

Introduction: Immunology and Types of Immunity



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Introduction

- ❖ **Immunology** is defined as study about structure and functioning of immune system.
- ❖ It also deals with the study of host responses to the introduction of foreign substances into the tissues and the methods by which the body tries to eliminate them and protect itself from further invasion by them.



Introduction

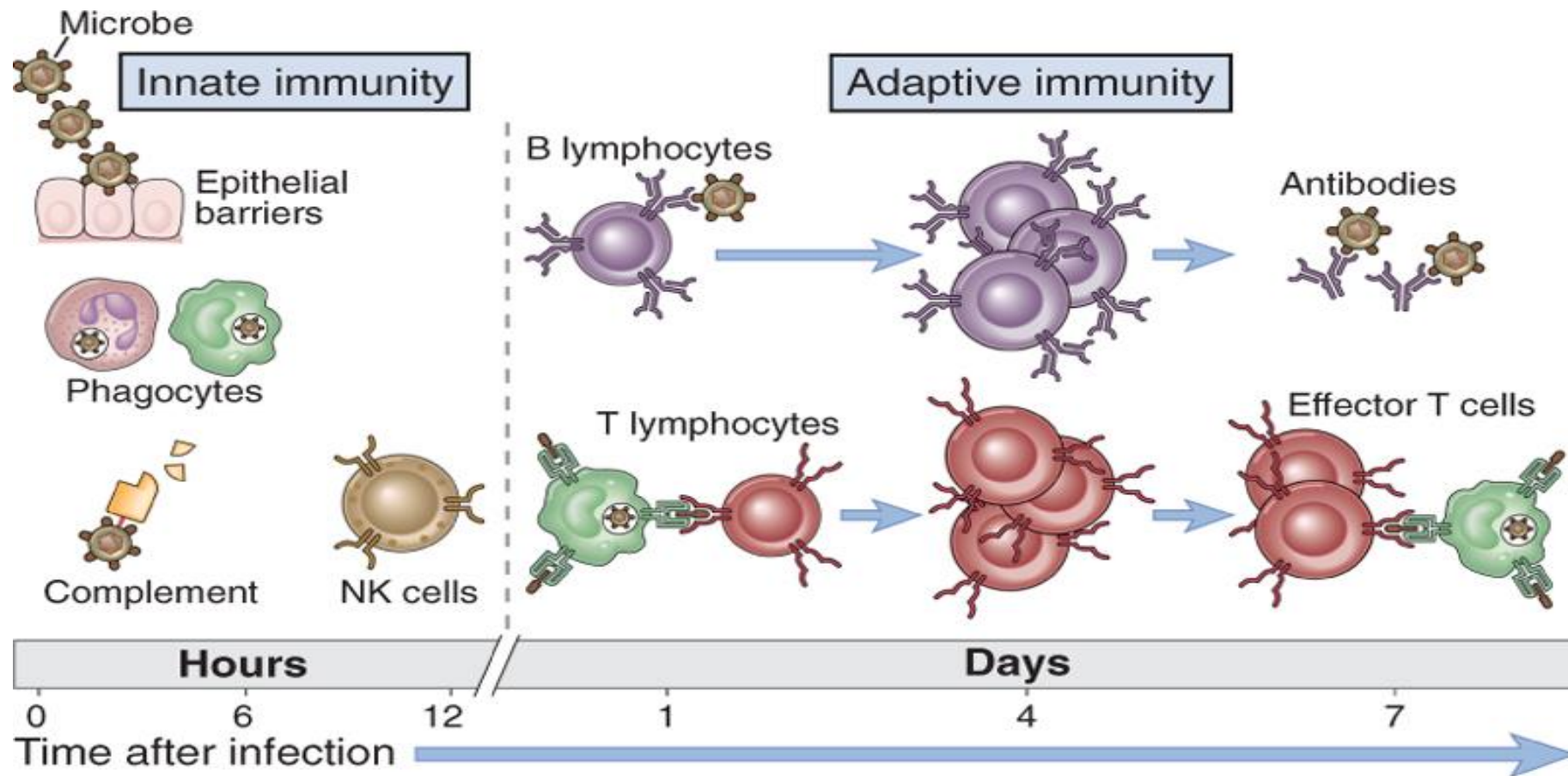
- ❖ The term immunity is derived from the *Latin word immunis / immunitas, meaning “exempt,”* is the source of the English word immunity, *meaning the state of protection from infectious and non infectious disease.*
- ❖ The cells and molecules responsible for immunity constitute the **immune system** and their collective and coordinated response to the introduction of foreign substances is defined **as immune response.**



