Basic Concepts in Immunology

Immunology is a branch of biology that covers the study of immune systems in all organisms. The immune system protects us from infection through various lines of defence. If the immune system is not functioning as it should, it can result in disease It was the Russian biologist Ilya Ilyich Mechnikov who boosted studies on immunology, and received the Nobel Prize in 1908 for his work.

Types of Immunity

The immune system

Immune system

Innate (non-specific) immunity

- Anatomic barriers (Skin, mucous membranes)
- Physological barriers (temperature, pH)
- Phagocytic Barriers (cells that eat invaders)
- Inflammatory barriers (redness, swelling, heat and pain)

Adaptive (specific) immunity

- Antigen specificity
- Diversity
- Immunological memory
- Self/nonself recognition

Innate or Natural or Nonspecific Immunity

- Innate immunity is inherited by the organism from the parents and protects it from birth throughout life. For example humans have innate immunity against distemper, a fatal disease of dogs.
- As its name nonspecific suggests that it lacks specific responses to specific invaders. Innate immunity or nonspecific immunity is well done by providing different barriers to the entry of the foreign agents into our body.

Innate immunity consists of **four** types of barriers—

1. Anatomic barriers
2. Physiological barriers
3. Phagocytic/endocytic/cellular barriers
4. Inflammatory barriers

Anatomic barriers

They are mechanical barriers to many microbial pathogens. These are of two types. Skin and mucous membrane.

(a) Skin:

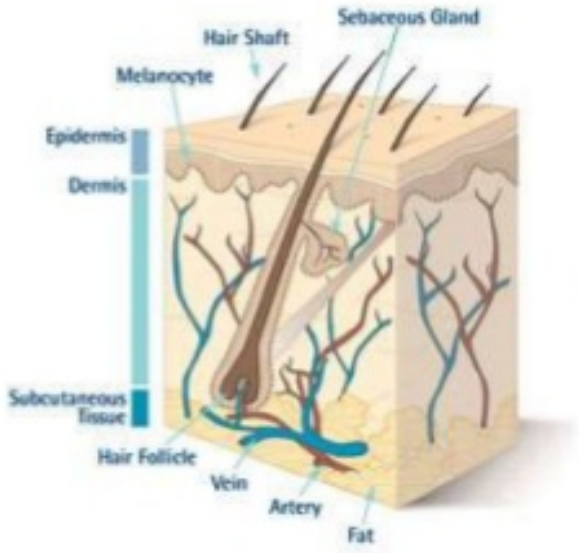
The skin is physical barrier of body. Its outer tough layer, the stratumcorneum prevents the entry of bacteria and viruses.

(b) Mucous Membranes:

Mucus secreted by mucous membrane traps the microor-ganisms and immobilises them. Microorganisms and dust particles can enter the respiratory tract with air during breathing which are trapped in the mucus. The cilia sweep the mucus loaded with microorganisms and dust particles into the pharynx (throat). From the pharynx it is thrown out or swallowed for elimination with the faeces.

Innate Immunity

Anatomical Barrier



- Skin
  - Epidermis acts as mechanical barrier and retards entry of microorganisms
  - Acidic environment (pH 3- 5) retards growth of microorganisms
- Mucous membrane
  - Normal microbial flora compete with pathogenic microorganisms for attachment and nutrients
  - Mucus entraps foreign microorganisms
  - Cilia of surface epithelium propel microbes out of the body

