Immunology Made Simple

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Table of Contents

The Basics of Immunology Guide

Background Information

Our amazing immune system protects our bodies from bacteria, viruses, and other harmful pathogens. The immune system is divided up into two distinct parts: Innate immunity and adaptive immunity. Each part has different roles and produce different types of cells. There are several different types of blood cells that fight to eliminate these invaders. During summer 2018, I was a recipient of High School Summer Research Program award from the American Association of Immunologists. Participation in this program has provided me the opportunity to learn more on theory and hands-on research experience of immunology at Bluefield State College. I have learned more about white blood cells. Cells of the immune system include natural killer cells, neutrophils, eosinophils, basophils, monocytes, dendritic cells, and macrophages, which are, associated innate immunity. B cells, T cells, Th cells, These cells differentiate creating are highly specific cells with highly specific tasks in the adaptive immunity! Although all cells originate in the bone marrow, these cells differentiate and are derived from different locations in the body. The 5 main locations of the immune system include: The lymphatic system, lymphoid tissue, lymph nodes, thymus and spleen. Bone marrow also helps control immunity. At this point, I am developing a curriculum to bring the enthusiasm of learning immunology at the high school level.

Student Outcomes

1. Basic immunology vocabulary
2. Specific blood cells of the immune system
3. Innate immunity
4. Adaptive immunity
    a. Humoral Immunity----B cells
    b. Cell Mediated Immunity----T cells

Next Generation Science Standards

1. Develop and use a model based on evidence to illustrate the relationships between systems or between components of a system (HS-LS-1-2)
2. Plan and conduct an investigation individually and collaboratively to produce data to serve as the basis for evidence, and in the design: decide on types, how much, and accuracy of data needed to produce reliable measurements and consider limitations on the precision of the data (e.g., number of trials, cost, risk, time), and refine the design accordingly. (HS-LS1-3)
3. Systems of specialized cells within organisms help them perform the essential functions of life. (HSLS1-1)
4. Multicellular organisms have a hierarchical structural organization, in which any one system is made up of numerous parts and is itself a component of the next level. (HS-LS1-2)
5. Construct an explanation based on evidence for how natural selection leads to adaptation of populations. (HS-LS4-4)
6. Construct an explanation based on evidence that the process of evolution primarily results from four factors: (1) the potential for a species to increase in number, (2) the heritable genetic variation of individuals in a species due to mutation and sexual reproduction, (3) competition for limited

resources, and (4) the proliferation of those organisms that are better able to survive and reproduce in the environment.

7. (HS-LS4-2) o Feedback mechanisms maintain a living system's internal conditions within certain limits and mediate behaviors, allowing it to remain alive and functional even as external conditions change within some range. Feedback mechanisms can encourage (through positive feedback) or discourage (negative feedback) what is going on inside the living system. (HS-LS1-3)

Recommended Course Placement

This unit will be taught in AP Biology classroom setting. AP biology is intended for high school sophomore or junior students.

Student Activities

1. Basic Immunology Pre Test
2. Lecture with PowerPoint: A Brief Overview of the Immune System
3. Students will complete Basic Immunology Vocabulary Crossword
4. Immune System Components
5. Quiz 1 – Basic Immune System Vocabulary
6. Lecture with PowerPoint: Immune Cells
7. Immune Cells Flow Chart
8. Cell Identification Table Assignment
9. Cells Alive Virtual Lab
10. Quiz 2 – Cell ID
11. Lecture with PowerPoint: Innate Immunity
12. Innate Immunity Activity
13. Phagocytosis Model
14. Quiz 3 – Innate Immunity
15. Lecture with PowerPoint: Adaptive Immunity – Humoral & Cell Mediated Immunity
16. Adaptive Immunity Activities
17. Humoral & Cell Mediated Comparative Essay
18. Quiz 4 – Adaptive Immunity
19. Lecture with PowerPoint: Laboratory & Molecular Methods
20. Identifying Organs of the Immune System Virtual Lab
21. ELSIA Virtual Lab
22. Mouse Dissection Laboratory
23. ELISA Laboratory
24. Quiz 5 – Immune Organs & ELISA

Relevance

Immunology is a branch of biology. This course of study will be relevant specifically to students who plan to enter the medical field.

Learning Objectives

Students will…

- Understand all basics components of the immune system.
- Be able to identify cells of the immune system.
- Describe the difference between innate and adaptive immunity.
- List the main locations in the body relevant to immunity.

- Understand the origin of the cells of the immune system.
- Recognize the differentiation of innate immune cells – Example: BMDC
- Preform mouse dissection.
- Preform ELISA and other assays and procedures commonly used in an immunology research lab.

Time Requirements

The suggested time requirement for this unit is approximately 20-25 days of a 90-minute block.

Advanced Requirements

Pre-requisite for this course is Honors Biology first semester. AP Biology will be offered second semester. HSTA members will also be accepted.

Advanced Preparation

- Photocopies of all student activities.
- Dissection and ELISA laboratories will require advanced preparation.
- Students will be required to read the following resource to prepare for the unit. http://www1.mans.edu.eg/FacMed/dept/microbiology/pdf/4-Basic-Immunology.pdf

Materials and Equipment

- Handouts
- PowerPoint
- Paper for student copies
- Labeling & coloring pages
- Internet
- Computers
- ELISA materials
- Dissection materials

Student Prior Knowledge and Skills

Pre-requisites for this course is Honors Biology first semester. AP Biology will be offered second semester. HSTA members will also be accepted.

Daily Unit Plans

Block	INSTRUCTION/STUDENT ACTIVITIES
1	Basic Immunology Pre Test
2	Lecture with PowerPoint: A Brief Overview of the Immune System
3	Students will complete Basic Immunology Vocabulary Crossword
4	Immune System Components
5	Quiz 1 – Basic Immune System Vocabulary
6	Lecture with PowerPoint: Immune Cells
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9	Cells Alive Virtual Lab

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15	Lecture with PowerPoint: Adaptive Immunity – Humoral & Cell Mediated Immunity
16	Adaptive Immunity Activities
17	Humoral & Cell Mediated Comparative Essay
18	Quiz 4 – Adaptive Immunity
19	Lecture with PowerPoint: Laboratory & Molecular Methods
20	Identifying Organs of the Immune System Virtual Lab
21	ELSIA Virtual Lab
22	Mouse Dissection Laboratory
23	ELISA Laboratory
24	Quiz 5 – Immune System: Assays

Summative Assessment

There were several assessments given throughout the unit. There were 5 quizzes that separated the different sections of the unit. Below, you will find the quizzes that were used in this unit.

- Quiz 1 – Basic Immunology Vocabulary
- Quiz 2 – Cell ID
- Quiz 3 – Innate Immunity
- Quiz 4 – Adaptive Immunity
- Quiz 5 – Immune System: Assays

Resources

Name: _____ Date: _____

Basic Immunology Pre-Test

Matching

1. Natural immunity, the first line of defense against foreign organisms and substances.
2. Skin and mucosal linings of respiratory and gastrointestinal tract
3. Tears and saliva contain this enzyme that kills bacteria by breaking the peptidoglycan layer of cell walls.
4. Host cell engulfs and destroys the foreign organism.
5. White cells in the blood; nucleated cells originated from bone marrow.
6. A group of plasma and cell surface proteins that fights invading organisms.
7. Secretory proteins produced by lymphocytes and monocytes in response to microbial antigens; help cell-to-cell communication, inflammatory reactions, immune response reactions.
8. Response to antigen
9. Second line of defense; develops memory for subsequent exposure to the previously encountered organisms.
10. Foreign microbial and non-microbial substances

a. Antigen
b. Adaptive immunity
c. Cytokines
d. Complement
e. Physical barriers
f. Lysozyme
g. Phagocytosis
h. Neutrophils
i. Antibody
j. Innate Immunity

Multiple Choice

11. A _____ is a disease causing organism.
    a. Bacteria
    b. Virus
    c. Pathogen
    d. Antigen

12. Molecules that stimulate an immune response
    a. Bacteria
    b. Virus
    c. Pathogen
    d. Antigen

13. White blood cells that produce antibodies and aid in immune response memory are called…
    a. B cells
    b. T cells
    c. Monocyte
    d. Granulocyte

14. White blood cells specialized to assist B cells are called...
    a. B cells
    b. T cells
    c. Monocyte
    d. Granulocyte

15. Nonliving particle containing protein and DNA/RNA that can infect a living cell
    a. Bacteria
    b. Microorganism
    c. Virus
    d. Fungus

16. Which of the following is an example of the first line of defense?
    a. Neutrophil
    b. B cell
    c. Inflammation
    d. Normal microbiota

17. Which of the following is an example of the second line of defense?
    a. Inflammation
    b. Skin
    c. T helper cells
    d. Antibodies

18. Which of the following is an example of the third line of defense?
    a. Lysozyme
    b. B cell
    c. Neutrophil
    d. Antibodies

