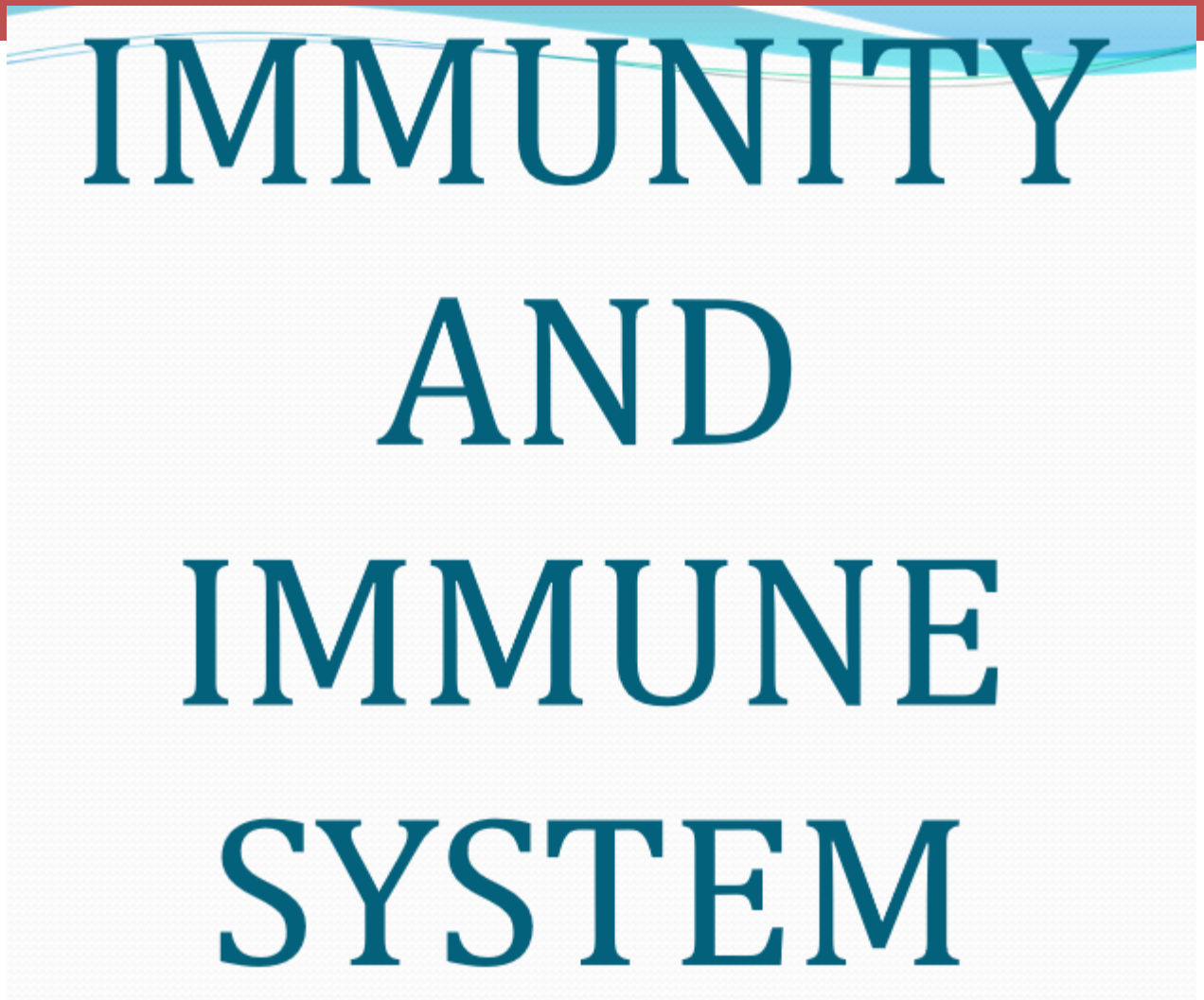
Defense Mechanisms of the Body



Defense Mechanisms of the Body

BY:

