BP 605 T. Pharmaceutical Biotechnology (Theory)

Innate immunity and Adaptive immunity

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Overview

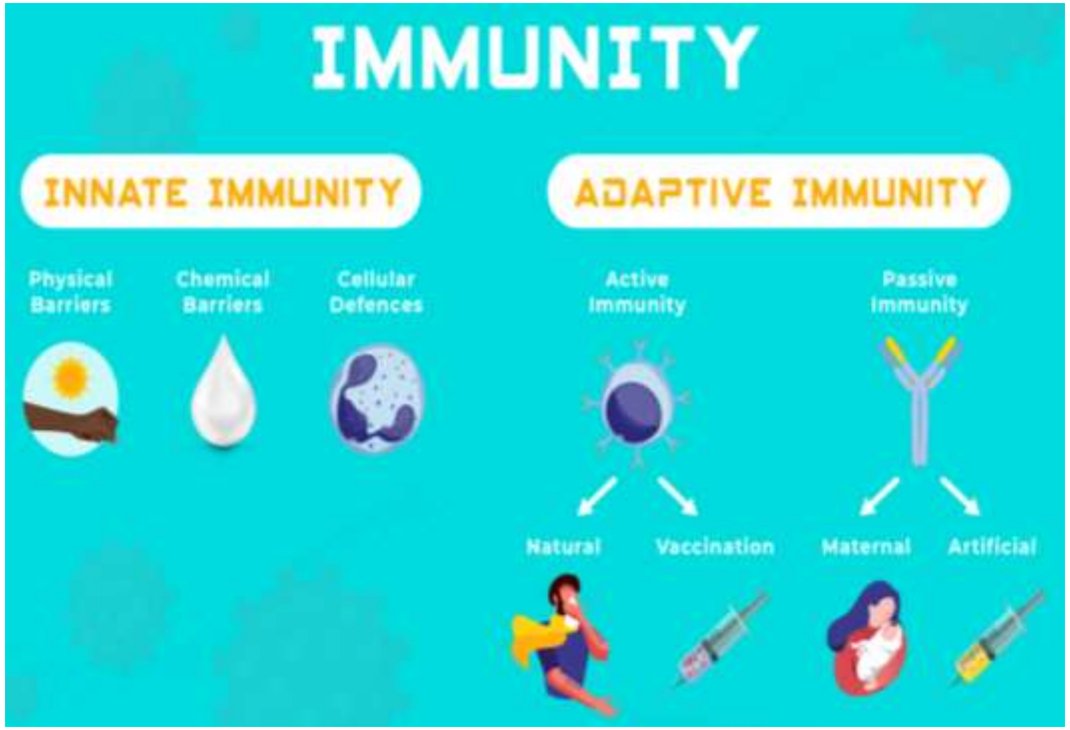
- Definition and Introduction
- Innate Immunity and Adaptive Immunity
- Humoral Immunity and Cellular Immunity

IMMUNITY

Definition: Immunity is defined as an organism's ability to protect itself from a pathogen or toxin.

"Latin term **immunis,** meaning **"exempt,"** is the source of the English word **immunity**, meaning the state of protection from infectious disease".

- ✓ Pathogens, agents that cause disease, infect a wide range of animals, including humans
- ✓ The immune system recognizes foreign bodies and responds with the production of immune cells and proteins
- ✓ All animals have innate immunity, a defense active immediately upon infection
- ✓ Vertebrates also have adaptive immunity



INNATE IMMUNITY

What is innate immunity?

Innate immunity, also known as **genetic or natural immunity**, is immunity that one is born with. This type of immunity is written in one's genes, offering lifelong protection.

- ✓ Innate immunity is **present before any exposure to pathogens** and is effective from the time of birth
- ✓ The innate immune response is **fast acting and non-specific**, meaning it does not respond differently based on the specific virus or bacteria that it detects.
- ✓ Innate immunity consists of **external barriers plus internal cellular and chemical defenses**
- ✓ **Physical barriers** protect the body from invasion. These include things like the **skin** and **eyelashes.**
- ✓ **Chemical barriers** are defense mechanisms that can destroy harmful agent. Examples include tears, mucous, and stomach acid.
- ✓ **Cellular defenses** of the innate immune response are non-specific. These cellular defenses identify pathogens and substances that are potentially dangerous and takes steps to neutralize or destroy them.

ADAPTIVE IMMUNITY

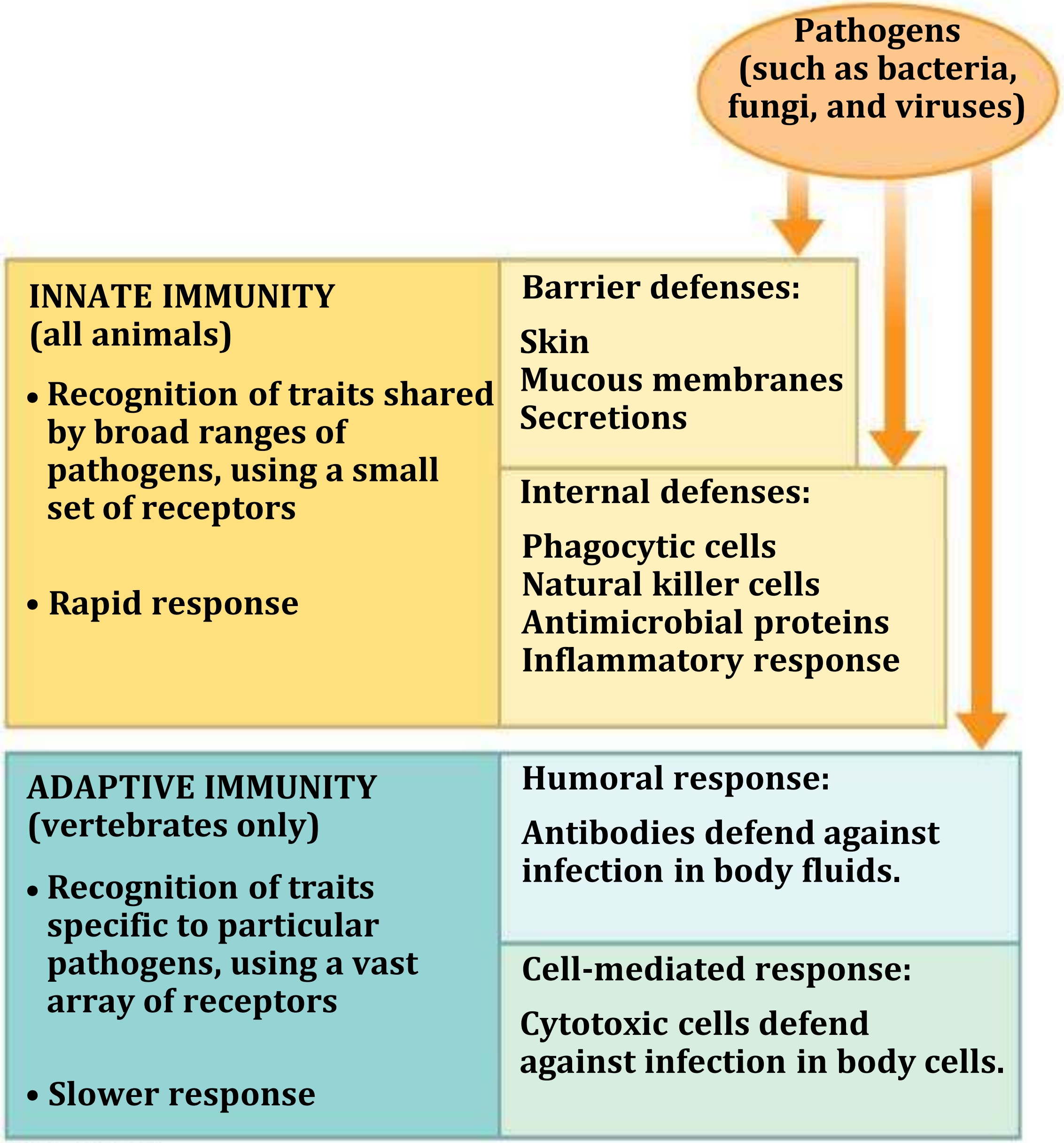
What is Adaptive Immunity?