Types of Immunity

- ❖ The term immunity that otherwise means protection or to protect comprise of two different mechanisms innate (natural or native, Nonspecific immunity, nonspecific resistance) immunity and adaptive (acquired or specific) immunity.
- ❖ Both specific and innate immunities act closely in removal of antigens





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Figure: Innate and adaptive immunity



Innate Immunity

- ❖ **Innate immunity** (also called **natural or native immunity**) consists of cellular and biochemical defense mechanisms that are **in place even before infection** and poised to respond rapidly to infections.
- ❖ These mechanisms react only to microbes and not to non infectious substances, and they respond in essentially the same way to repeated infections



Innate Immunity

❖ The **principal components of innate immunity** are

1. **Physical and chemical barriers**, such as epithelia and antimicrobial substances produced at epithelial surfaces
2. **Phagocytic cells** (neutrophils, macrophages) and NK (natural killer) cells
3. **Blood proteins**, including members of the **complement system** and other mediators of **inflammation**
4. Proteins called **cytokines** that regulate and coordinate many of the activities of the cells of innate immunity.



Innate Immunity

1. Physical barriers

| Physical barrier | Major activity |
|----------------------|---|
| Skin | Prevents penetration of pathogens |
| Body fluids | Prevents entry of pathogens |
| Tears | Contain lysozymes that prevent the entry of pathogens |
| Ciliated epithelium | Acts as a filter against invaded pathogen |
| Mucus | Prevents entry of pathogen |
| Acidic pH of stomach | Kills organisms |



Innate Immunity

2. Phagocytosis

- ❖ Phagocytosis involves the engulfment and destruction of pathogens and particulate matter by specialised cells that fall in two categories Polymorphonuclear (Neutrophils and Eosinophils) and Mononuclear (Macrophages and Monocytes).
- ❖ These phagocytes are also called first line of defence.



Innate Immunity

3. Inflammation

- ❖ The term inflammation that means 'setting on fire' is the **third component of innate immunity** and is initiated when **phagocytosis fails to control the infection**.
- ❖ Inflammation collectively involves a sequence of vascular events, which serve as a defence mechanism.
- ❖ The events are clotting mechanism activation, increased blood flow, increased capillary permeability and increased influx of phagocytic cells.



Adaptive (Specific) Immunity

- ❖ Immune responses that are stimulated by exposure to infectious agents and increase in magnitude and defensive capabilities with each successive exposure to a particular microbe.
- ❖ Because this form of immunity develops as a response to infection and adapts to the infection, it is called **adaptive immunity**.
- ❖ it has an extraordinary capacity to distinguish among different, even closely related, microbes and molecules, and for this reason it is also called **specific immunity**.
- ❖ It is also sometimes called **acquired immunity**



Adaptive (Specific) Immunity

❖ The specific (adaptive) immune system of vertebrates has three major functions:

1. To recognize anything that is foreign to the body (“nonself ”)
2. To respond to this foreign material; and
3. To remember the foreign invader.



Adaptive (Specific) Immunity

❖ Cardinal Features of Adaptive Immune Responses:

| Feature | Functional significance |
|----------------|--|
| 1. Specificity | Ensures that distinct antigens elicit specific responses |
| 2. Diversity | Enables immune system to respond to a large variety of antigens |
| 3. Memory | Leads to enhanced responses to repeated exposures to the same antigens |



Adaptive (Specific) Immunity

❖ Cardinal Features of Adaptive Immune Responses:

| Feature | Functional significance |
|---------------------------|--|
| 4. Specialization | Generates responses that are optimal for defense against different types of microbes |
| 5. Self-limitation | Allows immune system to respond to newly encountered antigens |
| 6. Non reactivity to self | Prevents injury to the host during responses to foreign antigens |



Cardinal Features of Adaptive Immune Responses:

- ❖ ***Specificity and diversity:***

- ❖ ***Specificity:*** Immune responses are **specific for distinct antigens and, in fact, for different portions of a single complex protein, polysaccharide, or other macromolecule.**
- ❖ The parts of such antigens that are specifically recognized by individual lymphocytes are called determinants or epitopes.



