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- The SPO Virtual Classrooms offer many educational resources, including practice test questions, review questions, lecture PowerPoints, video tutorials, sample assignments and course syllabi. New materials are continually being developed, so check back frequently, or follow us on Facebook (Science Prof Online) or Twitter (ScienceProfSPO) for updates.
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Alicia Cepaitis, MS
Chief Creative Nerd
Science Prof Online
Online Education Resources, LLC
alicia@scienceprofonline.com

Tami Port, MS
Creator of Science Prof Online
Chief Executive Nerd
Science Prof Online
Online Education Resources, LLC
info@scienceprofonline.com

Immune System I:

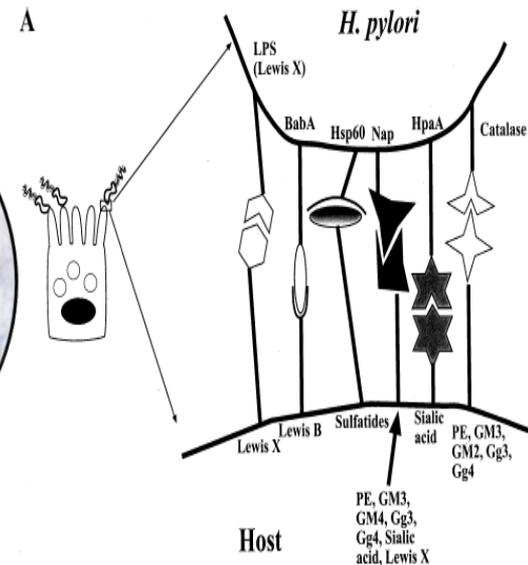
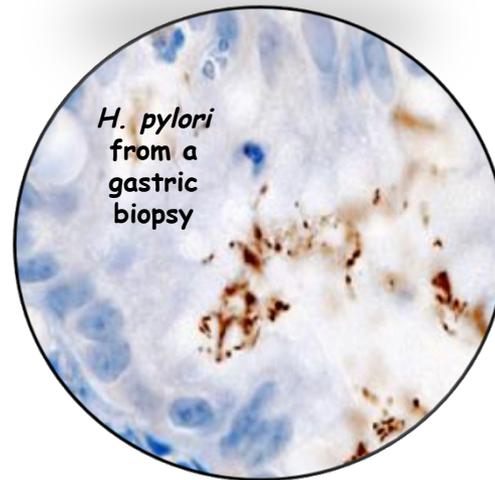
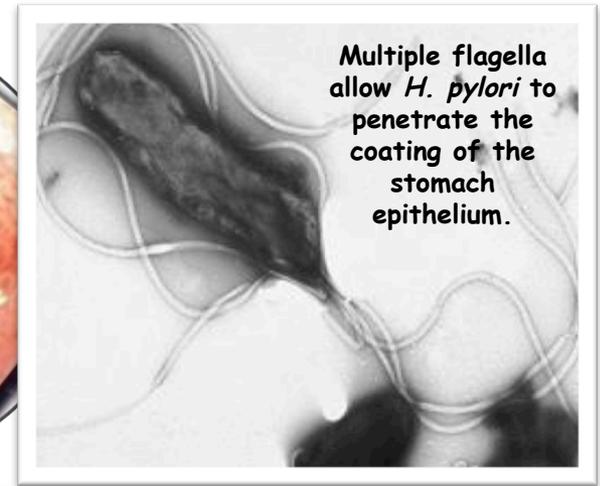
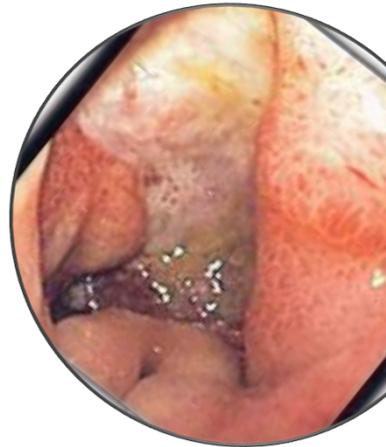
Innate Immunity