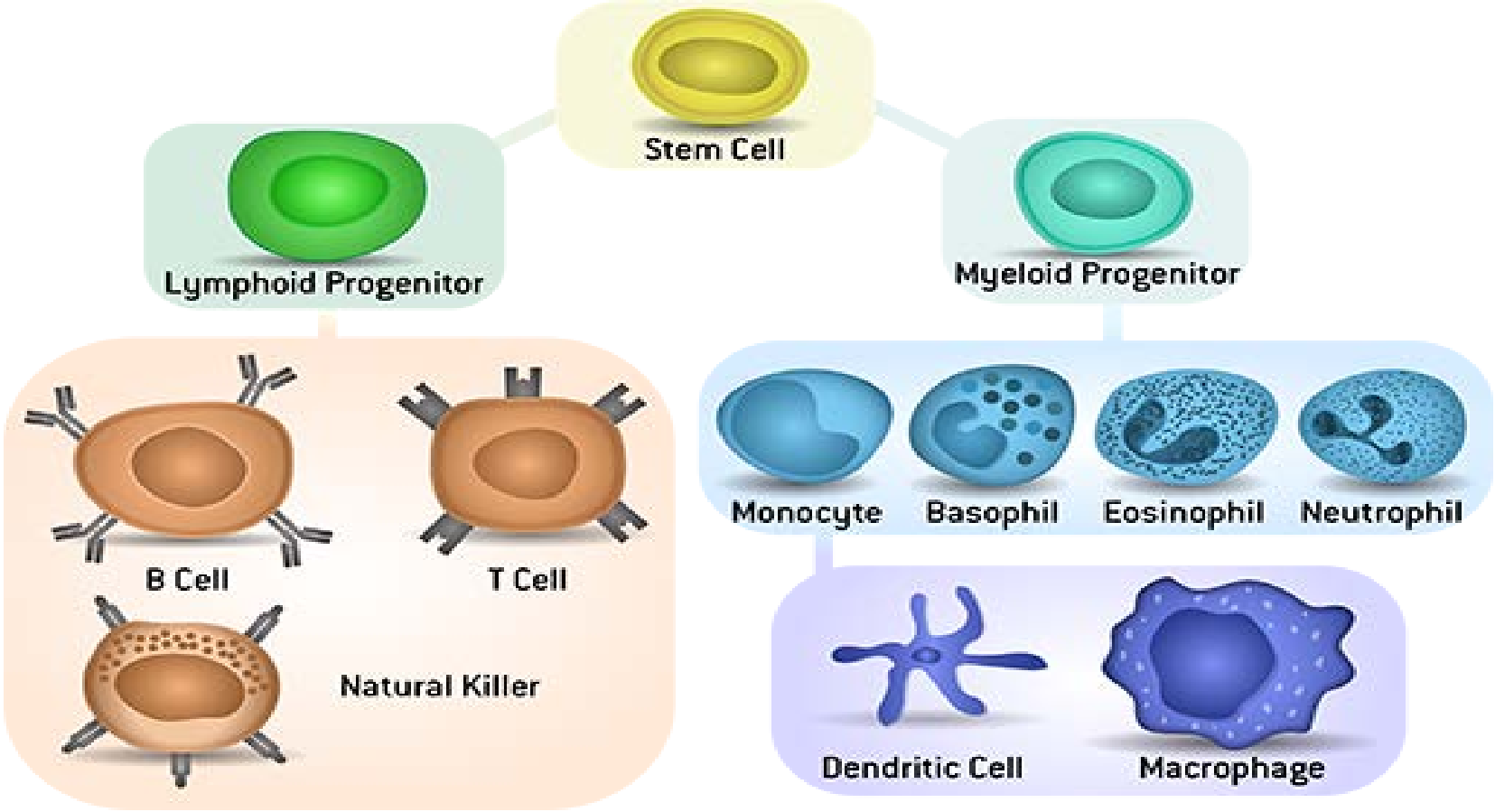
Physiological barriers

These include

- **Body temperature**- For example, body temperature i.e., fever, prevents the growth of pathogens.
- **pH** and other body secretions that prevent growth of any microorganisms entering into the body. Acidic atmosphere in the stomach do the same.
- **Lysozymes**, which is present in tears digest bacterial cell wall and kill them.
- **Interferons** - when viruses attack the body tissues, interferons present in cells protect the body tissues.
- **Complement** lysis of microorganisms.
- **Toll-like receptors**- secrete immunostimulatory cytokines.
- **Collectins** - disrupt cell wall of pathogen.

Phagocytic barriers

Phagocytes are cells that protect the body by ingesting (phagocytosing) harmful foreign particles, bacteria, and dead or dying cells.