Cardinal Features of Adaptive Immune Responses:

- ❖ ***Specificity and diversity:***

- ❖ ***Diversity:*** The total number of antigenic specificities of the lymphocytes in an individual, called the **lymphocyte repertoire**, is extremely large.

- ❖ It is estimated that the immune system of an individual can discriminate 10^7 to 10^9 distinct antigenic determinants. This property of the lymphocyte repertoire is called **diversity**.



Cardinal Features of Adaptive Immune Responses:

- ❖ **Memory:** Exposure of the immune system to a foreign antigen enhances its ability to respond again to that antigen.
- ❖ Responses to second and subsequent exposures to the same antigen, called **secondary immune responses**, are usually more rapid, larger, and often qualitatively different from the first, or primary, immune response.
- ❖ Immunologic memory occurs partly because each exposure to an antigen expands the clone of lymphocytes specific for that antigen.



Cardinal Features of Adaptive Immune Responses:

- ❖ **Specialization**: the immune system responds in distinct and special ways to different microbes, maximizing the efficiency of antimicrobial defense mechanisms.
- ❖ Thus, humoral immunity and cell-mediated immunity are elicited by different classes of microbes or by the same microbe at different stages of infection (extracellular and intracellular), and each type of immune response protects the host against that class of microbe.



Cardinal Features of Adaptive Immune Responses:

- ❖ ***Self-limitation***: All normal immune responses wane with time after antigen stimulation, thus returning the immune system to its resting basal state, a process called **homeostasis**.
- ❖ Homeostasis is maintained largely because immune responses are triggered by antigens and function to eliminate antigens, thus eliminating the essential stimulus for lymphocyte survival and activation.



Cardinal Features of Adaptive Immune Responses:

- ❖ ***Non reactivity to self***: One of the most remarkable properties of every normal individual's immune system is its **ability to recognize, respond to, and eliminate many foreign (nonself) antigens while not reacting harmfully to that individual's own (self) antigenic substances.**
- ❖ Immunologic unresponsiveness is also called **tolerance**.



