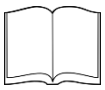
SUBJECT CODE:	Bio 1	*Fundamentals of Biology 1*
LEARNING GUIDE CODE:	4.0	*Immunity*
LESSON CODE:	4.1	*Trends and various strategies used by organisms for defense against disease*
TIME FRAME:		*30 minutes (1 session)*



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).

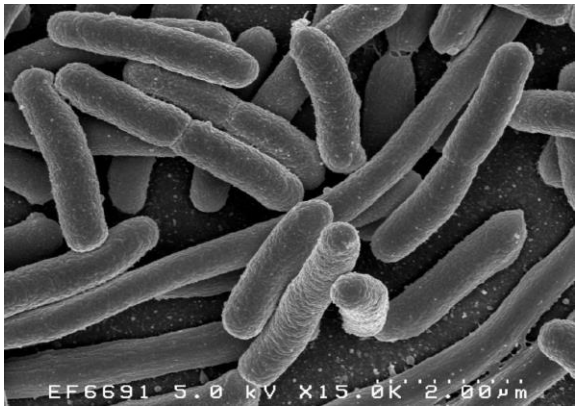
TARGET

After completing this lesson, you are expected to describe the trends and compare various strategies used by animals for defense.

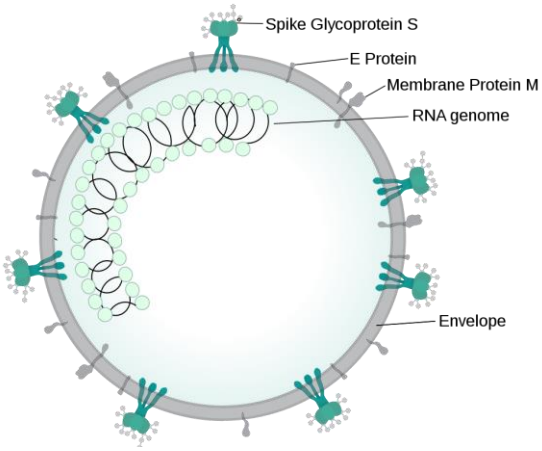
HOOK

WHO'S THAT PATHOGEN?

Pathogen is any organism which can cause disease to another organism. Shown below are three microorganisms which are common pathogens of animals. Can you identify the name of these microorganisms?

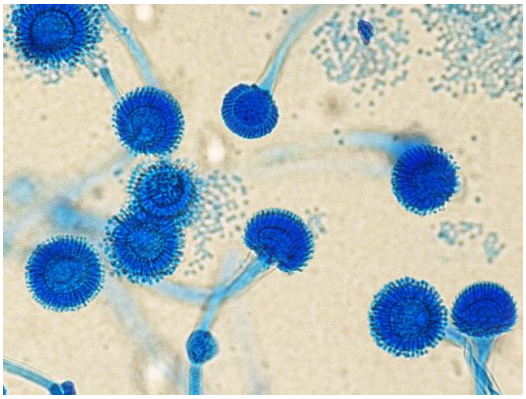


Bac - ter - You! You may know me by an easy name. Green metallic sheen in agar, that's my fame!



I wanna infect a billion men, so freaking bad. Go to the bodies I've never had. I could be the cover of news magazine, wearing my crown I look like a *queen.*

Coughs
Coughs
Coughs
Coughs



In which group do these organisms belong to?

IGNITE

The immune system or defense system is the body system which defends the body against any foreign molecule and aims to limit if not prevent many infections. An organism's body is a suitable habitat for the growth of many harmful and pathogenic (disease-causing) organisms and without structures to defend the body, it would be at risk and prone to damage.

Different animals have evolved a variety of structures in order to protect themselves from the threat of the outside environment ranging from stinging cells to more complex organ systems. In this module, we will be exploring the different trends and strategies utilized by major animal groups for defense and immunity.

The strategies utilized by animals for defense can be classified into either **innate immunity** or **adaptive immunity.** Innate immunity offers a primary defense in **all animals** and sets the stage for adaptive immunity which is **unique to vertebrates.** The table below shows the main difference between innate immunity and acquired/adaptive immunity.

