

**AP<sup>®</sup> BIOLOGY**  
**2007 SCORING GUIDELINES (Form B)**

**Question 2**

The defenses of the human body to the entry and establishment of a pathogen (disease-causing organism) can be divided into nonspecific responses and specific responses.

- (a) **Explain** how THREE types of nonspecific defenses can prevent the entry and/or establishment of a pathogen in a person's body.

**One point for each of the following explanations/identifications (3 points maximum):**

- Barrier (skin)
- Traps (mucous membranes, cilia, hair, ear wax)
- Phagocytosis (white blood cells)
- Elimination (coughing, sneezing, urination)
- Unfavorable pH (stomach acid, sweat, saliva, urine)
- Unfavorable environment (normal flora, fatty acids, enzymes)
- Cell destruction (complement, natural killer cells)
- Interference with viral replication (interferon)
- Lysozyme action (tears, sweat)
- Inflammatory response (increase in body temperature, capillary permeability, attraction of macrophages, histamine release, vasodilation)

- (b) **Discuss** how the immune system responds to an initial pathogenic exposure, and how this initial exposure can lead to a quicker response following a second exposure to the same pathogen.

**One point for each of the following explanations/identifications (6 points maximum):**

- APCs (macrophages, dendritic cells, B cells) present antigen
- B cells/plasma cells produce/secrete antibodies
- Helper T cells activate B cells, cytotoxic T cells, and/or macrophages
- Cytotoxic T cells cause cell death (apoptosis)
- Ag presented on MHC
- Explanation of how antibodies destroy the pathogen
- Secretion of cytokines (or interleukins) to signal or activate
- Memory cells produced in primary response speed up secondary response

- (c) **Explain** the biological mechanisms that lead to the rejection of transplanted organs.

**One point for each of the following explanations/identifications (3 points maximum):**

- Cell-mediated response or explanation of cytotoxic T, CD8, killer T cells, or natural killer cells
- Concept of nonself (foreign) or MHC incompatibility
- Explanation of the role of cell death or apoptosis or cell lysis

*Note:* To obtain a score of 10, the student must earn the memory cell point in part (b).

2. The defenses of the human body to the entry and establishment of a pathogen (disease-causing organism) can be divided into nonspecific responses and specific responses.
- Explain** how THREE types of nonspecific defenses can prevent the entry and/or establishment of a pathogen in a person's body.
  - Discuss** how the immune system responds to an initial pathogenic exposure, and how this initial exposure can lead to a quicker response following a second exposure to the same pathogen.
  - Explain** the biological mechanisms that lead to the rejection of transplanted organs.

A) Skin acts as a defensive barrier to bacteria & viruses in the environment. It prevents bacteria from reaching inner cells that will suffer if the skin is breached, so it cannot enter. Mucus ~~is~~ has certain enzymes that kill bacteria and viruses. Mucus is usually found at openings to the body, and therefore get rid of most germs that try to invade through body cavities. The inflammatory response responds to things like cuts on the skin, where bacteria can breach ~~the~~ Cells in infected area sends out histamine to attract ~~pathogens~~ <sup>Macrophages</sup>. It causes vasodilation of affected area, increasing blood flow ~~more~~ ~~more~~ Macrophages to inhibit. Macrophages ~~and~~ then engulf ~~infectious cells~~ pathogens, and complement proteins lyse ~~them~~ pathogens (Pathogens are foreign cells).

b) ~~Antigens~~ <sup>Antigens</sup> ~~will be engulfed~~ by any type of ~~cell~~ foreign substance, will be engulfed by ~~the~~ a ~~Macrophage~~ <sup>Macrophage</sup> ~~cell~~, that will subject the antibody shape to a helper-T cell. In the humoral response, the helper-T cell stimulates plasma B cells and memory B-cells. Plasma B-cells will produce antibodies that attach to an Antigen and clump it or call upon complement proteins, and somehow inactivate the antigen. In cell mediated response, the helper-T cell produces Cytotoxic T-cells.

## ADDITIONAL PAGE FOR ANSWERING QUESTION 2

and memory T cells, ~~which~~ cytotoxic T cells recognize antigens bound to MHC-complex / plasma<sup>membrane</sup> membranes of infected cells. It binds to it and lyses the infected cells.