Adaptive immunity is an **organism's acquired immunity to a specific pathogen**. As such, it's also referred to as **acquired immunity**.

- ✓ Adaptive immunity, or acquired immunity, **develops after exposure to agents such as microbes, toxins, or other foreign substances.** It involves a **very specific response to pathogens**
- ✓ Adaptive immunity is **not immediate, nor does it always last throughout an organism's entire lifespan**, although it can.
- ✓ The adaptive immune response is **marked by clonal expansion of T and B lymphocytes**, releasing many antibody copies to neutralize or destroy their target antigen.
- ✓ **The primary immune response;** When B lymphocytes, or B cells, encounter a novel antigen, they create antibodies specific to the antigen designed to destroy or neutralize it.
- ✓ **Secondary immune response;** B cells create memory cells, which are a type of B cell that survives for decades and can detect the pathogen during subsequent exposure

INNATE vs ADAPTIVE IMMUNITY

	Innate Immune Response	Adaptive Immune Response
Also Known As	Natural immunity; genetic immunity	Acquired immunity
Response time (Takes Effect)	Hours (Immediately)	Days (Over time)
Response type	Non-specific	Specific
Specificity	Limited and fixed	Highly diverse, improves during the course of immune response
Types	•External defenses •Internal defenses	•Active immunity •Passive immunity
Response to repeat infection	Identical to primary response	Much more rapid than primary response
Length of Efficacy	Lifelong	Short-term, long-term, lifelong

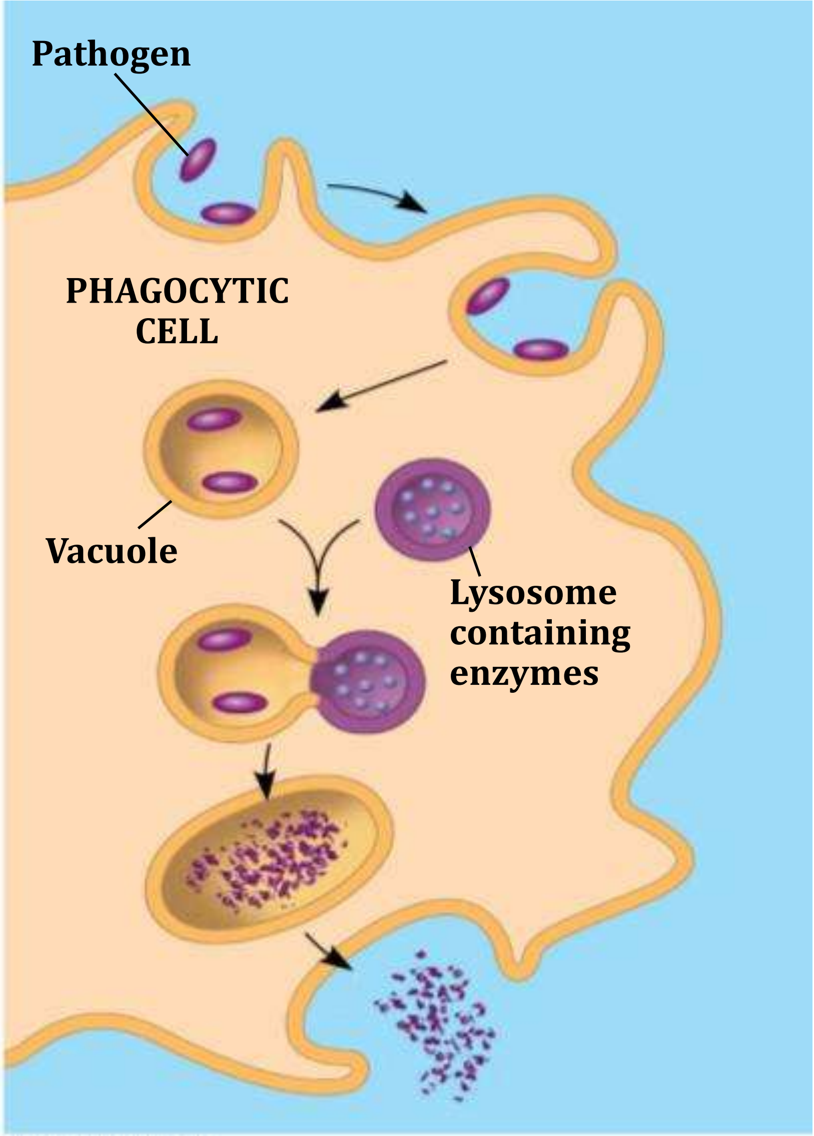


Innate immunity - recognition and response rely on traits common to groups of pathogens

