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VCE Biology ¾
The 1st & 2nd Line of Defense [0.12]
Workshop

Error Logbook:

New Ideas/Concepts	Didn't Read Question
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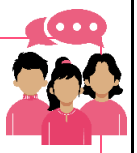
Section A: Revision and Recall



Discussion: Let's create a mind map about the immune system that we have learned so far!

Section B: Starter Questions (21 Marks)

INSTRUCTION: 21 Marks. 15 Minutes Writing.

Question 1 (2 marks)

Identify and describe two physical barriers preventing infection in plants.

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Question 2 (2 marks)

Identify and describe physical barriers preventing infection in animals.

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Question 3 (2 marks)

Define chemical barriers preventing infection in plants, giving an example of chemical defence.

Question 4 (2 marks)

Identify and describe chemical barriers preventing infection in animals.

Question 5 (2 marks)

Explain how mucous secretions provide a defence against pathogenic infection in animals.

Question 6 (2 marks)

Akkermansia muciniphilia secretes molecules that degrade mucin, the functional protein component of mucous. Explain how this may be beneficial to its ability to infect a host.

Question 7 (1 mark)

Explain what a prion is and why it is non-cellular.

Question 8 (3 marks)

What is meant by self and non-self? Explain how cells in the immune system differentiate between self and non-self.

Question 9 (2 marks)

With reference to immune function, explain why having a completely sterile body would be detrimental for an individual.

Question 10 (1 mark)

Explain the difference between a cellular and a non-cellular pathogen, giving an example of each.

Question 11 (2 marks)

Compare the similarities and differences of barriers to infection in plants and animals.

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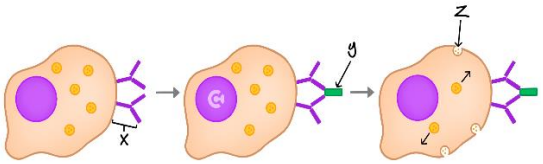
Section C: Multiple Choice Questions (17 Marks)

Question 12 (1 mark)

The diagram below shows an immune cell responding to a substance. This process occurs during certain types of allergic reactions.



Which type of immune cell is featured in the diagram above?

A. Mast cell

B. Neutrophil

C. Macrophage

D. Dendritic cell

Question 13 (1 mark)

The complement system is a group of 30 serum proteins that interact as part of the immune system. The complement system:

A. Enhances phagocytosis in the second line of defence.

B. Is activated by antibodies bound to the pathogen in the first line of defense.

C. Results in the lysis of a bacterial pathogen in the first line of defence.

D. Destroys cells that are occupied by viruses in the second line of defence.

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Question 14 (1 mark)

When specialised white blood cells called macrophages ingest and destroy bacteria, which of the following is an important step in the process?

A. Ingesting of the bacteria into vacuoles by endocytosis.

B. Fusion of the vacuoles containing the ingested bacteria with mitochondria.

C. Release of enzymes by lysosomes into the cell cytosol to digest the bacteria.

D. Expulsion of unwanted remains of digested bacteria by exocytosis.

Question 15 (1 mark)

The innate immune response of the body involves the activity of both cells and molecules.

Which of the following is involved in the second line of defence?

A. Antibodies produced by memory B-lymphocytes.

B. Sweat secreted by the skin containing lysozyme.

C. Natural Killer cells that destroy virus-infected cells.

D. Cytokine secreted by helper T-cells.

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Question 16 (1 mark)

Sarah was gardening when she accidentally cut her finger on a thorn. Shortly thereafter, she noticed swelling and redness around the wound. This immediate reaction is crucial in preventing infection by activating certain immune responses.

What primarily happens at the site of Sarah's injury in terms of innate immune response?

A. Immediate recruitment of T-cells to initiate adaptive immune responses.

B. Rapid mobilisation of neutrophils and macrophages to phagocytise potential pathogens entering through the cut.

C. Swift production of specific antibodies by plasma cells.

D. Formation of long-term immunological memory against common garden pathogens.

Question 17 (1 mark)

Dr. Lewis is conducting a study on how skin integrity impacts susceptibility to infections. In his observations, a participant with a minor abrasion on their arm developed a localised infection more quickly than expected, demonstrating the critical role of the skin as an innate barrier.

