WHITE BLOOD CELL VS. THE COMMON COLD

NobodY in or out. got that? it's chilly out and this kid doesn't have a jacket.

woah, cold virus has hot chocolate!

let him in.

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The Immune System:
Protector of the human body
Organs of the Immune System

- Tonsils and adenoids
- Lymph nodes
- Lymphatic vessels
- Thymus
- Lymph nodes
- Spleen
- Peyer’s patches
- Lymph nodes
- Lymphatic vessels
- Appendix
- Bone marrow

• You wake up one morning with a stuffy nose, slight fever, and fatigue. Do you have a cold or the flu? Or are they the same?

• Should you go to your doctor for an antibiotic? Why or why not?
The not-so-common cold

• A “cold” is an infection of the mucus membranes of the respiratory tract by a rhinovirus.

• Over 100 rhinoviruses have been identified, which is one reason why we don’t become immune to “the cold.”
Virus vs. Bacteria

- Colds and influenza are caused by viruses.
- Viruses are which is a non-living particle that contains genetic material, and hijacks your cells to reproduce.
- Viruses cannot be “killed” with antibiotics.
Virus vs. Bacteria

- Bacteria are living organisms that have a metabolism, have DNA, and can reproduce on their own.

- Bacteria can be killed with antibiotics because these substances target key processes in bacteria, such as production of the bacterial cell wall.
The immune system functions as the body's defense against invaders.
Muscle cell

Nerve cell

Epithelial cell

Leukocyte

Class I MHC self-marker protein

Self vs. Nonself

Antigen

Bacteria

SARS virus

Epitope

Antibody

Non-self nerve cell

Antigen

Epitope

Class I MHC protein

Antibody
Viruses and bacteria are everywhere. Some of them want to invade your body. How does your body defend itself against viruses and bacteria?
First line of defense
The barricade

- **Skin** prevents entry
- **Saliva** antibacterial enzymes
- **Tears** antibacterial enzymes
- **Mucus** linings traps dirt and microbes
- **Stomach acid** low pH kills harmful microbes
- **“Good” gut bacteria** out compete bad microbes
Defense Against Disease

If these barriers are penetrated, the body responds with

**Nonspecific External Barriers**  
skin, mucous membranes

If the innate immune response is insufficient, the body responds with

**Innate Immune Response**  
phagocytic and natural killer cells, inflammation, fever

If the innate immune response is insufficient, the body responds with

**Adaptive Immune Response**  
cell-mediated immunity, humoral immunity
Non-specific defenses are designed to prevent infections by viruses and bacteria. These include:

- Intact skin
- Mucus and Cilia
- Phagocytes
Role of skin

- Dead skin cells are constantly sloughed off, making it hard for invading bacteria to colonize.
- Sweat and oils contain anti-microbial chemicals, including some antibiotics.
Role of mucus and cilia

- Mucus contains lysozymes, enzymes that destroy bacterial cell walls.
- The normal flow of mucus washes bacteria and viruses off of mucus membranes.
- Cilia in the respiratory tract move mucus out of the lungs to keep bacteria and viruses out.
Second line of defense

*Non-specific patrol*

**phagocytes**
- Monocyte: circulate in the blood
- Dendritic cell: stationary monitors
- Eosinophil
- Neutrophil: blood cell can move into tissues as needed
- Basophil
- Mast cell: not a blood cell, allergy symptoms

**neutrophils**
- Macrophage: secrete signals, important in immune response

*Images by Annette Kelly ©2004*
Role of phagocytes

- Phagocytes are several types of white blood cells (including macrophages and neutrophils) that seek and destroy invaders. Some also destroy damaged body cells.
- Phagocytes are attracted by an inflammatory response of damaged cells.
What's in a pimple?

Accumulation of dead phagocytes, destroyed bacteria and dead cells
Ouch!

1. Tissue damage carries bacteria into wound.
2. Wounded cells release chemicals that stimulate mast cells.
3. Mast cells release histamine.
4. Histamine increases capillary blood flow and permeability.
5. Phagocytes leave capillaries and ingest bacteria and dead cells.
The Immune Response
Part of the second line of defense

Inflammation

Fever
Role of inflammation

• Inflammation is signaled by mast cells, which release histamine.

• Histamine causes fluids to collect around an injury to dilute toxins. This causes swelling.

