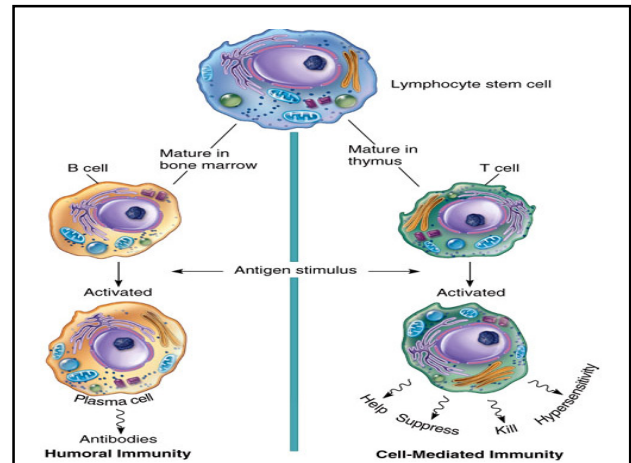


Chapter 15

Topics - Adaptive Immunity

- Second line of Defense
- B cells
- T cells

System has **Specificity** and **Memory**



Immune means free from burden.

The **immune system** consists of a number of organs, tissues, cells, cellular products and mechanisms that are coordinated to protect us from foreign insults.

Vulnerable is the opposite of immune and means susceptible to foreign insults.

Antigens are large molecules, generally proteins, although antigens may be carbohydrates, nucleic acids, etc.

Immunogens are antigens that can stimulate an immune response and are **immunogenic**.

Receptors

- Present on B and T cells
 - **BCR** on B cells - is an **ANTIBODY** - recognizes native antigen
 - **TCR** on T cells – a heterodimer that recognizes processed antigen that is presented on **MHC**
- B cell receptors are secreted as **antibodies**

Cytokines in Inflammation and Disease

Low molecular weight proteins secreted by white blood cells and other cells in response to stimuli, including invading pathogens

Inflammation and Disease

- **Th1 - type response** – **Cell Mediated Immunity**
IL-2, IFN- γ , IL-12
- **Th2 - type response** – **Humoral Mediated Immunity**
IL-4, IL-10, IL-13

Two arms of the adaptive immune system

Humoral immunity - B cells mature into mature plasma cells when they encounter foreign antigen.

Cellular immunity - certain types of T cells

Two classes of T cells - T_H (T helper cells) and T_C (cytotoxic T cells)

B cells and T cells can be distinguished by phenotypic markers on their surfaces called cellular differentiation or CD markers.

B cells - CD19, CD20, CD21 - SURFACE ANTIBODY

T_H cells - CD4

T_C cells - CD8

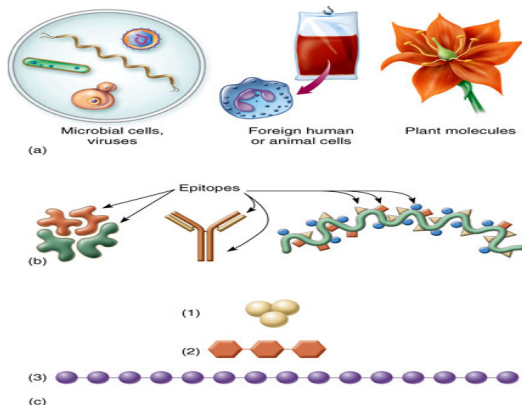
NK cells - CD16, CD56

Properties of antigens

An antigen is a foreign substance that has the capability to elicit an immune response

The sites on the antigen that are immunogenic are the **epitopes**

Characteristics of antigens



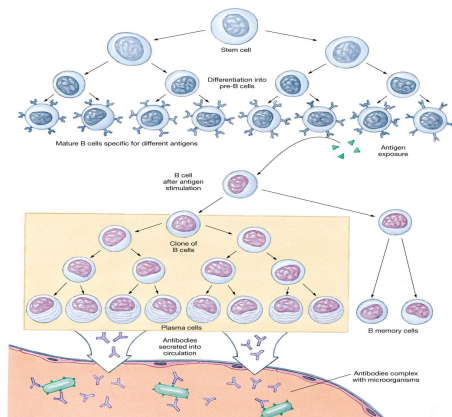
Superantigens

- Bacterial toxins
- T cell activation much greater than normal antigens
- Large release of cytokines
- Results in toxic shock syndrome and some autoimmune diseases
- *S. aureus* releases TSST

