Ch 43 Notes – Immune System

"IF YOU'RE NOT WITH US, THEN YOU'RE AGAINST US"

Three Parts

Lymphatic vessels

Lymph nodes

Organs

Lymphatic Vessels

Function: carries fluid back to blood from the tissues so blood can have a sufficient amount of volume

Cell debris, bacteria, and viruses can easily enter the lymph capillaries but not blood capillaries

Lymph Nodes

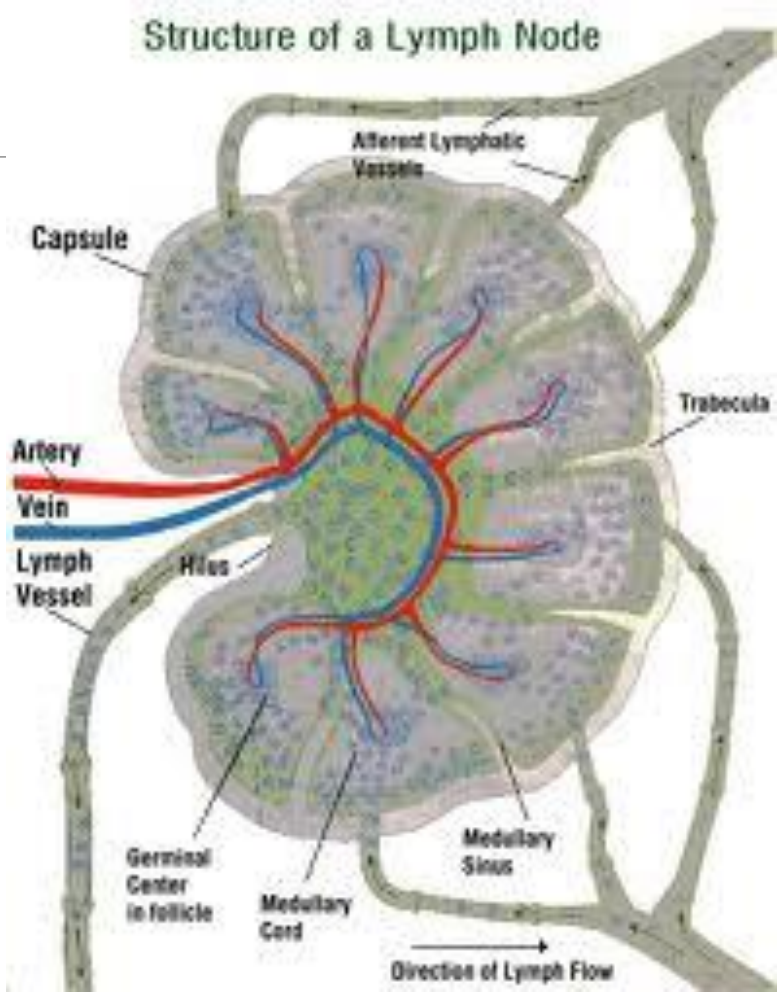
Function: contains phagocytic cells and lymphocytes to help protect the body by removing foreign material from lymph (immune response)

Location: large clusters found within the connective tissue of the groin, under arm, and neck regions

Nodes contain several chambers that hold the macrophages and lymphocytes

- **Macrophages** – engulf and destroy bacteria, viruses, and other foreign substances
- **Lymphocytes** – responds to specific foreign substances

Nodes can become secondary cancer sites if they get to large a number of the infectious cells



