

Conformers vs. Regulators

Regulating the Internal Environment

Maintaining Homeostasis



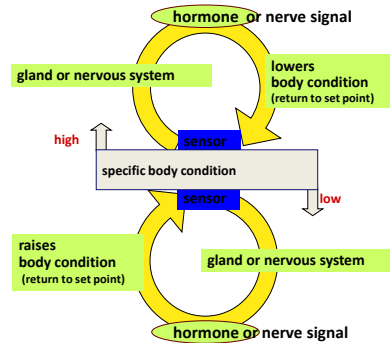
- Two evolutionary paths for organisms
 - regulate internal environment
 - maintain relatively constant internal conditions
 - conform to external environment
 - allow internal conditions to fluctuate along with external changes



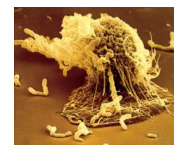
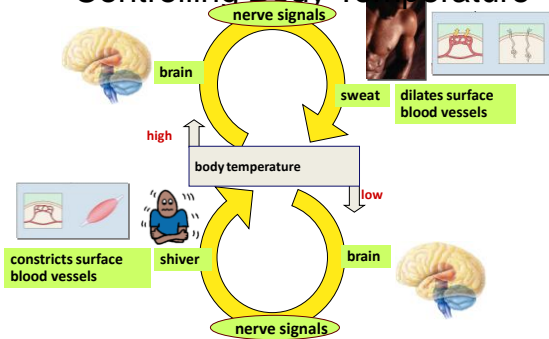
Homeostasis

- Keeping the balance
 - animal body needs to coordinate many systems all at once
 - temperature
 - blood sugar levels
 - energy production
 - water balance & intracellular waste disposal
 - nutrients
 - ion balance
 - cell growth
 - maintaining a "steady state" condition

Negative Feedback Loop

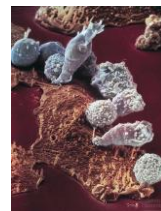


Nervous System Control Controlling Body Temperature



phagocytic leukocyte

Immune / Lymphatic System



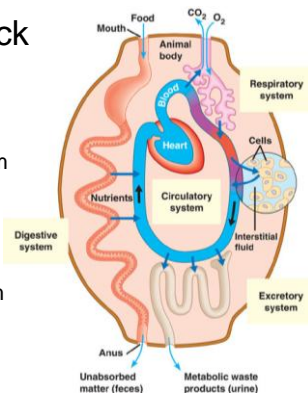
lymphocytes attacking cancer cell



lymph system

Avenues of attack

- Points of entry
 - digestive system
 - respiratory system
 - urogenital tract
 - break in skin
- Routes of attack
 - circulatory system
 - lymph system



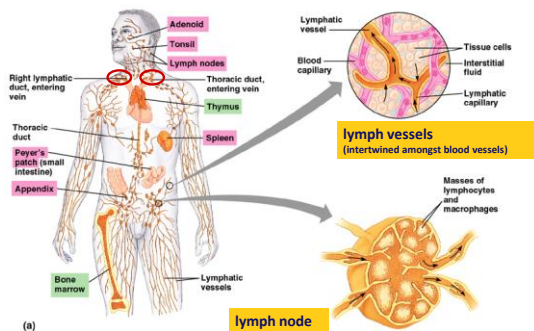
Why an immune system?

- Attack from outside
 - lots of organisms want you for lunch!
 - animals are a tasty nutrient- & vitamin-packed meal
 - cells are packages of macromolecules
 - no cell wall
 - traded mobility for susceptibility
 - animals must defend themselves against invaders
 - viruses
 - HIV, flu, cold, measles, chicken pox, SARS
 - bacteria
 - pneumonia, meningitis, tuberculosis
 - fungi
 - yeast ("Athlete's foot"...)
 - protists
 - amoeba, Lyme disease, malaria
- Attack from inside
 - defend against abnormal body cells = cancers