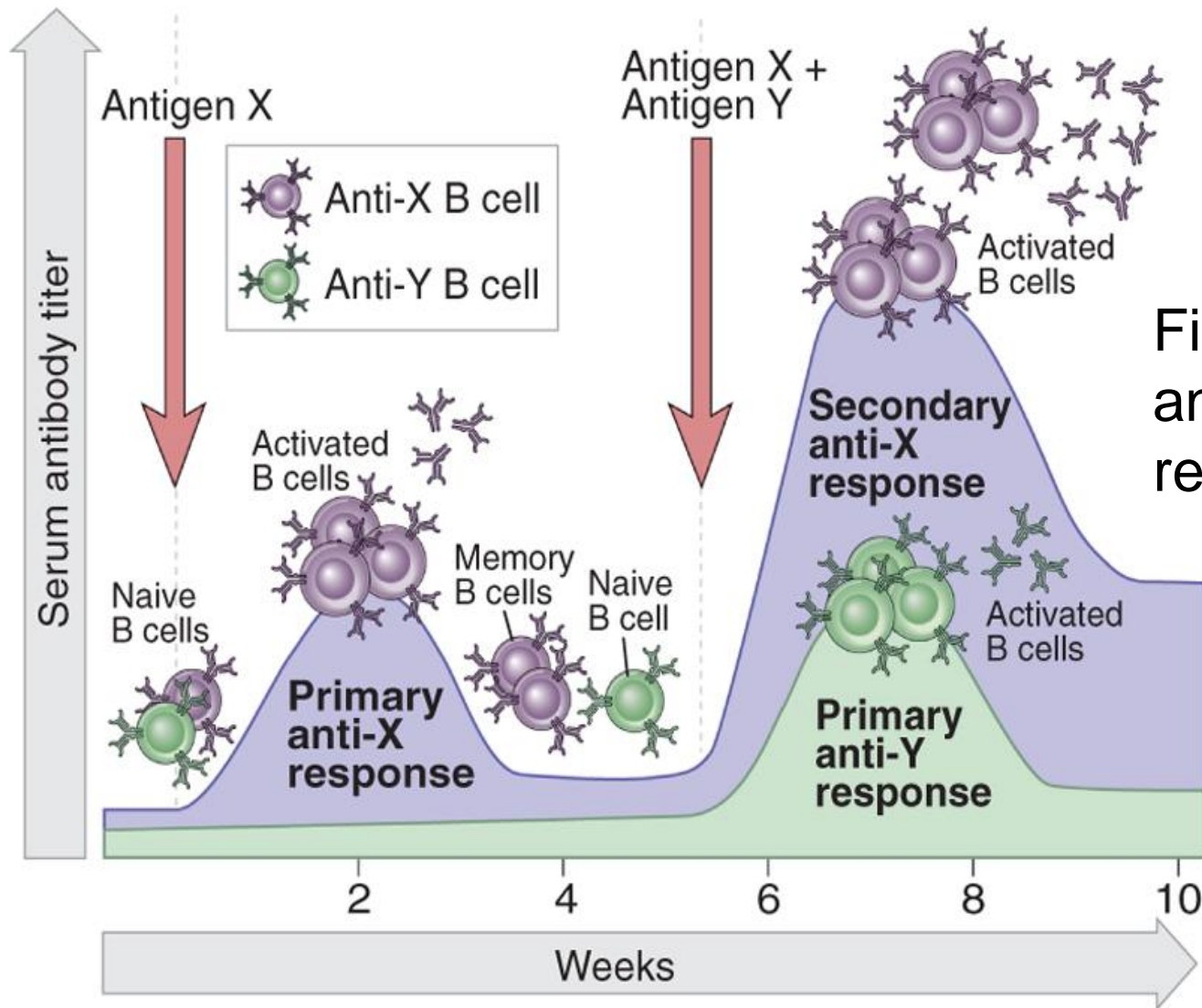


Figure: Specificity, memory, and self-limitation of immune responses.

Cellular Components of the Adaptive Immune System:

❖ The principal cells of the immune system are **lymphocytes, antigen-presenting cells, and effector cells.**

❖ Lymphocytes:

❑ **B lymphocytes** are the only cells capable of producing antibodies.

They recognize **extracellular** (including cell surface) antigens and differentiate into antibody-secreting cells, thus functioning as the mediators of humoral immunity.



Cellular Components of the Adaptive Immune System:

❖ Lymphocytes:

- ❑ **T lymphocytes** the cells of cell-mediated immunity, recognize the **antigens of intracellular** microbes and function to destroy these microbes or the infected cells.
- ❑ T lymphocytes have a restricted specificity for antigens thus T cells recognize and respond to cell surface-associated but not soluble antigens.
- ❑ **Helper T cells, cytolytic (cytotoxic), T lymphocytes (CTLs) and Regulatory T cells.**



Cellular Components of the Adaptive Immune System:

❖ Lymphocytes:

- ❑ A third class of lymphocytes, **natural killer (NK) cells**, is involved in innate immunity against viruses and other **intracellular microbes**.



Cellular Components of the Adaptive Immune System:

❖ **Antigen-presenting cells (APCs):**

- ❑ The initiation and development of adaptive immune responses require that antigens be **captured and displayed to specific lymphocytes**. The cells that serve this role are called **antigen-presenting cells (APCs)**.
- ❑ The most highly specialized APCs are **dendritic cells**.



Cellular Components of the Adaptive Immune System:

❖ **Effector cells :**

- ❑ The activation of lymphocytes by antigen leads to the **generation of numerous mechanisms that function to eliminate the antigen.**
- ❑ **Antigen elimination often requires the participation of cells called effector cells.**
- ❑ **Activated T lymphocytes, mononuclear phagocytes, and other leukocytes** function as effector cells in different immune responses.



