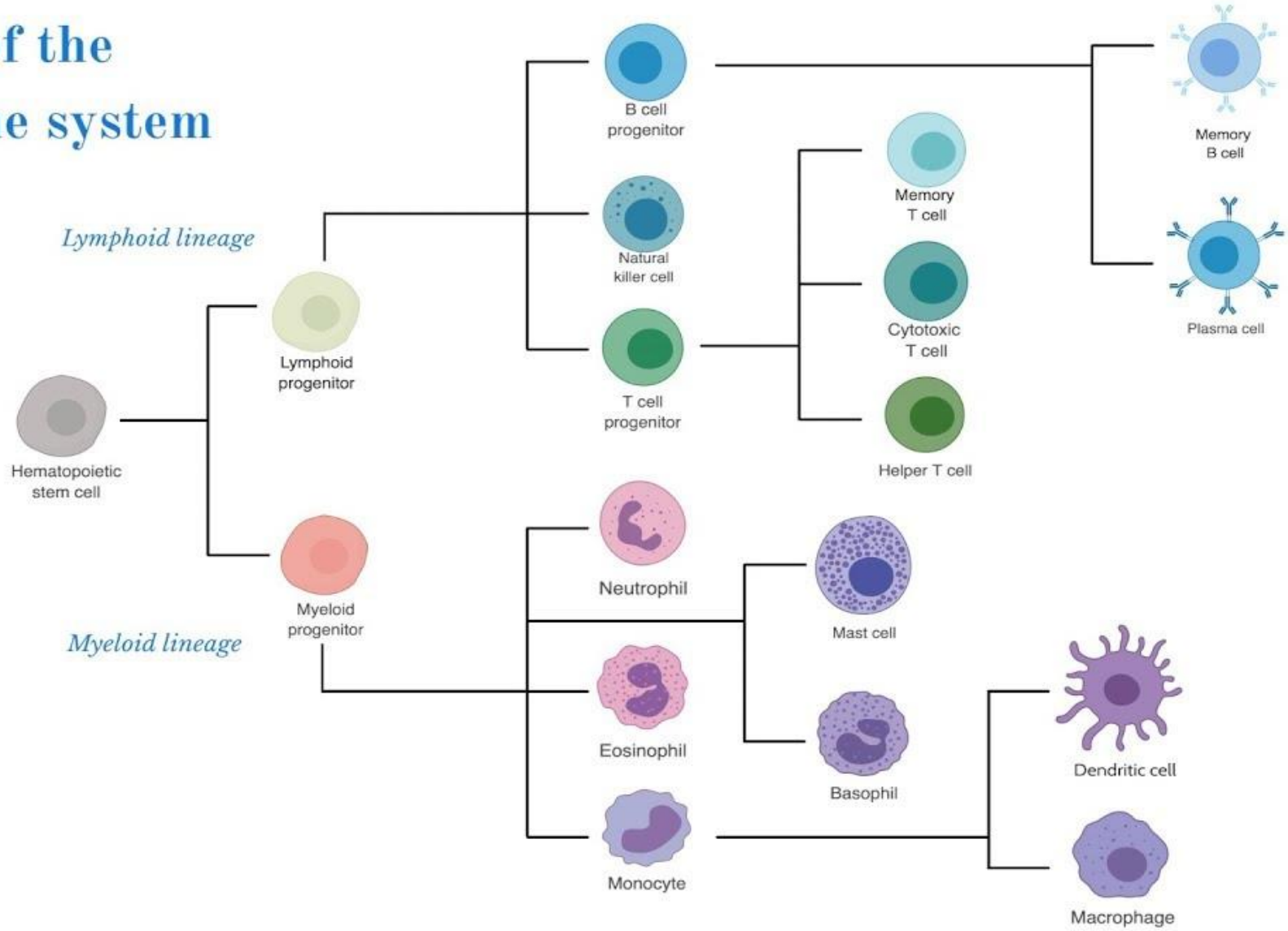
Cells of the immune system



Microbiology
Lecture 7

Immunology Introduction

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Immunity = resistance

- The word immunity was derived from the Latin word "immunis" meaning exempt.
- It is the sum of all naturally occurring defense mechanisms that protect humans from infectious disease.

The immune system = collection of organs, cells and proteins that function to protect all the body from foreign antigens, such as bacteria, fungi, viruses and parasites

Two important types

I. Innate (natural) or non-specific immunity

II. Adaptive (acquired) or specific immunity

**Lines of Protection Against Invading Pathogens

1. First Line of Defense: Non-specific natural barriers which restrict entry of pathogen. Examples: Skin and mucous membranes.

2. Second Line of Defense: Innate non-specific immune defenses provide rapid local response to pathogen after it has entered host. Examples: Fever, phagocytes (macrophages and neutrophils), inflammation, and interferon.

3. Third line of defense: Antigen-specific immune responses, specifically target and attack invaders that get past first two lines of defense. Examples: Antibodies and lymphocytes.

Natural or innate or non-specific immunity

-It is present at birth.

- Has the ability to resist infection

-Many of these mechanisms are subject to influence by factors as nutrition, age, fatigue, stress, and genetic determinants.

