Producing monoclonal antibodies

4.3.2.1 · Infection and response · revision notes

How scientists make large amounts of one identical antibody by combining mouse lymphocytes with tumour cells to make hybridoma cells. This subtopic is GCSE Biology only (not Combined Science) and Higher tier only. It is often a 4 to 6 mark 'describe' question.

Key facts

- Monoclonal antibodies: identical antibodies from a single clone of cells
- Lymphocyte: makes the antibody but does not divide in the laboratory
- Hybridoma cell = lymphocyte + tumour cell: divides AND makes the antibody
- Specific to one binding site on one protein antigen
- Tumour cell: divides rapidly but does not make the antibody
- Clone a single hybridoma cell → many identical cells → same antibody → collect and purify

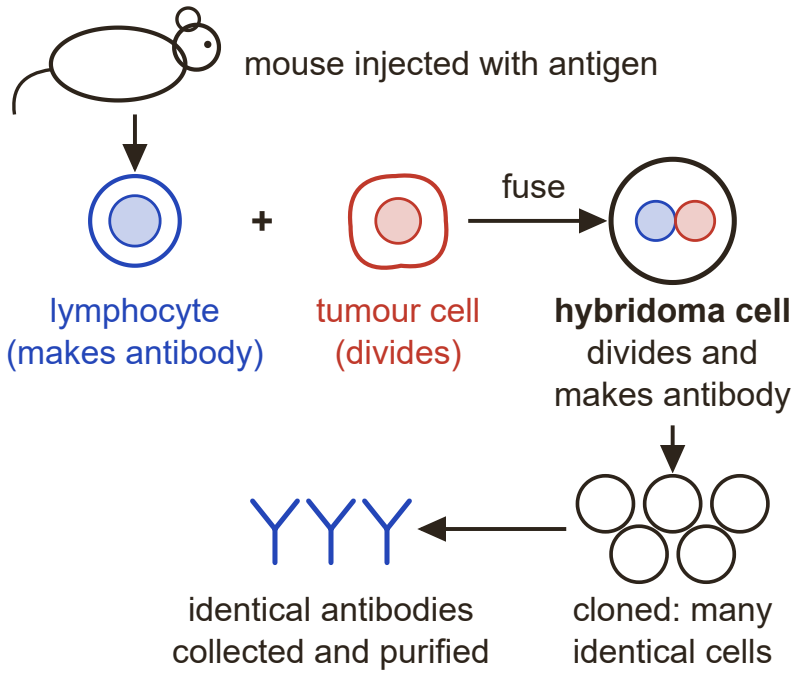
Notes

What monoclonal antibodies are

- **Monoclonal antibodies** are produced from a single **clone** of cells, so they are all identical.
- They are **specific** to one binding site on one protein **antigen**.
- So they can be used to target a **specific chemical** or **specific cells** in the body.

How they are made

- 1. Mouse **lymphocytes** are stimulated to make a particular antibody, by injecting the mouse with the antigen.
- 2. The lymphocytes are removed and combined with a particular kind of **tumour cell** to make a cell called a **hybridoma** cell.
- 3. The hybridoma cell can both **divide** and **make the antibody**.
- 4. A single hybridoma cell that makes the wanted antibody is **cloned** to produce many identical cells, which all produce the same antibody.
- 5. A large amount of the antibody is **collected and purified**.



From mouse to purified monoclonal antibodies.

Why a hybridoma cell?

- Lymphocytes make antibodies, but they do not divide when grown in the laboratory.
- Tumour cells divide rapidly, again and again, but they do not make the antibody.
- Combining them gives a cell with both properties, so huge numbers of cells can be grown, all making the same antibody.

How to answer each type of question

Describe how monoclonal antibodies are produced

4 to 6 marks | **Grade 6**

1. Stimulate mouse lymphocytes to make the antibody (inject the mouse with the antigen).
2. Combine the lymphocytes with tumour cells to make hybridoma cells.
3. Clone a single hybridoma cell to make many identical cells.
4. Collect and purify the antibody. In a 6-mark version, add why the hybridoma is used and why the antibodies are identical.

