

Monoclonal Antibodies

Mark Scheme



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1. Monoclonal antibodies are artificially produced molecules that are designed to bind to specific targets, such as pathogens or cancer cells. Answer the following questions.
Circle the letter of the correct answer for each.

- a) What type of cell produces monoclonal antibodies?

B – is the only correct answer.	1 mark
	Total: 1 mark

- b) The diagram with the structure labelled A shows a bacterium with proteins on its surface. The diagram labelled B shows proteins made by the human body.

Which row shows the correct combination for destroying the bacterium?

C – is the only correct answer.	1 mark
	Total: 1 mark

- c) Which of the following is **not** a potential use of monoclonal antibodies?

C – is the only correct answer.	1 mark
	Total: 1 mark

- d) Monoclonal antibodies can be used to treat some cancers.

Which property of monoclonal antibodies makes them suitable as a form of treatment?

B – is the only correct answer.	1 mark
	Total: 1 mark

(Total for Question 1 is 4 marks)

2. The body is capable of producing antibodies in response to an antigen.

a) Explain what is meant by the term "monoclonal antibodies"?

An explanation to include the following:	
Antibodies produced from a single <u>clone</u> of cells	1 mark
That are <u>identical</u> / all the same.	1 mark
Accept: are antibodies that bind to / target / specific to a single / one type of antigen.	
	Total: 2 marks

b) Describe one use of monoclonal antibodies in medical treatment.

A description to include one of the following:	
Use: - Treatment of cancer / specific named cancer. - Delivering drugs / radioactive substances / toxins to specific cells / types. - Treat (specific) disease / autoimmune disease / reduce transplant rejection risk.	1 mark
Description: - Bind / attach / target specific antigens / proteins / markers / receptors. - Trigger immune response / killing of cell / phagocytosis. - Block receptors / signals / growth factors (preventing cell growth). - Deliver attached drug / toxin / radioactive substance. - Neutralise a pathogen / toxin.	1 mark
	Total: 2 marks

c) Using the diagram and your own knowledge, explain how monoclonal antibodies are produced.

Marking guidance		
Level	Marks	Descriptor
Level 1	1 - 2	A simple description identifying some relevant points (e.g., inject mouse, get antibodies, cells are mixed). The steps may be isolated or not in a logical sequence. Limited or incorrect use of key scientific terminology.
Level 2	3 - 4	A generally correct description identifying several key steps in the process. Steps are mainly in sequence and logically linked, but the description may lack some detail or clarity in places.
Level 3	5 - 6	A clear and detailed description of the key steps involved in monoclonal antibody production, presented in a logical sequence. Appropriate scientific terminology (e.g., antigen, lymphocyte, myeloma/tumour cell, fuse, hybridoma, clone, monoclonal antibody) is used accurately throughout. Shows clear linkage between the diagram and recalled knowledge.

Indicative content:	
- Mouse/animal injected with antigen/pathogen. - Stimulates lymphocytes / B-cells (to produce antibodies). - Lymphocytes / B-cells are isolated/extracted (from mouse/spleen). - Lymphocytes are fused with tumour cells / myeloma cells. - This produces hybridoma cells. - Hybridoma cells are screened / selected (for desired antibody production). - Selected hybridoma cells are cloned / cultured / allowed to divide. - Large quantities of (identical) monoclonal antibodies are produced/collected.	
	Total: 6 marks

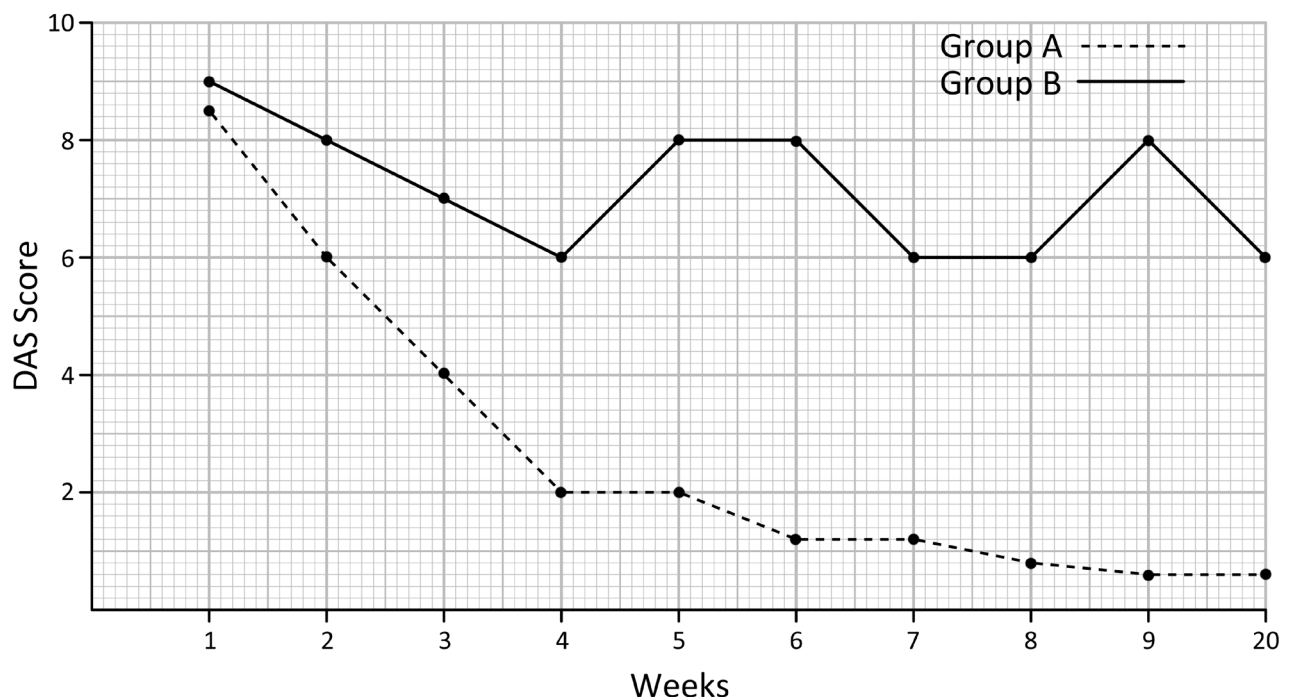
d) Evaluate the advantages and disadvantages of using monoclonal antibodies in medical treatments.