Short Answer

19. Compare and contrast innate and adaptive immunity.

20. What are the two primary lymphoid organs and what role do each play?

Basic Immunology Pre-Test

Matching

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Multiple Choice

11. A _____ is a disease-causing organism.
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Short Answer

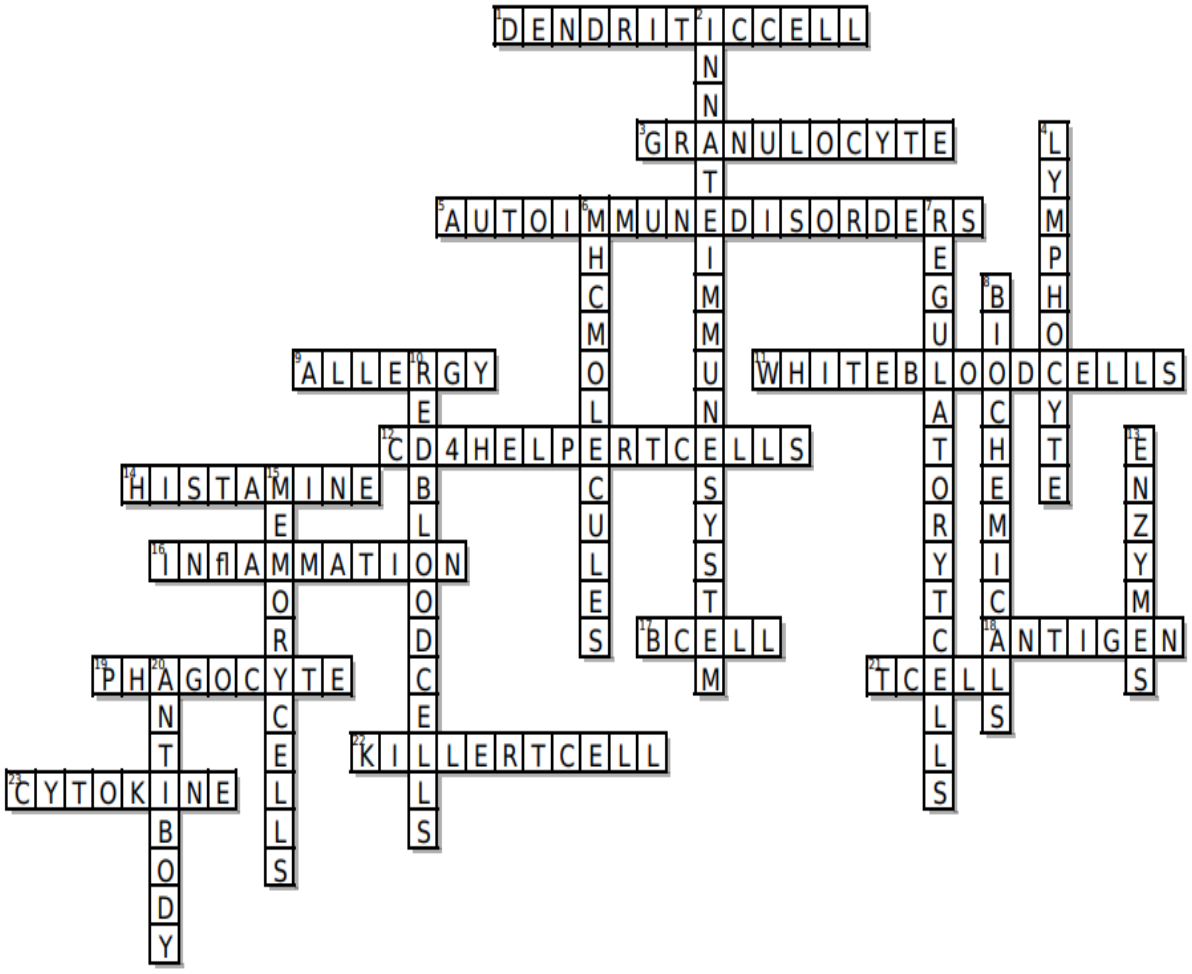
19. Compare and contrast innate and adaptive immunity.

Answers will vary. Innate – fast, nonspecific, first line of defense. Adaptive – takes longer, specific, second line of defense.

20. What are the two primary lymphoid organs and what role do each play?

Bone marrow – produces B cells and lymphocytes
Thymus – produces T cells

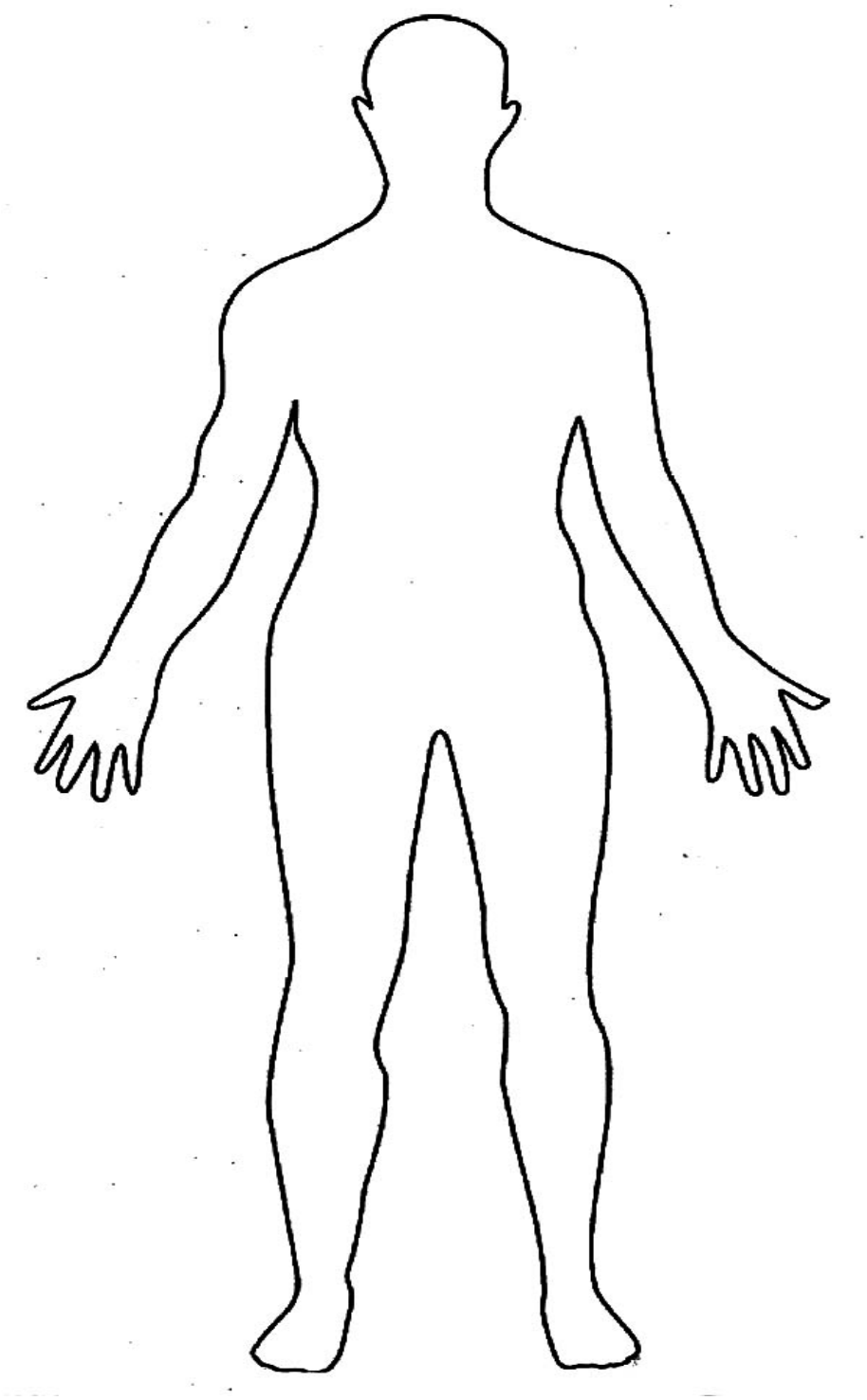
Key Immunology Terms



Name: _____

Immune System Components Diagram

Label & color the following immune system components: **thymus, lymph nodes, T cells, B cells, antibodies, bone marrow, spleen**. You may need to draw additional images to correctly label all immune system components.



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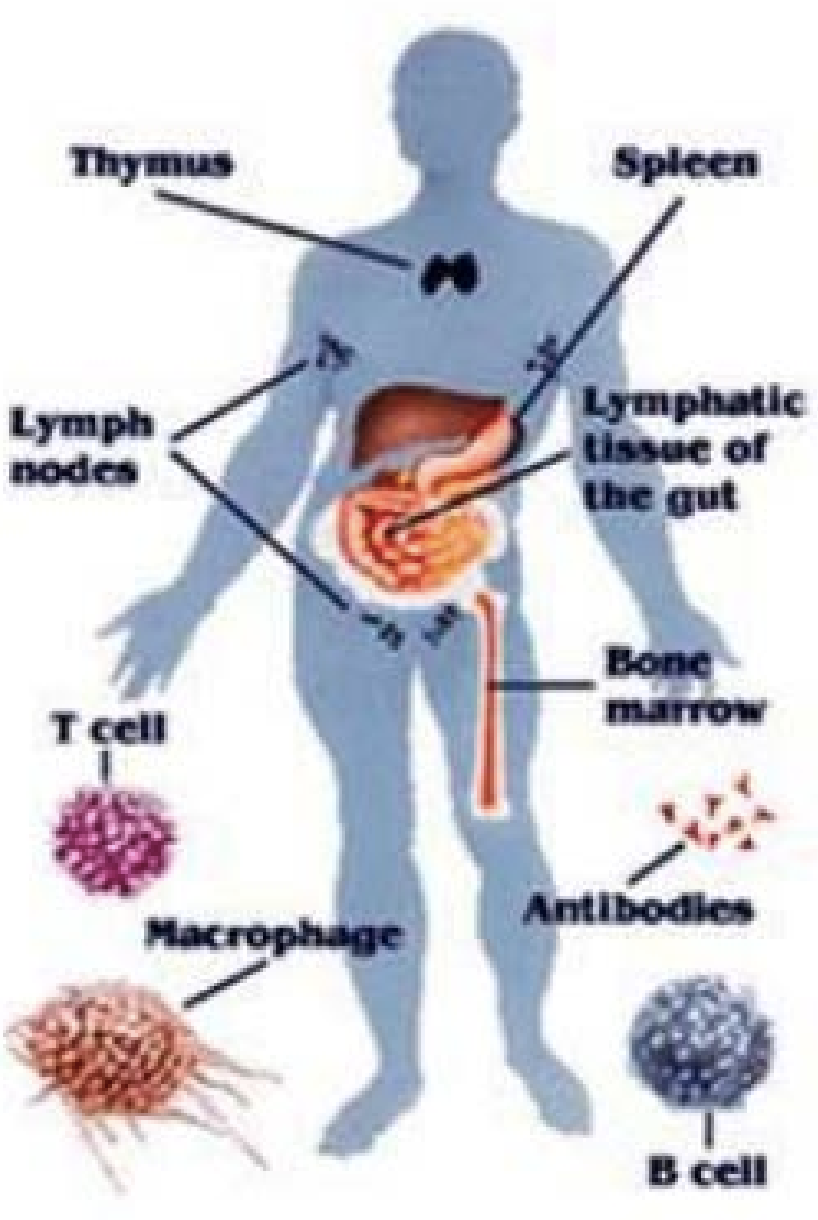

Name: _____ Date: _____

Name: _____ Date: _____

Quiz 1

Multiple Choice

1. Which of the following does not protect body surfaces?
    a. Skin
    b. Salivary amylase
    c. Gastric acid
    d. Gut microflora

2. The initiation of T cell responses requires multiple receptors on the T cells recognizing ligands on APCs. The MHC molecule located around the peptide-binding cleft is recognized by the:
    a. B cells
    b. CD4 or CD8 molecules
    c. NK cells
    d. CD3 or CD6 molecules

3. Neutrophil defensins are:
    a. Anti-toxins.
    b. Enzymes.
    c. Oxygen-dependent.
    d. Peptide antibiotics.

4. Acute inflammation characteristically involves:
    a. Influx of macrophages
    b. Influx of mast cells
    c. Influx of neutrophils
    d. Influx of antibodies

5. Lysozyme:
    a. Splits the peptidoglycan of bacterial cell walls.
    b. Is a cytoplasmic organelle
    c. Is released by mast cells.
    d. Activates complement.

