Stem cells

4.1.2.3 · Cell biology · revision notes

What stem cells are, where they are found in embryos, adults and plants, and how they could be used in medicine and to clone plants. Expect recall questions and a longer 'evaluate' question weighing up benefits, risks and ethical issues.

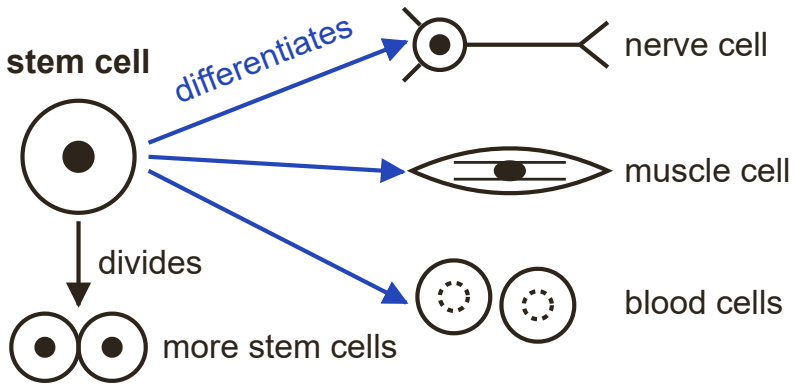
Key facts

- Stem cell: an undifferentiated cell that can make more cells of the same type and can differentiate into other types
- Adult bone marrow stem cells: form many types of cell, including blood cells
- Therapeutic cloning: embryo with the patient's genes, so the stem cells are not rejected
- Risks and issues: viral infection; ethical and religious objections
- Embryonic stem cells: can form most types of human cell
- Meristems (root and shoot tips): can form any type of plant cell, throughout the plant's life
- Possible treatments: diabetes, paralysis
- Meristem cloning: fast and cheap; protects rare species; copies crops with useful features

Notes

What stem cells are

- A **stem cell** is an undifferentiated cell. It can divide to make many more cells of the same type, and other types of cell can form from it by differentiation.



Stem cells are undifferentiated: they can divide, and they can differentiate into other types of cell.

- **Embryonic stem cells** (from human embryos) can be cloned and made to differentiate into most types of human cell.
- **Adult stem cells**, e.g. from bone marrow, can form many types of cell, including blood cells, but fewer types than embryonic stem cells.
- **Meristem** tissue in plants (at the tips of roots and shoots) can differentiate into any type of plant cell, throughout the life of the plant.

Uses in medicine

- Treatment with stem cells may be able to help conditions such as **diabetes** (replacing insulin-producing cells) and **paralysis** (replacing damaged nerve cells).
- In **therapeutic cloning**, an embryo is produced with the same genes as the patient. Stem cells from this embryo are not rejected by the patient's body, so they may be used for medical treatment.
- Adult stem cells from bone marrow are already used, e.g. in bone marrow transplants to treat some blood cancers.

Risks and issues

- Stem cells grown in a laboratory could be infected with a virus, which would then be passed to the patient.
- Some people have **ethical or religious objections**: embryos are destroyed to collect the stem cells, and some believe an embryo has a right to life.
- Treatments are still being researched and may not work. Cells that keep dividing could also form a tumour.
- Adult stem cells raise fewer objections (no embryo is destroyed) but can form fewer types of cell.

Plant meristems

- Meristem cells can be used to produce **clones** of plants quickly and economically.
- Rare species can be cloned to protect them from extinction.
- Crop plants with special features, such as disease resistance, can be cloned to produce large numbers of identical plants for farmers.
- Because the clones are genetically identical, a new disease that affects one plant could affect them all.
  Grade 7+ only

How to answer each type of question

Compare stem cells from different sources 1 to 2 marks **Grade 4**

1. State which cells each type of stem cell can form.
2. Write it as a comparison, using 'but' or 'whereas'.

Example. Give **one** difference between stem cells from a human embryo and stem cells from adult bone marrow.

Model answer. Embryonic stem cells can differentiate into most types of human cell, whereas adult bone marrow stem cells can form fewer types, such as blood cells (1).

Give reasons for cloning plants from meristems 2 to 3 marks **Grade 5**

1. Speed and cost: clones are produced quickly and economically.
2. Conservation: rare species can be saved from extinction.
3. Crops: every clone has the same useful feature, e.g. disease resistance.