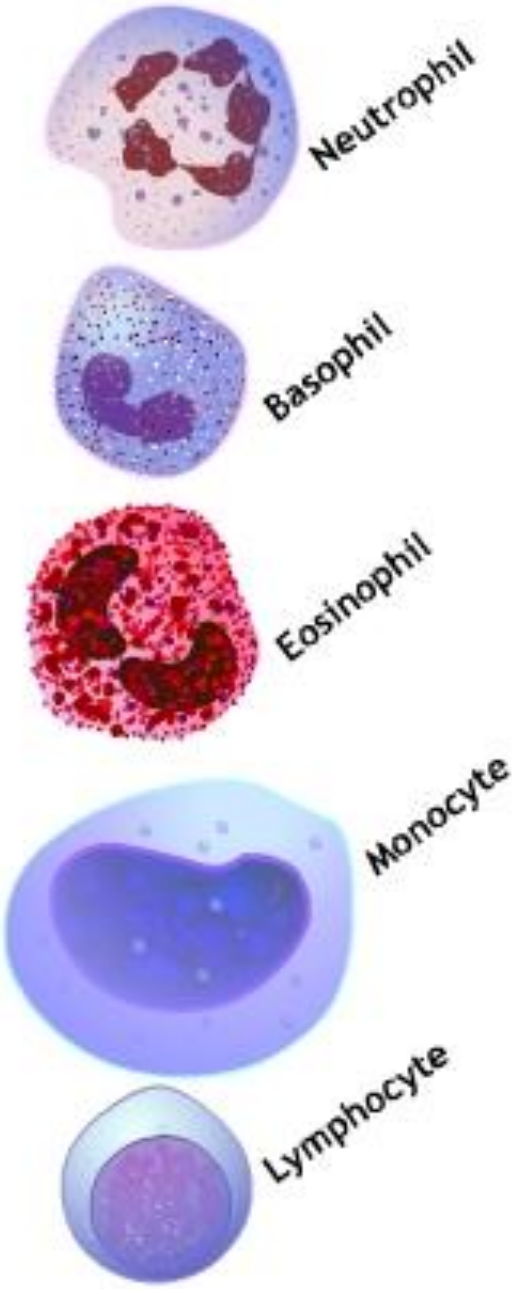
Types of White Blood Cells

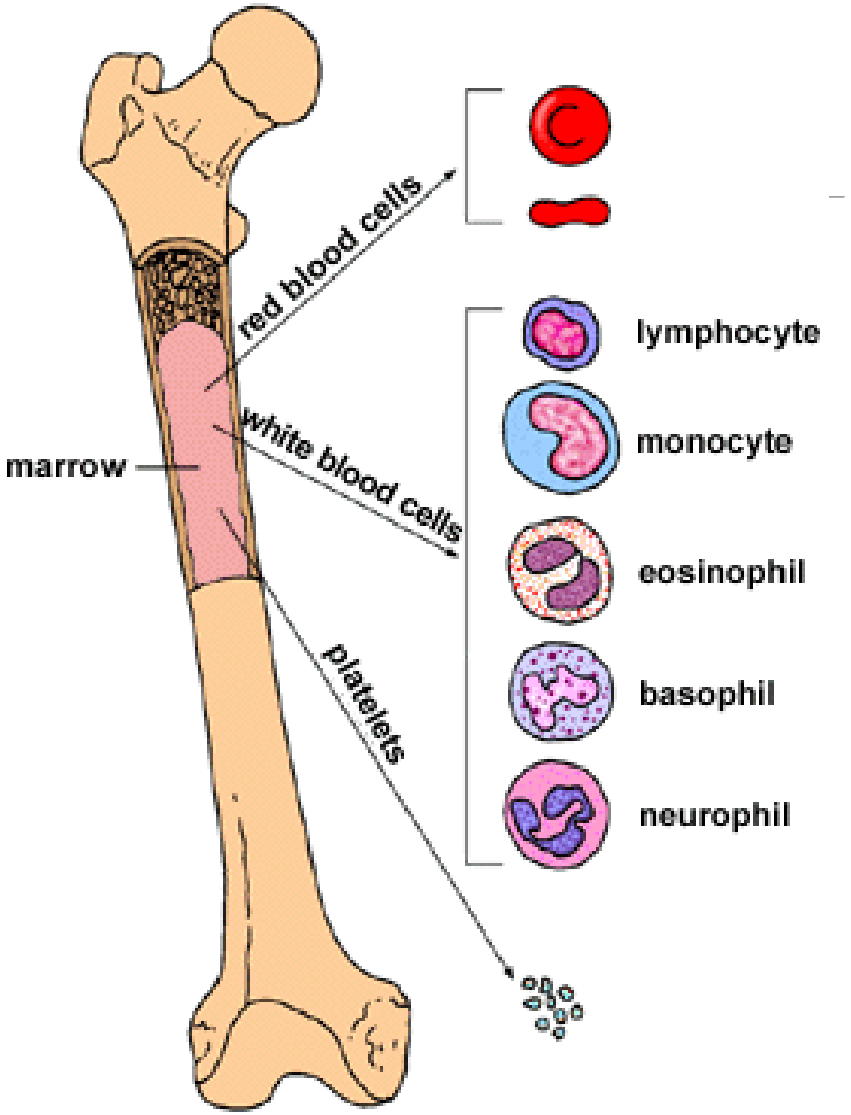
Granulocytes

- Neutrophils – acute infections
- Basophils
- Eosinophils

Agranulocytes

- Monocytes – become macrophages and perform phagocytosis
- Lymphocytes – specific immune response cells (B and T)


Neutrophil
Basophil
Eosinophil
Monocyte
Lymphocyte

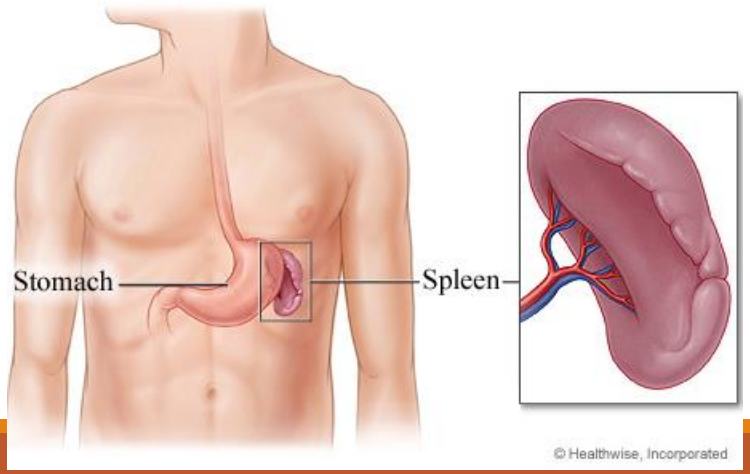

red blood cells
white blood cells
platelets
marrow
lymphocyte
monocyte
eosinophil
basophil
neurophil

Lymph Organs

Spleen – blood-rich organ that filters blood and destroys worn out red blood cells and returns pieces to liver

Stores platelets and is a blood reservoir

- Fetus – spleen makes red blood cells
- Adult – makes lymphocytes



Lymph Organs

Thymus – found overlying the heart and produces hormones (Thymosin) that program T lymphocytes

