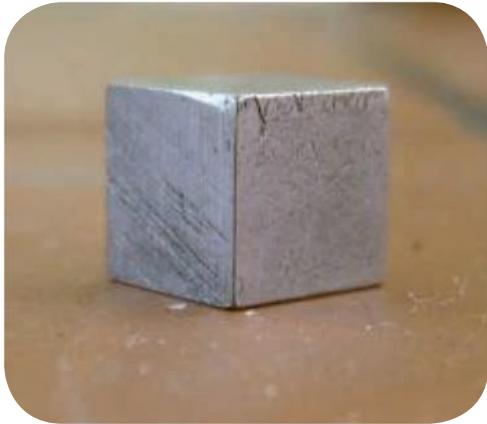


Differentiation = Making specialized cells



Differentiation = Making specialized cells

What the photo shows

A lump of metal and lots of different kinds of screws that can be made from it.

Things to think about

What is a specialized cell?

A specialized cell does a particular job in the body. Cells like blood, skin, muscle or nerve cells are all specialized cells. They are 'specialists' at their jobs.

Your body needs new specialized cells all the time. But most specialized cells cannot make copies of themselves. Stem cells solve this problem.

What is differentiation?

Stem cells can make new specialized cells. We call this process differentiation.

1. Embryonic stem cells can make all the different types of cells in your body.
2. Tissue stem cells can only make a few other types of cells. Skin stem cells only make skin cells. Blood stem cells only make the different types of cells that make up your blood. Blood stem cells do NOT make skin cells.

Self-renewal = copying



Self-renewal = copying

What the photo shows

A toolbox.

Things to think about

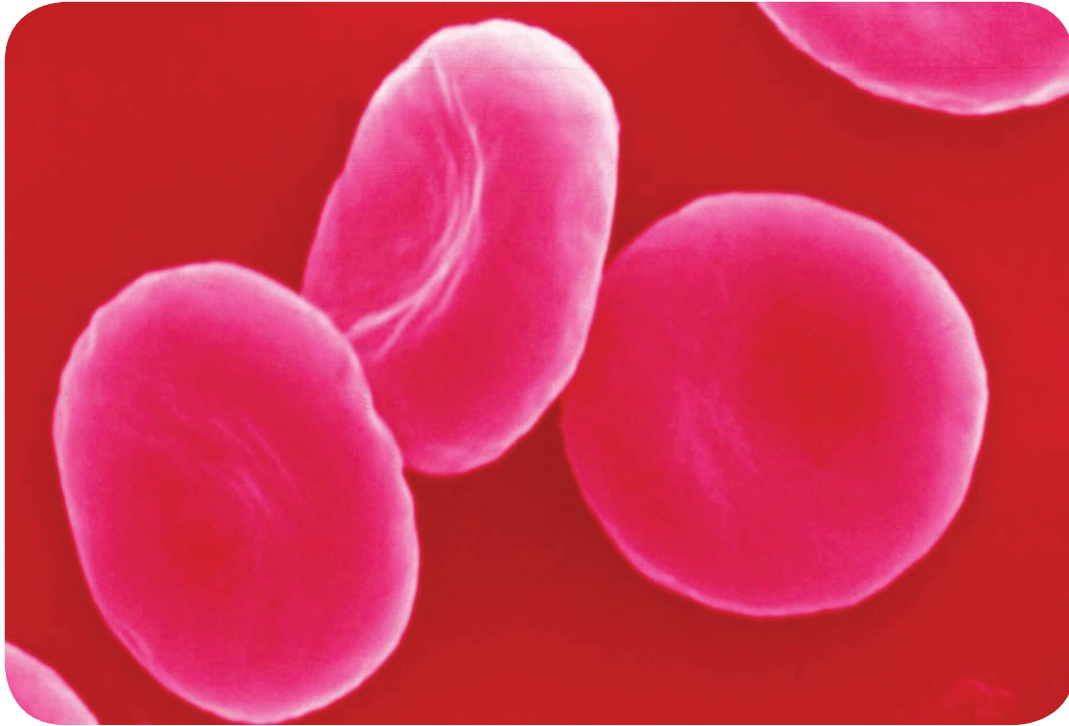
Stem cells can make copies of themselves. This is called self-renewal. Self-renewal makes sure that you do not run out of stem cells.

Stem cells are important tools in your body:

- They make new cells to replace cells that die in your body every day.
- They help repair damage, such as cuts and broken bones.

If your stem cells did not copy themselves, they would soon all be used up. Without stem cells, your body would not have the tools it needs to replace dead or damaged specialized cells. You would soon be very ill.

Your body needs stem cells



David Gregory and Debbie Marshall / Wellcome Images

Your body needs stem cells

What the photo shows

Red blood cells.

Things to think about

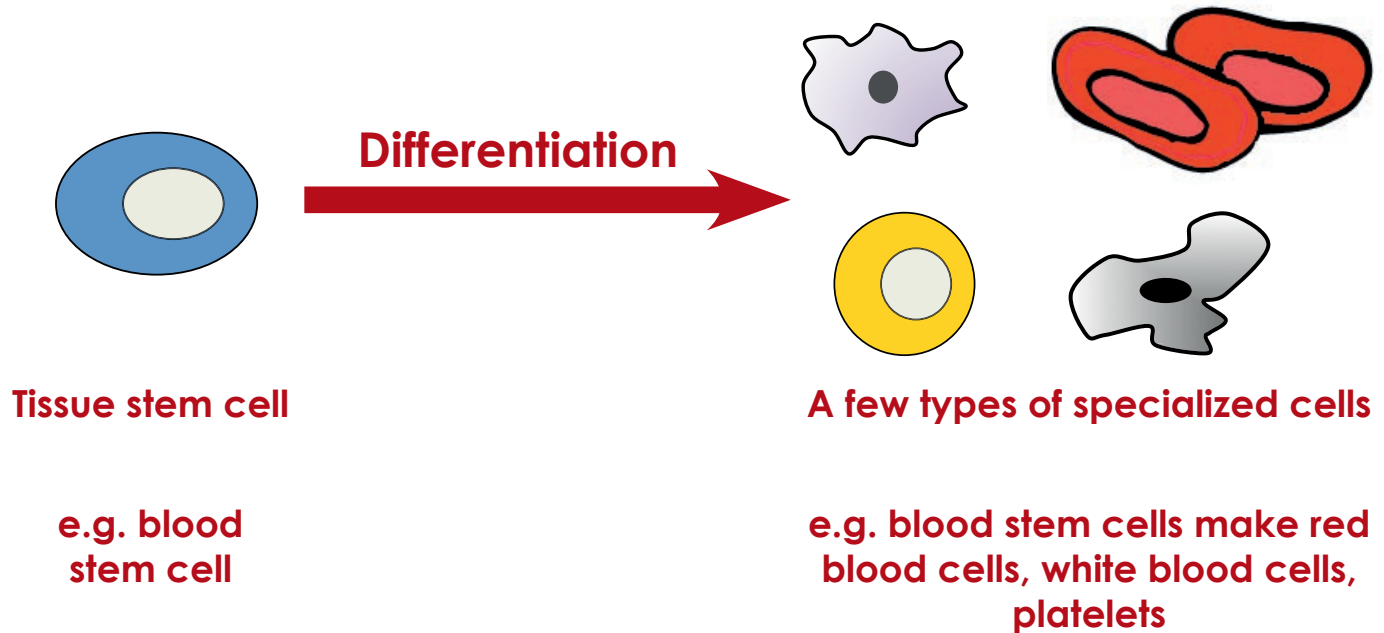
We need stem cells all our lives. They keep our bodies working by replacing cells that die, get damaged or are used up.