Example. Give **two** reasons why plant growers use meristem tissue to clone plants.

Model answer.

Any two from:

large numbers of plants can be produced quickly	(1)
it is cheap / economical	(1)
all the plants have the same desired features, e.g. disease resistance	(1)
rare species can be protected from extinction	(1)

Explain why cells from therapeutic cloning are not rejected 2 marks **Grade 5**

1. Say that the embryo, and so the stem cells, have the same genes as the patient.
2. Say that the patient's body therefore does not reject the cells.

Example. Explain why stem cells produced by therapeutic cloning would not be rejected by the patient.

Model answer. The embryo / stem cells have the same genes as the patient (1), so the patient's immune system does not recognise the cells as foreign and does not reject them (1).

6-mark: evaluate the use of stem cells 6 marks (level of response) **Grade 7**

1. Give the benefits: possible treatments, better quality of life, no rejection with therapeutic cloning.
2. Give the risks: viral infection, treatment may not work, possible tumours.
3. Give the ethical and religious issues: embryos are destroyed.
4. Finish with a conclusion that weighs up both sides and gives a reason.

Example. Scientists hope to use embryonic stem cells to treat people who are paralysed after a spinal injury.
Evaluate the use of embryonic stem cells to treat paralysis.

Model answer.

Model answer: Embryonic stem cells can differentiate into most types of human cell, including nerve cells, so they could replace the damaged nerve cells and give patients back some movement and a better quality of life. If therapeutic cloning is used, the embryo has the same genes as the patient, so the new cells would not be rejected. However, the treatment is still being researched and may not work. Stem cells grown in a laboratory could be infected with a virus that would be passed to the patient, and cells that keep dividing could form a tumour. Many people have ethical or religious objections, because embryos are destroyed to collect the stem cells and some believe an embryo has a right to life. Adult stem cells avoid this problem but cannot form as many types of cell. Overall, the treatment could greatly improve patients' lives, but it should only be used once trials show that it is safe and works.
Level 3 (5 to 6 marks): benefits, risks and ethical issues all described, with a conclusion supported by a reason.
Level 2 (3 to 4 marks): at least one benefit and one risk or ethical issue described, with little or no conclusion.
Level 1 (1 to 2 marks): one or two simple relevant points.

Don’t lose marks

- Saying adult stem cells can become any type of cell. Bone marrow stem cells form only some types, such as blood cells.
- Saying stem cells are 'specialised'. They are undifferentiated.
- Saying therapeutic cloning produces a baby. It produces an embryo as a source of stem cells.
- Writing a one-sided answer to an 'evaluate' question, with no risks or no conclusion.
- Giving vague ethical points, such as 'it is wrong'. Say why: embryos are destroyed, and some believe an embryo has a right to life.

More tips

Memory tricks

- Three sources of stem cells: Embryos, Adult bone marrow, Meristems ('EAM').
- Stem cell uses in medicine: think 'D and P': Diabetes and Paralysis.
- Evaluate = both sides + a conclusion. No conclusion, no top level.

Exam technique

- In 6-mark 'evaluate' questions, plan quickly: benefits, risks, ethics, conclusion.
- Use the words 'undifferentiated' and 'differentiate' when you describe stem cells.
- If the question is about plants, write about meristems and cloning, not embryos.

What each grade needs

What you need to be able to do, from the first marks up to the top grade.

Grade 3

State what a stem cell is

An undifferentiated cell that can make more cells of the same type and can differentiate into other types of cell.

Grade 4

Name where stem cells are found

In embryos, in adult bone marrow, and in the meristems of plants.

Grade 5

Compare embryonic and adult stem cells

Embryonic stem cells can become most types of human cell; adult bone marrow stem cells form fewer types, including blood cells.

Grade 5

Describe uses of meristem cloning

Making clones quickly and cheaply, saving rare species, and producing crops with useful features.

Grade 5

Describe therapeutic cloning and its advantage

An embryo is made with the same genes as the patient, so its stem cells are not rejected.

Grade 7

Evaluate the use of stem cells

Weigh possible treatments against risks such as viral infection, and against ethical or religious objections, then give a conclusion.

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