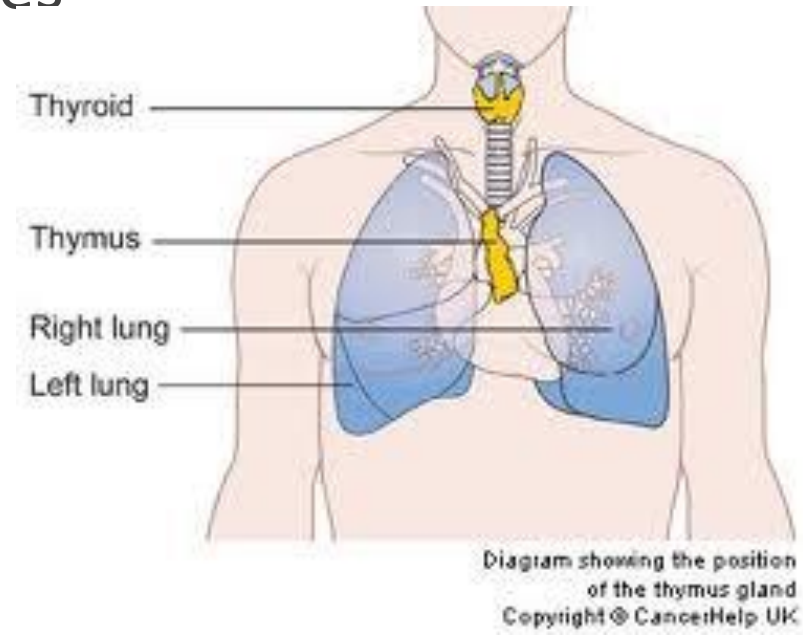


Diagram showing the position of the thymus gland

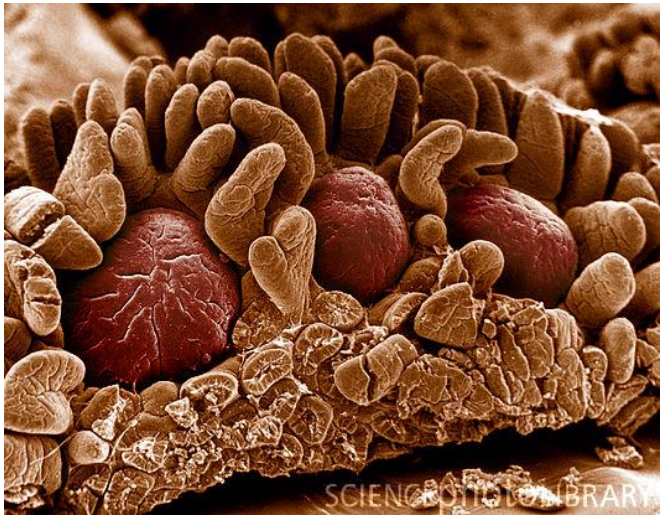
Lymph Organs

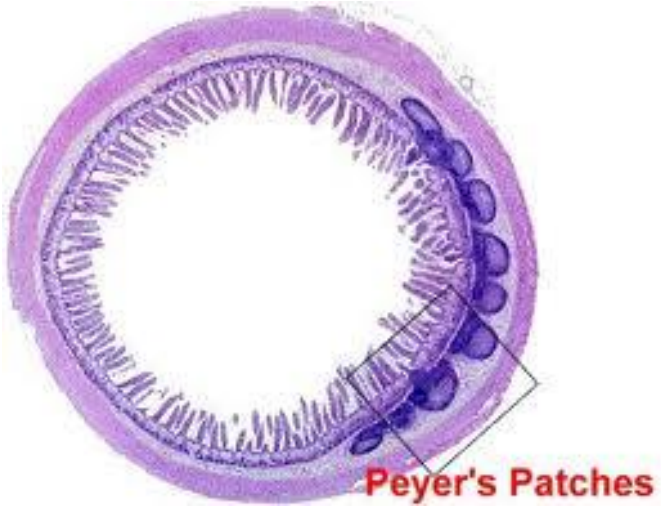
Tonsils – small masses of lymphatic tissue around the pharynx that protects the respiratory system

- Traps and removes bacteria and other foreign substances before they can enter the throat

Lymph Organs

Peyer's Patches – found in walls of intestines and protects the digestive system from bacteria, viruses, and other harmful substances





Nonspecific (Innate) Defense System

— responds immediately to protect body from all foreign substances

Antigens = any substance capable of exciting an immune response

- Pathogens = type of antigen that is a harmful or disease causing microorganisms

This system is composed of mechanical barriers that cover body surfaces, cells and chemicals that initially act to protect the body against pathogens

- Prevents the entry and spread of microorganisms throughout the body

Types of Nonspecific Defenses

Mechanical barriers

Inflammatory response

Cells

Antimicrobial chemicals

Fever

Mechanical Barriers

Skin and mucous membranes are the body's first line of defense

- How? Skin secretes acidic substances, stomach mucosa is acidic, saliva can kill bacteria, sticky mucous in digestive tract can trap microorganisms

When surface barrier is broken other nonspecific responses occur

Inflammatory response – body's second line of defense

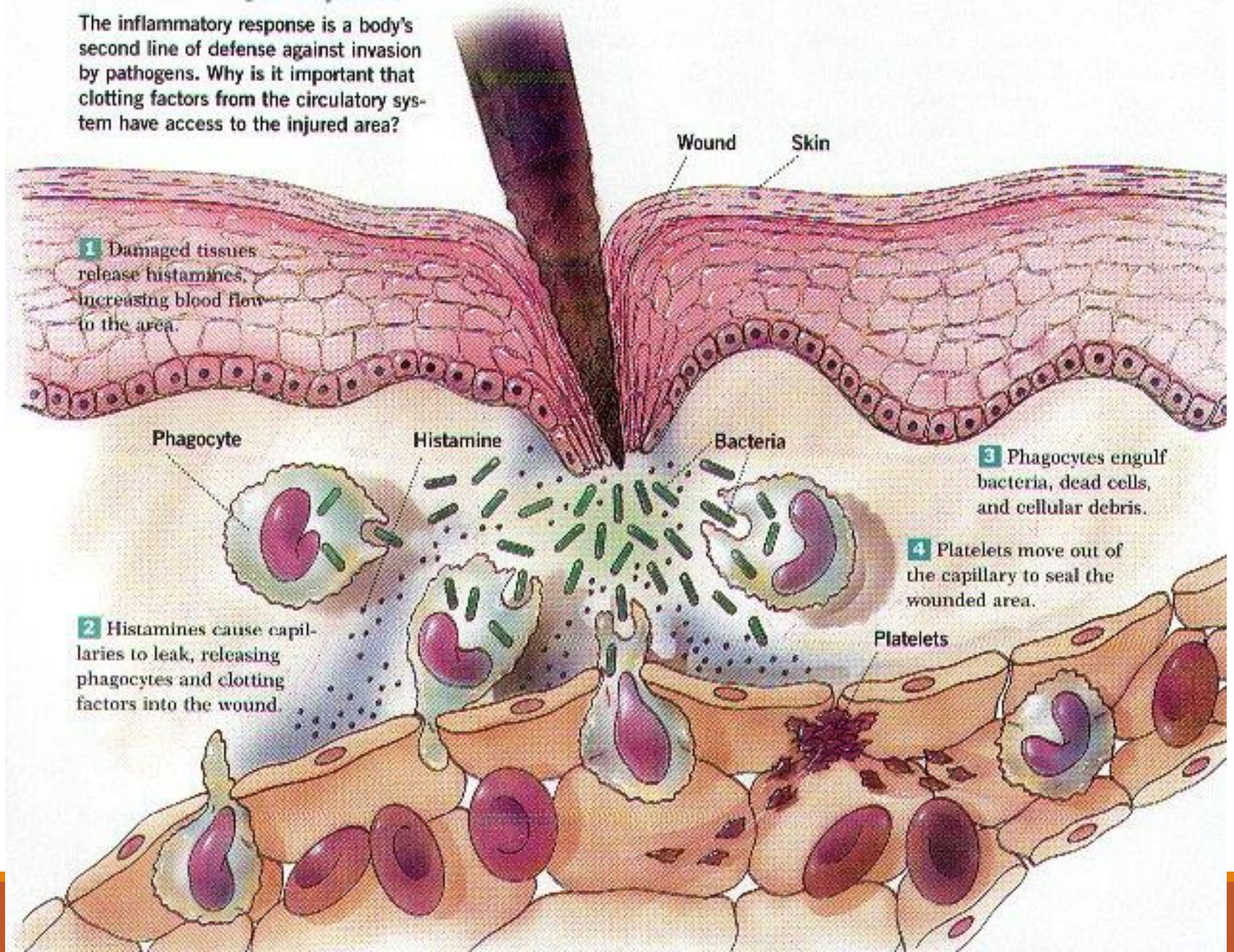
Triggered whenever body tissues are injured

Signs and Symptoms = redness, heat, swelling, and pain

Prevents spread of damaging agents, disposes cell debris and pathogens, and sets the stage for repair

Steps of the Inflammatory Response

The inflammatory response is a body's second line of defense against invasion by pathogens. Why is it important that clotting factors from the circulatory system have access to the injured area?



