stimulates class room discussion and prompts the students to think about the concept of stem cells. The method can be adapted to initiate a student led discussion on stem cells.</p> <p>Key skills: Thinking, tuning in on a topic and group work.</p> <p>Resources required: Access to white board or smart board.</p>
Graffiti group task	<p>On A3 or butcher's paper, write a word or phrase that relates to one aspect of stem cells. In small groups (three to four), students write all the words, phrases or draw diagrams that come to mind about that key idea and write it on the page.</p> <p>Students can use different coloured felt pens so each student's contribution to the task can be tracked. After a set period of time, the teacher stops the students and asks the groups to pass their page to the next group. The task begins again with the next key idea. Alternatively, students can physically move from one table to the next.</p> <p>After the pages have circulated around the room, the original group then reads what the other students have contributed. The group discusses the new notes, summarises the ideas, draws a conclusion about the key idea and presents their findings to the class. Alternatively, gather up all the pages and make a group listing of responses. Discuss key ideas and link to another stem cell activity. (Bennet <i>et al.</i> 1991.)</p>	<p>This activity can be used as a tuning activity or as a concluding activity for revision.</p> <p>Key skills: Cooperation during group work, thinking skills, evaluating, summarising.</p> <p>Resources required: Butcher's paper or A3 paper, felt tip pens.</p>
KWL (Know: want to know: what have I learned chart)	<p>Ask students to draw up a KWL chart. The headings for the three columns are: 1. What I already know, 2. What I would like to learn, 3. What I have learned. Column three is completed at the end of the learning task/s.</p>	<p>This activity helps students visualise what they already know about stem cells. This area of science is sometimes poorly understood by students and can be overwhelming. After completing the exercise, students may find they know more about stem cells than they first thought.</p> <p>Resources required: Student workbook or paper.</p>

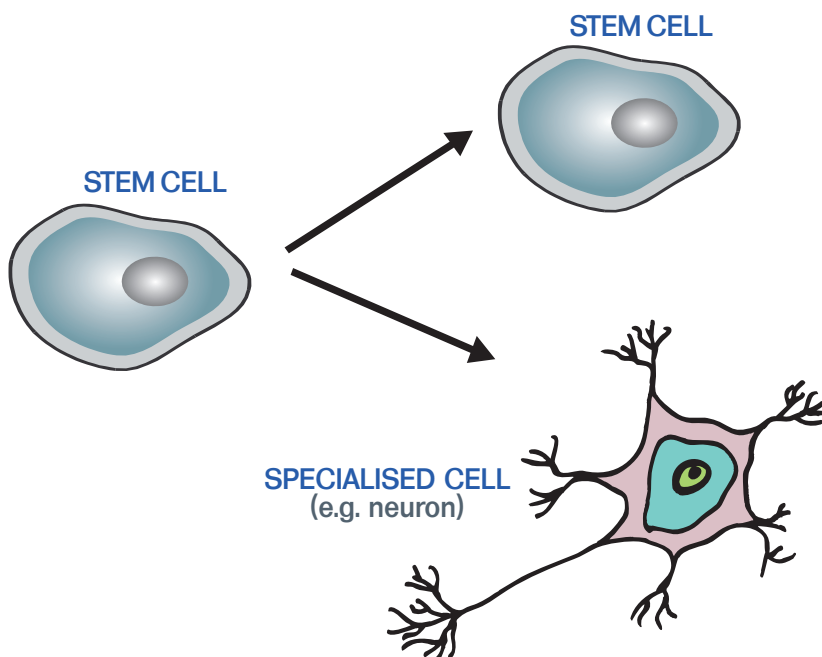
Activity 1.1	Task	Educational rational/aim/key skills and resources
Think–pair–share	<p>Present the central idea on the board and ask the students to think about stem cells. They can write a few comments/thoughts in their books. After a short while, ask students to pair up with a person beside them and share their thoughts. Student pairs could also share some ideas with the rest of the class.</p>	<p>This activity helps students share ideas about stem cells that they may not wish to publically share with the whole class. The second student provides a sounding board on which the first student can float their ideas.</p> <p>Key skills: Thinking and reflecting on prior understanding, formulating opinions and group work.</p> <p>Resources required: Student workbook or paper.</p>
Picture stimulation using diagrams	<p>Firstly, present students with a picture showing 'Image 1: Why are stem cells so special?'</p> <p>Without telling the students what the picture is about, ask them to list as many facts as they can about what they think the picture represents.</p> <p>This task should encourage the students to think about how stem cells are primitive cells giving rise to other cells. The task can also be used as a lead in to another activity about the different types of stem cells.</p> <p><i>NB: 'Image 2: Why are stem cells so special? Descriptive' has been provided as a descriptive, general handout for teachers to provide to students. Unlike 'Image 1', this image has descriptive information about what stem cells are.</i></p>	<p>This activity lends itself to a more inquiry based learning approach. The student is given the stimulus required to formulate their own understanding of the topic. This activity can be followed up with factual/formal teaching or students can be guided to resources where they can further enhance their knowledge of stem cells at their own pace.</p> <p>Key skills: Critical thinking, application of prior knowledge, problem solving.</p> <p>Resources required: Onscreen image or printed copies of Image 1: Why are stem cells so special?</p>

