

Warm-up

Objective:

- Explain how antigens react with specific lymphocytes to induce immune response and immunological memory.

Warm-up:

Which of the following would normally contain blood with the least amount of oxygen?

1. The left ventricle
2. The left atrium
3. The pulmonary veins
4. The pulmonary arteries
5. Capillaries that line the small intestine

Parts of the Immune system

- External Defense
 - Skin
 - Mucus
- Internal Defenses
 - Phagocyte cells
 - Inflammatory response
 - Natural killer cells
- Acquired Immunity
 - Antibodies
 - B cells, memory B cells
 - Helper T cells, cytotoxic T cells, memory T cells

Disease transmission

- Trace the spread of disease
- PREDICT – what do you think will happen?

Disease transmission

- What is the maximum number of infected individuals possible after three rounds?
- How can public health officials distinguish between environmental and contact transmission?
- How do public health officials work to control the spread of disease?

Chapter 43



Immune System

Why an immune system?

- Attack from outside
 - Lots of organisms want you for lunch!
 - Animals must defend themselves against unwelcome invaders
 - Viruses
 - Bacteria
 - Protists
 - Fungi
 - We are a tasty vitamin-packed meal
 - No cell wall
 - Traded mobility for susceptibility
- Attack from the inside
 - Also deal with abnormal body cells = may develop into cancers

Lines of defense

- 1st line: Barriers
 - "barbed wire"
 - Skin & mucus membranes
- 2nd line: Non-specific patrol
 - "untrained soldiers"
 - Phagocytic white blood cells
- 3rd line: Immune system
 - "elite trainer units"
 - Lymphocytes & antibodies

1st: Barriers

- Nonspecific defense
- External barrier
 - Epithelial cells & mucus membranes
 - Skin
 - Respiratory system
 - Digestive system
 - Genitourinary system



Lining of trachea: ciliated cells and mucus secreting cells

Chemical Barriers

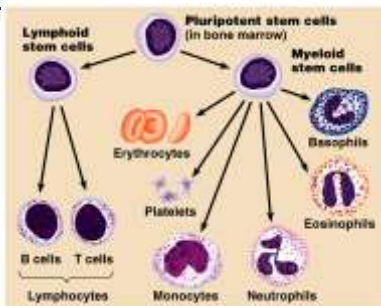
- Sweat = pH of 3-5
- Stomach acids = pH 2
- Other secretions
 - Tears, saliva, mucus
 - Washing actions = "lick your wounds"
 - Trap microbes
 - Anti-microbial proteins
 - Lysozyme = digest cell wall of bacteria, digesting them

2nd: non-specific defense

- Nonspecific defense
- Internal barrier
- Cells & proteins
 - Attack invaders that penetrate body's outer barriers
 - Phagocytic cells
 - Anti-microbial proteins
 - Inflammatory response



Phagocytic leukocytes (WBC)

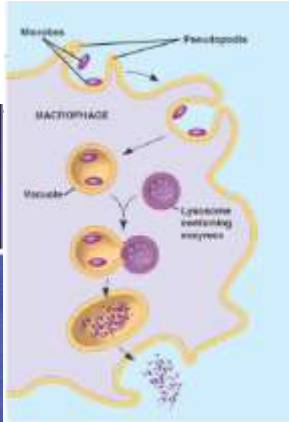
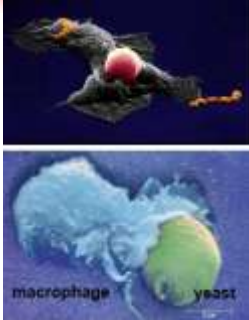


Phagocytes

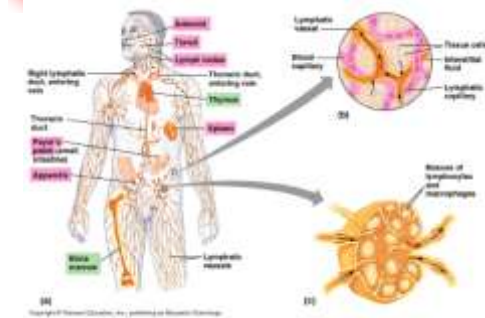
- Neutrophils
 - Attracted by chemical signals released by damaged cells
 - Enter infected tissue, engulf & ingest microbes
 - Amoeba-like
 - Lysosomes
 - ~3 day life span
- Macrophages
 - "big eater"
 - Bigger, long-lived phagocytes



