Foundations of Public Health

Immunology Principles

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

The immune system protects the body from foreign invaders, such as viruses and bacteria. It has two main lines of defense:

1. **The Attackers**
   - Viruses
   - Bacteria
   - Allergens
   - Mites
   - Fungi
   - Infections
   - Physical or chemical injuries

2. **The Defenders**
   - Phagocytes: Cells that engulf and destroy invaders.
   - Antibodies: Proteins that recognize and neutralize foreign substances.
   - Complement system: A network of proteins that work together to destroy pathogens.
   - Natural killer cells: Cells that can kill virus-infected cells and cancer cells.

3. **The ‘Kill’**
   - The immune system can recognize and destroy invaders before they cause harm.

**WHY YOUR NOSE RUNS**
When an organism invades, the body has an inflammatory response. It starts producing mucus, which can be helpful in blocking or swallowing an attacker.

**YOUR BODY’S BEST DEFENDERS**
- **Tonsils**: Collections of lymph tissue in the back of the throat that filter out organisms that cause infection.
- **Liver**: White blood cells in this ‘filter’ organ remove organisms from the blood as it passes through.
- **Spleen**: Removes abnormal cells from circulation.
- **bone marrow**: All immune system cells start out here. White blood cells (neutrophils, lymphocytes) are formed, then released into circulation.
- **Skin**: Keeps organisms and allergens from entering the body.

**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.

**ANTIBODIES**
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.

**THE ‘KILL’**
At the entry point, white blood cells literally swallow the invaders, releasing powerful substances to destroy them.
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
Resistence

- 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

<table>
<thead>
<tr>
<th></th>
<th>Innate Resistance</th>
<th>Acquired Immunity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Physicochemical Barriers</td>
<td>Skin &amp; mucous membranes</td>
<td>Mucosal Immune systems, SIgA</td>
</tr>
<tr>
<td>Circulating Molecules</td>
<td>Complement</td>
<td>Antibody</td>
</tr>
<tr>
<td>Cells</td>
<td>Phagocytes, granulocytes &amp; NK Cells</td>
<td>T &amp; B Lymphocytes</td>
</tr>
<tr>
<td>Soluble Mediators</td>
<td>Non-L’cyte derived cytokines</td>
<td>L’cyte derived cytokines</td>
</tr>
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### TABLE 3-7 Receptors of innate and adaptive immunity

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Innate immunity</th>
<th>Adaptive immunity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Specificity</td>
<td>Specific for conserved molecular patterns or types</td>
<td>Specific for details of antigen structure</td>
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**RECEPTORS OF THE ADAPTIVE IMMUNE SYSTEM**

<table>
<thead>
<tr>
<th>Receptor (location)</th>
<th>Target (source)</th>
<th>Effect of recognition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Antibody (B-cell membrane,</td>
<td>Specific components of</td>
<td>Labeling of pathogen for destruction and removal</td>
</tr>
<tr>
<td>blood, tissue fluids)</td>
<td>pathogen</td>
<td></td>
</tr>
<tr>
<td>T-cell receptor (T-cell</td>
<td>Proteins or certain lipids of pathogen</td>
<td>Induction of pathogen-specific humoral and cell-mediated immunity</td>
</tr>
<tr>
<td>membrane)</td>
<td></td>
<td></td>
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</tbody>
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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.