Immunology

Lecture 1: Introduction

Immunology

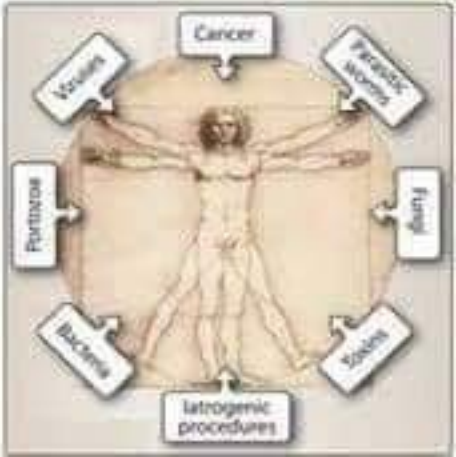
- is a branch of biomedical sciences that study host defence against infectious diseases and foreign (non-self) antigens.

composed of many cell types,

the majority of which are

organized into separate lymphoid

tissues and organs.



Immunity

- Immunity: is continuous dynamic process of normal (physiological) protective mechanisms (Anti infective) ensuring body health and normal processes.
- Other wise, It will be abnormal:

1. Immunodeficiency.
2. Hypersensitivity.
3. Autoimmunity.
4. Failure in monitoring of abnormal growth (tumors).

types of immunity

- There are two types of defence mechanisms:
- 1. **None specific (innate) defence mechanism.** The first line of defence, which is nonspecific to the invading pathogen, is rapidly mobilized at the initial site of infection but lacks immunologic memory.
- 2. **Specific (acquired) defence mechanism.** It is specific for the pathogen and can confer protective immunity to reinfection with that pathogen.

Immune system has 2 arms: Innate and Adaptive

Immense Immunology Insight

Adaptive

It comprimises of
Lymphocytes
Antigen presenting cells

Innate

Bodys first line of defence
includes four main types of defensive barriers

Physical or Anatomical barrier
Physiological barrier
Phagocytic barrier
Inflamatory barrier

