Immunology and Vaccines

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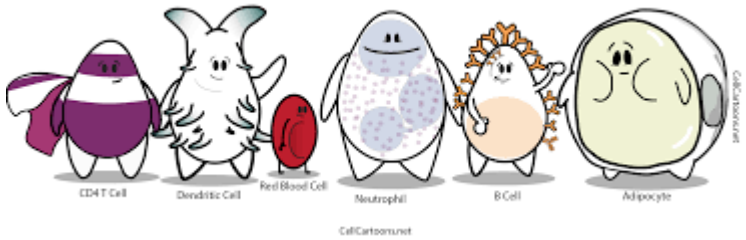


Objectives

- **Definition of Immunology**
- **Importance of Immunology**
- **Historical background of Immunology**
- **Modern Immunology**
- **Outline the major principles of the human immune response (innate immunity, humoral immunity, and adaptive immunity)**

Introduction

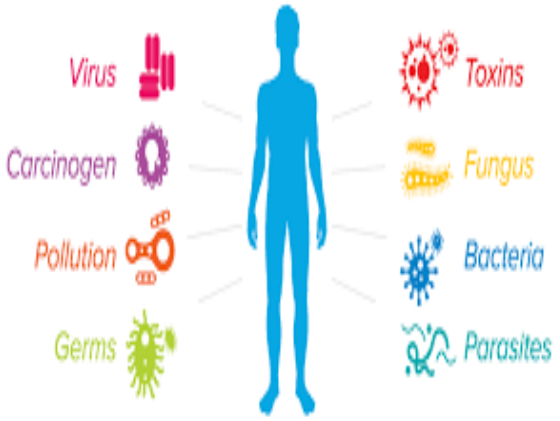
- **Immunology** stems from
  - Latin - *immunis* = “exempt;”
  - English = protection from disease

- **Immunology is the study of our protection from foreign macromolecules or invading organisms and our responses to them.**

Definitions

- **Immune system** = cells, tissues, and molecules that mediate resistance to infections
- **Immunology** = study of structure and function of the immune system

- **Immunity** = resistance of a host to pathogens and their toxic effects
- **Immune response** = collective and coordinated response to the introduction of foreign substances in an individual mediated by the cells and molecules of the immune system



Role of the immune system

- Defense against microbes
- Defense against the growth of tumor cells
  - ✓kills the growth of tumor cells
- Homeostasis
  - ✓destruction of abnormal or dead cells (e.g. dead red or white blood cells, antigen-antibody complex)

Virus vs. Bacteria

- **Colds and influenza are caused by viruses.**
- **Viruses are which is a non-living particle that contains genetic material, and hijacks your cells to reproduce.**
- **Viruses cannot be “killed” with antibiotics.**

- **Bacteria are living organisms that have a metabolism, have DNA, and can reproduce on their own.**
- **Bacteria can be killed with antibiotics because these substances target key processes in bacteria, such as production of the bacterial cell wall.**