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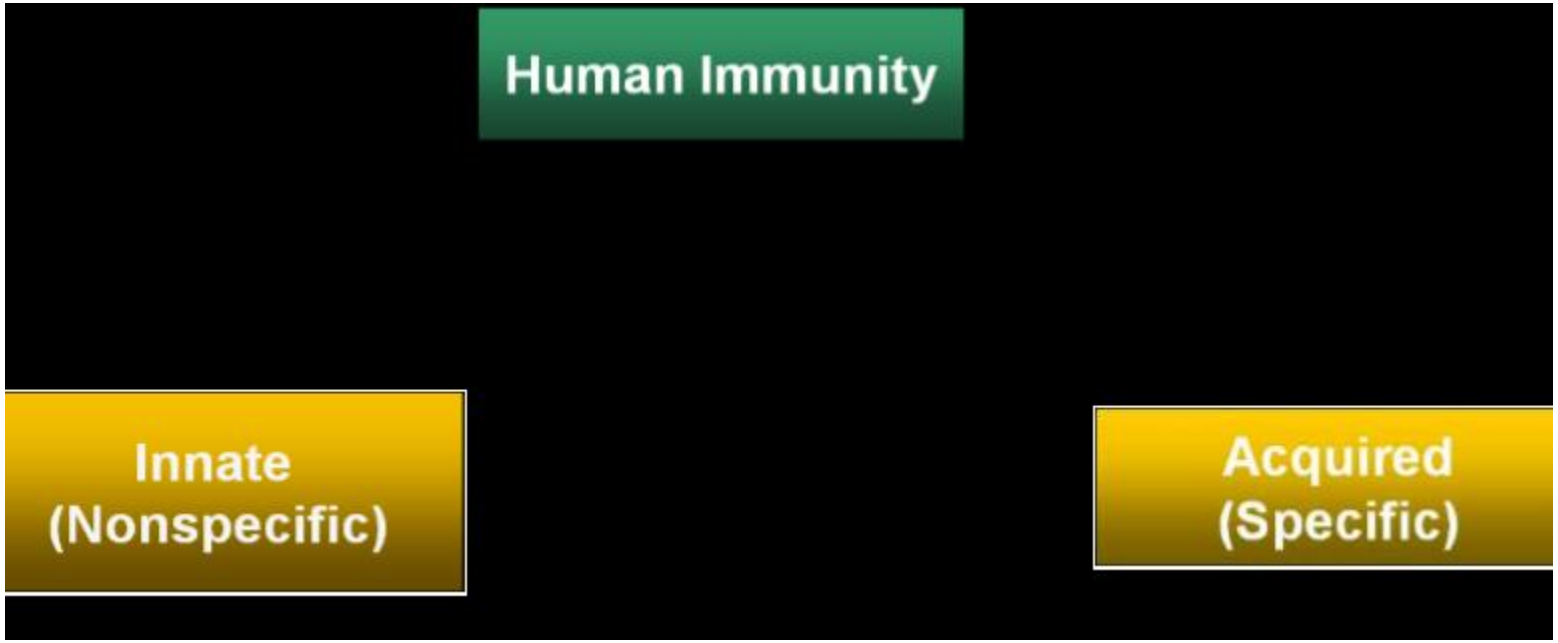
Immunology

- capacity of the body to resist pathogenic agents. It is the ability of body to resist the entry of different types of foreign bodies like bacteria, virus, toxic substances, etc
- Bacteria
- Viruses
- Pathogens
- Pollution

The immune system recognizes foreign bodies and responds with the production of immune cells


Human Immunity
Innate
(Nonspecific)
Acquired
(Specific)

Innate or Natural or Nonspecific Immunity

- inborn capacity of the body to resist pathogens. if the organisms enter the body, innate immunity eliminates them before the development of any disease. It is otherwise called the natural or non-specific immunity.
- This type of immunity represents the first line of defense against any type of pathogens. Therefore, it is also called non-specific immunity.

