Cell biology

Model answers and marking points

GCSE science 6-mark questions

This topic online

1 Priya looks at two samples under a microscope. Sample A is a cell scraped from the inside of her cheek. Sample B is a bacterium from yoghurt.

Compare the structure of the cheek cell with the structure of the bacterial cell. (6 marks)

Model answer

Both cells have a cell membrane that controls what enters and leaves, cytoplasm where chemical reactions happen, and ribosomes where proteins are made.

The cheek cell is a eukaryotic cell, so its genetic material is kept inside a nucleus. The bacterium is a prokaryotic cell and has no nucleus. Instead its DNA is a single loop that lies free in the cytoplasm, and it may also have extra small rings of DNA called plasmids, which the cheek cell does not have.

The bacterium is surrounded by a cell wall outside its membrane, but the cheek cell is an animal cell and has no cell wall. The cheek cell contains mitochondria for aerobic respiration, whereas the bacterium has no mitochondria.

The two cells are also very different in size. The bacterium is much smaller, only a few micrometres long, while the cheek cell is roughly ten times bigger or more. This is why Priya would need a higher magnification to see any detail inside the bacterium.

Marking points (credit any 6 relevant points, linked in a sensible order)

- both cells have a cell membrane
- both cells have cytoplasm
- both cells have ribosomes
- the cheek cell has a nucleus; the bacterium has no nucleus
- in the bacterium the genetic material is a single loop of DNA free in the cytoplasm
- the bacterium may also have small rings of DNA called plasmids; the cheek cell does not
- the bacterium has a cell wall; the cheek cell has no cell wall
- the cheek cell has mitochondria; the bacterium does not
- the bacterium is much smaller, roughly 1 to 10 micrometres compared with roughly 10 to 100 micrometres
- the cheek cell is eukaryotic and the bacterium is prokaryotic

How it is marked

- 5-6 marks: gives both similarities and several differences, each difference stated for both cells, including where the DNA is found in each.
- 3-4 marks: gives a few correct differences, but some only describe one of the cells, or similarities are missing.
- 1-2 marks: lists one or two structures in one cell with little or no direct comparison.

What loses marks

- saying bacteria have no DNA rather than no nucleus
- listing parts of one cell only without saying what the other cell has
- giving the cheek cell a cell wall or chloroplasts

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2 A research team is looking at ways to treat a condition in which cells in the pancreas stop working. They are considering three sources of stem cells.

Source	Information
Early embryo left over from fertility treatment	Can become any type of cell. Cells come from another person, so may be rejected.
Patient's own bone marrow	Can only become a few types of cell. No rejection.
Embryo made by therapeutic cloning using the patient's own body cell	Can become any type of cell. No rejection. Process is difficult and expensive.

Evaluate the use of each source of stem cells for this treatment. Give a justified conclusion. (6 marks)

Model answer

Stem cells from a leftover embryo can turn into any type of cell, so they could make new pancreas cells. However, they come from a different person, so the patient's immune system may attack them and the patient would need drugs to stop rejection. Some people also think it is wrong to use embryos because they could have grown into a baby.

Bone marrow stem cells from the patient would not be rejected because they have the patient's own genes, and no embryo is destroyed. The problem is that they can only become a few types of cell, so they might not be able to form pancreas cells at all.

Therapeutic cloning makes an embryo with the patient's own genes, so the cells can become pancreas cells and will not be rejected. But it still involves destroying an embryo and it is difficult and expensive. All stem cell treatments carry a risk, for example of passing on a viral infection.

Overall I think therapeutic cloning is the best choice, because it is the only source that can make the right cells without rejection. The cost and ethical concerns are drawbacks, but the treatment would actually work.

Marking points (credit any 6 relevant points, linked in a sensible order)

- embryonic stem cells can differentiate into any type of cell, so could form pancreas cells
- cells from a donor embryo are not genetically identical to the patient, so the immune system may reject them
- rejection means the patient may need drugs to suppress the immune system
- some people object to using embryos because the embryo could have developed into a person
- adult bone marrow stem cells give no rejection and no embryo is destroyed
- bone marrow stem cells can only form a limited range of cells, so may not form pancreas cells
- therapeutic cloning gives cells with the same genes as the patient, so no rejection
- therapeutic cloning still creates and destroys an embryo, and is costly and difficult
- risk with any stem cells, such as infection from contaminated cells or uncontrolled cell division
- a justified conclusion weighing effectiveness against ethics and cost

How it is marked

- 5-6 marks: weighs a benefit and a drawback for all three sources, using the table and own knowledge, and reaches a conclusion that follows from the points made.
- 3-4 marks: gives benefits or drawbacks for at least two sources, or a conclusion with only limited support.
- 1-2 marks: copies information from the table with little evaluation and no clear conclusion.

What loses marks

- giving a conclusion with no reason, or one that contradicts the points made
- saying bone marrow cells can become any cell
- ignoring ethical issues completely

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3 Early scientists used light microscopes to study cells. Since the 1930s, electron microscopes have also been used.

Explain how the development of the electron microscope has improved our understanding of cells. (6 marks)

Model answer

A light microscope uses light to form an image, but an electron microscope uses a beam of electrons. This gives the electron microscope a much higher magnification, so structures can be made to look far bigger.

More importantly, it has a much higher resolution. Resolution is the ability to tell apart two points that are very close together, so a higher resolution means much finer detail can be seen instead of a blur.

Because of this, scientists could see sub-cellular structures that are too small for a light microscope. For example, ribosomes can only be seen with an electron microscope. They could also see the inside of mitochondria and chloroplasts, including their folded internal membranes. This helped scientists work out how the structure of each organelle relates to its job, such as where respiration and photosynthesis happen.