Table 1. Differences between innate and acquired/adaptive immunity

PARAMETERS	TYPES OF IMMUNITY	
	Innate Immunity	**Adaptive Immunity**
DEFINITION	Recognizes traits shared by **broad ranges of pathogens** using a **small set of receptors.**	Recognizes traits **specific to particular pathogens**, using a **vast array of receptors.**
SPECIFICITY	Not too specific	Specific
RESPONSE	Rapid	Slower
MEMORY	No memory	With memory
ORIGIN	From birth	Acquired after birth
TRIGGERS	Natural infection, Acute allergy infection	Natural infection, vaccination and delayed allergy reactions
EXAMPLES	**Barrier defense** (Skin, Mucous membranes, Secretions) **Internal defense** (Phagocytic cells, natural killer cells, antimicrobial proteins, inflammatory response)	**Humoral response** (Antibodies defend against infection in body fluids using B cells) **Cell-mediated response** (Cytotoxic cells defend against infection in body cells)

INNATE IMMUNITY OF
PORIFERANS

Sponges feed through filter feeding wherein they take in large amounts of water and filter, extract, and absorb edible materials which are suspended in the liquid medium. This type of feeding poses a threat to the organism's simple body plan as large concentrations of viruses and bacteria which can be potentially harmful are also suspended in marine water. This threat is countered by sponges by producing secondary metabolites (such as antibiotic compounds) which kill and prevent the growth of bacteria and viruses inside their multicellular body plan. Weins, et al (2005) discussed in their paper that *Suberites domuncula*, a species of sponge scattered around marine waters across the world, can recognize Gram positive and Gram negative bacteria as well as fungi. This species can also produce ***suberitine,*** a neurotoxin which can disrupt an invertebrate's nervous and circulatory system.

FIGURE 4: Suberites domuncula

By Guido Picchetti http://www.guidopicchetti.it - http://www.mondomarino.net, CC BY-SA 3.0, https://commons.wikimedia.org/w/index.php?curid=4875313.

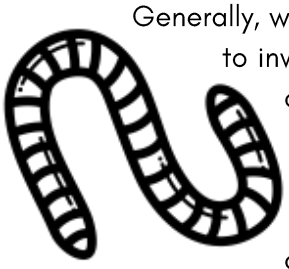
INNATE IMMUNITY OF
CNIDARIANS

Most cnidarians have **nematocysts,** stinging cells used to inject toxins into the body of a prey or a predator. Cnidarians produce a variety of toxins which include palytoxins and hypnotoxins (Suput, 2011). The discovery of this toxin by Charles Ritchet in 1913 paved the way for the discovery of *anaphylaxis* - a severe, potentially lethal allergic reaction to a pathogen). Some hydras (a group of cnidarians) also produce antimicrobial compounds which prevent the growth of different microorganisms.

FIGURE 5: Stinging cells of a cnidarian

By David D. Brand (Dbrand at English Wikipedia) - Own work by the original uploader, Public Domain, https://commons.wikimedia.org/w/index.php?curid=39575417

INNATE IMMUNITY OF
HELMINTHES



Generally, worms possess structures which can recognize bacteria and viruses aiming to invade their simple body structure. Flatworms usually have phagocytic cells along their digestive tract which engulfs or "swallows" microbes which are absorbed together with the food they eat. These phagocytic cells also produce **perforin** – a protein which induces lysis and destroys microbial cell membranes. *Caenorhabditis elegans*, a species of nematode commonly used in biological research, responds to viral, bacterial, and

fungal infection. *C. elegans* has an ancestral mechanism of responding to the RNA component of viruses (Ermolaeva & Schumacher, 2014). This species also produces antimicrobial compounds in the form of carbohydrates and proteins which can disrupt bacterial cell walls. Annelids, on the other hand, relies also on antimicrobial compounds and phagocytic abilities of their cell as well as in the antimicrobial and clotting ability of their body fluids (Salzet et al., 2006).

INNATE IMMUNITY OF MOLLUSKS

Mollusks, just like other vertebrates, possess an innate immunity against invading pathogens in the form of anatomic barrier defense, phagocytic cells, and body fluids. The hardened shells in some of the members of this group presents a first line of defense against invading pathogens. When these anatomic barrier defenses are breached by the pathogen, the innate immune response of the mollusk will be triggered. **Hemocytes** – phagocytic cells which are circulating in the body fluids – engulf and destroy small invaders. In response to larger invaders, the mollusk's bodily fluid secretes toxic enzymes and compounds such as lysozymes and nitric oxide in order to neutralize and kill the invading pathogen (Al-Khalaifah & Al-Nasser, 2018).

FIGURE 6: Diversity of shell (barrier defense) in molluscs

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https://commons.wikimedia.org/w/index.php?curid=12991577

INNATE IMMUNITY OF

ARTHROPODS

Arthropod's defense system is an **innate immunity** classified as either **barrier defense** or **internal immune defense**. Innate immune response of insects is specific for particular classes of pathogens. **Barrier defense is the** first line of defense, and they defend against any outside invaders (Reece et al., 2011). The barrier defenses include:

- **exoskeleton** – physical barrier against infection made up of **chitin**
- **lining of chitin** in the insect's digestive tract which defends against pathogens ingested with food
- **lysozyme** – an enzyme that breaks down bacterial cell walls; protects the insect digestive system

Internal Immune Defense, on the other hand, is the second line of defense, usually activated when a pathogen breaches an insect's barrier defense. Insect's immune cells produce a **set of recognition proteins**, each of which binds to a **molecule common to a broad class of pathogens.** These molecules are often found in fungal and bacterial pathogens but not in animal cells; hence these molecules function as **identity tags** and will be recognized as pathogens. Once these proteins are bound to a pathogen molecule, an innate immune response will be activated.