6. Interferons:
    a. Induce enzyme synthesis in the target cell.
    b. Are divided into 5 main families.
    c. Only affected infected cells.
    d. Are specific for individual viruses.

7. Natural killer cells do not contain tumor necrosis factor (TNF).
    a. True
    b. False

8. Which one of the following is a primary lymphoid organ?
    a. Spleen
    b. Tonsils
    c. Thymus
    d. Lymph nodes

9. Which of the following functions are macrophages unable to carry out:
    a. Phagocytosis
    b. T-cell priming
    c. Antigen processing
    d. Antigen presentation to activated cells.

10. Lymphocytes:
    a. Enter the tissues and remain there for the rest of their life.
    b. When mature are only found in secondary lymphoid organs.
    c. Recirculate between blood and lymphoid tissues.
    d. Are only located in the thymus.

Short Answer

Define origin and function/role of the following cells of the immune system.

11. Basophil –

12. Eosinophil –

13. Neutrophil –

14. Lymphocyte –

15. Monocyte –

16. Dendritic cells –

17. Macrophage –

18. T cells

19. B cells

Compare and Contrast

20. Humoral and Cell-mediated immunity.

Quiz 1

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    d. Are only located in the thymus.

Short Answer Define function/role of the following cells of the immune system.

11. Basophil
    Basophils originate from hematopoietic stem cell appear in many specific kinds of inflammatory reactions, particularly those that cause allergic symptoms. Basophils are a type of white blood cell called a granulocyte which cells contain granules that they use to secrete important substances. The granules inside basophils contain heparin, histamine, and other molecules that play a role in inflammation. Basophils contain anticoagulant heparin, which prevents blood from clotting too quickly. They also contain the vasodilator histamine, which promotes blood flow to tissues.
12. Eosinophil
    Eosinophils are pleiotropic multi-functional leukocytes that are typically associated with the initiation and propagation of inflammatory responses, particularly helminth infection and allergic disease.
13. Neutrophil
    A type of immune cell that is one of the first cell types to travel to the site of an infection. Neutrophils help fight infection by ingesting microorganisms and releasing enzymes that kill the microorganisms. A neutrophil is a type of white blood cell, a type of granulocyte, and a type of phagocyte.
14. Lymphocyte
    A type of immune cell that is made in the bone marrow and is found in the blood and in lymph tissue. The two main types of lymphocytes are B lymphocytes and T lymphocytes. B lymphocytes make antibodies, and T lymphocytes help kill tumor cells and help control immune responses. A lymphocyte is a type of white blood cell.
15. Monocyte
    A type of immune cell that is made in the bone marrow and travels through the blood to tissues in the body where it becomes a macrophage. Macrophages surround and kill microorganisms, ingest foreign material, remove dead cells, and boost immune responses. A monocyte is a type of white blood cell and a type of phagocyte.
16. Dendritic cells
    A special type of immune cell that is found in tissues, such as the skin, and boosts immune responses by showing antigens on its surface to other cells of the immune system. A dendritic cell is a type of phagocyte and a type of antigen-presenting cell (APC).
17. Macrophage

A type of white blood cell that surrounds and kills microorganisms, removes dead cells, and stimulates the action of other immune system cells.

18. T cells

    Generated in the bone marrow and complete development in the thymus.

19. B cells

    Generated and mature in the bone marrow.

Compare and Contrast

20. Humoral and Cell-mediated immunity.

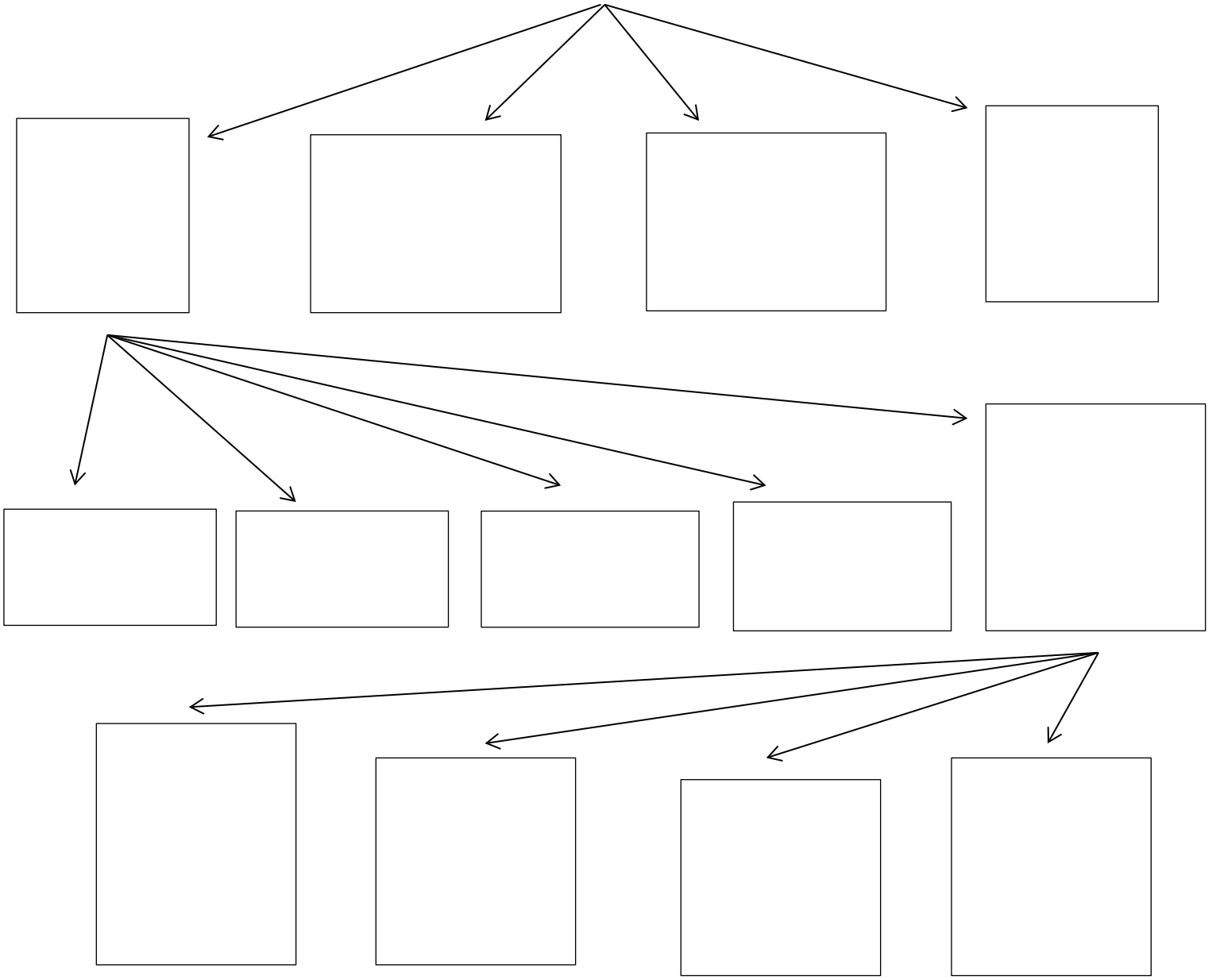
    Humoral – mediated by macromolecules found in the extracellular body fluids; protects against extracellular pathogens; main cells involved are B cells; rapid onset.

    Cell mediated – immunity that identifies and destroys infected cells; protects against intracellular pathogens; main cells involved are T cells; delayed onset.

