Overview of adaptive immune mechanisms.

Learning objectives:

- **Types of adaptive immunity**
- **Humoral immunity**
- **Cell mediated immunity**
- **Properties of Acquired immunity**
- **Limitations of adaptive immunity**

Adaptive (acquired) immunity.

- Refers to **antigen-specific defense mechanisms** that take several days to become protective and are **designed to remove a specific antigen**.
- This is the immunity one develops throughout life.

Some terminologies encountered in adaptive immunity.

- An **antigen** is defined as a substance that reacts with antibody molecules and antigen receptors on lymphocytes.
- An **immunogen** is an antigen that is recognized by the body as **non self** and stimulates an adaptive immune response.
- For simplicity, we will use the term antigen when referring to both antigens and immunogens.
- The actual portions or fragments of an antigen that react with antibodies and lymphocyte receptors are called **epitopes**

- The body recognizes an antigen as foreign **when epitopes of that antigen bind to B-lymphocytes by means of epitope-specific receptor** molecules having a shape complementary to that of the epitope.

- The epitope receptor on the surface of a B-lymphocyte is called a B-cell receptor (BCR) and is actually an antibody molecule called **surface immunoglobulin** (sIg)

- The receptor on a T lymphocyte is called a **T-cell receptor (TCR)**.

- It is thought that the human body has the genetic ability to recognize 10^7- 10^9 different epitopes.

- In other words, the body has 10^7-10^9 distinct clones of both B-lymphocytes and T-lymphocytes, each with a unique B-cell receptor or T-cell receptor.

Note.

- The downside to the specificity of adaptive immunity is that **only a few B-cells and T-cells in the body recognize any one epitope**.
- These few cells then must rapidly proliferate in order to produce enough cells to mount an effective immune response against that particular epitope, and that typically takes several days.
- During this time the pathogen could be causing considerable harm, and that is why innate immunity is also essential.

The main features of the adaptive immune system are:

- **Clonal selection** and expression of cells expressing clonally distributed Ag-specific receptors.
- **Challenge memory**: responses to previously encountered Ags are more fast and vigorous on subsequent exposures.
- **Adaptive immunity usually improves upon repeated exposure to a given infection and involves:**

a) antigen-presenting cells (APCs) such as macrophages and dendritic cells;

b) the activation and proliferation of antigen-specific B-lymphocytes;

c) the activation and proliferation of antigen-specific T-lymphocytes; and

d) the production of antibody molecules, cytotoxic T-lymphocytes (CTLs), activated macrophages and NK cells

Types of Adaptive Immunity.

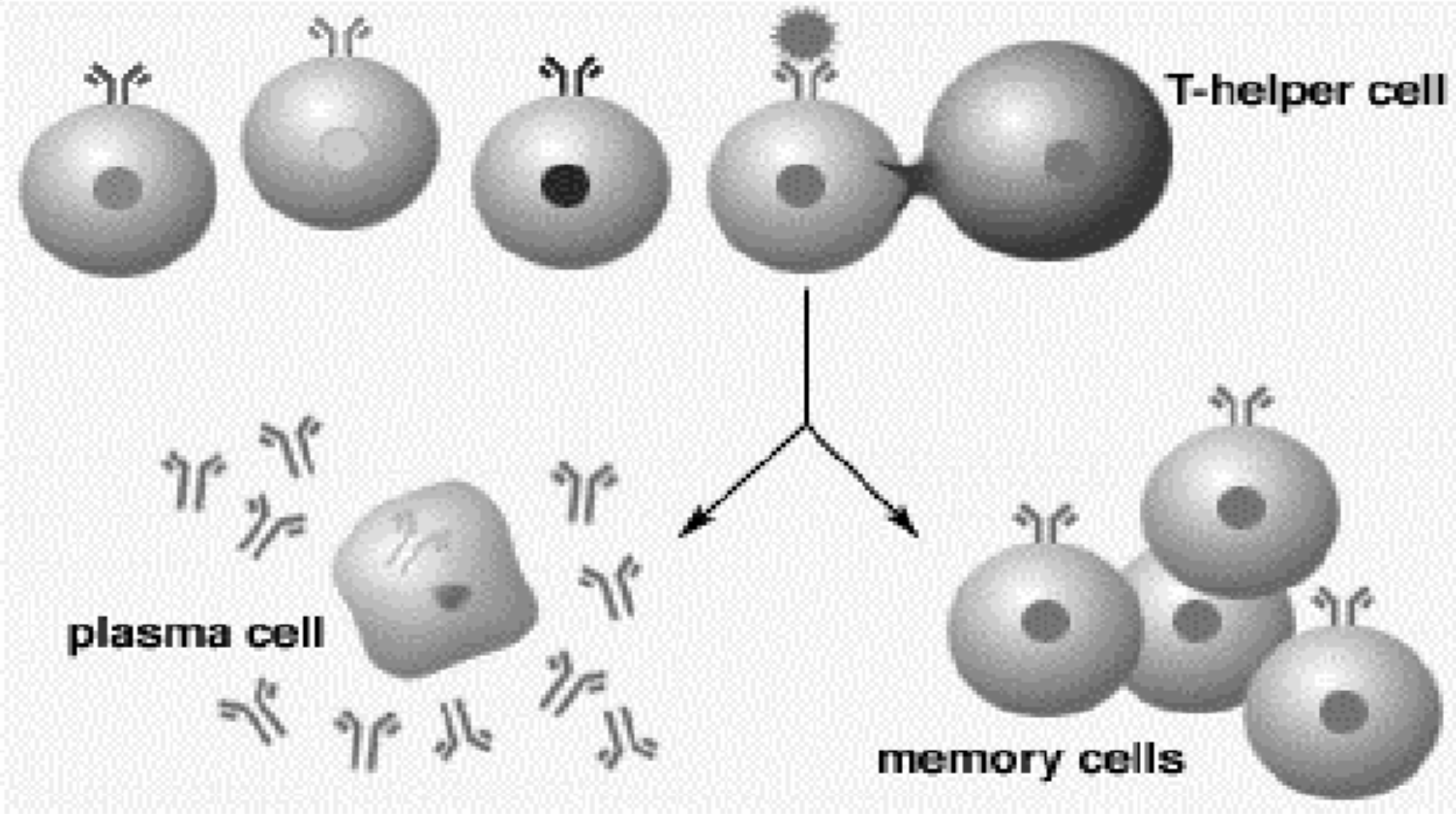
- There are **two major branches** of the adaptive immune responses: humoral and cell-mediated immunity.
- **1. Humoral immunity:** humoral immunity involves the production of antibody molecules in response to an antigen and is mediated by B-lymphocytes
- **2. Cell-mediated immunity:** Cell-mediated immunity involves the production of cytotoxic T-lymphocytes, activated macrophages, activated NK cells, and cytokines in response to an antigen and is mediated by T-lymphocytes.