Phagocytes

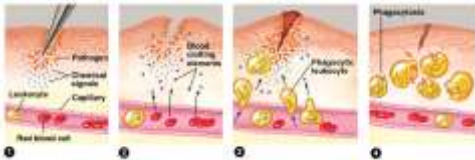


Lymph System



Inflammatory response

- Damage in tissue triggers local inflammatory response
 - Histamines & prostaglandins released
 - Capillaries dilate, more permeable
 - Lead to clot formation
 - Increased blood supply
 - Swelling, redness, & heat of inflammation & infection
 - Delivers RBC, WBC, platelets, clotting factors



Fever

- When a local response is not enough
 - Systemic response to infection
 - Resets body's thermostat
 - Higher temperature helps defense
 - Inhibiting the growth of microbes
 - Facilitating phagocytosis
 - Speeding up repair of tissues

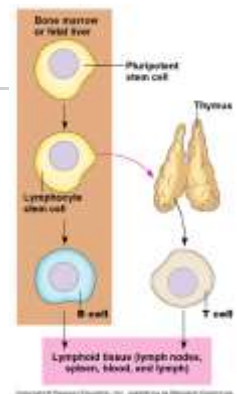
3rd: Immune system

- Specific response
 - Lymphocytes
 - B lymphocytes (B cells)
 - T lymphocytes (T cells)
 - Antibodies
 - immunoglobulins



Lymphocytes

- Develop from pluripotent stem cells
- B cells
 - Mature in bone marrow
 - Humoral response system
 - Antibodies
- T cells
 - Mature in thymus
 - Cellular response system
- Learn to distinguish "self" from "non-self"
 - antigens



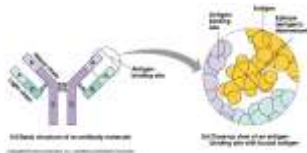
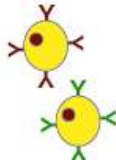
B cells

- Humoral response = "in fluid"
 - Defense against attackers circulating freely in blood & lymph
- B cell recognizes specific antigen
 - Millions of different B cells, each produces different antibodies
 - Recognize different antigens
 - Stimulated to reproduce clone colonies
 - Plasma cells**
 - Immediate production of antibodies
 - Short term release
 - Memory cells**
 - Long term immunity



Antibodies

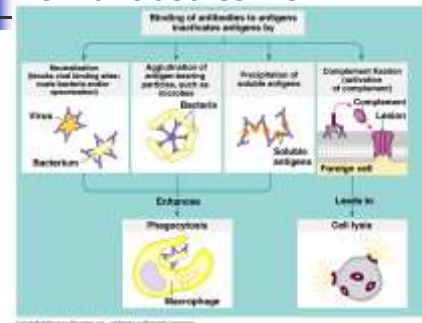
- Proteins bind to specific antigen
 - Multi-chain proteins produced by B cells
 - Antibodies match molecular shape of antigens
 - Immune system has antibodies to respond millions of antigens
 - Respond to millions of potential pathogens
 - Tagging system
 - " This is foreign"



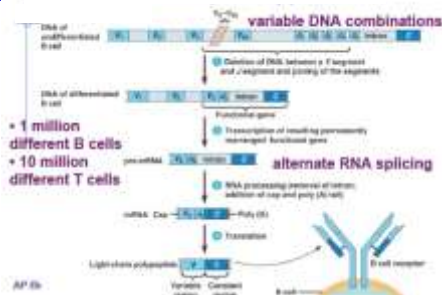
Antigens

- Foreign proteins that elicit specific response by lymphocytes
 - Proteins belonging:
 - Viruses, bacteria, fungi, protozoa, parasitic worms, toxins, non-pathogens: pollen, transplanted tissue
 - B & T cells respond to different antigen mechanisms
 - B cells recognize intact antigens
 - T cells recognize antigen fragments

How antibodies work

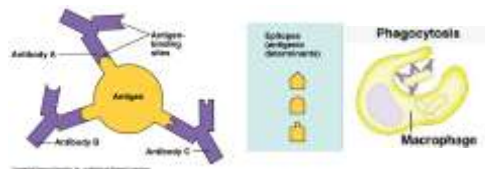


How can we have so many antibody proteins & so few genes?