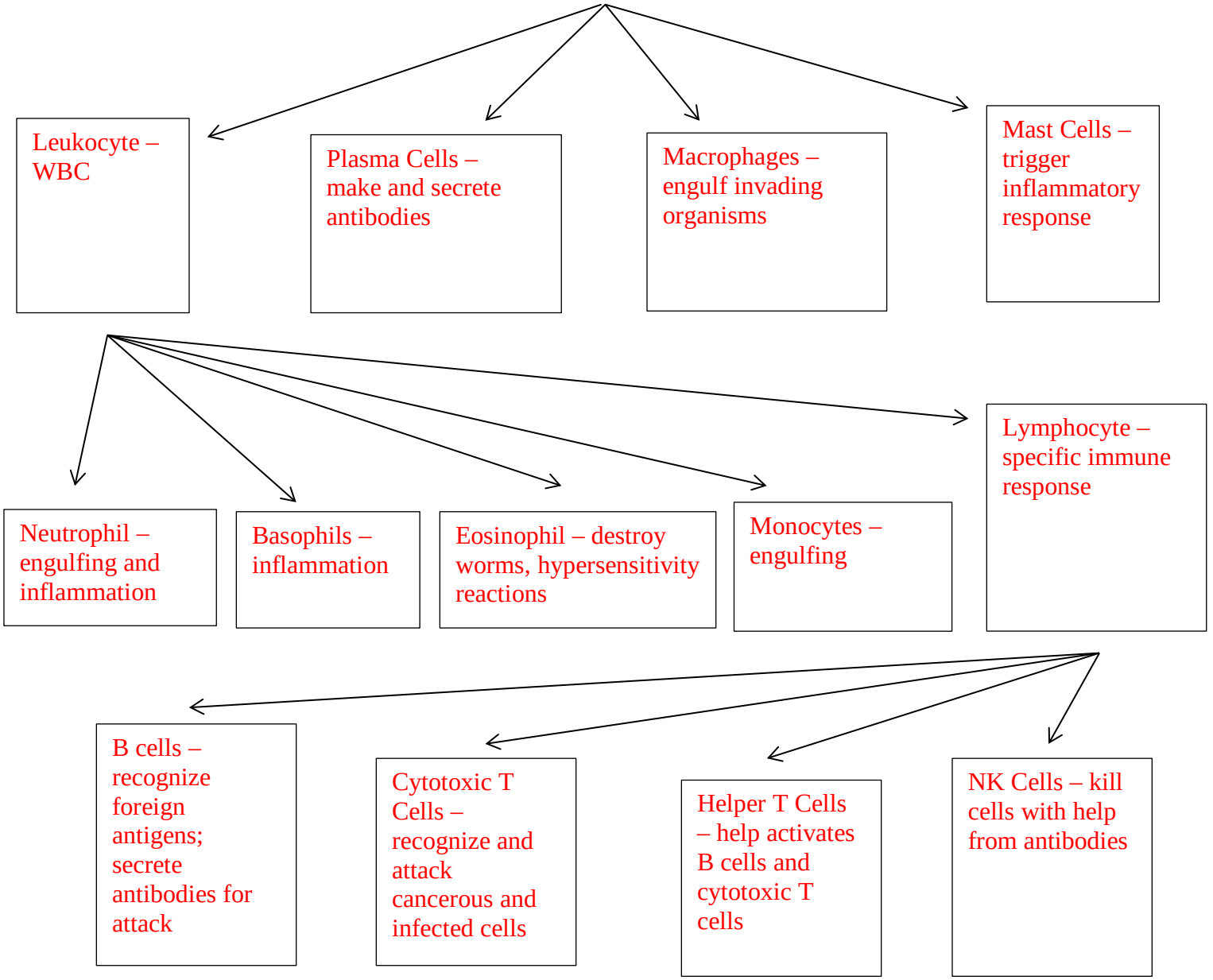
Name: _____

Complete the flow chart with the following immune cells: **Basophil, B cell, Cytotoxic T cell, Eosinophil, Helper T Cells, Leukocytes, Lymphocytes, NK cells, Monocytes, Neutrophils, Macrophages, Plasma cells.** Include a brief description of function.

Immune Cells

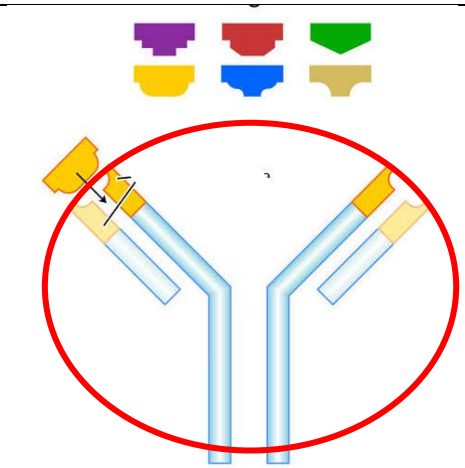
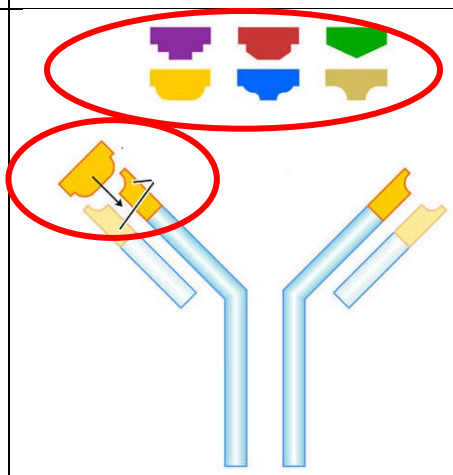
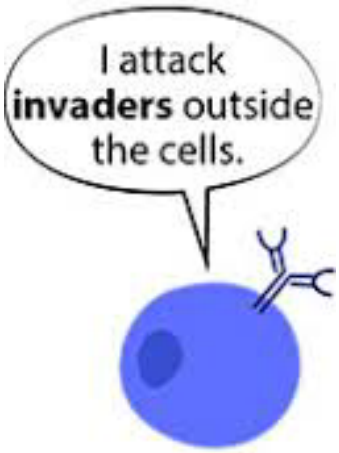


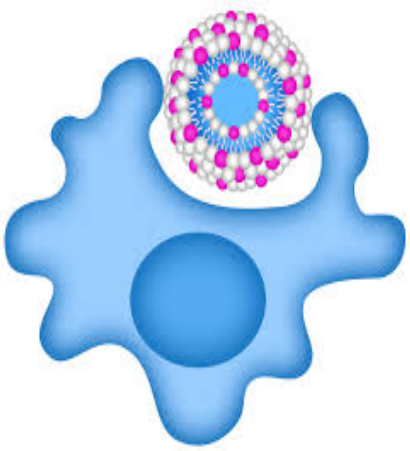
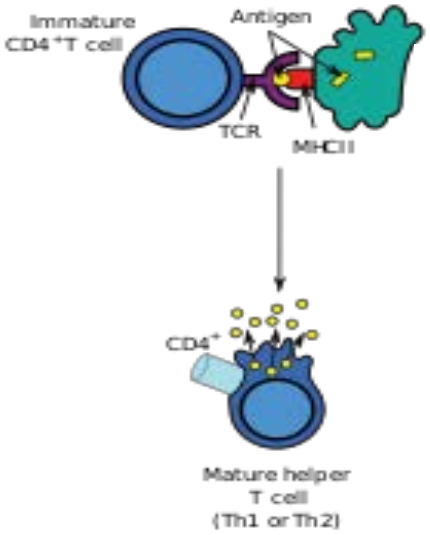
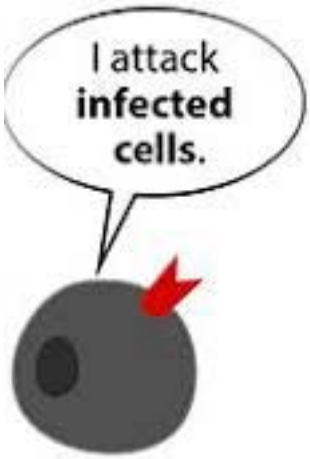
Immune Cells Flow Chart



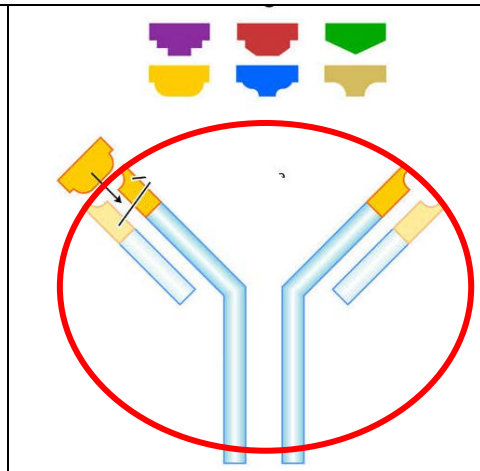
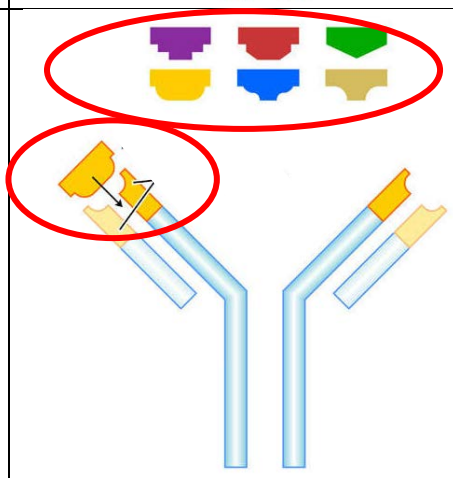
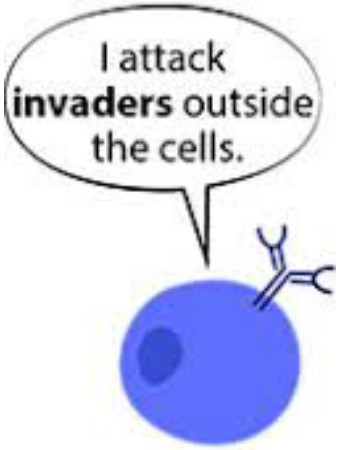
Name: _____ Date: _____

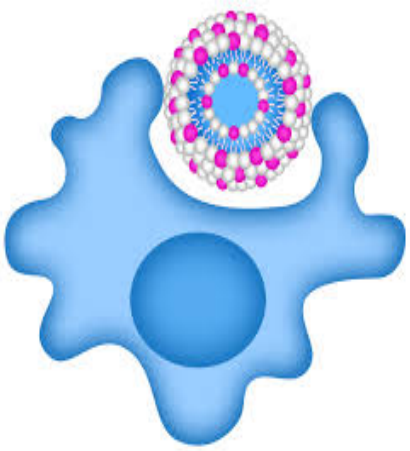
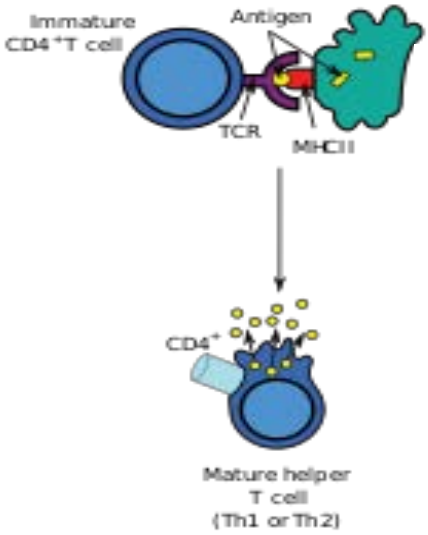
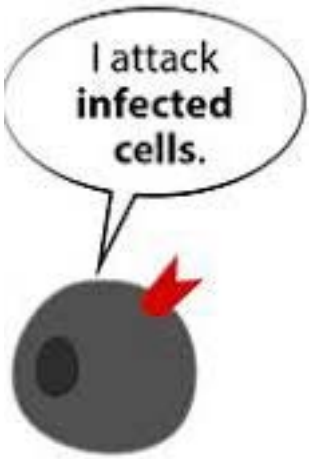
Cell Identification

1.		Adaptive immune system; manufactured in the body; proteins that label pathogens as foreign substances in the body
2.		Toxin or foreign substance; induces an immune response in the body
3.		Derived from the bone marrow, responsible for producing antibodies

4.		WBC; ability to locate and eat particles such as viruses, fungi, bacteria, and parasites.
5.		Process a protein antigen, break it into peptides, and present it in conjunction with class II MHC molecules on the cell surface where it may interact with appropriate T cell receptors.
6.		WBC that works with macrophages to fight viruses.