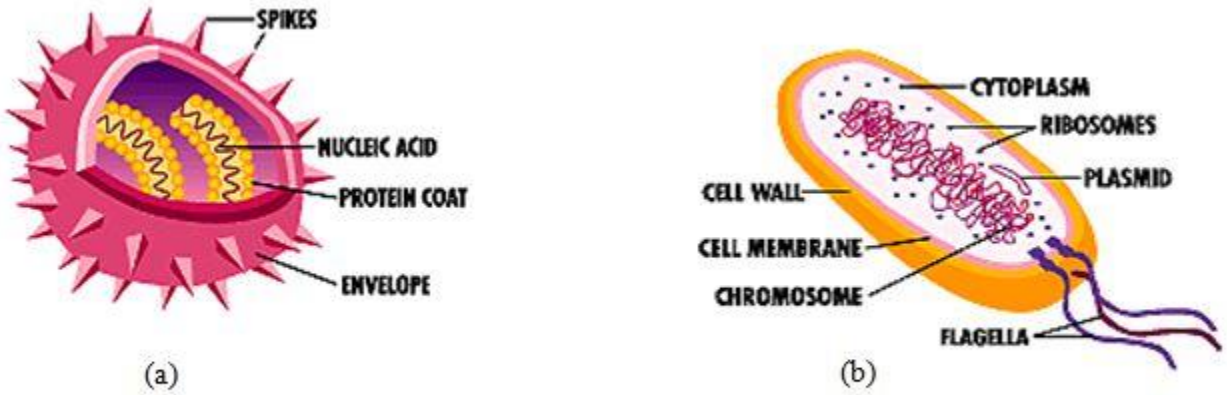
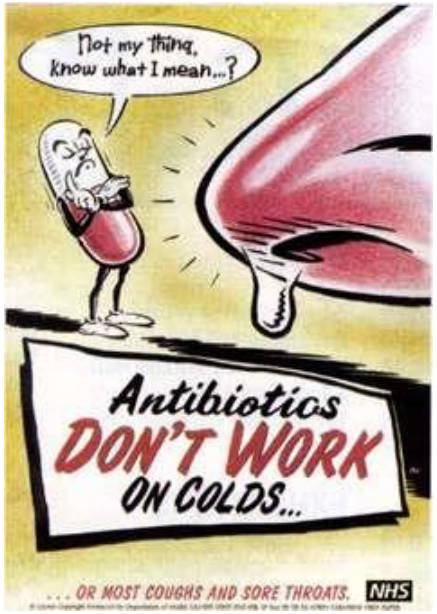
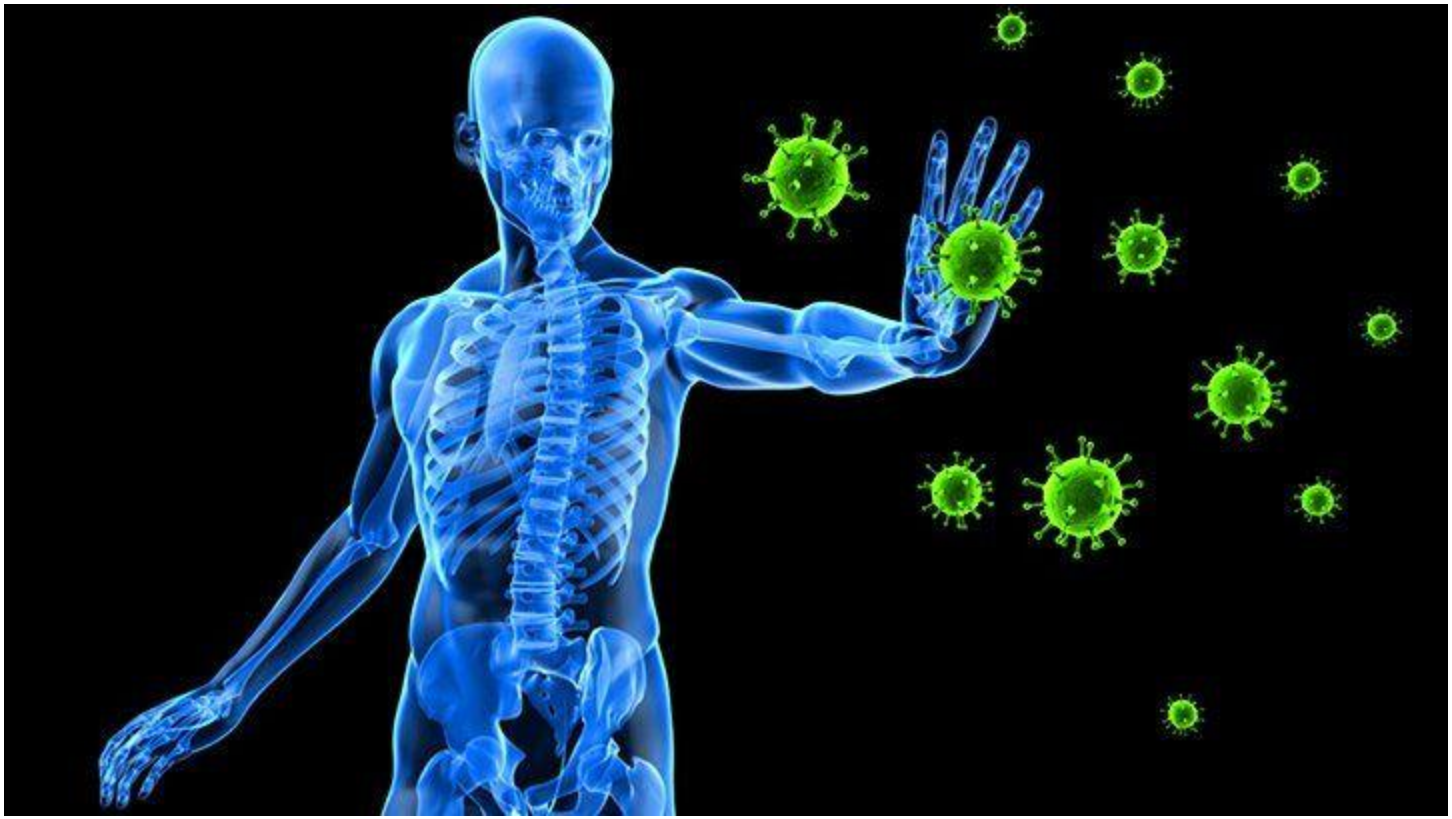