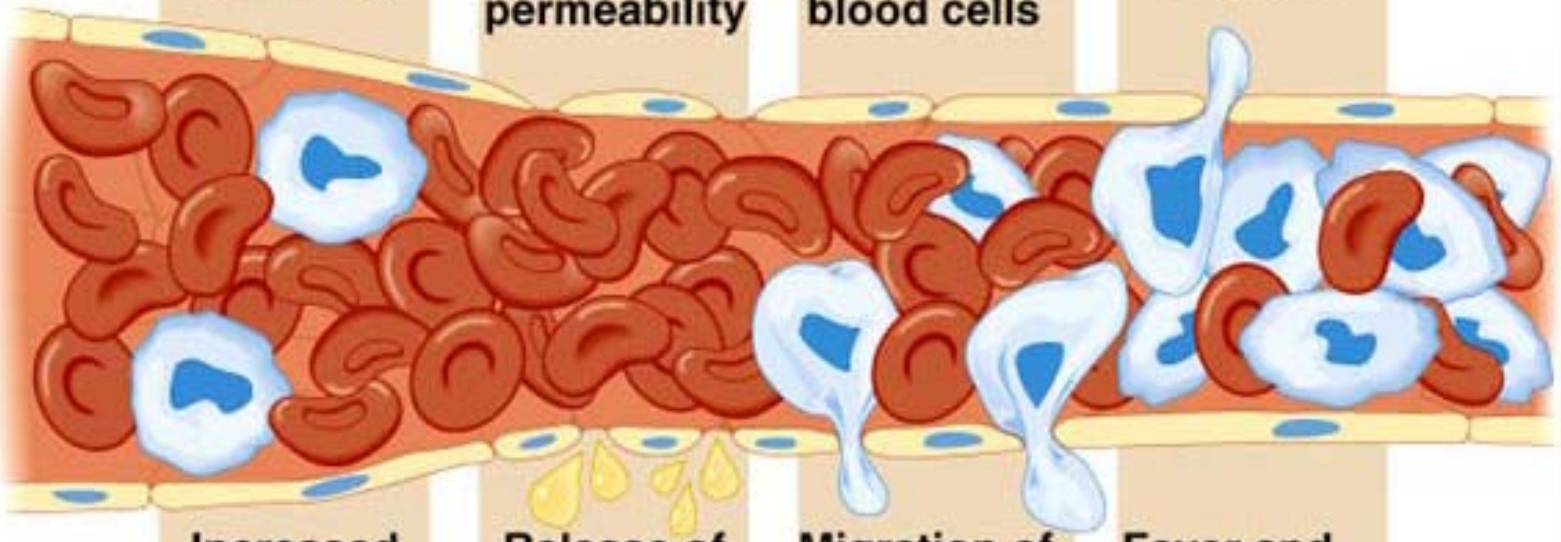


Inflammatory barriers

A localized physical condition in which part of the body becomes reddened, swollen, hot, and often painful, especially as a reaction to injury or infection.

Inflammation

Tissue injury caused by physical or chemical agent or pathogenic microorganism



Capillary widening	Increased capillary permeability	Attraction of white blood cells	Systemic response
Increased blood flow	Release of fluid	Migration of white blood cells to injury	Fever and proliferation of white blood cells

Heat Redness Tenderness Swelling Pain

Adaptive Immunity

Adaptive immunity refers to antigen-specific **immune** response. The **adaptive immune** response is more complex than the innate. The antigen first must be processed and recognized. Once an antigen has been recognized, the **adaptive immune** system creates an army of **immune** cells specifically designed to attack that antigen.