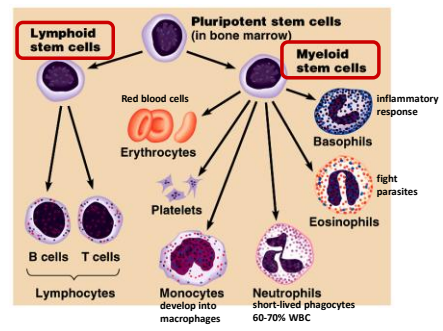


Lymph system

Production & transport of leukocytes
Traps foreign invaders



Development of Red & White blood cells



Lines of defense

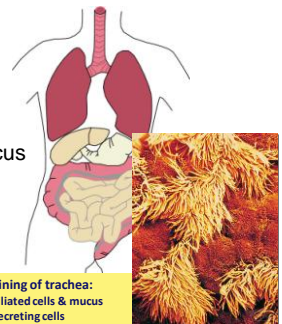
- 1st line: **Barriers**
 - broad, **external** defense
 - "walls & moats"
 - skin & mucus membranes
- 2nd line: **Non-specific patrol**
 - broad, **internal** defense
 - "patrolling soldiers"
 - **leukocytes = phagocytic WBC**
 - macrophages
- 3rd line: **Immune system**
 - specific, **acquired immunity**
 - "spies"
 - **lymphocytes & antibodies**
 - B cells & T cells



Bacteria & insects inherit **resistance**.
Vertebrates acquire **immunity**.

1st line: External defense

- Physical & chemical defenses
 - non-specific defense
- external barrier
 - epithelial cells & mucus membranes
 - skin
 - respiratory system
 - digestive system
 - uro-genital tract



Lining of trachea: ciliated cells & mucus secreting cells

1st line: Chemical barriers on epithelium

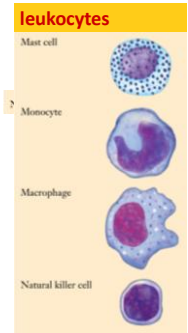
▪ Skin & mucous membrane secretions

- sweat
 - pH 3-5
- tears
 - washing action
- mucus
 - traps microbes
- saliva
 - anti-bacterial = "lick your wounds"
- stomach acid
 - pH 2
- anti-microbial proteins
 - lysozyme enzyme
 - digests bacterial cell walls



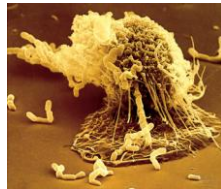
2nd line: Internal, broad range patrol

- Innate, general defense
 - rapid response
- Patrolling cells & proteins
 - attack invaders that penetrate body's outer barriers
 - **leukocytes**
 - **phagocytic** white blood cells
 - complement system
 - anti-microbial proteins
 - inflammatory response

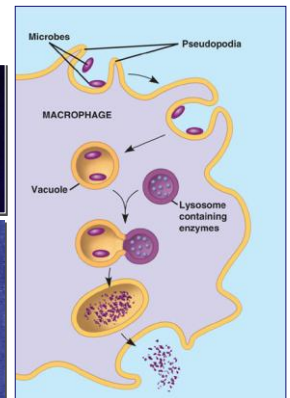
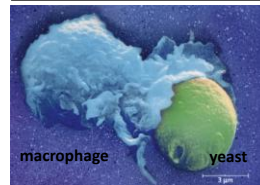
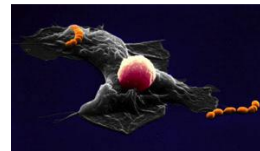


Leukocytes: Phagocytic WBCs

- Attracted by chemical signals released by damaged cells
 - enter infected tissue, engulf & ingest microbes
 - **lysosomes**
- **Neutrophils**
 - most abundant WBC (~70%)
 - ~ 3 day lifespan
- **Macrophages**
 - "big eater", long-lived
- **Natural Killer Cells**
 - destroy virus-infected cells & cancer cells

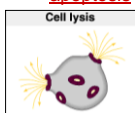


Phagocytes

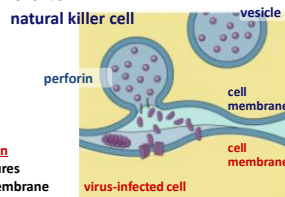


Destroying cells gone bad!