Humoral Immunity: an Overview

- Humoral Immunity refers to the production of antibody molecules in response to an antigen.
- The antibody molecules circulate in the blood and enter the tissue via inflammation.
- **Humoral immunity is most effective against bacteria, bacterial toxins, and viruses prior to these agents entering cells.**

Humoral system

- B cells are specialized white cells produced in the bone marrow.
- Each B cell contains multiple copies of one kind of antibody as a surface receptor for antigen.
- The entire population of B cells has the ability to specifically bind to millions of different antigens.



Humoral immunity: An overview

- When the ab on the surface of a B cell binds to an ag, the cell can be stimulated to undergo proliferation and differentiation: This process is called clonal selection.

- The cells produced make the same ab, but become memory cells and plasma cells.

- **Memory cells ensure that subsequent infections by the pathogen receive a more rapid response**.

- **Plasma cells secrete large amounts of the antigen-specific antibody**.

- T helper cells, part of the cellular system, are usually required for the clonal selection of B cells.

Cell Mediated Immunity: An Overview.

- Cell-mediated immunity (CMI) is an immune response that does not involve antibodies but rather involves the activation of macrophages and NK-cells, the production of ag-specific CTLs, and the release of various cytokines in response to an ag.

Cellular immunity protects the body by:

- 1. Activating ag-specific cytotoxic T-lymphocytes (CTLs) that are able to lyse body cell displaying epitopes of foreign ag on their surface, such as virus-infected cells, cells with intracellular bacteria, and cancer cells displaying tumor ags

- 2. Activating macrophages and NK cells, **enabling them to destroy intracellular pathogens** ; and

