V. Vertebrate Immune System

A. Non-specific defenses against pathogens

1. Skin - physical barrier
   a. Tough armor protein KERATIN
   b. Surface fluids (sweat, tears, saliva)
      (1) Contain bacteria killing enzymes, LYSOZYMES
      (2) Wash away bacteria
   c. Symbiotic bacteria prevent fungi & bacteria from growing (showers) (antibiotic problem)
   d. Body cavities
      (1) Mucus traps bacteria
      (2) Enzymes & acid stomach kill bacteria in food

2. If pathogens evade the blocks to entry
   a. Cells - LEUKOCYTES = WBCs such as PHAGOCYTES
      (1) Ingest bacteria
      (2) Dead remains form PUS
      (3) Attack ALL foreign invaders, not specific
   b. Chemicals
      (1) HISTAMINE
         (a) Dilates arterioles inducing inflammation
         (b) Increase blood flow
      (2) KININS
         (a) Attract WBCs
         (b) Stimulate pain neurons & induce tender care of wound
      (3) COMPLEMENT
         (a) Group of plasma proteins
         (b) Bind to bacteria coat
            i) Phagocytes recognize complement
            ii) Forms pores in coat causing them to swell & burst
      (4) INTERFERON
         (a) Stimulates cell resistance to viruses
         (b) Blocks synthesis of viral coat

B. Specific Defenses against pathogens or Responses of Immune System

1. HUMORAL [= fluid] IMMUNE RESPONSE
   a. Proteins in blood & lymph
   b. Attack bacteria & viruses inside body, but outside cells
   c. ANTIBODY proteins (IMMUNOGLOBINS)
      (1) Proteins that bind to specific molecules (ANTIGENS or IMMUNOGENS) on foreign cells
      (2) "Y" shaped
         (a) Amino acid composition of stalk is constant among antibodies
(b) Composition of arms varies
   i) Millions of variations
   ii) Arms bind to antigens at the ANTIGENIC DETERMINANT

d. Fundamental concept
   (1) Vertebrates born with genes that code for millions of antibodies; most never used
   (2) Immune system does NOT detect foreign substance and then build a specific protein that will bind to it

2. CELLULAR IMMUNE RESPONSE
   a. Cells do the attacking
   b. Fight:
      (1) Viruses
      (2) Fungi
      (3) Animal parasites

C. Immunoglobins: Agents of the humoral response
   1. Killing mechanisms
      a. Multiple binding sites
         (1) Function like glue to link invading cells
         (2) Mass of foreign material easier to destroy
      b. OPSONIZATION
         (1) Coat foreign cells
         (2) Antibody stalks (protruding outward) recognized
         (3) Some lymphocytes only engulf antibody-labeled cells
      c. Activate complement

2. Types of antibodies
   a. IgM
      (1) 1st secreted by plasma cells
      (2) Bind invader into clumps (easier for phagocytes to engulf)
   b. IgG
      (1) About 85% of antibodies in blood
      (2) Activate complement
      (3) Neutralize toxins
      (4) Bind to antigens making them easier to be ingested by macrophages
   c. IgE
      (1) Trigger inflammation
      (2) Allergic reactions
      (3) Active in schistosome worm infections
   d. IgA
      (1) Secreted across epithelial membranes
      (2) In tears, saliva, gastric juices
      (3) In mother's milk giving some immunity to nursing infant
   e. IgD serve as membrane receptors on B-cells

D. T-Cells: Agents of both responses
   1. Originate in red marrow
2. Mature in thymus gland
3. Participate in both cellular & humoral immune responses
   a. Cytotoxic T-cells = TC-cells kill virus infected cells
   b. Helper T-cells = TH-cells
      (1) Activate B-cells
         (a) Originate in red marrow & liver of fetus
         (b) Make antibodies
      (2) Become Suppressor cells TS-cells
4. MAJOR HISTOCOMPATIBILITY COMPLEX (MHC) proteins
   a. Class II MHC - Humoral Immune Response
      (1) Primary Response
         (a) Antigen-presenting cells
            i) Macrophage engulfs foreign material
            ii) Foreign antigen is placed on its own surface next to Class II MHC
         (b) Activation Phase
            i) TH -cell with matching receptor binds to macrophage with invader antigen next to Class II MHC (DUAL SITE RECOGNITION)
            ii) Bound macrophage secretes INTERLEUKIN I
            iii) Stimulates TH -cell to divide producing clone of TH -cells of that variety
         (c) Effector Phase
            i) If an antigen binds to its receptors, a B-cell will display it next to Class II MHC,
            ii) This B-cell can produce antibodies to that antigen
            iii) TH -cell (activated above) binds to B-cells with matching antigen next to MHC II
            iv) TH -cell releases chemicals that cause B-cells to produce clones
            v) 2 types of B-cells activated
               a) PLASMA B-CELLS: Live few days & produce antibodies to invader
               b) MEMORY B-CELLS: Live years & impt. in secondary response
         (d) Suppression phase
            i) SUPPRESSOR T-CELLS = TS-cells activated as infection subsides
            ii) Stop proliferation of lymphocytes
      (2) Secondary response
         (a) Re-invasion of foreign cells
         (b) Memory B-cells activated quickly to produce antibodies to invader
         (c) Invader attacked before infection reaches high levels
(d) Vaccinations  
   i) "Weakened" antigens injected  
   ii) Population of memory cells produced for that disease  

b. Class I MHC - Cellular Immune Response  
   (1) Present on surface of every cell in host  
   (2) Involved in anti-viral activity  
      (a) Body cells infected w/ viruses (or cancerous) display viral proteins (antigens) next to Class I MHC  
      (b) TC-cell w/ matching receptor is activated when it binds to viral antigen & MHC Type I complex (DUAL SITE RECOGNITION)  
      (c) Activated TC-cell lyses infected cell  

E. Disorders of the Immune System  
   1. Transplant rejection  
      a. MHC on new organ acts as antigen  
      b. Recipients immune system will attack it.  
      c. Circumvention  
         (1) Match up MHC  
         (2) Suppress immune system (recipient susceptible to disease)  
   2. Allergies  
      a. Immune system over-responds to an antigen  
      b. Dilation & constriction of vessels (such as bee sting) can cause death  
   3. Autoimmune diseases  
      a. T- & B-cells recognize antigens on body cells as"foreign"  
      b. Immune cells attack cells of own body  
      c. Examples  
         (1) Rheumatoid arthritis  
         (2) Myasthenia gravis (= MSG)  
   4. Acquired Immune Deficiency Syndrome (AIDS)  
      a. Believed to be caused by HIV virus  
         (1) Virus attacks TH -cells  
         (2) HIV DNA remains dormant inside cell for years  
         (3) Antibody tests reveal that HIV has entered body and & person called "HIV positive"  
      b. AIDS  
         (1) After incubation period, HIV DNA is activated & infected cells produce more HIV viral particles  
         (2) Patient has AIDS  
            (a) More TH -cells infected  
            (b) Infected cells die  
            (c) AIDS patient loses ability to fight diseases