Memory B & T cells remain in the blood and circulate, ~~it is specific~~ All B & T cells are specific for an antigen, so if the same ~~antigen~~<sup>pathogen</sup> attacks ~~again~~ again, the memory B & T cells stimulate cytotoxic T cells and plasma B-cells, resulting in a quicker response the second time.

c) All cells have MHC complexes specific to an individual on its plasma membrane. When an ~~organ~~ organ is transplanted, its cells are foreign to the cytotoxic T-cells and ~~many~~ macrophages, which only know not to attack the cells with MHC complexes of its own individual organism. Since the organ is from a foreign person, T-cells & B-cells do ~~not~~ recognize it as a pathogen / antibody, and attack and kill the transplanted organ cells, leading to ~~rejection~~ rejection of the organ.

GO ON TO THE NEXT PAGE.

2. The defenses of the human body to the entry and establishment of a pathogen (disease-causing organism) can be divided into nonspecific responses and specific responses.

- (a) **Explain** how THREE types of nonspecific defenses can prevent the entry and/or establishment of a pathogen in a person's body. <sup>skin</sup> <sup>macrophages</sup> <sup>histamines</sup> <sup>inflamed</sup>
- (b) **Discuss** how the immune system responds to an initial pathogenic exposure, and how this initial exposure can lead to a quicker response following a second exposure to the same pathogen. <sup>B cells</sup> <sup>T cells</sup>
- (c) **Explain** the biological mechanisms that lead to the rejection of transplanted organs. <sup>cell mediated</sup> <sup>cloning</sup>

a) Skin is perhaps one of the most important lines of nonspecific defense against pathogens. Thick and shielded by a layer of dead cells, skin is dry, waterproof, and effectively resistant to bacteria. In order to enter the body, a pathogen must first make its way past the skin.

A variety of secretions also keep pathogens at bay. Anti bacterial agents in the saliva, mucus in the sinuses & inner lining of the body, and the acid in the stomach all work to neutralize pathogens before they negatively affect the body.

The third type of nonspecific defense is the macrophage, which engulf and digest debris and conspicuous pathogens from the bloodstream. Coupled with histamines and the body's reaction of inflammation, the macrophage works to eliminate many pathogens before they are even noticeable.

b) Many phagocytotic cells do not recognize pathogens easily, and because of this B and T cells work together to create specific defenses versus pathogens. When a pathogen is initially exposed to the body the B cell with the correct antibody match is cloned. Some stay in the lymph node as memory cells but the rest are used

## ADDITIONAL PAGE FOR ANSWERING QUESTION 2

to produce antibodies. Antibodies are specific, binding to pathogens and labelling them so that another phagocytotic cell, can detect and engulf them.

After the initial exposure, the body is better prepared to deal with that pathogen. As memory cells remain in the body, every time the same pathogen resurfaces, the body has the template for the antibodies already made so as to expediate removal of the pathogens. This is the concept that lies behind vaccinations.

c) Transplanted ~~organs~~<sup>organs</sup> are rejected when they are recognized to be foreign. Since the body is designed to eliminate all foreign bodies, the immune system targets the transplanted organ. This often leads to complications to those ~~needing~~ needing organ transplants, and often strong drugs are needed to suppress the immune system. However, the side effect of this is that the body is susceptible to infection, and the patient must ~~be~~ usually be put on strong antibiotics as well.

GO ON TO THE NEXT PAGE.

2. The defenses of the human body to the entry and establishment of a pathogen (disease-causing organism) can be divided into nonspecific responses and specific responses.
- Explain** how THREE types of nonspecific defenses can prevent the entry and/or establishment of a pathogen in a person's body.
  - Discuss** how the immune system responds to an initial pathogenic exposure, and how this initial exposure can lead to a quicker response following a second exposure to the same pathogen.
  - Explain** the biological mechanisms that lead to the rejection of transplanted organs.

A) Skin, nonspecific white blood cells, and cilia and mucous membranes are all nonspecific defenses of the body. These defenses all serve as the foremost barriers an invading pathogen would meet when trying to enter the body. Skin is the largest of these barriers, covering the entire body with a water tight ~~and~~ coating. Pathogens of all types are blocked from entering, hence skin is nonspecific in its defense. The only entry would be through a cut or an opening such as the nose or mouth.