• The temperature of the tissues may rise, which can kill temperature-sensitive microbes.
Role of fever

- Fever is a defense mechanism that can destroy many types of microbes.
- Fever also helps fight viral infections by increasing interferon production.
- While high fevers can be dangerous, some doctors recommend letting low fevers run their course without taking aspirin or ibuprofen.
Fever is caused by:

1. Toxins on the surface of viruses.
2. Release of histamines by damaged cells.
3. Your own body’s accumulated toxins.
4. Your body’s pyrogens signaling the hypothalamus.
Based on what you know about non-specific defenses, what’s the best way to treat a cut in your skin?

1. Leave it exposed to open air.
2. Wash it, and cover it with a clean bandage.
3. Rub it with dirt.
• Why aren’t non-specific defenses enough? Why do we also need specific defenses?
Specific defenses

- Specific defenses are those that give us immunity to certain diseases.
- In specific defenses, the immune system forms a chemical “memory” of the invading microbe. If the microbe is encountered again, the body reacts so quickly that few or no symptoms are felt.
Major players

- The major players in the immune system include:
  - Macrophage
  - T cells (helper, cytotoxic, memory)
  - B cells (plasma, memory)
  - Antibodies
Some vocabulary:

- **Antibody**: a protein produced by the human immune system to tag and destroy invasive microbes.
- **Antibiotic**: various chemicals produced by certain soil microbes that are toxic to many bacteria. Some we use as medicines.
- **Antigen**: any protein that our immune system uses to recognize “self” vs. “not self.”
Antibodies

- Antibodies are assembled out of protein chains.
- There are many different chains that the immune system assembles in different ways to make different antibodies.
Antibodies as Receptors

- Antibodies can attach to B cells, and serve to recognize foreign antigens.
Antigens as Effectors

- Free antibodies can bind to antigens, which “tags” the antigen for the immune system to attack and destroy.
Antigen recognition

• Cells of the immune system are “trained” to recognize “self” proteins vs. “not self” proteins.

• If an antigen (“not self”) protein is encountered by a macrophage, it will bring the protein to a helper T-cell for identification.

• If the helper T-cell recognizes the protein as “not self,” it will launch an immune response.
Helper T cells

- Helper T-cells have receptors for recognizing antigens. If they are presented with an antigen, they release cytokines to stimulate B-cell division.

- The helper T-cell is the key cell to signal an immune response. If helper T-cells are disabled, as they are in people with AIDS, the immune system will not respond.
B cells

• B-cells in general produce antibodies. Those with antibodies that bind with the invader’s antigen are stimulated to reproduce rapidly.

• B-cells differentiate into either plasma cells or memory B-cells. Plasma cells rapidly produce antibodies. Memory cells retain the “memory” of the invader and remain ready to divide rapidly if an invasion occurs again.
Clonal Selection

1. Invading antigens bind to antibodies on one B cell.
2. The B cell "selected" by antigen multiplies rapidly.
3. A large clone of genetically identical B cells is produced.
4. B cells differentiate into plasma cells and memory cells.
Role of antibodies

- Antibodies released into the blood stream will bind to the antigens that they are specific for.
- Antibodies may disable some microbes, or cause them to stick together (agglutinate). They “tag” microbes so that the microbes are quickly recognized by various white blood cells.
“Killer” T cells

- While B-cells divide and differentiate, so do T-cells.
- Some T-cells become cytotoxic, or “killer” T-cells. These T-cells seek out and destroy any antigens in the system, and destroy microbes “tagged” by antibodies.
- Some cytotoxic T-cells can recognize and destroy cancer cells.
Calling a halt

• When the invader is destroyed, the helper T-cell calls a halt to the immune response.

• Memory T-cells are formed, which can quickly divide and produce cytotoxic T-cells to quickly fight off the invader if it is encountered again in the future.
A foreign protein that enters the body is an:

1. antibiotic.  
2. antigen.  
3. antibody.  
4. anti-inflammatory.

25% 25% 25% 25%
The specific immune response is triggered when:

1. A macrophage delivers an antigen to a T-helper cell.
2. Plasma cells begin making antibodies.
3. Pyrogen stimulates a fever.
4. Clonal selection of B-cells occurs.
• Why is it important for the immune system to have a way of stopping the immune response? Why not just keep going and fight off everything as it comes?
Human Assist
Helping the immune system

- Medical science has created two systems for augmenting the human immune system:
  - Antibiotics (NOT the same as antibodies)
  - Vaccines
How antibiotics work

- Antibiotics help destroy bacteria (but not viruses).
- Antibiotics work in one of several ways:
  - Slowing bacteria reproduction.
  - Interfering with bacterial cell wall formation.
Antibiotic myths