Image 1 Why are stem cells so special?



cut along line

Image 2 Why are stem cells so special? Descriptive



When a stem cell divides, it can either:

Self renew – make more stem cells
or

They can specialise and make a different cell type

A stem cell that can:

- become many types of cells in the body is called **pluripotent**
- become only a few types of cells is called **multipotent**



Activity 1.2

Tuning in – stem cell word splash

For introductory information, resources, links and key knowledge see the information at the start of activity 1.1.

Class time

20–30 minutes

Purpose

This is a 'word splash' exercise designed to generate thought and discussion about stem cells. Below are some examples of how this collection of 'stem cell' words could be used in the classroom.

- Use at the beginning of a lesson/activity as a tuning in exercise to start a topic. Show the page on the data projector/smart board or print off a copy and distribute to students. The following is a list of possible student tasks:
 - Ask students to look at the words and then comment as part of a group discussion/brainstorming exercise on stem cells in general.
 - Ask students to write down some thoughts about how one or many phrases made them feel.
 - Ask students to select a word/topic that may be familiar to them. Ask them to write down what they already know about that word/topic.
 - Think–pair–share. Students think about the words in general or select one in particular, pair up with the person next to them and share their thoughts. Ask them to share some of their discussions with the rest of the class.

- Use as a KWL activity.

- Ask students to read the words and then draw up a table with three columns, as shown below. Put the words into the appropriate columns.

What I already know about stem cells	What I want to know about stem cells	What I have learned about stem cells

- The first two columns can be filled in at the start of the activity and the third column filled in after the teaching activities have been completed.

- Cut out the words:

- Divide students into groups and distribute one or a couple of related words to each group. Ask the student groups to discuss and record their interpretation of the words and present their thoughts with the rest of the class.
- Ask students to hypothesise how their words fit into the concept of stem cells. Write a brief scenario/explanation about the words. (Note to teachers: although students may not know a great deal about stem cells at this stage, their answers here will reflect certain misconceptions which can be used to highlight areas to focus teaching and learning activities.)

- Use the words for revision at the end of a teaching unit:

- Words make newspaper headlines. Ask students to pick one/couple of the words and make a newspaper headline using that word. Write a brief synopsis of the article or swap headlines and ask a partner to write their interpretation of the headline.

This idea may also be used at the end of a teaching topic when the ethics of stem cells have been discussed and students have a better understanding of the words. In this context, this activity can be used as a synthesis/application task.

- Ask students to use one or more words to make a sentence about stem cells. Again, this will highlight any misconceptions at the end of a teaching unit.



Handout 1.2

Tuning in – stem cell word splash

Ethical

Embryo

Pluripotent

Leukaemia

Backlash

Parkinson's disease

IVF

SCNT

Human eggs

Stem cells

Research

Hope

Controversy

Cord blood

treatment

Cloning

ART

Debate

Therapy

BREAKTHROUGH!

Drug research

Cure

Grow

iPS cells



Activity 1.3

What are stem cells?

Purpose: This activity is a reading comprehension task that aims to consolidate three main facts about stem cells: they are unspecialised, they can be induced to specialise and they can self renew and grow in culture. Questions increase in difficulty and higher order thinking.

Class time required: 20–30 minutes

Resources required

A copy of the black line master Handout 1.3 'What are stem cells?'.

Video: Creation of Human Embryonic Stem Cells can be used as a tuning in activity.

(<http://www.stemcellchannel.com.au/> go to 'What are stem cells' and select the video titled 'Creation of Human Embryonic Stem Cells'.)

Student knowledge outcomes

- To understand that stem cells are undifferentiated cells that can self renew or become specialised.
- To understand how stem cells give rise to other cells in the body.
- To understand that pluripotent stem cells are unspecialised cells that can be induced to specialise into different cell types.

