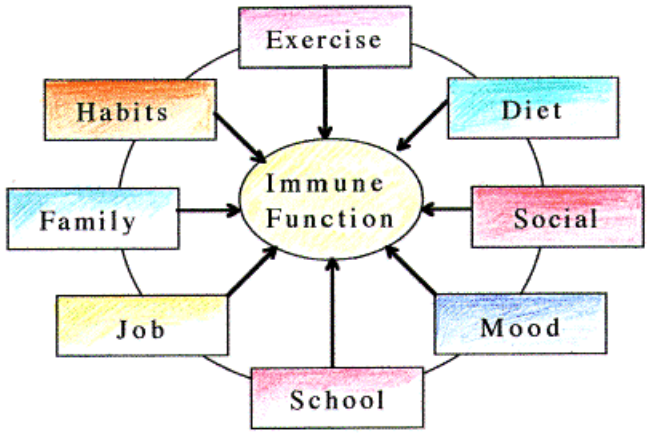
Foundations of Public Health Immunology



Source: http://www.rice.edu/~jenky/sports/fatigue.html

Immunology Principles

Immunology & Public Health

- Study of immunology closely linked to practice of medicine
  - Transplants, treatments, & vaccines
- Increasing importance to public health
  - Infectious diseases, malnutrition, & tropical medicine
  - Worldwide a large immuno-compromised population
  - Spread of disease!

HIV/AIDS patients in Africa are receiving anti-retroviral drugs through a charitable campaign called RED, with some famous supporters. **The destruction of the immune system by HIV has significantly increased morbidity and mortality worldwide, and is a leading global health concern.** This semester we will learn more about public health efforts to stop the spread of the disease, as well as how HIV directly targets T cells.

Objectives

- Immunology Principles
  - Describe the innate immune system
  - Describe the adaptive immune system
  - Identify characteristics & types of each system
  - Identify accessories to these systems

Immunology

Definition:

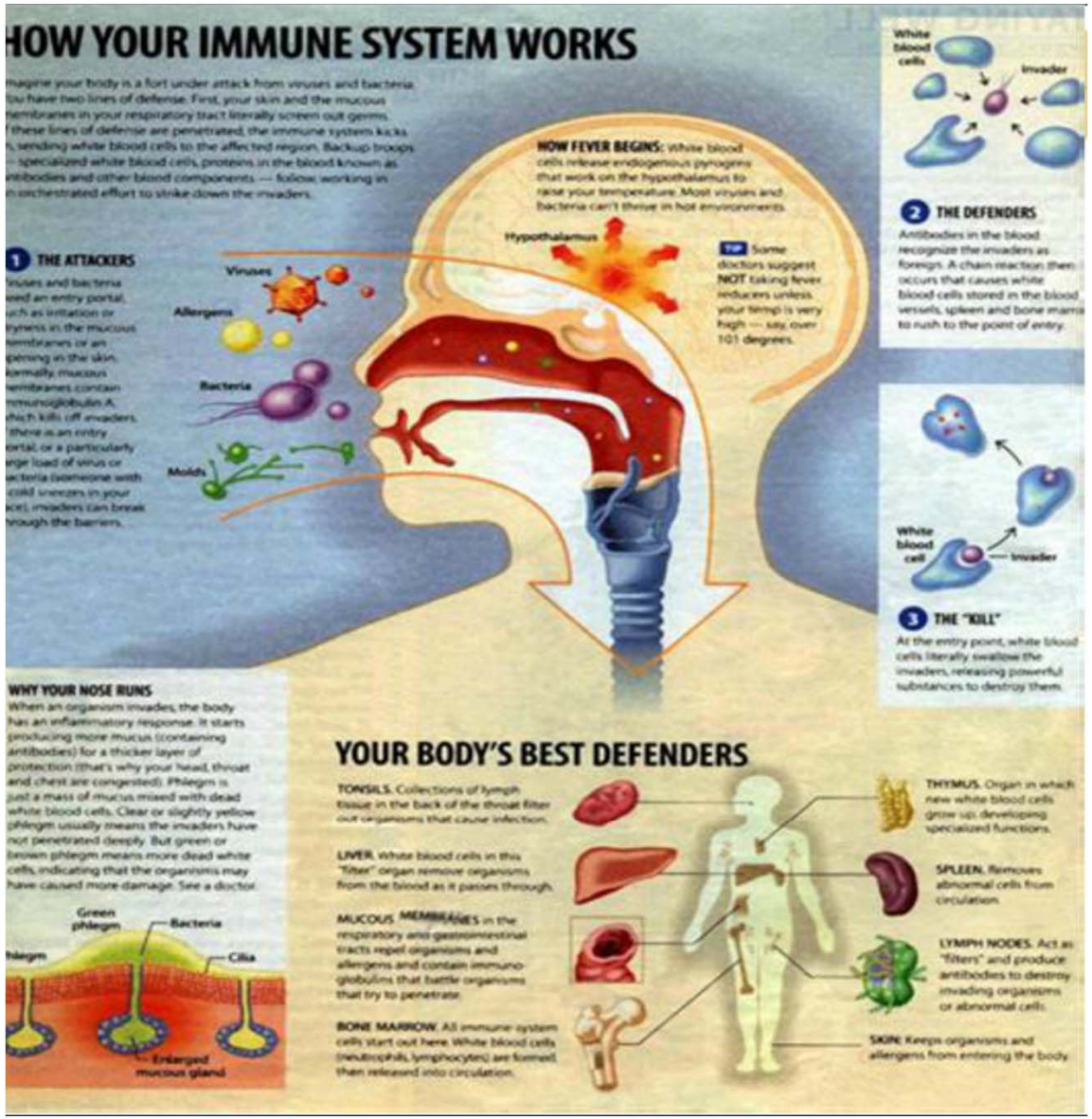
The study of the organs, cells, and molecules of the immune system & accessory systems