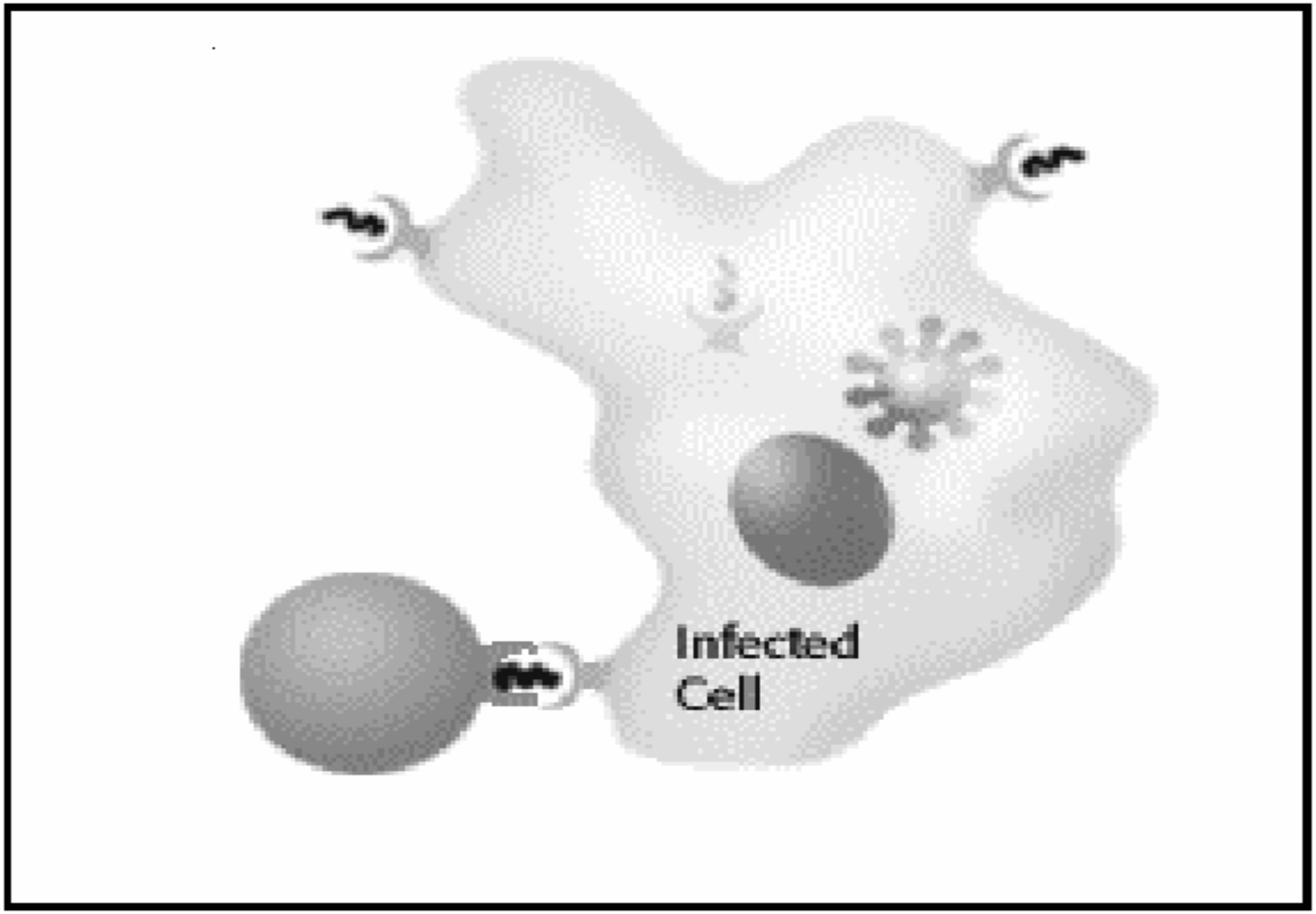
- 3. Stimulating cells to secrete a variety of cytokines that influence the function of other cells involved in adaptive immune responses and innate immune responses.

NB.

- Cell mediated immunity is directed primarily on microbes that survive in phagocytes and microbes that infect non-phagocytic cells.
- It is most effective in removing virus-infected cells, but also participates in defending against fungi, protozoans, cancers, and intracellular bacteria.
- It also plays a major role in transplant rejection

Cellular System.

- Some pathogens can escape ab detection by infecting cells.
- Cells containing pathogen display ag fragments on their cell surfaces.
- Receptors on the surface of CTL (called CD8 cells) can detect the presence of pathogen specific ag fragments and activate a killing response (apoptosis) that leads to the death of the infected cell.



Cell mediated immunity: an overview

Properties of Acquired Immunity.

- This type of immunity occurs in response to infection and is called ADAPTIVE as the immune system must adapt itself to previously encountered molecules

- This form of protection due to previous infection is called IMMUNITY and an individual is said to be IMMUNISED against that organism.

- The induction of immunity by infection or with a vaccine is called ACTIVE IMMUNITY.

- Historically, it has been shown that a non-immune individual can be made immune by transferring serum or lymphocytes from an immune individual- PASSIVE IMMUNITY- serum constituents (Abs) and lymphocytes are involved in immunity

- The immune system responds to micro-organisms but not to its own cells and the system knows that the body has been infected previously with a particular organism.

This implies:

- 1. **Immunological recognition**
- **2. Self/Non-self discrimination**
- **3. Immunological specificity.**
- **4. Immunogical memory.**

An immune response must:

- 1. Recognize a micro-organism as foreign (non-self) as distinct from self (AFFERENT LIMB).
- 2. Respond to a micro-organism by production of specific abs and specific lymphocytes.
- 3. Mediate the elimination of micro-organisms (EFFERENT LIMB).

Limitations of Adaptive Immunity.

- Randomly generated ag receptors are unable to determine the source and the biological context of the ag for which they are specific.
- A clonal distribution of ag receptors requires that specific clones expand and differentiate into effector cells before they can contribute to host defense.
- As a result, primary adaptive immune responses are delayed, typically for 4-7 days.

Quizes.

- 1. State three different ways by which cell-mediated immunity protects the body.

- 2. In terms of infectious disease, state what humoral immunity is most effective against.