You need new cells in some parts of your body every day. For example:

- Blood cells – Red blood cells only live for about three months at the most. Stem cells in your bone marrow make millions of new red blood cells every single day.
- Skin cells – You lose a few kilograms of dead cells from the surface of your skin every year. They need to be replaced!

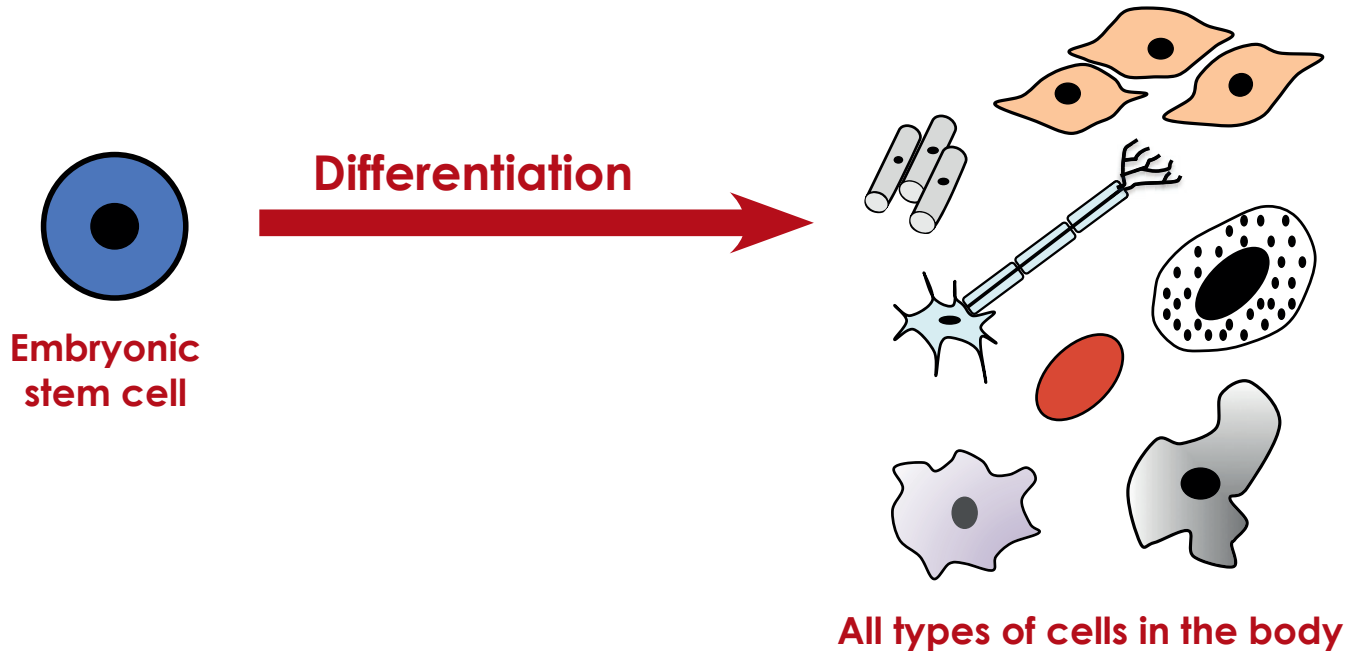
In most other parts of your body, the stem cells only need to replace damaged cells from time to time, e.g. in your heart or lungs.

Tissue stem cells



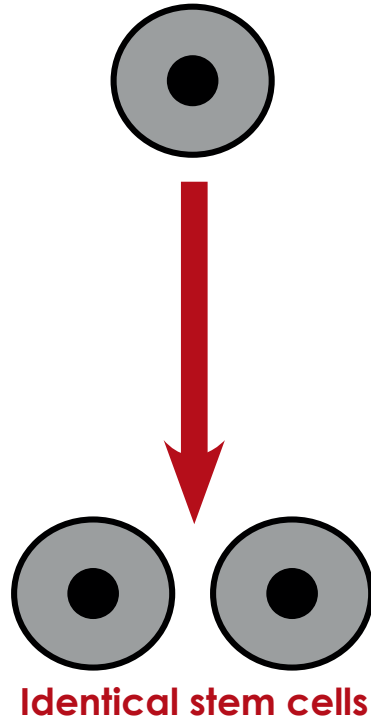
All about stem cells

Embryonic stem cells

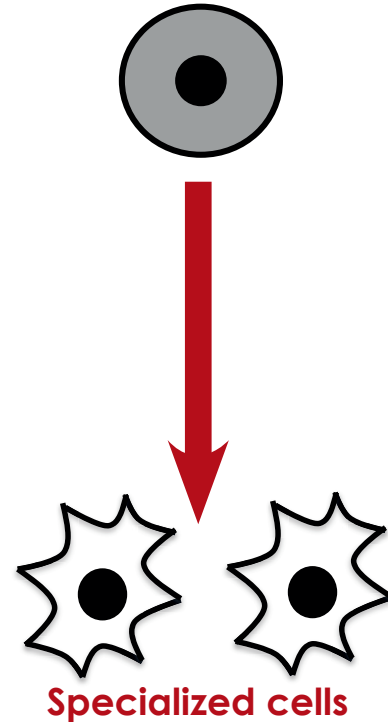


All about stem cells

What stem cells can do



Stem cells



All about stem cells

Your task

Look at the cards you have been given and read the information.

Make a poster or presentation to explain the most important facts to other students in your class. Your poster or presentation **MUST** answer all the questions below.

Questions

1. What is a stem cell? (Hint: Explain what 2 things stem cells can do.)
2. Why do our bodies need stem cells?
3. What different kinds of stem cell are there? (Hint: Find 2 kinds of stem cell that are mentioned on the cards and explain what each kind can do.)

Hints and tips for posters

- Write headings on your poster to help people find the most important points.
- Draw or stick the photos and diagrams onto your poster. You don't have to use them all if you don't want to.
- Write short notes, lists, labels or headings to explain the pictures and diagrams.
- Add arrows, boxes or drawings to help explain what you want to say or make important facts stand out.
- **Do not** write out all the information from the cards onto the poster. People need to see quickly and easily what your poster is about.

All about stem cells

Where do embryonic stem cells come from?

Embryonic stem cells come from a blastocyst



Kate Blair

Embryonic stem cells come from a blastocyst

What the photo shows

A human blastocyst next to a human hair.

Things to think about

A blastocyst is an embryo at a very early stage of development. The blastocyst in the picture is 5 days old.

A blastocyst has around 100 cells. Embryonic stem cells can be grown from cells taken out of the blastocyst.

Embryonic stem cells and the law

In the UK, scientists are only allowed to do research on embryos up to 14 days old. When an embryo is about 14 days old it starts to develop a nervous system.

Where do embryonic stem cells come from?

Growing cells in the lab



Wellcome Library London

Growing cells in the lab

What the photo shows

A flask containing human embryonic stem cells.