What is the main consequence of compromised skin integrity in Dr. Lewis's study?

A. A significant reduction in lymphatic drainage leading to diminished immune response.

B. Increased susceptibility to infections due to a breach in the physical barrier provided by the skin, facilitating easier pathogen entry.

C. Immediate enhancement of adaptive immune responses due to increased antigen exposure.

D. Uncontrolled cytokine storm leading to systemic inflammatory responses.

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Question 18 (1 mark)

A health newsletter recently featured an article on the benefits of fever in fighting infections. The article included a case study of a patient with a viral infection who experienced a moderate fever, which helped reduce the severity of the illness.

Why is a moderate fever beneficial in the context of this viral infection?

A. It decreases metabolic activity within pathogens, slowing their replication rate.

B. It induces an environment less favourable for the virus, as many viruses are sensitive to increased temperatures, potentially slowing their replication.

C. It stimulates the infected cells to produce specific antibodies against the virus.

D. It speeds up tissue repair and regeneration processes, quickly healing damaged tissues.

Question 19 (1 mark)

In a recent public health lecture, the topic of discussion was how the body's vascular system responds during inflammation. The lecturer used the example of a patient with a bacterial skin infection, emphasising the role of increased blood flow and vascular permeability in mobilising immune defences.

What is the primary advantage of increased vascular permeability in the context of the patient's bacterial skin infection?

A. It confines pathogens to the infected area, preventing systemic spread.

B. It allows more immune cells like neutrophils and proteins like complement to enter the infected tissue, enhancing the local immune response to fight the infection.

C. It lowers overall body temperature, which inhibits bacterial growth.

D. It triggers the development of specific immune responses by exposing the blood to bacterial antigens.

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Question 20 (1 mark)

A group of medical students is exploring how the body's mucosal surfaces contribute to the first line of defence against pathogens. They focus on how saliva in the oral cavity traps and neutralises bacteria, using an experiment where they measure bacterial activity before and after exposure to saliva.

What crucial role does saliva play in the oral cavity as part of the innate immune defence?

A. It contains cells that adaptively respond to microbial exposure.

B. It is rich in enzymes like lysozyme and antibodies such as IgA, which trap and destroy bacteria, serving as an effective chemical barrier.

C. It rapidly generates large quantities of specific antibodies.

D. It neutralises bacterial toxins directly through chemical breakdown.

Question 21 (1 mark)

Which of the following outlines the function of dendritic cells?

A. Form an important role as an antigen-presenting cell.

B. Communicate with foreign particle's MHC.

C. Communicate with accessory cells.

D. All of the above.

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Question 22 (1 mark)

Role of Mucus in Pathogen Defense

Context: After spraining her ankle, Emily catches a cold. Increased mucus production in her respiratory tract is noted.

Question: How does mucus contribute to the innate immune defence against respiratory pathogens during Emily's cold?

A. By creating a slippery surface that prevents pathogen adherence to the respiratory lining.

B. By trapping pathogens and debris, which are later expelled by ciliary action.

C. By enhancing the activation of local immune cells that release more cytokines.

D. By altering the pH of the respiratory tract to inhibit pathogen growth.

Question 23 (1 mark)

Complement System Activation

Context: Emily's immune vigilance increased after her ankle sprain, particularly for monitoring bacteria that might enter through skin abrasions.

Question: How does the complement system function to combat potential bacterial infection near the site of Emily's ankle sprain?

A. By facilitating the clearance of dead cells and debris to prevent secondary infection.

B. By mediating the lysis of bacteria through the formation of the membrane attack complex.

C. By binding to pathogens and marking them for destruction by other immune cells (opsonisation).

D. By blocking pathogen entry into cells through receptor inhibition.

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Question 24 (1 mark)

Activation of the Adaptive Immune System

Context: If the innate immune response near Emily's sprained ankle is overwhelmed, the adaptive immune system may need to engage.

