



## Immune System Worksheet - Answers

1. We have various types of physical barriers to prevent invasion by a micro-organism. Name three of these barriers and explain how they are specialised to prevent infection.

Any three of the following: Skin, Cilia/hairs in [nose/throat/lungs], Tears, Gastric/stomach acid

Skin provides a physical barrier for our body. Entry through this barrier for pathogens (micro-organisms that cause disease) can occur when the skin is broken/ irritated/ damaged

Tears: The eye has a mechanism of cleaning itself through the movement of substances through blinking. The film of moisture over the eye can trap substances such as dust and through blinking can move it to the corners of the eye where it can be removed. Our tears also contain enzymes, called lysozyme and amylase which can kill some bacteria providing another level of protection.

Gastric acid in the stomach: The acid in our stomach not only aids digestion but can also kill some pathogens. Pathogens that are not killed by this acid can potentially cause disease, such as Salmonella which causes food poisoning.

Cilia: Cilia are small hairs found along the airways in our nose and lungs. These hairs are located next to mucosal cells which secrete mucus. The mucus can trap particles we inhale, including bacteria and viruses. The movement of the hairs in the nose stimulates sneezing and in the lungs they can move the mucus to the throat where it can be coughed out or swallowed.

2. If a micro-organism isn't cleared from the body by the innate response (phagocyte response), what happens next?

The innate immune response may not always clear an infection. If this happens, the acquired/adaptive immunity is activated. The macrophages that have taken up the antigen can also transport the antigen to sites where an acquired immune response can be activated. When the macrophage bearing an antigen enters the lymphatic system it circulates towards the lymphoid organs which include the spleen, the tonsils, adenoids and Peyer's patches. These organs are rich in two types of specialised white blood cells called lymphocytes. Also known as B cells and T cells, these lymphocytes are distributed in strategic sites throughout the body ready to respond to antigens. There are also many B and T cells circulating in the blood.



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3. *Legionella pneumophila* is a bacterium that causes Legionnaire's disease. In humans it is engulfed by macrophages but is able to evade the normal mechanisms that macrophages use to kill it. It is therefore able to live inside the macrophage and use its nutrients to stay alive.

- a. Why can't B cells recognise the *L. pneumophila* antigens?

B cells cannot recognise intracellular antigens as they respond to free antigens. Free antigens are found outside our own cells or on the surface of organisms that circulate around our body. *L. pneumophila* is an intracellular pathogen/micro-organism and so does not display a free antigen to the immune system.

- b. How would the immune system identify *L. pneumophila* and how is it removed from the body?

The antigen from *L. pneumophila* can be displayed on an MHC molecule on the surface of the infected cell. This means that it can be identified by the immune system. MHC molecules on our own cells are recognised by cytotoxic T cells. Once identified, the T cell can release cytokines to influence other cells of the immune system.

- c. Why would someone with a deficiency in T-cells be more prone to an intracellular micro-organism infection?

T cells are crucial in identifying an intracellular infection. Without them the immune system can fail to identify and destroy these intracellular pathogens and they would be able to replicate and spread to other cells. Some examples include: viruses, mycobacteria and meningococcal bacteria.

4. Once the acquired immune response is initiated, plasma cells (lymphocytes) can produce antibodies. Explain why antibodies will only be effective against one antigen.

When the receptors on the B cell surface recognise free antigens they are stimulated to become plasma cells (lymphocytes) which make antibody. The antibodies protein molecules are folded in such a way as to form a 3-dimensional cleft into which only antigens of a corresponding shape can bind.



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5. Cytokines have many roles in the immune response. From the animation, can you describe two ways that cytokines help the body fight infection?

Two of the following:

Cytokines can:

- Help regulate the innate immune response and attract additional macrophages from the blood stream to the site of infection.
- T cells do not manufacture antibodies but they can secrete cytokines which influence other immune cells.
- When the T cells binds to the MHC-antigen complex, the activated T cells enlarge, multiply and secrete cytokines which can then affect other immune cells nearby.
- When an antigen binds to the antibody receptor on a B cell, a bit of the antigen is also taken up into the cell and is then presented to the B cell surface by a MHC molecule. This MHC-antigen complex is recognised by a T cell, usually a T helper cell, which secretes cytokines. In this case the cytokines assist the B cells to proliferate to form identical cells producing the same antibody.

6. *Clostridium botulinum* is a bacterium that produces the botulinum neurotoxin. This is commonly known in the medical industry as Botox. It is the botulinum toxin that is lethal as it causes flaccid paralysis in humans and animals. *Clostridium botulinum* that produces it however is not considered dangerous by itself. The immune system can recognise toxins as well as micro-organisms.

a) How does the immune system recognise and clear toxins?

The immune system uses the humoral response of the adaptive immunity to clear toxins. This involves the binding of an antibody to the toxin/antigen and it can be immobilised and neutralised.

b) Why would a vaccine for the *Clostridium botulinum* bacterium not be considered as effective as a vaccine against the botulinum toxin?

The toxin is the lethal component. Without the toxin the bacterium is not considered dangerous. A vaccine against the toxin is effective because it can stimulate the immune system to produce antibodies against the toxin thus preventing the harmful effects of the disease.



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7. What is the function of the following cells:

- a. Cytotoxic T cells?  
Cytotoxic T cells can recognise intracellular antigens and kill infected cells
  
- b. Helper T cells?  
Helper T cells are involved in T-cell dependent responses. They can help stimulate B cells to proliferate and they can also help them to become plasma cells.
  
- c. Plasma cells?  
Plasma cells are derived from B cells. Once a B cell recognises a free antigen it can become a plasma cell. These plasma cells are antibody producing cells and so are large in size.

8. Explain why vaccines are preventative in protecting against infection.

Vaccines show the antigen for a particular infection to the immune system so that specific antibodies can be produced without the disease developing in the individual. If an individual contracts the disease naturally a vaccine will not help as the specific antibodies will already have been produced. Vaccines provide immunity artificially whereas a disease will give natural immunity. Contracting the disease is potentially dangerous so vaccination is safer.

9. Explain how a vaccine results in a memory response in the immune system.

A vaccine contains antigenic material/antigens for a micro-organism/disease. This results in the production of antibodies by the plasma cells/B cells that are complementary/a match to the antigen from the vaccine. The antibodies produced in a memory response are IgG/immunoglobulin G so they persist for a long time in the body. Some of the B cells and T cells involved in identifying the antigen from the vaccine differentiate/change into memory cells which will mount a quicker immune response the next time the antigen is encountered.



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10. Herd immunity arises when a significant proportion of the population is vaccinated against a disease. What could happen if the vaccination rates were to fall in a population for the following vaccines? (Hint: think about their transmission methods. Measles is spread through touch and in the air through contagious droplets from infected people, and cholera is a water-borne disease).

a) Measles

If vaccination rates were to fall for measles vaccines, sporadic outbreaks could occur as the measles can pass between unvaccinated and susceptible individuals in the air or through contact with an infected person.

b) Cholera

Just like measles, decreased vaccination rates for cholera in countries where cholera is a major health concern, can result in outbreaks. Herd immunity is still important; however as cholera is a water-borne disease it can still affect people who are unvaccinated even if they are around people who have been vaccinated.