Cell Identification

1. Antibody		Adaptive immune system; manufactured in the body; proteins that label pathogens as foreign substances in the body
2. Pathogen		Toxin or foreign substance; induces an immune response in the body
3. B Cell		Derived from the bone marrow, responsible for producing antibodies

4. Macrophages		WBC; ability to locate and eat particles such as viruses, fungi, bacteria, and parasites.
5. APC		Process a protein antigen, break it into peptides, and present it in conjunction with class II MHC molecules on the cell surface where it may interact with appropriate T cell receptors.
6. T cell		WBC that works with macrophages to fight viruses.

Name: _____ Date: _____

Cells Alive Virtual Lab

Go to the following website: https://www.cellsalive.com/ and explore the section Immune Response: Ouch!, Antibodies, Allergy, Cytotoxic T-Cell!

- Click on **Ouch!**

1. What is every tissue in the body loaded with?

2. What will you find coursing through the capillaries?

3. What does blood plasma do?

4. Amongst the red cells is an array of specialized cells that are ready to spring into action at the slightest nick of the skin. These include…

5. Ouch! A scratch or a splinter!! What signals the immune systems WBC's for damage control?

6. What are the most active and phagocytic of the white blood cells?

7. Why do neutrophils become sticky and begin to adhere to the inside of the vessel wall?

8. How do WBC's find the bacteria?

9. How do WBC's eat the bacteria?

10. What is oxidative burst?

11. Describe what you watched in the video Oxidative Burst?

- Click on **Antibodies**.

12. What does the scanning electron micrograph show?

13. How are the antigens processed?

14. What do helper T cells do?

15. What does the B cell do?

16. What do the antibodies bind to?

17. What is complement?

- Click on **Allergy**.

18. What are dust mites? What can they cause?

19. Just under our skin are capillaries carrying blood with its circulating red cells and a variety of white blood cell types. Just outside of the capillaries, in the tissue of the dermis, lurk specialized immune cells called _____ _____.

20. What are mast cells covered with?

21. So what causes those itchy red bumps?

- Click on **Cytotoxic T Cell**.

22. What do cytotoxic T lymphocytes (CTL) recognize?

23. Describe what you watched in the video Cytotoxic T cell?

Name: _____ Date: _____

Cells Alive Virtual Lab

Go to the following website: https://www.cellsalive.com/ and explore the section Immune Response: Ouch!, Antibodies, Allergy, Cytotoxic T-Cell!

- Click on **Ouch!**

1. What is every tissue in the body loaded with? Capillaries
2. What will you find coursing through the capillaries? blood plasma
3. What does blood plasma do? Transporting nutrients to the tissue and removing waste. Red cells slip by single file releasing their load of oxygen and picking up carbon dioxide for return to the lungs.
4. Amongst the red cells is an array of specialized cells that are ready to spring into action at the slightest nick of the skin. These include…neutrophils, platelets, monocytes, lymphocytes
5. Ouch! A scratch or a splinter!! What signals the immune systems WBC's for damage control? Trauma, bacteria and dirt.
6. What are the most active and phagocytic of the white blood cells? Neutrophils
7. Why do neutrophils become sticky and begin to adhere to the inside of the vessel wall? Adherence slows the cells down, making them "roll" on the inside of the vessel. The neutrophils then become superadherent and squeeze out between endothelial cells that line the vessel, a phenomenon called "diapedesis".
8. How do WBC's find the bacteria? Neutrophils are our body's first line of defense against bacterial infections. After leaving nearby blood vessels, these cells recognize chemicals produced by bacteria in a cut or scratch and migrate "toward the smell". The above neutrophils were placed in a gradient of fMLP (n formyl methionine- leucine- phenylalanine), a peptide chain produced by some bacteria. The cells charge out like a "posse" after the bad guys.
9. How do WBC's eat the bacteria? Once a white cell has left the blood vessel and migrated to the enemy, the next job is to EAT the microbe. This human macrophage, like its cousin the neutrophil, is a professional "phagocyte" or eating cell (phago = "eating", cyte = "cell"). The macrophage is using its internal cytoskeleton to envelop a cell of the fungus Candida albicans. The capsule on some bacteria allows them to avoid phagocytosis But eating the organisms is not enough. To insure that the organisms not grow and divide within the macrophage, the white cell must kill the organisms.
10. What is oxidative burst? Neutrophils kill microbes by the production of reactive oxygen species.
11. Describe what you watched in the video Oxidative Burst? In this video sequence, a human neutrophil senses, moves toward and ingests an ovoid yeast. The indicator dye nitroblue tetrazolium (NBT) demonstrates that the white cell is using its lethal oxidative ability to kill the yeast. Black and white time-lapse video has been color enhanced to show the degree and location of the oxidative burst.

- Click on **Antibodies**.

12. What does the scanning electron micrograph show? A human macrophage approaching a chain of Streptococcus Pyogenes. Riding atop the macrophage is a spherical lymphocyte.
13. How are the antigens processed? When the macrophage eats bacteria, proteins (antigens) from the bacteria are broken down into short peptide chains and those peptides are then "displayed" on the macrophage surface attached to special molecules called MHC II (for Major Histocompatibility

Complex Class II). Bacterial peptides are similarly processed and displayed on MHC II molecules on the surface of B lymphocytes.

14. What do helper T cells do? When a T lymphocyte "sees" the same peptide on the macrophage and on the B cell, the T cell stimulates the B cell to turn on antibody production. The helper t cell stimulates b cells through the release of cytokines.
15. What does the B cell do? The stimulated B cell undergoes repeated cell divisions, enlargement and differentiation to form a clone of antibody secreting plasma cells. Hence. through specific antigen recognition of the invader, clonal expansion and B cell differentiation you acquire an effective number of plasma cells all secreting the same needed antibody.
16. What do the antibodies bind to? The bacteria which making them easier to ingest by white cells.
17. What is complement? Antibody combined with a plasma component called "complement" may also kill the bacteria directly.

- Click on **Allergy**.

18. What are dust mites? What can they cause? Dust mites are arachnids, the class of arthropods which includes spiders, scorpions and ticks. Dust mites feed on dead skin that sloughs from our bodies (and probably potato chips & cookie crumbs). They live their whole lives in dark corner dust bunnies: hatching, growing, eating, defecating, mating, laying eggs. It's their bathroom habits that make us itch and wheeze. Many people develop severe allergies to dust mite droppings. Lie on a rug where they live and you might get itchy red bumps on your skin. Breath in dust and you may have more serious symptoms like difficulty breathing or even a severe asthma attack.
19. Just under our skin are capillaries carrying blood with its circulating red cells and a variety of white blood cell types. Just outside of the capillaries, in the tissue of the dermis, lurk specialized immune cells called MAST CELLS.
20. What are mast cells covered with? Mast cells are covered with molecules of Immunoglobulin E antibody.
21. So what causes those itchy red bumps? There are antigens in dust mites, in their droppings and shed exoskeletons. Once these antigens get under the skin of an allergic host, the antigens cause mast cells to go berserk, releasing histamine which leads to localized leakage of fluid from capillaries, hence the itchy red bumps.

- Click on **Cytotoxic T Cell**.

22. What do cytotoxic T lymphocytes (CTL) recognize? CTL recognize surface markers on other cells in the body that label those cells for destruction.
23. Describe what you watched in the video Cytotoxic T cell? The smaller CTL is attacking and killing a much larger influenza virus-infected target. The sequence represents 30 minutes elapsed time. The changing morphology of the target cell is typical of that seen in the process of apoptosis.

Name: _____ Date: _____

Quiz 2 – Cell ID

1. What is the term used to describe white blood cells migrating toward bacteria?
   a) Zeiosis
   b) Phagocytosis
   c) Chemotaxis
   d) Phototaxis

2. Which immune cell is responsible for the quickest release of histamine that causes the red itchy welts associated with allergies?
   a) Mast Cell
   b) Lymphocyte
   c) Eosinophil
   d) Basophil

3. When human immunodeficiency virus (HIV) attaches to a host cell what genetic material is released into the cell's cytoplasm?
   a) Chromosome
   b) RNA
   c) DNA
   d) Ligand

4. Name the process a cell such as a neutrophil or a macrophage uses to ingest (eat) its prey…
   a) Halitosis
   b) Chemotaxis
   c) Botulism
   d) Phagocytosis

5. In HIV infection, reverse transcription describes which of the following?
   a) Converting viral DNA into RNA
   b) Converting viral RNA into DNA
   c) Converting proteins into viral RNA
   d) Converting viral RNA to proteins

6. Which of these produces and secretes antibodies in the body?
   a) Bacteria
   b) Plasma cell
   c) Red blood cell
   d) Viruses

7. What is a specific term for a bacterial or other foreign protein that initiates antibody production by the body?
   a) Peptide
   b) MHCII molecule
   c) Complement
   d) Antigen

8. Which of these cell types can play a primary role in attacking and killing cancer cells?
    a) RBC
    b) CTL
    c) APC
    d) BMDC

9. What is an important mechanism white blood cells use to kill bacteria, fungi and other invading pathogens?
    a) Asphyxiation
    b) Oxidative activity
    c) Fright
    d) Drowning

10. What is the term applied to white blood cells squeezing between endothelial cells lining the blood vessel to reach the site of an infection?
    a) Diapedesis
    b) Chemotaxis
    c) Phagocytosis
    d) Enucleation

11. Innate mechanism that mediates destruction of foreign substances in the body is called…
    a) Complement
    b) Plasma
    c) Mast cells
    d) Interferons

12. Mediates immune responses of both T & B cells…
    a) Antigen presenting cells
    b) Cytotoxic T cells
    c) Helper T cells
    d) Perforins

13. Directional movement of ells in response to chemicals
    a) Phagocytosis
    b) Chemotaxis
    c) Pinocytosis
    d) Phototaxis

14. Are released by activated T cells and macrophages to mobilize immune cells and attract other leukocytes into the area
    a) Cytokines
    b) Natural killer cells
    c) B cells
    d) Antibodies

15. Which of the following releases histamines?
    a) Eosinophils & basophils
    b) Monocytes & macrophages
    c) Mast cells & eosinophils
    d) Mast cells & basophils

16. Binds with mast cells & basophils; causes them to release histamines
    a) IgE
    b) IgA
    c) IgG
    d) IgD

17. Which of the following is an antigen-presenting cell?
    a) B cell
    b) Macrophages
    c) NK cell
    d) Dendritic cell

18. Where are B cells produced?
    a) Bone marrow
    b) Thymus
    c) Spleen
    d) Lymph nodes

19. Where are T cells produced?
    a) Bone marrow
    b) Lymph nodes
    c) Spleen
    d) Thymus

20. These cells process a protein antigen, break it into peptides, and present it in conjunction with class II MHC molecules on the cell surface where it may interact with appropriate T cell receptors
    a) Antigen Presenting Cells
    b) Dendritic cells
    c) Antibodies
    d) Antigens

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Name: _____ Date: _____

Innate Immunology

Define Vocabulary:

1. Complement system –

2. Cytokines –

3. Edema –

4. Inflammatory response –

5. Macrophages –

6. Mucous Membranes –

7. Natural Killer cells –

8. Neutrophils –

9. Phagocytosis –

How does the innate immune system work?