- Recognition and disposal of foreign (non-self) materials (also know as antigens – Ag)
- How the systems respond and interact
- Desirable and/or undesirable consequences of their activity
- The ways these activities can be advantageously increase or decreased.

Immune System

Purpose: Prevent Infection

- Responsiveness to a diverse range of environmental information
- Responses are usually adaptive & specific to the stimulus
- Complex internal regulatory networks
- Capacity to respond to unexpected stimuli
- Self-referential & self-protective

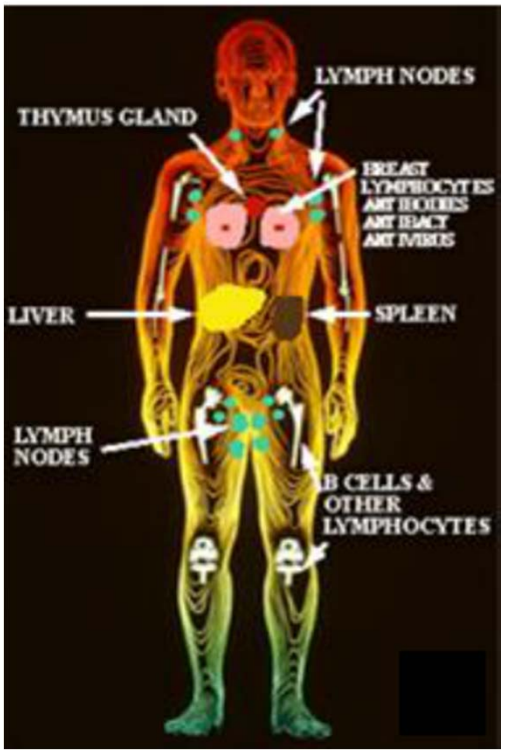

HOW YOUR IMMUNE SYSTEM WORKS
magine your body is a fort under attack from viruses and bacteria. ou have two lines of defense. First, your skin and the mucous embranes in your respiratory tract literally screen out germs. f these lines of defense are penetrated, the immune system kicks , sending white blood cells to the affected region. Backup troops – specialized white blood cells, proteins in the blood known as ntibodies and other blood components — follow, working in n orchestrated effort to strike down the invaders.
1 THE ATTACKERS
iruses and bacteria eed an entry portal, uch as irritation or ryness in the mucous embranes or an pening in the skin. ormally, mucous embranes contain mmunoglobulin A, hich kills off invaders. f there is an entry ortal, or a particularly arge load of virus or acteria (someone with cold sneezes in your ace), invaders can break hrough the barriers.
Viruses
Allergens
Bacteria
Molds
HOW FEVER BEGINS: White blood cells release endogenous pyrogens that work on the hypothalamus to raise your temperature. Most viruses and bacteria can't thrive in hot environments.
Hypothalamus
TIP Some doctors suggest NOT taking fever reducers unless your temp is very high — say, over 101 degrees.
White blood cells
Invader
2 THE DEFENDERS
Antibodies in the blood recognize the invaders as foreign. A chain reaction then occurs that causes white blood cells stored in the blood vessels, spleen and bone marrow to rush to the point of entry.
White blood cell
Invader
3 THE "KILL"
