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| **SUBJECT CODE:** | Bio 1 | *Fundamentals of Biology 1* |
| **LEARNING GUIDE CODE:** | 4.0 | *Immunity* |
| **LESSON CODE:** | 4.4 | *Immunization and Human Immune Disorders* |
| **TIME FRAME:** | | *30 minutes (1 session)* |

## MATERIALS NEEDED

To complete this lesson, you need the following:

1. pen;
2. paper;
3. phone/tablet/laptop;
4. Moodle app;
5. Moodle (PSHS Knowledge Hub) account;
6. stable internet connection and;
7. Biology: A global Approach by Campbell et al. (2015).

## TARGET

After completing this lesson, you are expected to:

1. enumerate and describe the different mechanisms of acquiring immunity;
2. list down common immune disorders of human and explain their corresponding pathophysiology.

## HOOK

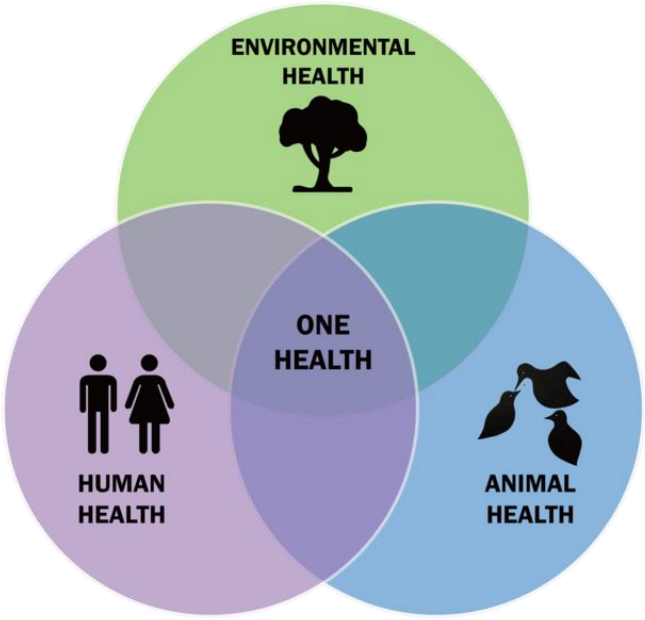


*Figure 1.* One Health. By Thddbfk - Own work, CC BY-SA 4.0, https://commons.wikimedia.org/w/index.php?curid=81872126

This logo represents the concept of One Health - "a collaborative, multisectoral, and transdisciplinary approach—working at the local, regional, national, and global levels—with the goal of achieving optimal health outcomes recognizing the interconnection between people, animals, plants, and their shared environment" (CDC, 2020). With this approach, different people from different sectors and different nations communicate, coordinate, and collaborate in order to achieve the best outcome for the health of the people, animals, and the environment. This approach recognizes that human health is affected by animal and environmental health and that humans also have great impact on the health of animals and the environment. This concept has been around for years but was highlighted due to the emergence of pandemics like the COVID-19 pandemic which essentially revealed the interconnectedness between people, environment, and animals.

In this module, you will be learning another aspect of human health - the different methods of acquiring immunity and common immune disorders. You will also see that One Health as an approach is an emerging theme in different aspects of human immunity such as vaccination and immune disorders.

## IGNITE

In the previous lesson, we have learned that vertebrates have two types of immune defenses, the **innate defenses** which are non-specific and **acquired or adaptive defenses** which are specific to a class of pathogens.

**Do you know that there are two methods of acquiring immunity and each method can be natural or artificially induced?**

## NATURAL ACTIVE AND NATURAL PASSIVE IMMUNITY

In the humoral immune response, the body produces antibodies as a response to the invading pathogen. As we have discussed, antibodies bind to the receptors of pathogens making them inactive and also mark pathogens for phagocytosis by phagocytic cells. This type of immunity is also known as **active immunity,** which are defenses of the body against invading pathogens which trigger primary or secondary immune response. Another type of immunity is **passive immunity,** wherein antibodies are transferred from an immune individual to a non-immune individual as in the case of fetal-maternal antibody transfer.