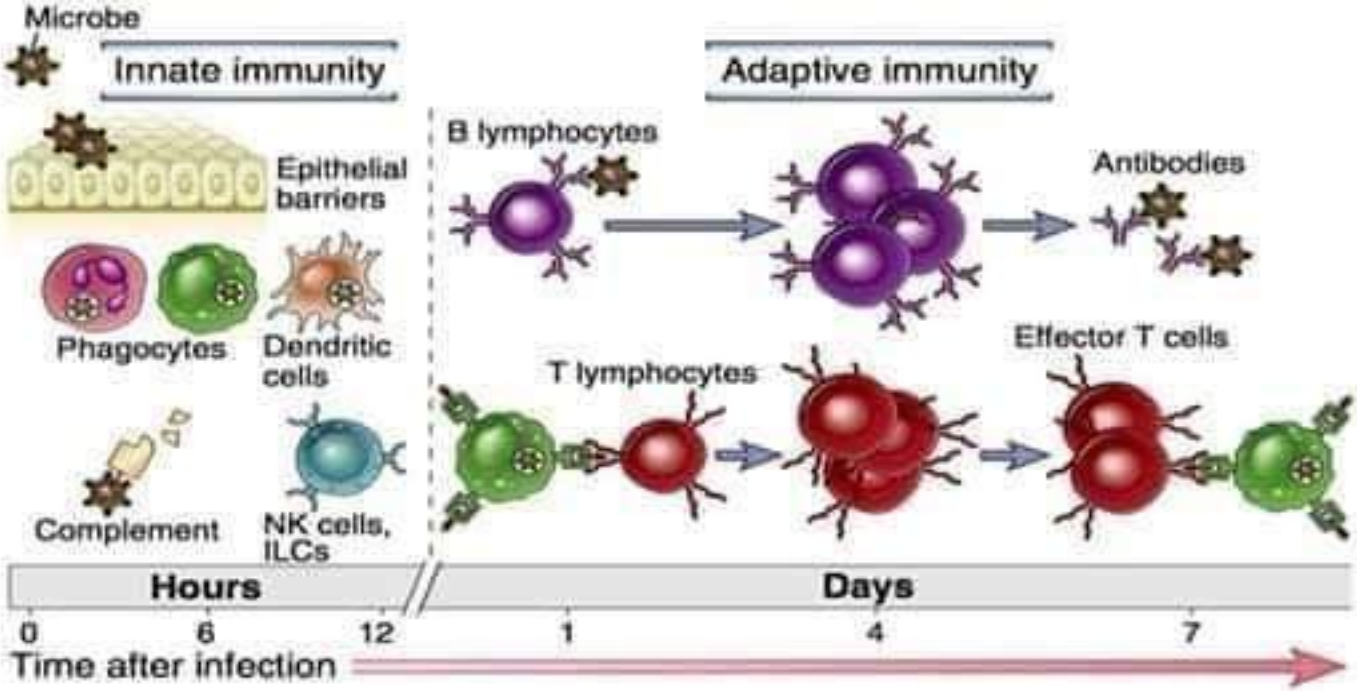


FIGURE 1-1 Innate and adaptive immunity. The mechanisms of innate immunity provide the initial defense against infections. Adaptive immune responses develop later and require the activation of lymphocytes. The kinetics of the innate and adaptive immune responses are approximations and may vary in different infections. *ILC*, innate lymphoid cell; *NK*, natural killer.

Factors affecting immunity:

1. Genetics.
2. Age.
3. Protein–calorie malnutrition or deficiency of vitamin A, vitamin C, and folic. acid makes an individual highly susceptible to infection by many microbial pathogens.

Factors affecting immunity:

4. Hormonal levels: an increase in corticosteroids decreases the inflammatory response and lower the resistance to infection.

5. Oxygen tension, which is especially high in the lung and inhibit the growth of anaerobic bacteria.

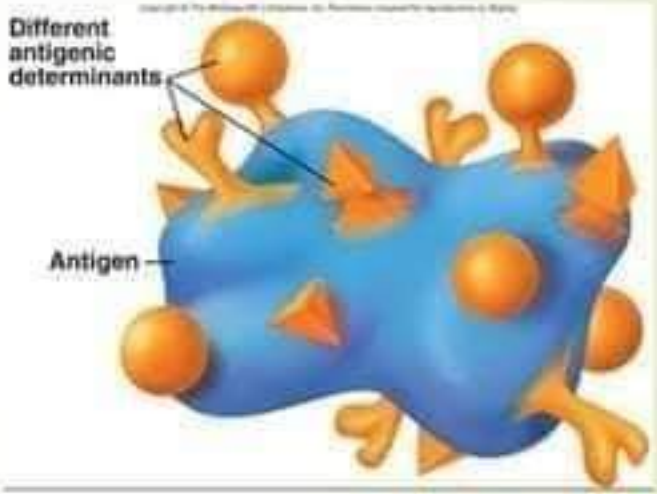
6. Body temperature, many organisms does not infect human because they cant grow at 37.

Antigen

"Antigen"
An organism, a molecule, or part of a molecule that is recognized by the immune system.

It may be simple or complex, protein, carbohydrate, or synthetic in origin.

"Epitope" (antigenic determinant)
The basic recognition unite. a part of antigen that recognized and bound by recognition molecules.



Immunogen vs. Hapten

Immunogens (Complete antigen)

epitopes can induce an immune response and are the targets of that response.

High MW.

Haptens (Incomplete antigen)

Haptens are antigens and can bind to immune receptors but cannot by themselves induce a specific immune response and hence are not immunogenic.

small (low MW), normally nonimmunogenic, unless they bound to an immunogen (also called a carrier), immune responses may be generated against both the hapten and the epitopes on the immunogen.

Chemical nature of immunogen

Proteins

The vast majority of immunogens are proteins. These may be pure proteins or they may be glycoproteins or lipoproteins. In general, proteins are usually very good immunogens.

Polysaccharides

Pure polysaccharides and lipopolysaccharides are good immunogens.

Nucleic Acids

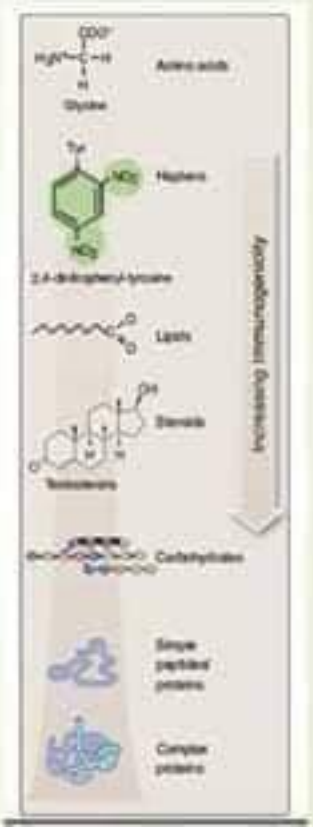
Nucleic acids are usually poorly immunogenic. However, they may become immunogenic when single stranded or when complexed with proteins.