Cellular Components of the Adaptive Immune System:

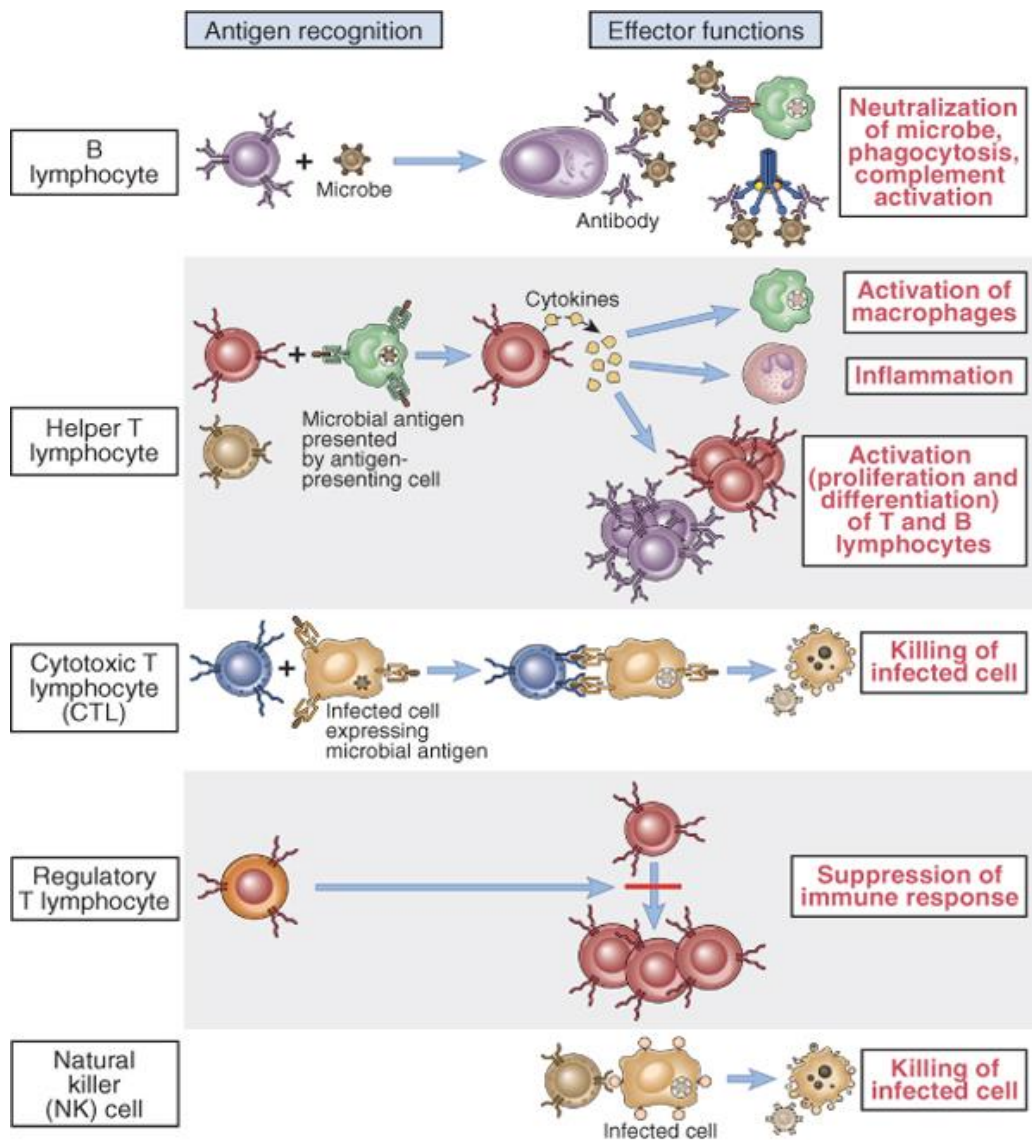



Figure: Classes of lymphocytes.

Adaptive (Specific) Immunity

- ❖ The recognition response is **highly specific**.
- ❖ The immune system is able to distinguish one pathogen from another, to identify cancer cells, and to discriminate the body's own "self" proteins and cells as different from "nonself " proteins, cells, tissues, and organs.
- ❖ After recognition of an invader, the specific immune system responds by amplifying and activating specific lymphocytes to attack it. **This is called an effector response.**



Adaptive (Specific) Immunity

- ❖ A successful effector response either eliminates the foreign material or renders it harmless to the host.
 - ❖ If the same invader is encountered at a later time, the immune system is prepared to mount a more intense and **rapid memory or anamnestic response** that eliminates the invader once again and protects the host from disease.
 - ❖ This immunologic memory helps in mounting a faster and efficient removal when the same antigen enters subsequently.
- 