Innate or Natural or Nonspecific Immunity

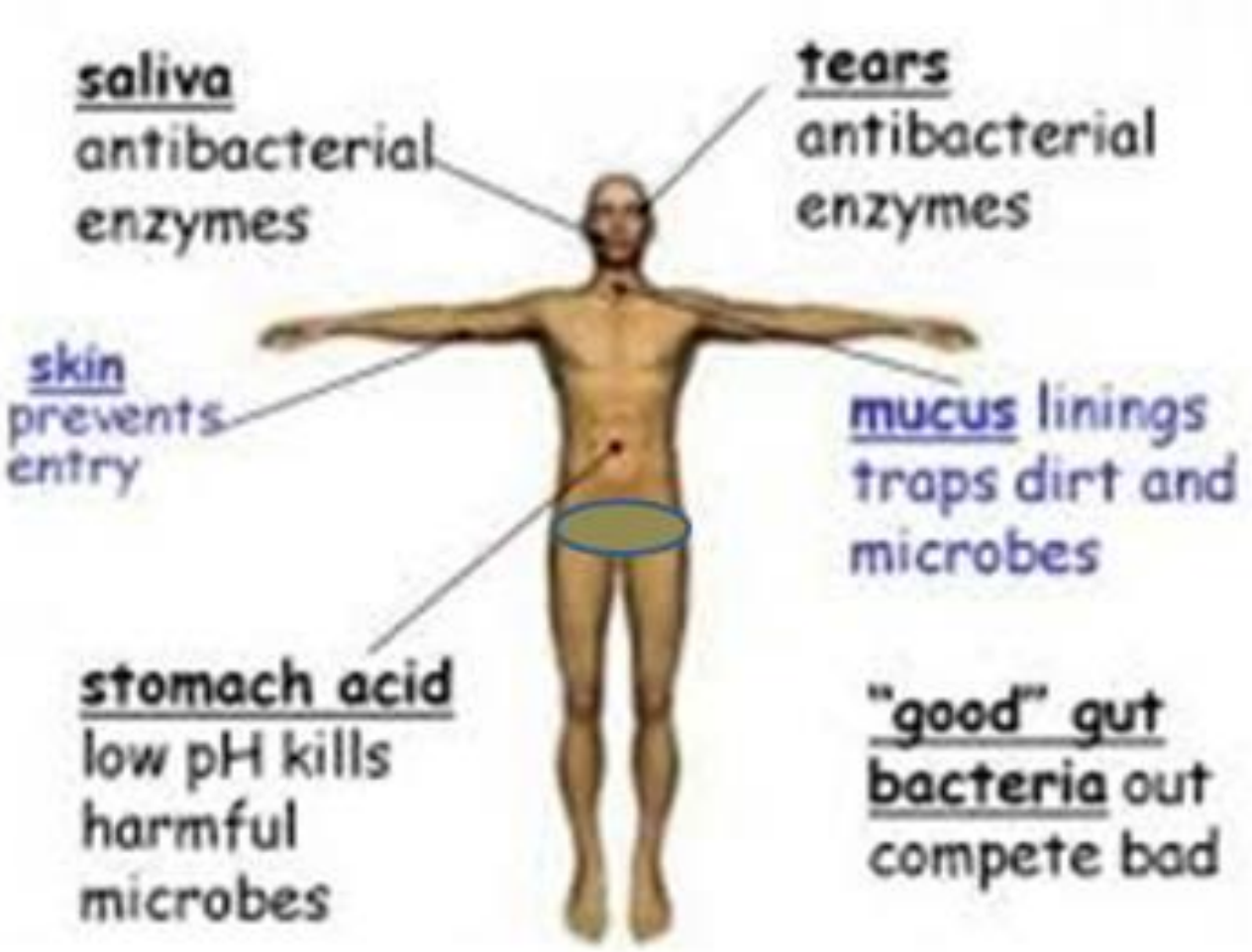
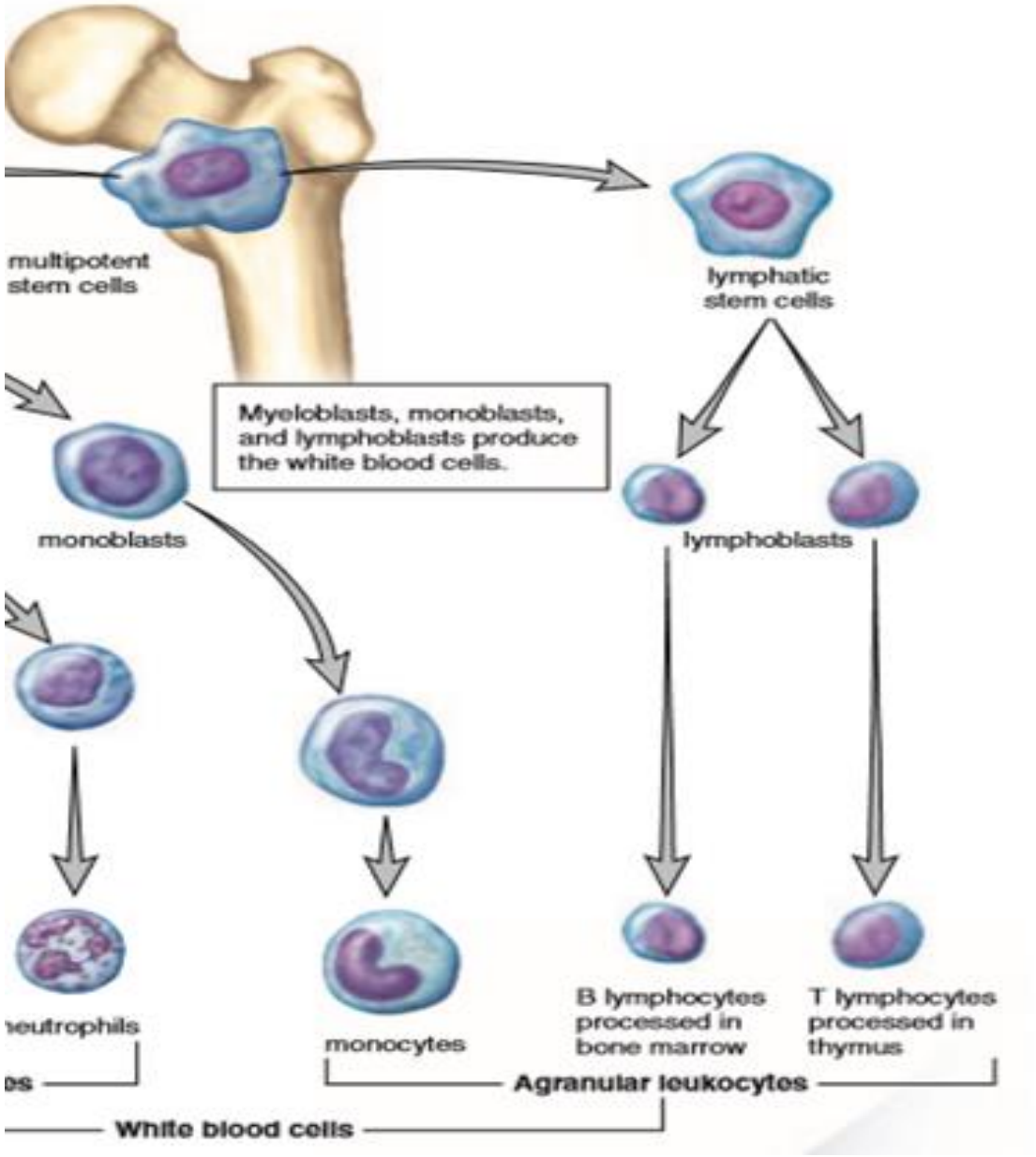