Humoral immunity

Immune response distinguishes foreign from self

Clonal selection - An antigen is presented by an APC to a specific B cell that is specific for the antigen. The B cell proliferates into a plasma cell that secretes antibody specific for the epitope presented by the APC. **Memory cells also!!**

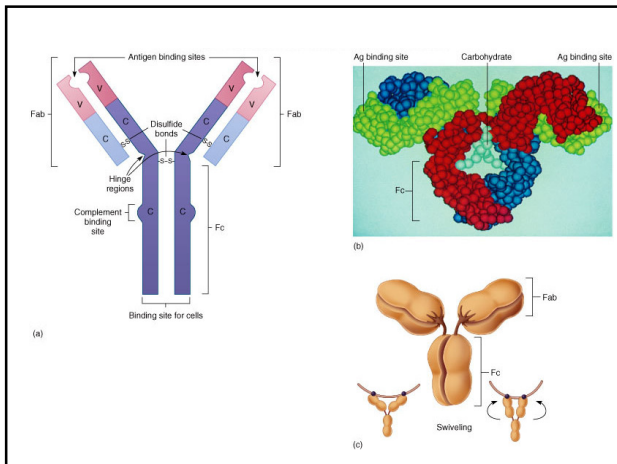


B cells

- Antibody
- Antibody-antigen interaction
- Response

Antibody

- Product of B cell (plasma cell) activation
 - Immunoglobulin (Ig) or antibody
- Structure
- Classes - there are 5



Isotypes of Antibodies

- Based on the Fc (constant) fragment
 - IgG - peripheral
 - IgA - gut/mucosal
 - IgM - surface & secreted
 - IgD - surface
 - IgE - allergies - worms

Characteristics of the immunoglobulins

TABLE 15.2 Characteristics of the Immunoglobulin (Ig) Classes

	IgG	IgA (dimer only)	IgM	IgD	IgE
Number of Antigen Binding Sites	2	4	10	2	2
Molecular Weight	150,000	170,000–385,000	900,000	180,000	200,000
Percent of Total Antibody in Serum	80%	13%	6%	1%	0.002%
Average Life in Serum (Days)	23	6	5	3	2.5
Crosses Placenta?	Yes	No	No	No	No
Fixes Complement?	Yes	No	Yes	No	No
Fc Binds To	Phagocytes				Mast cells and basophils
Biological Function	Long-term immunity; memory antibodies	Secretory antibody; on mucous membranes	Produced at first response to antigen; can serve as B-cell receptor	Receptor on B cells	Antibody of allergy; worm infections

C = carbohydrate.
J = J chain.

Antibody-antigen interactions

- Opsonization
- Neutralization
- Complement fixation

Opsonization

- Microbes or particles coated with antibodies - **similar to C3b**
- Enables macrophages to recognize and phagocytize microbe

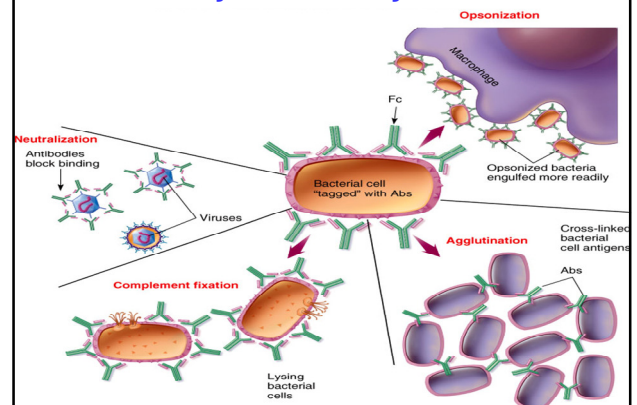
Neutralization

- Antibody binds to
 - The microbe or virus receptor
 - Antigenic site of a molecule (Eg. Exotoxin)
- Prevents further binding of microbe (no cell entrance for virus) or toxin