**IgA antibodies** from the blood of a pregnant female are being transferred to the fetus through the placental circulation. In this case, the fetus gains immunity in the form of antibodies even if the fetus has not been exposed to any invading pathogen. However, the transferred antibodies last only for a few weeks to few months; hence, rendering immunity to the recipient only during this time frame. After birth, a mother still provides **IgA antibodies** to the child through her breast milk, and these antibodies in the breast milk protects the child's digestive tract while his/her own digestive tract is still developing.

The method of acquiring the active and passive immunities discussed above can be described as **natural.** Active and passive immunity can also be acquired **artificially**.

## ARTIFICIAL ACTIVE AND ARTIFICIAL PASSIVE IMMUNITY

**Artificial active immunity** is a type of immunity wherein an individual develops B cells and T cells which trigger primary immune response when inactivated forms of pathogen are injected to the body of the individual. This process is also known as **immunization.** The inactivated

forms are also known as **vaccines** and could take the form of viral surface protein, inactivated bacterial toxin, killed pathogens, and weakened pathogens. This inactivated form cannot cause sickness to the individual but will enable the body to produce memory T cells and memory B cells against the pathogen. When the pathogen enters the individual's body in the future, the body already has a more rapid and stronger response against the pathogen which is a characteristic we know as immunological memory. **Immunization** or **vaccination** was pioneered by Edward Jenner in 1798. Jenner was able to discover the vaccine for smallpox virus which was widespread in the 18$^{th}$ century. Jenner observed that the dairymaids who are exposed to cowpox virus (a virus which can be transferred from cow) are somehow not affected by the smallpox virus. He then extracted a sample from the skin lesions of a dairymaid who is infected with cowpox virus and inoculated the sample to the bloodstream of a young boy. The young boy became ill for nine days and recovered on the tenth day. Almost a month after, Jenner inoculated the same boy with extracts from a patient suffering from small pox virus. The boy did not suffer any symptoms of smallpox virus. This led to the development of a vaccine against smallpox virus which contains inactivated antigens of cowpox virus. The mechanism is summarized in the figure below.

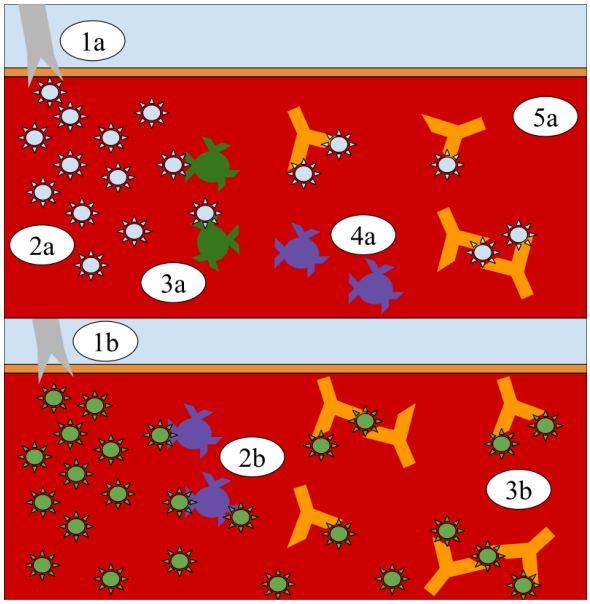


*Figure 2*. How immunity against smallpox virus can be obtained from cowpox exposure 1a. Cowpox virus is injected into the bloodstream. 2a. The virus enters the cells and a mild fever develops. 3a. T-cells and B-cells recognize the antigen as a threat. 4a. Activated T and B cells replicate, and their offspring become memory T-cells and B-cells. 5a. Antibodies are produced and destroy the virus. 1b. Smallpox virus is injected into the bloodstream. 2b. Memory T and B cells recognize the virus. 3b. Antibodies are produced and destroy the virus. By Gnomstah - Own work, CC BY-SA 4.0, https://commons.wikimedia.org/w/index.php?curid=69698470