Characterstic attributes of adaptive immunity

1. Antigenic specificity
2. Diversity
3. Immunologic memory
4. Self/nonself recognition

Cells of Adaptive immunity

- B lymphocytes (B cells)
- T lymphocytes (T cells) and antigen-presenting cells

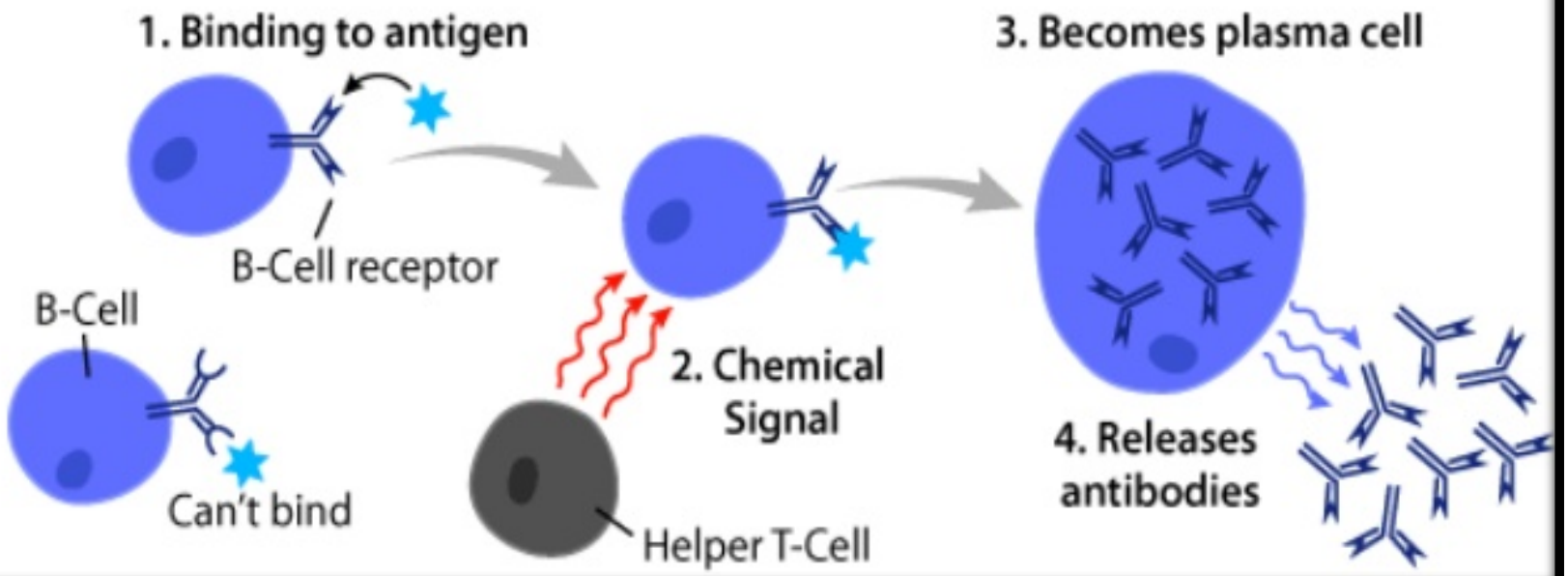
B-lymphocytes

B Cells are the major cells involved in the creation of antibodies that circulate in blood plasma and lymph, known as Humoral Immunity. B lymphocytes produced and mature within the bone marrow. Antibodies (also known as immunoglobulin, Ig) are large Y-shaped proteins used by the immune system to identify and neutralize foreign objects.

B-Lymphocytes

Derived its name from its site of maturation in the Bursa of fabricius in birds and Bone marrow in humans

- Plasma cells (Ab producing)
- Memory cells



T lymphocytes

A **T cell**, or **T** lymphocyte, is a type of lymphocyte (a subtype of white blood **cell**) that plays a central role in **cell**-mediated immunity. **T cells** can be distinguished from other lymphocytes, such as B **cells** and natural killer **cells**, by the presence of a **T**-**cell** receptor on the **cell** surface. T lymphocytes also arise in the bone marrow but mature in the thymus gland.

- T cell express a unique antigen-binding molecule called T-cell receptor (TCR) on its membrane which cannot recognize antigen alone.
- TCR can recognize only antigen that is bound to cell-membrane proteins called Major Histo-compatability Complex (MHC) molecules.
- There are 2 major types of MHC molecules:

