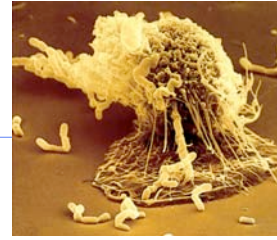
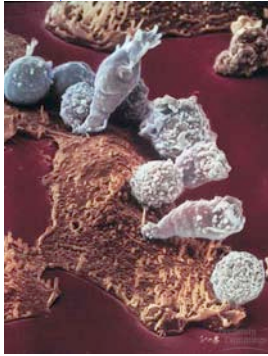


Chapter 43.



phagocytosis

Immune System



lymphocytes

2004-2005

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 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 trained units”
 - ◆ lymphocytes & antibodies

1st: Barriers

- nonspecific defense
- external barrier
 - ◆ epithelial cells & mucus membranes
 - skin
 - respiratory system
 - digestive system
 - genito-urinary tract










Lining of trachea: ciliated cells
& mucus secreting cells

Chemical barriers

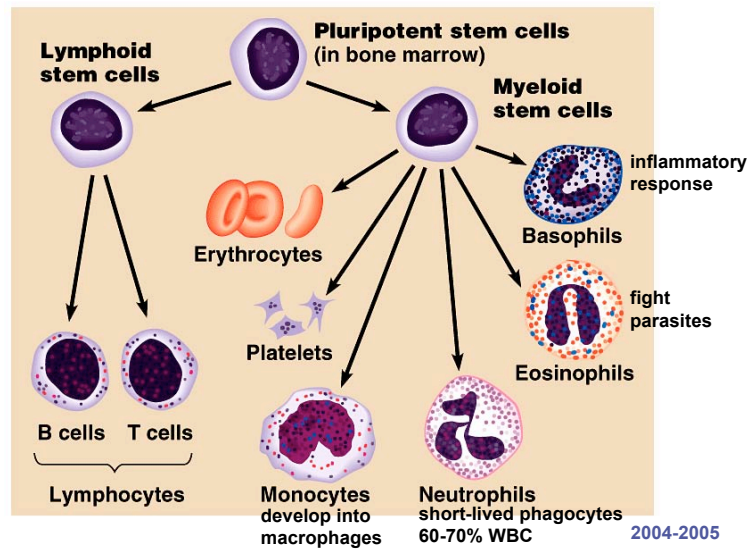
- **Sweat = pH 3-5**
 - ◆ fatty acids
- **Stomach acid = pH 2**
- **Other secretions**
 - ◆ tears, saliva, mucus
 - washing action = “lick your wounds”
 - traps microbes
 - ◆ anti-microbial proteins
 - lysozyme = digests cell walls of bacteria, destroying them

2nd: Non-specific patrol

- nonspecific defense
- internal barrier
- cells & proteins
 - ◆ attack invaders that penetrate body's outer barriers
 - phagocytic cells
 - anti-microbial proteins
 - inflammatory response

Cellular elements 45%		
Cell type	Number (per mm ³ of blood)	Functions
Erythrocytes (red blood cells) 	5–6 million	Transport oxygen and help transport carbon dioxide
Leukocytes (white blood cells)	5000–10,000	Defense and immunity
 Basophil  Eosinophil  Lymphocyte  Neutrophil  Monocyte		
Platelets 	250,000–400,000	Blood clotting

Phagocytic leukocytes (WBC)



Phagocytes

■ Neutrophils

- ◆ attracted by chemical signals released by damaged cells
- ◆ enter infected tissue, engulf & ingest microbes
 - amoeba-like (fierce!)
 - lysosomes
 - ~3 day life span