Global efforts on vaccination have paid off in the past years as some diseases such as smallpox disease in the late 1970s were completely eradicated. National governments have been employing massive vaccination among children and infants and these efforts have led to a global decrease in the incidence of fatal diseases such as polio, measles, and whooping cough. However, in the past years, many diseases cannot still be prevented by vaccination. In some impoverished areas of the world, the lack of economic resources made it hard for vaccines to be readily-available for consumption. Misinformation and fake news about vaccines also led to a noticeable decrease in the rate of vaccination across the whole world as in the case of Dengvaxia in the Philippines. Measles, for instance, is a disease which can be prevented by vaccination but due to misinformation, around 200,000 people die from this disease every year.

**Artificial passive immunity,** on the other hand, is acquired when antibodies from an immune animal are injected and transferred to the body of a non-immune animal. **Serum** (a mixture which contains the antibodies) is injected to the body of a non-immune individual but only takes effect for a limited time. Tetanus and botulinum infections are often treated by injecting the infected person with **antitoxin** which is extracted from immune horses. **Antivenin** from immune horses and sheep is also used in treating individuals who are bitten by venomous snakes, spiders, and scorpions. Immediate application of antivenin can counteract the toxin from snake bites and can save the life of an individual.

Shown below is a pictorial representation of the differences among the four methods of acquiring immunity.

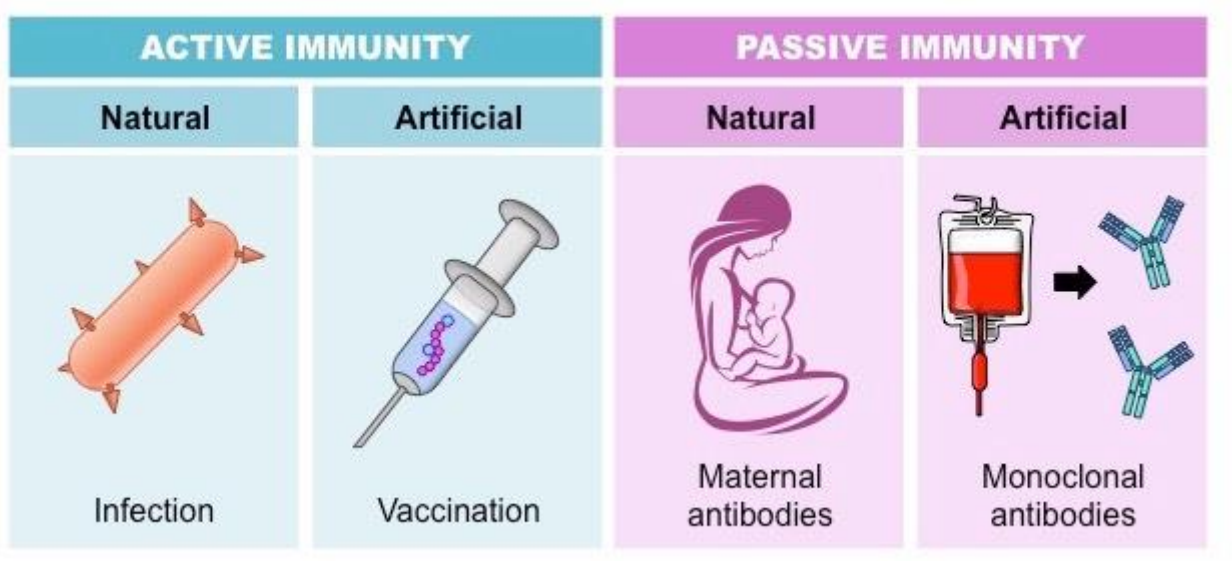


*Figure 3.* Methods of Acquiring Immunity. Reprinted from Types of Immunity, In *https://ib.bioninja.com.au/higher-level/topic-11-animal-physiology/111-antibody-production-and/types-of-immunity.html.* Reprinted with permission.