- ✓ Innate immunity is found in all animals and plants
- ✓ In vertebrates, innate immunity is a first response to infections and also serves as the foundation of adaptive immunity
- ✓ Innate immunity was known chiefly through the work of the **great Russian immunologist Elie Metchnikoff,** who discovered that many microorganisms could be engulfed and digested by **phagocytic cells,** which he called **'macrophages.'**

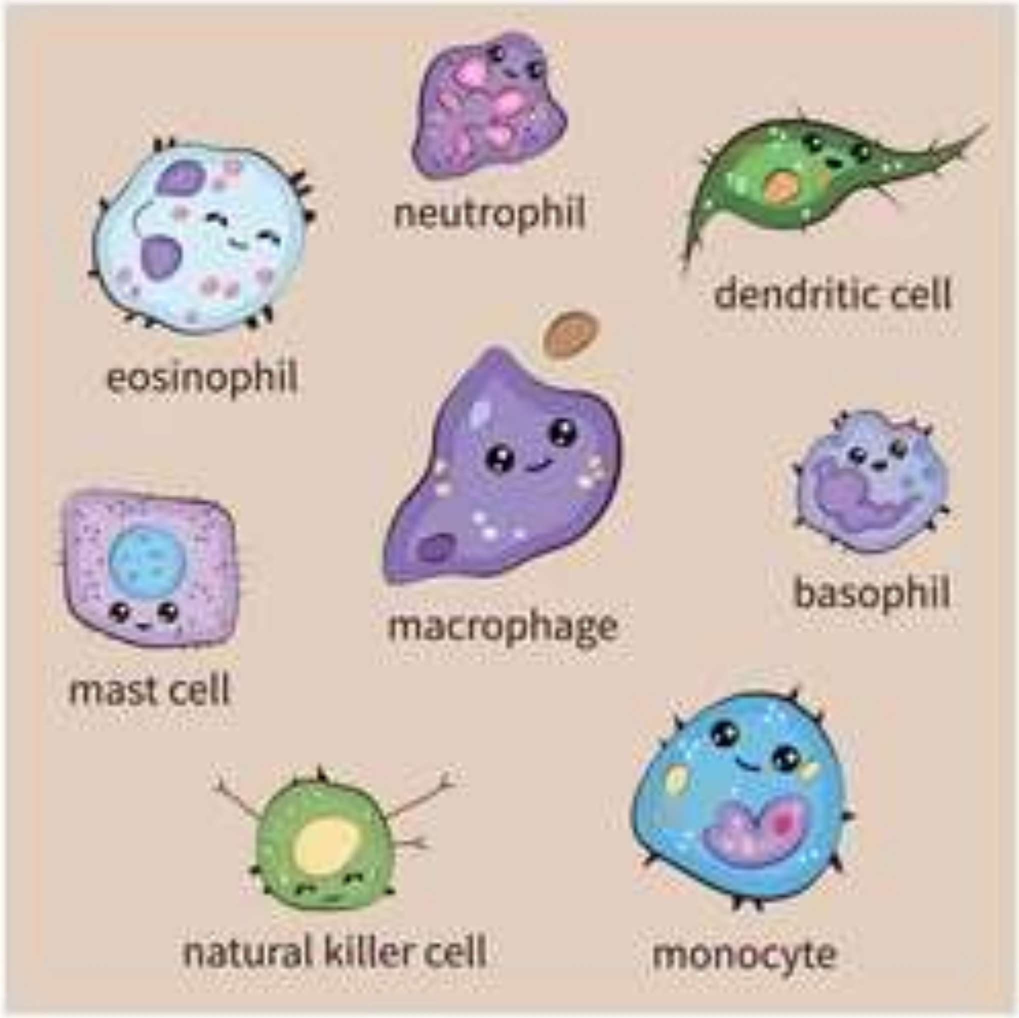
Innate Immunity of Invertebrates

- ✓ In insects, an exoskeleton made of chitin forms the first barrier to pathogens
- ✓ The digestive system is protected by a **chitin-based barrier and lysozyme**, an enzyme that breaks down bacterial cell walls
- ✓ **Hemocytes** circulate within **hemolymph** and carry out **phagocytosis**, the ingestion and digestion of foreign substances including bacteria
- ✓ Hemocytes also **secrete antimicrobial peptides** that disrupt the **plasma membranes of fungi and bacteria**
- ✓ The immune system recognizes bacteria and fungi by structures on their cell walls
- ✓ An immune response varies with the class of pathogen encountered



Innate Immunity of Vertebrates

- ✓ The immune system of mammals is the best understood of the vertebrates
- ✓ Innate defenses include barrier defenses, phagocytosis, antimicrobial peptides
- ✓ Additional defenses are unique to vertebrates: natural killer cells, interferons, and the inflammatory response

