Adaptive Immunity: Specific Defenses of the Host (Chapter 17)
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Immunity = resistance: defense against foreign material
Innate immunity = defenses that are always present to provide instant protection against infection
Adaptive immunity = induced, adapts to a specific foreign substance, acquired memory of the infection
Antigens = substances that provoke an immune response, immunogenic molecules

Dual Nature of Adaptive Immune Response:
1. Humoral / Antibody-Mediated Immunity
   -involves antibodies produced by B cells to confer immunity
   -best against bacteria, toxins, and virus that are free in body fluids
2. Cell-Mediated Immunity
   -involves T cells that act against foreign organisms or tissues
   -involves cytokines & cytotoxicity

-works best on bacteria- or virus-infected cells, fungi, protozoa, tissue grafts and cancer

Four Types of Adaptive Immunity:
(on handout)

1. Naturally Acquired Active Immunity
   -everyday exposure to antigens & disease
   -development of B and T cell responses & memory, immunity may be life long
2. Naturally Acquired Passive Immunity
   -transfer of antibodies from mother to fetus or infant across placenta or in milk
   -immunity lasts as long as antibodies, weeks to months
3. Artificially Acquired Active Immunity
   -vaccination / immunization: forced introduction of nonvirulent antigens
   -development of B and/or T cell responses & memory, immunity may be life long
4. Artificially Acquired Passive Immunity
   -injection of preformed antibodies from people or animals, called antiserum
   -immunity lasts as long as antibodies, weeks to months

Primary Source for figures and content:
Antigens:
- determine self vs. non-self
- non-self provokes immune response
- located on the surface of cells:
  - capsules, walls, flagella, fimbriae, pentons, spikes, etc., or toxin molecules
- most are proteins or large polysaccharides
- the specific antigenic compound recognized by lymphocytes or antibodies is called the epitope / antigenic determinant

- antibodies recognize and bind to specific shape of antigen’s epitope
- antibodies have great specificity
- affinity = strength of bond between antigen and antibody
- each has minimum of 2 antigen binding sites:
  - both recognize same epitope (antigen)

Antibody Molecule Structure: (on handout)

Classes of Antibodies/Immunoglobulins

IgG antibodies
- Monomer
- 80% of serum antibodies
- Produced on second exposures
- In blood, lymph
- Can enter tissues, cross placenta
- Fix complement, enhance phagocytosis, neutralize toxins & viruses, protects fetus & newborn, antiserum

IgM antibodies
- Pentamer
- 5-10% of serum antibodies
- Produced only on first exposure
- In blood, lymph, in B cells
- Fix complement, agglutinates antigens

IgA antibodies
- Dimer
- 10-15% of serum antibodies
- In secretions
- Mucosal protection

IgD antibodies
- Monomer
- 0.2% of serum antibodies
- Surface receptor on B cells
- Initiate humoral immune response by B cells

IgE antibodies
- Monomer
- 0.002% of serum antibodies
- Surface receptor on mast cells and basophils
- Inflammation, allergic reactions; lysis of parasitic worms

Antigens have receptors to recognize and specifically bind to the epitope
- antibodies have specific antigen-binding sites

- a single pathogen or antigen can have hundreds of different epitopes / antigenic determinants on its surface, each of which would be recognized and bound by a different antibody or lymphocyte

Antibodies / Immunoglobulins
- special protein produced by plasma cells (B cells) that will recognize and bind to its specific epitope of an antigen via its antigen binding sites
B cells and Humoral Immunity
- B cells produce antibodies = humoral / antibody-mediated immunity
- B cells arise from stem cells in bone marrow
- when mature, migrate to lymphoid tissue
- wait to recognize and bind to antigen to be stimulated to produce antibodies

Activation of B cells by clonal selection:
- each B cells produces only one antibody against one antigen/epitope
- recognizes antigen/epitope via IgD receptor on cell surface
- when activated it will divide to produce clones
(on handout)

Activation and Clonal Selection of B cells
T-independent Antigen
(Epitope tends to be polysaccharide, produces weaker immune response than T-dependent Antigen)

Results of Antigen-Antibody Binding:(handout)

Primary Response:
- initial exposure to antigen results in IgM production
- peak titer 10-17 days
- peak titer of antibodies low

Secondary/Memory Response:
- second and subsequent exposure results in IgG production
- peak titer 2-7 days
- much higher peak titer of antibodies

Function of Antibodies
antigen-antibody complex = antibody bound by its antigen-binding sites to the epitope
T cells and Cell-Mediated Immunity
- requires coordinated activity of specialized cells that must communicate Communication chemicals = cytokines - chemical messengers used within immune system (proteins or glycoproteins)
- many kinds, each has specific message Cells = T cells
- originate from stem cells in bone marrow but mature in thymus, travel to blood & lymph
- each only recognizes one antigen
- when it binds to antigen, will undergo clonal selection to produce effector and memory cells
- effector cells: attack foreign cells or stimulate other defense cells via cytokines
- memory cells: rapid response upon second exposure, long term immunity
- T cells do not bind free antigen: must be on cell surface in association with molecules of the major histocompatibility complex (MHC)

Types of T cells:
1. $T_H$ (Helper T cells) / CD4 Cells
   - activated by antigen in Class II MHC
   - respond by secreting cytokines to influence other immune cells

A. $T_{H1}$: activate cells related to cell-mediated immunity ($T_C$ and Macrophages)
B. $T_{H2}$: activate B cells to make antibodies (T-dependent antigens)

Class I MHC
Class II MHC
Infected cell
Antigen Presenting Cell
Class I MHC is found on all cell types and displays all antigens that are present in a cell, both self and non-self.
Class II MHC is found only on APCs and only displays antigens that have been endocytosed

Activation of Helper T Cells

Helper T cell
Memory $T_C$ cells (inactive)
Cytotoxic T cell
Humoral immunity (secretion of antibodies by plasma cells)

Defense against intracellular pathogens
Defense against free pathogens
2. T\(_C\) (Cytotoxic T cells) / CD8 Cells
   - activated by antigen in Class I MHC
   - respond by secreting perforin and lysing the target cell:
   - this usually requires pre-activation of the T\(_C\) by cytokines produced by a T\(_{H1}\) cell
   Activation of Cytotoxic T Cells
   (on handout)

   - Most activity of the immune system requires cytokines produced by T Helper cells

3. T\(_S\) (Suppressor T cells) aka T\(_{reg}\) (Regulatory T cells)
   - regulate the immune response
   - prevent autoimmunity
   - inhibit T and B cell activity when antigen levels decline

   - Inter-relationship of Cell-Mediated and Antibody-Mediated Immunity
   T-dependent antigens:
   - more common than T-independent antigens
   - protein epitopes
   - require T\(_{H2}\) cells to signal B cells to produce antibodies
   (on handout)

   - Natural Killer Cells (NK cells)
   - not immunologically specific
   - attack any abnormal antigen on eukaryotic cells: virus-infected, cancer, large parasites
   - attack cells lacking proper class I MHC
   - lyse target cell by releasing perforins to disrupt membrane

   - Most activities of B and T cells function to enhance non-specific defenses / innate immunity (on handout)
Body Defense Summary

Non-specific defenses and the immune response are integrated:
both function together for overall defense

- Direct physical and chemical attack
- Attack by circulating proteins
- Attack by antibodies

**Non-specific defenses**
- NK cells
- Macrophages

**Specific defenses** (Immune response)
- Helper T cells stimulate
- Suppressor T cells inhibit

**Cell-mediated immunity**
- Defense against intracellular pathogens

**Antibody-mediated immunity**
- Defense against free pathogens