Advantages (Max 3 marks from this section). • (Highly) specific / only target specific cells / antigens / pathogens. • Fewer / less severe side effects than other treatments for example chemotherapy. • Can be used to deliver drugs / toxins / radioactive isotopes (to target cells). • Can trigger the body's immune system (to attack specific cells / pathogens). • Wide range of potential applications / treat different diseases.	
Disadvantages (Max 3 marks from this section). • Can cause side effects / adverse reactions / immune response. • Expensive / high cost (to produce / for treatment). • Time-consuming / difficult / complex to produce. • May require multiple / repeated treatments / infusions. • Ethical concerns related to use of animals (mice) in production	
	Total: 4 marks

(Total for Question 2 is 14 marks)

3. A group of scientists are investigating the effectiveness of a new monoclonal antibody (mAb-X) in treating rheumatoid arthritis, an autoimmune disease that causes inflammation in the joints.

The mean DAS scores for each group are recorded over a 10 week period and shown in the graph below.



a) Describe the trend in the mean DAS score for both Group A and Group B over the 10 week period?

A description to include one of the following:	
For Group A mean <u>DAS score decreases</u> (over the period).	1 mark
Accept: shows improvement / gets better / goes down / significant decrease	
For Group B mean DAS score fluctuates / shows little overall change / decreases less.	1 mark
	Total: 2 marks

- b) Based on the data in the graph, what conclusions can be made about the effectiveness of mAb-X in treating rheumatoid arthritis? Explain your reasoning.

An explanation to include the following:	
Conclusion: mAb-X is effective / reduces disease activity / improves rheumatoid arthritis symptoms	1 mark
Reasoning Point 1: (Evidence from Group A): Because the mean DAS score for Group A decreased (significantly). Accept: went down / got lower / showed improvement. Reference to specific values optional e.g., 'decreased from 8.4 to 0.8'	1 mark
Reasoning Point 2: (Comparison with Group B) This decrease was (much) greater than in Group B. Accept: Group B's score remained high / fluctuated / decreased much less / did not decrease significantly.	1 mark
	Total: 3 marks

- c) Suggest **one** reason why the mean DAS score in Group B (placebo) decreased slightly over the 10-week period, even though they did not receive the monoclonal antibody treatment.

An answer to include one of the following:	
<u>Placebo effect.</u> Accept: Patients believed they were getting treatment / psychological effect / felt better because they were in the trial / expectation bias	1 mark
The standard rheumatoid arthritis medication they were taking was working.	1 mark
Lifestyle changes associated with being in a trial. Accept: Taking better care of themselves / feeling monitored improved things slightly	1 mark
	Total: 1 mark

- d) Identify **one** ethical consideration that scientists should consider when conducting clinical trials of new medical treatments like mAb-X.

Identifies any one of the following:	
• Patient safety / minimising harm • Confidentiality. Accept: Keeping patient data private. • Potential risks vs potential benefits.	1 mark
	Total: 1 mark

- e) Monoclonal antibody technology can also be used in pregnancy tests and in the treatment of cancer. Explain how monoclonal antibodies are used to test for pregnancy.

An explanation to include the following:	
Test detects a specific hormone / hCG (human chorionic gonadotropin).	1 mark
(Found) in the urine (of a pregnant woman). Accept: wee / pee.	1 mark
Test strip contains monoclonal antibodies specific to hCG; some are mobile / attached to a label / dye / bead.	1 mark
If pregnant (hCG present): Hormone moves up strip and binds to antibodies in the test window / line, causing colour change / line to appear.	1 mark
Mobile antibodies (without hCG attached or spare ones) move up strip and bind to immobilised antibodies in the control window / line, causing colour change.	1 mark
	Total: 4 marks

- f) The use of monoclonal antibodies to treat cancer has advantages over the use of traditional chemotherapy and radiotherapy.