- Natural Killer Cells perforate cells
 - release **perforin** protein
 - insert into membrane of target cell
 - forms pore allowing fluid to flow into cell
 - cell ruptures (lysis)
 - **apoptosis**

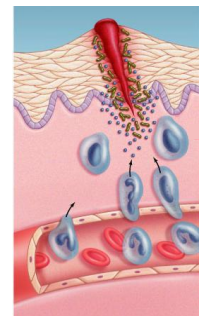


perforin punctures cell membrane



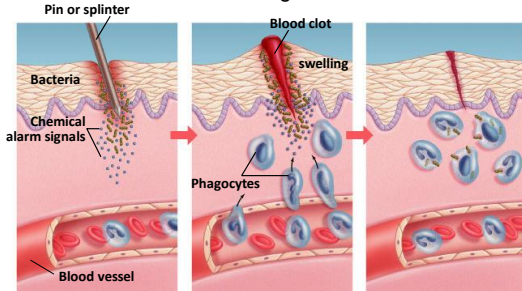
Inflammatory response

- Damage to tissue triggers local non-specific **inflammatory response**
 - release **histamines** & **prostaglandins**
 - capillaries dilate, more permeable (leaky)
 - increase blood supply
 - delivers WBC, RBC, platelets, clotting factors
 - fight pathogens
 - clot formation
 - accounts for swelling, redness & heat of inflammation & infection



Inflammatory response

- Reaction to tissue damage



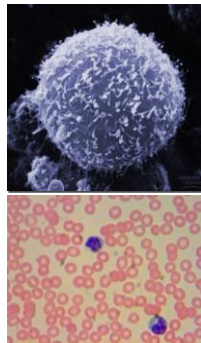
Fever

- When a local response is not enough
 - systemic response to infection
 - activated macrophages release **interleukin-1**
 - triggers **hypothalamus in brain** to readjust body thermostat to raise body temperature
 - higher temperature helps defense
 - inhibits bacterial growth
 - stimulates phagocytosis
 - speeds up repair of tissues
 - causes liver & spleen to store iron, reducing blood iron levels
 - bacteria need large amounts of iron to grow



3rd line: Acquired (active) Immunity

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



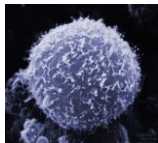
How are invaders recognized: Antigens

- **Antigens**
 - proteins that serve as cellular name tags
 - **foreign antigens** cause response from WBCs
 - viruses, bacteria, protozoa, parasitic worms, fungi, toxins
 - non-pathogens: pollen & transplanted tissue
- B cells & T cells respond to different antigens
 - B cells recognize **intact antigens**
 - pathogens in blood & lymph
 - T cells recognize **antigen fragments**
 - pathogens which have already infected cells



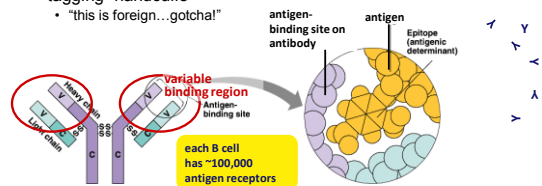
B cells

- **Humoral response** = "in fluid"
 - defense against attackers circulating freely in blood & lymph
- **Specific response**
 - produce specific **antibodies** against specific **antigen**
- **Types of B cells**
 - **plasma cells**
 - immediate production of antibodies
 - rapid response, short term release
 - **memory cells**
 - long term immunity

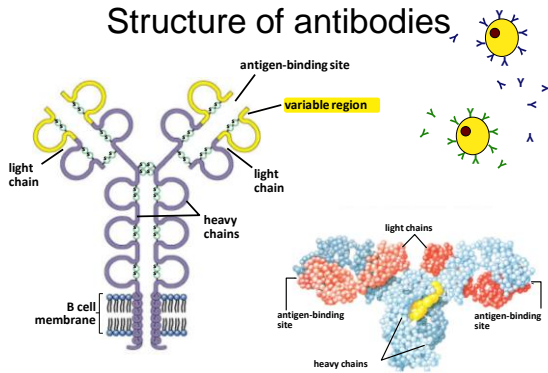


Antibodies

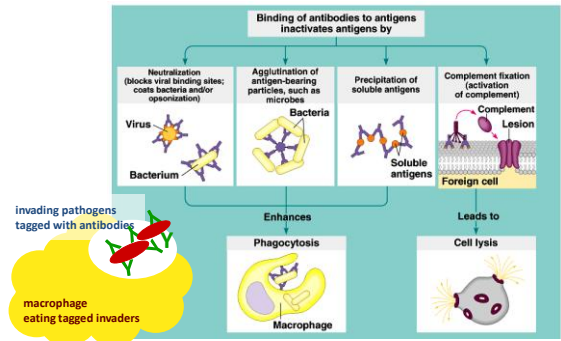
- Proteins that bind to a specific antigen
 - multi-chain proteins produced by B cells
 - binding region matches molecular shape of antigens
 - each antibody is unique & specific
 - millions of antibodies respond to millions of foreign antigens
 - tagging "handcuffs"
 - "this is foreign...gotcha!"