****It can be classified into three main groups:**

1. Barriers to infection

2. Humoral factor (Soluble proteins).

3. Cells

1. Barriers to infection

A. Physical and mechanical barriers

Skin and mucosal membranes

- Tight junctions between cells prevent the majority of pathogens from entering the body.
- The flushing actions of tears, saliva and urine protect epithelial surfaces from colonization.
- High oxygen tension in the lungs, and body temperature, can also inhibit microbial growth.
- In the respiratory tract, mucus is secreted to trap microorganisms.
  They are then mechanically expelled by:

    - Beating cilia
    - Coughing
    - Sneezing.

B. Chemical barriers

The growth of microorganisms is inhibited at acidic pH (in the stomach and vagina).
-Lactic acid and fatty acids in sebum (produced by sebaceous glands) maintain the skin pH between 3 and 5.
-Enzymes such as lysozyme (found in saliva, sweat and tears) and pepsin (present in the gut) destroy microorganisms.

C. Biological barriers

(normal flora) Normal flora is formed when non pathogenic bacteria colonize epithelial surfaces. Normal flora protects the host by:

- Competing with pathogenic bacteria for nutrients and attachment sites
- Production of antibacterial substances.

2. Humoral factor (Soluble proteins).

When infectious agents have penetrated tissues another innate defense mechanism play role in protection. Humoral factors play an important role in inflammations, and these factors found in serum or they are formed at the site of infection.

1. Complement system: is a group of serum proteins which inactive functionally, but when activated they damage the membranes of the pathogenic organisms, either destroying the pathogens or facilitating their clearance.

2. Beta-lysin: is a protein produce by platelets during coagulation can lyses many bacteria by chemotactic agents for phagocytic cells.

3. Interferons (INF): which are group of proteins produced by

virus infected cells. Among the many functions of INF is the ability to bind to nearby cells and induce a generalized antiviral state. There are three types of them (IFN α, γ, β). • • •

4. Lactoferrin and transferrin: are iron-binding proteins that compete with microorganisms for iron, an essential metabolite.

5. Lysozyme: bactericidal enzyme in mucus, saliva, tears, sweat and breast milk, it cleaves peptidoglycan in the cell wall of microorganisms.

6. Cytokines: Tumor necrosis factor-alpha (TNF α), interleukin-1 (IL-1) and IL-12.

3. Cells of innate immunity

- The cells of the innate immune system consist of:

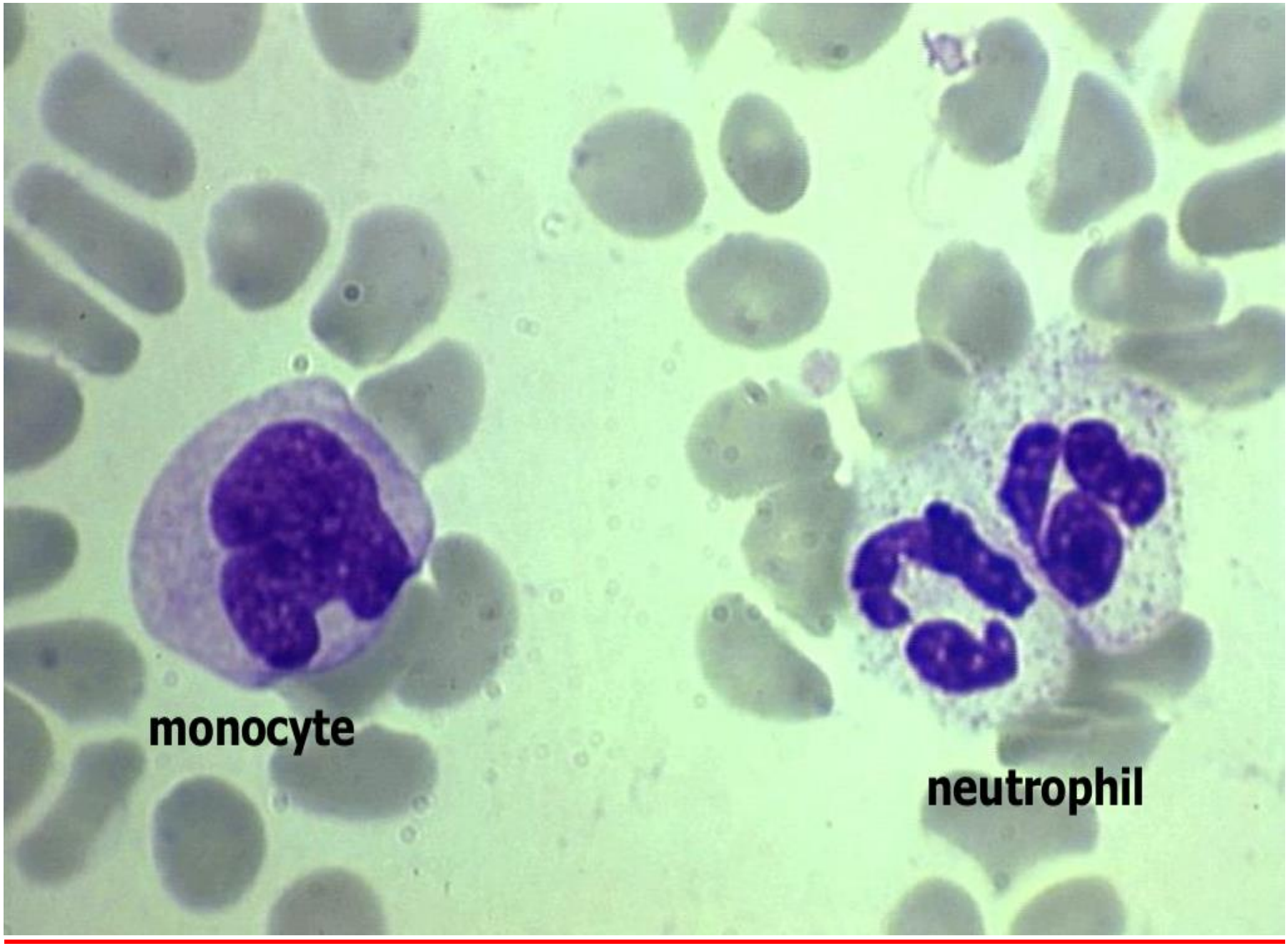
1. Phagocytes (Macrophage and Neutrophils)
2. Antigen presenting cells (APC)
3. Natural killer cells.