Student skills outcome

- Low and higher order thinking: Reading comprehension, understanding, application, synthesis and evaluation.
- Using analogies to explain a new concept.

Prior knowledge

- All living things are made up of cells.
- Cells can specialise into different cell types, tissues and organs. These cells, tissues and organs make up all the systems of the body.

Common misconceptions

- Stem cells in the body are automatically pre-programmed to become a certain cell type.
Fact: Stem cells require signals from surrounding cells to determine their growth and cell specialisation.
- Stem cells can choose which cell types they develop into.
Fact: Chemical signals determine cellular fate.
- IVF embryos already have specialised cells.
Fact: An early embryo (1–5 days old) is made up of a cluster of unspecialised cells. Embryonic stem cells are isolated from the inner cell mass (ICM) of the early embryo.
Teachers note: The words differentiation and specialisation have essentially the same meaning when used to describe how unspecialised stem cells give rise to other more specialised cell types.

Further Resources

Information on stem cells can be found at:

- The Stem Cell Channel: <http://www.stemcellchannel.com.au/> – Click on 'What are stem cells?' and watch 'This is how it begins'. Resources hexagon include fact sheet.
- ABC TV Catalyst – Stem Cell Special: <http://www.abc.net.au/catalyst/stemcells>
- The National Institutes of Health website with information about stem cells: <http://stemcells.nih.gov/info/basics>
- California Institute for Regenerative Medicine. Information about types of stem cells. Great teacher resources. Videos and pictures: http://www.cirm.ca.gov/StemCellBasics_Definitions
- EuroStemCell—the European stem cell portal. Watch relevant segments of the video 'A stem cell story': <http://www.eurostemcell.org>

References: ASCC Fact sheets: http://www.stemcellcentre.edu.au/For_the_Public/FactSheets.aspx

Handout 1.3

What are stem cells?

The body is made up of about 200 different kinds of **specialised cells** such as muscle cells, nerve cells, fat cells and skin cells. All cells in the body are derived from **stem cells**. Stem cells are precursor cells that have not yet been **specialised**. Stem cells become specialised through a process known as **specialisation** (also known as **differentiation**). During specialisation, different chemical stimuli act on the cell and cause it to develop into a specific cell type. Once a cell is specialised it has a particular pattern of gene expression that sets it apart from other cell types.

Think of a stem cell as a blob of plasticine with no specific form. Once a certain stimulus is applied to the plasticine, such as moulding it with your fingers, it can be changed into a different shape. However, once a cell is differentiated it cannot easily go back to being unspecialised, unlike the blob of plasticine!

Stem cells differ from other cells in the body in several ways

1. Stem cells are unspecialised. They have not developed into cells that perform a specific function.
2. Stem cells can **specialise**. They can divide and produce cells that have the potential to become other more specialised cell types or tissues. These new cells and tissues are used to repair or replace damaged or diseased cells in the body.
3. Unspecialised stem cells are capable of **self renewal**. Stem cells are able to divide and produce many copies of themselves. Many cell types once they have become completely specialised (terminally differentiated) have a limited capacity to produce new cells of the same type. If a mature nerve or blood cell is damaged it cannot replace itself.
4. When stem cells divide, each daughter cell can either:
 - a. stay as a stem cell, or
 - b. the daughter cell can undergo many more cell divisions. With each division the cell becomes more specialised until it finally becomes a terminally specialised cell type. There are many intermediate cell types between the pluripotent stem cell and the final specialised cell type.

Stem cells play a critical role in normal growth and development by providing new cells for growth and for replacing and repairing used and damaged tissues.

Once stem cells have been obtained from the body they can, in the right conditions, be grown in a laboratory. Scientists can then influence what type of cell a stem cell grows in to by adding chemicals to the cell culture or changing how the cells are grown.

Stem cell analogy

Below is an analogy showing how unspecialised stem cells can be likened to an 'unspecialised' high school student.

Stem cell facts	Analogy to help explain the concept of stem cells
There are about 200 different kinds of specialised cells in the human body.	There are thousands of different jobs that people can do once they leave school.
All cells in the body are made from stem cells that are unspecialised.	High school students do not have a career. They are in one way; all the same.
The process of cell specialisation is also called differentiation.	Students train for their specialised career by going to university, TAFE, completing an apprenticeship or training on the job.
Once cell specialisation has taken place the cell cannot easily become another cell type.	People can change careers by retraining. Lucky we are not stem cells! (Newsflash: recent scientific advances have been able to reprogram specialised cells! But this research is still in its infancy.)