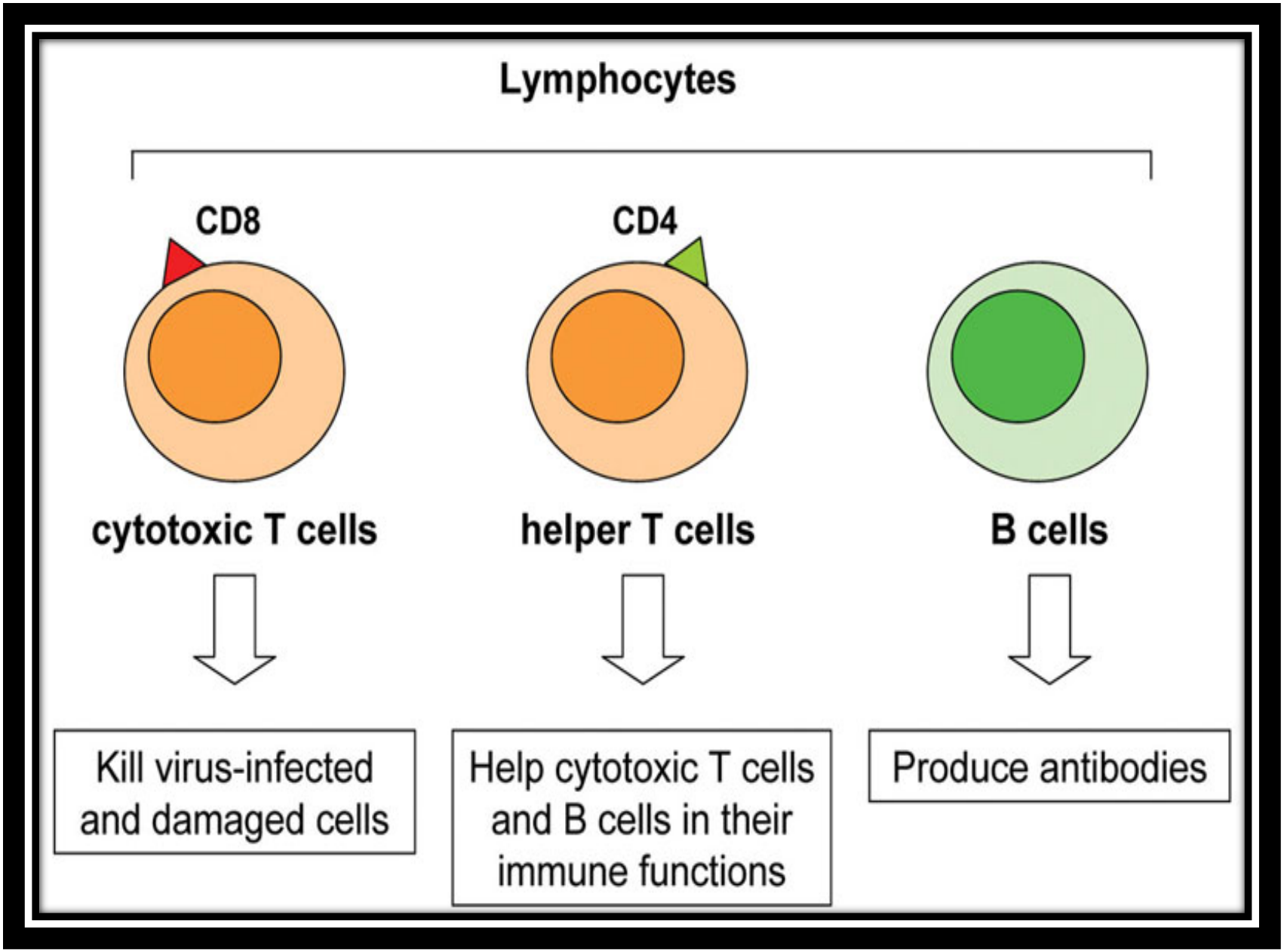
1. Class I MHC molecules- expressed by all nucleated cells.
2. Class II MHC molecules-expressed by only antigen presenting cells(APC) which may be macrophages, B lymphocytes and dendritic cells.

