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VCE Biology $\frac{3}{4}$

The Innate Immune System [3.2]

Test Solutions

37 Marks. 1 Minute Reading. 30 Minutes Writing.

Results:

Test	_____ / 37
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Section A: Test (37 Marks)

Question 1 (5 marks)

Tick whether the following statements are **true** or **false**.

Statement	True	False
a. The innate immune system is fast and non-specific, providing a rapid response to a pathogen. It delivers a rapid, uniform response regardless of the pathogen type.	<input checked="" type="checkbox"/>	
b. Pattern Recognition Receptors (PRRs) detect general patterns (PAMPs and DAMPs), not specific antigens like antibodies do.		<input checked="" type="checkbox"/>
c. Neutrophils eliminate pathogens. Neutrophils also release toxic granules and form NETs (Neutrophil Extracellular Traps) to destroy pathogens.		<input checked="" type="checkbox"/>
d. Natural Killer (NK) cells look for "missing self" markers to detect unhealthy host cells. detecting abnormal or missing MHC markers.	<input checked="" type="checkbox"/>	
e. Mast cells are primary cells in the inflammatory response. Upon injury or infection, mast cells degranulate and release histamine, increasing blood flow and vessel permeability.	<input checked="" type="checkbox"/>	
f. Complement proteins tag pathogens, attract immune cells, and form membrane attack complexes to kill bacteria.	<input checked="" type="checkbox"/>	
g. Interferons directly destroy viruses. Interferons signal nearby cells to prepare for viral invasion; they do not kill viruses directly.		<input checked="" type="checkbox"/>
h. Eosinophils are involved in allergic reactions. Eosinophils release toxic granules to attack large invaders and play a role in allergy responses.	<input checked="" type="checkbox"/>	
i. The inflammatory response aims to contain and limit infection spread. It involves vasodilation , increasing blood flow and to recruit immune cells to the site.		<input checked="" type="checkbox"/>
j. PAMPs and DAMPs are molecular patterns recognised by the innate immune system to identify pathogens and damaged cells, respectively. PAMPs come from pathogens; DAMPs signal internal cell damage.	<input checked="" type="checkbox"/>	

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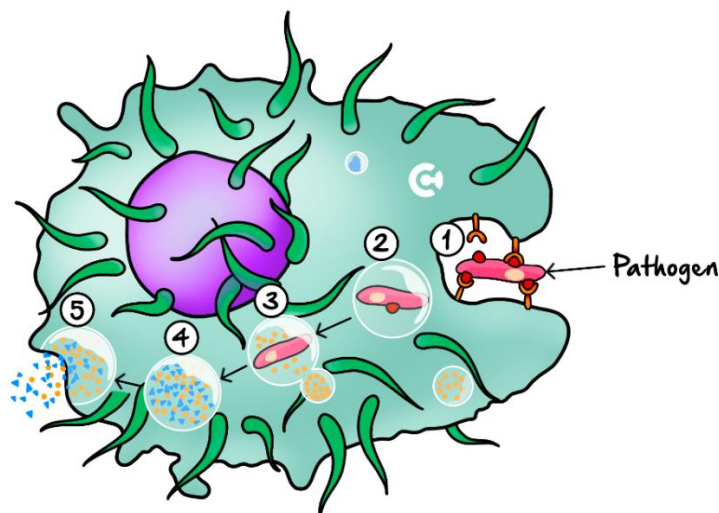
Question 2 (1 mark)

The first line of defence against pathogens includes the:

- A. Activation of *T* helper cells.
- B. Presence of acid in the stomach.**
- C. Release of toxic mediators from eosinophils.
- D. Activation of complement proteins.

Question 3 (1 mark)

The diagram below shows the process of phagocytosis. This process is vital for immunity against extracellular infections.



What is happening at position 3?

- A. Enzymes that break down the microorganism are released into the vesicle.**
- B. Antibodies are added to the vesicle to kill the microorganism.
- C. The cell is sampling the vesicle for antigen presentation.
- D. Intracellular microbes are attacking the microorganism.

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Question 4 (1 mark)

Mast and basophil cells:

- A. Are involved in the allergic response to foreign particles.**
- B. Use immunoglobulin A (IgA) antibodies to bind to foreign particles.
- C. Release chemicals that reduce inflammation.
- D. Are responsible for the relaxation of smooth muscles.

Question 5 (1 mark)

Complement proteins:

- A. Can coat and lyse bacteria ready for phagocyte ingestion.**
- B. Are secreted by some cells when they are infected by virus particles.
- C. Are produced by none of the immune system cells.
- D. Kill body cells that have been infected by virus particles.

Question 6 (1 mark)

Which of the following outlines the function of dendritic cells?

- A. Communicate with foreign particle's MHC.
- B. Communicate with accessory cells.
- C. Form an important role as an antigen-presenting cell.**
- D. All of the above.

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Question 7 (1 mark)

Viruses are described as non-cellular pathogens because they:

- A. Do not contain any nucleic acids.
- B. Cannot reproduce outside a host cell.**
- C. Are unable to produce antigenic proteins.
- D. Do not have membrane-bound organelles.

Question 8 (1 mark)

Lysosomes are organelles found in the cytoplasm of some eukaryotic cells. These organelles contain enzymes enclosed by a membrane.