It Isn't Easy Being a Pathogen

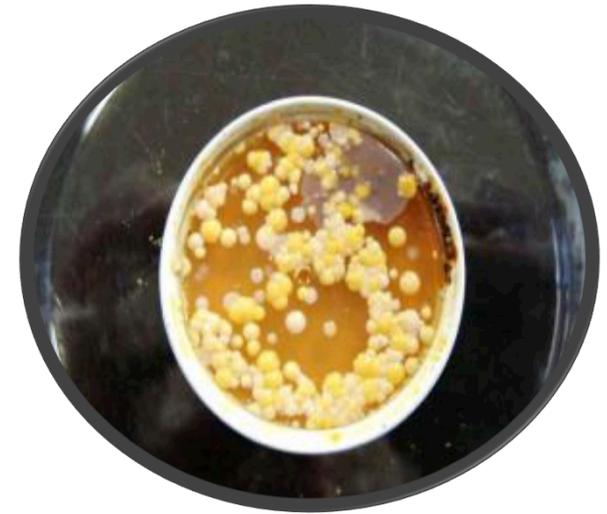
What a pathogen must do in order to cause disease:

1. Gain access to the body.
2. - Attach to and/or enter cells of its host.
 - Receptors on pathogen must fit, lock-and-key, with receptor sites on host cell.
3. Reproduce while avoiding host's immune system long enough to produce harmful changes.



Normal Flora

- Protect the body by competing with potential pathogens.
- This is called **microbial antagonism**.
- Normal microbiota protect us by:
 - Consuming nutrients that would otherwise be available to pathogens.
 - Sometimes change the **pH** of the area they inhabit in ways that help them and hinder competing microbes.
 - Presence stimulates certain parts of the second line of immune defense, helping the body defend itself from invaders.
 - Normal flora of the intestines improve our overall health by producing several types of vitamins.



Innate Immunity

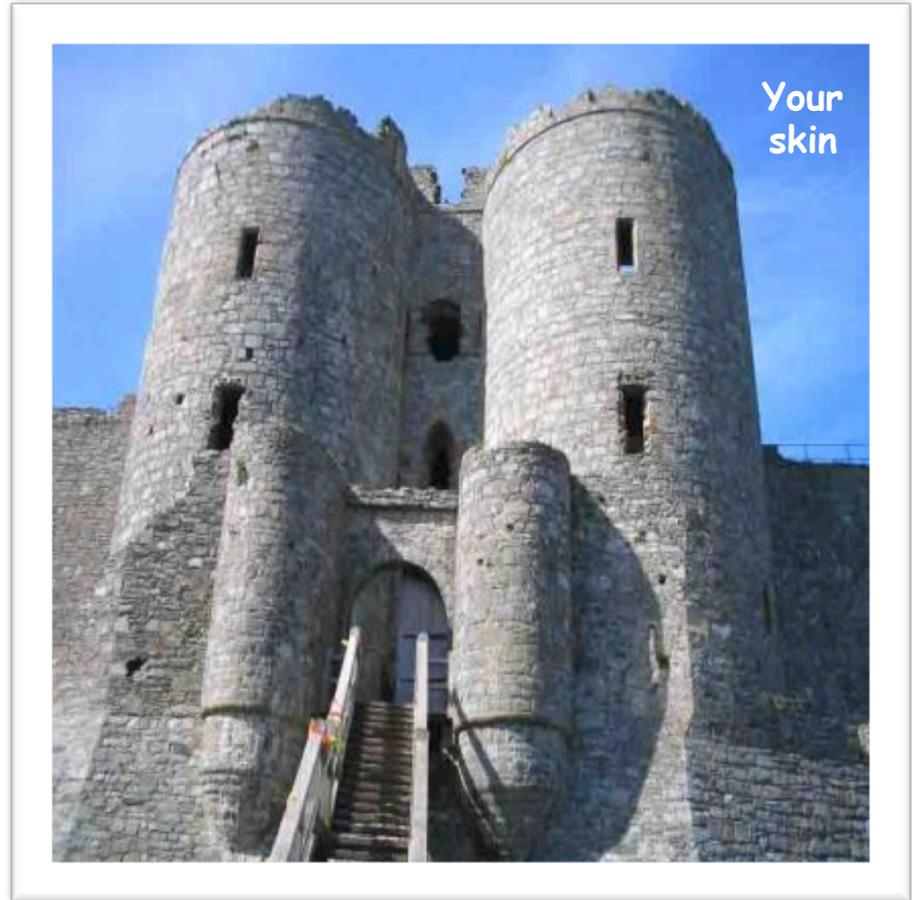
- First two lines of immune defense considered together.
- **Q:** Why do you think that they are called innate immunity?
- Innate immunity is **nonspecific**, meaning that these lines of defense work against a wide range of pathogens.