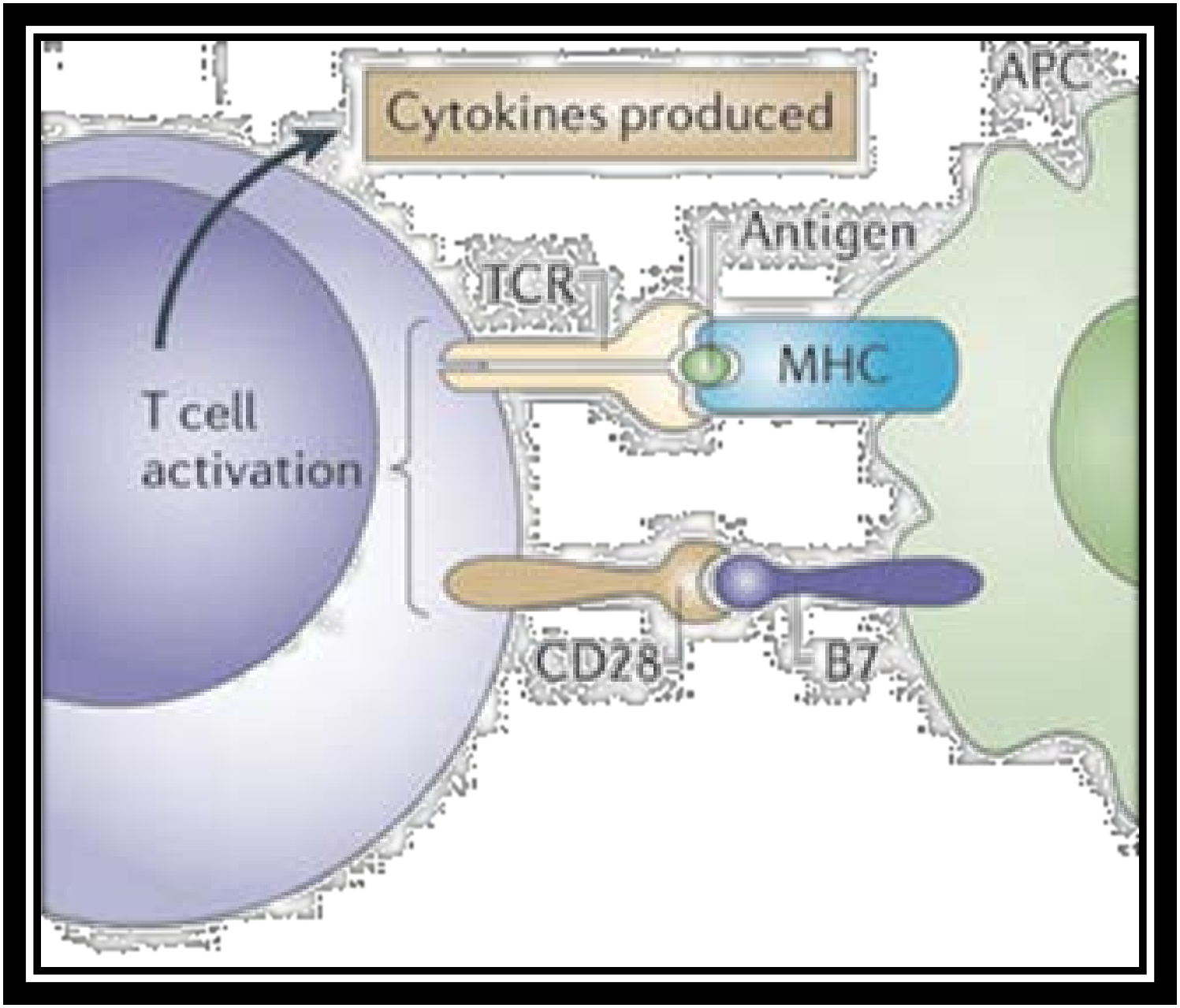
Types of T cells

- **Helper T cells** become activated when they are presented with peptide antigens by MHC class II molecules, which are expressed on the surface of antigen-presenting cells (APCs). Once activated, they divide rapidly and secrete small proteins called cytokines that regulate or assist in the active immune response.
- **Cytotoxic (killer)-** Cytotoxic T cells (T_C cells, CTLs, T-killer cells, killer T cells) destroy virus-infected cells and tumor cells, and are also implicated in transplantrejection. These cells are also known as **$CD8^+$ T cells** since they express the CD8 glycoprotein at their surfaces. These cells recognize their targets by binding to antigen associated with MHC class I molecules, which are present on the surface of all nucleated cells.