• Antibiotics are not antibodies.
• Antibiotics do not weaken our immune system. They help it by weakening bacteria.
• Humans do not become “immune” to antibiotics. Bacteria that resist antibiotics and are not completely destroyed may multiply, producing more antibiotic-resistant bacteria.
Vaccine history

- Variolation: The deliberate inoculation of people with secretions from smallpox (*Variola*) sores, by inhaling the dried secretions or rubbing them on broken skin. Used for centuries in Asia and Africa.
Vaccine history

- Vaccination: (From *vacca*, Latin for cow.) Invented by Edward Jenner in 1796. Jenner knew that dairy maids who had contracted cowpox never got smallpox. He inoculated a boy with secretions from cowpox sores, and showed the boy was immune to smallpox.
Not that everyone accepted the process. Cartoons like this created widespread fear of the “cow pock” vaccine.
How vaccines work

- Modern vaccines are created from killed bacteria or viruses, or fragments of proteins from these microbes.
- The proteins are recognized as antigens by our immune systems. This causes a mild immune response. Memory T-cells and B-cells remain ready to fight off the illness if it is encountered again.
Vaccine myths

- The flu vaccine does not give you the flu. Some people get the vaccine too late, or catch a cold and think they have the flu.
- Vaccines are not less effective than a “natural” infection with the illness. The immunity is the same, and a mild response to a vaccine is much less risky than a full-blown infection of measles.
- The proposed link between vaccines and autism turns out to have far less experimental support than was originally reported.
True or false: Antibiotics weaken the immune system because your body doesn’t learn to make enough antibodies.

1. True. Antibiotics are a type of antibody.
2. False. Antibiotics are not antibodies.
True or false: Vaccines weaken the immune system because the body doesn’t learn to defend itself without help.

1. True. The immune system needs to exercise itself or it won’t get strong.

2. False. Vaccination causes the body to learn to defend itself.
Vaccines stimulate the production of:

1. Antibodies.
2. Helper T-cells.
3. Antigens.
4. Memory cells.
• Why will antibiotics work against bacteria but not viruses?
• Why don’t antibiotics kill your own cells?
Immune system challenges
But I caught a cold... again!

- Because there are over 100 different known rhinoviruses, it’s possible to catch colds again and again.

- In addition, cold viruses can mutate quickly. No sooner do we have immunity to one form than along comes another.
How did I get this cold?

- To catch a cold, a rhinovirus must reach the mucus membranes of your upper respiratory system.

- Your hands pick up rhinoviruses from surfaces. Every time you touch your eyes or nose, or eat something with your hands, the viruses get a free ride. Like Mom said, wash your hands!

- Viruses may also ride on re-circulated air, or reach you if someone sneezes right at you.
Cold myths

- Colds and “the flu” are different illnesses. Not every respiratory infection is “the flu.”
- Colds are not caused by getting chilled. This belief comes from medical ideas of prior centuries, when it was believed that illness was caused by an imbalance of “humors,” and that a person with a cold actually had too much “coldness.”
- “Feed a cold, starve a fever” also comes from prior centuries, when it was thought that people with a cold had too much “cold” and “moisture” in their bodies, and needed food to increase heat, while people with fever had too much “dryness” and “heat,” so needed less food to cool them down.
# Cold vs. “Flu” (influenza)

<table>
<thead>
<tr>
<th>Symptoms</th>
<th>Cold</th>
<th>Flu</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fever</td>
<td>rare</td>
<td>characteristic</td>
</tr>
<tr>
<td>Headache</td>
<td>mild (sinus)</td>
<td>strong</td>
</tr>
<tr>
<td>Aches &amp; Pains</td>
<td>slight</td>
<td>usual, strong</td>
</tr>
<tr>
<td>Fatigue</td>
<td>mild</td>
<td>2-3 weeks</td>
</tr>
<tr>
<td>Exhaustion</td>
<td>never</td>
<td>early, profound</td>
</tr>
<tr>
<td>Stuffy nose</td>
<td>usual</td>
<td>sometimes</td>
</tr>
<tr>
<td>Sneezing</td>
<td>usual</td>
<td>sometimes</td>
</tr>
<tr>
<td>Sore throat</td>
<td>common</td>
<td>sometimes</td>
</tr>
<tr>
<td>Chest discomfort</td>
<td>mild</td>
<td>common, strong</td>
</tr>
</tbody>
</table>
Stomach flu?