Figure: (a) Components of virus, (b) components of bacteria



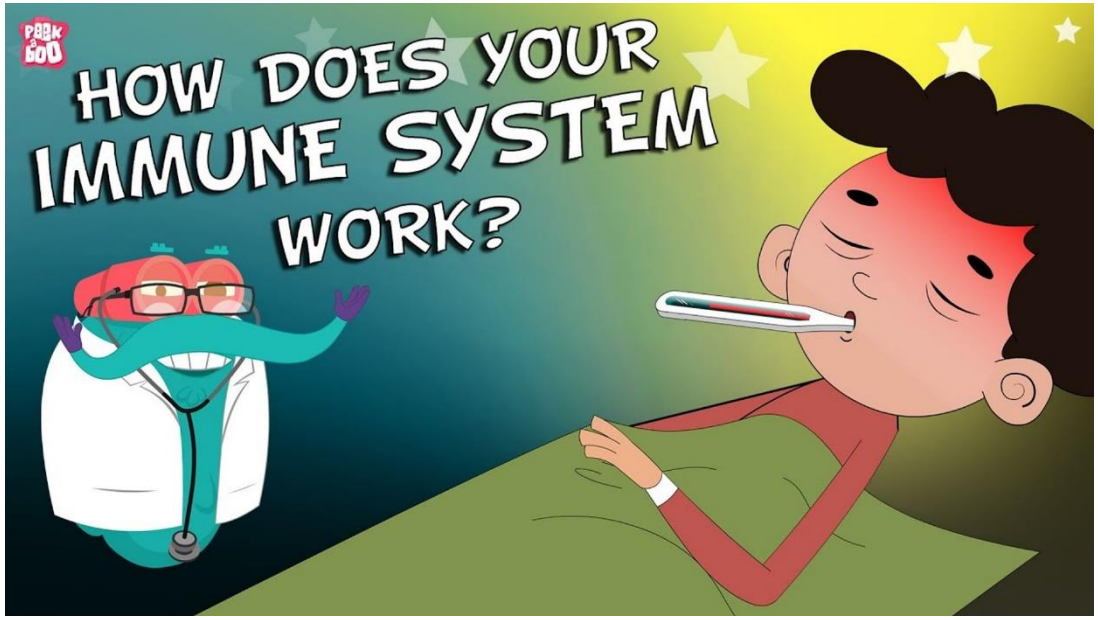
Viruses and bacteria are everywhere. Some of them want to invade your body.

How does your body defend itself against viruses and bacteria?