Cells

Phagocytes (Macrophage) – engulfs foreign substance and breaks it down

Natural killer (NK) cells – found in blood and lymph and can kill cancer cells and virus-infected cells; can act against any foreign cell

Antimicrobial Chemicals

Complement – proteins that attach to and break apart foreign cells, which amplifies the inflammatory response

Interferon – proteins released by virus-infected cells that protect uninfected cells from viral takeover

- Interferon Video

Fever

Abnormally high body temperature inhibits multiplication of bacteria

Systemic response triggered by pyrogens (chemicals secreted by white blood cells and macrophages that have been exposed to foreign cells)

Enhances repair processes

Specific Defense System – Immune system

Attacks very specific foreign substances – either direct cell attack or by releasing antibodies – and acts to destroy or inactive them

Must first encounter a substance (antigen) before it can protect the body against it

Immune Response – immune system's response to a threat that starts with the inflammatory response and then attacks specific antigens

- Body will attack anything that is recognized has not being part of the body

3 Characteristics of the Immune Response

Antigen specific – acts on particular pathogens

Systemic – not restricted to infection site

Has “memory” – recognizes and has even stronger attacks on previously encountered pathogens

Types of immunity

Humoral immunity – antibody-mediated

- Provided by antibodies present in body's fluids

Cellular immunity – cell-mediated

- When lymphocytes (living cells) defend the body

Lymphocytes

Formed in red bone marrow

- **B cells** – produce antibodies and oversee humoral immunity
- **T cells** – nonantibody-producing lymphocytes that make up cell mediated immunity
  - Mature in thymus

Our genes, not antigens, determines what specific foreign substances our immune system will recognize and resist

Macrophages

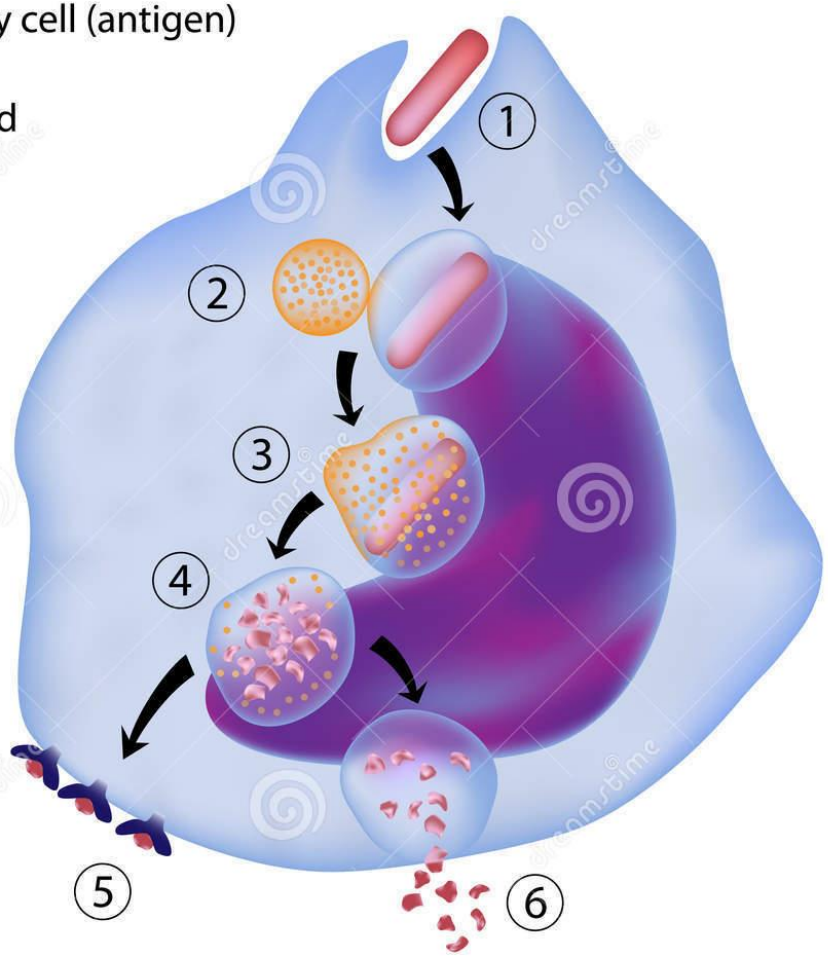
- Do not respond to specific antigens, but help lymphocytes

- Engulf the antigens and break them down

- Leave parts of antigens on their surface so T cells can recognize the antigen
  - Become Antigen-presenting cells

Role of an Antigen-Presenting Cell

1. Phagocytosis of enemy cell (antigen)
2. Fusion of lysosome and phagosome
3. Enzymes start to degrade enemy cell
4. Enemy cell broken into small fragments
5. Fragments of antigen presented on APC surface
6. Leftover fragments released by exocytosis



Humoral (Antibody-Mediated) Immune Response

B lymphocyte finally matures and activates when it binds to an antigen or it is stimulated by Helper T cells

Clonal selection – B lymphocytes are selected out of billions and begin to grow and multiple rapidly

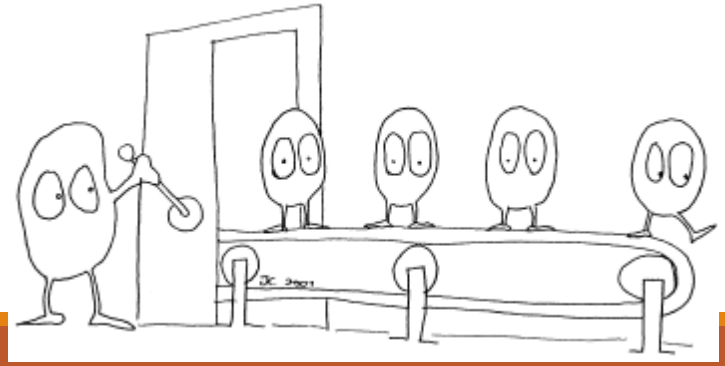
Cloned lymphocytes (antibodies) are primary humoral response to antigens