Possible misconceptions due to the analogy: Students can **choose** which career they pursue, stem cells **do not choose** which cell types they become. Unlike choosing a career, it is not a conscious process. Growth factors and the environment within the tissue in which the stem cell resides actually influence the type of cell that the stem cell will develop into.

Evaluation Questions

1. Explain what is meant by a specialised cell.
2. How do stem cells become specialised?
3. What might happen if a stem cell does not differentiate properly?
4. Answer true or false to the following statements:
 - a. A nerve cell is the same as a stem cell.
 - b. Sperm and egg cells are unspecialised cells.
 - c. One stem cell could theoretically make millions of stem cells.
 - d. A pluripotent stem cell can differentiate into a heart muscle cell.
5. Analogies are a helpful way of describing a new situation to another person. Write your own analogy, similar to the one above that describes the difference between an undifferentiated cell and a differentiated cell.
 - a. Are there any possible misconceptions that might be apparent in your analogy?
 - b. Explain your analogy to another person. Did they understand your analogy?
 - c. After using your analogy to explain cell specialisation, are there any changes you would make to it?
6. Imagine you had a stem cell culture. What cell type of the body would you want your culture to grow into? Explain why you chose this cell type.
7. Summarise what you now know about stem cells. Use your own words to write down what you have learned in a couple of sentences.





Handout 1.3

What are stem cells

– Teacher copy

Questions and answers

1. Explain what is meant by a specialised cell.

A specialised cell has a specific function or set of functions. A specialised cell may also have a distinctive appearance (morphology).

2. How do stem cells become specialised?

Stem cells differentiate through many intermediate cell stages into a specific cell or tissue type. Chemical factors within the tissue will influence what cell type the resident stem cell specialises into.

3. What might happen if a stem cell does not differentiate properly?

If a stem cell does not differentiate properly it would not develop into the specific cell type intended, and that new cell type or tissue would not grow and develop properly. It is also possible that the stem cell could develop into cancer.

4. Answer true or false to the following questions.

- a. A nerve cell is the same as a stem cell.

False. A nerve cell is a specialised cell. It has a specialised function and a distinctive morphology.

- b. Sperm and egg cells are unspecialised cells.

False. Gametes have a specific function and a distinctive morphology.

- c. One stem cell could theoretically make millions of stem cells.

True. Stem cells are self renewing and in the right conditions can make many more copies of themselves.

- d. A pluripotent stem cell can differentiate into a heart muscle cell.

True. Pluripotent stem cells make all specialised cell types. Including heart muscle. Specific chemical signals will influence what type of cell the pluripotent stem cell develops into. Note the use of the word differentiate instead of specialise. Both words are interchangeable and can be used in this context.

5. Analogies are a helpful way of describing a new situation to another person. Construct your own analogy, similar to the one above that describes the difference between an undifferentiated cell and a differentiated cell.

Many possibilities. The idea here is to get students thinking about how some objects can be transformed into many different things. For example, an apple being differentiated into different apple products, such as an apple pie, apple puree, apple roll up etc. Flaws with this analogy are: the apple cannot make other apples (not self renewing). The apple can't grow indefinitely.

- a. Not all analogies fit exactly. Are there any flaws in your analogy? Are there any possible misconceptions that might be apparent in your analogy?

- b. Explain your analogy to another person. Did they understand your analogy?

- c. After using your analogy to explain cell specialisation, are there any changes you would make to it?

Self reflection about content and how well the student performed the task. These questions are designed to further the students understanding of the concept of differentiation.

6. Imagine you had a stem cell culture. What cell type of the body would you want your culture to grow into? Explain why you chose this cell type.

This is a synthesis type question. There will be many possible answers and most will be fanciful. Although the exact science will not be understood and adhered to, students can still consider the number of possibilities that stem cells might provide. The key here is whether the students are thinking about the base stem cell and

then the body/tissue/organ cell it could make and the benefits. For example, making skin cells to repair scarring. Making spinal cord cells to repair motorcycle victim's injuries.

7. Summarise what you now know about stem cells. Use your own words to write down what you have learned in a couple of sentences.

Various answers. Students should understand that stem cells are precursor cells that make every cell type in the body. Answers should also include the understanding that stem cells are unspecialised and will become specialised during a process known as differentiation. Stem cells are also capable renewing themselves indefinitely (under favourable conditions).