However, those openings <sup>(mouth, nose, ears, etc.)</sup> are guarded as well by mucous and cilia. Mucous is designed to capture the invading pathogens in its sticky coating it forms <sup>and or around</sup> over ~~the~~ the opening. The mucous is then ~~then~~ pushed out of the body by ~~a~~ coughing ~~for~~ mucous in the throat, blowing your nose, etc. Cilia, tiny hairs coating areas of possible entry such as <sup>the</sup> throat, work in a similar way. They capture all <sup>possible</sup> invading pathogens, or foreign organisms to the body, and beat them up and out of the body.

If a pathogen does get in the body, through a cut ~~or~~ for example, the body's first defence

## ADDITIONAL PAGE FOR ANSWERING QUESTION 2

is with nonspecific white blood cells. These are white blood cells such as <sup>some</sup> phagocytes that attack all pathogens and are not designated to go for any one specific invader. White blood cells kill the pathogen by engulfing it by phagocytosis (eating it and then killing it with chemicals), ~~or~~ causing it to burst, or killing it with chemicals.

B) Initial pathogen exposure results in white blood cells rushing to the sight of entry. ~~And~~ These cells kill the pathogen as quickly as possible and memory cells memorize certain codons of the pathogen's surface so that future invasions will have an antibody to fight.

C) Transplanted organs are often rejected because the body thinks it is a pathogen. This occurs when the surface molecules of the organ's cells are not similar enough to surface molecules of the body's cells and therefore the body's immune system attacks the organ.

GO ON TO THE NEXT PAGE.

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**2007 SCORING COMMENTARY (Form B)**

**Question 2**

**Sample: 2A**

**Score: 10**

In part (a) the student earned 3 points: 1 point for the statement that the “[s]kin acts as a defensive barrier to bacteria”; 1 point for the statement that “[m]ucus has certain enzymes that kill bacteria”; and 1 point for noting that the macrophages that engulf bacteria were attracted to the area because of the release of histamine.

In part (b) the student received 6 points: 1 point for stating that the macrophage presents an antibody shape to a helper T cell; 1 point for noting that the helper T cell stimulates plasma B and memory B cells; 1 point for the statement that the B cells are stimulated to produce antibodies; 1 point for noting that the antibodies work by attaching to an antigen and clumping cells as they call upon complement proteins; 1 point for noting that the cytotoxic T cells recognize antigens bound to the MHC complex of infected cells and lyse them; and 1 point for the indication that the same pathogen would be responded to by memory.

In part (c) the student was awarded 2 points: 1 point for the statement that cells are “specific to an individual,” followed by the concept that the transplant cells are foreign; and 1 point for the recognition that it is the cytotoxic T cells that respond to the foreign cells.

**Sample: 2B**

**Score: 7**

In part (a) the student received 3 points: 1 point for recognizing that the skin provides a barrier to most organisms; 1 point for stating that there are antibacterial agents in saliva and mucus; and 1 point for describing the role of macrophages.

The student earned 3 points in part (b): 1 point for stating that B cells produce antibodies; 1 point for correctly explaining that antibodies destroy pathogens by labeling them so that phagocytic cells can detect and engulf them; and 1 point for accurately explaining how memory cells can lead to a secondary response for the same pathogen. The student fails to describe the cell-mediated immune response or the role of antigen-presenting cells (APCs) or helper T cells, so no other points were granted.

One point was credited in part (c) for stating that transplants “are rejected when they are recognized to be foreign” or nonself by the body. No further points were earned because the student does not correctly explain how the immune system attacks the transplant.

**Sample: 2C**

**Score: 5**

The student earned 3 points in part (a): 1 point for stating that the skin covers the body and blocks the entry of pathogens; 1 point for stating that mucus captures pathogens; and 1 point for stating that phagocytes engulf and kill pathogens.

One point was awarded in part (b) for stating that memory cells remember the pathogen’s surface and thus can give rise to a secondary response. The incorrect usage of the word “codon” was not penalized, but this was typical of student responses in this section; many students thought that DNA was involved in the specific immune response.



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**Question 2 (continued)**

The student received 1 point in part (c) for showing an understanding of self versus nonself but did not earn any further points because there is no demonstrated comprehension of how the immune system attacks the transplant.