Lipids

In general lipids are non-immunogenic, although they may be haptens.

Factors that enhance Immunogenicity

1. **Foreignness:** self vs. non self.
2. **Size:** >10 kDa are usually more immunogenic.
3. **Chemical and structural complexity:** Complex proteins with numerous, diverse epitopes are more likely to induce an immune response than are simple peptides that contain only one or a few epitopes. Proteins are more immunogenic than carbohydrates, steroids, and lipids. Amino acids and haptens are, by themselves, not immunogenic.
4. **Conformation and accessibility:** Epitopes must be "seen by" and be accessible to the immune system.
5. **Dosage, route, and timing of antigen administration**



Immune system

Consists of many organs, tissues and cells that are found throughout the body.
Dynamic nature of Innate and Adaptive immune system is due to the circulatory capacity of immune cells.
Some of them were fixed in tissues.

Primary Lymphoid Organs

- Also called "central lymphoid organs"
- It is where immature lymphocytes develop
- Organs where differentiation, proliferation and maturation of stem cells into immuno competent cells take place.

Includes:

- Thymus
- Bone Marrow

Secondary Lymphoid Organs

- It is where antigen is localized so that it can be effectively exposed to mature lymphocytes.
- initiate adaptive immune response.

Includes:

- Spleen
- Lymph Nodes
- Tonsils
- Appendix
- Peyer's patches

- THYMUS

- A bilateral organ located in the mediastinum
- Attains its peak development during youth
- Where T lymphocytes are formed

Function:

Generate and select T cells that will protect the body from infection.

- BLOOD MARROW

- The site of B cell maturation and hematopoiesis

Function:

Responsible for the production of important immune system cells like B cells, granulocytes, natural killer cells and immature thymocytes. Also produces platelets and RBC.

Peripheral organs

LYMPH NODES

Bean-shaped, encapsulated structures distributed throughout the body along the course of lymphatic vessel.

They are made up of mostly B-cells, T-cells, macrophages and dendritic cells.

Function:

They act as immunologic filters and drain the lymph from most of the body tissues and filter out the antigens present in them, before allowing the lymph to return to circulation.

Peripheral organs

SPLEEN

Organ of the immune system composed of T-cells, B-cells, natural killer cells, macrophages, dendritic cells and red blood cell.
It is a production site of antibodies and activated lymphocytes, which are delivered to the blood.

Function:
Filters the blood and entraps foreign materials (antigen).
Provides defense against blood-borne antigens.

TONSILS

Two masses of soft glandular tissue on either side or the back of the mouth.
Function:
Traps bacteria and viruses from inhaled air.

APPENDIX

Thin, dead-end tube measuring about three-to-four inches in length and it hangs from the cecum.
Functions:
Help tell the lymphocytes exactly where they have to head over to attack infection and it also enhances the massive intestine's defenses to a range of drugs and foods.

PEYER'S PATCHES

The nodules of lymphatic cells that combine to make patches or bundles and appear generally only within the lowest part of intestine (ileum)
Functions:
Detect antigens such as bacteria and toxins and mobilize highly specialized white blood cells termed B-cells to produce an antibody.

NEUTROPHIL

IMMENSE IMMUNOLOGY INSIGHT

Count
40% - 60% in peripheral blood

Cytoplasmic Granules
- Neutrally staining
- Pink in color

Multilobed nucleus

Killing strategy
- Go to the battlefield (Chemotaxis)
- Recognize enemy (IgG & C3b receptors)
- Eat them up (Phagocytosis)

EOSINOPHIL

IMMENSE IMMUNOLOGY INSIGHT

Count
1% - 3% in peripheral blood

Bilobed nucleus
- Spectacle shaped

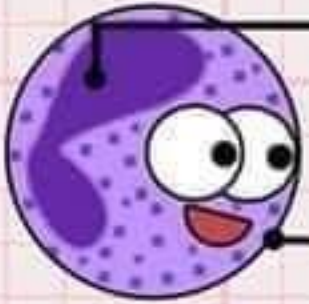
Cytoplasmic granules
- Bright pink in color
- Small in size