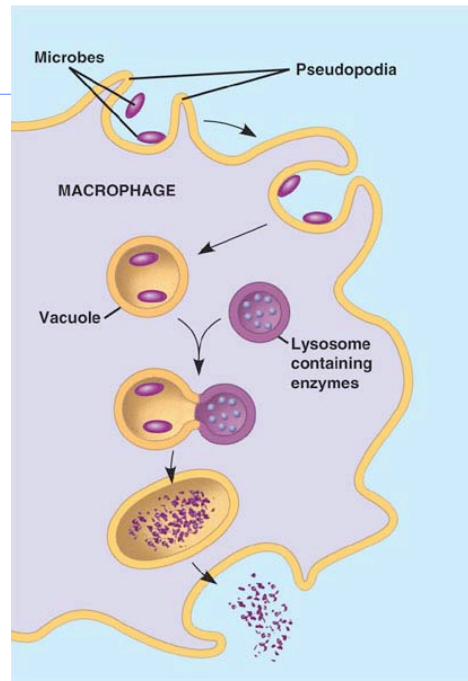
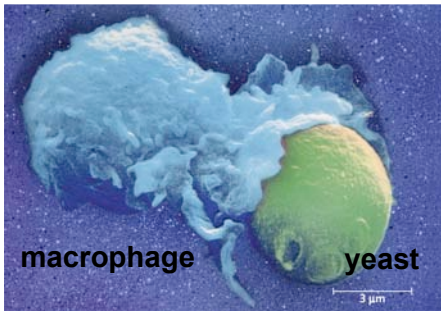
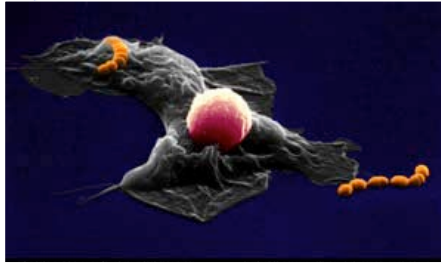
■ Macrophages

- ◆ “big eater”
- ◆ bigger, long-lived phagocytes



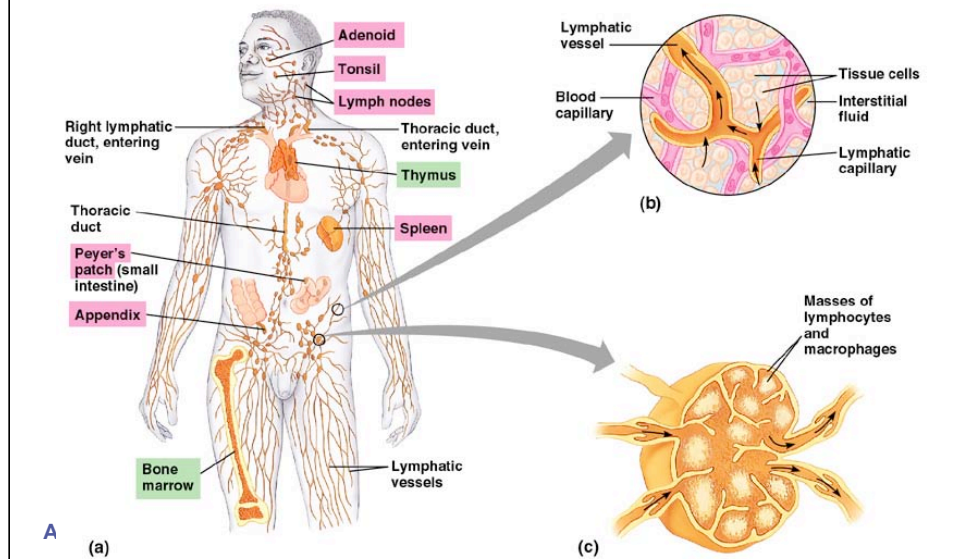
AP Biology

Phagocytes



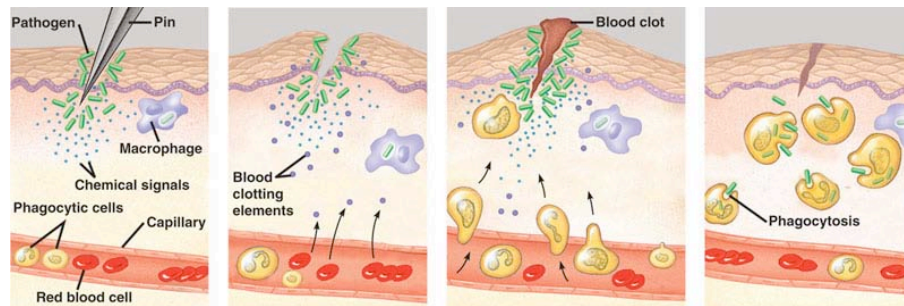
Lymph system

Production of leukocytes
& traps "foreign" material



Inflammatory response

- Damage to 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 WBC, RBC, platelets, clotting factors