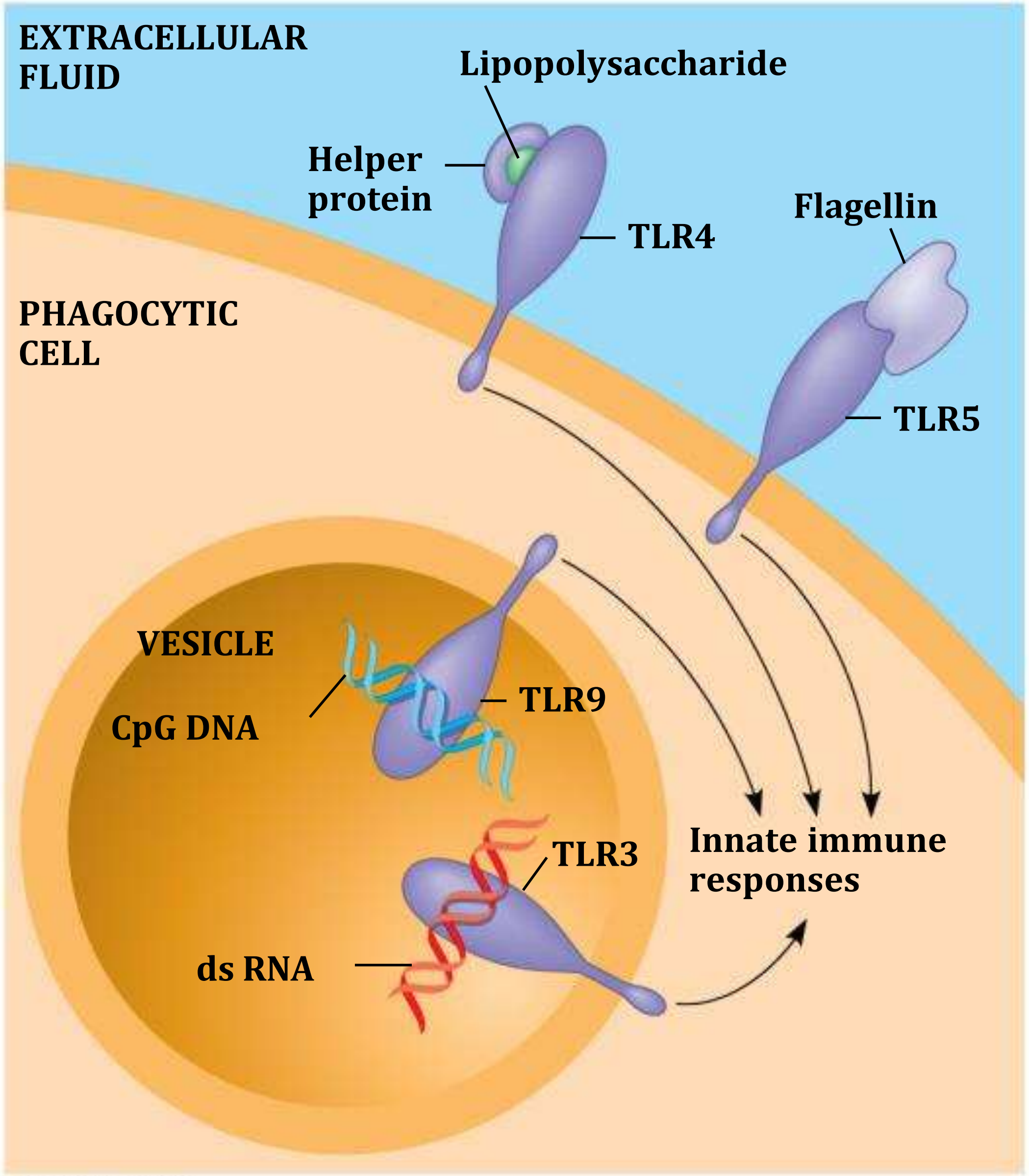


Barrier Defenses

- ✓ **Barrier defenses include the skin and mucous membranes** of the respiratory, urinary, and reproductive tracts
- ✓ Mucus traps and allows for the removal of microbes
- ✓ Many body fluids including saliva, mucus, and tears are hostile to many microbes
- ✓ The low pH of skin and the digestive system prevents growth of many bacteria

Cellular Innate Defenses

- ✓ Pathogens entering the mammalian body are subject to phagocytosis
- ✓ Phagocytic cells recognize groups of pathogens by **TLRs, Toll-like receptors**
- ✓ A white blood cell engulfs a microbe, then fuses with a lysosome to destroy the microbe
- ✓ There are different types of phagocytic cells
- ○ **Neutrophils** engulf and destroy pathogens
- ○ **Macrophages** are found throughout the body
- ○ **Dendritic cells** stimulate development of adaptive immunity
- ○ Eosinophils discharge destructive enzyme



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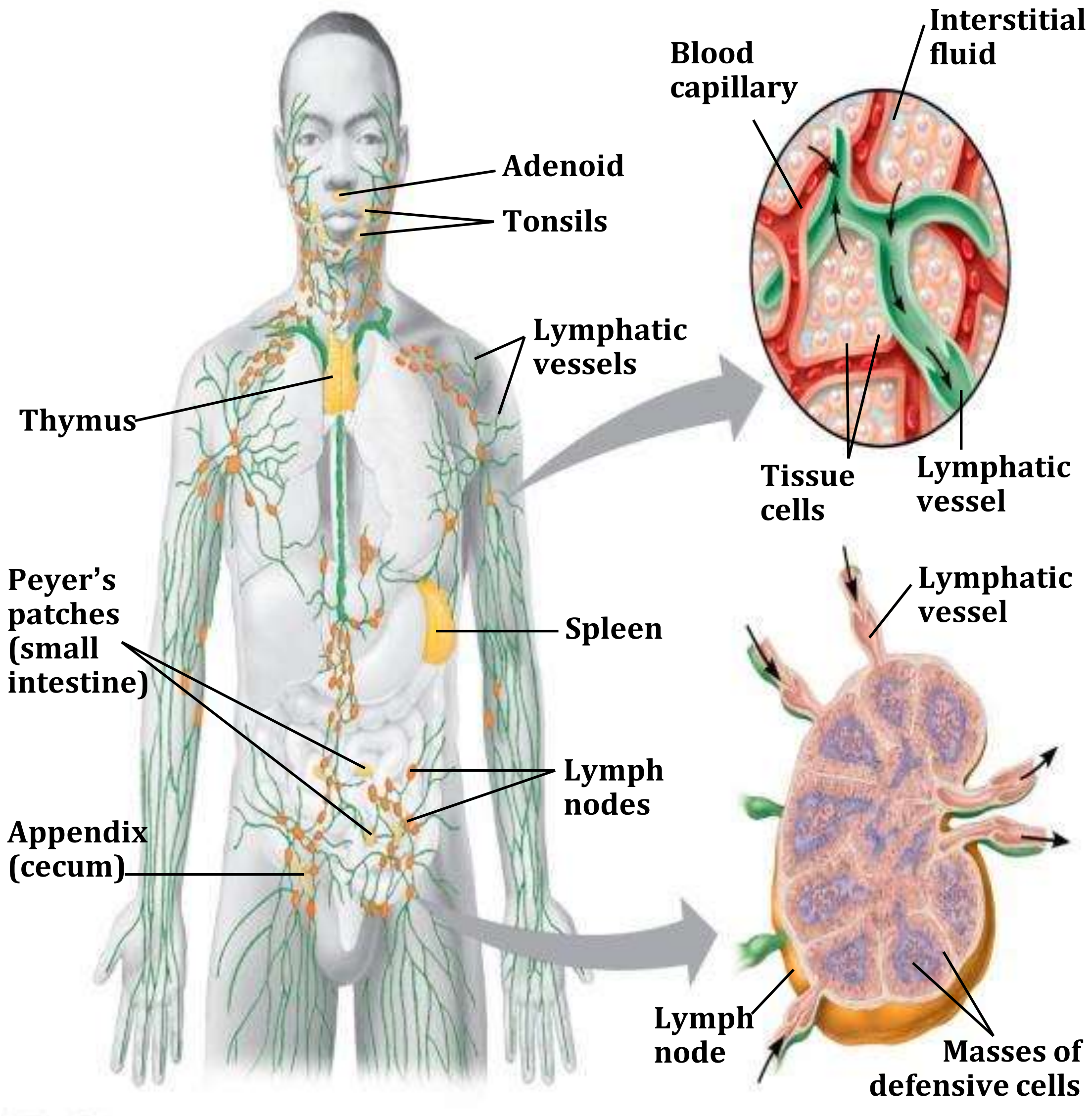
- ✓ Cellular innate defenses in vertebrates also involve natural killer cells
- ✓ These circulate through the body and detect abnormal cells
- ✓ They release chemicals leading to cell death, inhibiting the spread of virally infected or cancerous cells
- ✓ Many cellular innate defenses involve the lymphatic system