TABLE 17.1: Mechanisms of innate immunity

Structures and Mediators	Mechanism
Gastrointestinal tract	Enzymes in digestive juices and the acid in stomach destroy the toxic substances or organisms entering digestive tract through food Lysozyme present in saliva destroys bacteria
Respiratory system	Defensins and cathelicidins in epithelial cells of air passage are antimicrobial peptides Neutrophils, lymphocytes, macrophages and natural killer cells present in lungs act against bacteria and virus
Urinogenital system	Acidity in urine and vaginal fluid destroy the bacteria
Skin	The keratinized stratum corneum of epidermis protects the skin against toxic chemicals The β-defensins in skin are antimicrobial peptides Lysozyme secreted in skin destroys bacteria
Phagocytic cells	Neutrophils, monocytes and macrophages ingest and destroy the microorganisms and foreign bodies by phagocytosis
Interferons	Inhibit multiplication of viruses, parasites and cancer cells
Complement proteins	Accelerate the destruction of microorganisms

Acquired Immunity (= Adaptive or Specific Immunity):

- The immunity that an individual acquires after the birth is called acquired or adaptive or specific immunity.
- Acquired immunity is the *resistance developed in the body against any specific foreign body* like *bacteria, viruses, toxins, vaccines or transplanted tissues*. So, this type of immunity is also known as specific immunity. It is the powerful immune mechanism that protects the body from the invading organisms or toxic substances. **Lymphocytes are responsible for acquired immunity**


multipotent
stem cells
lymphatic
stem cells
Myeloblasts, monoblasts,
and lymphoblasts produce
the white blood cells.
monoblasts
lymphoblasts
eutrophils
monocytes
B lymphocytes
processed in
bone marrow
T lymphocytes
processed in
thymus
Agranular leukocytes
White blood cells

Types/Components of Acquired Immunity:

- Acquired immunity has two components: humeral immunity or Antibody mediated immune system (AMIS) and cellular immunity or cell mediated immune system (CMIS).

Types of Acquired Immunity

Two types of acquired immunity develop in the body:

1. Cellular immunity
2. Humoral immunity.

Lymphocytes are responsible for the development of these two types of immunity.

Cell-mediated immunity is defined as the immunity developed by cell-mediated response. It is also called cellular immunity or T cell immunity. It involves several types of cells such as T lymphocytes, macrophages and natural killer cells and hence the name cell mediated immunity. Cell-mediated immunity does not involve antibodies.

Cellular immunity is the major defense mechanism against infections by viruses, fungi and few bacteria like tubercle bacillus. It is also responsible for delayed allergic reactions and the rejection of transplanted tissues.

Cell-mediated immunity is offered by T lymphocytes and it starts developing when T cells come in contact with the antigens. Usually, the invading microbial or non-microbial organisms carry the antigenic materials. These antigenic materials are released from invading organisms and are presented to the helper T cells by antigen-presenting cells.

Antigens are the substances which induce specific immune reactions in the body

NON-SELF ANTIGENS

Following are non-self antigens:

1. Receptors on the cell membrane of microbial organisms such as bacteria, viruses and fungi.
2. Toxins from microbial organisms.
3. Materials from transplanted organs or incompatible blood cells.
4. **Allergens** or allergic substances like pollen grains.

Types of Antigen-Presenting Cells

Antigen-presenting cells are of three types:

1. Macrophages
2. Dendritic cells
3. B lymphocytes.

Among these cells, macrophages are the major antigen-presenting cells.

The two categories are:

1. T lymphocytes or T cells, which are responsible for the development of cellular immunity
2. B lymphocytes or B cells, which are responsible for humoral immunity

Types of T Lymphocytes

During the processing, T lymphocytes are transformed into four types:

1. Helper T cells or inducer T cells. These cells are also called **CD4 cells** because of the presence of molecules called CD4 on their surface.
2. Cytotoxic T cells or killer T cells. These cells are also called **CD8 cells** because of the presence of molecules called CD8 on their surface.
3. Suppressor T cells.
4. Memory T cells.

Acquired Immune Deficiency Syndrome (AIDS)

AIDS is an infectious disease caused by immune deficiency virus (HIV). A person is diagnosed with AIDS when the CD4 count is below 200 cells per cubic millimeter of blood.