Things to think about

When scientists grow cells in the laboratory, we call the process 'cell culture'.

Embryonic stem cells in the lab

Scientists can only get a few embryonic stem cells from a blastocyst. They grow more cells in the lab using cell culture.

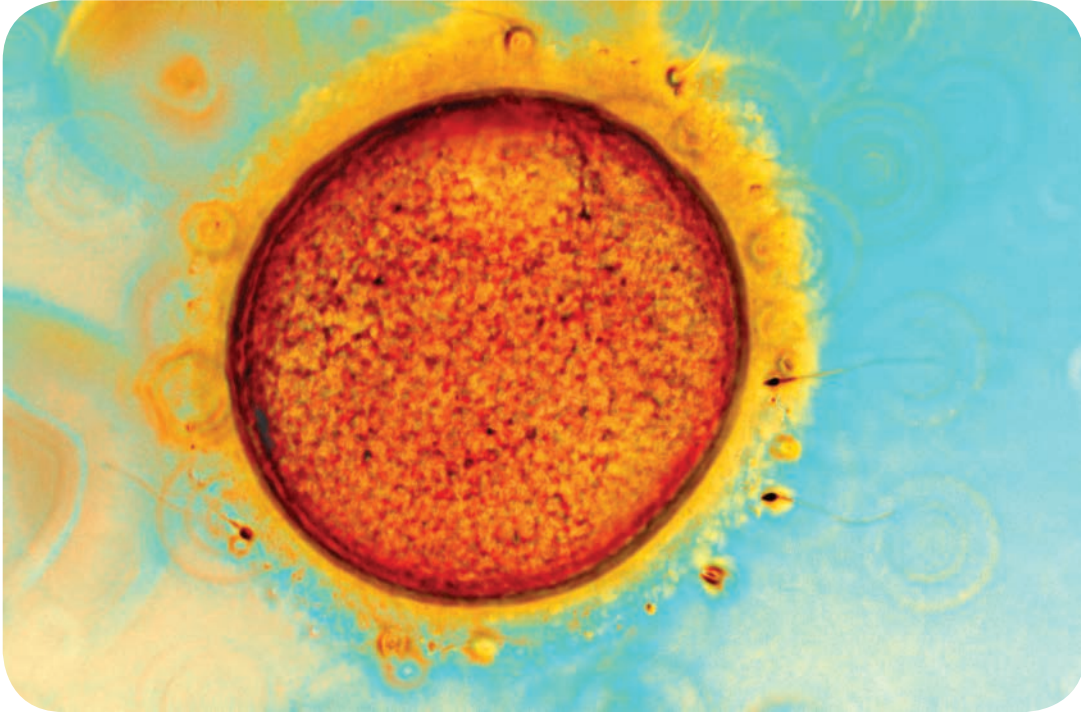
Cells from a blastocyst are put in a flask with the nutrients they need to survive. The cells divide and multiply.

The nutrients in the flask and the temperature have to be very carefully controlled:

- to keep the cells alive
- to make sure they stay as stem cells and do not make specialized cells.

Where do embryonic stem cells come from?

IVF embryos in research



Spike Walker / Wellcome Images

IVF embryos in research

What the photo shows

Human egg and sperm. This picture was taken during IVF treatment.

Things to think about

What is IVF?

IVF stands for 'in vitro fertilization'. It is a technique used to help some people have a baby.

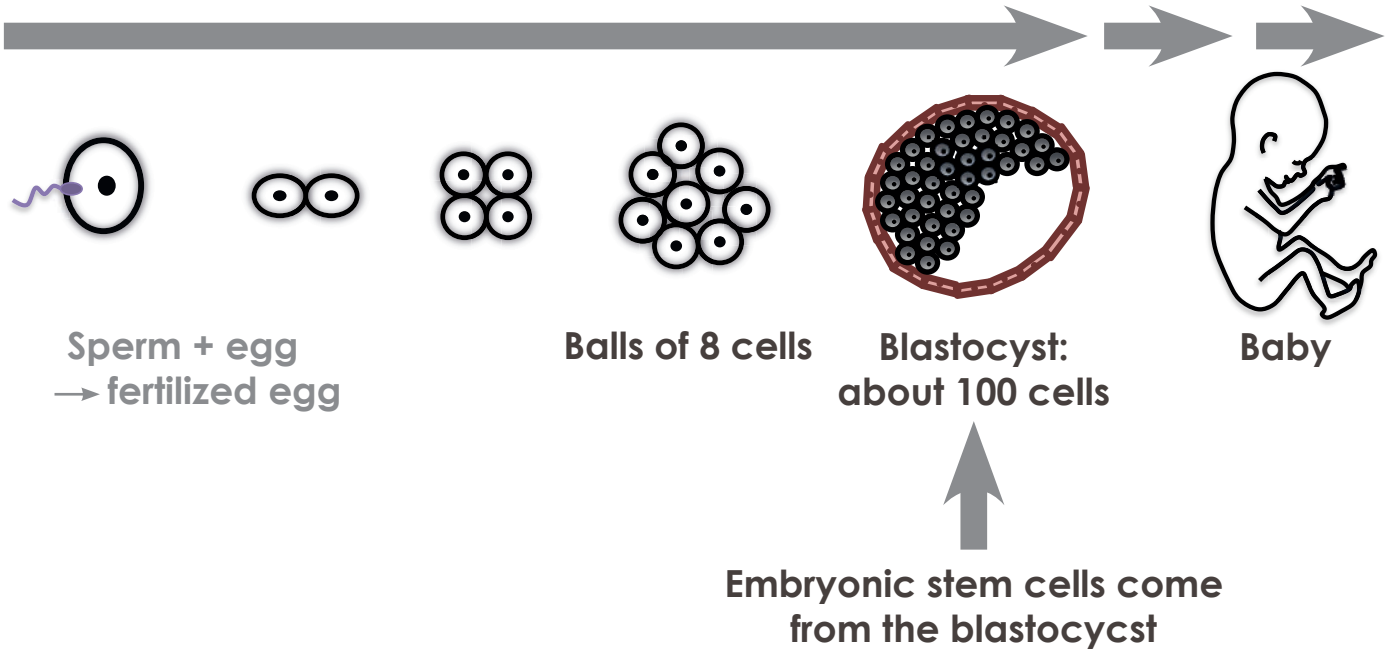
Egg cells are taken from the mother and sperm cells from the father. The sperm and eggs are mixed together to make several embryos. A healthy embryo is chosen and put into the mother's womb.

IVF embryos can be used in research

After a couple has IVF treatment, they can decide what should happen to their left over embryos. In the UK the embryos can be frozen and stored, or they can be donated to research. In some other countries scientists are not allowed to use IVF embryos for research.

Embryonic stem cells

Cells divide during development



All about stem cells

Your task

Look at the cards you have been given and read the information.

Make a poster or presentation to explain the most important facts to other students in your class. Your poster or presentation **MUST** answer all the questions below.

Questions

1. Where are embryonic stem cells found? (Hint: Think about the stages of human development.)
2. Where can scientists get embryonic stem cells for research? (Hint: What is IVF? Explain this as part of your answer.)
3. How do scientists grow enough cells for their research?