Now that we have discussed the different mechanisms on how vertebrates protect their internal body from the threats of the outside environment, let us ask ourselves with this question, **"What will happen if acquired immune defenses malfunction, are blocked, or misregulated?"**

# IMMUNE DISORDERS

An immune system of an individual may be disrupted due to different causes such as genes, environment, lifestyle, or a simple regulatory malfunction. When this disruption happens, the capability of the immune system to protect the body is diminished. In worse cases, the immune system attacks the body's own molecules, tissues, and organs. The most common immune disorders are listed and described below.

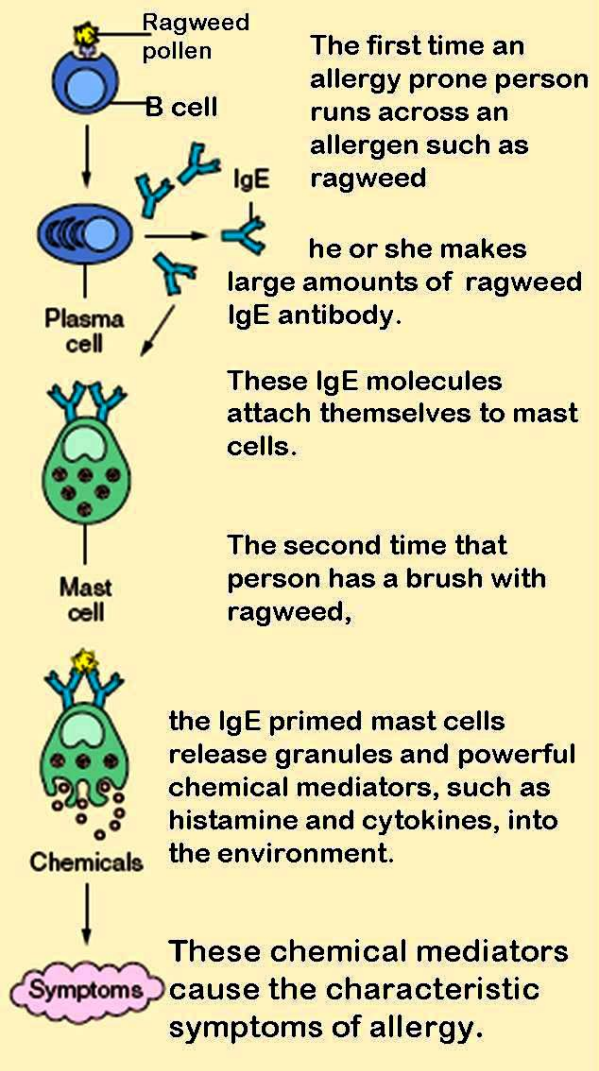


*Figure 4.* Allergic Reaction. By Template drawing from "The Immune System", any modifications, made by myself are released into the public domain. - The Immune System (pdf), Public Domain, https://commons.wikimedia.org/w/index.php?curid=1142780

**1. Allergy** – Hypersensitive responses to certain antigens called **allergens (pollen, dairy, peanuts, among others).** Symptoms include runny nose, teary eyes, and smooth muscle contractions in the lungs inhibiting breathing. *Antihistamine drugs* such as Cetirizine and Loratadine are used to treat allergies. Allergy is a product of the interaction among **allergen, mast cells, and antibody IgE** as shown on Figure 4. When an allergen such as pollen grain enters the body through the respiratory tract, B cells may produce *IgE antibodies* which are specific for the antigens on the surface of pollens. These *IgE antibodies* can bind to the receptors found on the surface of *mast cells*. If you will remember, mast cells are cells which contain histamine and other inflammatory chemicals. When pollen grains enter the bloodstream for the second time, they may attach to the IgE antibodies which are now bound to the mast cells. The attachment of pollen grain will trigger the mast cell to release histamines and other inflammatory responses. These released chemicals will result in a variety of symptoms as enumerated above. Drugs which contain antihistamine can be used to counter allergic reactions by blocking the histamine and preventing it from affecting the different cells of the body. A serious condition which can result from allergy is **anaphylactic shock,** a

condition wherein the massive release of histamines upon the exposure to an allergen results in the dilation of blood vessels and constriction of bronchioles. These events lower blood pressure and makes it hard for the affected individual to breathe and may lead to death if not immediately treated. Epinephrine, a hormone naturally produced by the body, can counter the effects of allergy in the body especially for those with severe hypersensitivity.