Phases of Adaptive Immune Responses

❖ *Adaptive immune responses may be divided into distinct phases-*

- ☐ The recognition of antigen
- ☐ The activation of lymphocytes, and
- ☐ The effector phase of antigen elimination
- ☐ Followed by the return to homeostasis
- ☐ The maintenance of memory



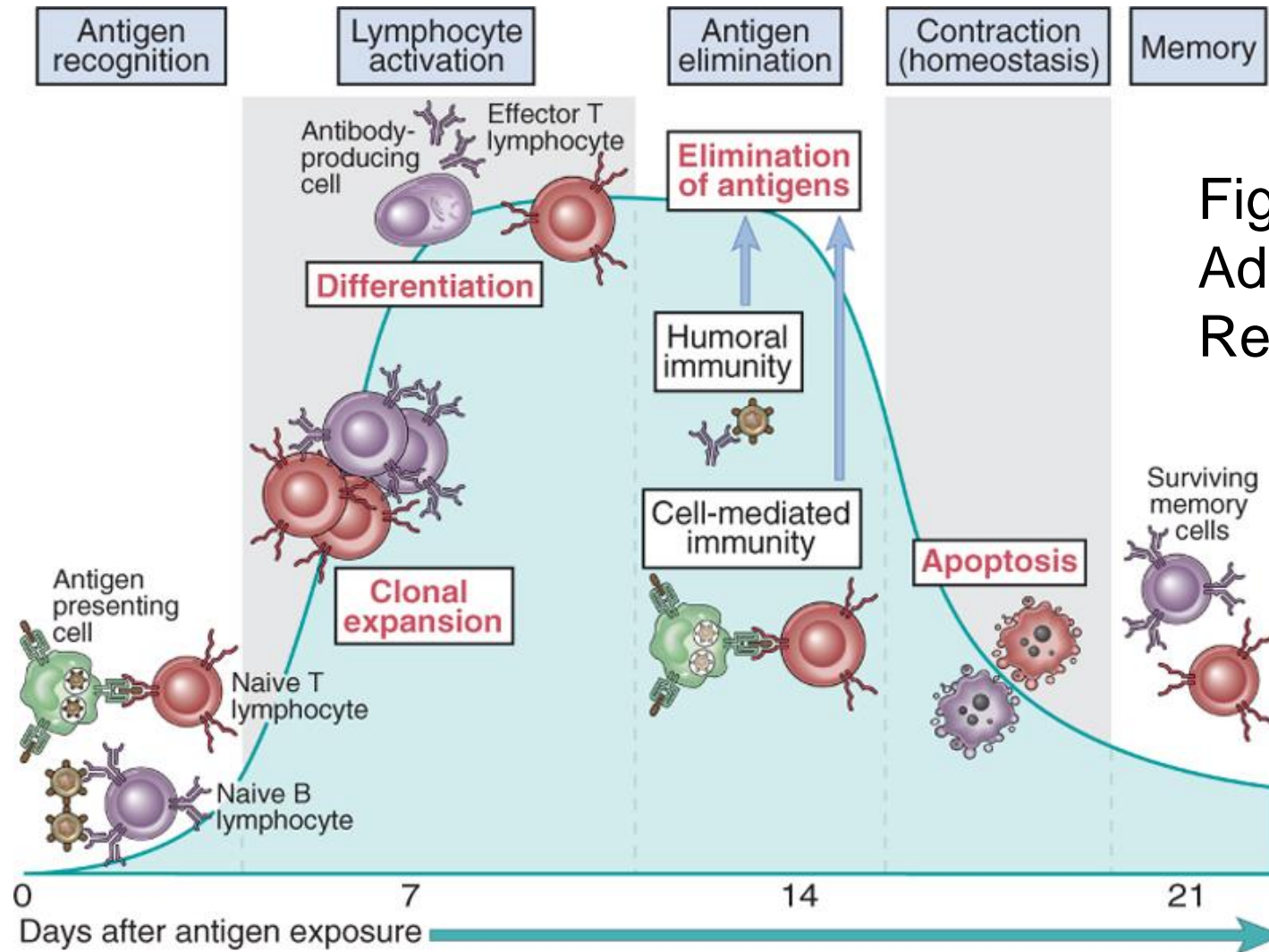


Figure: Phases of Adaptive Immune Responses

Difference between Innate and Adaptive immunity

| Characteristics | Innate immunity | Adaptive immunity |
|------------------------|---|--|
| Specificity | For structures shared by groups of related microbes | For antigens of microbes and for non microbial antigens |
| Diversity | Limited; germline encoded | Very large; receptors are produced by somatic recombination of gene segments |
| Memory | None | Yes |
| Non reactivity to self | Yes | Yes |