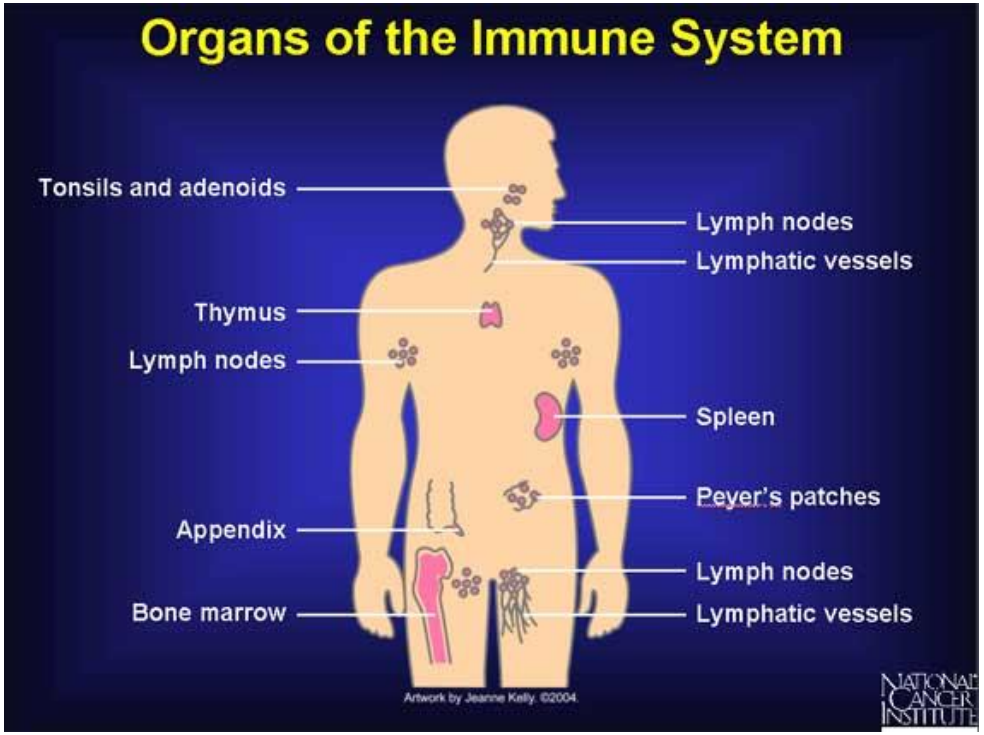
Immune System

1. **Organs**
2. **Cells**
3. **Molecules**



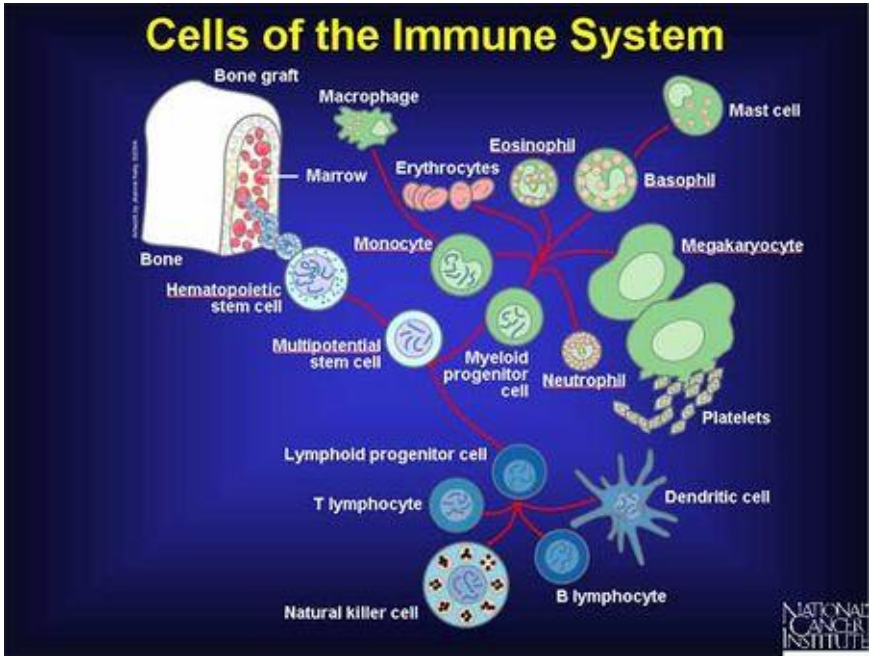
Immune System: (1) organs

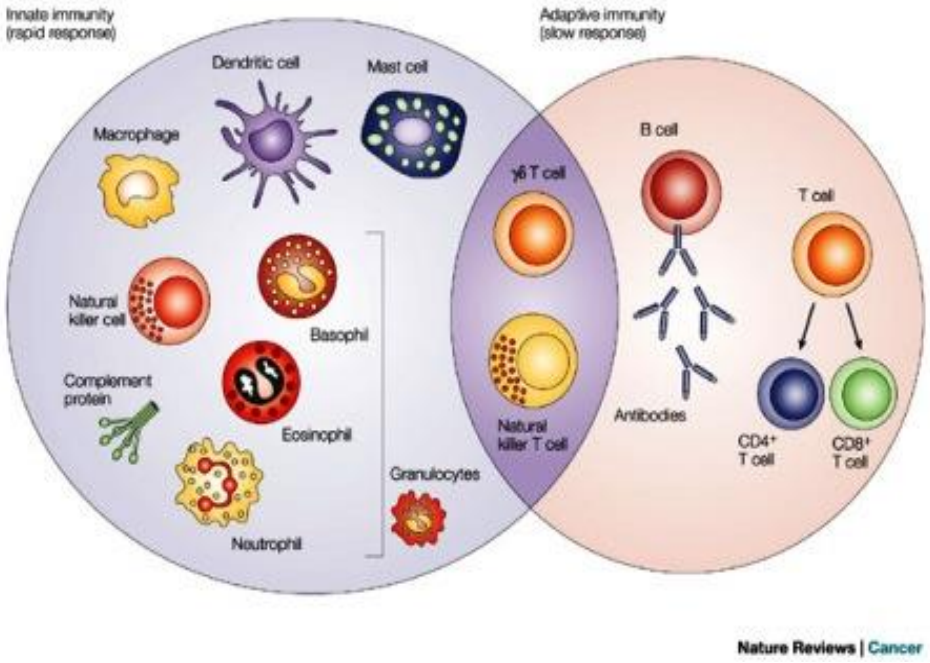
- **Tonsils and adenoids**
- **Thymus**
- **Lymph nodes**
- **Spleen**
- **Payer's patches**
- **Appendix**
- **Lymphatic vessels**
- **Bone marrow**



Immune system: (2) cells

- **Lymphocytes**
  - T-lymphocytes
  - B-Lymphocytes, plasma cells
  - natural killer lymphocytes
- **Monocytes, Macrophage**
- **Granulocytes**
  - neutrophils
  - eosinophils
  - basophils





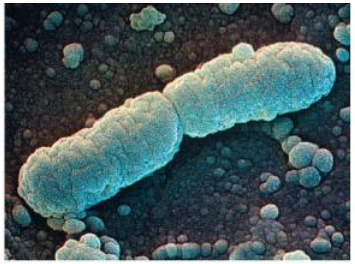
Immune system: (3) molecules

- **Antibodies**
- **Complement**
- **Cytokines**
- **Interleukins**
- **Interferons**