Hints and tips for posters

- Write headings on your poster to help people find the most important points.
- Draw or stick the photos and diagrams onto your poster. You don't have to use them all if you don't want to.
- Write short notes, lists, labels or headings to explain the pictures and diagrams.
- Add arrows, boxes or drawings to help explain what you want to say or make important facts stand out.
- **Do not** write out all the information from the cards onto the poster. People need to see quickly and easily what your poster is about.

All about stem cells

Understanding disease



Understanding disease

What the photo shows

Scientist using a microscope.

Things to think about

It is often difficult to get to the cells that have gone wrong in a disease – they might be deep inside a patient's body. Instead, scientists could use stem cells to study how the disease develops:

1. Take stem cells from a patient with a particular disease. Their stem cells will have the genes that cause the disease.
2. Use the stem cells to grow cells just like the diseased cells in the patient. For example, grow the type of brain cells that have gone wrong in a patient with a particular brain disease.
3. Study how the cells grow and behave. Try to find out why they do not work properly.

Testing drugs



Testing drugs

What the photo shows

Medicines.

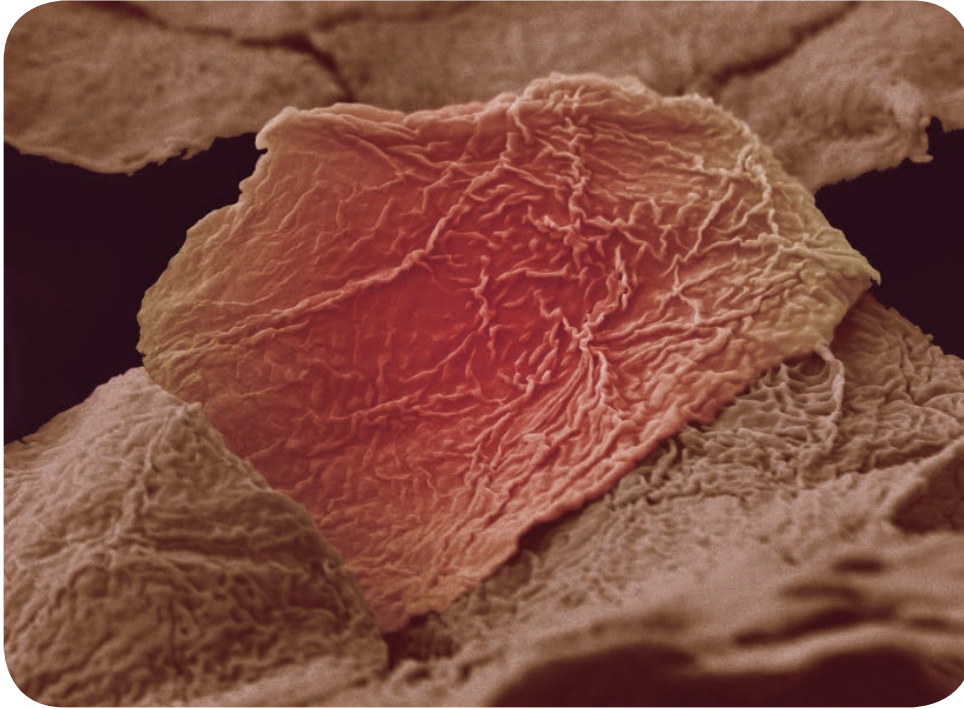
Things to think about

Stem cells could be used to test new drugs in the lab. Scientists could:

1. Use stem cells to grow a lot of specialized cells in the lab, for example brain, liver or blood cells.
2. Take a new drug that they want to test and add it to the specialized cells.
3. Look carefully at what the drug does to the cells. This could help predict what the drug might do in a patient.

This kind of testing might help reduce the need for animal testing.

Stem cells in treatments now



Stem cells in treatments now

What the photo shows

Skin cells from a patient who has been burned.

Things to think about

Stem cells are already used to treat patients. For example, stem cells are used to make skin grafts for people with very bad burns.

Patients who have lost most of their skin would die without a skin graft. Doctors can save them using stem cells. What they do is:

1. Take a few stem cells from a tiny unburned part of the patient's body.
2. Use the stem cells to grow new skin in the lab.
3. Put the new skin back onto the patient. The skin is not rejected by the patient's body because it is made from the patient's own cells.

The new skin is not perfect: it cannot grow hair and it has no sweat glands. Scientists are trying to solve this problem now.

New treatments for disease



New treatments for disease

What the photo shows

Diabetes patient injecting herself with insulin.

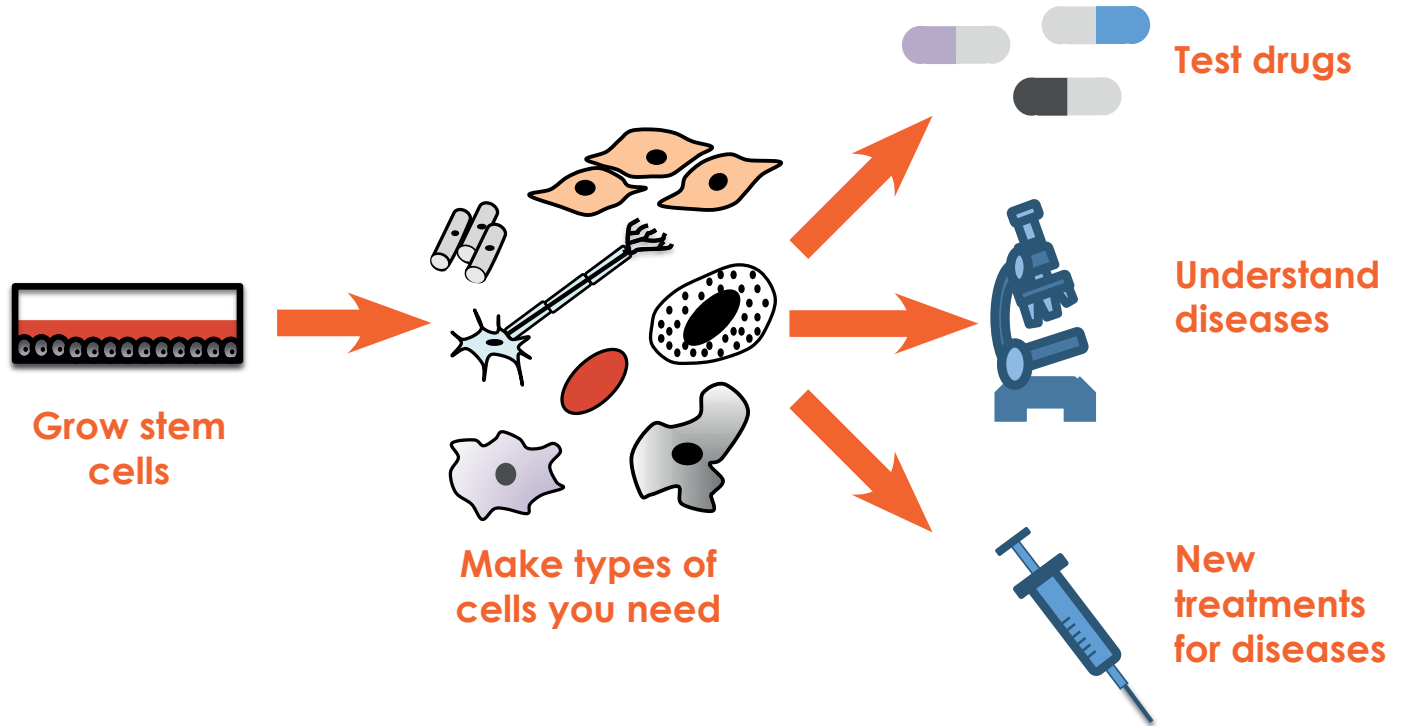
Things to think about

Scientists are trying to find out how to control stem cells. They want to use stem cells to make whatever type of cells we need, when we need them. They hope to cure diseases that we cannot cure today. For example:

- Diabetes – grow new insulin-producing cells for the patient's pancreas.
- Parkinson's or Alzheimer's disease – grow cells to replace damaged cells in the brain.
- Liver disease – grow cells for an artificial liver machine that could do the work for a patient's own liver until it recovers from its disease.
- And perhaps many more!