1. Phagocytes

(macrophages and neutrophils) engulf and then destroy pathogens by process of phagocytosis

Macrophages are long lived cells at sites of infection; they release cytokines that recruit the shorter-lived but more actively phagocytic neutrophils.

Neutrophils circulating white cells arrive quickly at the site of inflammation and in the act of killing pathogens these cells die.


monocyte
neutrophil

Stages of Phagocytosis

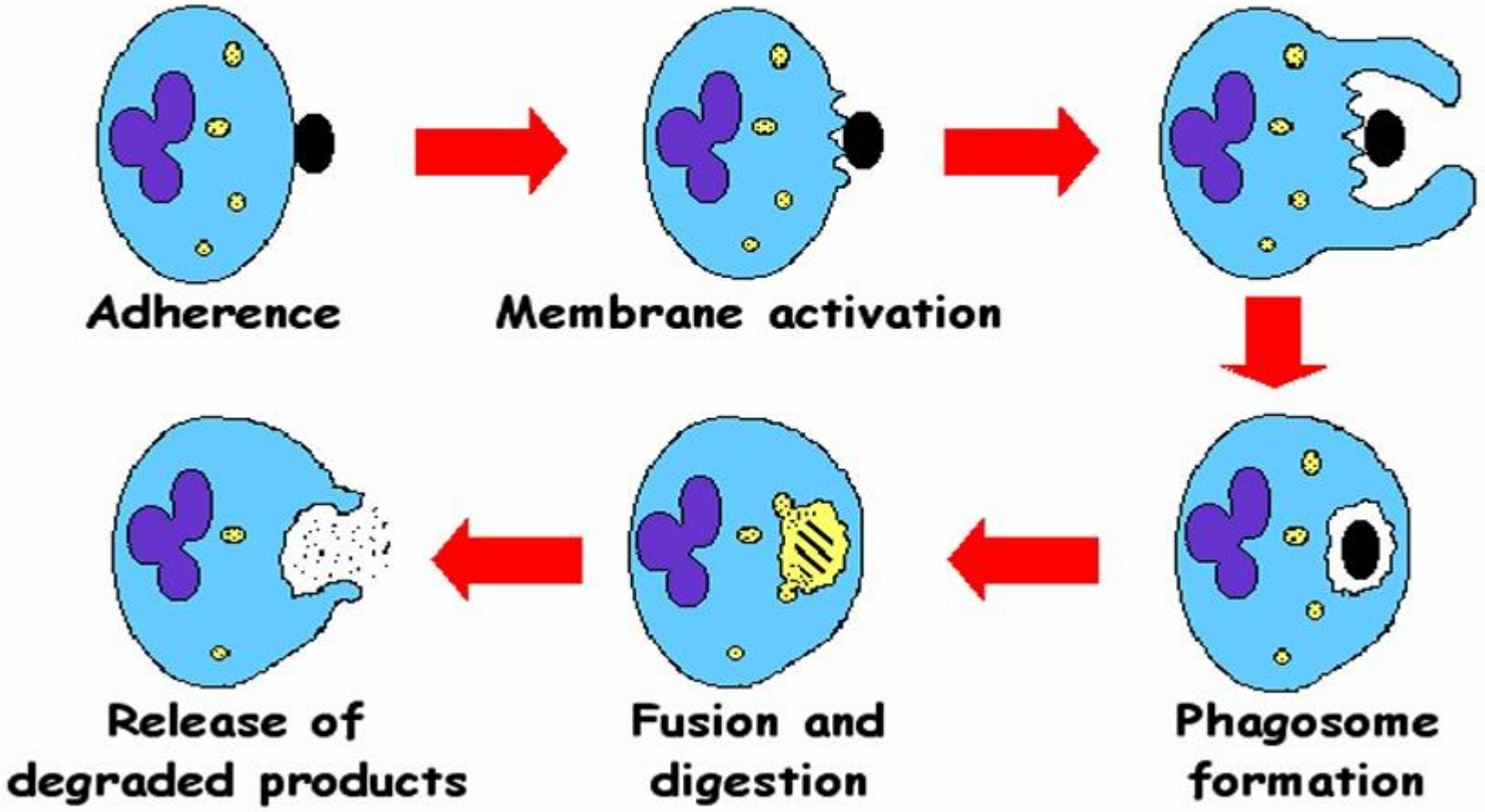
1.Chemotaxis: Phagocytes are chemically attracted to site of infection.

2.Adherence: Phagocyte plasma membrane attaches to surface of pathogen or foreign material.

3. Ingestion: Plasma membrane of phagocytes extends projections (pseudopods) which engulf the microbe. Microbe is enclosed in a sac called phagosome.