Question: Which process best describes the signalling from the innate to the adaptive immune system in response to an infection threat?

A. Dendritic cells capture and present antigens to T-cells in the nearest lymph node.

B. Neutrophils release chemicals that directly stimulate the maturation of B-cells.

C. Complement components activate macrophages to produce antibodies.

D. Cytokines released by mast cells promote the differentiation of memory cells.

Question 25 (1 mark)

The table below shows the proportion of each type of white blood cell as a percentage of the total number of white blood cells that are typically present in a healthy, adult human body.

White blood cell	Proportion present (%)
Neutrophil	50
Lymphocyte	30
Macrophages	4
Eosinophils	2

Reading from the table, the cells involved in the innate immune response are:

A. Neutrophils, Macrophages and Eosinophils only.

B. Lymphocytes and Eosinophils only.

C. Lymphocytes, Macrophages and Eosinophils only.

D. Neutrophils, Lymphocytes, Macrophages and Eosinophils.

Question 26 (1 mark)

Characteristics of inflammation include:

A. Leaky capillaries.

B. Drop in temperature.

C. Vasoconstriction.

D. Swollen lymph nodes.

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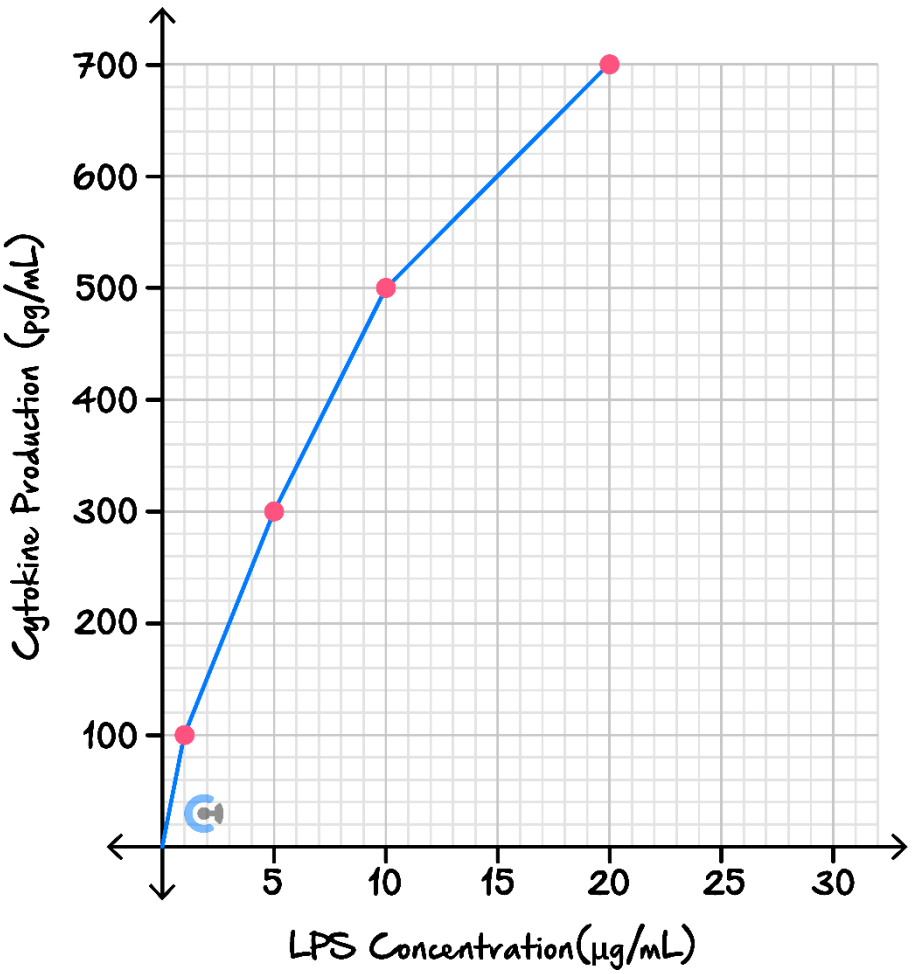
Question 27 (1 mark)

Researchers are examining the role of macrophages in responding to bacterial infections. They conducted an experiment where macrophages were exposed to varying concentrations of bacterial Lipopolysaccharide (LPS) and measured the production of pro-inflammatory cytokines over time.