- The major function of the helper T cells is to *activate cytotoxic T cells and B cells*.
- The cytotoxic T cells destroy pathogens by phagocytosis

ROLE OF CYTOTOXIC T CELLS Cytotoxic T cells that are activated by helper T cells, circulate through blood, lymph and lymphatic tissues and destroy the invading organisms by attacking them directly. cytotoxic substances like the lysosomal enzymes

Cytotoxic T cells also destroy cancer cells, transplanted cells, such as those of transplanted heart or kidney or any other cells

Cytotoxic T cells destroy even body's own tissues which are affected by the foreign bodies, particularly the viruses. Many viruses are entrapped in the membrane of affected cells. The antigen of the viruses attracts the T cells. And the cytotoxic T cells kill the affected cells also along with viruses. Because of this, the cytotoxic T cell is called killer cell.

ROLE OF SUPPRESSOR T CELLS Suppressor T cells are also called regulatory T cells. These T cells suppress the activities of the killer T cells. Thus, the suppressor T cells play an important role in *preventing the killer T cells from destroying the body's own tis*sues along with invaded organisms. Suppressor cells *suppress the activities of helper T cells also.*

ROLE OF MEMORY T CELLS Some of the T cells activated by an antigen do not enter the circulation but remain in lymphoid tissue. These T cells are called memory T cells. In later periods, the memory cells migrate to various lymphoid tissues throughout the body. *When the body is exposed to the same organism for the second time*, the memory cells identify the organism and immediately activate the other T cells. So, the invading organism is destroyed very quickly. The response of the T cells is also more powerful this time..