One day stem cells might even be used to grow new organs for patients who need a transplant. This would be very difficult to do. Organs like your heart, liver or lungs have complicated three-dimensional shapes and contain lots of different types of cells.

How stem cells could be used



All about stem cells

Your task

Look at the cards you have been given and read the information.

Make a poster or presentation to explain the most important facts to other students in your class. Your poster or presentation **MUST** answer all the questions below.

Questions

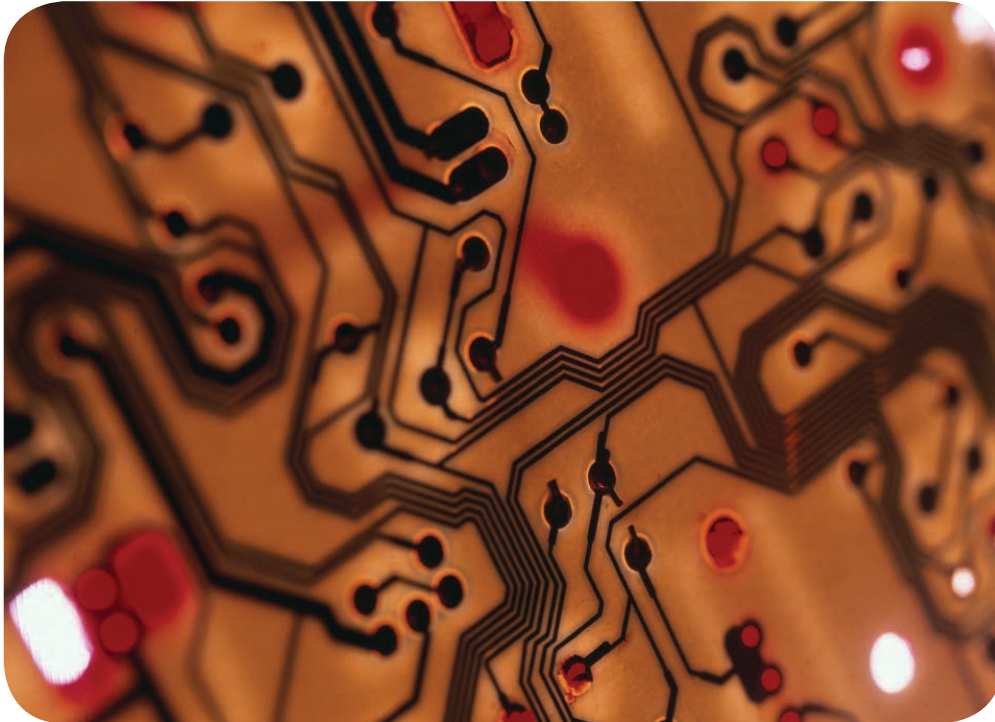
1. How are stem cells used to treat patients now?
2. How might stem cells be used to treat patients in the future?
3. How else could stem cells be used?
(Hint: Two ways are described on the cards. You can add more ideas of your own if you wish.)

Hints and tips for posters

- Write headings on your poster to help people find the most important points.
- Draw or stick the photos and diagrams onto your poster. You don't have to use them all if you don't want to.
- Write short notes, lists, labels or headings to explain the pictures and diagrams.
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- **Do not** write out all the information from the cards onto the poster. People need to see quickly and easily what your poster is about.

All about stem cells

Reprogramming cells



Paul Griggs / Wellcome Images

Reprogramming cells

What the photo shows

Silicon chip.

Things to think about

Making induced pluripotent stem (iPS) cells is like turning back time. Scientists make specialized skin cells behave like embryonic stem cells.

How do scientists make iPS cells?

To make iPS cells, scientists add certain genes to skin cells. Genes are the cell's instructions. The new genes tell the iPS cells to behave like embryonic stem cells.

Genetic reprogramming

Making iPS cells is a bit like changing the instructions in a computer programme. The new instructions make the computer do a new task. In iPS cells, new genes make the cells do what embryonic stem cells do.

So, scientists say they have reprogrammed skin cells to become stem cells. They call the process used to make iPS cells 'genetic reprogramming'.

iPS cells in medicine



Adrian Wressell / Wellcome Images

iPS cells in medicine

What the photo shows

Surgeon performing an operation.

Things to think about

Scientists hope that one day induced pluripotent stem cells (iPS cells) could help treat diseases like diabetes, Parkinson's, muscle diseases or heart disease.

Scientists hope to:

1. Take skin cells from a patient.
2. Make iPS cells from the skin cells.
3. Use the iPS cells to grow new healthy cells to replace the patient's damaged ones, e.g. brain, heart, muscle or insulin-producing cells.
4. Put the new cells into the patient. These cells would be made from the patient's own skin cells so the body would not reject them.

There is a long way to go before we can do this, but iPS cells are an exciting discovery.

No need for embryos?



Jenny Nichols / Wellcome Images

No need for embryos?

What the photo shows

Human blastocyst (a very early stage embryo).

Things to think about

In 2007, scientists discovered a way to make human stem cells in the lab. They took human skin cells and turned them into stem cells.

The new stem cells are called induced pluripotent stem cells (iPS cells). They are just like embryonic stem cells and can make all the different kinds of cells in the body.