Example. Describe how monoclonal antibodies are produced. (4 marks)

Model answer. Mouse lymphocytes are stimulated to make a particular antibody, by injecting the mouse with the antigen (1). The lymphocytes are combined with tumour cells to make hybridoma cells (1). A single hybridoma cell is cloned to produce many identical cells (1). These cells all make the same antibody, which is collected and purified (1).

Explain why hybridoma cells are used

2 to 3 marks | **Grade 7**

1. Give the property of the lymphocyte: makes the antibody but does not divide.
2. Give the property of the tumour cell: divides rapidly but does not make antibodies.
3. Say that the hybridoma does both, so a large amount of antibody can be made.

Example. Explain why scientists combine lymphocytes with tumour cells, rather than just growing lymphocytes.

Model answer. Lymphocytes make the antibody but do not divide in the laboratory (1). Tumour cells divide rapidly but do not make antibodies (1). The hybridoma cell can both divide and make the antibody, so a large amount of antibody can be produced (1).

Explain why the antibodies are identical and specific

2 marks | **Grade 7**

1. Say that they come from a clone of one hybridoma cell.
2. So all the cells make the same antibody, which binds to the same binding site on the same antigen.

Example. Explain why all the antibodies produced in this process bind to the same antigen.

Model answer. They are made by a clone of one hybridoma cell, so all the cells are genetically identical (1). So they all make the same antibody, which fits the same binding site on the same antigen (1).

Calculate: growth of a hybridoma culture

2 marks | Grade 7

1. Work out how many doubling times fit into the total time.
2. Multiply the starting number by 2 to the power of the number of doublings.
3. Give the answer in standard form if asked.

Example. A culture starts with 5×10^4 hybridoma cells. The number of cells doubles every 12 hours. Calculate the number of cells after 3 days. Give your answer in standard form.

Model answer. 3 days = 72 hours = 6 doublings, so $5 \times 10^4 \times 2^6$ (1) = 3.2×10^6 cells (1)

Don't lose marks

- Saying the tumour cell makes the antibody. The lymphocyte part does; the tumour part lets the cell divide.
- Leaving out the mouse: the lymphocytes come from a mouse that has been stimulated to make the particular antibody.
- Forgetting the last step: the antibody is collected and purified.
- Writing 'white blood cells' or 'phagocytes' when the answer needs 'lymphocytes'.
- Saying the antibodies are identical because 'they are the same type of cell'. They are identical because they come from a clone of one hybridoma cell.

More tips

Memory tricks

- Hybridoma = 'hybrid' + '-oma' (a tumour): half lymphocyte (makes the antibody), half tumour cell (keeps dividing).
- Four-step story: stimulate → combine → clone → collect and purify.
- 'Mono-clonal' = one clone, so one kind of antibody.

Exam technique

- Learn the key words: lymphocyte, tumour cell, hybridoma, clone, specific, antigen, purified.
- In 'describe' questions, give the steps in order; each correct step is usually worth a mark.
- When explaining why hybridomas are used, give both properties: divides (from the tumour cell) and makes the antibody (from the lymphocyte).

What each grade needs

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

Grade 5 — **Define monoclonal antibodies**
Identical antibodies produced from a single clone of cells, specific to one binding site on one protein antigen.

Grade 5 — **Name the cells that make a hybridoma**
A mouse lymphocyte (which makes the antibody) combined with a tumour cell (which divides rapidly).

Grade 6 — **Describe how monoclonal antibodies are produced**

Stimulate mouse lymphocytes, combine them with tumour cells, clone a single hybridoma cell, then collect and purify the antibody.

Grade 7

Explain why hybridoma cells are used

They can divide, like the tumour cell, and make the antibody, like the lymphocyte.

Grade 7

Explain why monoclonal antibodies are identical

They come from clones of a single hybridoma cell, so all the cells make the same antibody.

Grade 8

Explain how specificity lets antibodies target cells

Each antibody binds only to one binding site on one antigen, so it attaches only to the chemical or cells carrying that antigen.

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