4. Digestion: Inside the cell, phagosome fuses with lysosome to form a phagolysosome. Lysosomal enzymes kill most bacteria within 30 minutes

Phagocytosis



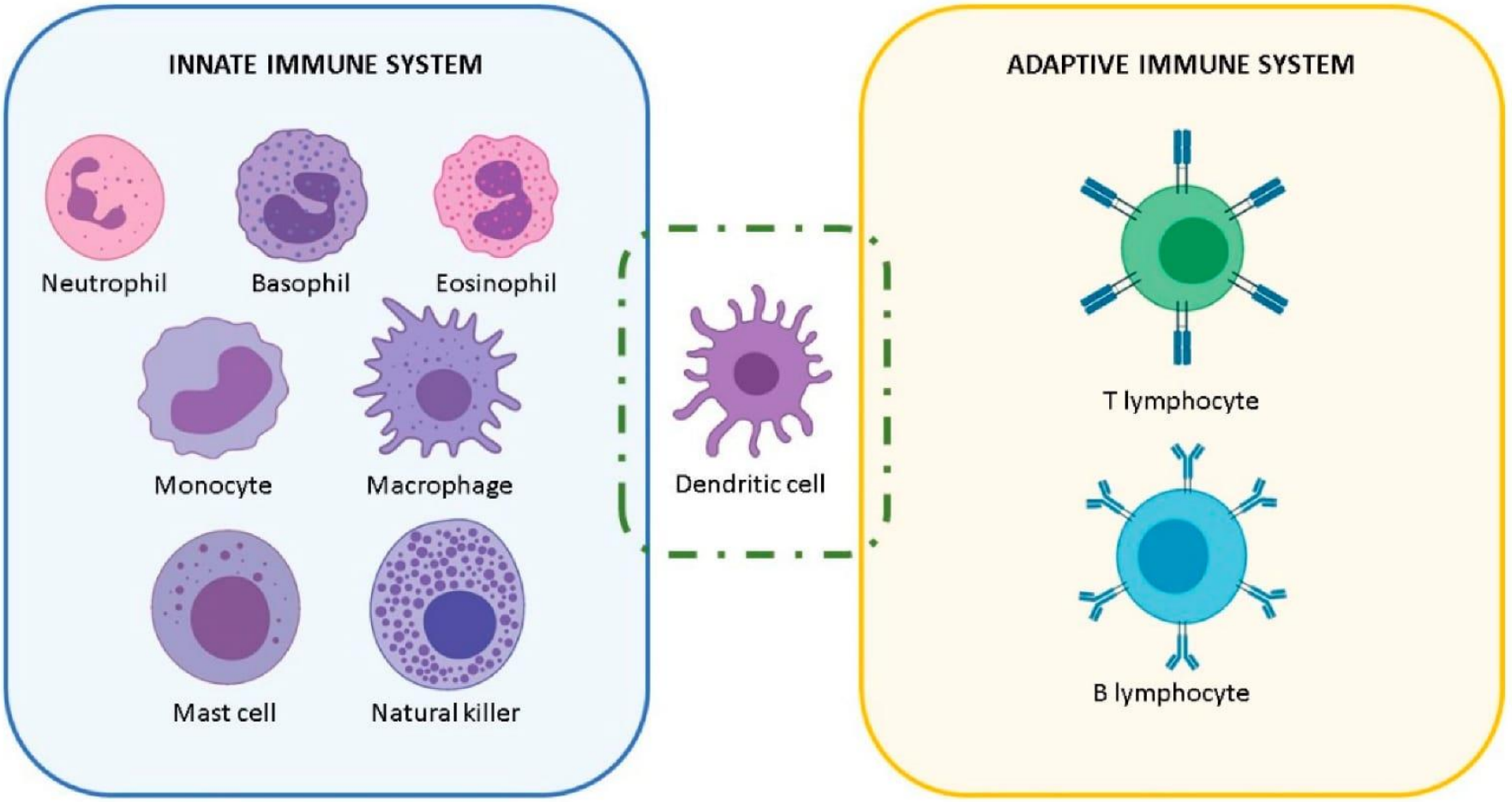
2. Antigen presenting cells (APC)

• these are cells that mediate cellular immune response by engulfment, processing and presenting antigens to the T-cell receptor.

• Traditional APC include: macrophages, dendritic cells, langerhans cells, and B- lymphocytes.

3. Natural killer (NK) cells

- Large granular lymphocytes (not B-cell or T-cell) Kills tumor cells & viral inf. cells (intracellular pathogens)
- NK cells do not require prior immunization or activation
- They attach to 'target' cells, then cytotoxic granules are released onto surface of cell and effectors proteins penetrate cell membrane and induce death.


INNATE IMMUNE SYSTEM
Neutrophil
Basophil
Eosinophil
Monocyte
Macrophage
Mast cell
Natural killer
Dendritic cell
ADAPTIVE IMMUNE SYSTEM
T lymphocyte
B lymphocyte

-

Inflammation

Triggered by tissue damage due to infection, heat, wound, etc.

*Major Symptoms of Inflammation

1. Redness
2. Pain
3. Heat May also observe
4. Swelling
5. Loss of function

*Functions of Inflammation

1. Destroy and remove pathogens
2. If destruction is not possible, to limit effects by confining the pathogen and its products.
3. Repair and replace tissue damaged by pathogen and its products.

Adaptive or acquired or specific immunity

**is a type of resistance that is characterized by specificity for each individual pathogen, or microbial agent, and the ability to remember a prior exposure, which results in an increased response upon repeated exposure.