First Line of Defense

Nonspecific

- Structures, chemicals, processes that work to *prevent pathogens entering the body.*
- Includes the **skin** and **mucous membranes** of the respiratory, digestive, urinary, and reproductive systems.



First Line of Defense

Skin – Physical Components of Defense

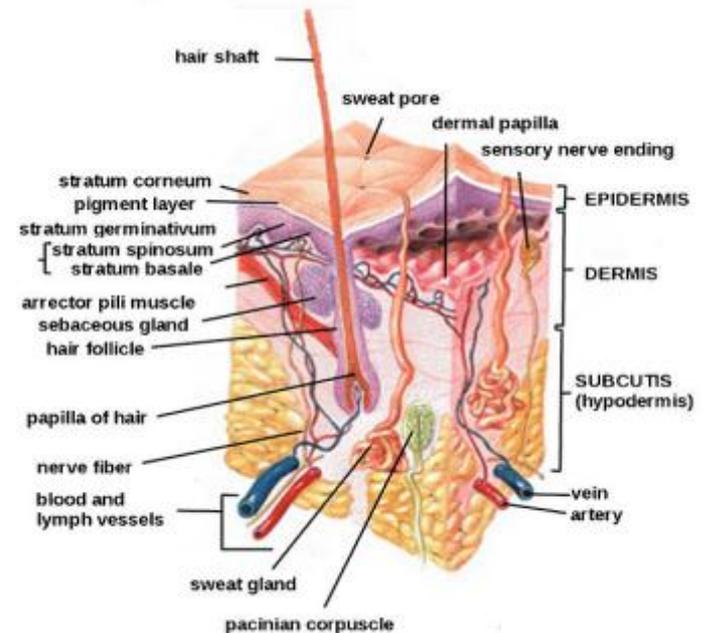
Two major layers:

1. epidermis

- Outer layer composed of multiple layers of tightly packed cells
 - Few pathogens can penetrate these layers
 - Shedding of dead skin cells removes attached microorganisms
- Epidermal dendritic cells phagocytize pathogens.
 - These cells extend out among other cells of the epidermis, forming a network to intercept invaders.

2. dermis

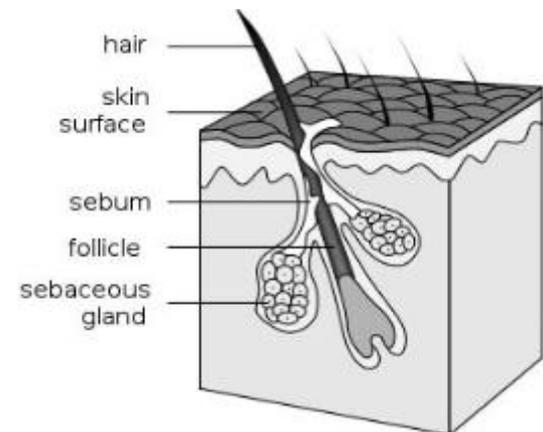
- Contains **protein** fibers called collagen
 - Give skin strength and pliability to resist abrasions that could introduce microorganisms