What does the increasing cytokine production in response to higher concentrations of LPS suggest about macrophage activation?

A. Macrophages are activated in a dose-dependent manner by LPS, leading to increased cytokine production which plays a critical role in initiating and propagating inflammatory responses.

B. Macrophages decrease cytokine production as a negative feedback mechanism to prevent overactivation of the immune response.

C. LPS concentrations are irrelevant to macrophage activation, and the observed increase in cytokines is likely due to other uncontrolled experimental variables.

D. Increasing cytokine production indicates a malfunction of macrophages, suggesting a pathological response rather than a protective one.

Question 28 (1 mark)

Considering the role of cytokines in the inflammatory response, what potential effects could this macrophage activation have on the affected tissue?

A. Enhanced cytokine production can lead to increased blood flow, permeability, and recruitment of other immune cells, intensifying the inflammatory response to effectively contain and eliminate bacterial pathogens.

B. Excessive cytokine production might suppress the inflammatory response, leading to inadequate immune activation and the potential spread of infection.

C. Cytokine production in this scenario is likely to cause immune tolerance, reducing the effectiveness of the immune response.

D. The increase in cytokines would specifically activate adaptive immune components, which is contradictory to the innate nature of macrophage responses.

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Section D: Exam Style Questions (80 Marks)

Question 29 (8 marks)

One of the most common infection-causing bacteria is *Staphylococcus aureus*, and it is responsible for a variety of different diseases, depending on its location of infection.

It is found as one of the "normal flora" in our body, commonly found residing on the skin, and has been described as causing "opportunistic infections."

a. Is *S. aureus* a cellular pathogen? Explain. (1 mark)

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b. Name the main physical barrier that prevents *S. aureus* from entering the body. (1 mark)

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c. Explain what is meant by the term 'opportunistic infection.' (1 mark)

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d. Describe why it is useful for the body to retain *S. aureus* on its skin, despite its ability to cause infection. (1 mark)

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e. Briefly explain how the immune system would recognise *S. aureus*, in order to engage a ***non-specific*** response. (2 marks)

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f. Would interferons be useful for the innate immune response to fight *S. aureus* infection? Explain. (2 marks)

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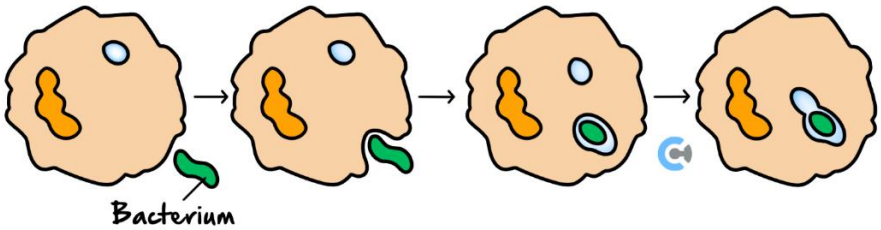
Question 30 (3 marks)



a. Use one word to describe the process shown in the diagram above. (1 mark)

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b. Is this response specific or non-specific? Explain your selection. (2 marks)

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Question 31 (11 marks)

As the weather gets colder in winter, many people find themselves sick with a 'cold', and although the name is misleading, what people typically associate a 'cold' with is an upper respiratory tract viral infection, caused commonly by rhinovirus. This generally impacts epithelial cells in the nose and throat – those lining the external surfaces.

a. Identify and describe a barrier to viral infection of those epithelial cells. (2 marks)