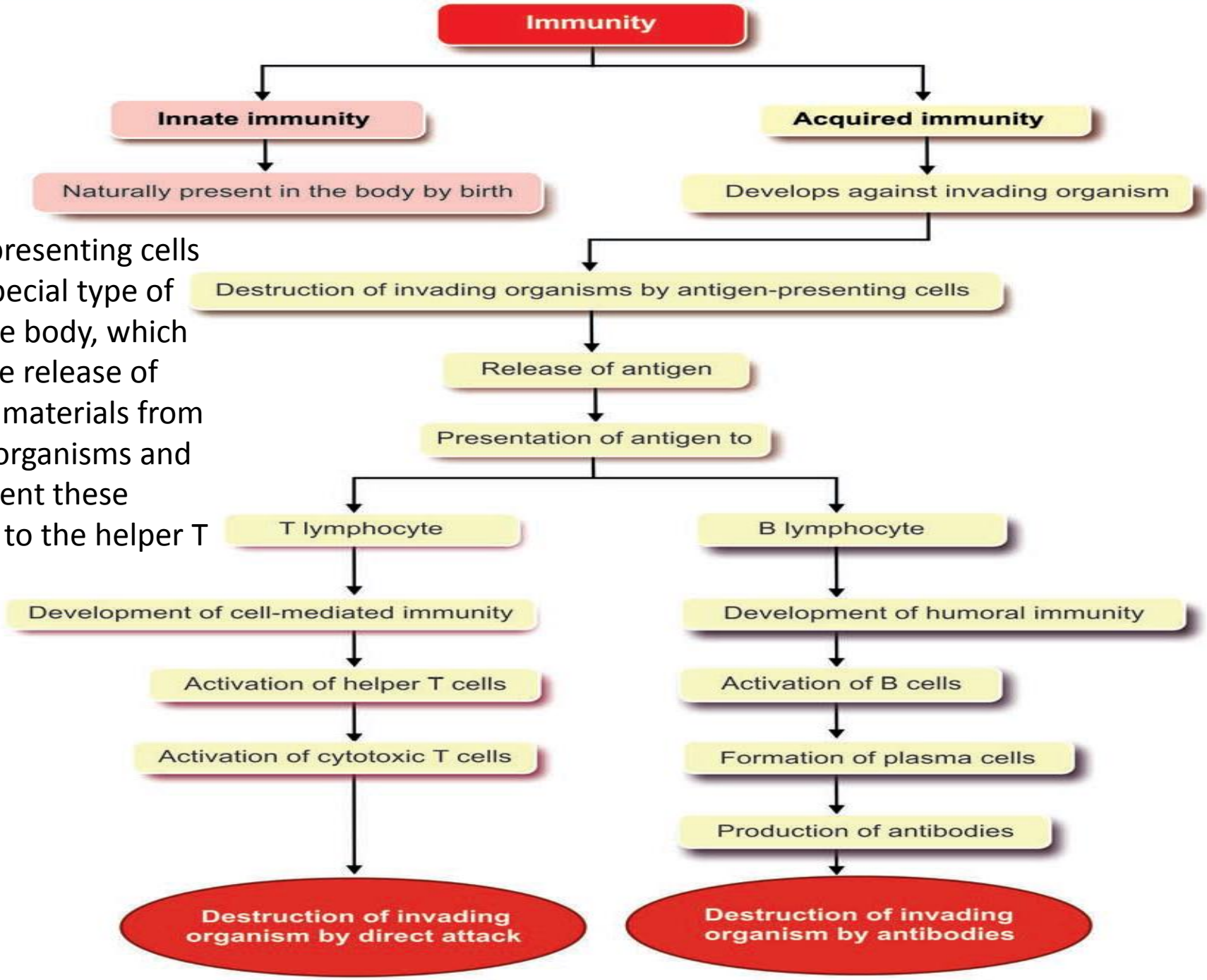
■ INTRODUCTION

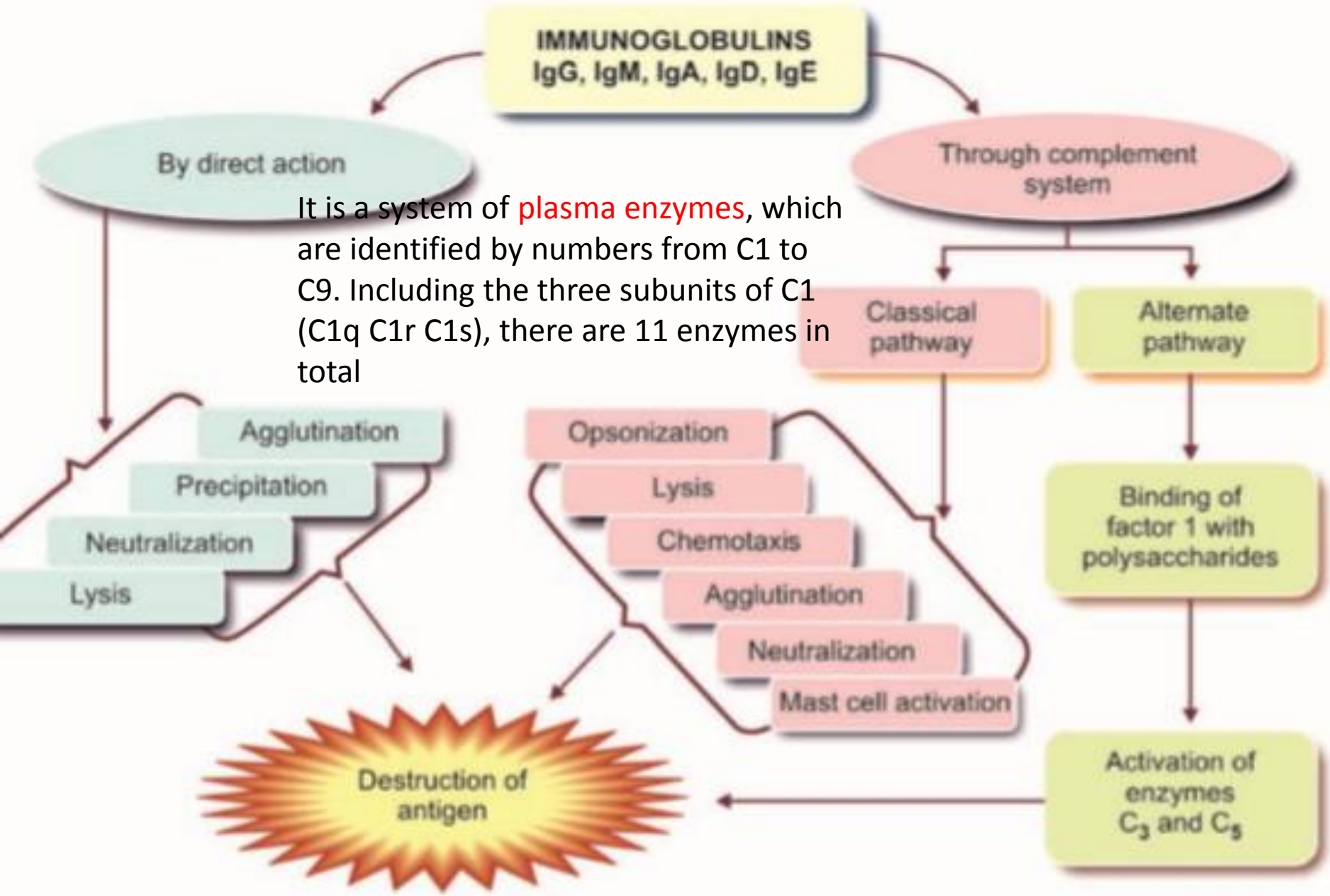
Humoral immunity is defined as the immunity mediated by antibodies, which are secreted by B lymphocytes. B lymphocytes secrete the antibodies into the blood and lymph. The blood and lymph are the body fluids (**humours** or **humors** in Latin). Since the B lymphocytes provide immunity through humors, this type of immunity is called humoral immunity or B cell immunity.

Antibodies are the gamma globulins produced by B lymphocytes. These antibodies fight against the invading organisms. The humoral immunity is the major defense mechanism against the bacterial infection.

As in the case of cell-mediated immunity, the macrophages and other antigen-presenting cells play an important role in the development of humoral immunity also.