Fever

- **When a local response is not enough**
 - ◆ systemic response to infection
 - ◆ resets body's thermostat
 - ◆ higher temperature helps defense
 - inhibiting growth of microbes
 - facilitating phagocytosis
 - speeding up repair of tissues

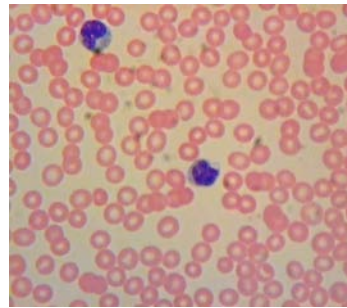
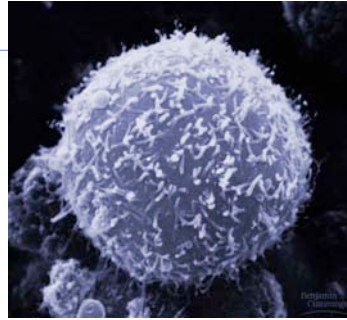
Certain bacterial infections can induce an overwhelming systemic inflammatory response leading to a condition known as *septic shock*.

Characterized by high fever and low blood pressure, septic shock is the most common cause of death in U.S. critical care units.

Clearly, while local inflammation is an essential step toward healing, widespread inflammation can be devastating.

3rd: Immune system

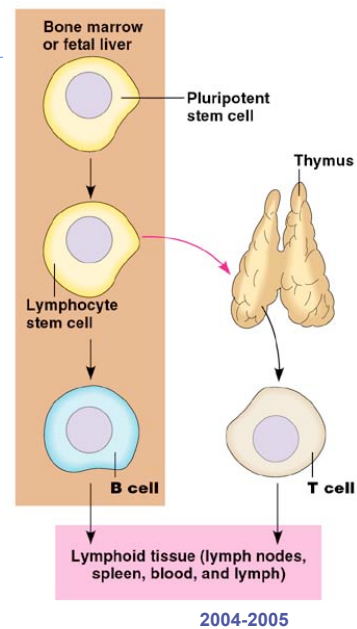
- **Specific defense**
 - ◆ lymphocytes
 - B lymphocytes (B cells)
 - T lymphocytes (T cells)
 - ◆ antibodies
 - immunoglobulins
- **Responds to...**
 - ◆ specific toxins
 - ◆ microorganisms
 - ◆ abnormal body cells
 - ◆ antigens



AP Biology

Lymphocytes

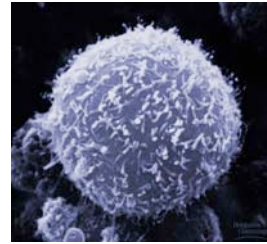
- **Develop from pluripotent stem cell**
- **B cells**
 - ◆ mature in bone marrow
 - ◆ humoral response system
 - antibodies
- **T cells**
 - ◆ mature in thymus
 - ◆ cellular response system
- **Learn to distinguish “self” from “non-self”**
 - ◆ antigens



AP Bi

B cells

- **Humoral response = “in fluid”**
 - ♦ defense against attackers circulating freely in blood & lymph
- **B cell recognizes a 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



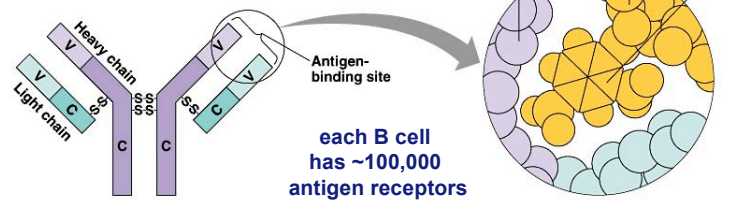
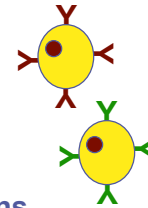
AP Biology

Antigens

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

Antibodies

- **Proteins that bind to a specific antigen**
 - ◆ multi-chain proteins produced by B cells
 - ◆ antibodies match molecular shape of antigens
 - ◆ immune system has antibodies to respond to millions of antigens
 - respond to millions of potential pathogens
 - ◆ **tagging system**
 - “This is foreign!”