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b. Compare and contrast the roles of macrophages and natural killer cells in the response against viral infection. (4 marks)

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Some individuals often mistake these symptoms for hay fever and take antihistamines to avoid the symptoms.

c. Naming the cell that releases histamine, describe the process of the inflammatory response and its role in preventing and limiting infection. (4 marks)

Some people may also get a fever with an infection.

d. Explain why this may be beneficial to the immune response. (1 mark)

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Question 32 (10 marks)

Sepsis, or infection of the blood, is an extremely urgent and life-threatening medical situation, which is why it is extremely important for the innate immune system to quickly eliminate any pathogens in the blood.

The complement system is an example of one of these innate immune systems which can act quickly to eliminate pathogens.

a. Describe how the complement system functions, with reference to each of the three possible outcomes of complement activation. (4 marks)

b. Identify two cells which use different mechanisms to kill pathogens, and compare and contrast them. (4 marks)

c. Pus can form in some cases when the infection spreads elsewhere. Explain what pus is and with reference to its component explain why infections can result in pus being generated. (2 marks)

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Question 33 (6 marks)

With many infections, our body can handle them efficiently and we do not even notice that we have been infected. However, in some infections, particularly bacterial ones, we often require antibiotics to ensure that we don't die.

a. How might excessive antibiotic use be detrimental to immune responses against pathogens? Explain. (2 marks)

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b. Does the innate immune response have the same response for all pathogens? Describe how pathogen recognition occurs with the innate immune response, including natural killer cell recognition. (4 marks)

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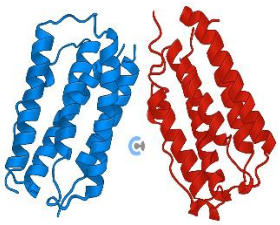
Question 34 (6 marks)

Interferons (IFNs) are proteins released by host cells in response to the presence of pathogens. The image shows a representation of interferon beta 1.



a. What type and level of protein structure is most evident in the image of interferon beta 1 ? (1 mark)

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b.

i. What is a pathogen? (1 mark)

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ii. Identify a pathogen that is likely to trigger a response by interferon. (1 mark)

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c. Describe how protein signalling molecules, such as interferon, can trigger the protective defences of the immune system in response to infection by a pathogen. (2 marks)

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d. Suggest why some pathogens may show resistance to interferon. How might this occur? (1 mark)

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Question 35 (4 marks)

Tumour Necrosis Factor (TNF) is a naturally occurring protein secreted by cells of the immune system, especially macrophages. This molecule regulates the production of several pro-inflammatory molecules.

a. Name the group of molecules that TNF belongs to. (1 mark)

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b. What is the role of the group of molecules named in **part a.** in protecting the individual against pathogens? (1 mark)

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c. What part of the immune system would TNF belong to? (1 mark)

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TNF can bind to two different cell surface receptors TNF1 and TNF2. The result is a different outcome depending on which receptor is activated.

d. Why does TNF bind to a cell surface membrane rather than entering the cell? (1 mark)

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Question 36 (7 marks)

When Emily, a wildlife biologist, returned from a field study in a tropical rainforest, she began experiencing severe abdominal discomfort and unusual fatigue. Unbeknownst to her, she had contracted a parasitic infection from contaminated water. Parasites, such as worms, can invade various body systems, leading to a range of health issues, depending on their type and the site of infection. In Emily's case, the parasites had begun to affect her digestive system, causing symptoms like nausea, diarrhoea, and bloating.

a. Which innate cell would be most likely to form part of the response against this pathogen? Explain. (3 marks)

b. Explain how the inflammatory response could be responsible for some of her symptoms. (2 marks)

c. Would interferons be effective in Emily's case? Explain. (2 marks)

Question 37 (5 marks)