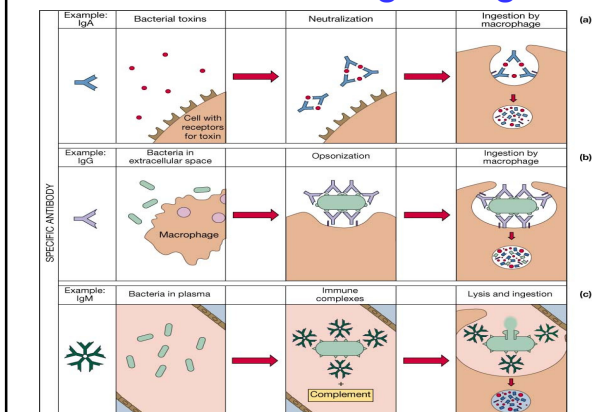
Complement fixation (activation)

- Antibodies interact with complement proteins - activate complement cascade (Eg. **Classical pathway**)
- Lysis of microbial cell

Summary of antibody functions



Elimination of Foreign Antigens

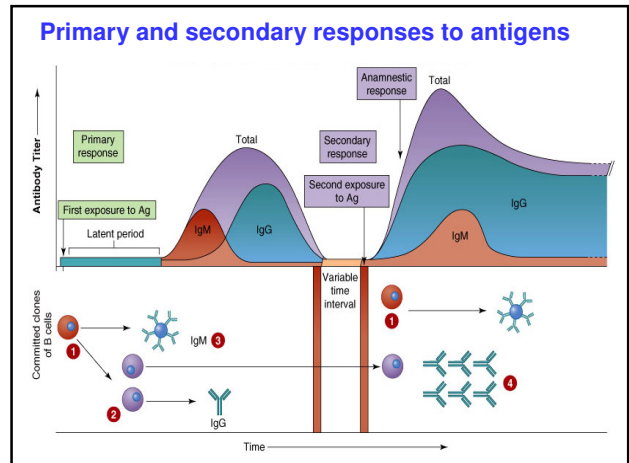


Primary Response

- **First exposure**
 - Latent period - initial response to Ag
 - Synthesis of antibodies
 - Slower response - less antibody generated
 - IgM first
 - Followed by IgG

Secondary Response

- **Re-exposure** to the same immunogen
- **Antibody synthesis, titer, and length of antibody persistence is rapid and amplified**
 - Due to presence of **memory cells**



Antigen presenting cells (APC) – 3 total

- **Macrophages** and **dendritic cells**
 - Process and present antigen in association with **MHC I/II**
 - T cell receptor recognize antigen/MHC I/II
- **B - cells** are the 3rd major APC

Macrophages

Most antigens are processed by antigen-presenting cells including macrophages such that the antigen fragments are in a state that lymphocytes can be stimulated. Antigen presentation is in the context of the **major histocompatibility complex (MHC)**.

Classes of MHC

- Each individual has a unique **MHC genetic profile**
- **Class I** – all nucleated cells
- **Class II** – macrophages, dendritic cells, B cells - or – **APCs**
- **CLASS I** = CD8 T cell
- **CLASS II** = CD4 T cell

Cell-mediated immunity (CMI)

CMI is the type of immunity where T cells protect against many viral infections, and reject tumors and transplants -

T cells **do not** make antibody

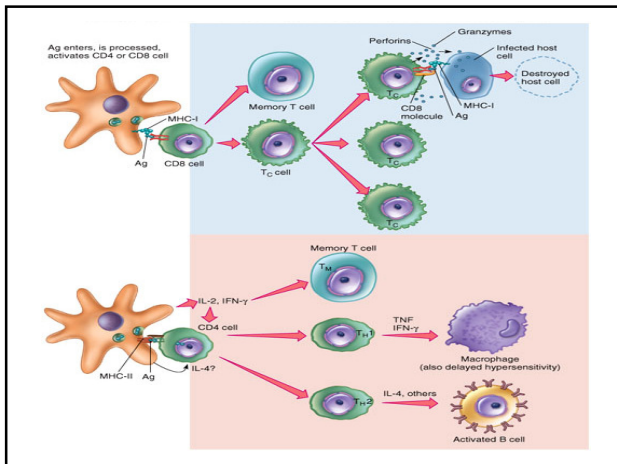
Good at killing **intracellular** pathogens