**2. Autoimmune disease** – Occurs when the immune system is active against particular molecules of the body due to *lack of self-tolerance*.

When a body cell is lysed or broken down, it normally releases histones and DNA. In **lupus**, an autoimmune disorder, the body produces antibodies which can bind to these histones and DNA which can result in skin rashes, fever, and kidney dysfunction.

**Myasthenia gravis** is an auto-immune disorder that is genetically inherited and is more common in females and males due to its recessive nature. In myasthenia gravis, the body produces antibodies which bind to acetylcholine receptors in muscle causing these receptors to be inactivated. A result of this inactivation is the loss of muscular contraction which will later on develop into skeletal muscle weakness and muscle atrophy or loss. Shown below is ptosis, or drooping eyelids, which is one of the symptoms of myasthenia gravis.

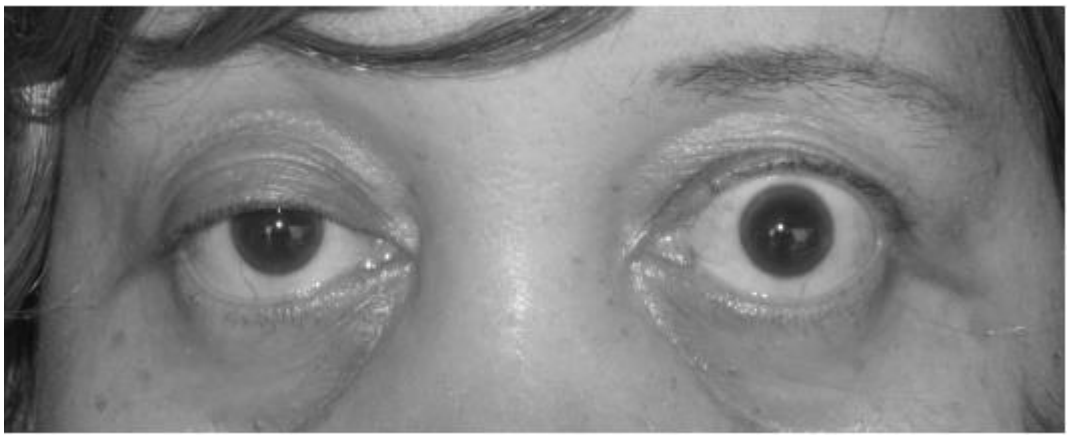

*Figure 5*. Ptosis: Symptom of Myasthenia Gravis. By Mohankumar Kurukumbi, Roger L Weir, Janaki Kalyanam, Mansoor Nasim, Annapurni Jayam-Trouth. - Rare association of thymoma, myasthenia gravis and sarcoidosis : a case report. Journal of Medical Case Reports. 2008;2:245. doi:10.1186/1752-1947-2-245, CC BY 2.0, https://commons.wikimedia.org/w/index.php?curid=4979873

Other autoimmune diseases include **rheumatoid arthritis, diabetes mellitus type 1, and multiple sclerosis**. Different treatments have been developed to address the symptoms of these disorders, and the search for more effective treatment and prevention is still ongoing.

**3. Inborn Immunodeficiency disease** – A type of disease where the immune system response to pathogens is defective or absent which results from a *genetic or developmental defect in the production of antibodies*. Inborn immunodeficiency diseases are treated by bone marrow transplant and stem cell therapy. Infants born with immunodeficiency are prone to infection.