Use the scenarios below to consider symptoms that indicate the innate immune system is functioning. Working in small groups, select one of the scenarios and list the symptoms that might occur. Discuss and record possible innate immune system responses. Use the discussion questions when considering your chosen scenario. Record your thoughts on the table.

Scenarios

A. It's a summer day. You are at your pool, sunbathing and swimming. Your favorite part of the pool is running on your wooden deck and doing a cannon ball into the pool. Later that evening, your toe is sore. When you look, you discover that you have a splinter! Ouch!!

Discussion Questions:

10. What symptoms indicate that your body is fighting a potential infection?

11. For each symptom, describe what part of the innate immune system contributes to the symptom.

12. What are the effects or results of each innate immune response?

B. Prom is tomorrow. You've picked out the perfect outfit, found the perfect date, made reservations at the fanciest restaurant in town. When you look in the mirror, you are horrified to see a giant pimple right on your nose.

Discussion Questions:

13. What symptoms indicate that your body is fighting a potential infection?

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15. What are the effects or results of each innate immune response?

C. It's taco Tuesday! You and your family go to your favorite Mexican restaurant. Chips, salsa, cheese dip and tacos! A couple of hours later, you aren't feeling so good.

Discussion Questions:

16. What symptoms indicate that your body is fighting a potential infection?

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D. You are at basketball practice and become very thirsty but you forgot your water bottle at home. Your friend offers you a drink of his water. A day later, your throat is sore.

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Name: _____ Date: _____

Innate Immunology

Define Vocabulary:

1. Complement system – proteins in blood plasma that identifies pathogens and activates the inflammatory response to an infection.
2. Cytokines – small proteins molecules that play a role in all phases of the immune system; they mediate the innate immune response with several functions.
3. Edema – swelling of tissue that is a feature of the inflammatory response
4. Inflammatory response – a response initiated by macrophages and characterized by pain, redness, heat, and swelling at the site of infection.
5. Macrophages – Long-lived cells of the immune system that are often found in tissues just beneath epithelial cells. These cells are activated when a pathogen breaches a physical barrier such as the skin. These cells play a central role in the innate immune response because they ingest pathogens and debris, such as dead cells in tissues. They also release cytokines, which activate other parts of the immune response.
6. Mucous Membranes – A layer of epithelial cells that lines many parts of the body including the digestive and reproductive tracts and secretes mucous to protect the body against pathogens.
7. Natural Killer cells – Cells of the innate immune system that are activated early during an infection and play a key role in preventing it from spreading.
8. Neutrophils – Cells that circulate in the blood, then enter tissues when signaled by cytokines to combat an infection. These short-lived cells ingest and kill pathogens and are a major component of pus.
9. Phagocytosis – A process in which a cell, such as a macrophage, engulfs another cell or particle to create a compartment and ingest it in preparation to destroy it.

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Scenarios – Answers will vary depending on what symptoms are recorded.

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Name: _____ Date: _____

Phagocytosis Model

Phagocytosis is part of the innate immune system. There are two types of phagocytic cells normally present in interstitial spaces throughout the body, and especially under epithelia. These are the **dendritic cells** and the **resident macrophages**, both of which are the first immunological cells to interact with a pathogen. Both are also similar in that they do **not need an specific immune response** in order to phagocytize a pathogen. You can think of these two types of cells as sentinels, always out in the tissues waiting to encounter any microbes that might enter the body. They then alert the immune system so that the various defense mechanisms begin. But the two types of phagocytes have quite different roles.

Choose a phagocytic cells and model the process of phagocytosis. Include the release of cytokines. To research this topic, find 3 articles on google scholar pertaining to phagocytosis. Site and briefly describe each article you used. Your model can be a 3D model, a visual drawing, or a computer animation.

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Depictions will vary – accept all reasonable answers.

NAME: _____ DATE: _____

QUIZ 3 – Innate Immunity

1. Innate immunity, also called natural immunity, consists of mechanisms that respond specifically to:
    a. Self-cells
    b. Microbes
    c. Antibodies
    d. Inflammation

2. Skin and mucous membranes are the _____ line of defense.
    a. First
    b. Second
    c. Third
    d. Last

3. Innate immunity…
    a. Is slower than adaptive immunity in responding to pathogens
    b. Is nonspecific and present at birth
    c. Involves a memory component
    d. Involves T and B cells

4. All of the following protect the skin and mucous membranes from infection EXCEPT:
    a. Multiple layers of cells
    b. Tears
    c. Saliva
    d. The ciliary escalator

5. A 6 year old boy stepped on a rusty nail on the playground. Two days later, he is taken to the pediatrician because his foot if painful, red, and swollen and is warm to the touch. All of the following are mechanisms of innate immunity that by be protecting the patient against pathogenic microbes in the foot wound EXCEPT:
    a. Epithelial barrier function of the skin on his foot
    b. Intraepithelial lymphocytes present in the skin
    c. Circulating neutrophils migrating to the site of the wound
    d. Soluble cytokines that induce a local inflammatory response
    e. Circulating anti-tetanus toxin antibodies

6. Innate immunity is the first line of defense against infections, yet many pathogenic microbes have evolved strategies to resist innate immunity.
    a. True
    b. False

7. Which of the following statements about the innate immune system is NOT true?
    a. Innate immunity is present in all multicellular organisms, including plants and insects.
    b. Deficiencies in innate immunity markedly increase host susceptibility to infection, even in the setting of an intact adaptive immune response.

c. Innate immunity is better suited for eliminating virulent, resistant microbes than is adaptive immunity.
d. The innate immune response can be divided into recognition, activation, and effector phases.
e. The innate immune response against microbes influences the type of adaptive immune response that develops.

8. _____ that mediate inflammation (e.g., tumor necrosis factor, interleukin-1, chemokines) are components of innate immunity.
    a. Neutrophils
    b. B cells
    c. Cytokines
    d. T cells

9. Toll-like receptors (TLRs) are a family of homologous receptors expressed on many cell types and are involved in innate immune responses. Ten different mammalian TLRs have been identified, and several ligands for many of these receptors are known. Which of the following is a TLR ligand?
    a. Single-stranded RNA
    b. Transfer RNA
    c. Double-stranded DNA
    d. Unmethylated CpG DNA

10. More than 10 mammalian Toll-like receptors (TLRs) have been identified, and each appears to recognize a different set of structures that are found in pathogenic microbes but not in mammalian cells. Such structures are called…
    a. pathogen-associated molecular patterns (PAMPs)
    b. Cytokines
    c. Ligands
    d. Heterochromatin

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    b. False

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Name:_____ Date:_____

Adaptive Immunity

Directions: Read the passage and complete activity 1 & 2.

Reading Passage:

Killer Cells, Memory Cells: A Brief Introduction to the Adaptive Immune System

Imagine the siege of a castle. All of a sudden, the besiegers break through the castle's defenses. During the invasion, the invader breaches the castle's first line of defense. The defenders meet it with more powerful weapons and specialized troops.

The same scenario is true of invading pathogens. If a pathogen overcomes the protection of the innate (or non-specific) immune system, the adaptive (or specific) immune system leaps into action. The adaptive immune system is a more specialized approach to defending our bodies from infection. Its defense mechanisms directly target the specific pathogen. The defenses match small parts of the pathogen, called antigens, like a key fits into a lock. Antigens are parts of pathogens that cause an immune response.

T cells and B cells are the two main cell types of the adaptive immune system.

T cells are activated when they recognize antigens on antigen-presenting cells, or APCs. The APCs gather and present antigens to T cells (and B cells). Killer T cells travel to the site of the infection and kill infected cells. Helper T cells work in nearby lymph nodes as well as at the site of the infection. These cells help B cells to make antibodies and they help killer T cells eliminate virus-infected cells. A third type of T cell is the memory T cell. This long-lived cell monitors the body for future invasions by the same pathogen.

B cells have important roles as well. Some B cells act as APCs. A second type, the plasma B cell, is activated and produces large quantities of antibodies. Antibodies directly stop the invader by attaching to the surface of pathogens. This accomplishes two things. First, the pathogen is disabled because it cannot infect other cells with the antibody attached to it. Second, the antibody serves as a flag for other cells of the immune system looking to kill the pathogen. As with T cells, long-lived B cells, called memory B cells, refine their pathogen recognition tools as they monitor and protect the body from future infections by the same pathogen.

The cells of the adaptive immune system must endure over time and expand the response needed to overcome the pathogen. Otherwise, as in war, the battle will be lost.

Activity 1

Function of the Adaptive Immune System

Using resources suggested by your teacher, research the function of each of the adaptive immune system's components. Then work with your group to create a simple graphical model that explains the adaptive immune system. Sketch your model in the space below.

Activity 2

The Components of the Adaptive Immune System

Complete the table below with the adaptive immune system component that carries out specific functions.