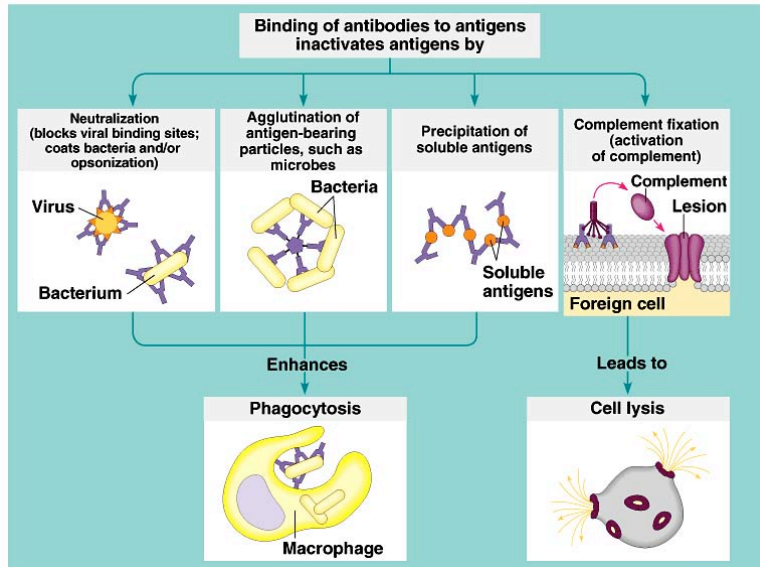


AP Biolo (a) Basic structure of an antibody molecule

(b) Close-up view of an antigen-binding site with bound antigen

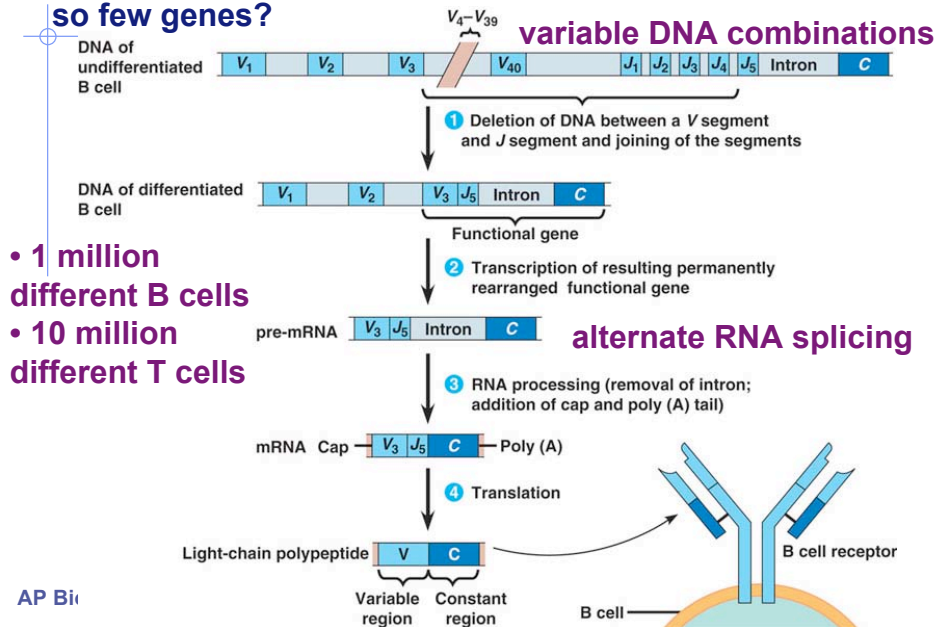
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How antibodies work



AP Biol

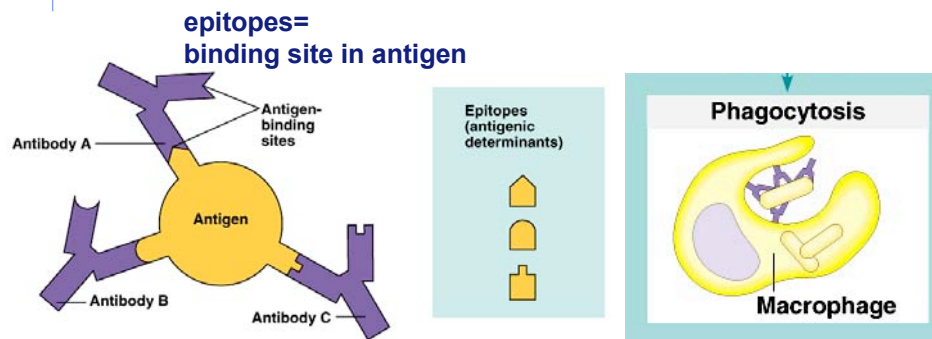
How can we have so many antibody proteins & so few genes?