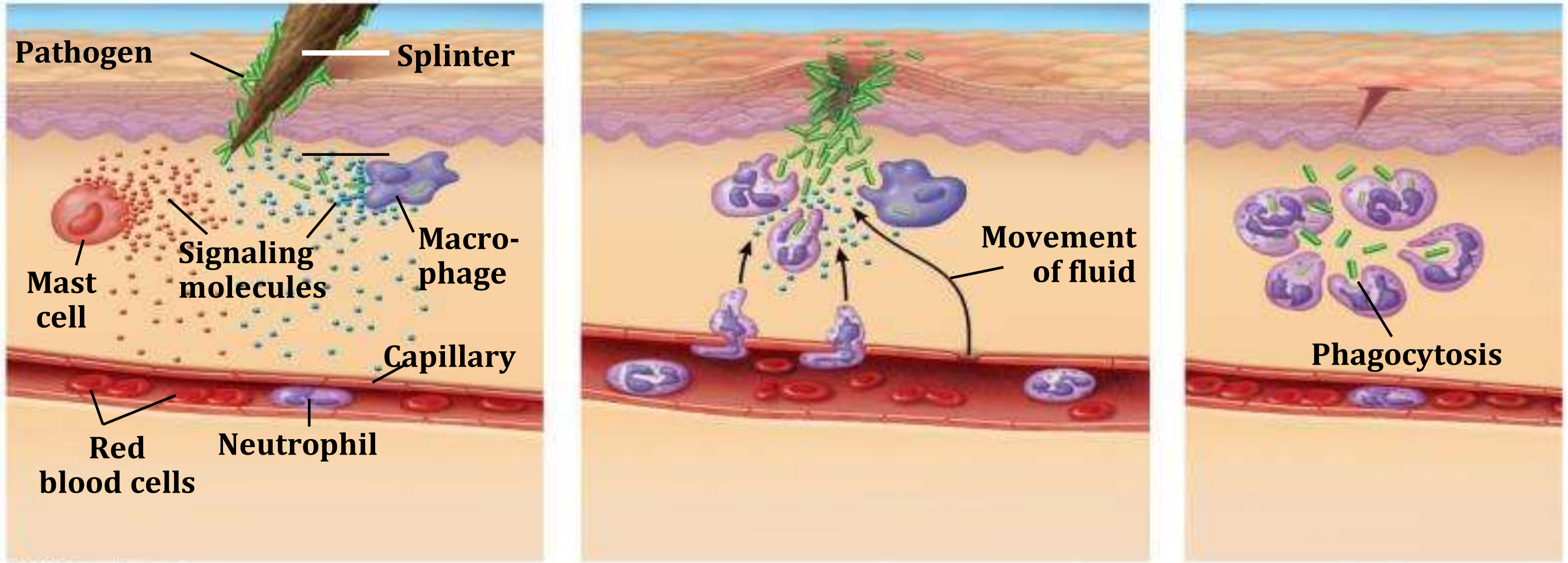


Antimicrobial Peptides and Proteins

- ✓ Peptides and proteins function in innate defense by attacking pathogens or impeding their reproduction
- ✓ Interferon proteins provide innate defense, interfering with viruses and helping activate macrophages
- ✓ About 30 proteins make up the complement system, which causes lysis of invading cells and helps trigger inflammation

Inflammatory Responses

- ✓ The inflammatory response, such as pain and swelling, is brought about by molecules released upon injury of infection
- ✓ Mast cells, a type of connective tissue, release histamine, which triggers blood vessels to dilate and become more permeable
- ✓ Activated macrophages and neutrophils release cytokines, signaling molecules that enhance the immune response
- ✓ Pus, a fluid rich in white blood cells, dead pathogens, and cell debris from damaged tissues



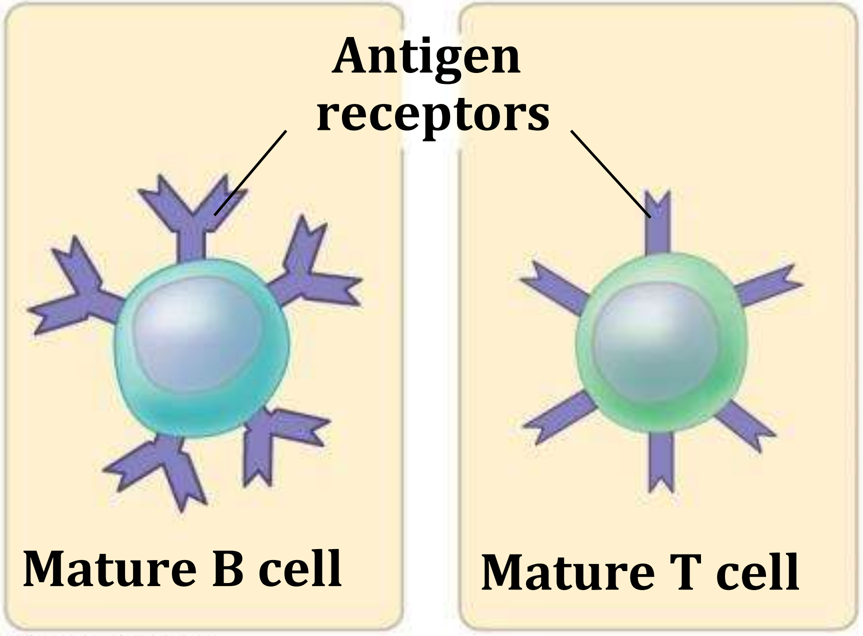
- ✓ Inflammation can be either local or systemic (throughout the body)
- ✓ Fever is a systemic inflammatory response triggered by pyrogens released by macrophages and by toxins from pathogens
- ✓ Septic shock is a life-threatening condition caused by an overwhelming inflammatory response

Evasion of Innate Immunity by Pathogens

- ✓ Some pathogens avoid destruction by modifying their surface to prevent recognition or by resisting breakdown following phagocytosis
- ✓ Tuberculosis (TB) is one such disease and kills more than a million people a year