Electron microscopes also allowed bacteria to be studied in detail and made it possible to see viruses for the first time, which helped explain how some diseases are caused.

Marking points (credit any 6 relevant points, linked in a sensible order)

- a light microscope uses light; an electron microscope uses a beam of electrons
- electron microscopes have a much higher magnification
- electron microscopes have a much higher resolution, so two points close together can be seen separately
- higher resolution means finer detail is visible
- small sub-cellular structures such as ribosomes can only be seen with an electron microscope
- the internal structure of mitochondria and chloroplasts can be seen
- scientists could link the structure of organelles to their function
- very small cells such as bacteria could be studied in detail
- viruses are too small to see with a light microscope but can be seen with an electron microscope

How it is marked

- 5-6 marks: explains that greater magnification and resolution let much smaller structures be seen, and links this to named examples of new knowledge about cells.
- 3-4 marks: states that electron microscopes magnify more or show more detail, with one example, but the link to understanding is weak.
- 1-2 marks: makes a simple statement such as electron microscopes are more powerful.

What loses marks

- saying it just makes things bigger without mentioning resolution
- claiming nuclei or chloroplasts could not be seen at all with a light microscope
- giving no examples of what was discovered

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4 **Higher tier | Separate science only**

Tomasz is studying a species of bacterium in a food safety lab. He grows it in a nutrient broth at two temperatures and records its mean division time.

Temperature in °C	Mean division time in minutes
20	60
37	20

He starts each culture with 500 bacteria.

Use the data to calculate the number of bacteria in each culture after 4 hours, giving your answers in standard form. Explain what the results show and why food should be kept in a fridge. (6 marks)

Model answer

4 hours = 240 minutes.

At 20 °C:

number of divisions = 240 / 60 = 4

number of bacteria = 500×2^4

= $500 \times 16 = 8000 = 8 \times 10^3$

At 37 °C:

number of divisions = 240 / 20 = 12

number of bacteria = 500×2^{12}

= $500 \times 4096 = 2\,048\,000 = 2.048 \times 10^6$

Bacteria reproduce by binary fission, so the population doubles every time they divide. At 37 °C they divide three times as often, so after 4 hours there are 256 times as many bacteria as at 20 °C. This is because their enzymes work faster as the temperature gets closer to their optimum.

A fridge keeps food at around 4 °C or lower. At this temperature the bacteria divide very slowly, so far fewer are present when the food is eaten and there is less risk of food poisoning.

Marking points (credit any 6 relevant points, linked in a sensible order)

- 4 hours is 240 minutes
- at 20 °C the number of divisions is 240 / 60 = 4
- bacteria after 4 divisions = $500 \times 2^4 = 8000 = 8 \times 10^3$
- at 37 °C the number of divisions is 240 / 20 = 12
- bacteria after 12 divisions = $500 \times 2^{12} = 2\,048\,000 = 2.048 \times 10^6$
- bacteria reproduce by binary fission, so the number doubles each division
- at the higher temperature the bacteria divide faster, so the population is about 256 times larger
- the enzymes in the bacteria work faster nearer their optimum temperature
- a fridge keeps food at about 4 °C or below, so division is very slow
- fewer bacteria means less chance of food poisoning

How it is marked

- 5-6 marks: both calculations correct in standard form with working, plus an explanation of the effect of temperature linked to keeping food cold.
- 3-4 marks: one calculation correct, or both attempted with a slip, with some explanation of the temperature effect.
- 1-2 marks: correct number of divisions found or a simple statement that bacteria grow faster when warm.

What loses marks

- using hours instead of minutes for the division time
- multiplying by the number of divisions instead of raising 2 to that power

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- not giving the answer in standard form
- saying cold kills the bacteria rather than slowing division

5 In hospital, fluid given into a vein through a drip is a salt solution with the same concentration as blood plasma. It is never pure water.

Explain why pure water would damage red blood cells but does not burst plant cells in a garden after heavy rain.

(6 marks)

Model answer

Osmosis is the net movement of water from a dilute solution to a more concentrated solution through a partially permeable membrane.

Pure water is more dilute than the inside of a red blood cell. If it were put into the blood, water would move into the red blood cells by osmosis. Red blood cells are animal cells with only a thin membrane and no cell wall, so they would keep swelling until they burst, which would stop them carrying oxygen. A drip that has the same concentration as plasma causes no net movement of water, so the cells keep their normal shape.

After heavy rain, the water around the roots is also more dilute than the cytoplasm of plant cells, so water enters these cells by osmosis too. However, plant cells have a strong cell wall made of cellulose outside the membrane. As the cell fills, it pushes against the wall, which stops it swelling any further, so it does not burst. Instead the cell becomes turgid, which helps keep the plant upright.

Marking points (credit any 6 relevant points, linked in a sensible order)

- osmosis is the movement of water across a partially permeable membrane
- water moves from a dilute solution to a more concentrated solution
- pure water is more dilute than the cytoplasm of red blood cells
- water would enter the red blood cells by osmosis
- red blood cells have no cell wall, so they swell and burst
- a solution with the same concentration as plasma means no net movement of water, so cells keep their shape
- plant cells also take in water by osmosis when surrounded by water
- the plant cell wall is strong and stops the cell from bursting
- the plant cell becomes firm or turgid, which helps support the plant

How it is marked

- 5-6 marks: explains osmosis in terms of concentration and the membrane, applies it to both cell types and uses the cell wall to explain the difference.
- 3-4 marks: explains that water enters cells by osmosis and that red blood cells burst, but the plant cell explanation is weak or missing.
- 1-2 marks: states that water goes into cells, or that plant cells have a cell wall, with little explanation.

What loses marks

- saying water moves from a low to a high water concentration
- describing salt moving instead of water
- saying the cell membrane rather than the cell wall stops plant cells bursting

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