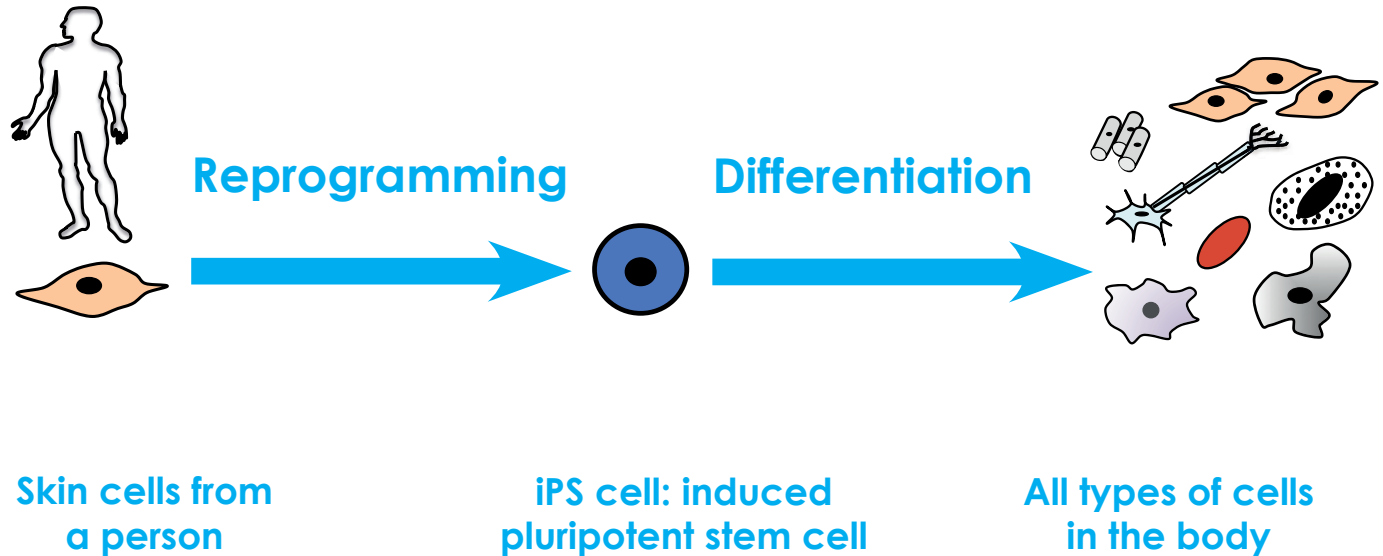
Do we still need embryos for research?

Some people think it is wrong to use embryos in research. Scientists do not need embryos to make iPS cells. But they would never have discovered iPS cells if they had not studied embryonic stem cells first.

iPS cells are a very new discovery. Scientists still need to study embryonic stem cells to:

- help them understand how iPS cells and other stem cells work
- learn about how we develop from a fertilized egg into a baby.

Turning skin cells into stem cells



All about stem cells

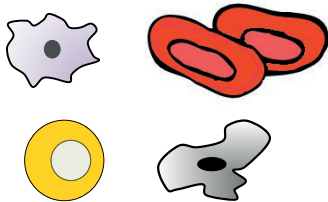
What does *pluripotent* mean?

Stem cell scientists use particular words to describe what stem cells can do.

Multipotent

Multi = more than one
Potent = powerful

Multipotent stem cells have the power to make several types of specialized cells.

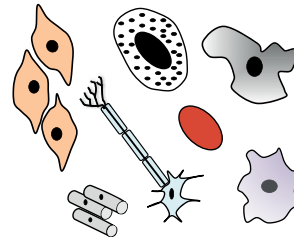


Tissue stem cells are multipotent.

Pluripotent

Pluri = many
Potent = powerful

Pluripotent stem cells have the power to make ALL types of specialized cells in the body.



Embryonic stem cells are pluripotent.

All about stem cells

Your task

Look at the cards you have been given and read the information.

Make a poster or presentation to explain the most important facts to other students in your class. Your poster or presentation **MUST** answer all the questions below.

Questions

1. What are iPS cells and what does the name 'iPS' mean? (Hint: Explain how iPS cells are made and what they can do. What other kind of stem cell are they like?)
2. How could iPS cells be used?
3. Do we still need embryos for research? (Hint: Explain whether scientists can learn anything by studying embryos, then add some of your own opinions if you wish.)

Hints and tips for posters

- Write headings on your poster to help people find the most important points.
- Draw or stick the photos and diagrams onto your poster. You don't have to use them all if you don't want to.
- Write short notes, lists, labels or headings to explain the pictures and diagrams.
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All about stem cells

Activity overview

Students aged 16+ work in groups to prepare presentations to inform their classmates about a particular aspect of stem cell science.

Learning objectives

All students:

- Understand that stem cells can both self-renew and differentiate, unlike specialised cells
- Understand that there are different types of stem cells, and describe some key features of tissue and embryonic stem cells
- Consider the potential applications of stem cell research, including the use of cells in therapy, drug testing and disease modelling
- Consider induced pluripotent stem cells as an example of new technology and discuss their potential applications

Timing

1.5 to 2 lessons (95 to 120 mins). **OR** may be adapted to create a shorter lesson or extended project.

Materials per group of 3-4 students

- A set of cards from one of the four themes (one of each provided; photocopy as needed):
 1. **What is a stem cell?** What stem cells can do; types of stem cell
 2. **Where do embryonic stem cells come from?** The blastocyst; cell culture; IVF
 3. **Why bother with stem cells?** Applications now and in the future
 4. **Making stem cells** Induced pluripotent stem cells (iPS cells); students working on this theme may need more time and/or support
- A Questions card
- Poster-making materials or access to computers with PowerPoint (optional)

Lesson plan

Introduction

Briefly introduce key concepts: What is a stem cell and how are stem cells different from specialized cells? What types of stem cell are there? How might stem cells be used? You could use the 15-min film, *A Stem Cell Story* available online at www.eurostemcell.org/films or order a DVD.

20 mins

Group work preparing presentations

Students prepare a 5-minute presentation explaining the key points on a set of activity cards from one theme. Their presentation MUST answer the three questions on the *Your task* card. Every member of the group must deliver part of the presentation. Photocopied cards could be cut up and glued onto large sheets to make posters to be used in the presentations. Or ask students to prepare a PowerPoint for presentation next lesson. **Less able students:** Download worksheets from www.eurostemcell.org/toolkititem/all-about-stem-cells to provide a structure for the presentation or poster. **More able students:** Ask students to set their own questions about their topic to test their classmates.

30-45 mins

Talk stem cells

While each group presents their theme, the class listens and tries to write down answers to the relevant questions on the *Questions* card.

30-40 mins

Plenary

Go through the answers to the questions as a class. You could run this as a competition, with groups working as teams to answer the questions and mark each others' answers.

15 mins

Questions

What is a stem cell?

1. Why are stem cells special? Name 2 things they can do.
2. Why do our bodies need stem cells?
3. Name 2 kinds of stem cell.

Where do embryonic stem cells come from?

4. What stage of human development do embryonic stem cells come from?
5. What is IVF?
6. What technique do scientists use to grow cells in the lab?

Why bother with stem cells?

7. Give an example of how stem cells are used to treat patients now.
8. What diseases might stem cells help us treat in the future?
9. Give 2 other ways we could use stem cells.

Making stem cells

10. What kind of stem cell is an iPS cell like?
11. Name one way iPS cells could be used.
12. Do we still need embryos for research?

All about stem cells

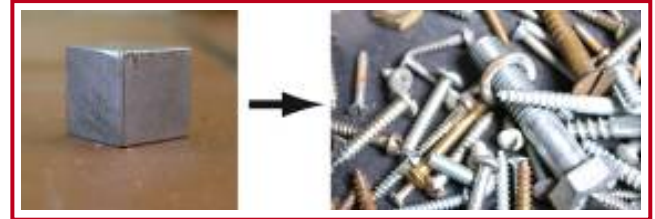
All about stem cells

Worksheets (optional)

Stem cells are special because...

...they can

1. _____



AND

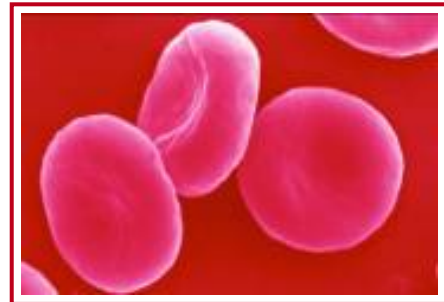
2. _____



Our bodies need stem cells to...