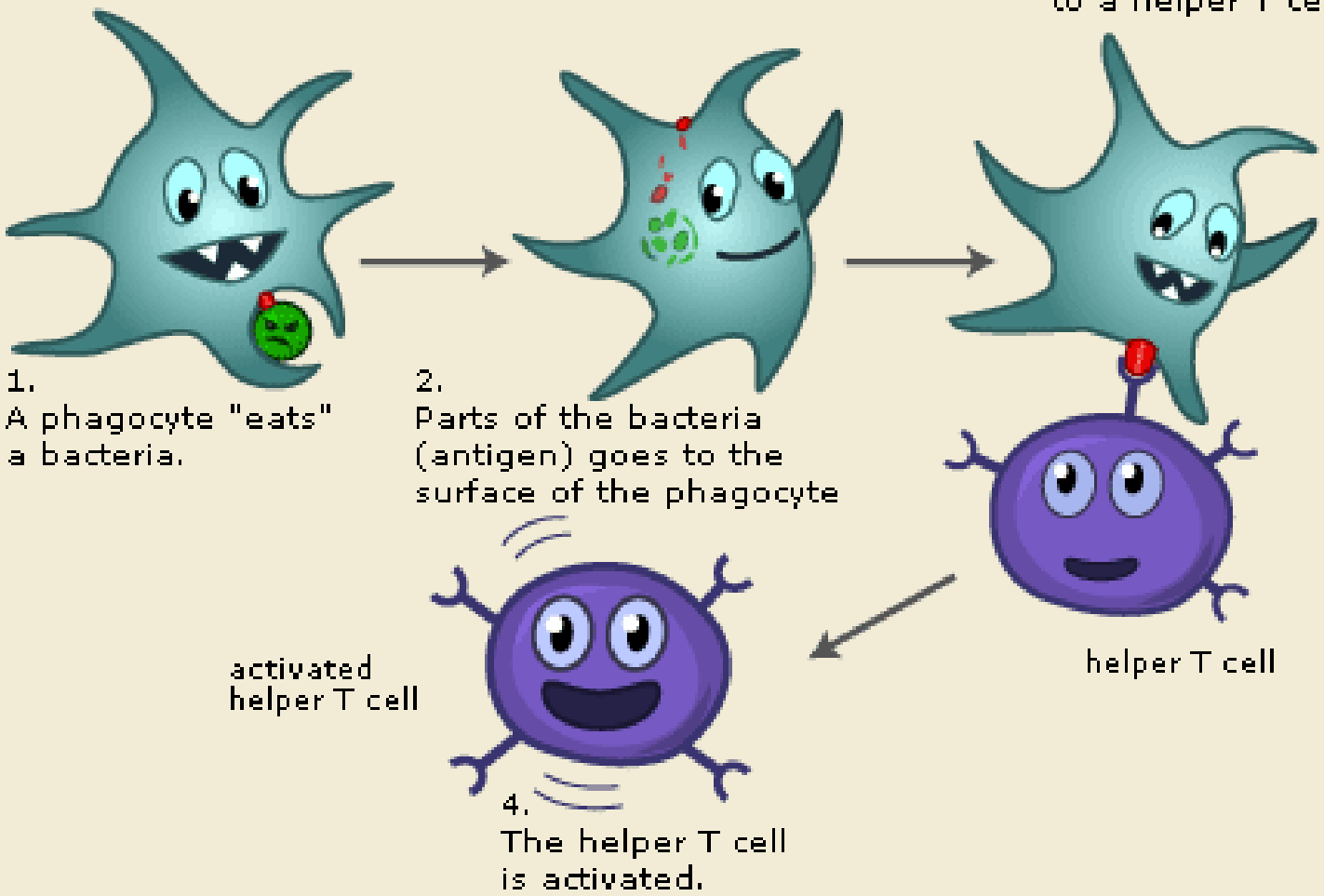
TYPES OF T-CELLS

- → T helper cells / T_H cells / $CD4^+$ T cells.
- → Cytotoxic T Cells / T_c cells / CLT / $CD8^+$ T cells.
- → Memory T cells.
- → Regulatory T cells / T_{reg} cells also formerly known as Suppressor T cells.
- → Natural Killer T cells / NKT cells.
- → $\gamma\delta$ T cells / gamma delta T cells.


Lymphocytes
CD8
CD4
cytotoxic T cells
helper T cells
B cells
Kill virus-infected and damaged cells
Help cytotoxic T cells and B cells in their immune functions
Produce antibodies