Two types of immunity

1. **Innate (non-adaptive)**
   - first line of immune response
   - relies on mechanisms that exist before infection
2. **Acquired (adaptive)**
   - Second line of response (if innate fails)
   - relies on mechanisms that adapt after infection
   - handled by T- and B- lymphocytes
   - one cell determines one antigenic determinant

Defense Against Disease



Nonspecific External Barriers
skin, mucous membranes

If these barriers are penetrated,
the body responds with

Innate Immune Response
phagocytic and natural killer cells,
inflammation, fever

If the innate immune response is insufficient,
the body responds with

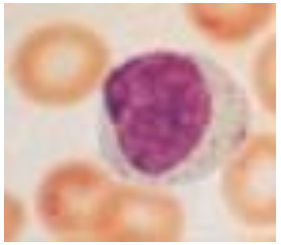
Adaptive Immune Response
cell-mediated immunity, humoral immunity

Innate immunity

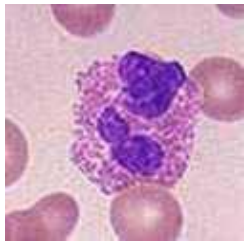
- Based on genetic make-up
- Relies on already formed components
- Rapid response: within minutes of infection
- Not specific
  - same molecules / cells respond to a range of pathogens
- Has no memory
  - same response after repeated exposure
- Does not lead to clonal expansion

Innate immunity: mechanisms

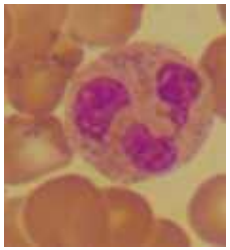
- **Mechanical barriers / surface secretion**
  - skin, acidic pH in stomach, cilia
- **Humoral mechanisms**
  - lysozymes, basic proteins, complement, interferons
- **Cellular defense mechanisms**
  - natural killer cells neutrophils, macrophages,, mast cells, basophils, eosinophils



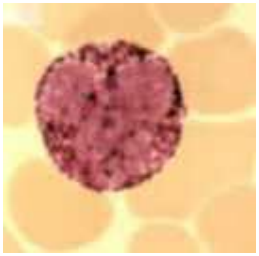
NK Cell



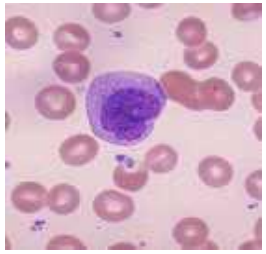
Eosinophils



Neutrophil



Basophils & Mast cells



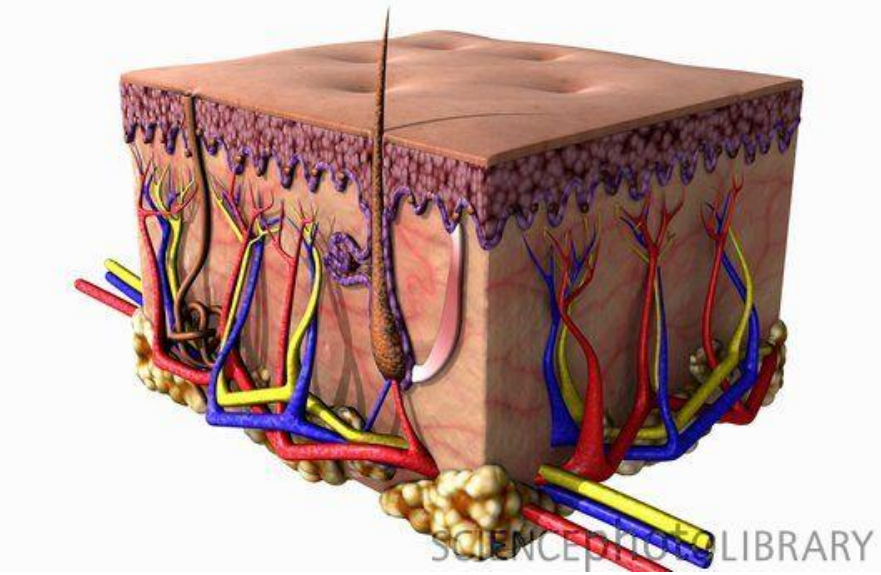
Monocyte Macrophage

First line of defense

- **Non-specific** defenses are designed to prevent infections by viruses and bacteria. These include:
  - **Intact skin**
  - **Mucus and Cilia**
  - **Phagocytes**