...replace cells that:

- _____
- _____



Some cells in your body are replaced a lot,

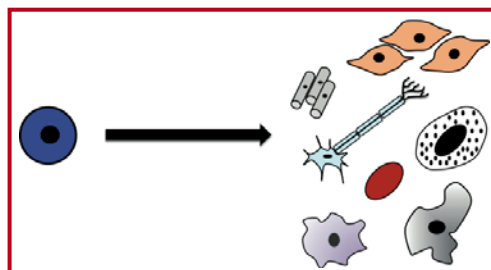
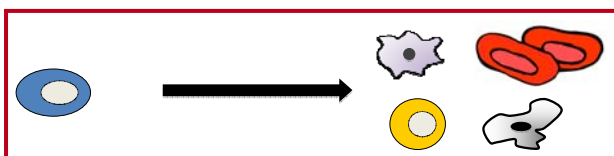
e.g. _____

In many parts of your body, you only need new cells from time-to-time, e.g. _____

There are different kinds of stem cells...

can make all types of cell in your body

can make a few particular types of cell



Where do embryonic stem cells come from?

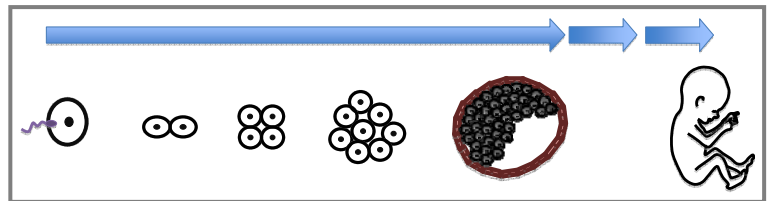
16+ worksheet

All about stem cells

Embryonic stem cells come from...

...a very early stage of human development

called a _____



A _____ is a ball of around 100 cells.

The one in the picture is _____ days old.

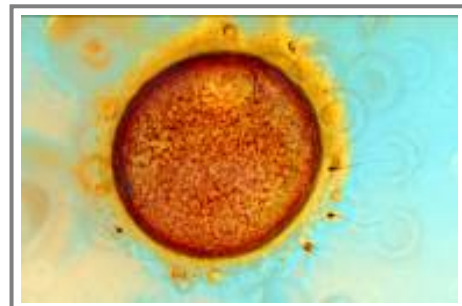


Scientists use embryonic stem cells from...

...IVF embryos.

IVF stands for _____

It is a technique used to _____



In the UK, couples can donate left over IVF embryos for research if they wish.

Scientists grow cells in the lab...

... using a technique called _____



The cells are put in a flask with the nutrients they need to survive.

The nutrients and temperature are carefully controlled to:

- _____
- _____



Stem cells are used to treat patients now...

...for example, we can use stem cells to grow new skin for people who are badly burned.

The skin is not perfect because it:

- _____
- _____



Stem cells could be used in new treatments...

...for diseases we cannot cure today. Scientists hope to use stem cells to grow new, healthy cells for patients with diseases like

- _____
- _____
- _____



They could also be used for ...

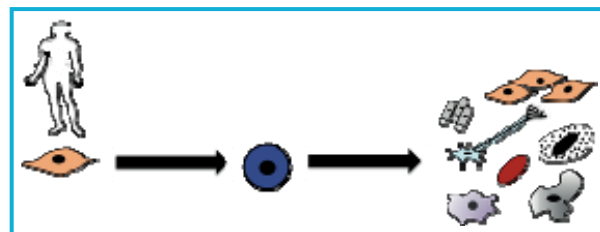


iPS cells are made in the lab...

...from normal cells in the body, for example skin cells.

iPS stands for _____

iPS cells behave just like _____ stem cells.



The process used to make iPS cells is called

genetic _____

New genes are added to skin cells to turn them into iPS cells.



iPS cells could be used in medicine...

...to grow new, healthy cells to treat diseases like

- _____
- _____
- _____



We don't need embryos to make iPS cells...

...so people who think embryos should not be used in research are very pleased.

BUT scientists still need to study embryonic stem cells to:

- _____
- _____



All about stem cells

Poster templates (optional)

What is a stem cell?

All about stem cells

Stem cells are special because they can...

1. _____

AND

2. _____

Our bodies need stem cells to...

...replace cells that:

- _____
- _____

Some cells in your body are replaced a lot,

e.g. _____

In many parts of your body, you only need new cells from time to time, e.g. _____

There are different kinds of stem cells...

_____ can make all types of cell in your body

_____ can make a few particular types of cell

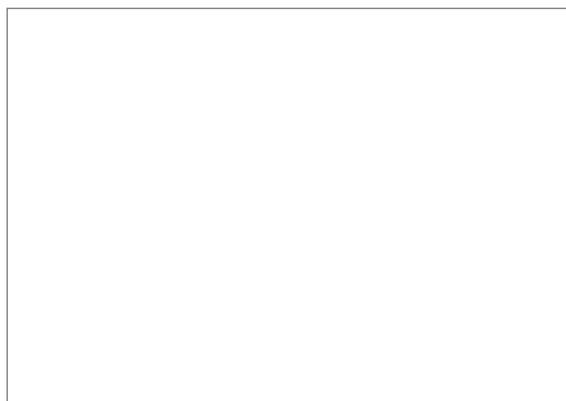
Where do embryonic stem cells come from?

16+ poster

All about stem cells

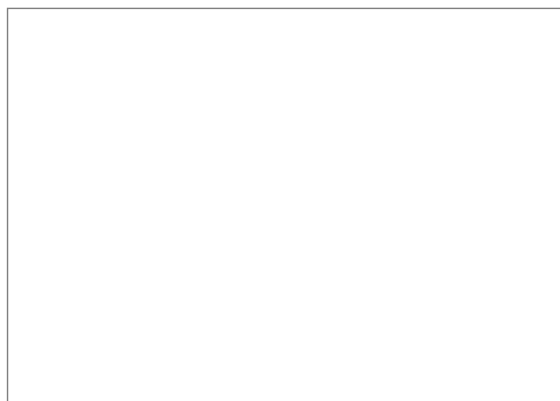
Embryonic stem cells come from...

...a very early stage of human development called a



A _____ is a ball of around 100 cells.

The one in the picture is _____ days old.

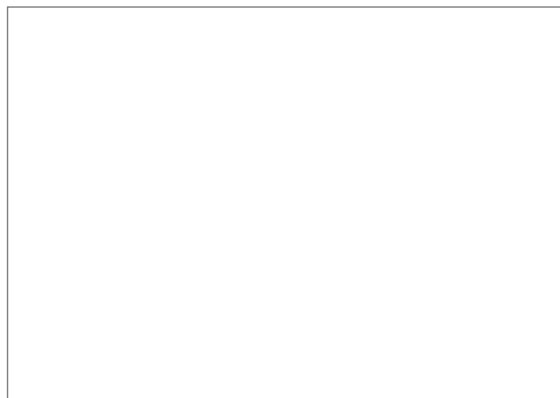


Scientists use embryonic stem cells from...

...IVF embryos.

IVF stands for _____

It is a technique used to _____



In the UK, couples can donate left over IVF embryos for research if they wish.