- Influenza is a respiratory virus. Strictly speaking, there is no stomach flu.
- There are, however, viruses that attack the digestive system. Norovirus and rotavirus cause the nausea, vomiting, and diarrhea that many people call “stomach flu.” If left untreated, the rapid dehydration these viruses cause can be fatal.
- Bacterial food poisoning can also cause fast-onset vomiting and diarrhea.
Echinacea for colds?

• Echinacea is supposed to “strengthen” the immune system.

• Studies in petri dishes showed Echinacea stimulated white blood cells to produce more virus-killing peroxides, but controlled human trials have not had consistent results.
Vitamin C for colds?

• Vitamin C is necessary for making collagen, and for many body functions.

• Absorption of Vitamin C increases during illness. It also has a very slight antihistamine effect.

• Vitamin C won’t cure a cold, but may support some aspects of immune response.
Zinc for colds?

• Some studies have shown that moderate use of zinc lozenges slightly decreases the duration and severity of colds.

• However, too much zinc can suppress the immune system, and can reach toxic levels. Zinc nasal sprays can destroy olfactory receptors.
Vitamin D for colds?

- New research suggests that Vitamin D plays a role in immune response, and may be critical for fighting off viruses.

- Vitamin D is fat-soluble and can accumulate to toxic levels. A blood test can determine if a person needs to take Vitamin D.
Evolution of the flu

• Flu viruses also mutate quickly.
• The same form of the flu may have the ability to infect several different vertebrate animals.
• Different forms may hybridize their genetic material, causing new strains to develop in a single generation.
New Flu

Hybrid human-bird virus forms in pig and may infect people.
Flu Pandemic

- The deadly 1918 flu pandemic has been recently identified as an avian flu. Unlike common flu, it killed mostly young, healthy people.

- The recent H1N1 flu, mostly a swine flu, had many avian genetic markers similar to the 1918 flu.
Allergies

- Allergies are an immune system reaction to harmless antigens.
- Some, such as pollen, may get in through the respiratory system. Fragments of food proteins may get through the digestive system.
- The next time these proteins are encountered, the immune system attacks them.
Achoo!

• Pollen is a harmless protein, yet we can become allergic to it.

• Most of the symptoms are caused by histamines released by mast cells. That is why antihistamines are used to treat allergies.
Autoimmune disorders

• Autoimmune disorders occur when the immune system fails to recognize a protein as “self” and launches an attack.

• Multiple sclerosis, lupus, and rheumatoid arthritis are examples. None of these can be cured, but drugs can help slow the progress of these diseases.
Cancer

- Cancer occurs when the mechanisms that control cell division fail, and body cells divide out of control.
- Cytotoxic T-cells can recognize and destroy these cells. But if division is too rapid, the T-cells cannot keep up.
- Some cancer research involves assisting cytotoxic T-cells in recognizing and destroying cancer cells.
AIDS

- AIDS (Acquired Immune Deficiency Syndrome) is caused by an infection by the HIV (Human Immunodeficiency Virus), which attacks and destroys T-helper cells. Because it attacks the immune system directly, finding a vaccine has been difficult.

- Some drugs can slow down HIV reproduction, but no cure exists yet. Prevention is still the best “cure.”
AIDS

The HIV virus fools helper T-cells into thinking its proteins are “self,” and so is able to infect the cells that trigger specific immunity.

The virus forces T-cells to make more viruses, killing the T-cells when the new viruses burst out.
AIDS Prevention

• HIV is a fragile virus that cannot live outside the human body for more than a few minutes.

• Preventing HIV spread comes down to preventing exposure to body fluids of an infected person.
SCID

• Severe Combined Immune Deficiency is a genetic condition in which one or more genes for proteins crucial for the immune system are defective. Children born with SCID have no immune system.

• Gene therapy has been used to inject a good copy of the defective gene into blood cells or bone marrow cells. In several cases this has been effective, though it is still experimental.
Which cell does HIV attack?

1. Macrophage.
2. Red blood cell.
3. Helper T-cell.
4. B-Memory cell.
If AIDS attacks specific immune defense, would a person with AIDS have a fever if they catch the flu?

1. Yes. Fever is a non-specific response.
2. No. The entire immune system has been compromised.
For some people, pollen allergies grow worse every year. Why?

1. More pollen is produced every year.
2. Memory cells cause a stronger reaction.
3. Pollen evolves stronger toxins.
4. Suppressor T-cells become more active with time.
• Discuss the best ways to *prevent* yourself from catching colds and influenza.