Antigen-presenting cells are the special type of cells in the body, which induce the release of antigenic materials from invading organisms and later present these materials to the helper T cells





It is a system of plasma enzymes, which are identified by numbers from C1 to C9. Including the three subunits of C1 (C1q C1r C1s), there are 11 enzymes in total

FIGURE 17.4: Mechanism of action of immunoglobulins

TABLE 17.2: Cytokines

Interleukins	1. T cells 2. B cells 3. Eosinophils 4. Basophils 5. Monocytes 6. Mast cells 7. Macrophages 8. NK cells	1. Activation of T cells, macrophages and natural killer (NK) cells 2. Promotion of growth of hemopoietic cells and B cells 3. Acceleration of inflammatory response by activating eosinophils 4. Chemotaxis of neutrophils, eosinophils, basophils and T cells 5. Destruction of invading organisms
Interferons	1. WBCs 2. NK cells 3. Fibroblasts	1. Fighting against viral infection by suppressing virus multiplication in target cells 2. Inhibition of multiplication of parasites and cancer cells 3. Promotion of phagocytosis by monocytes and macrophages 4. Activation of NK cells
Tumor necrosis factors	1. T cells 2. B cells 3. Mast cells 4. Macrophages 5. NK cells 6. Platelets	1. Causing necrosis of tumor 2. Activation of general immune system 3. Production of vascular effects 4. Promotion of inflammation
Chemokines	1. T cells 2. B cells 3. Monocytes 4. Macrophages	Attraction of WBCs by chemotaxis
Defensins	1. Neutrophils 2. Macrophages 3. Paneth cells in small intestine 4. Airway epithelial cells 5. Salivary glands 6. Cutaneous cells	1. Role in innate immunity in airway surface and lungs 2. Killing the phagocytozed bacteria 3. Antiinflammatory actions 4. Promotion of wound healing 5. Attraction of monocytes and T cells by chemotaxis
Cathelicidins	1. Neutrophils 2. Macrophages 3. Airway epithelial cells 4. Macrophages	Antimicrobial activity in air passage and lungs
Platelet-activating factor	1. Neutrophils 2. Monocytes	Acceleration of agglutination and aggregation of platelets

Immunoglobulins

Acute ←	IgM	Largest in Size	First Ab. detected after Infection	
Chronic ←	IgG	Largest in No.	75%	Pass the Placenta
	IgA	Breast Milk + Mucus + Blood		
Hypersensitivity or ALLERGIC Response ←	IgE			
	IgD	Differentiation of B-Lymphocytes		

■ IMMUNE DEFICIENCY DISEASES

Immune deficiency diseases are a group of diseases in which some components of immune system is missing or defective. Normally, the defense mechanism protects the body from invading pathogenic organism. When the defense mechanism fails or becomes faulty (defective), the organisms of even low virulence produce severe disease. The organisms, which take advantage of defective defense mechanism, are called opportunists.

Acquired Immune Deficiency Syndrome (AIDS)

AIDS is an infectious disease caused by immune deficiency virus (HIV). A person is diagnosed with AIDS when the CD4 count is below 200 cells per cubic millimeter of blood.

AUTOIMMUNE DISEASES

Autoimmune disease is defined as a condition in which the immune system mistakenly attacks body's own cells and tissues. Normally, an antigen induces the immune response in the body. The condition in which the immune system fails to give response to an antigen is called tolerance. This is true with respect to body's own antigens that are called self antigens or autoantigens. Normally, body has the **tolerance** against self antigen. However, in some occasions, the tolerance fails or becomes incomplete against self antigen. This state is called autoimmunity and it leads to the activation of T lymphocytes or production of autoantibodies from B lymphocytes. The T lymphocytes (cytotoxic T cells) or autoantibodies attack the body's normal cells whose surface contains the self antigen or autoantigen.

COMMON AUTOIMMUNE DISEASES

Common autoimmune diseases are:

1. Insulin-dependent diabetes mellitus — islet cell autoantibody against β-cells in the islets of Langerhans in pancreas. Activation of T cells against islets
2. Myasthenia gravis — autoantibodies against the receptors acetylcholine in neuromuscular junction
3. Hashimoto thyroiditis — autoantibodies impair the activity of thyroid follicles leading to hypothyroidism
4. Rheumatoid arthritis. Rheumatiod arthritis is the disease due to chronic inflammation of synovial lining of joints (synovitis). The synovium becomes thick, leading to the development of swelling around joint and tendons. The characteristic symp toms are pain and stiffness of joints. The chronic inflamma tion occurs due to the continuous production of autoantibodies called rheumatoid arthritis factors (RA factors).

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Autoimmunity

Autoimmune disease is defined as a condition in which the immune system mistakenly attacks body's own cells and tissues.

- DM type I
- Myasthenia Gravis
- Graves disease

Immune deficiency disease

AIDS

AIDS is an infectious disease caused by immune deficiency virus (HIV).

A person is diagnosed with

AIDS is the most advanced stage of HIV infection.