Hemocytes are major immune cells of insects. The following are the mechanisms on how the hemocyte kills and neutralizes invading pathogens:

- Ingest and break down microorganisms (**phagocytosis**)
- Produce defense molecule that traps large pathogen
- Release **antimicrobial peptides,** which circulate throughout the body and inactivate or kill fungi and bacteria by disrupting their plasma membrane. **Toll,** a transmembrane receptor, is activated when a fungus infects an insect. Toll, in turn, activates the production and secretion of **antimicrobial peptides** that **specifically kill fungal cells.**

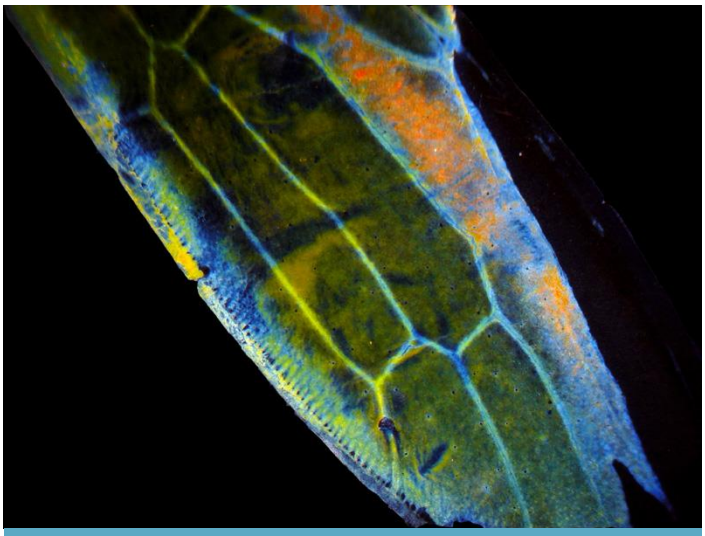

FIGURE 7: Chitin on a grasshopper's wing

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FIGURE 8: Exoskeleton of a cicada

By Jodelet / Lépinay - Own work, CC BY-SA 2.0 fr,https://commons.wikimedia.org/w/index.php?curid=893690

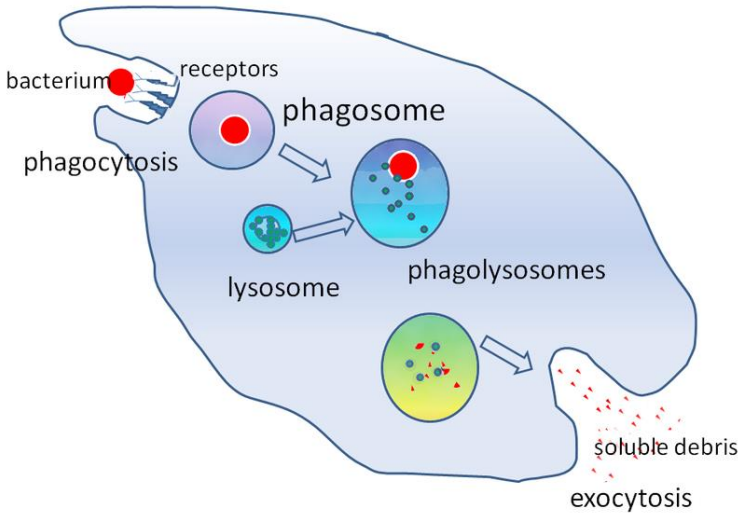


FIGURE 9: General mechanism of phagocytosis

By GrahamColm at English Wikipedia, CC BY-SA 3.0, https://commons.wikimedia.org/w/index.php?curid=6811745

IMMUNITY OF

VERTEBRATES

Vertebrate, on the other hand, possesses both innate and adaptive immunity. We will be focusing on the vertebrate immune system in the next lesson.

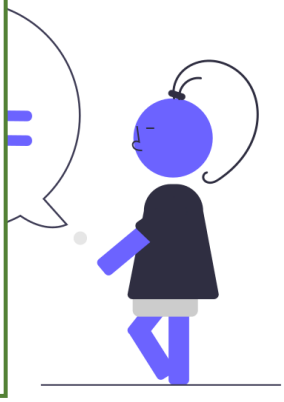
NAVIGATE

Based on what you have learned from above, answer the following questions using five to ten sentences only. Write your answers on the space provided. **THIS IS A NON-GRADED ASSESSMENT.**

THINK FURTHER

1. What do you think are the reasons why the internal body of an animal is a suitable habitat for the growth and development of many pathogenic organisms?