Explain the benefits of using monoclonal antibodies to treat cancer.

An explanation to include three of the following:	
Monoclonal antibodies are specific / only target specific antigens / proteins / markers (on cancer cells).	1 mark
Less / no damage / harm to healthy cells / normal body cells / tissues	1 mark
Fewer / reduced / less severe side effects (than chemo / radiotherapy)	1 mark
Can be used to deliver drugs / toxins / radioactive substances directly to cancer cells	1 mark
	Total: 3 marks

(Total for Question 3 is 14 marks)

4. A person who is living with late stage HIV infection may develop AIDS. Scientists have successfully produced monoclonal antibodies for HIV. The monoclonal antibodies can be used to treat early stage HIV to prevent the development of AIDS.

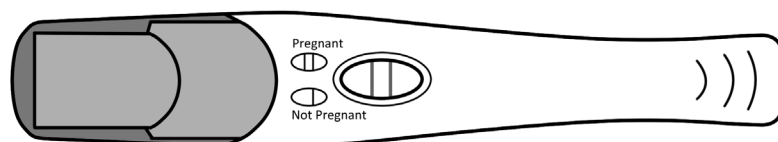
Describe how the monoclonal antibody for HIV can be produced.

Marking guidance		
Level	Marks	Descriptor
Level 1	1 - 2	A simple description identifying some relevant points (e.g., inject mouse, use cells, get antibodies). The steps may be isolated or not in a logical sequence.
Level 2	3 - 4	A generally correct description identifying several key steps in the process. Steps are mainly in sequence and logically linked, but the description may lack some detail or clarity in places. There is some accurate use of scientific terminology
Level 3	5 - 6	A clear and detailed description of the key steps involved in monoclonal antibody production, presented in a logical sequence. Appropriate scientific terminology (e.g., antigen, lymphocyte, myeloma/tumour cell, fuse, hybridoma, clone, monoclonal antibody) is used accurately throughout.

Indicative content:	
- Inject mouse / animal with HIV antigen / protein / inactivated HIV (HIV antigen) stimulates lymphocytes / B-cells (in mouse) to produce anti-HIV antibodies - Isolate / extract / collect lymphocytes / B-cells (from mouse / spleen) - Fuse lymphocytes / B-cells with tumour cells / myeloma cells - Produces hybridoma (cells) - Select / screen hybridoma cells that produce the specific antibody against HIV - Clone / culture the (selected) hybridoma cells (Hybridoma cells) produce / release large quantities of the monoclonal antibodies (specific to HIV) - Antibodies are collected / harvested / purified.	
	Total: 6 marks

(Total for Question 4 is 6 marks)

5. Pregnancy tests commonly use monoclonal antibodies.
The figure below shows a pregnancy test showing a positive result.



- a) What specific molecule in the urine does the monoclonal antibody in a pregnancy test target?

hCG / human chorionic gonadotropin hormone.	1 mark
	Total: 1 mark

- b) Explain why it is important that the monoclonal antibody used in a pregnancy test is very specific to this molecule.

This ensures that it only binds only to hCG.	1 mark
This will help to prevent / avoid a false positive result.	1 mark
To ensure a positive result / line only appears if the woman is pregnant.	1 mark
Accept: ensures test is accurate / reliable / gives correct result.	
	Total: 2 marks

- c) Describe how a typical pregnancy test stick uses monoclonal antibodies to indicate a positive result.

An explanation to include the following:	
Test detects a specific hormone / hCG (human chorionic gonadotropin).	1 mark
(Found) in the urine (of a pregnant woman).	1 mark
Accept: wee / pee.	
Test strip contains monoclonal antibodies specific to hCG; some are mobile / attached to a label / dye / bead.	1 mark
If pregnant (hCG present): Hormone moves up strip and binds to antibodies in the test window / line, causing colour change / line to appear.	1 mark
Mobile antibodies (without hCG attached or spare ones) move up strip and bind to immobilised antibodies in the control window / line, causing colour change / line to appear.	1 mark
	Total: 4 marks

- d) State **two** advantages of using monoclonal antibodies for medical treatments.

Award 1 mark for each correct advantage up to a maximum of 2 marks.	
Monoclonal antibodies are very specific / only target specific cells / antigens / pathogens / molecules.	1 mark
There are fewer / reduced / less severe side effects (than other treatments e.g. chemo/radio)	1 mark
Can be used to deliver drugs / toxins / radioactive substances (to specific target cells).	1 mark
Can trigger the immune system (to attack specific cells / pathogens)	1 mark
Wide range of uses / treat many different conditions / diagnostic uses.	1 mark
	Total: 2 marks

(Total for Question 5 is 9 marks)