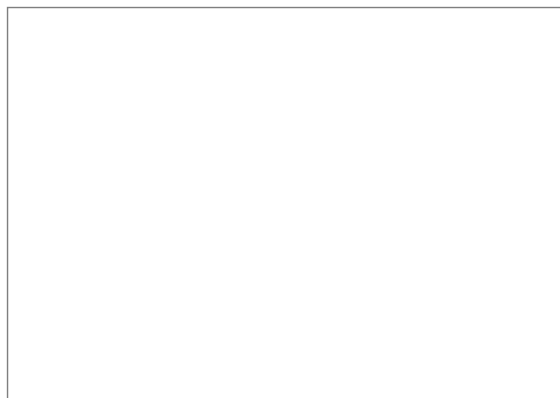
Scientists grow cells in the lab ...

... using a technique called _____

The cells are put in a flask with the nutrients they need to survive.

The nutrients and temperature are carefully controlled to:

- _____
- _____



Why bother with stem cells?

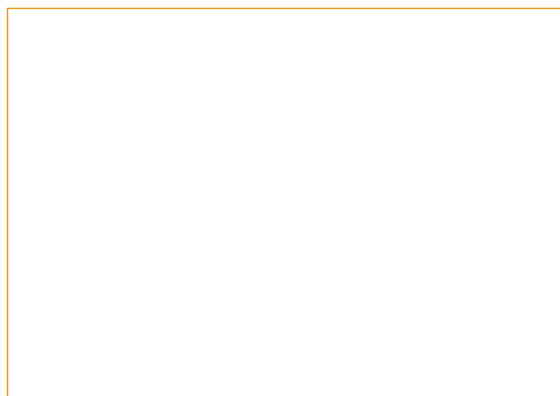
All about stem cells

Stem cells are used to treat patients now...

...for example, we can use stem cells to grow new skin for people who are badly burned.

The skin is not perfect because it:

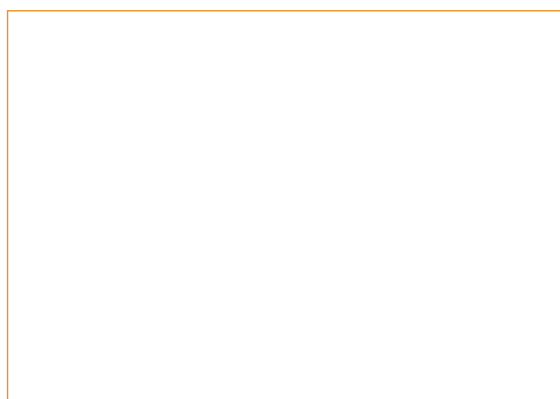
- _____
- _____



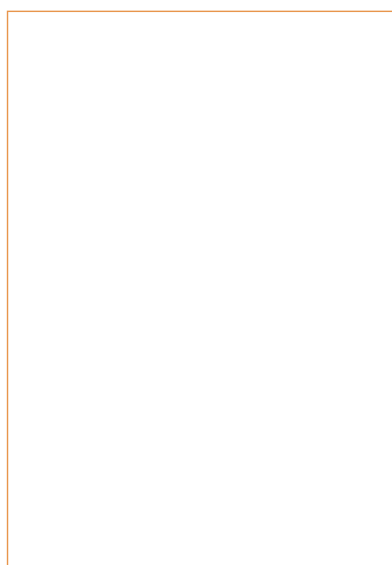
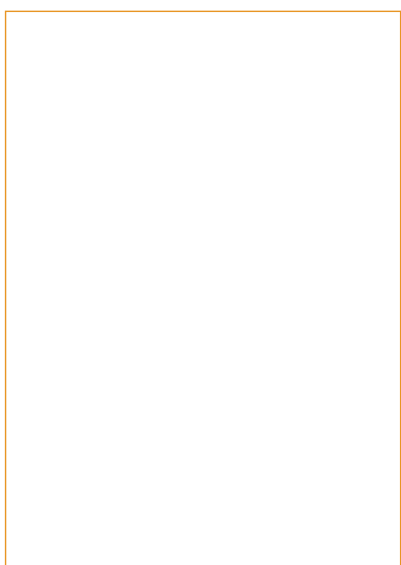
Stem cells could be used in new treatments...

...for diseases we cannot cure today. Scientists hope to use stem cells to grow new, healthy cells for patients with diseases like

- _____
- _____
- _____



Stem cells could also be used for ...



Making stem cells

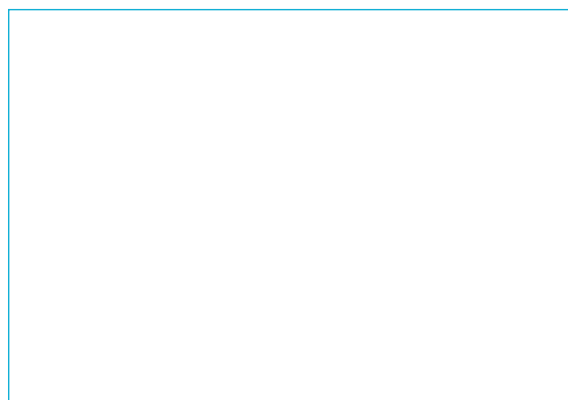
All about stem cells

iPS cells are made in the lab...

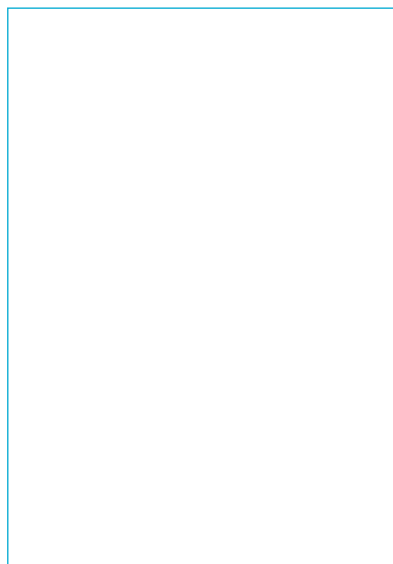
...from cells in the body, e.g. skin cells.

iPS stands for _____

iPS cells behave just like _____
stem cells.



The process used to make iPS cells is called genetic _____

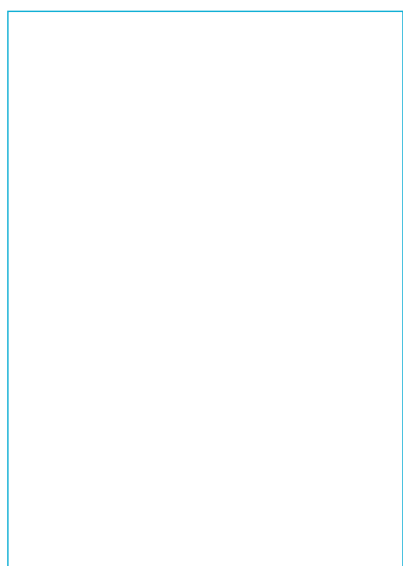


New genes are added to skin cells to turn them into iPS cells.

iPS cells could be used in medicine...

...to grow new, healthy cells to treat diseases like

- _____
- _____
- _____



We don't need embryos to make iPS cells...

...so people who think embryos should not be used in research are very pleased.

BUT scientists still need embryonic stem cells to:

- _____
- _____