Difference between Innate and Adaptive immunity

| Characteristics | Innate immunity | Adaptive immunity |
|--------------------------------|---|--|
| Physical and chemical barriers | Skin, mucosal epithelia; antimicrobial chemicals | Lymphocytes in epithelia; antibodies secreted at epithelial surfaces |
| Blood proteins | Complement | Antibodies |
| Cells | Phagocytes (macrophages, neutrophils), natural killer cells | Lymphocytes |



Types of Adaptive Immune Responses

- ❖ There are two types of adaptive immune responses, called humoral immunity and cell-mediated immunity, that are mediated by different components of the immune system and function to eliminate different types of microbes



Humoral Immunity

- ❖ It is mediated by molecules in the blood and mucosal secretions, called **antibodies**, that are produced by cells called **B lymphocytes** (also called B cells).
- ❖ Antibodies recognize microbial antigens, neutralize the infectivity of the microbes, and target microbes for elimination by various effector mechanisms.



Humoral Immunity

- ❖ Humoral immunity is the principal defense mechanism against **extracellular microbes** and their toxins because secreted antibodies can bind to these microbes and toxins and assist in their elimination.
- ❖ Antibodies themselves are specialized, and different types of antibodies may activate different effector mechanisms.



Cell-mediated Immunity

- ❖ **Cell-mediated immunity**, also called cellular immunity, is mediated by **T lymphocytes (also called T cells)**.
- ❖ **Intracellular** microbes, such as viruses and some bacteria, survive and proliferate inside phagocytes and other host cells, where they are inaccessible to circulating antibodies.
- ❖ Defense against such infections is a function of cell-mediated immunity, which promotes the destruction of microbes residing in phagocytes or the killing of infected cells to eliminate reservoirs of infection.









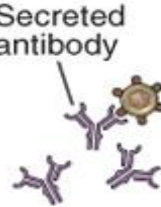
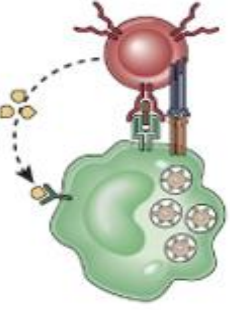

| | Humoral immunity | Cell-mediated immunity | |
|------------------------|---|--|--|
| Microbe |  <p>Extracellular microbes</p> |  <p>Phagocytosed microbes in macrophage</p> |  <p>Intracellular microbes (e.g., viruses) replicating within infected cell</p> |
| Responding lymphocytes |  <p>B lymphocyte</p> |  <p>Helper T lymphocyte</p> |  <p>Cytotoxic T lymphocyte</p> |
| Effector mechanism |  <p>Secreted antibody</p> |  |  |
| Transferred by | Serum (antibodies) | Cells (T lymphocytes) | Cells (T lymphocytes) |
| Functions | Block infections and eliminate extracellular microbes | Activate macrophages to kill phagocytosed microbes | Kill infected cells and eliminate reservoirs of infection |

Figure: Types of adaptive immunity

Differences between Humoral and Cell mediated immunity

| Feature | Humoral immunity | Cell mediated immunity |
|------------------------|-------------------------------|------------------------|
| Antigen | Extracellular antigens | Intracellular antigens |
| Responding lymphocytes | B lymphocytes | T lymphocytes |
| Effector mechanism | Antibody mediated elimination | Lysis of infected cell |
| Transferred by | Serum | T lymphocytes |



Active and Passive Immunity

- ❖ Humoral and cell mediated immunity can each be divided into active and passive immunity.
- ❖ Specific immune responses are stimulated when a host is exposed to and antigen.
- ❖ This immunity is called active immunity, which is acquired gradually, lasts longer and is highly protective.
- ❖ It also stimulates immunological memory.