Killing strategy
- Go to the battlefield (Chemotaxis)
- Recognize target (via Fc receptors)
- Eat (Phagocytosis)
- Chemical attack
(Release toxic contents of granules)

BASOPHIL

IMMENSE IMMUNOLOGY INSIGHT

Count
<1% in peripheral blood



Bilobed nucleus
- Less distinct indentations
- Long "ribbon-like"

Cytoplasmic granules
- Purple in color

Killing strategy
- Go to the battlefield (Chemotaxis)
- Recognize target (Cross-linkage of receptor bound IgE molecules by antigen)
- Explode (Degranulation)

Monocyte

Immense Immunology Insight

Count
1% - 6% in peripheral blood

Abundant cytoplasm
- Pale blue
- Agranular

Kidney-bean shaped nucleus

Killing strategy
- Go to the battlefield (Chemotaxis)
- Eat (Phagocytosis)
- Transformer mode (Transforms into larger phagocytic cell, the macrophage)

Dendritic cell

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Expresses high levels of MHC class II

Long cytoplasmic processes
For efficient antigen presentation

Killing strategy
- Ingests the enemy (Phagocytosis)
- Ingests ECF and contents (Macropinocytosis)
- Shows it to other cells (Antigen presentation)
- Activates them (Via co-stimulatory signals)

Natural Killer

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Expresses
CD16 glycoprotein
CD 56 glycoprotein

Killing strategy

① Recognize antigen combined with class I MHC (altered self cells)

② Signal for activation:
- IFN - α
- IFN - β
- IL-12

③ Releases cytotoxic proteins:

- Perforin: Forms a pore for delivery of granzymes
- Granzymes: Programmes cell to die

Helper T cell

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Expresses
CD4 glycoprotein
(CD4+ T cells)

Warrior types

T_H1 cells
Activates:
- Macrophages
- Killer T cells
- B cells

Secretes:
- IFN - γ
- IL - 2
- TNF - α

T_H2 cells
Activates:
- Eosinophils
- Mast cells
- Basophils

Secretes:
- IL - 4
- IL - 5
- IL - 13

T_{FH} cells
Activates B cells for:
- Isotype switching
- Affinity maturation

T_H17 cells
Recruits:
- Neutrophils

Secretes:
- IL - 17

T_{reg} cells
Inhibits dendritic cells:
- Prevents autoimmunity
- Supresses T cell

Lymphocytes
B cells & T cells

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Count
20% - 40% in peripheral blood

Round nucleus
- Large
- Dark staining

Scanty cytoplasm
- Thin rim around the nucleus
- Pale eosinophilic
- Barely visible

Killing strategy
Coming soon!

To be continued...

B CELL

Immense Immunology Insight

Count
20% of total lymphocytes

War strategy

① Recognize enemy (B cell receptor)

② Recieve signal for activation:
- Show antigen to CD4 T cells (Antigen presentation)
- Recognize multiple crosslinking (Thymus independent activation)

③ Transform into:
- Plasma cell (Secretes antibodies)
- Memory B cell (For faster recognition of the same enemy in the future)

Antigen presenting cell (APC)

- ***Antigen-presenting cells (APCs) are cells that capture microbial and other antigens, display them to lymphocytes, and provide signals that stimulate the proliferation and differentiation of the lymphocytes.***
- ***Dendritic Cells***
  - ***Dendritic cells are the most important APCs for activating naive T cells, and they play major roles in innate responses to infections and in linking innate and adaptive immune responses.***
- Macrophages.
- B cells

Lymphocytes

- ***Lymphocytes, the unique cells of adaptive immunity, are the only cells in the body that express clonally distributed antigen receptors, each specific for a different antigenic determinant.***
- T lymphocytes (CD3)
  - $CD^{3+}CD^{4+}$ helper T lymphocytes.
  - $CD^{3+}CD^{8+}$ Cytotoxic T lymphocytes.
  - CD^{3+}, CD^{4+}, CD^{25+} $foxP^{3+}$: Regulatory T lymphocytes.
- B Lymphocytes:
- CD19 Plasma cells producing immunoglobulins.