First Line of Defense

Skin - Chemical Components of Defense

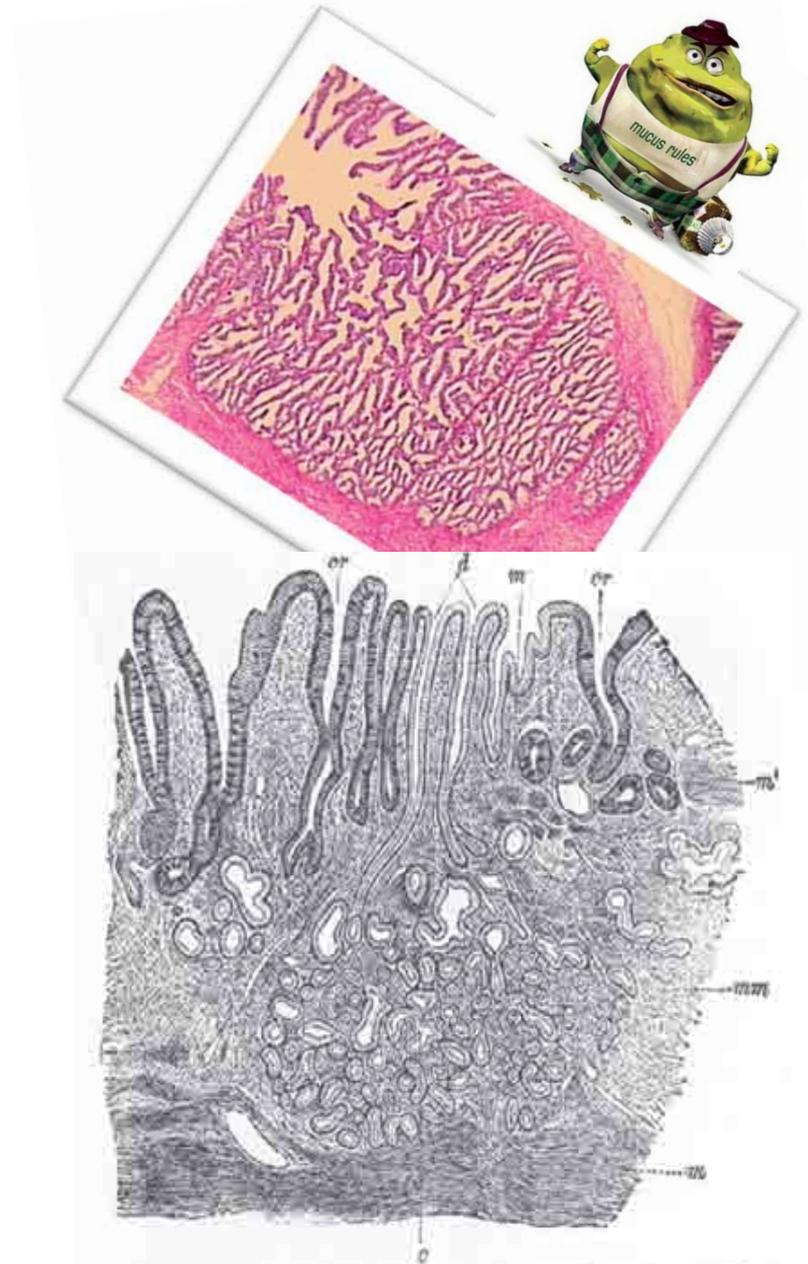
- **perspiration** secreted by sweat glands
 - Salt- inhibits growth of pathogen by drawing water from their cells
 - Antimicrobial **peptides**
 - Lysozyme- destroys cell wall of bacteria
- **sebum** secreted by sebaceous (oil) glands
 - Helps keep skin pliable and less likely to break or tear
 - Lowers **pH** of skin to a level inhibitory to many bacteria



First Line of Defense

Mucous Membrane

- Line all body cavities open to the outside environment.
- Unlike surface epidermal cells, epithelial cells are living.
- Epithelial cells packed tightly to prevent entry of pathogens, but often only one cell layer thick, so pathogens sometimes breach the barrier.
- Continual shedding of cells carries attached microorganisms away
- Besides producing mucus, mucous membranes also produce lysozyme and other antimicrobial **peptides**.
- **OMG U R Nasty** > Every day you swallow and digest about 1 liter of mucus.