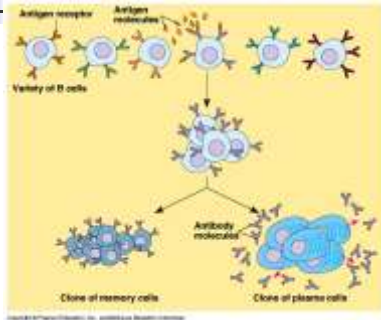


Antigen Disposal

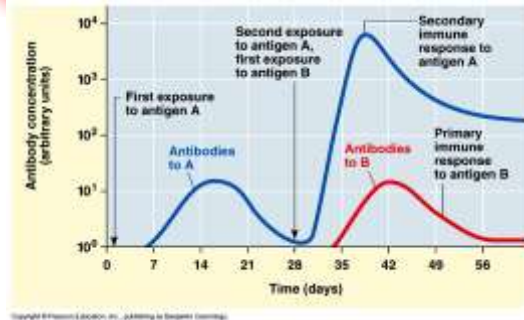
- Antigen-Antibody complexes
- Antigen disposal mechanisms
 - Phagocytosis by macrophages



Immune Response



1^o vs. 2^o response to disease



Vaccinations



- Active immunity
 - Immune system exposed to harmless version of disease causing microbe
- Stimulates immune system to produce antibodies to invader
 - Rapid response if future exposure
- Most successful against viral disease

Passive Immunity

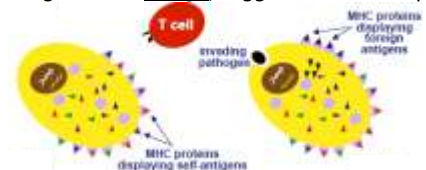
- Person receives antibodies only
 - Temporary
- Maternal Immunity
 - Antibodies pass from mother to baby across placenta or in breast milk
- Injection
 - Injection of antibodies
 - Short-term immunity

Self vs. non-self

- How does immune system recognize "self"?
 - Unique arrangements of proteins on surface of cells
 - Major histocompatibility complex (MHC) proteins
 - 6 loci: 12 genes (in diploid cells), hundreds of alleles
 - Impossible for 2 individuals to be the same
 - Cellular "fingerprint"
 - Mark cells that are off-limits to immune system

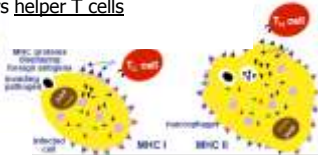
Self vs. non-self

- MHC proteins constantly export bits of cellular protein (antigens) to cell surface
 - If recognize as self, then ignored
 - If recognized as foreign, triggers immune response



MHC I & MHC II

- MHC I
 - Presents antigens from infected cells & cancer cells
 - Triggers cytotoxic T cells
- MHC II
 - In phagocytic cells = antigen-presenting cells
 - Present antigens from digested pathogens
 - Triggers helper T cells

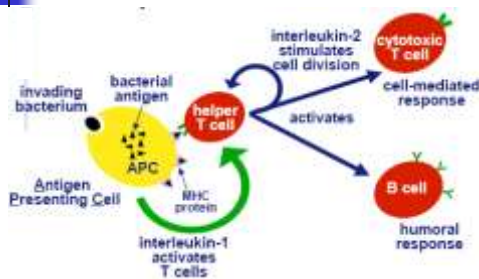


T cells

- Cell-mediated immunity
 - Defense against invaders of cells
 - Viruses & bacteria within infected cells, fungi, protozoa, & parasitic worms
 - Defense against "non-self" cells
 - Cancer & transplant cells
- Kinds of T cells
 - Helper T cells
 - Stimulate other immune components
 - Cytotoxic T cells
 - Attack infected body cells