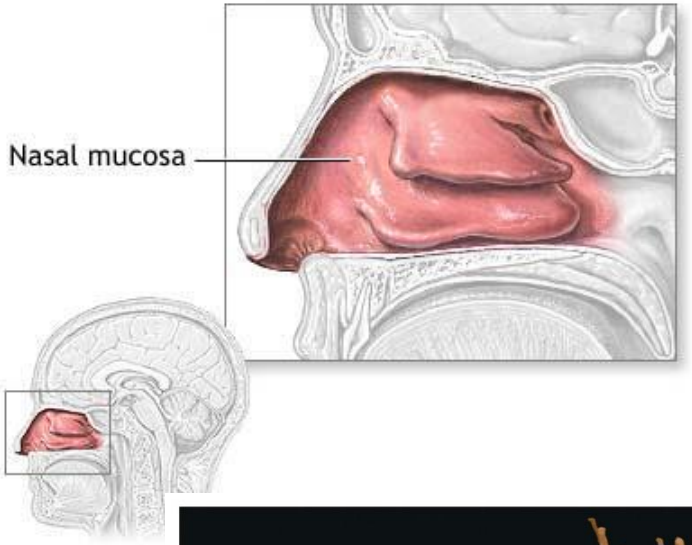
Role of skin

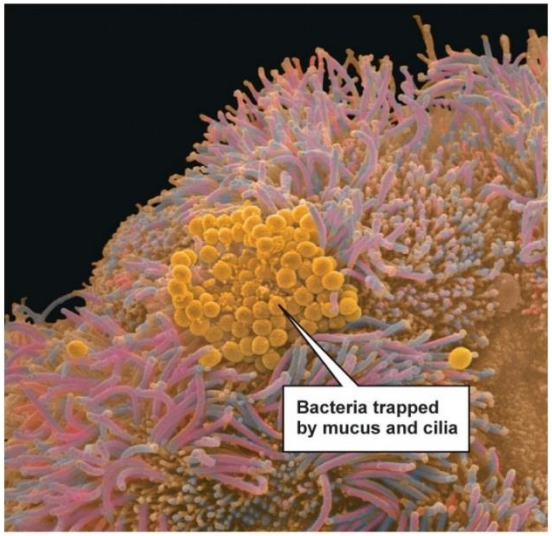
- Dead skin cells are constantly sloughed off, making it hard for invading bacteria to colonize.
- Sweat and oils contain anti-microbial chemicals, including some antibiotics.



Role of mucus and cilia

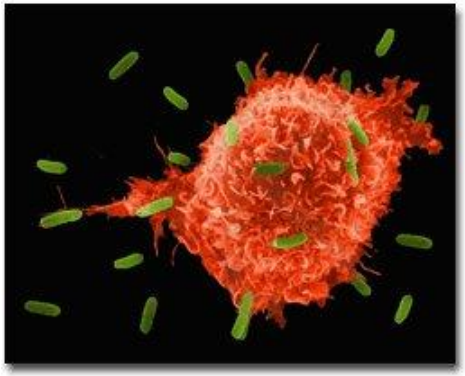
- Mucus contains lysozymes, enzymes that destroy bacterial cell walls.
- The normal flow of mucus washes bacteria and viruses off of mucus membranes.
- Cilia in the respiratory tract move mucus out of the lungs to keep bacteria and viruses out.

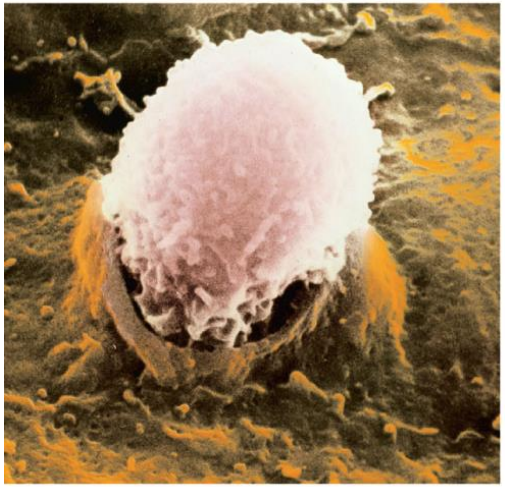




Role of phagocytes

- Phagocytes are several types of white blood cells (including macrophages and neutrophils) that seek and destroy invaders. Some also destroy damaged body cells.
- Phagocytes are attracted by an inflammatory response of damaged cells.