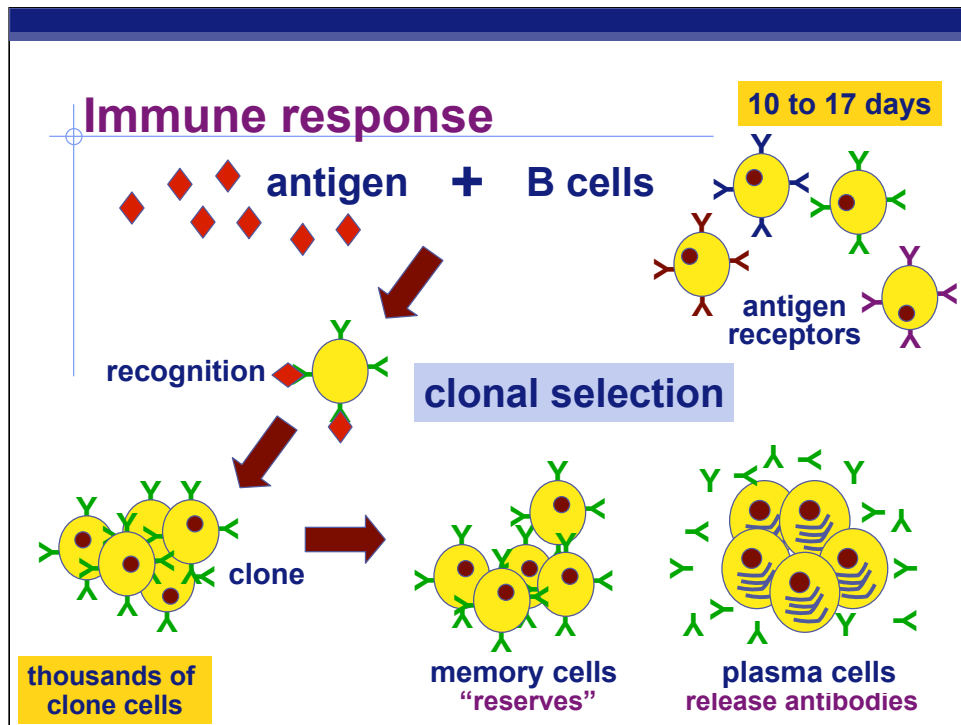


- 1 million different B cells
- 10 million different T cells

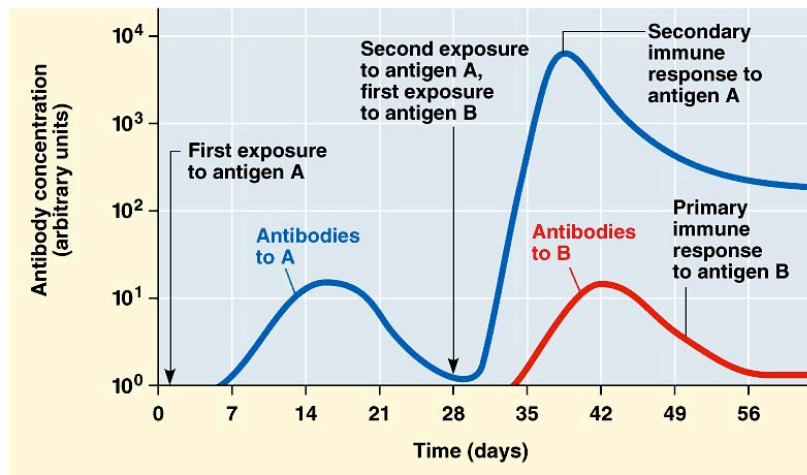
Antigen disposal

- Antigen-antibody complexes
- Antigen disposal mechanisms
 - ◆ phagocytosis by macrophages