Cytokines produced
APC
Antigen
TCR
MHC
T cell
activation
CD28
B7

Antigen Presentation

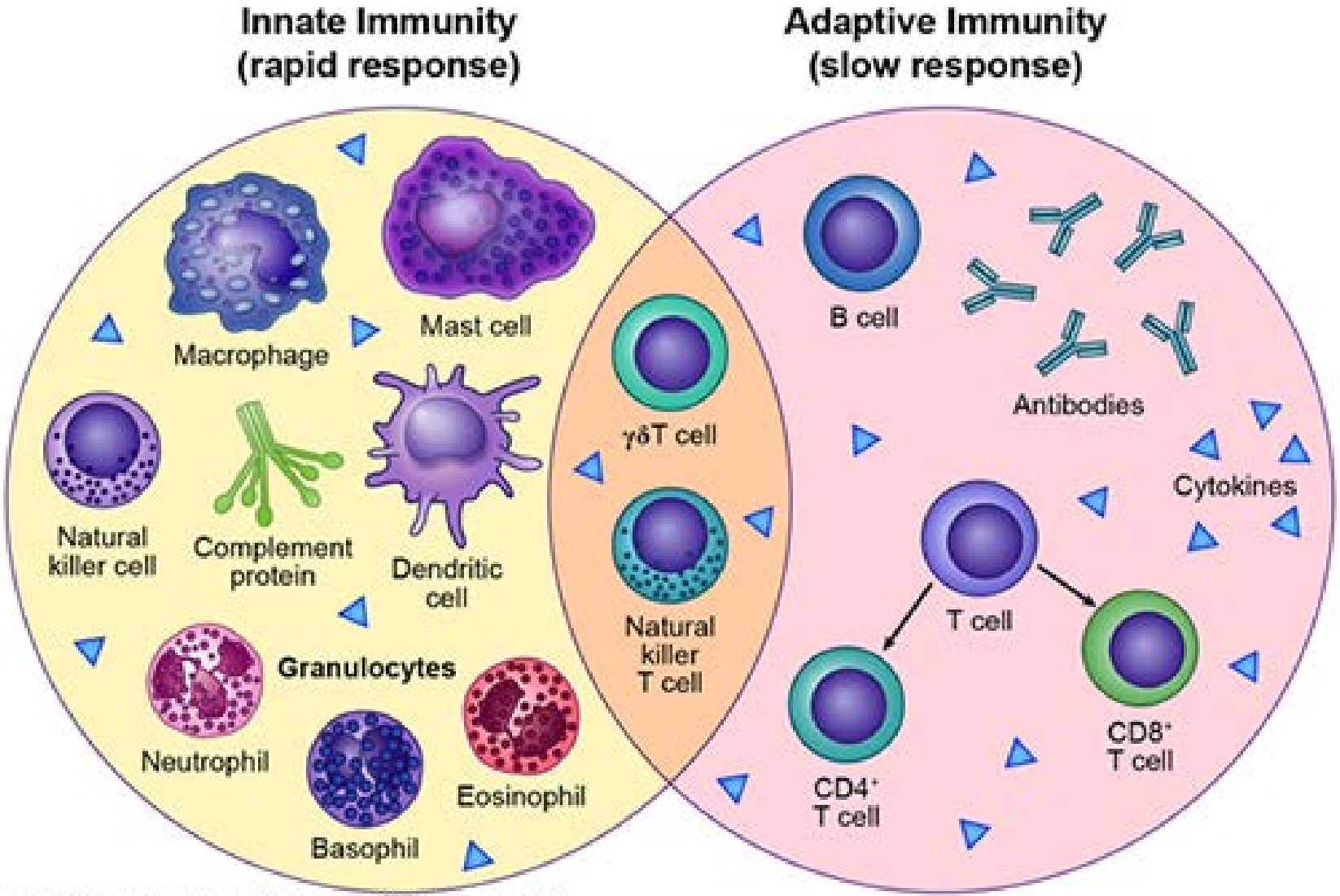


Comparison

Table 15.4 | Comparison of B and T Lymphocytes

Characteristic	B Lymphocytes	T Lymphocytes
Site where processed	Bone marrow	Thymus
Type of immunity	Humoral (secretes antibodies)	Cell-mediated
Subpopulations	Memory cells and plasma cells	Cytotoxic (killer) T cells, helper cells, suppresso
Presence of surface antibodies	Yes—IgM or IgD	Not detectable
Receptors for antigens	Present—are surface antibodies	Present—are related to immunoglobulins
Life span	Short	Long
Tissue distribution	High in spleen, low in blood	High in blood and lymph
Percentage of blood lymphocytes	10%–15%	75%–80%
Transformed by antigens into	Plasma cells	Activated lymphocytes
Secretory product	Antibodies	Lymphokines
Immunity to viral infections	Enteroviruses, poliomyelitis	Most others
Immunity to bacterial infections	*Streptococcus, Staphylococcus,* many others	Tuberculosis, leprosy
Immunity to fungal infections	None known	Many
Immunity to parasitic infections	Trypanosomiasis, maybe to malaria	Most others

Innate vs Adaptive Immune Players



Dranoff G. *Nat Rev Cancer*. 2004;4:11-22.

Active Vs Passive immunity

Comparison of Active & Passive Immunity

Active immunity	Passive immunity
Produced actively by host's immune system	Received passively, no active host participation
Induced by infection or by immunogen	Readymade antibody transferred
Durable effective protection	Transient, less effective
Immunity effective only after long period	Immediate immunity
Immunological memory present	No memory
Booster effective	Not effective
Not applicable in the immunodeficient	Applicable in the immunodeficient