Function	Component(s)
Fight infection	
Communicate information about infection	
Establish immunological memory	
Create antibodies to fight infection	

Complete the table below with descriptions of how adaptive immune system components function to fight infection.

Component	Function to fight infection
Antibodies	
T cells	
B cells	
Antigen presenting cells	
Cytokines	

Name:_____ Date:_____

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T cells and B cells are the two main cell types of the adaptive immune system.

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B cells have important roles as well. Some B cells act as APCs. A second type, the plasma B cell, is activated and produces large quantities of antibodies. Antibodies directly stop the invader by attaching to the surface of pathogens. This accomplishes two things. First, the pathogen is disabled because it cannot infect other cells with the antibody attached to it. Second, the antibody serves as a flag for other cells of the immune system looking to kill the pathogen. As with T cells, long-lived B cells, called memory B cells, refine their pathogen recognition tools as they monitor and protect the body from future infections by the same pathogen.

The cells of the adaptive immune system must endure over time and expand the response needed to overcome the pathogen. Otherwise, as in war, the battle will be lost.

Activity 1

Function of the Adaptive Immune System

Using resources suggested by your teacher, research the function of each of the adaptive immune system's components. Then work with your group to create a simple graphical model that explains the adaptive immune system. Sketch your model in the space below.

Activity 2

The Components of the Adaptive Immune System

Complete the table below with the adaptive immune system component that carries out specific functions.

Function	Component(s)
Fight infection	
Communicate information about infection	
Establish immunological memory	
Create antibodies to fight infection	

Complete the table below with descriptions of how adaptive immune system components function to fight infection.

Component	Function to fight infection
Antibodies	
T cells	
B cells	
Antigen presenting cells	
Cytokines	

Comparative Essay

Directions: Write a comparative essay on **Humoral & Cell Mediated Immunity**. Your essay must be in proper APA format and be at least 3-5 pages long. Use the rubric as your guide, this is how you will be graded.

	5 points	3 points	1 point	0 points
Structure & Organization	The introduction is engaging, states the main topic and provides an overview of the paper. Information is relevant and presented in a logical order. The conclusion is strong.	The introduction states the main topic and provides an overview of the paper. A conclusion is included.	The introduction states the main topic. A conclusion is included.	There is no clear introduction, structure, or conclusion.
Compare & Contrast	There is a clear, focused comparison & contrast between humoral & cell mediated immunity.	There is a clear, focused compare and contrast of humoral & cell mediated immunity. Main ideas are clear but not well supported by detailed information.	There is a comparison and contrast of humoral & cell mediated immunity. Main ideas are not clear nor supported by detailed information.	No compare and contrast of humoral & cell mediated immunity was made.
APA Format & Length	Essay was between 3-5 pages and in proper APA format.	Essay was between 3-5 pages and/or in proper APA format.	Essay was between 3-5 pages and/or in proper APA format but with several mistakes.	Essay was not between 3-5 pages and was not in proper APA format.
Resources	Resources were relevant and cited in APA format.	Resources were relevant but not cited in APA format.	Resources were not relevant but cited in APA format.	Resources were not reported.

Comparative Essay Rubric

Humoral & Cell Mediated Immunity

	5 points	3 points	1 point	0 points
Structure & Organization	The introduction is engaging, states the main topic and provides an overview of the paper. Information is relevant and presented in a logical order. The conclusion is strong.	The introduction states the main topic and provides an overview of the paper. A conclusion is included.	The introduction states the main topic. A conclusion is included.	There is no clear introduction, structure, or conclusion.
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Name:_____ Date:_____

Quiz 4 – Adaptive Immunity

1. Lymphocytes are the effector cells of the adaptive immune system.
    a. True
    b. False
2. A client who was exposed to hepatitis A at a local restaurant has recovered from the disease. At her annual physical, the client asks the health care provider if she should go to her health department and get the hepatitis a vaccine. The best response, based on the concepts of adaptive immunity, by the health care provider would be:
    a. "Yes, because you could get a worse case the next time you are exposed."
    b. "Of course. The virus changes every year."
    c. "I wouldn't since the vaccine can damage your liver."
    d. "No, since having an active case, you already developed antigens against hepatitis A."

3. Secreted antibodies against protein antigens are effectors of humoral immunity, a component of the adaptive immune system.
    a. True
    b. False

4. Which of the following comparisons of the innate and adaptive immune systems is FALSE?
    a. The innate immune system is more likely to recognize normal self, and therefore cause autoimmunity, than is the adaptive immune system.
    b. Receptors used for recognition in innate immunity are encoded in the germline, whereas those of the adaptive immune system are encoded by genes generated via somatic recombination of germline receptor gene loci.
    c. The innate and adaptive immune systems share some of the same effector mechanisms.
    d. Both the innate and adaptive immune systems can recognize nonmicrobial substances.
    e. The innate immune system does not have memory, but the adaptive immune system does.

5. The Adaptive Immune System includes the cells of the myeloid lineage; being granulocytes and agranulocytes.
    a. True
    b. False

6. The cytokine IL-2, as produced by Helper (CD4+) T cells stimulates differentiation of Cytotoxic (CD8+) T-cells, Regulatory T cells, and Natural Killer cells.
    a. True
    b. False

7. The cytokine IL-2, as produced by Helper (CD4+) T cells stimulates differentiation of Cytotoxic (CD8+) T-cells, Regulatory T cells, and Natural Killer cells.
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    b. False

8. B-lymphocytes differentiate into...
    a. Mast cells
    b. Plasma
    c. Memory B cells
    d. Both B & C

9. Which of the following is correct regarding where B and T cells mature, just prior to traveling to lymph nodes?
    a. B cells mature in the thymus; T cells mature in the thyroid gland
    b. B cells mature in the thyroid; T cells mature in the thymus
    c. B cells mature in the bone marrow; T cells mature in the thymus
    d. B cells mature in the pancreas; T cells mature in the bone marrow

10. Which of the following in NOT true?
    a. Neutrophils help activate B & T cells
    b. Neutrophils are phagocytes
    c. Neutrophils circulated in the blood
    d. Neutrophils are the most common cell of the immune system

11. If B cells did not require help from T cells in order to activate, what would be one possible negative result?
    a. Antibodies would not bind as tightly to specific antigens
    b. B cells would not know where to migrate in order to fight infection
    c. B cells would be over-reactive and attack cells of the body
    d. B cells would not be able to attack cancerous cells in the body

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Name: _____ Date:_____

Identifying Organs of The Immune System

Complete the virtual lab. Follow the prompts. Click to animate!

https://www.medicine.mcgill.ca/physio/vlab/immun/backg.htm

Take notes on each section of the virtual lab. Please include sketches & drawings.

Name: _____ Date:_____

ELISA Virtual Lab

Complete the virtual lab. Follow the prompts. Click to animate!

https://www.medicine.mcgill.ca/physio/vlab/immun/elisa1.htm

Take notes on each section of the virtual lab. Please include sketches & drawings.

Name: _____ Date: _____

Cells & Organs of the Immune System - Mouse Dissection

Answer study questions.

In this lab exercise, you will observe a dissected mouse to locate the lymphoid organs.

Primary Lymphoid Organs: Organs where immune cells develop and mature to the stage at which they are able to respond to a pathogen.

Bone marrow: sites where all the cells that circulate in the blood are developed. B lymphocytes develop and mature in bone marrow.

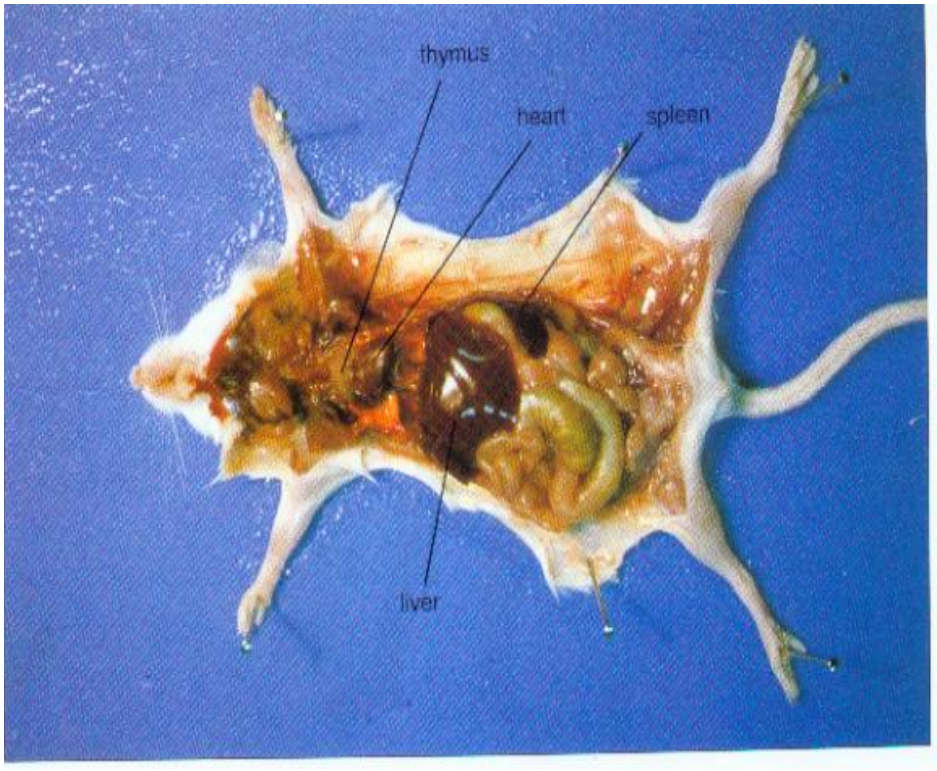
Thymus: organ in which T lymphocytes develop and mature.

Secondary Lymphoid Organs: Organs where mature lymphocytes become stimulated to respond to invading pathogens.

Spleen: an organ where lymphocytes meet with pathogens from the blood. It serves as a filter for the blood and removes damaged or old red cells.

Lymph nodes: an organ where lymphocytes meet with pathogens drained from infection sites.

Mucosal associated lymphoid tissue: a general term for the encapsulated lymphoid tissues associated with submucosal areas of the gastrointestinal, genitourinary and respiratory tracts. It includes the tonsils, the adenoids, the appendix, and the Peyer's patches which line the small intestine.