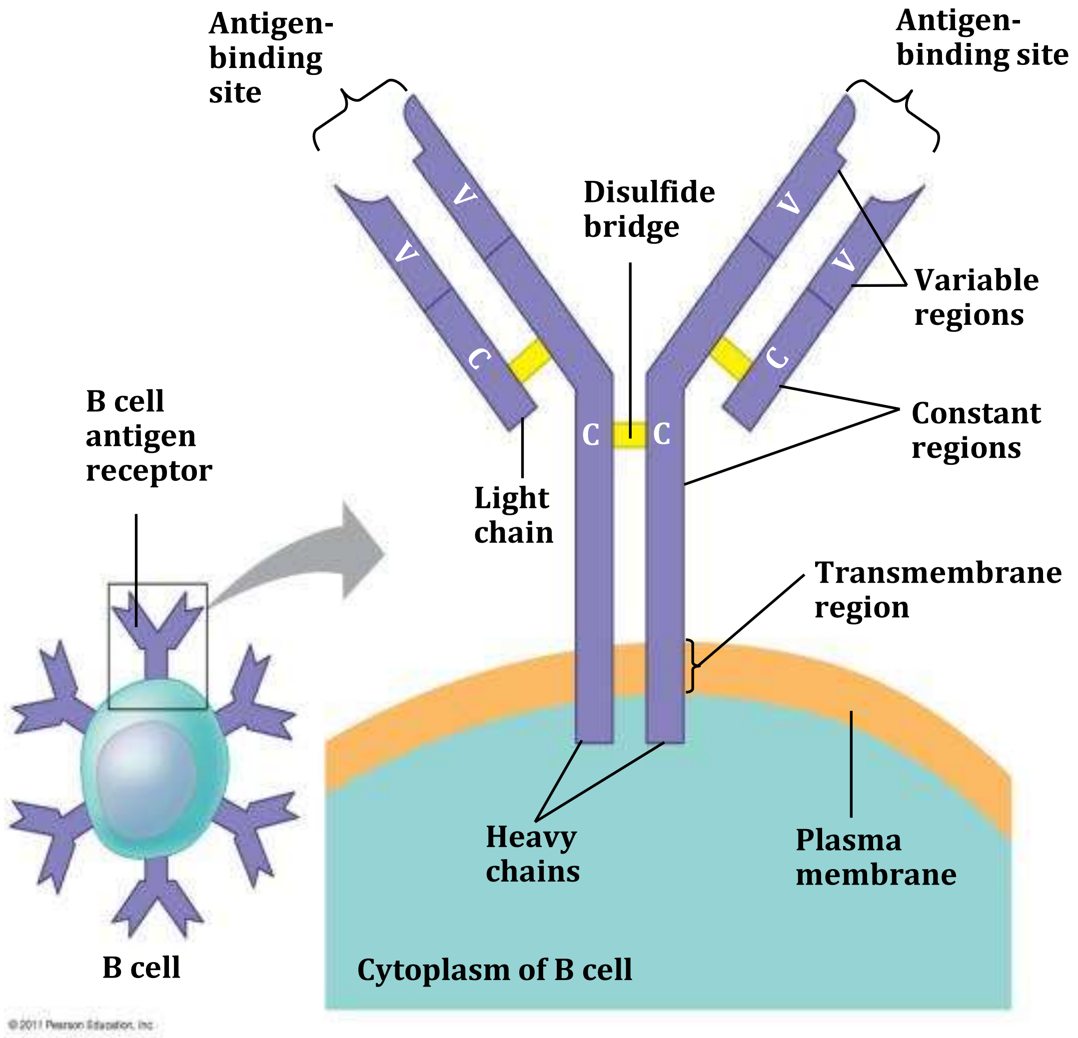
Adaptive immunity - receptors provide pathogen-specific recognition

- ✓ The adaptive response relies on two types of lymphocytes, or white blood cells
- ✓ Lymphocytes that mature in the thymus above the heart are called T cells, and those that mature in bone marrow are called B cells
- ✓ Antigens are substances that can elicit a response from a B or T cell
- ✓ Exposure to the pathogen activates B and T cells with antigen receptors specific for parts of that pathogen
- ✓ The small accessible part of an antigen that binds to an antigen receptor is called an epitope
- ✓ B cells and T cells have receptor proteins that can bind to foreign molecules
- ✓ Each individual lymphocyte is specialized to recognize a specific type of molecule



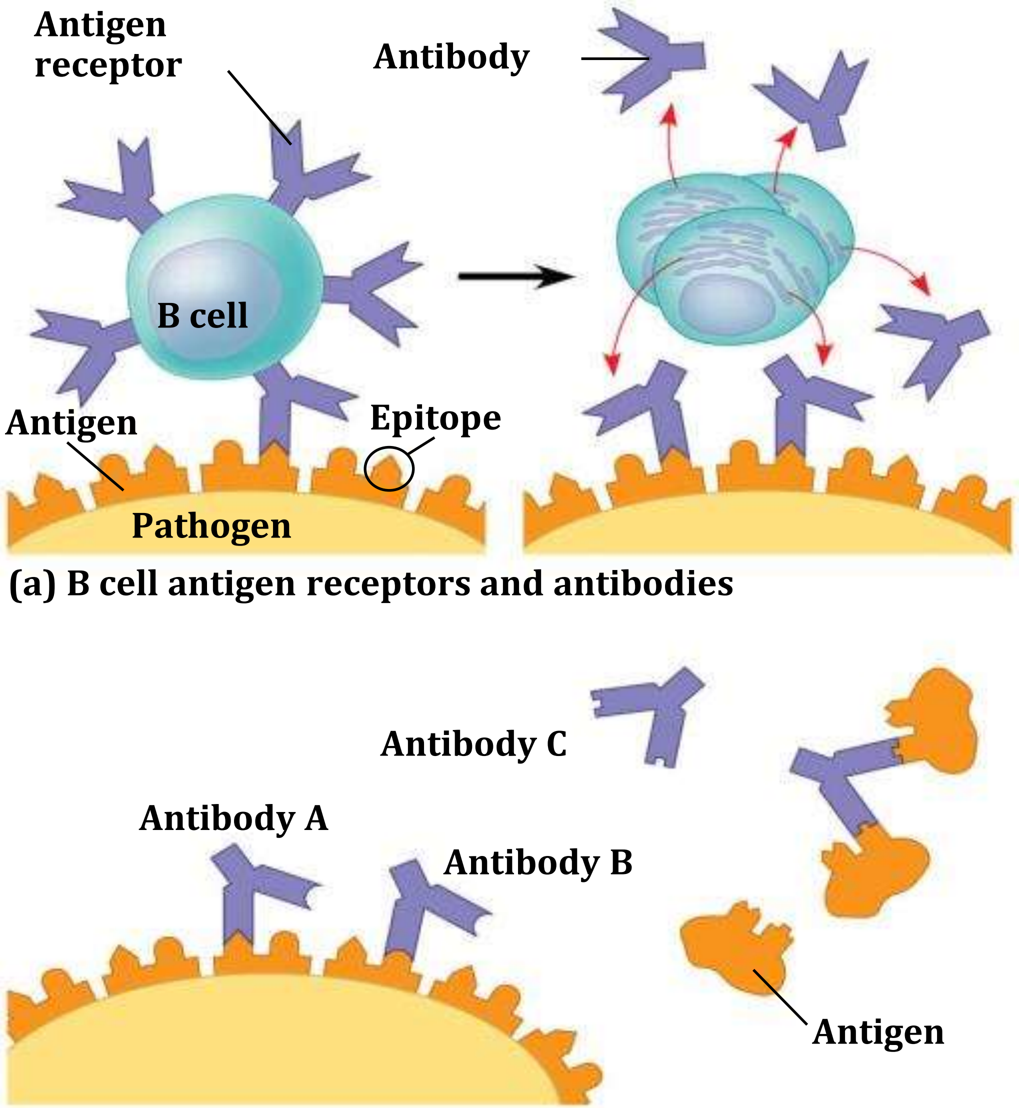
Antigen Recognition by B Cells and Antibodies