2. Should a molecule be pathogenic in order to trigger an immune response from an animal?



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In summary, the immune system is the body system utilized by animals in order to protect their body from the threats of the external environment. Generally, we can classify an animal's immune mechanism into two which includes either innate or adaptive/acquired immunity. Innate immunity, found in both invertebrates and vertebrates, is not specific and protects the animal against a wide range of pathogens. There is a wide range of innate immunity mechanisms utilized by invertebrates which include but is not limited to phagocytic cells, antimicrobial enzymes, and toxic substances. Acquired/adaptive immunity, on the other hand, is a very specific immune defense which protects vertebrates from specific classes of pathogens. One unique aspect of this type of immunity is immunological memory, a stronger and more rapid response to a pathogen which has been previously encountered by the body.

REFERENCES

Photographs:

Brand, D. (1990). Nematocyst1 [Photograph]. Wikimedia Commons. https://commons.wikimedia.org/wiki/File:Nematocyst1.jpg

Coli3.jpg. (2006, February 1). [Photograph]. https://commons.wikimedia.org/wiki/File:Coli3.jpg

Colm, G. (2009, March 22). Phagocytosis2 [Illustration]. Wikimedia Commons. https://commons.wikimedia.org/wiki/File:Phagocytosis2.png

Coronavirus virion structure.svg. (2020, March 20). [Illustration]. https://commons.wikimedia.org/wiki/File:Coronavirus_virion_structure.svg

Joedelet/Lipanay. (2006, June). Lyristes plebejus.jpg [Photograph]. Wikimedia Commons. https://commons.wikimedia.org/wiki/File:Lyristes_plebejus.jpg

LoKiLeCh. (2010, October 13). Berlin Naturkundemuseum Muscheln.jpg [Photograph]. Wikimedia Commons.https://commons.wikimedia.org/wiki/File:Berlin_Naturkundemuseum_Muscheln.jpg

Picchetti, G. (2003, June 27). Suberites domuncula [Photograph]. Wikimedia Commons. https://commons.wikimedia.org/wiki/File:Suberites_domuncula.jpg

Ufficio Comunicazione, Azienda Ospedaliera SS. Antonio e Biagio e Cesare Arrigo, Alessandria and Biblioteca Biomedica Centro di Documentazione. (2019, December 13). *Antonio e Biagio e Cesare Arrigo Aspergillus fumigatus 01.jpg* [Photograph]. https://commons.wikimedia.org/wiki/File:Antonio_e_Biagio_e_Cesare_Arrigo_Aspergillus_fumigatus_01.jpg

Zituba. (2007, December 6). Glanzkaefer.jpg [Photograph]. Wikimedia Commons. https://commons.wikimedia.org/wiki/File:Glanzkaefer.jpg

Textbook/ Journals:

Al-Khalaifah, H & Al-Nasser, A. (2018). Immune Response of Molluscs, Molluscs, Genaro Diarte-Plata and Ruth Escamilla-Montes, IntechOpen, https://doi.org/10.5772/intechopen.81778. Available from: https://www.intechopen.com/books/molluscs/immune-response-of-molluscs

Ermolaeva, M. A., & Schumacher, B. (2014). Insights from the worm: The C. elegans model for innate immunity. *Seminars in Immunology*, *26*(4), 303-309. https://doi.org/10.1016/j.smim.2014.04.005

Reece, J., Urry, L. A., Cain, M. L., Wasserman, S. A., Minorsky, P. V., & Jackson, R. B. (2011). Campbell Biology 10th edition. San Francisco: Pearson Education Inc.

Salzet, M., Tasiemski, A., & Cooper, E. (2006). Innate Immunity in Lophotrochozoans: The Annelids. *Current Pharmaceutical Design*, *12*(24), 3043-3050. https://doi.org/10.2174/138161206777947551

Suput, D. (2011). Interactions of Cnidarian Toxins with the Immune System. *Inflammation & Allergy - Drug Targets*, *10*(5), 429-437. https://doi.org/10.2174/187152811797200678

Wiens, M., Korzhev, M., Krasko, A., Thakur, N. L., Perović-Ottstadt, S., Breter, H. J., Ushijima, H., Diehl-Seifert, B., Müller, I. M., & Müller, W. E. G. (2005). Innate Immune Defense of the Sponge Suberites domuncula against Bacteria Involves a MyD88-dependent Signaling Pathway. *Journal of Biological Chemistry*, *280*(30), 27949-27959. https://doi.org/10.1074/jbc.m504049200

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