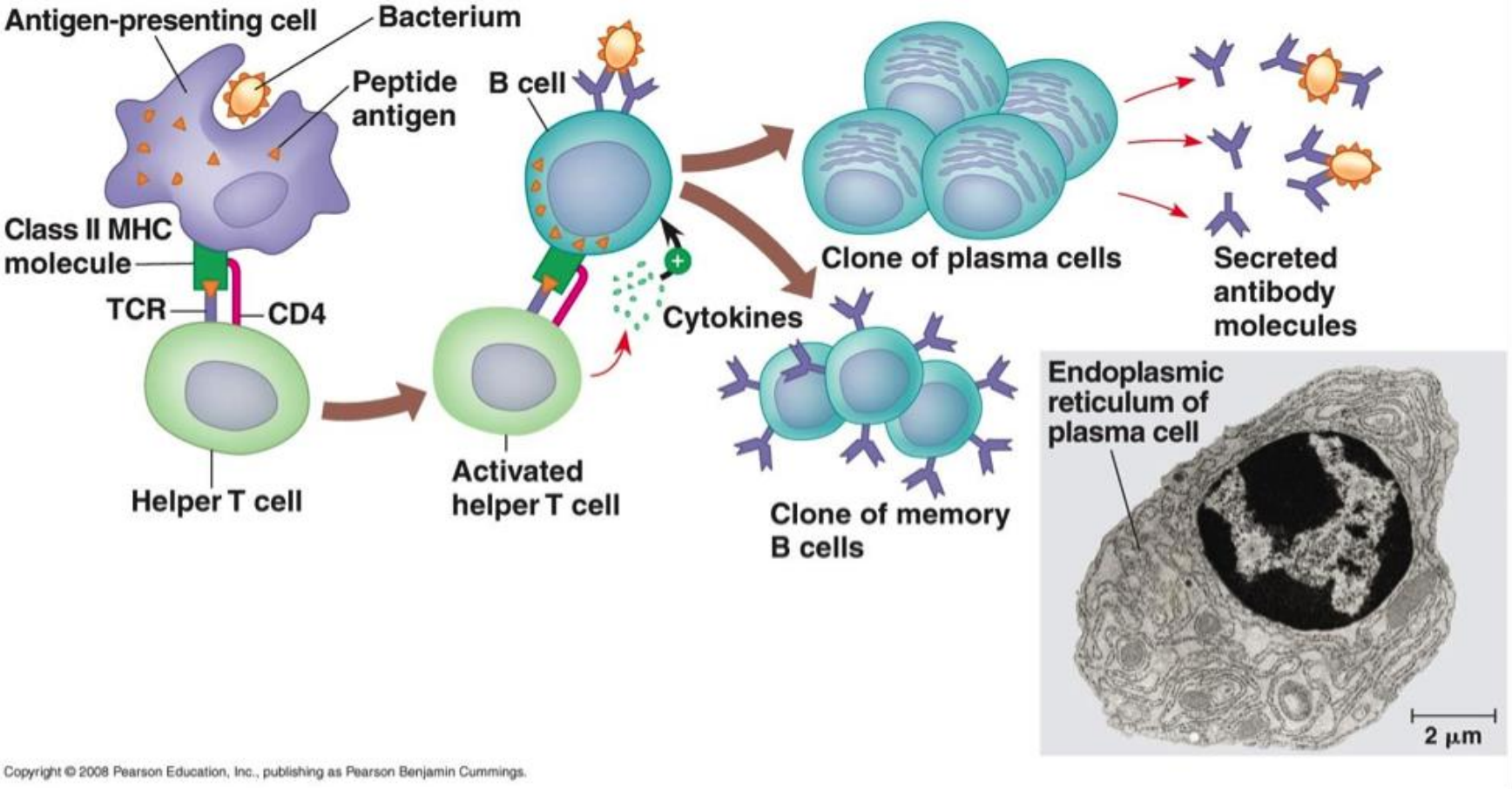
Humoral (Antibody-Mediated)

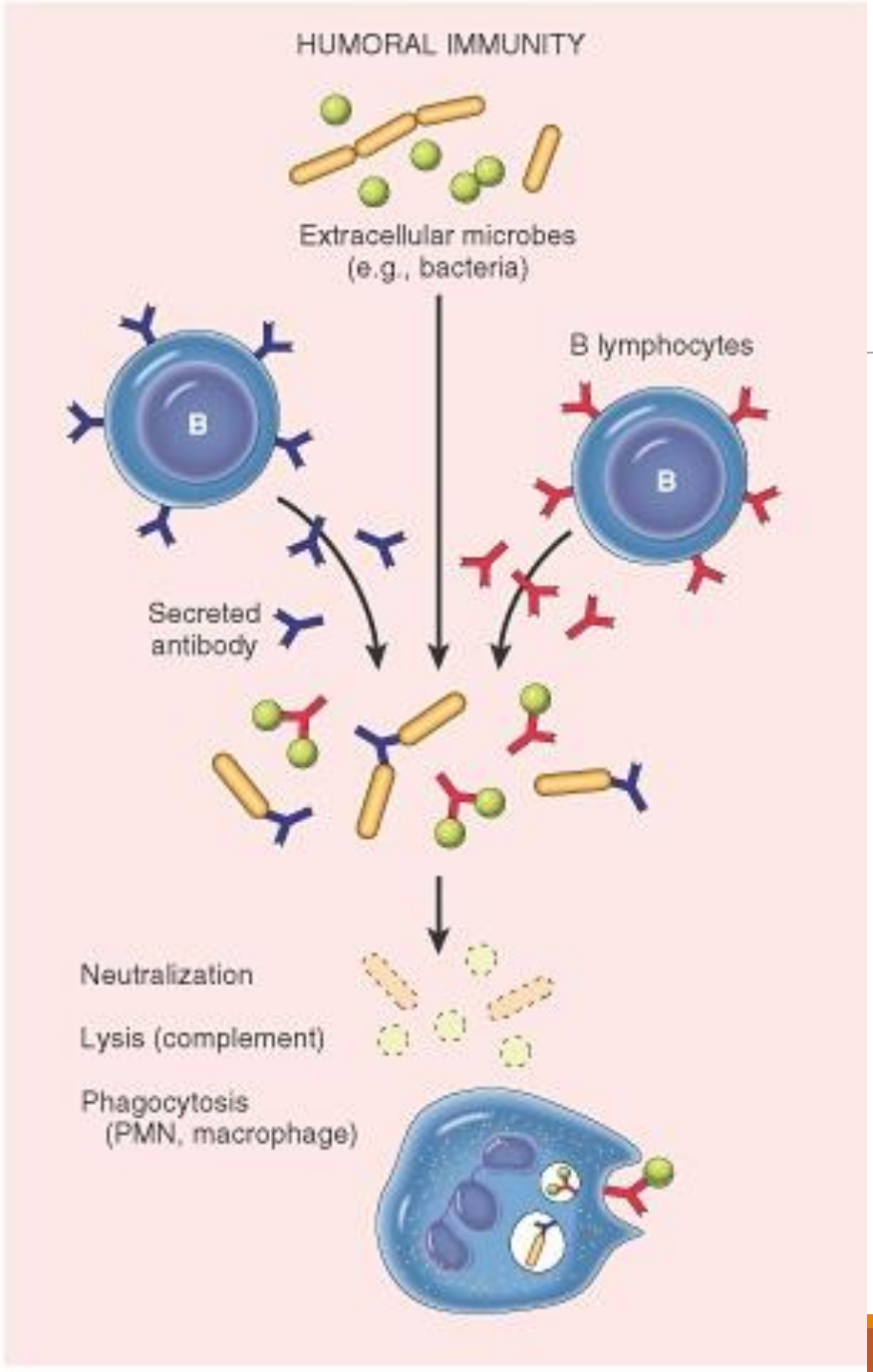
- B cells turn into plasma cells (rapid multiplication) or memory cells (long lived and can respond to antigen later)