1° vs 2° response to disease



AP Biology

2004-2005

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 diseases**



AP Biology

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

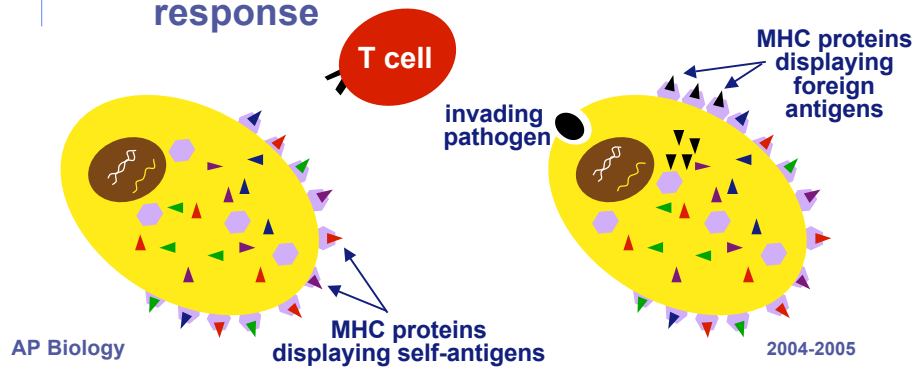


Self vs. non-self

- 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
 - except identical twins
 - cellular “fingerprint”
 - mark cells as off-limits to immune system

Self vs. non-self

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



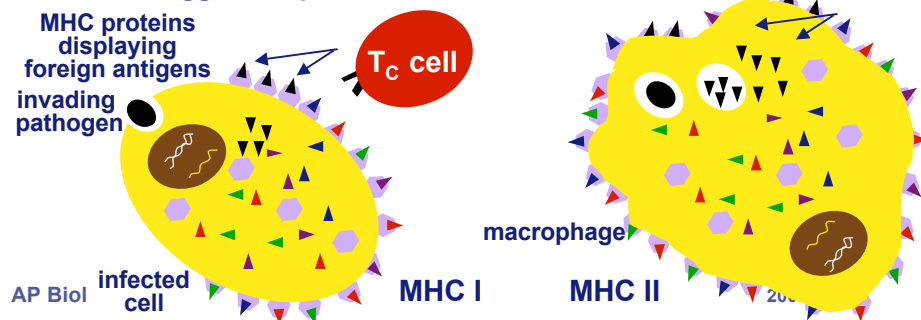
MHC I & MHC II

- **MHC I**

- ♦ presents antigens from infected cells & cancer cells
- ♦ triggers cytotoxic T cells

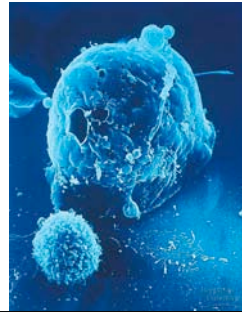
- **MHC II**

- ♦ in phagocytic cells = antigen-presenting cells
- ♦ present antigens from digested pathogens
- ♦ triggers helper T cells