Adaptive immunity is often sub-divided into two major types

• depending on how the immunity was introduced:
a. Naturally acquired immunity: is occurs through contact with a disease.
b. Artificially acquired immunity: is develops only through deliberate actions such as vaccination.
**Both naturally and artificially acquired immunity can be >>>>

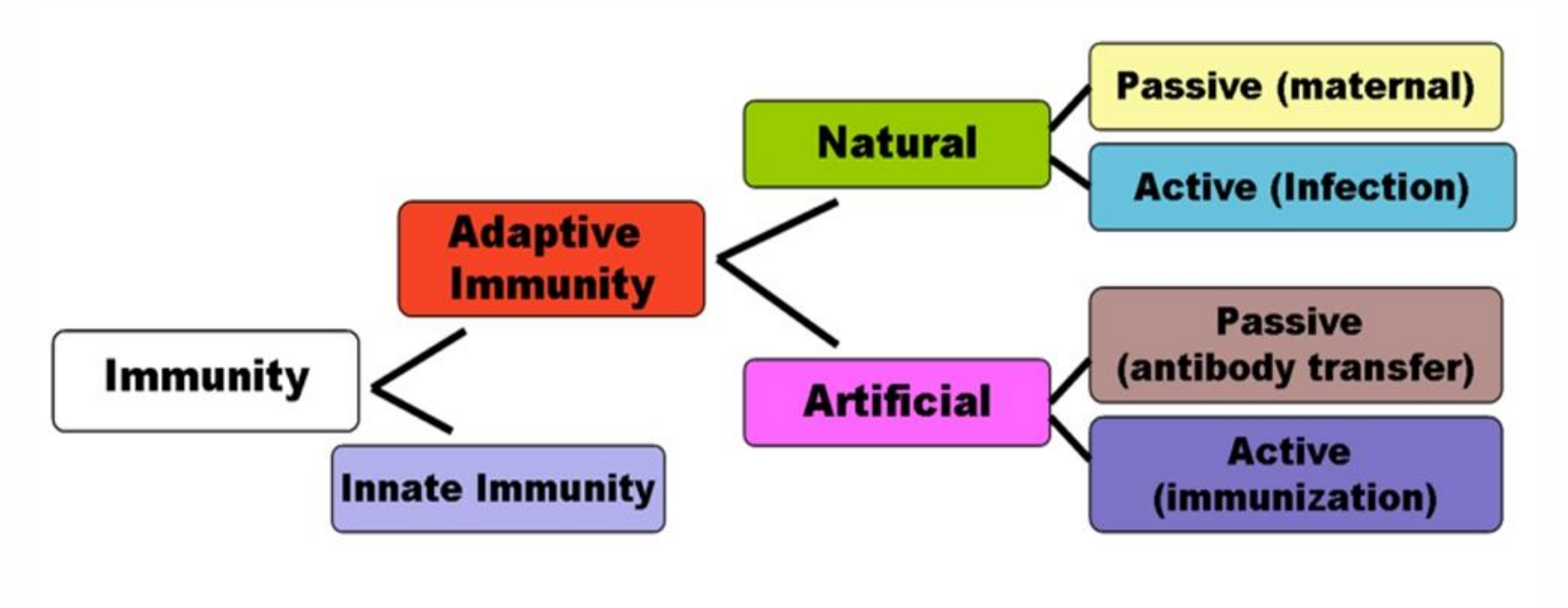
further subdivided depending on whether immunity is

a. induced in the host

b. passively transferred from an immune host.

Categories are :

- Naturally acquired Placental transfer of antibody (Passive)
- Artificially acquired administration of antitoxin (Passive)
- Recovery from disease (Active)
- Vaccination (Active)

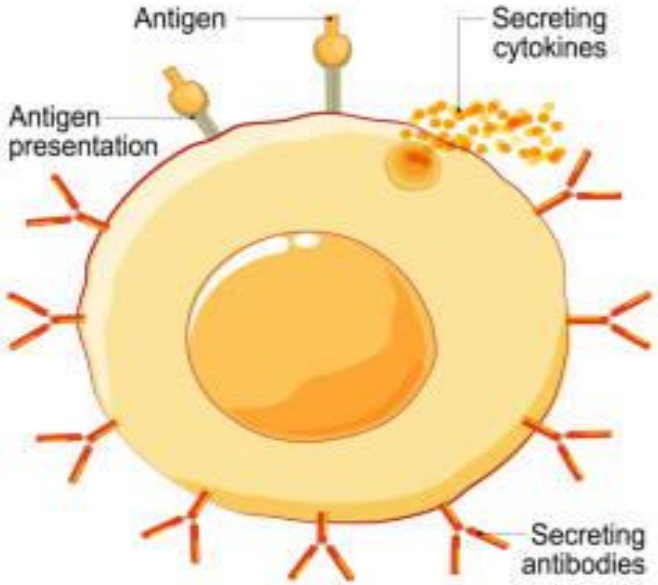


Adaptive immunity is mediated by B or T lymphocytes and stimulated by exposure to infectious agents :

