Now Presenting…Antigens
Specific Defenses of the Host:
The Immune Response

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The Immune Response
- Innate (nonspecific) Immunity- Defenses against any pathogen
- Adaptive Immunity- Specific antibody and lymphocyte response to an antigen

The Immune Response
- Acquired immunity- Developed during an individual's lifetime
- Humoral immunity- Involves Ab produced by B cells
- Cell-mediated immunity- Involves T cells

Lymphocytes
- Key cells controlling the immune response.
- They specifically recognize foreign material and distinguish it as non-self.
- There are two main types of lymphocytes: B cells and T cells.

B cells
- Humoral Immunity
  - Develop in fetal liver and subsequently in the bone marrow.
  - They are named after the bursa of Fabricius.
  - Mature B cells carry surface immunoglobulins which act as their antigen receptor.
  - They are distributed throughout the body.
  - They respond to antigenic stimuli by dividing and differentiating into plasma cells.

T cells
- Cellular Immunity
  - Develop in the thymus.
  - It is seeded with lymphocytic stem cells.
  - These develop T cell antigen receptors (TCRs) and differentiate into the two major T cell subsets- one with CD4, one with CD8.
  - The T cell subsets each will bind to different MHC molecules.

Antigens and Antibodies
- Antigen (Ag)- A substances that causes the body to produce specific antibodies or sensitized T cells
- Antibody (Ab)- Proteins made in response to an antigen
  - Antibodies (Ab) interact with epitopes, or antigenic determinants
  - Hapten: antigen is combined with carrier molecules

The Nature of Antibodies
- Globular proteins called immunoglobulins
- The number of antigen-binding sites determines valence
IgG antibodies
- Monomer
- 80% of serum antibodies
- Fix complement
- In blood, lymph, intestine
- Cross placenta
- Enhance phagocytosis; neutralize toxins & viruses; protects fetus & newborn
- Half-life = 23 days

IgM antibodies
- Pentamer
- 5-10% of serum antibodies
- Fix complement
- In blood, lymph, on B cells
- Agglutinates microbes; first Ab produced in response to infection
- Half-life = 5 days

IgA antibodies
- Dimer
- 10-15% of serum antibodies
- In secretions
- Mucosal protection
- Half-life = 6 days

IgD antibodies
- Monomer
- 0.2% of serum antibodies
- In blood, lymph, on B cells
- On B cells, initiate immune response
- Half-life = 3 days

IgE antibodies
- Monomer
- 0.002% of serum antibodies
- On mast cells and basophils, in blood
- Allergic reactions; lysis of parasitic worms
- Half-life = 2 days

Activation of B Cells
- Major histocompatibility complex (MHC) expressed on mammalian cells
- T-dependent antigens
  - Ag presented with (self) MHC to T<sub>H</sub> cell
  - T<sub>H</sub> cell produces cytokines that activate the B cell
- T-independent antigens
  - Stimulate the B cell to make Abs
- B cells differentiate into:
- Antibody-producing **plasma cells**
- Memory cells

**Clonal deletion** eliminates harmful B cells

**Antigen–Antibody Binding**
- Agglutination
- Opsonization
- Activation of complement
- Antibody-dependent cell-mediated cytotoxicity
- Neutralization

**T Cells and Cellular Immunity**
- T cells mature in the thymus
  - Thymic selection eliminates many immature T cells
- T cells respond to Ag by **T-cell receptors (TCRs)**
- T cells require **antigen-presenting cells (APCs)**
- Pathogens entering the gastrointestinal or respiratory tracts pass through:
  - M (microfold) cells over
  - Peyer’s patches, which contain APCs

**T Helper Cells**
- **CD4**\(^+\) or \(T_H\) cells
  - TCRs recognize Ags and MHC II on APC
  - TLRs are a costimulatory signal on APC and \(T_H\)
  - \(T_H\) cells produce cytokines and differentiate into:
    - \(T_H1\) cells
    - \(T_H2\) cells
    - \(T_H17\) cells
    - Memory cells
  - \(T_H1\) produce IFN-\(\gamma\) which activates cells related to cell-mediated immunity, macrophages, and Abs
  - \(T_H2\) activate eosinophils and B cells to produce IgE
  - \(T_H17\) stimulate the innate immune system
  - **T Helper cells** also stimulate B cells to produce plasma cells and are involved in class switching

**T Cytotoxic Cells**
- **CD8**\(^+\) or \(T_C\) cells
- Target cells are self-cells carrying endogenous antigens
- Activated into **cytotoxic T lymphocytes (CTLs)**
  - CTLs recognize Ag + MHC I
  - Induce **apoptosis** in target cell
- CTL releases **perforin** and **granzymes**

**T Regulatory Cells**
• **T<sub>reg</sub> cells**
  • CD4 and CD25 on surface
  • Suppress T cells against self

**Antigen-Presenting Cells**
• Digest antigen
• Ag fragments on APC surface with MHC
  – B cells
  – Dendritic cells
  – Activated macrophages

**Natural Killer (NK) Cells**
• Granular leukocytes destroy cells that don’t express MHC I
• Kill virus-infected and tumor cells
• Attack parasites

**ADCC**
• Antibody-dependent cell-mediated cytotoxicity

**Cytokines**
• Chemical messengers
• Overproduction may lead to **cytokine storm**

**Immunological Memory**
• **Antibody titer** is the amount of Ab in serum
• **Primary response** occurs after initial contact with Ag
• **Secondary (memory or anamnestic) response** occurs after second exposure

**Types of Adaptive Immunity**
• **Naturally acquired active immunity**
  – Resulting from infection
• **Naturally acquired passive immunity**
  – Transplacental or via colostrum
• **Artificially acquired active immunity**
  – Injection of Ag (vaccination)
• **Artificially acquired passive immunity**
  – Injection of Ab

**Terminology of Adaptive Immunity**
• **Serology**: the study of reactions between antibodies and antigens
• **Antiserum**: the generic term for serum because it contains Ab
• **Globulins**: serum proteins
• **Immunoglobulins**: antibodies
• **Gamma (γ) globulin**: serum fraction containing Ab