- ✓ Each B cell antigen receptor is a Y-shaped molecule with two identical heavy chains and two identical light chains
- ✓ The constant regions of the chains vary little among B cells, whereas the variable regions differ greatly
- ✓ The variable regions provide antigen specificity



Antigen Recognition by B Cells and Antibodies……Contd..

- ✓ Binding of a B cell antigen receptor to an antigen is an early step in B cell activation
- ✓ This gives rise to cells that secrete a soluble form of the protein called an antibody or immunoglobulin (Ig)
- ✓ Secreted antibodies are similar to B cell receptors but lack transmembrane regions that anchor receptors in the plasma membrane



(a) B cell antigen receptors and antibodies

(b) Antigen receptor specificity

Antigen Recognition by T Cells

- ✓ Each T cell receptor consists of two different polypeptide chains (called α and β)
- ✓ The tips of the chain form a variable (V) region; the rest is a constant (C) region
- ✓ T cell and B cell antigen receptors are functionally different

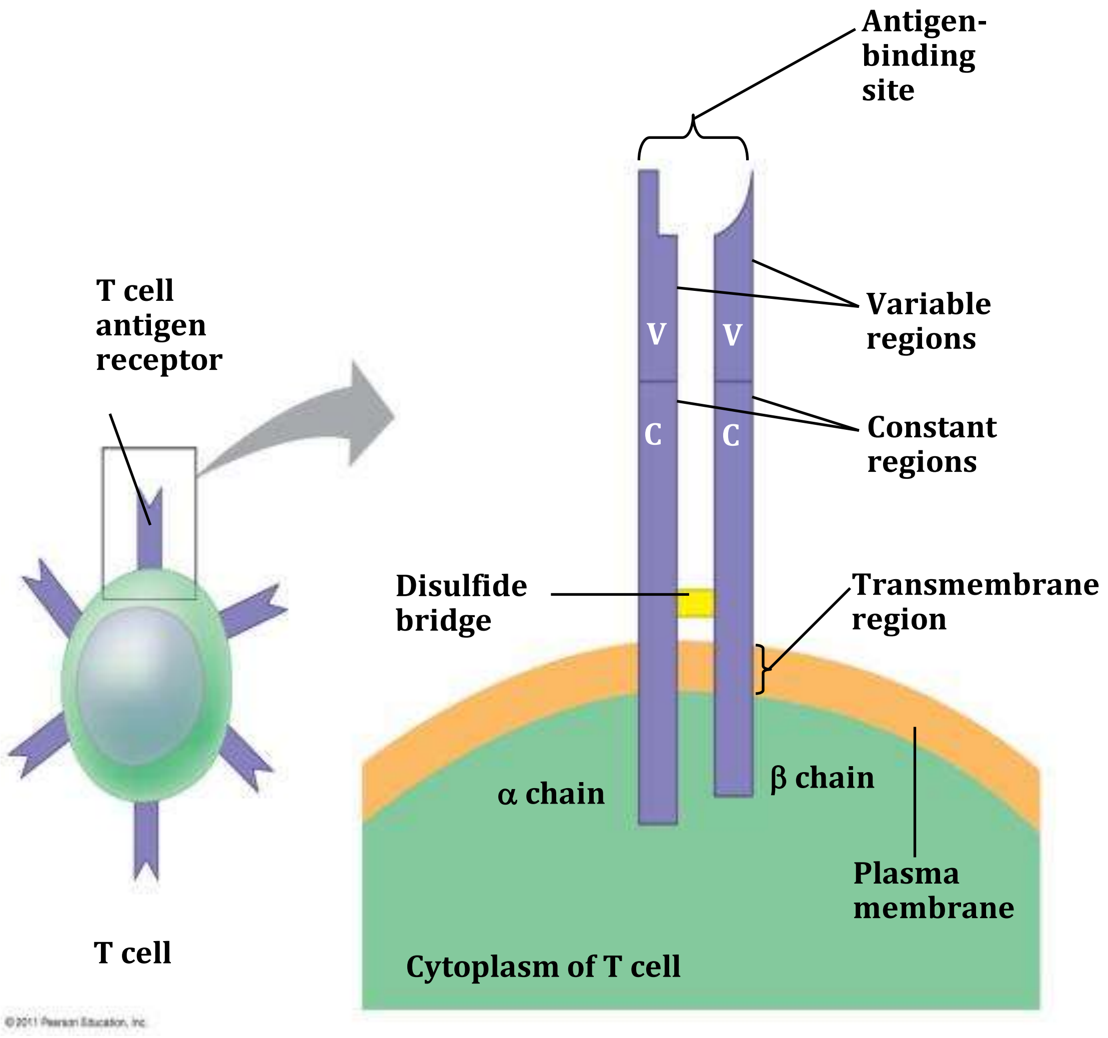
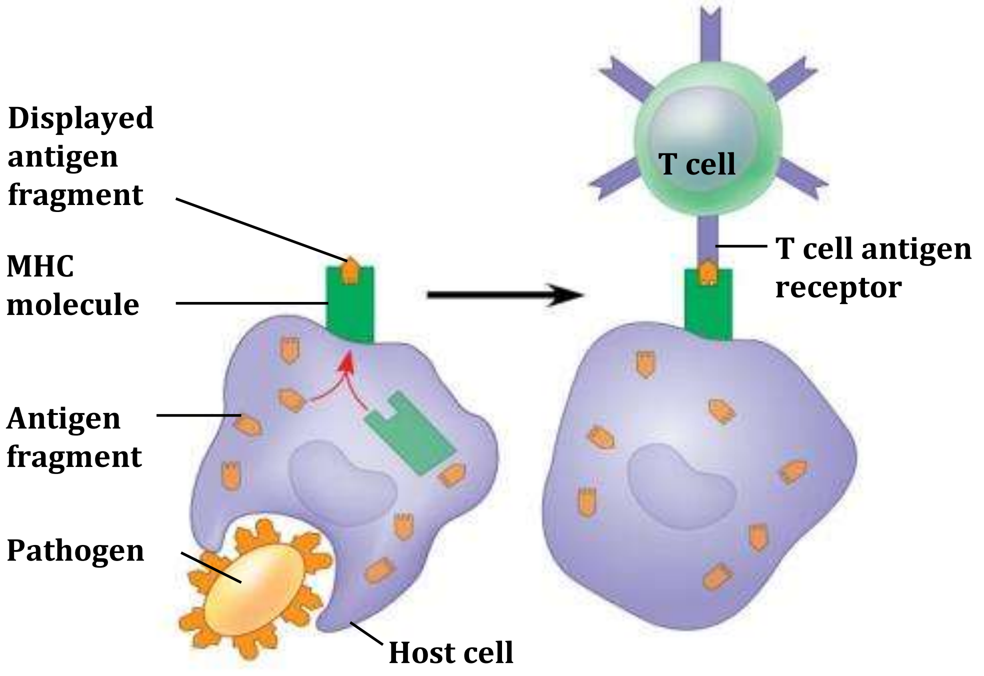