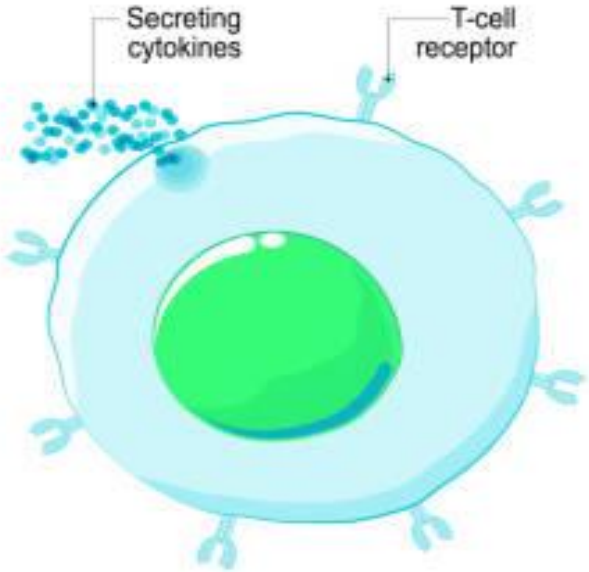
A. Humoral Immunity (Antibody Immunity)
B. Cell-mediated immunity (Cellular Immunity)

Cellular Immunity	Antibody or Humoral Immunity
• Carried out by T-Cells • Infected cells are killed by Cytotoxic T –Cells.	• Carried out by B-cells • Antibodies are produced and dumped into blood stream. • Antibodies bind to antigens and deactivate them.

Cells of the adaptive immune system



B-cell



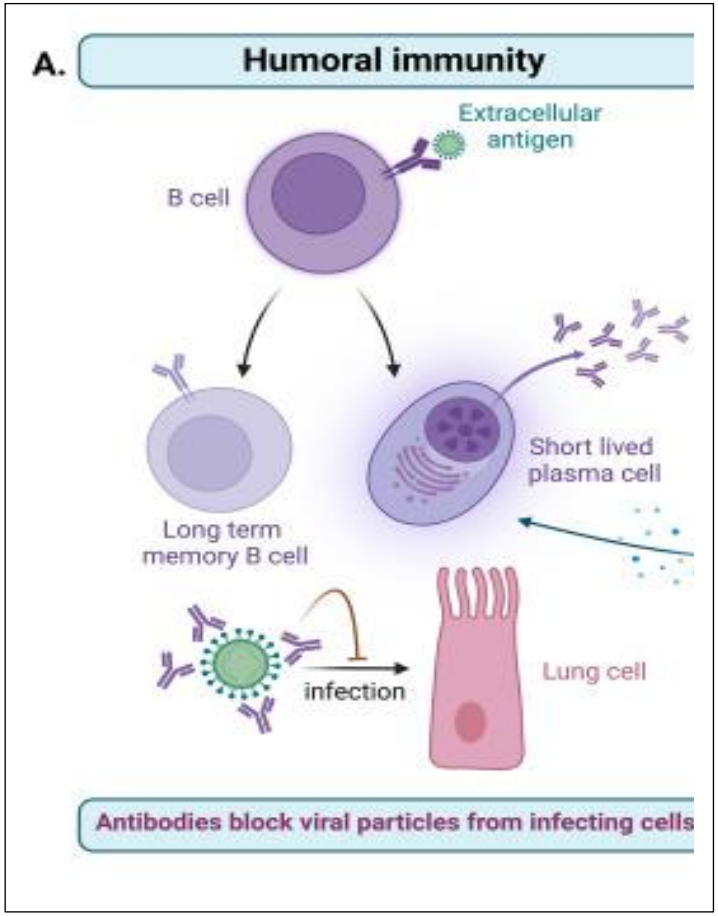
T-cell

A. Humoral Immunity (Antibody Immunity):

• Type of immunity that is mediated by secreted antibodies produced by the B-lymphocyte cells.

Secreted antibodies bind to antigens on the surfaces of invading microbes (such as viruses or bacteria), which exposure them for destruction.

**Humoral immunity is called as such, because it involves substances found in the body fluids.



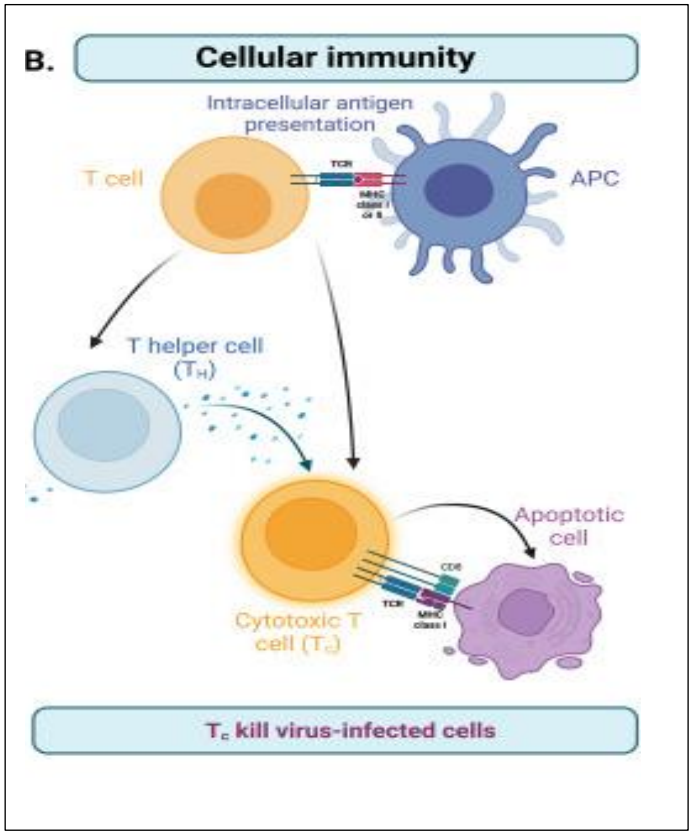
B. Cell-mediated immunity (Cellular Immunity):

• Since antibodies are useless against intracellular antigens, cell-mediated immunity is needed.