T_H - THE GENERAL

- Regulate immune reactions to antigens by releasing cytokines
- CD4 receptor
- Type of cytokine will determine subset of T_H
 - T_{H1} (CMI)
 - T_{H2} (Humoral)
- Cytokines activate macrophages & other cells
- Most prevalent T cell in the blood

T_C - THE KILLER

- Bind and lyse cells (apoptosis)
 - microbe, viral infected cells, foreign cells, cancer cells
- CD8 receptor
- Perforins – punch holes in the membrane
- Granzymes – degrade proteins
- Natural killer (NK) cells
 - related to T_C
 - attack virus infected cells and cancer cells

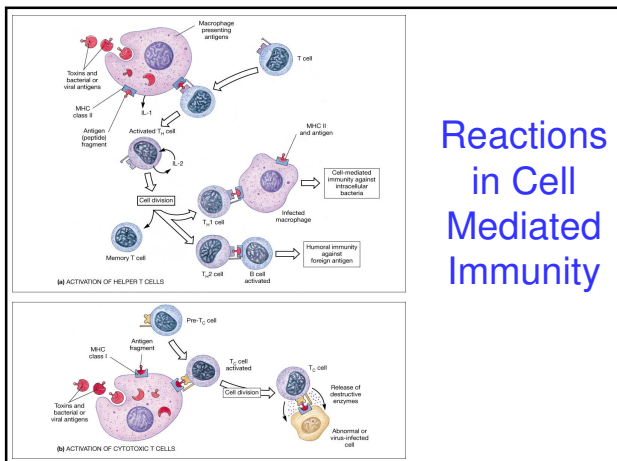


Activated T_H cells produce cytokines that regulate T cells, B cells and other cells of the immune system.

HIV destroys T_H cells and abrogates both humoral and cell-mediated immunity.

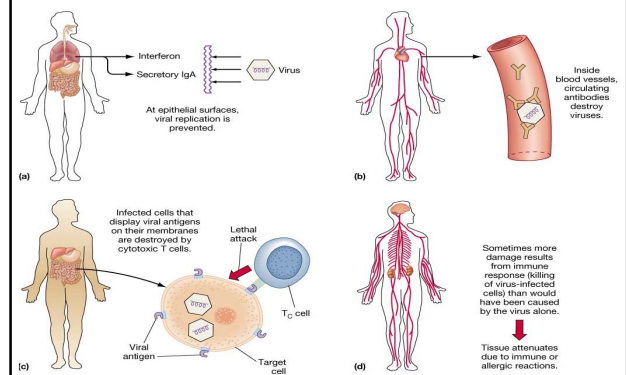
T_C kill virus-infected cells and tumor cells by releasing cytotoxins such as perforin (perforates the cells) and granzyme.

NK cells are large lymphocytes that kill tumor cells, virus-infected cells and foreign cells (transplants).



Reactions in Cell Mediated Immunity

Effect of Immune System on Viruses



Specific Immunities

- Active
- Passive
- Natural
- Artificial

Active

- Natural or artificial
- Antigen activates B and T cells
- Memory cells
- Long-term protection

Passive

- Natural or artificial
- Receive antibodies from another individual or animal
- No memory cells
- No antibody production
- Short-term protection

Natural

- Immunity produced by normal biological exposure, no medical intervention
 - Natural active
 - Eg. Infection
 - Natural passive
 - Eg. Mother to child

Artificial

- Immune protection through medical procedures or intervention
 - Artificial active
 - Eg. vaccination
 - Artificial passive
 - Eg. immunotherapy - anti-toxins or anti-venoms (antibodies)

There are many, many, many, many, very, very, very important terminologies that are very, very, very important in understanding immunology.

Fortunately, there are only a few cells that are important to us in our collective defense against foreign invaders.

All in all, understanding how the immune system interacts with microorganisms is the other half of the infectious disease story