

## Chapt. 43 – The Immune System

How does the human body defend against invaders? [Fig. 43.2]

### External defenses

**Skin** is an inhospitable barrier of dead, dry cells, & **secretions** containing **oil** & **lactic acid**  
**Mucous membranes** in respiratory, digestive & urogenital tracts secrete **mucus** & antibiotic chemicals (*e.g.*, **lysozyme**, which digests bacterial cell walls)

If external defenses are not effective – **nonspecific, innate response**

Four types of **phagocytic leucocytes (WBCs)** engulf invaders (*e.g.*, **macrophages, dendritic cells**) [Fig. 43.4]

**Natural killer cells (WBCs)** – destroy infected cells & cancer cells by inducing **apoptosis** (programmed cell death)

**Antimicrobial proteins** – (*e.g.*, **lysozyme**) produced by many cells of the body, often in response to infection; actively destroy microbes

**Local inflammatory response** – injury or pathogens can cause **mast cells** of **connective tissues** to release **histamine**, triggering dilation and increased **permeability** of **capillaries**

**Fever** – **systemic (widespread) response** that increases the body's thermostat

**Immune system** – mounts attack on specific disease agents

2 main types of **lymphocytes (WBCs)**:

**B cells** – [Fig. 43.10]

produced in bone marrow; differentiate in bone marrow

**T cells** – [Fig. 43.10]

produced in bone marrow; differentiate in **thymus**

Mature B and T cells are found throughout the body in lymph and blood

### RECOGNITION

Lymphocytes recognize and respond to particular microbes and foreign molecules, *i.e.*, they display **specificity**

A foreign molecule that induces an immune response is known as an **antigen**

Multiple **antibodies** may recognize the same **antigen** by different **epitopes** (small accessible portions of the larger molecule) [Fig. 43.7]

**B cells** produce **antibodies**, that are either secreted out of the cells or remain embedded in the **B cell** membranes, and that bind to **antigens**

**T cells** have **T-cell receptors**, embedded in their cell membranes, that bind to **antigens**

Even though many **receptors (antibodies or T-cell receptors)** encounter a given type of **antigen**, only the **receptors** that are compatible will bind to them [Fig. 43.12]  
This process is known as **clonal selection**

Secreted **antibodies** constitute a group of proteins called **immunoglobulins** [Fig. 43.8]  
Antibodies have 2 **heavy chain** and 2 **light chain subunits**  
Each **subunit** has a **constant region** and a **variable region**  
The **variable region** can bind to an **antigen**

Recognition of **non-self** molecules

Construction of **antibodies** (and **T-cell receptors**)

Millions of **antigens** are recognized by randomly combining the protein products of hundreds of genes

Card analogy: although there are only 52 cards in the deck, random combinations can produce an enormous number of different hands

Recognition of **self** molecules

In a healthy **immune system**, as **B** and **T cells** mature they are destroyed by **apoptosis** if they attack self molecules

Healthy, mature **B** and **T cells** then have the capacity to distinguish self from non-self molecules

Almost all cells in an individual human's body have **major histocompatibility complex (MHC) glycoproteins** embedded in their cell membranes

**Class I MHC** molecules are found on almost every nucleated cell

**Class II MHC** molecules are restricted to a few specialized cells, including **macrophages, dendritic cells, B cells, etc.**

**MHC glycoproteins** migrate to the cell membrane after they are produced

**MHC glycoproteins** pick up molecules from the cytosol that are presented at the cell's surface

**T cells** bind to **MHC glycoproteins** and the molecules they present

An individual's own **MHC glycoproteins**, and molecules of its own body that the **MHC glycoproteins** present, are treated as self

However, **T cells** recognize foreign molecules presented by **MHC glycoproteins** as **antigens** [Fig. 43.9]

**Cytotoxic T cells** bind to cells that carry **Class I MHC glycoproteins**

**Helper T cells** bind to cells that carry **Class II MHC glycoproteins**

## **ATTACK & MEMORY**

The **B** and **T cells** that recognize a given foreign **antigen** produce two types of clones: **effector cells (attackers)** and **memory cells** [Fig. 43.12]

The **B** and **T cells** that first recognize a given foreign **antigen** are short lived, whereas **immune memory cells** can have long lifetimes  
Memory cells help produce a **secondary immune response** that is faster, of greater magnitude, and of longer duration than the **primary immune response** [Fig. 43.13]

There are two types of immune response:

**Humoral response**

**B cells** and **antibodies**

Attack **antigens** that have not yet infected cells (toxins, bacteria, and viruses in body fluids)

**Deactivate, coat, and clump** antigens (which are then often engulfed and destroyed by **macrophages**)

**Cell-mediated response**

**T cells**

Attack **antigens** after they have entered cells, as well as fungi, protozoa, and parasitic worms

**Activated T cells** kill antigen-containing cells by creating pores in their cell membranes

**Summary of Recognition, Attack & Memory = Fig. 43.14**

**Humoral immune response**

Involves the **activation** and **clonal selection** of **B cells**

Results in the production of **antibodies** that circulate in the **blood** and **lymph**

**Cell-mediated immune response**

Involves the **activation** and **clonal selection** of **cytotoxic T cells**

**Cytotoxic T cells** directly destroy certain target cells

A **primary immune response** begins with the first exposure to an **antigen**

A **secondary immune response** begins with a re-exposure to an **antigen**, and stimulates **memory cells**

Medical practices can augment our immune response by inhibiting invaders or enhancing the immune response

**Antibiotics**

Inhibit microbial reproduction

Potent agents of natural selection

**Vaccines** (weakened or dead microbes, or their toxins)

Stimulate development of memory cells = faster response to invasion

Selectively effective

The immune system and blood types [Table 43.1]

What happens when the immune system malfunctions?

### Allergies

Exaggerated immune responses to otherwise benign substances [Fig. 43.20]

1. **Antibodies** are produced
2. Stems of **antibodies** attach to **mast cells**, especially in the respiratory tract
3. When **antibodies** attached to **mast cells** bind **antigens**, the **mast cells** release **histamine**, which causes **inflammation**

### Autoimmune diseases

The immune system lacks or loses its ability to distinguish self vs. non-self molecules, *i.e.*, it loses its **self-tolerance** and produces **anti-self antibodies**

Examples:

Rheumatoid arthritis (attacks cartilage of joints)

Multiple sclerosis (attacks myelin sheaths of neurons)

Insulin-dependent diabetes mellitus (attacks insulin-secreting cells of the pancreas)

### Immunodeficiency diseases

Inhibit effective immune response; either **inherited** or **acquired**

Examples:

Severe Combined Immunodeficiency (SCID)

An inherited disorder

### Acquired Immunodeficiency Syndrome (AIDS)

Caused by retroviruses (**Human Immunodeficiency Viruses – HIV**) that especially infect helper T cells

Adults and children estimated to be living with HIV as of the end of 2001: 40 million

Estimated number of deaths from AIDS during 2001: 3 million

The global AIDS epidemic:

HIV destroys helper T cells – Victims die from other diseases

Transmission – Direct contact between broken skin, mucous membranes & body fluids

No cure

Treatments = inhibitors of reverse-transcriptase and protease

Problem = virus evolves quickly

How to reduce your risk: Practice safe sex & avoid used needles

### Cancer

Malfunction in cell production combined with a lack of recognition by the immune system of aberrant cells or too many of them

Uncontrolled growth = **tumor**

Causes: Carcinogens, viruses, inheritance

No guaranteed cure: Most treatments also destroy healthy cells

How to reduce your risk: Reduce exposure to **carcinogens**