**4. Acquired Immunodeficiency disease** – Immune system response to pathogens is defective or absent which results from *exposure to chemical and biological* agents**.**

One of the most common acquired immunodeficiency diseases which killed about 690,000 humans in 2019 is **Acquired Immunodeficiency Syndrome (AIDS)** caused by **Human Immunodeficiency Virus (HIV).**

**HIV** can be transmitted through bodily fluids such as blood and saliva. Sufficient number of HIV in the blood will promote infection. HIV attacks helper T cells by binding to the **CD4** protein found on the surface of these cells. Once the HIV has already hijacked the T cell, HIV will direct the cell to produce more HIV viral proteins which will then be manufactured into infective HIVs. The body's immune response may act against HIV, but HIV escapes the detection of the other immune cells by becoming latent inside the helper T cells. The rapid reproduction of HIV in the body also increases the rate of mutation in the HIV population. Since the HIV is evolving inside the body, the body will not be able to produce antibodies and cytotoxic T cells specific for this virus since the antigens on the surface are continuously mutating. Since helper T cells are the one being attacked and killed, the body becomes susceptible to other pathogens since helper T cells play an important role in the body's acquired immune response. If the number of helper T cells continues to drop and the number of HIV continues to increase, the body becomes prone to organ infections such as respiratory tract infection, and in some cases cancer. This susceptibility to diseases is what we call as **Acquired Immunodeficiency Syndrome.** People living with HIV die due to the complications of AIDS such as pneumonia and cancer and not due to HIV itself. Currently, there is no single vaccine or drug which can treat HIV, but modern treatments are focusing on slowing the increase of HIV in the body using **antiretroviral drugs** which work by preventing HIV to undergo reproduction.