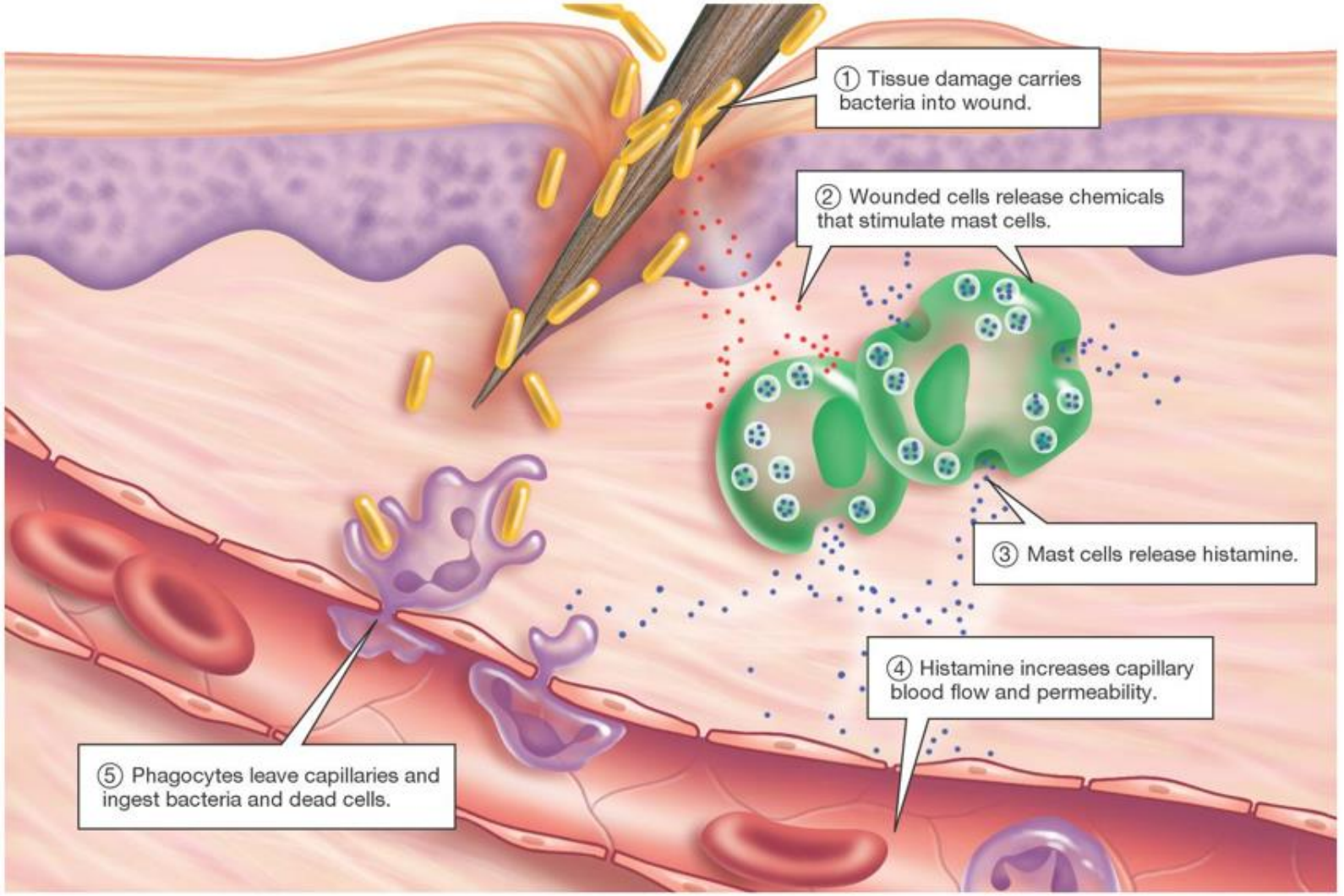
Role of inflammation

- Inflammation is signaled by mast cells, which release histamine.
- Histamine causes fluids to collect around an injury to dilute toxins. This causes swelling.
- The temperature of the tissues may rise, which can kill temperature-sensitive microbes.

Role of fever

- Fever is a defense mechanism that can destroy many types of microbes.
- Fever also helps fight viral infections by increasing interferon production.
- While high fevers can be dangerous, some doctors recommend letting low fevers run their course without taking aspirin or ibuprofen.

Ouch!


① Tissue damage carries bacteria into wound.
② Wounded cells release chemicals that stimulate mast cells.
③ Mast cells release histamine.
④ Histamine increases capillary blood flow and permeability.
⑤ Phagocytes leave capillaries and ingest bacteria and dead cells.

Fever is caused by:

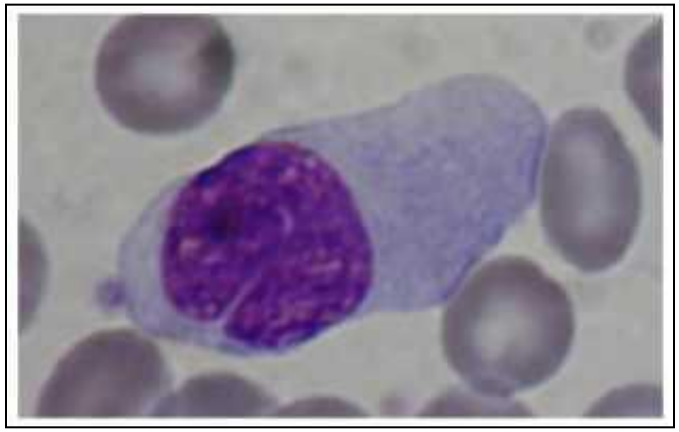
1. Toxins on the surface of viruses.
2. Release of histamines by damaged cells.
3. Your own body's accumulated toxins.
4. Your body's pyrogens signaling the hypothalamus.