Large numbers of lysosomes would be most likely to occur in cells that are:

- A. Carrying out mitosis.
- B. Producing antibodies.
- C. Carrying out apoptosis.
- D. Carrying out phagocytosis.**

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Question 9 (1 mark)

An unknown disease caused severe symptoms in one particular human. An epidemiologist took a sample of diseased tissue from the patient and analysed it to determine the cause. The table below shows the results of the analysis:

Test	Test type	Findings
1	Microscopic analysis	No pathogenic cells were found in the sample
2	Denaturing any nucleic acid in the sample	The sample was still infectious
3	Denaturing any nucleic acid and protein in the sample	The sample was no longer infectious
4	Denaturing the proteins only within the sample	The sample was no longer infectious

Based on the results of the tests, the disease could be caused by a:

- A. Prion**
- B. Virus
- C. Bacteria
- D. Protozoan

Question 10 (1 mark)

The complement system causes lysis of bacteria and enables more effective removal of pathogens.

The complement system involves:

- A. *B* cells and the action of *T* cells.
- B. *T* cells and the action of phagocytes.
- C. Antibodies and the action of phagocytes.**
- D. Large blood proteins and the action of phagocytes.

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Question 11 (1 mark)

Phagocytes:

- A. Are specialised red blood cells.
- B. Are involved in the humoral response.
- C. Engulf eukaryotic cells such as fungi.**
- D. Are produced by lymph nodes.

Question 12 (1 mark)

Which of the following matches a cell correctly with its role in the immune response?

	Cell	Role
A.	Macrophage	Stimulates inflammation by secreting interferon
B.	Dendritic cell	Presents fragments of antigens to <i>T</i> helper cells
C.	Mast cell	Engulfs bacteria and debris
D.	Neutrophil	Secretes antibodies

Question 13 (1 mark)

'Complement' is the term applied to a set of over 30 different proteins that play a role in the immune system.

Which one of the following identifies

A. They trigger clonal expansion.

B. They facilitate the production of a

C. They facilitate and enhance the phagocytosis of pathogens.

D. They act as a barrier, preventing pathogens from entering cells.

Answer: C

Explanatory notes

Option A is incorrect because clonal expansion occurs after B cells are presented with antigenic fragments.

Option B is incorrect because antibodies are produced by B plasma cells.

Option C is correct because complement binds to pathogens and increases the ability of phagocytes to clear bacteria.

Option D is incorrect because complement does not act as a cellular barrier.

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Question 14 (7 marks)

While gardening, Priya accidentally pierces her palm with a rusted nail. Within hours, the site becomes red, swollen, and painful. A doctor notes pus forming under the skin and prescribes a topical antiseptic.

a. Explain the role of mast cells in the development of Priya's symptoms. (2 marks)

- Mast cells in the tissue degranulate and release histamine upon detecting injury.
- Histamine triggers vasodilation and increases vessel permeability, recruiting immune cells.

b. Describe the cellular events that lead to the formation of pus. (2 marks)

- Neutrophils migrate to the site and phagocytose bacteria.
- The accumulation of dead neutrophils, bacteria, and tissue debris forms pus.

c. Connect each of Priya's symptoms (redness, swelling, pain) to a specific physiological process. (3 marks)

- Redness: Increased blood flow from vasodilation.
- Swelling: Fluid leakage into tissue due to vessel permeability.
- Pain: Pressure on nerve endings and release of inflammatory mediators.

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Question 15 (8 marks)

A study tracks interferon levels and NK cell activity in three patients (*A*, *B*, and *C*) over the first five days of viral infection. All patients were infected with the same respiratory virus.

Day	Patient <i>A</i> - Interferon (pg/mL)	Patient <i>A</i> - NK Cell Activity (%)	Patient <i>B</i> - Interferon (pg/mL)	Patient <i>B</i> - NK Cell Activity (%)	Patient <i>C</i> - Interferon (pg/mL)	Patient <i>C</i> - NK Cell Activity (%)
1	15	65	5	25	0	10
2	20	72	10	40	2	12
3	25	80	12	45	3	15

- a. Describe the relationship between interferon levels and NK cell activity in Patient *A*. (2 marks)

- As interferon levels increase from Day 1 to Day 5, NK cell activity also increases.
- This suggests a strong, coordinated innate response in Patient *A*.

- b. Compare the immune responses of Patient *B* and Patient *C*. What does this suggest about their ability to fight the infection? (2 marks)

- Patient *B* shows a moderate increase in both interferon and NK activity.
- Patient *C* has low interferon levels and minimal NK cell activation, suggesting a weak response.

- c. Explain why interferons help stimulate NK cell activity during viral infections. (2 marks)

- Interferons are released by virus-infected cells and signal nearby cells to activate antiviral responses.
- They also stimulate NK cells to identify and destroy infected cells through apoptosis.

- d. Based on the data, predict which patient is most likely to experience severe symptoms and justify your reasoning. (2 marks)

- ▶ Patient *C* is most likely to experience severe symptoms.
- ▶ Their low interferon and NK activity indicate poor early viral control, allowing greater viral replication and spread.

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Question 16 (5 marks)

A child is enrolled in a clinical trial testing gene therapy for a congenital complement protein C5 deficiency. C5 is needed to form the membrane attack complex (MAC). Before treatment, the child experienced recurrent bacterial infections, especially meningococcal, which is caused by gram-negative bacteria *Neisseria meningitidis*.

a. Explain how the MAC normally defends against bacteria. (1 mark)

▶ The MAC forms pores in bacterial membranes, causing lysis and death.

b. Identify two other functions of the complement system that may still be active in this child. (2 marks)

- ▶ Opsonisation: Complement proteins tag bacteria for phagocytosis.
- ▶ Chemotaxis: Complement proteins attract neutrophils to the site of infection.

c. Explain why a lack of MAC specifically increases susceptibility to meningococcal infections. (2 marks)

- ▶ *Neisseria meningitidis* is a gram-negative bacterium with an outer membrane targeted by MAC.
- ▶ Without MAC, this pathogen can survive in the bloodstream and cross into the brain.

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