At the entry point, white blood cells literally swallow the invaders, releasing powerful substances to destroy them.
WHY YOUR NOSE RUNS
When an organism invades, the body has an inflammatory response. It starts producing more mucus (containing antibodies) for a thicker layer of protection (that's why your head, throat and chest are congested). Phlegm is just a mass of mucus mixed with dead white blood cells. Clear or slightly yellow phlegm usually means the invaders have not penetrated deeply. But green or brown phlegm means more dead white cells, indicating that the organisms may have caused more damage. See a doctor.
Green phlegm
Bacteria
Phlegm
Cilia
Enlarged mucous gland
YOUR BODY'S BEST DEFENDERS
TONSILS. Collections of lymph tissue in the back of the throat filter out organisms that cause infection.
LIVER. White blood cells in this "filter" organ remove organisms from the blood as it passes through.
MUCOUS MEMBRANES in the respiratory and gastrointestinal tracts repel organisms and allergens and contain immuno-globulins that battle organisms that try to penetrate.
BONE MARROW. All immune system cells start out here. White blood cells (neutrophils, lymphocytes) are formed, then released into circulation.
THYMUS. Organ in which new white blood cells grow up, developing specialized functions.
SPLEEN. Removes abnormal cells from circulation.
LYMPH NODES. Act as "filters" and produce antibodies to destroy invading organisms or abnormal cells.
SKIN. Keeps organisms and allergens from entering the body.

Innate and Acquired Immunity

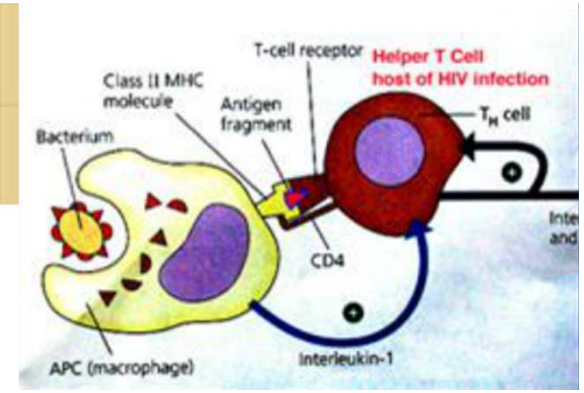
- Innate immunity
  - Natural immunity
  - No specificity
  - Defense through skin, macrophages, etc
- Acquired immunity
  - Adaptive immunity
  - Highly specific, leads to memory
  - Defense through lymphocytes – T and B cells

Mission Near Impossible

- For an organism to cause an infection, it must first colonize the host
- Pathogens must complete the following tasks:
  - Penetrate barriers (skin)
  - Resist physical removal (cilia)
  - Compete against normal flora
  - Defuse chemical defenses
  - Avoid stimulating inflammation
  - AND, escape acquired immunity

