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Activity

How do vaccines protect against infectious diseases?

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Introduction

The questions in this worksheet relate to Megan MacLeod's article, *How do vaccines protect against infectious diseases?* on pages 2–6 of the February 2021 issue. See also the short article *Alternative splicing* on page 6.

The SQA Higher Biology specification does not include the topic of immunity and the WJEC Eduqas A-level Biology specification includes the topic of immunity only as one of its three optional components. Consequently, most students following these specifications are unlikely to be able to answer any of the following questions that test AO1 (recall with understanding) of this topic.

Questions

1 Edward Jenner used pus from the sores of people suffering from cowpox to make a formulation that protected people against smallpox.

Explain why Jenner's formulation was able to protect people against smallpox. [2 marks]

2 During its development, a B cell or a T cell undergoes a process called somatic rearrangement.

Use information given in the article and your own knowledge to give **two** ways in which this somatic rearrangement **differs** from alternative splicing during DNA transcription. [2 marks]

3 The course you are following is unlikely to include dendritic cells in the subject content for immunity.

With the help of information from Megan MacLeod's article, answer the following questions.

a Explain why dendritic cells are described as 'innate immune cells'. [1 mark]

b Describe the role of dendritic cells in the human immune response. [5 marks]

c Explain why dendritic cells might not be activated by sub-unit vaccines. [1 mark]

4 a Without referring to the article, produce a simple line drawing of an antibody molecule.

Label an antigen-binding site on your drawing. [2 marks]

b Name the type of chemical bond that holds together the polypeptide chains within an antibody molecule. [1 mark]

5 The article tells us 'We need both B cells and T cells as they perform different functions.'

Using information in this article and your own knowledge:

a give **two** functions of a helper T cell. [2 marks]

b describe how a cytotoxic T cell brings about its function. [2 marks]

c describe how a B cell brings about its function. [2 marks]

6 Suggest an explanation for each of the following practices.

a The vaccine used in the 2020 vaccination programme against flu is different from the one that will be used in the 2021 vaccination programme. [2 marks]

b Each year, young children are vaccinated against flu in a different way from adults over the age of 65. [2 marks]

7 Box 2 of the article shows that complement proteins form holes in the pathogen.

Suggest how this leads to the death of the pathogen. [3 marks]

Model answers

1 (At least one) antigen on the cowpox virus must have the same / similar structure to one on the smallpox virus.

So antibodies made against cowpox virus are also complementary to smallpox virus.

2 (Credit any two contrasting statements, for example:)

- During somatic rearrangement DNA is cut but during alternative splicing (pre-)mRNA is cut.
- During somatic rearrangement, a new gene / DNA base sequence is formed but in alternative splicing the gene / DNA base sequence remains unaltered.
- Somatic rearrangement results in many more gene products than alternative splicing.

3 a They are not specific to any particular pathogen.

b (Any five of the following)

- Engulf / phagocytose pathogen.
- Digest pathogen into smaller units.
- Display these units on their cell surface / act as antigen-presenting cells.
- (Display units) attached to major histocompatibility complex II proteins / MHC II proteins.
- Migrate to lymph nodes.
- (Where they) stimulate development of / activate T cells.

c Sub-unit vaccines lack PAMPs/pathogen associated molecular patterns that stimulate the activity of dendritic cells.

4 a Y-shape formed by two large polypeptides each with smaller polypeptide outside its arm.

Labelled binding site at tip/end of one of the arms.

b Disulfide (bond).

5 a Activates specific B cell / B cell with binding site complementary to antigen.

Stimulates specific cytotoxic T cell / cytotoxic T cell with binding site complementary to antigen.

b Releases cytotoxins/perforins.

That kill cancer cell / infected cells / damaged cells.

c Divide to produce (a clone of) B cells.

That release (one type of) antibody.

6 a Regular / frequent mutations in genome of flu virus.

Antibodies from previous year no longer complementary to new surface proteins.

b Immune systems of older people not as responsive as those of children.

So greater concentration of antigen needed in each dose for older adults.

or

Immune systems of older people not as responsive as those of children.

So more adjuvant needed in each dose for older adults.

or

Intramuscular injection likely to reduce uptake with younger children.

So nasal spray used instead.

7 (Any three of the following)

- Makes cell-surface membrane permeable to large molecules.
- Allows entry of proteases / of granzymes.
- By passive diffusion.
- (Proteases / granzymes) hydrolyse the proteins of the pathogen.

or

(Any three of the following)

- Makes cell-surface membrane permeable to large molecules.
- Allows loss of proteins / enzymes.
- By passive diffusion.
- So metabolism of pathogen stops / slows.