When a tattoo is performed, pigments that make up the ink are injected into the skin. New research has investigated the role of macrophages in tattoos. When the wound is created as a result of the skin being punctured, macrophages are present at the site of the wound. The research has found that the macrophages move to the site where they capture the pigment and remain there until they die. They become trapped, due to the size of the pigment, and the pigment is then released. This creates a cycle, that is continually repeated when another macrophage then arrives to take up the pigment and subsequently dies. Prior to this research. it was thought that dermal cells in the skin had permanently trapped the pigment.

a. Explain the steps of the inflammation process and its importance for tattooing. (2 marks)

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b. By what process would the macrophage 'capture' the pigment in the ink? (1 mark)

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c. Explain the process for how the pigment would be identified as foreign by the macrophages. (2 marks)

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Question 38 (10 marks)

A 38-year-old woman named Hana visited her local GP after developing redness, swelling, and warmth around a cut on her lower leg. The GP suspected a bacterial skin infection and collected a sample for testing. Laboratory analysis revealed the presence of *Pseudomonas aeruginosa*, a bacterium commonly found in soil and water that can cause opportunistic infections in open wounds.

The clinic monitored Hana's condition for 10 days without antibiotics to study the natural course of her **innate immune response**. The following observations were made:

- **Day 1–2:** Local swelling, pain, and redness developed. Her temperature increased to 38.5℃.
- **Day 3–5:** Blood tests revealed increased levels of neutrophils and macrophages.
- **Day 6–8:** Complement proteins (e.g., C3b) and inflammatory cytokines peaked.
- **Day 9–10:** The redness subsided and her temperature returned to normal

a. Describe how Hana's innate immune system responded in the **first few days** of the infection and explain the biological function of the fever in this context. (3 marks)

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b. Explain the role of **phagocytes** during Hana's infection. Include a reference to how pathogens are identified. (2 marks)

c. One of the lab reports showed a significant increase in **complement protein C3b** on Day 6.

Explain one **direct effect** of complement proteins like C3b and describe how this supports the innate immune response. (2 marks)

d. What specific innate immune system **cell type** is most responsible for initiating the release of histamine at the site of the wound? (1 mark)

e. After reviewing this case, a group of researchers proposes to deliberately expose patients with minor cuts to *P. aeruginosa* under controlled conditions to study innate responses.
Suggest one bioethical principle this study might violate, and explain why. (2 marks)

Question 39 (10 marks)

Jacob, a 70-year-old man, was admitted to the hospital with chills, high fever, and confusion. His symptoms started two days after a routine bladder catheterisation. Blood cultures revealed a Gram-negative bacterium, *Escherichia coli*, had entered his bloodstream, leading to **bacterial sepsis** — a potentially life-threatening condition caused by an overwhelming immune response.

Sepsis triggers a widespread **innate immune response**, including activation of the **complement system**, **inflammatory cytokines**, and **phagocytes**. Doctors collected Jacob's immune profile over four days to monitor his response before antibiotics were administered. The table below shows a summary of the results:

Day of Illness	C3b Levels	Neutrophil Count	Body Temperature (℃)	TNF-α (Cytokine) Levels
Day 1	Low	Low	37.2	Low
Day 2	High	High	39.5	High
Day 3	High	High	38.7	Moderate
Day 4	Moderate	Moderate	37.8	Low

a. Explain how the **complement protein C3b** helps Jacob's immune system fight *E. coli* infection. Include both the mechanism and its impact. (3 marks)

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b. On Day 2, Jacob's body temperature rose sharply and his TNF-α levels were high.

Explain the **benefits** of fever and TNF-α in an innate immune response. (2 marks)

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c. Use the data in the table to describe how Jacob's **innate immune response changed** over time and what this suggests about his recovery between Day 2 and Day 4 (3 marks)

d. Neutrophils are often the first cells to respond to bacterial infections.

Explain how neutrophils recognise and destroy pathogens like *E. coli*. (2 marks)

e. A sample from Jacob's blood was analysed using flow cytometry. The lab found that a large number of neutrophils had internalised *E. coli* cells coated in C3b.

Explain why C3b-coated bacteria were more likely to be phagocytosed than uncoated bacteria.

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