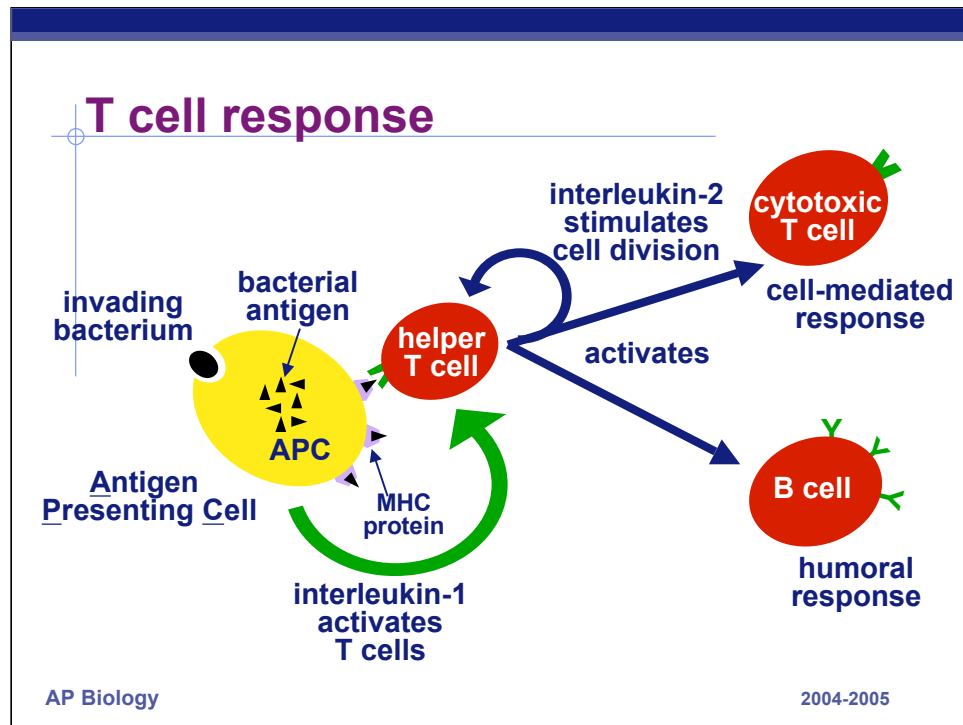


T cells

- **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
 - ◆ respond to antigen-MHC complexes on surface of the body’s own cells
- **Kinds of T cells**
 - ◆ helper T cells
 - stimulate other immune components
 - ◆ cytotoxic T cells
 - attack infected body cells



T cell



Its at this point that helper T cells recognize MHC-antigen complexes

Helper T cells

- Stimulated by body cells' reactions to invaders
 - ◆ interacts with antigen presenting cells (APCs)
 - macrophages & B cells that display invader's antigen on their cell surface
 - ◆ also stimulated by interleukin-1 released by APC
- T cell signals to turn on body's immune responses

Helper T cells

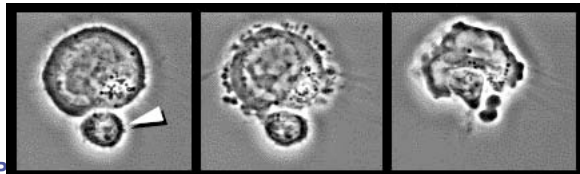
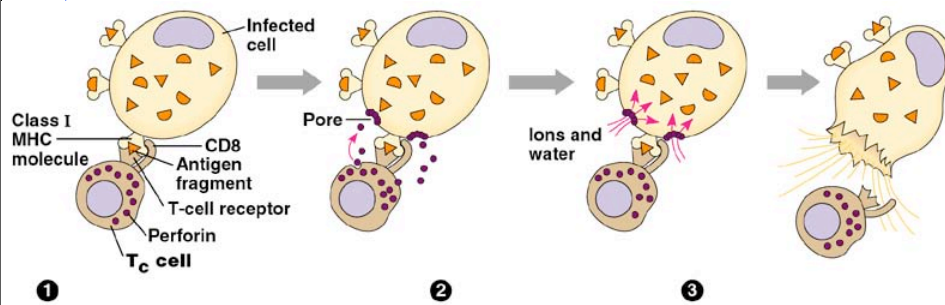
- **Binding to APCs stimulates T cell to turn on body's immune responses**
 - ◆ **signal-transduction pathway**
 - external signal stimulates genes to turn on & cell to produce new proteins
 - ◆ **release interleukin-2**
 - **activates other T cells**
 - ◆ produces more helper T cells
 - ◆ produces memory 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 genes 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!