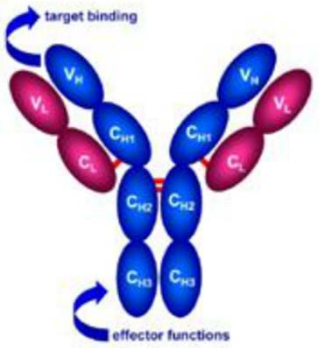


Antigen (Ag)



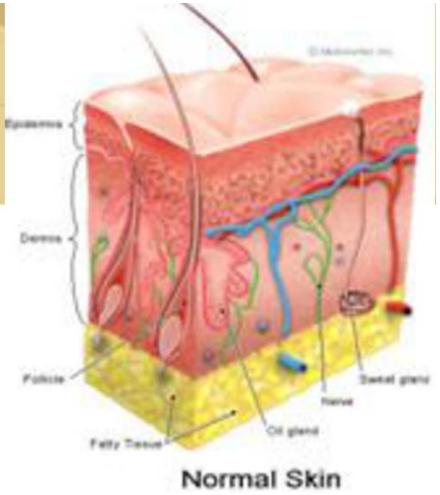
- Antigens will be described in more detail in Block Four, but for now …
- They are non-self particles that have gained access to the body (such as a microbe or pollen)
- They are recognized by the immune system as foreign (by both innate & adaptive systems) & targeted for removal.

Antibody (Ab)



- Antibodies will be described in more detail in Block Three, but for now …
- They are proteins that are produced by B cells to a specific pathogen or antigen
- Antibodies can attach to the pathogen & neutralize it, or target it for removal by other immune cells
- Integral component of the acquired defense

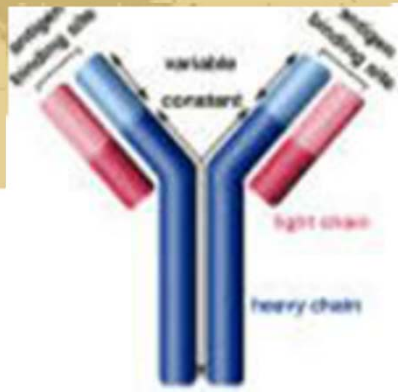
Resistance



- Innate (non-adaptive) or Constitutive "immunity"
- *Not specific* for any given pathogen or Ag
- Does not improve with successive exposures to the same pathogen or antigen – *no memory*
- Accessories to the adaptive immune system; complement, phagocytes, enzymes work to enhance adaptive response

Adaptive Immune System

- Purpose: must recognize self vs. non-self
  - Mostly recognizes pathogens
  - Many times innocuous particles (pet dander)
  - Sometimes self (autoimmunity)
- Components:
  - Antigen (substance capable of eliciting immune response)
  - Cellular limb – T and B cells (cell mediated)
  - Humoral limb – antibodies (ab mediated)



Adaptive Immunity

- Also called Acquired immunity
- *Specific* response to a given pathogen or antigen (antigens are non-self to the body)
- Improves with successive exposures to the same pathogen or Ag – *memory*
- Works together with accessories to protect against pathogens or to exert other effects such as immunopathology

Acquired Immunity

- Can be antibody or cell-mediated – usually both!
- Which type of immune response is effective is determined primarily by the site of the infection and type of pathogen involved
  - Extracellular, intracellular, persistent, etc.
- Immune responses are intimately connected to all other systems in the body

Types of Acquired Immunity

- **Acquired Naturally**

  Active: exposure to pathogen with resulting disease & immune response made

  Passive: transplacental Ab to fetus, no immune response made

- **Acquired Artificially**

  Active: exposure to Ag (tetanus toxoid vaccine) with immune response made

  Passive: injection of Ab (tetanus antitoxin), no immune response made

Examples of Innate Resistance & Acquired Immunity

	Innate Resistance	Acquired Immunity
Physicochemical Barriers	Skin & mucous membranes	Mucosal Immune systems, SIgA
Circulating Molecules	Complement	Antibody
Cells	Phagocytes, granulocytes & NK Cells	T & B Lymphocytes
Soluble Mediators	Non-L'cyte derived cytokines	L'cyte derived cytokines