- Blood antibody levels rise and then decline

- Secondary responses are with memory cells – faster, more prolonged, and more effective







Types of Immunity

Active = response to encountering an antigen or injection of vaccine in order to produce the antibodies; permanent

Passive = receiving antibodies from a donor (mother to fetus) or through an injection of immune serum; temporary

Active and Passive Humoral Immunity

Active Immunity – B cells encounter antigens and produce antibodies

- Naturally acquired – during infections
- Artificially acquired – receive vaccines
  - Vaccines spare us from most signs and symptoms and can stimulate antibodies to fight off antigen

Passive Immunity – getting antibodies from another immune human or animal donor

- Naturally acquired – antibodies from mother during fetal development
- Artificially acquired – received from immune serum

Antibodies

Part of blood proteins and each type only binds to one antigen

Structure:

- Long and short chains of amino acids that form a Y shape
- All antibodies have a region that is the same and a region that allows them to bind to a specific antigen

Function of Antibodies

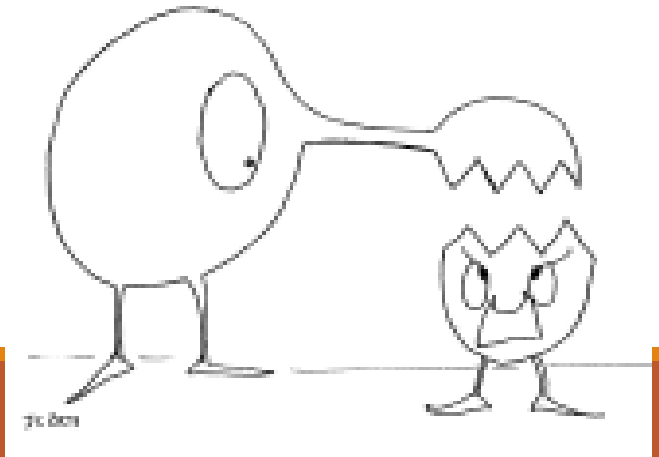
Inactivate antigens by:

- **complement fixation** - proteins bind to foreign cell and causing it to break apart
- **neutralization** – block harmful effects of toxins released from bacteria or virus
- **agglutination** – antibodies can bind to more than one antigen at a time and they can clump foreign cells together; used in blood typing
- **precipitation** – antigen-antibody complexes are so large that they settle out of solution; this makes it easier for phagocytes to engulf and destroy antigens

Cellular (Cell-Mediated) Immune Response

T cells are activated to form clones (just like B cells) when the macrophage present broken down parts of antigens and T cells can recognize it as “non-self”