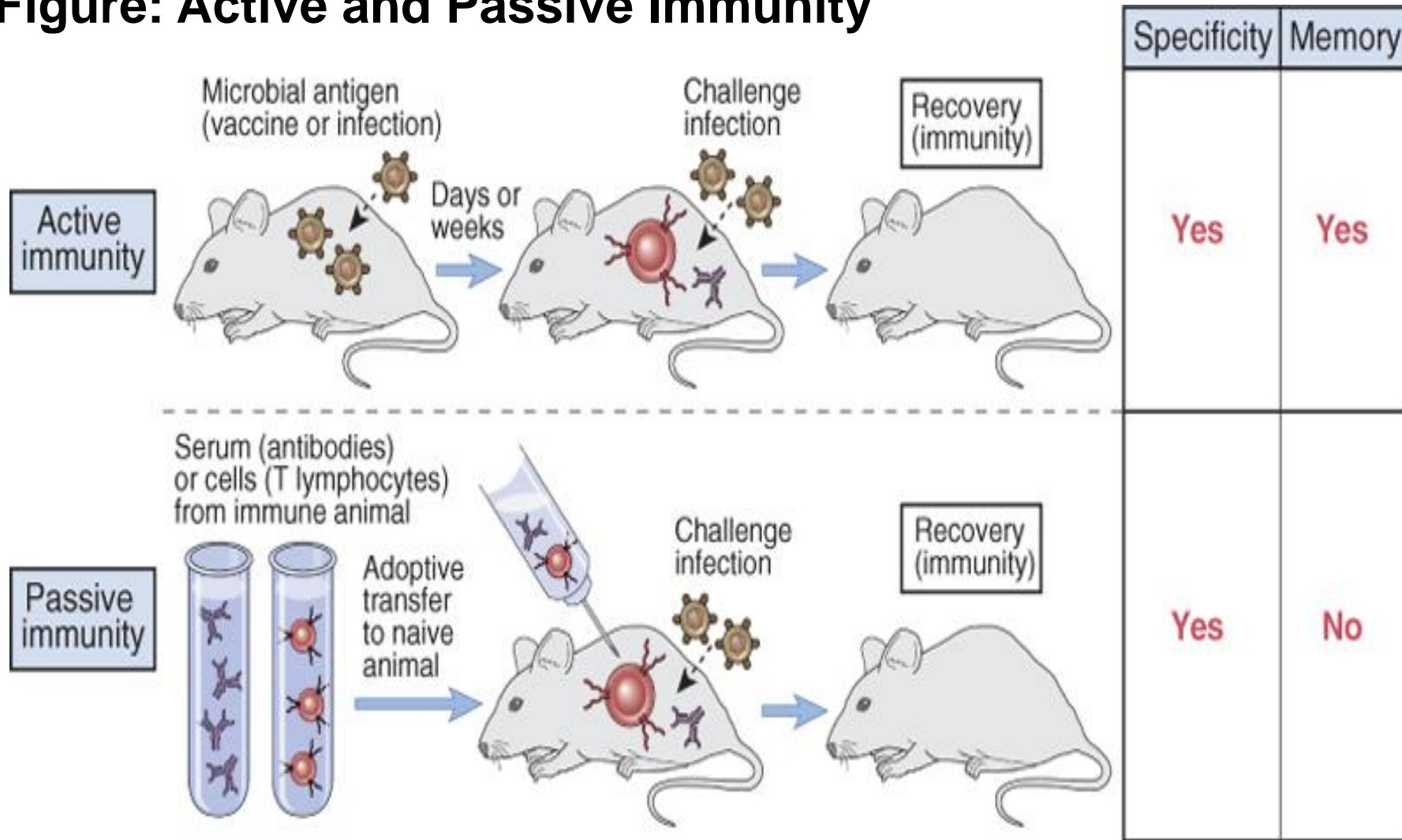


Active and Passive Immunity

- ❖ Passive immunity is obtained either by **transfer of serum or T cell**.
- ❖ The recipient of such a transfer becomes immune to the particular antigen without ever having been exposed to or having responded to that antigen. Therefore, It is called **passive immunity**.
- ❖ The recipient of such transfer becomes immune immediately. However, the immunity is short lived with moderate protection.
- ❖ There is **no immunological memory** associated with passive immunity.



Figure: Active and Passive Immunity



Thank You

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