- HIV destroys CD4 cells, making it harder for the body to fight infections.
- AIDS when the CD4 count is below 200 cells per cubic millimeter of blood.
- HIV transmission Blood
- Elisa, PCR
- ART

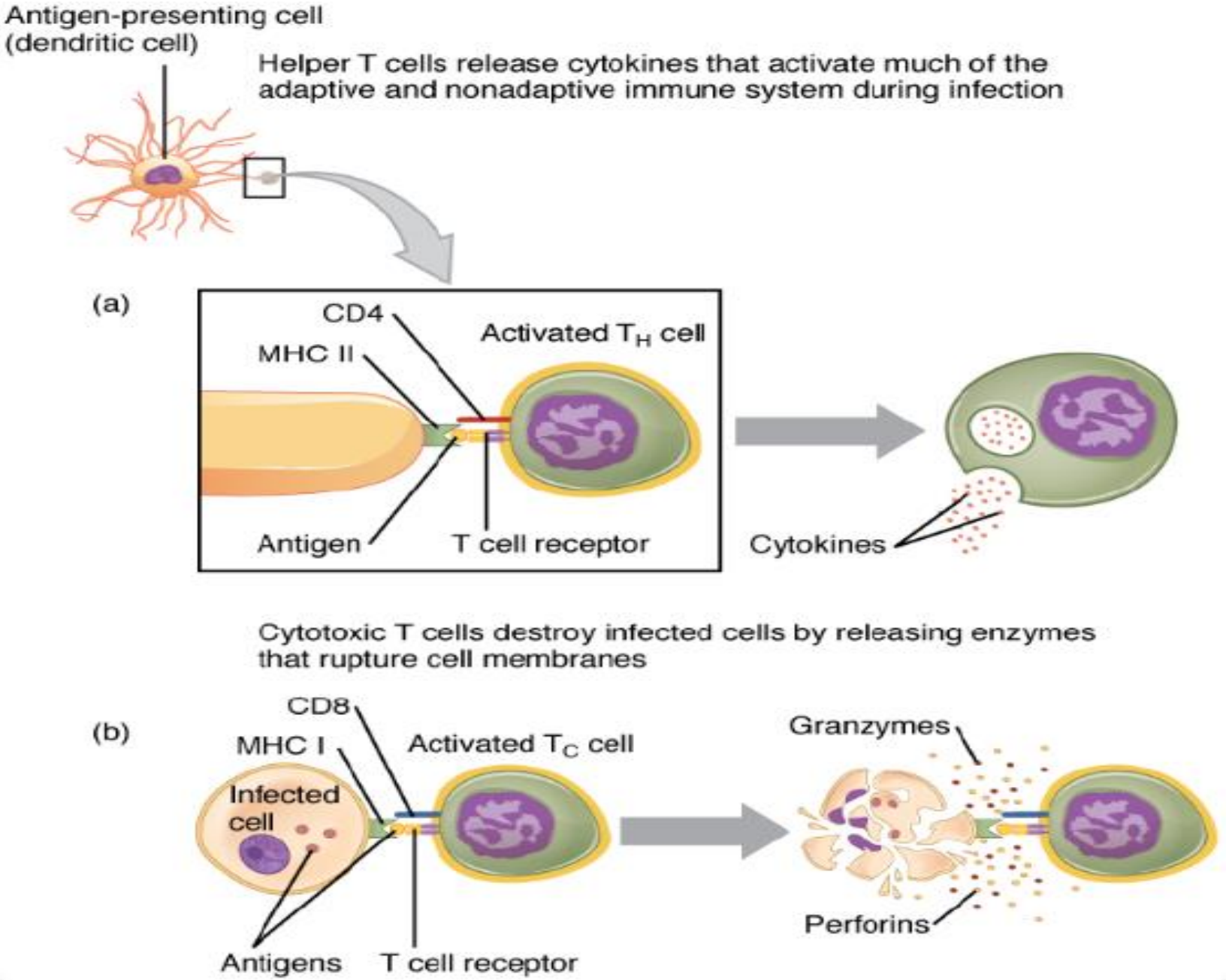

Figure 1: Helper T Cells and Cytotoxic T Cells in Action

Similarities Between T Cells and B Cells

- Both T cells and B cells originate from the bone marrow.
- Both T cells and B cells are the two types of lymphocytes.
- Since both T cells and B cells are subtypes of white blood cells, both cells occur in the blood.
- Both T cells and B cells also occur in the lymphatic system.
- Both T cells and B cells are involved in the adaptive immunity.
- Both T cells and B cells can recognize the various pathogenic antigens.

Origin
T Cells: T cells originate in the bone marrow and mature in the thymus.
B Cells: B cells originate and mature in the bone marrow

Secretion
T Cells: The T cells secrete lymphokines.
B Cells: The B cells secrete antibodies

T Cells: The 80% of the blood lymphocytes are
T cells.
B Cells: The 20% of the blood lymphocytes are
B cel

T Cells: The T cells move to the site of infection.
B Cells: The B cells do not move to the site of infection

T Cells: The T cells act against tumor cells and transplants.
B Cells: The B cells do not act against tumor cells or transplants

T Cells: The suppressor T cells have an inhibitory effect on the immune system.
B Cells: The B cells do not have any inhibitory effect on the immune system