T cells cannot bind to free antigens

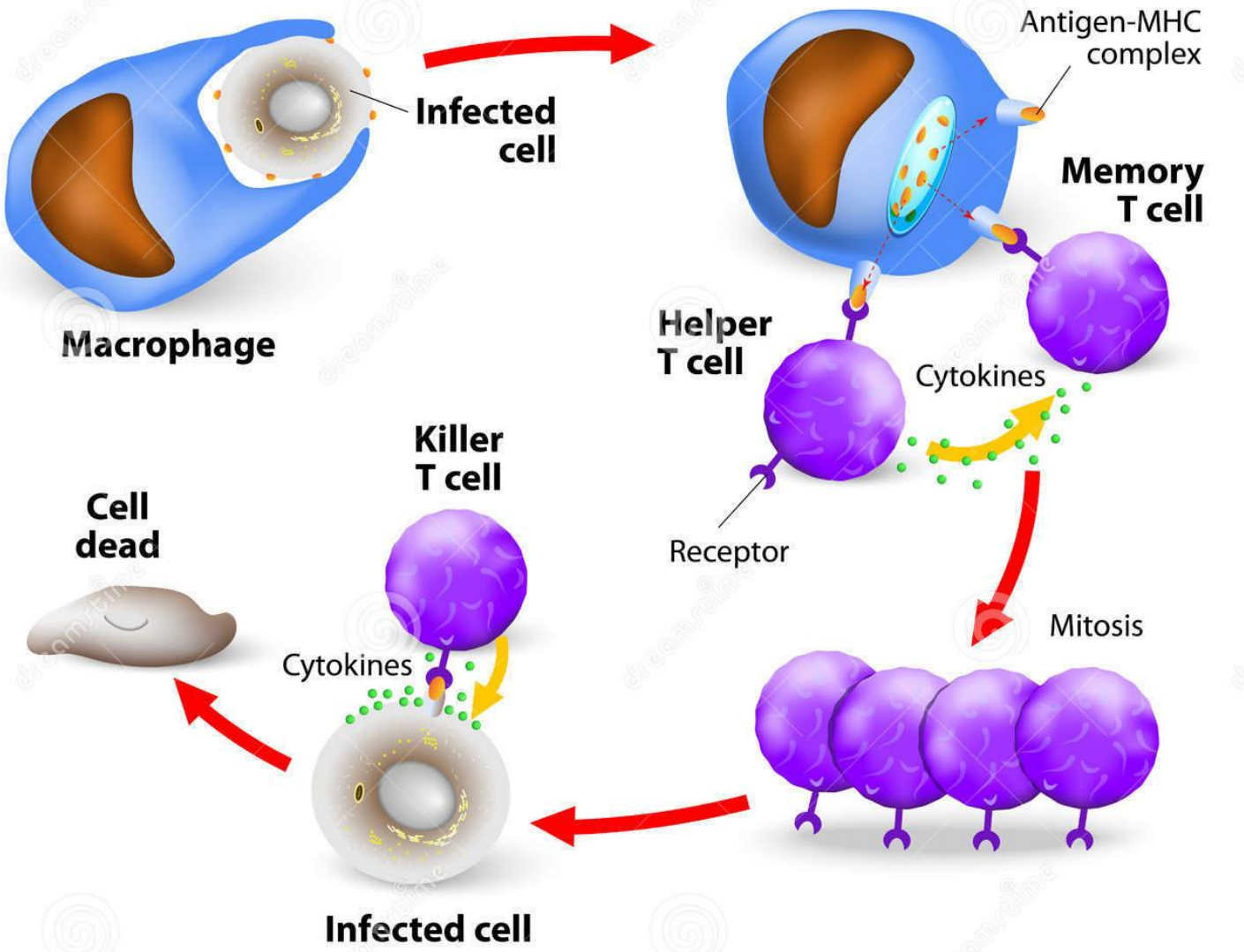


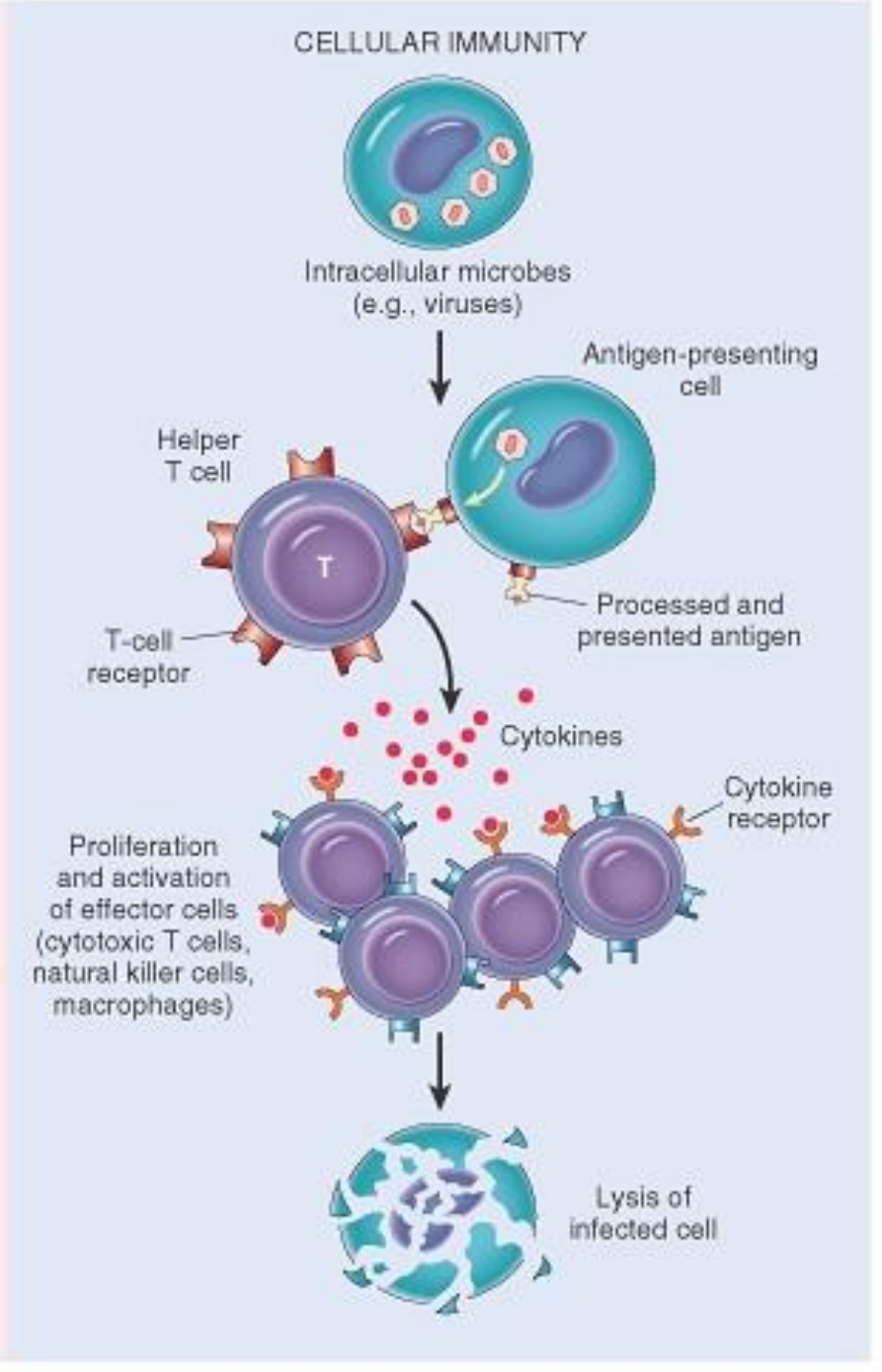
Cellular (Cell-Mediated)

Classes:

- Cytotoxic (killer) T cells – kill virus infected, cancer, or foreign graft cells
- Helper T cells – directors of immune system; recruit other cells to fight infections
- Suppressor T cells – slows activity of T and B cells; vital for stopping immune response
- Memory cells – remain behind to be activated again if antigen returns

CELL-MEDIATED IMMUNE RESPONSE




CELLULAR IMMUNITY
Intracellular microbes
(e.g., viruses)
Antigen-presenting
cell
Helper
T cell
T
T-cell
receptor
Processed and
presented antigen
Cytokines
Cytokine
receptor
Proliferation
and activation
of effector cells
(cytotoxic T cells,
natural killer cells,
macrophages)
Lysis of
infected cell

Website Links

Lymphatic Videos on notes website

Clonal Selection

Flu Virus

Antigen Recognition

B and T cells have antigen receptors on its surface

Other cells have Major Histocompatibility Complex (MHC) molecules on its surface

- Collection of cell surface markers that helps the body recognize cells as self and can present antigens to other cells

- No two people have the same markers

Major Histocompatibility Complex (MHC) molecules

Class I → found on almost every body cell (even infected cells)