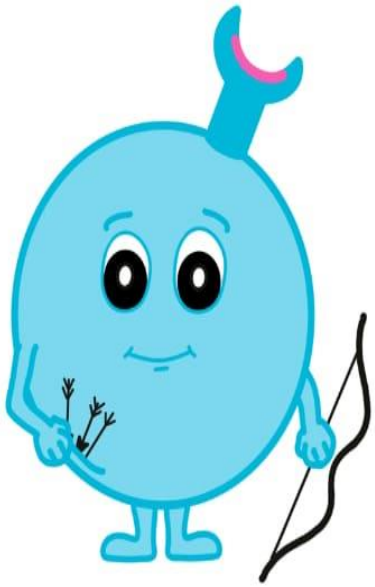
Two major populations of T cells mediate cellular immunity:

1. CD4 cells are helper T cells (TH).
2. CD8 cells are cytotoxic T cells (TC) that destroy cells harboring foreign antigens.

■ Regulatory T cells that release cytokines, which suppress the activity of both T cells and B cells

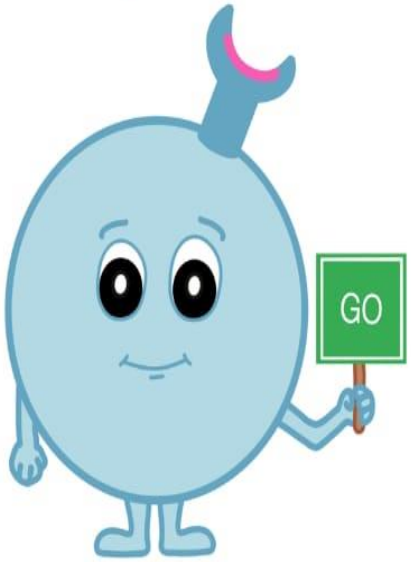


cytotoxic T cells



produce toxic agents to kill their targets

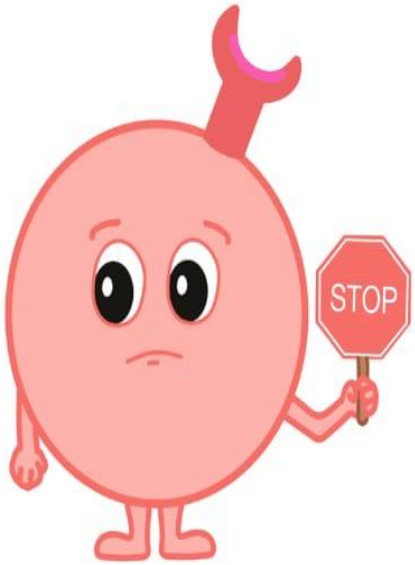
helper T cells



stimulate B cells to make antibodies

stimulate T cells to become active

regulatory T cells



suppress immune responses

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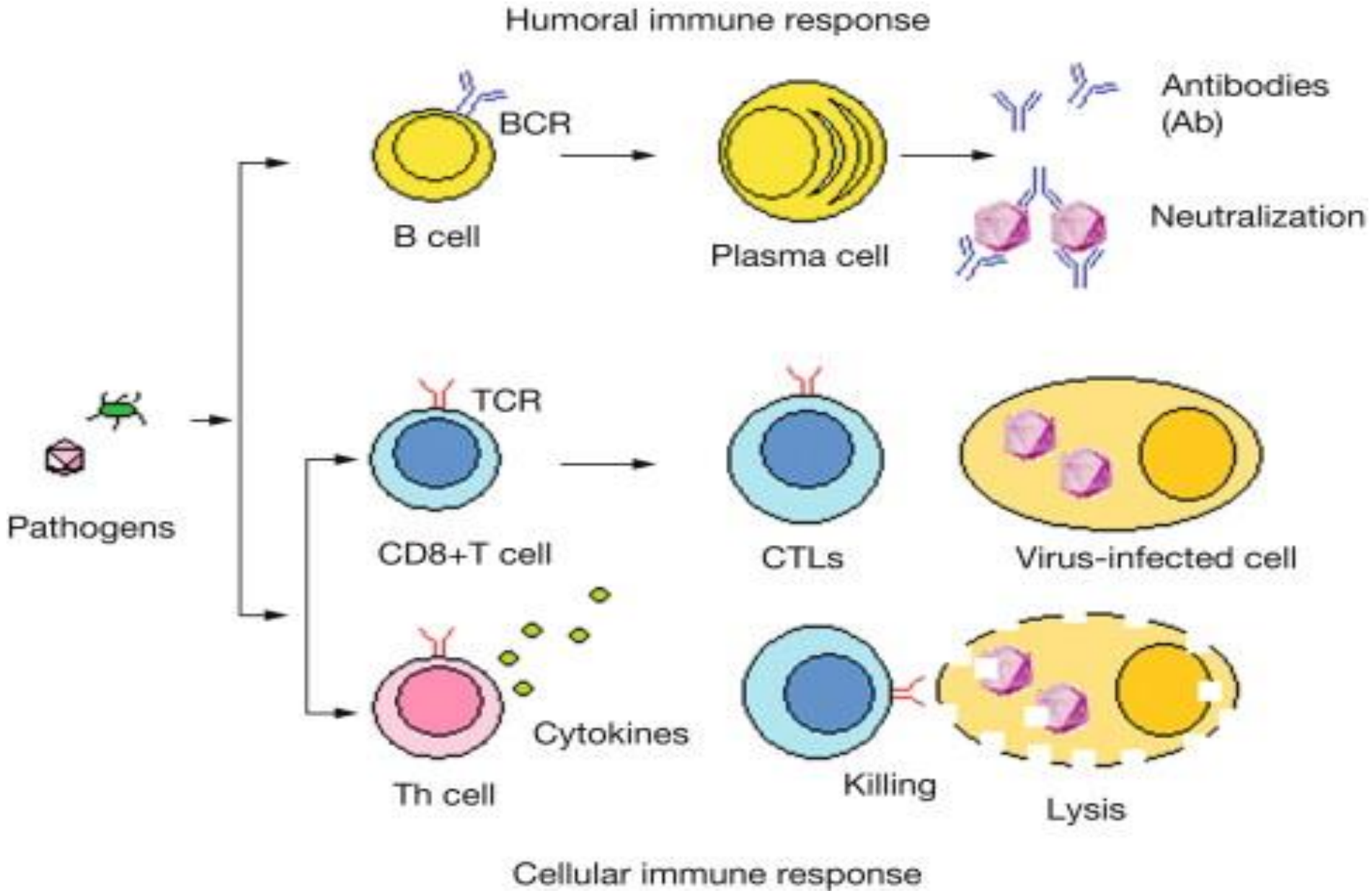
The innate and adaptive immune response