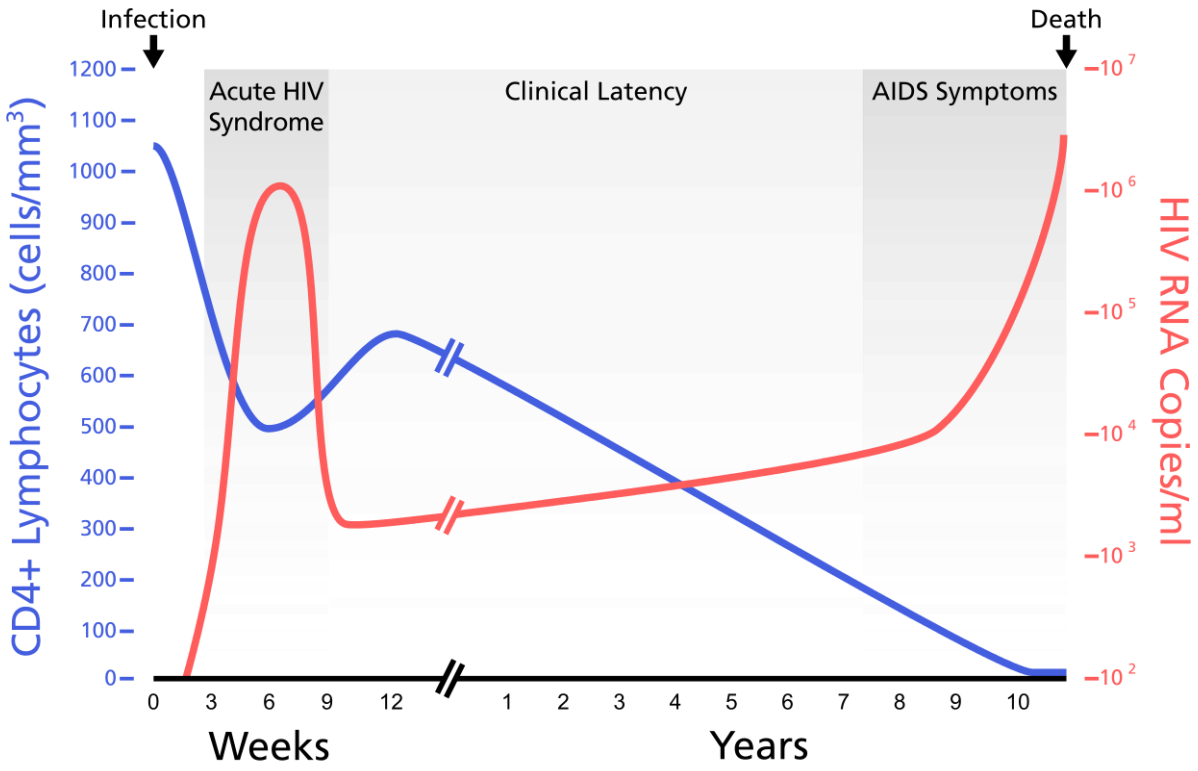


*Figure 6.* Graph of CD4 Helper T Cell count compared to HIV count as years progress. By Thomas Splettstoesser - This file was derived from: Hiv-timecourse copy.svg:, CC0, https://commons.wikimedia.org/w/index.php?curid=29857845

## NAVIGATE

# HOW COULD WE PREVENT ANOTHER PANDEMIC?

The COVID-19 pandemic has affected millions of lives across the planet. This pandemic paralyzed major economies, and detrimentally affected underprivileged areas especially in impoverished nations. How can we prevent the next pandemic? What are the lessons we have learned from COVID-19? How can the concept of One Health be applied in preventing future pandemics?

In this part of the module for Immunity, you are tasked to create an infographic which will answer the questions above. Make sure to include the following details in your infographic.

- **A catchy title**
- **A short background about COVID-19**
- **Things we have learned as a nation from the COVID-19 pandemic**
- **Things we can do in order to prevent the next pandemic**
- **Application of the concept of One Health in preventing future pandemics**
- **References**

**THIS IS A GRADED ALTERNATIVE ASSESSMENT** and you will be graded using the rubrics below.

**RUBRICS**

**TOTAL NUMBER OF POINTS: 15 POINTS**

| | | | |
|---|---|---|---|
| **Submission/ Compliance** | **2** | **1** | **0** |
| | The student submitted the output on or before the deadline. | The student submitted the output beyond the given deadline. | The student did not submit any output. |
| **Application of Concepts Learned and Completeness of Output** | **6** | **4** | **3** |
| | **All** of the explanations are accurately anchored to the concepts presented in the lesson. Information adequately supports the purpose of the infographic. | There is **at most one part** of the concept map which is inaccurate and not founded on the scientific principles learned. Information is mostly adequate and mostly supports the purpose of the infographic. | There are **more than one part** of the concept map which is inaccurate and not founded on the scientific principles learned. Information is inadequate and poorly supports the purpose of the infographic. |
| **Completeness of Infographic** | **3** | **2** | **1** |
| | **All required** parts are present in the infographic. | **2-3** parts are missing in the infographic. | **At least 4** parts are missing in the infographic. |
| **Creativity/ Appropriateness of Infographic Design** | **4** | **3** | **2** |
| | The design of the infographic is appropriate to the topic, creativity and organization is evident on all parts of the infographic. | The design of the infographic is appropriate to the topic, creativity and organization is evident on most parts of the infographic. | The design of the infographic is not appropriate to the topic, creativity and organization is evident on only some parts of the infographic. |

*Take a picture or scan the activity sheet provided and submit your output through your Knowledge Hub classroom on or before the deadline set by your teacher.*

## KNOT

In summary, we have learned that there are four methods of acquiring immunity. **Natural active immunity** are defenses that arise when a pathogen infection prompts an immune response. **Artificial active immunity** involves the introduction of antigens into the body also known as vaccination or immunization. **Natural passive immunity** is acquired when IgA antibodies in the blood of a female cross the placenta to her fetus. Lastly, **artificial passive immunity** is acquired when antibodies from an immune animal are injected to the body of a non-immune animal. When a human's immune system is disrupted, inactivated, or is not able to distinguish foreign molecules from its own, immune system disorders may arise. These disorders may be in the form of hypersensitivity, lack of self-tolerance of autoimmunity, inborn immunodeficiency, and acquired immunodeficiency.

## REFERENCES

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