T cell attacking cancer cell

2004-2005

B cells vs T cells Review

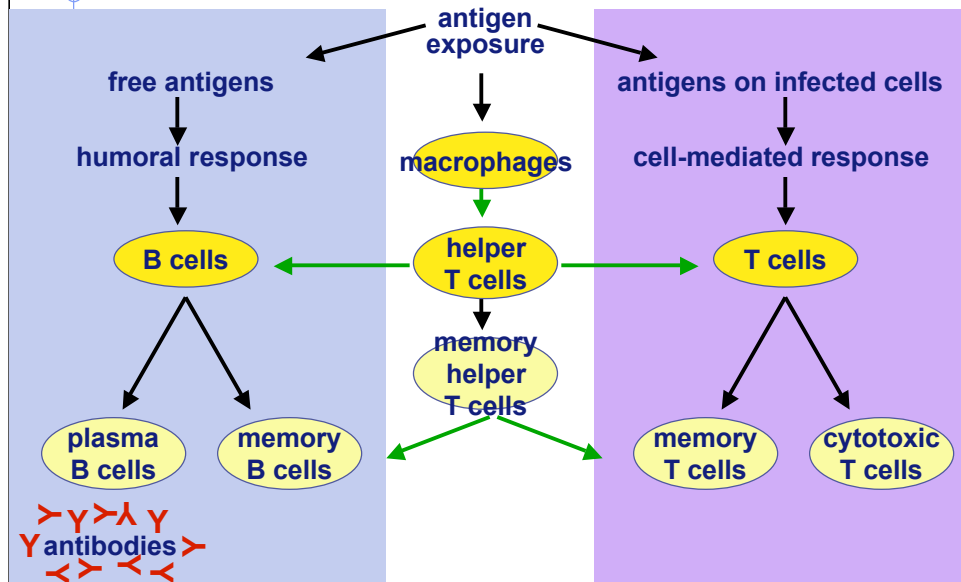
- **B cells**

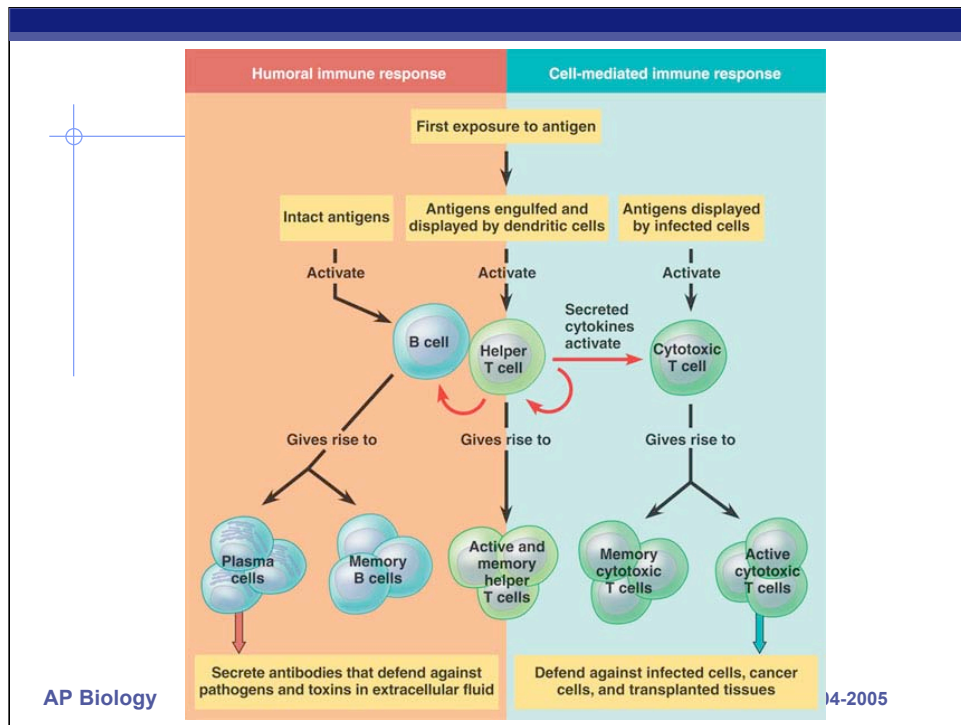
- ♦ humoral response = “in fluid”
- ♦ defend against extracellular pathogens (**invaders in body fluids**) by binding to antigens, making pathogens easier targets for phagocytes

- **T cells**

- ♦ cell-mediated response
- ♦ defend against intracellular pathogens (**invaders inside of cells**) & cancer cells by binding to & lysing infected cells or abnormal cells

Immune response





Immune system malfunctions

■ Auto-immune diseases

- ◆ 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 attacked & destroyed
 - multiple sclerosis
 - ◆ T cells attack myelin sheath of brain & spinal cord nerves

■ Allergies

- ◆ over-reaction to environmental antigens
 - allergens = proteins on pollen, from dust mites, in animal saliva

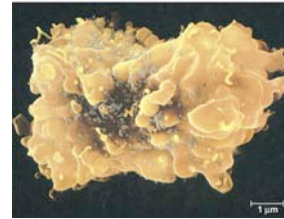
HIV & AIDS

- **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



AP Biology

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° response
 - ◆ **ability to distinguish self vs. non-self**
 - maturation & training process to reduce auto-immune disease