TABLE 3-7 Receptors of innate and adaptive immunity

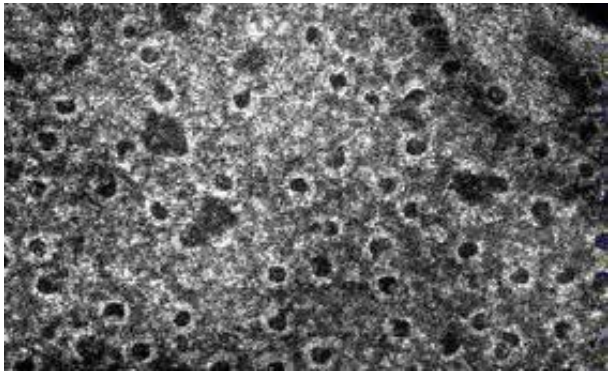
Characteristic	Innate immunity	Adaptive immunity
Specificity	Specific for conserved molecular patterns or types	Specific for details of antigen structure
Self/nonself discrimination	Perfect: evolutionarily selected to distinguish phylogenetic differences. Never recognizes self.	Excellent: but imperfect. Occasional reaction with self antigens

RECEPTORS OF THE ADAPTIVE IMMUNE SYSTEM

Receptor (location)	Target (source)	Effect of recognition
Antibody (B-cell membrane, blood, tissue fluids)	Specific components of pathogen	Labeling of pathogen for destruction and removal
T-cell receptor (T-cell membrane)	Proteins or certain lipids of pathogen	Induction of pathogen-specific humoral and cell-mediated immunity

Accessories to the Immune System

- **Complement:** a set of ~20 proteins, present in the body fluids in inactive form, that can be sequentially activated in a controlled sequence (zymogens)



Complement membrane attack complexes (above) punch holes in the membranes of microbial invaders.

Functions of Complement

- Plays an essential role in inflammation
- Assists Abs in effector functions (Antibody Dependent Cell-mediated Cytotoxicity – ADCC)
- Assist in clearing immune complexes
- Deficiencies can result in severe inflammation
- Opsonization and facilitation of phagocytosis
- No Ag specificity

Accessories to the Immune System

- Inflammation: the body's nonspecific reaction to invasion by pathogen, antigenic challenge or physical damage
- Acute Inflammation: short-lived response to transient injury
  - Cardinal signs: redness, heat, swelling, pain & immobility
  - Response is exudative in nature – neutrophils
  - Major goal: allow products of the immune response to enter area of infection or damage

Accessories to the Immune System

- Chronic Inflammation: sustained reaction to persistent injurious stimulus or Ag
  - May follow acute inflammatory response
  - Response is proliferative in nature – mononuclear cells, granuloma formation
  - Major goal: containment of injurious stimulus or Ag
- Acute and Chronic are different!

Immunopathology

- The immune system can be the cause of disease or other undesirable consequences – two-edged sword
  - Autoimmunity: inappropriate reaction to self as foreign
  - Immunodeficiency: ineffective immune responses, congenital & acquired
  - Hypersensitivity: overactive immune response to harmless Ags
  - Inconvenient responses: graft rejection, blood transfusions, reactions to drugs

In Summary

- Important components of the immune response:
  - Innate vs. acquired
  - Complement
  - Inflammation
  - Antibody
  - Antigen
  - Immunopathology
- These topics will be covered in more detail in upcoming units…

Keep in mind …

- Our immune systems are always on watch for intruders & ready to respond immediately!

Self-Test Questions: Principles

- Which type of immunity improves after specifically recognizing antigen?
- What is an antibody? An antigen?
- Give 2 types of acquired immunity & examples of each.
- What is complement? Inflammation?
- Name & describe 2 types of inflammation.