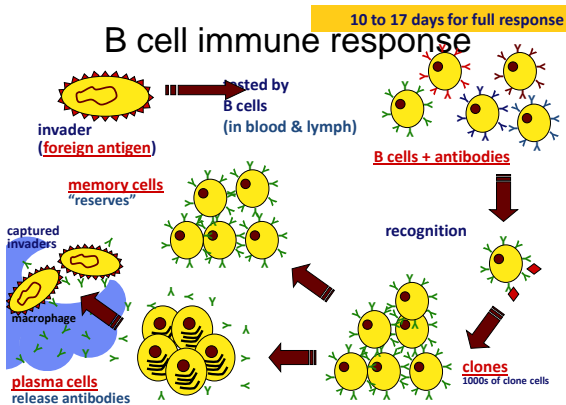
Structure of antibodies



How antibodies work

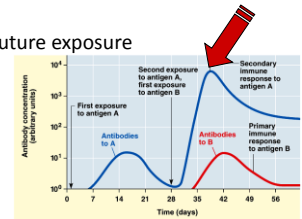


B cell immune response



Vaccinations

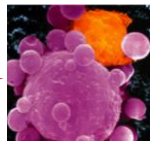
- Immune system exposed to harmless version of pathogen
 - stimulates B cell system to produce antibodies to pathogen
 - "active immunity"
 - rapid response on future exposure
 - creates immunity without getting disease!
- Most successful against viruses



What if the attacker gets past the B cells in the blood & actually infects some of your cells?

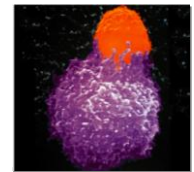
You need trained assassins to kill off these infected cells!

Attack of the Killer T cells!



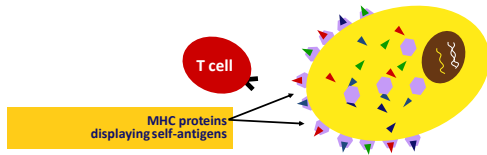
T cells

- Cell-mediated response**
 - immune response to infected cells
 - viruses, bacteria & parasites (pathogens) within cells
 - defense against "non-self" cells
 - cancer & transplant cells
- Types of T cells
 - helper T cells**
 - alerts immune system
 - killer (cytotoxic) T cells**
 - attack infected body cells



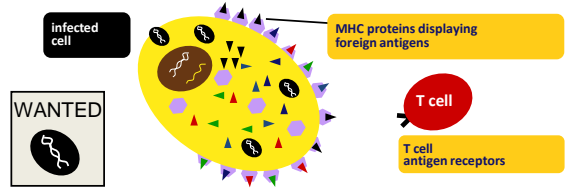
How are cells tagged with antigens

- Major histocompatibility (MHC) proteins
 - antigen glycoproteins
- MHC proteins constantly carry bits of cellular material from the cytosol to the cell surface
 - “snapshot” of what is going on inside cell
 - give the surface of cells a unique label or “fingerprint”

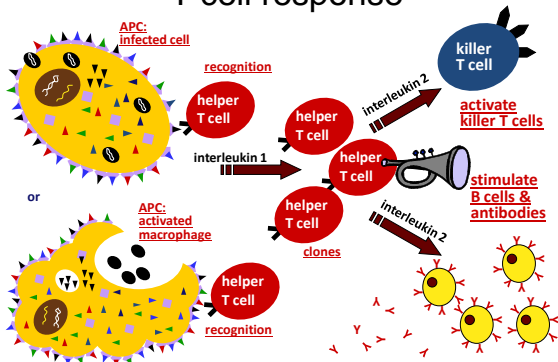


How do T cells know a cell is infected?

- Infected cells digest pathogens & MHC proteins bind & carry pieces to cell surface
 - antigen presenting cells (APC)
 - alerts Helper T cells



T cell response



Attack of the Killer T cells

- Destroys infected body cells
 - binds to target cell
 - secretes perforin protein
 - punctures cell membrane of infected cell