- Activate cytotoxic T cells

Class II → found on specialized cells (macrophage, B cells, and activated T cells and do phagocytosis to get the antigen)

- Activate cytotoxic T cells and helper T cells

Acquired Immunity

T cells

- Mature in the thymus gland
- Activated by antigen-presenting cells or other infected cells
- **Helper T Cells**
  - Bind to class II MHC molecules
  - CD4 protein holds the 2 cells in place until the T cell is activated
- **Cytotoxic T Cells**
  - Bind to class I MHC molecules
  - CD8 protein holds the 2 cells in place until the T cell is activated

Activation of Immune Response

1st exposure to antigen

- Macrophage engulfs pathogen and presents the fragments of its cell surface with **MHC II molecules**
- Helper T cell is activated by binding to the MHC-antigen complex on the macrophage
  - Process enhanced by **interleukin** (type of cytokine) and **CD4 proteins** – helps hold the two cells together
  - Macrophage secretes **cytokines** to help activate the helper T cell
- Activated helper T cells proliferate and secretes cytokines, which further stimulate helper T cells, B cells, and cytotoxic T cells

Humeral Immunity

B cells will attach to the antigen and present it on its own **MHC II**

Activated helper T cell with the correct receptors will bind to MHC II on the B cells (along with a CD4 protein to hold the cells together)

With the help of cytokines, the B cell will be activated and will proliferate into plasma cells and memory B cells

Plasma cells will secrete antibodies to interact with the antigens

Cell-mediated Immunity

Macrophage became the antigen-presenting cell and, along with activated helper T cells, will activate cytotoxic T cells

Cytotoxic T cell then binds to an infected target cell's antigen presented on **MHC I molecules**

- Process enhanced by **CD8 proteins** – helps hold the two cells together

Cytotoxic T cells release **perforin** (proteins that form holes in the cell membrane) and enzymes to break apart the cell

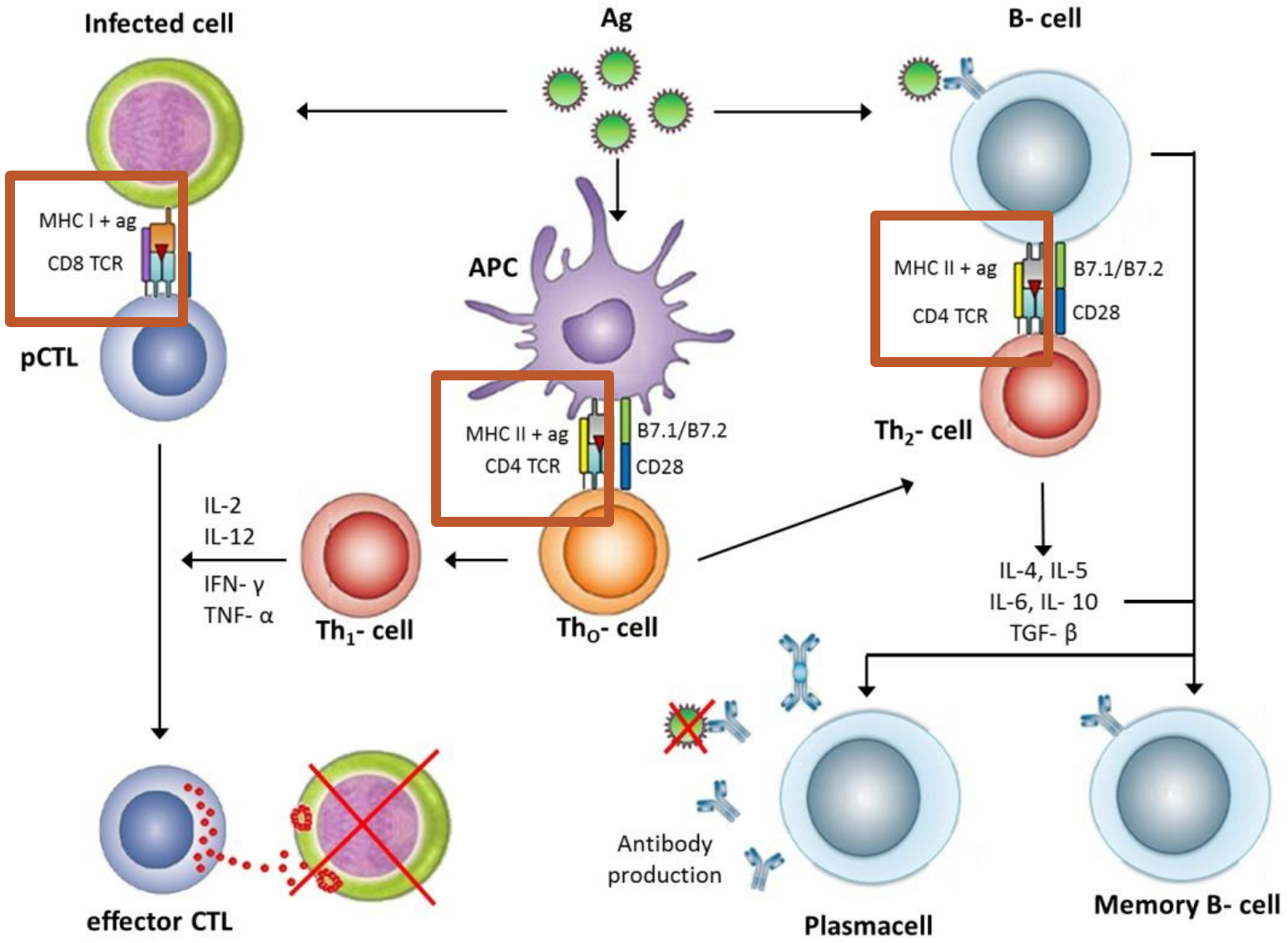
Activation of Immune Response

2nd exposure to antigen

- **Memory cells** bind to the antigen and start the process of humeral and cell-mediated immunity immediately

Cell-mediated

Humeral



Positive Feedback

Enhances the process until an endpoint is reached

- Ex: Helper T cells releases cytokines to maximize the activity of these cells

Disorders/Diseases

AIDS Virus

- Attacks cells with CD4 molecules, which is mainly helper T cells
- Works as a retrovirus – uses reverse transcriptase to permanently inject its DNA into the host's genome to produce new viruses

Immunodeficiency diseases

- Ability of the immune system to protect against pathogens is defective
- Sometimes the body will begin to recognize self as non-self