T cell response



Helper T cells

- Stimulated by body cells' reaction to invaders
 - Interacts with antigen presenting cells (APCs)
 - Macrophage & B cells that display invader's antigen on their cell surface
 - Also stimulated by interleukin-1 released by APC
- T cells signals to turn on body's immune response

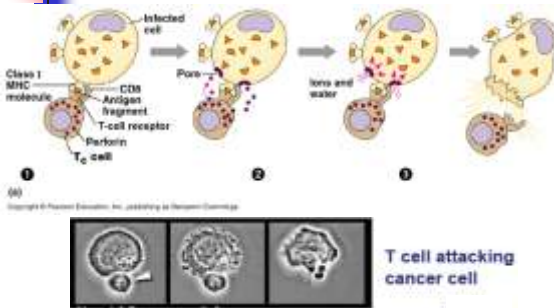
Helper T cells

- Binding to APCs stimulate T cell to turn on body's immune response
 - Signal-transduction pathway
 - External signal stimulates the gene to turn on & cell to produce new proteins
 - Release interleukin-2
 - Activates other T cells
 - Produces more helper T cells
 - Produces memory helper T cells
 - Stimulates cytotoxic T cells
 - Kills infected body cells
 - Activates B cells = humoral response

Cytotoxic T cells

- "Cell Killers"
 - Kills infected body cells
 - Binds to infected cell
 - Signal-transduction pathway
 - External signal stimulates gene to turn on & cell to produce new proteins
 - Produces proteins that bind to infected cell to destroy it
 - Perforin protein = punches holes in cell membrane allowing fluids to flow in & burst cell
 - Other proteins enter cell & trigger pre-programmed cell death (apoptosis)

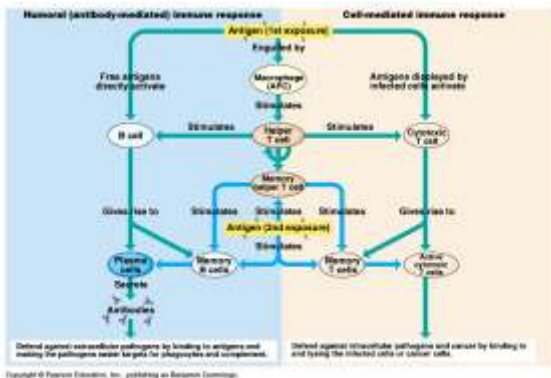
Cytotoxic T cells attack!



B cells vs. T cells review

- B cells
 - Humoral response = "in fluid"
 - Defend against extracellular pathogens (invaders in body fluid) by binding to antigens, making pathogens easier targets for phagocytes
- T cells
 - Cell-mediated response
 - Defend against intercellular pathogens (invaders inside of cells) & cancer cells by binding to & lysing infected cells or abnormal cells

Immune Response



Immune system malfunctions

- Auto-immune disease
 - Immune system attacks own molecules & cells
 - Lupus
 - Antibodies against many molecules released by normal breakdown of cells
 - Rheumatoid arthritis
 - Antibodies causing damage to cartilage & bone
 - Diabetes
 - Beta-islet cells of pancreas destroyed
 - Multiple sclerosis
 - T cells attack myelin sheath of brain & spinal cord nerves
 - Allergies
 - Over-reaction to environmental antigens
 - Allergies = proteins on pollen, from dust mites, in animal saliva

HIV & AIDS

- Human Immunodeficiency Virus
 - Infects helper T cells
 - Helper T cells then don't activate T cells & B cells
 - Body can't mount a humoral or cell-mediated response
- Acquired ImmunoDeficiency Syndrome
 - Infections by opportunistic diseases
 - Death usually from other diseases or cancer

Key attributes of immune system

- 4 attributes that characterize the immune system as a whole
 - Specificity
 - Antigen-antibody specificity
 - Diversity
 - React to millions of antigens
 - Memory
 - Rapid 2^o response
 - Ability to distinguish between self vs. non-self
 - Maturation & training process to reduce auto-immune disease