Adaptive immunity: second line of response

- Based upon resistance acquired during life
- Relies on genetic events and cellular growth
- Responds more slowly, over few days
- Is specific
  - each cell responds to a single epitope on an antigen
- Has anamnestic memory
  - repeated exposure leads to faster, stronger response
- Leads to clonal expansion

Adaptive immunity: mechanisms

- Cell-mediated immune response (CMIR)
  - T-lymphocytes
  - eliminate **intracellular** microbes that survive within phagocytes or other infected cells
- Humoral immune response (HIR)
  - B-lymphocytes
  - mediated by antibodies
  - eliminate **extra-cellular** microbes and their toxins

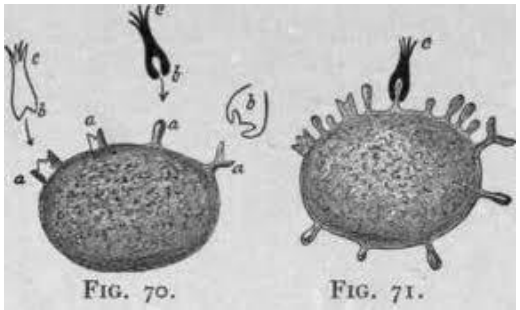


Plasma cell
(Derived from B-lymphocyte, produces antibodies)

History of Immunology

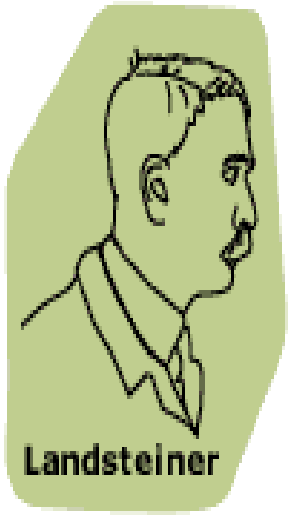
- 430 B.C.: Philosophers noted resistance to plague by those who recovered “Only those who had recovered from plague can nurse for sick people because they would not contract the disease a second time”
- 15th century: Chinese and Turks use dried crusts of smallpox by inhalation or introduction into small cut of skin in order to prevent the disease
- 1796: Edward Jennar discovered that cowpox vaccination protected against smallpox. He inoculated an 8 years boy with fluids from a cowpox pustule and then intentionally infected the boy with smallpox but the child did not develop the disease

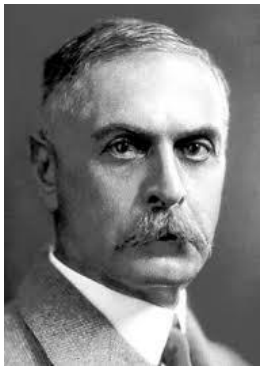
- In 1880: Pasteur discover Anti-cholera live-attenuated vaccine. He noticed that old cultures in his lab did not kill chicken after inoculation and that chicken become immune to cholera. He applies the same principle for anthrax and rabies vaccine
- In 1890: Von Behring and Kitasato discover diphtheriae antitoxin. They notice that serum from animals previously immunized to dipthteria could transfer the immune state to unimmunzed animals
- 1883 Ellie Metchinkoff that cells like phagocytes contribute to the immune state of animals

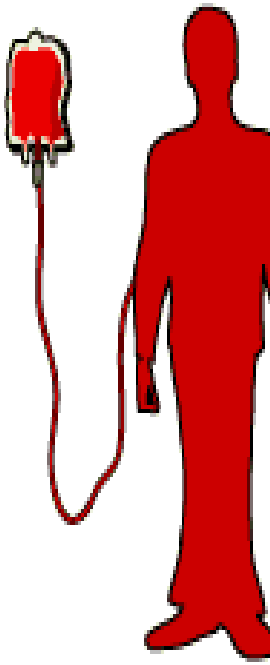


Blood Grouping and Immunology

- Experiments with blood transfusions have been carried out for hundreds of years with out any success.
- In 1901, Karl Landsteiner discovered human blood groups, and blood transfusions became safer.
- He found that mixing blood from two individuals can lead to blood clumping. The clumped RBCs can crack and cause toxic reactions. This can be fatal.
- Karl Landsteiner work on blood grouping has discover the fundamental principles of Immunology







Modern Immunology

According to modern theory:

- The body depends on the immune system to fight against various infections from bacteria, microbes, viruses, toxins and parasites.
- When immune system is normal, health can be maintained.
- When the immune system is malfunctioning, disharmony will occur and give rise to illness.
- So the above functions are carried out by an integrated body system, which includes:

✓Organs (thymus, spleen and lymph node)

✓Tissues (skin and mucosal layers)

✓Cells (lymph cells and macrophage)

✓Cell products (immunoglobulin, antibodies and complement).

Immune system

Innate (non-specific) immunity

- Anatomic barriers (Skin,mucous membranes)
- Physiological 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

Humoral

Cellular

Immunology- The Balance