Characteristics	Cells	Molecules
Innate immunity		
Responds rapidly No memory No specificity No prior exposure is required	Physical barriers Phagocytes (PMNs and macrophages) Natural killer cells	Humoral factors Complement Acute phase Proteins Cytokines
Adaptive immunity		
Responds Slowly Memory Highly specific Present after exposure to an Ag	T cells B cells Dendritic cells	Antibodies Cytokines Granzymes


Humoral immune response
BCR
B cell
Plasma cell
Antibodies
(Ab)
Neutralization
Pathogens
TCR
CD8+T cell
CTLs
Virus-infected cell
Cytokines
Th cell
Killing
Lysis
Cellular immune response

Immunogens: substance that induce specific immune response.

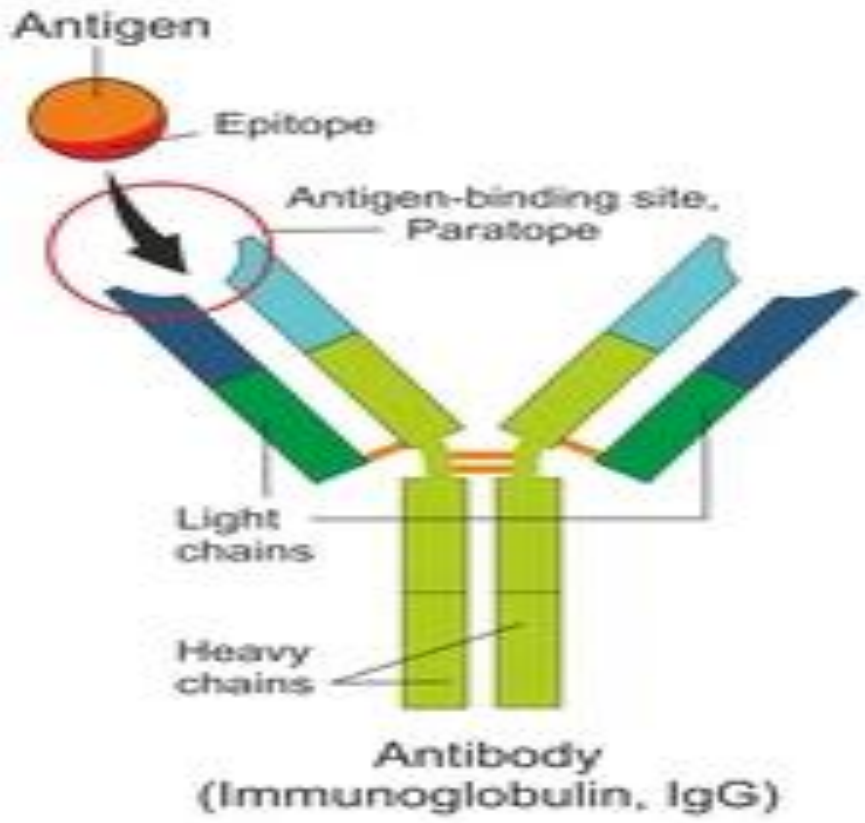
- Adjuvant: substance that can enhance the immune response to an immunogen.
- Hapten: substance that are non-immunogenic, small molecules and can never induces immune response by themselves unless coupled to a carrier molecules, but can react with the specific immune products therefore haptens have the property of antigenicity but not immunogenicity

Antigen: substance that react with the product of specific immune response (antibody)

- Epitope or antigenic determinant: the portion of antigen (Ag) that combines with antibody (Ab).

Antibody: specific protein which is produced in response to immunogen and reacts with an antigen

- Paratope: the portion of antibody (Ab) that combines with antigen (Ag)


Antigen
Epitope
Antigen-binding site,
Paratope
Light
chains
Heavy
chains
Antibody
(Immunoglobulin, IgG)