Study Questions

1. Define the primary and secondary lymphoid organs.

2. What is the most important difference between the primary and secondary lymphoid organs?

3. Name two areas of the human body where lymph nodes can be found.

4. Where are the spleen and thymus located in mice?

5. Name all the primary and secondary lymphoid organs.

Immunology Mouse Dissection

Objectives

- To understand the concepts of mouse Euthanasia.
- To learn the basic procedures involved in mouse dissection.
- To learn how to identify and remove lymphoid organs
- To isolate BMDC's.

Materials Required

- DMEM Medium
- Carbondioxide chamber
- 70% Isopropyl Alcohol
- Dissection Board
- Surgical Tray
- Scissors
- Petridishes
- Forceps
- RPMI 1640
- Mortar & pestle
- 50 mL test tube
- Filter
- Centerfuge

Procedure

Euthanasia of Mouse: Carbon Dioxide Asphyxiation

1. Place animals in the container filled with CO2 and replace the lid.
2. Unconsciousness will occur within 30 sec, but animals should be left in the container for several minutes to ensure death.
3. Verify death by lack of cardiac pulse and fixed and dilated pupils prior to carcass disposal.

Removal of Mouse Lymphoid Organs

1. After sacrificing the animal in a humane manner. Place it on its back on clean, dry, absorbent paper [or dissection board].
2. Wet the fur with 70% ethanol to sterilize the area and reduce the possibility of contamination.
3. Make a midline incision with iris scissors.
4. Retract the skin above the head and below the thighs.

Removal of the Spleen

1. Make a 1-inch. incision at the left of the peritoneal wall with surgical scissors.
2. Grasp as much of the spleen as possible with curved iris forceps.
3. Gently pull the spleen free of the peritoneum, tearing the connective tissue behind the spleen.
4. Place the spleen in several millilitres of tissue culture medium in a tissue culture plate. [The choice of medium is dependent upon the protocol the cells will be subjected to.]

Removal of the Thymus

1. Make an incision in the chest, beginning at the xiphoid and extending to the neck with surgical scissors.
2. Retract the ribs with curved forceps. [It may be necessary to crack the ribs for effective retraction. The thymus is a yellowish-white bi-lobed organ found just under the ribs, attached above the heart in the midline.]
3. Grasp each lobe of the thymus with curved forceps and gently pull the thymus away. [Because the thymus is delicate, it is not unusual to tear it during removal. Unless maximal cell recovery is required, the tearing will not be harmful]
4. Place the thymus tissue in several milliliters of tissue culture medium in a tissue culture plate.

Removal of Femur (for isolation of BMDC's)

1. Position the mouse of its dorsal back on a clean blotting sheet and thoroughly spray all the external with 70% alcohol for disinfection.
2. Make an incision in each hind leg using blunt-end sterile scissors. Firmly grasp skin and gently pull outward to expose the muscles.
3. Cut the hind leg just above the pelvis/hip joint using sharp and sterile dissecting scissors.
4. After removal of hind leg, carefully hold it from the lower side. Using sterile scissors, make an incision above the claws to remove the lower portion of the hind leg. Remove the femur bone.
5. Use lint-free tissue paper to remove any excess muscle//tissue on the femur.
6. Crush the bones with a pestle and mortar. Crush the bones.
7. Place a filter on top of a 50 mL tube. Empty the contents of the mortar. Wash/flush the bones with RPMI-1640.
8. Centrifuge the cell.
9. Remove the supernatant.

Textbooks:

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1. http://thyroid.about.com/library/immune/blimm06.htm
2. http://eulep.pdn.cam.ac.uk/Necropsy_of_the_Mouse/printable.php

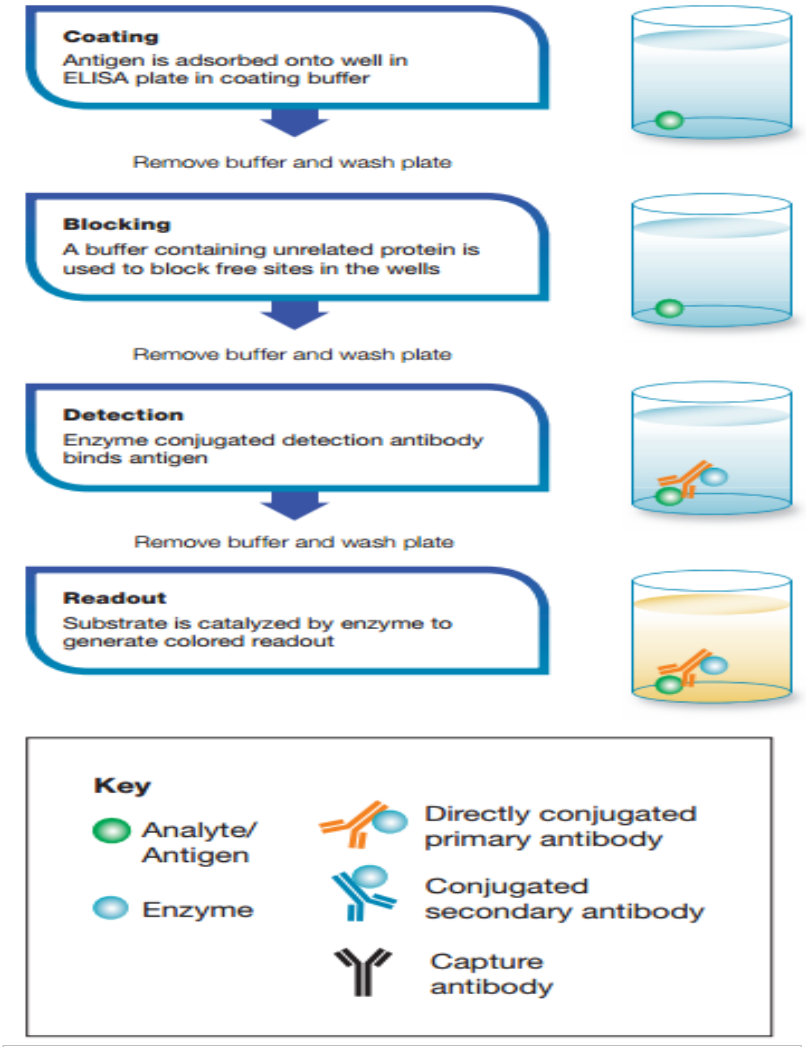
Name:_____ Date:_____

ELISAs begin with a coating step, where the first layer, either an antigen or an antibody, is adsorbed to a well in an ELISA plate. Coating is followed by blocking and detection steps as shown in the simple schematic diagram below.

Since the assay uses surface binding for separation, several washes are repeated between each ELISA step to remove unbound materials. During this process it is essential that excess liquid is removed in order to prevent the dilution of the solutions added in the next stage. For greatest consistency specialized plate washers are used.

ELISAs can be quite complex, including various intervening steps and the ability to measure protein concentrations in heterogeneous samples such as blood. The most complex and varying step in the overall process is detection, where multiple layers of antibodies can be used to amplify signal.

ELISA Steps



1. To prepare for the lab, read the following article and take notes.

   https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2915469/

2. Complete the virtual lab and take notes.

   http://www.biology.arizona.edu/immunology/activities/elisa/elisa_intro.html

3. Visit this website. Read all sections and take notes.

   https://www.bio-rad-antibodies.com/elisa-types-direct-indirect-sandwich-competition-elisa-formats.html

4. Lastly, with your lab partner, complete the Biosciences, Thermscientific & Sigma Cytokine Detection/ELISA kits following the instructions and cell samples provided.

Name:_____ Date: _____

Quiz 5 - Immune Organs & ELISA

1. A general term for the encapsulated lymphoid tissues associated with submucosal areas of the gastrointestinal, genitourinary and respiratory tracts
    a. Mucosal associated lymphoid tissue
    b. Lymph nodes
    c. Saliva
    d. Tears

2. An organ where lymphocytes meet with pathogens from the blood. It serves as a filter for the blood and removes damaged or old red cells…
    a. Kidney
    b. Liver
    c. Spleen
    d. Thyroid gland

3. Organ in which T lymphocytes develop and mature…
    a. Thyroid gland
    b. Thymus
    c. Spleen
    d. Liver

4. Organs where immune cells develop and mature to the stage at which they are able to respond to a pathogen…
    a. Bone marrow
    b. Primary Lymphoid Organs
    c. Secondary Lymphoid Organs
    d. All organs

5. An organ where lymphocytes meet with pathogens drained from infection sites…
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6. Organs where mature lymphocytes become stimulated to respond to invading pathogens…
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7. Sites where all the cells that circulate in the blood are developed. B lymphocytes develop and mature in bone marrow…
    a. Bone Marrow
    b. Thymus
    c. Spleen
    d. Lymph nodes

8. Antibodies not only protect us from infections, they can also be used in laboratories to determine whether or not a patient has or has had a disease.
    a. True
    b. False

9. When a positive + result occurs ELISA, then one could conclude that...
    a. It's a false positive
    b. A positive result always means illness
    c. The antibodies are present
    d. An enzyme is present

10. Why is a positive and negative control necessary in the setup of ELISA?
    a. positive controls are equal to negative controls
    b. ELISA is subject to errors; if controls fail the results are untrustworthy
    c. ELISA is a test that typically does not need controls
    d. negative and positive controls are needed to exclude all results

11. Why is it necessary to wash the samples repeatedly?
    a. it is important to keep the lab wells clean
    b. it is important to wash away all bound and unbound antibodies from the wells
    c. it is important to wash away the unbound antibodies
    d. washing the wells is just solid lab practice

12. A serial dilution is
    a. the stepwise saturation of a substance in solution.
    b. a dilution that increase by a factor of 1/10 every step
    c. the stepwise dilution of a substance in solution.
    d. a series of sequential dilutions used to increase a dense culture of cells to a more usable concentration.

13. What does the symbol μL stand for?
    a. Nanoliters
    b. Microliters
    c. Milliliters
    d. Muliter

14. What is another name for antibodies?
    a. Helper T Cells
    b. Immunoglynocists
    c. Hemoglobin
    d. Immunoglobin

15. Which of the following are commonly tested for using the ELISA method?
    a. HIV
    b. Lyme Disease
    c. Pregnancy
    d. All of these

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