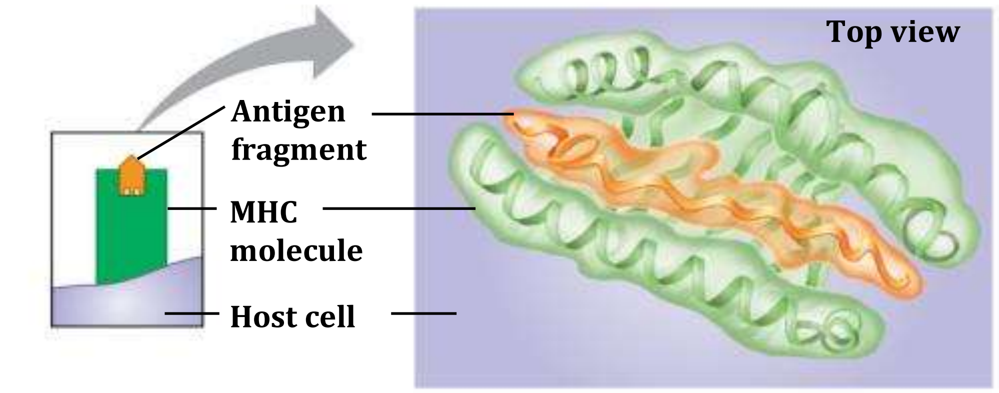
Figure 43.12

Antigen Recognition by T Cells….. Contd..

- ✓ T cells bind to antigen fragments displayed or presented on a host cell
- ✓ These antigen fragments are bound to cell-surface proteins called MHC molecules
- ✓ MHC (major histocompatibility complex) molecules are host proteins that display the antigen fragments on the cell surface
- ✓ In infected cells, MHC molecules bind and transport antigen fragments to the cell surface, a process called antigen presentation
- ✓ A T cell can then bind both the antigen fragment and the MHC molecule
- ✓ This interaction is necessary for the T cell to participate in the adaptive immune response

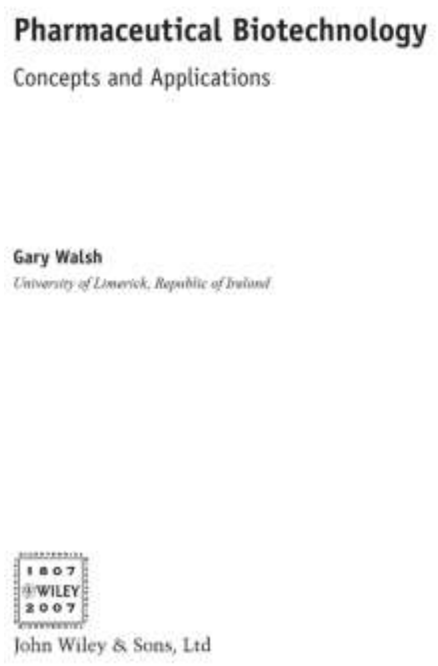


(a) Antigen recognition by a T cell



(b) A closer look at antigen presentation

Acknowledgement


Pharmaceutical Biotechnology

Concepts and Applications

Gary Walsh

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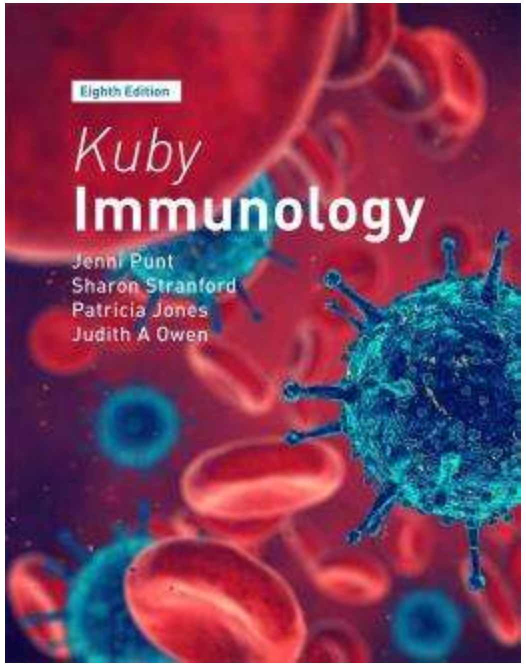

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