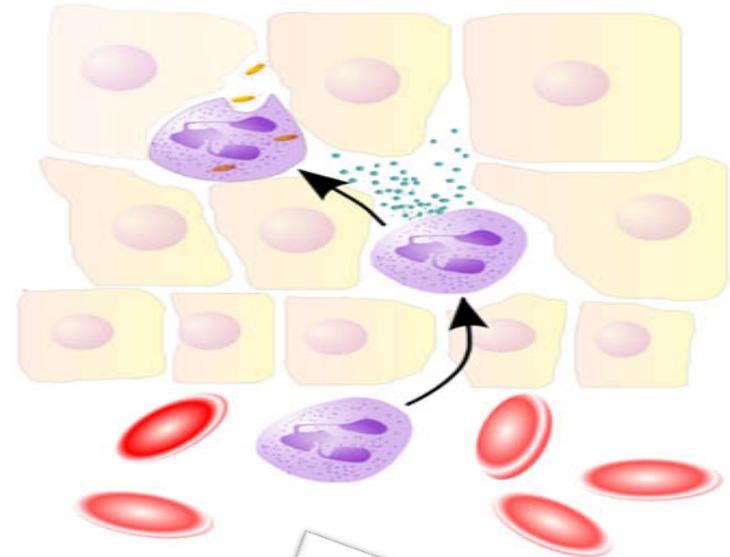


First Line of Defense

Second Line of Defense

Nonspecific

- Operates when pathogens penetrate skin or mucous membranes.
- Cells, antimicrobial chemicals, and processes, but no physical barriers.
- Many of these components are contained or originate in the blood.



Second Line of Defense

Blood

Composed of cells and portions of cells within a fluid called **plasma**.

Plasma is mostly water containing electrolytes, dissolved gases, nutrients, and protein.

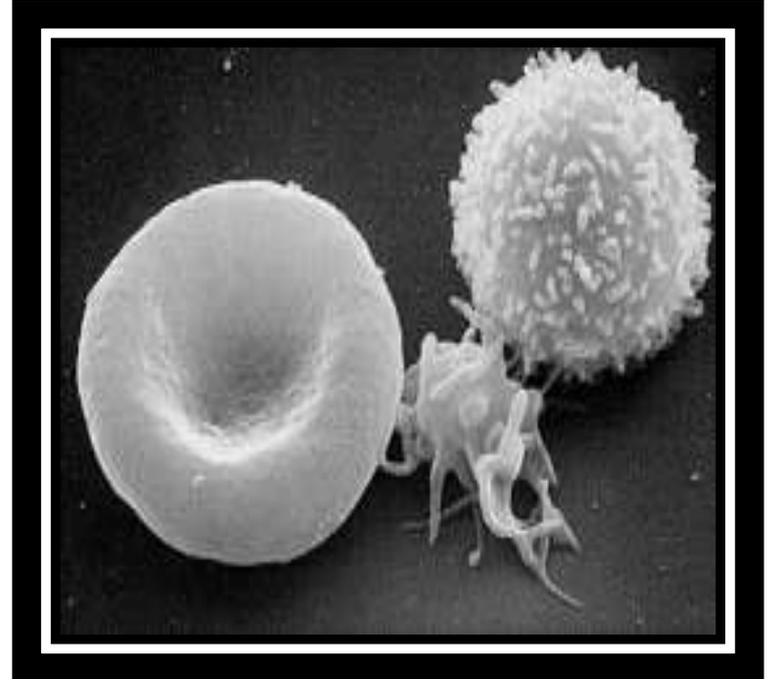
The cells and cell fragments in plasma are called **formed elements**.



Formed Elements

Three types of formed elements:

- **erythrocytes** - red blood cell, carry oxygen & carbon dioxide in the blood.
- **platelets** - involved in blood clotting (also called thrombocytes).
- **leukocytes** - white blood cells; involved in defending the body against invaders.
 - 2 groups
 - Granulocytes
 - Agranulocytes



Scanning electron micrograph
of formed elements

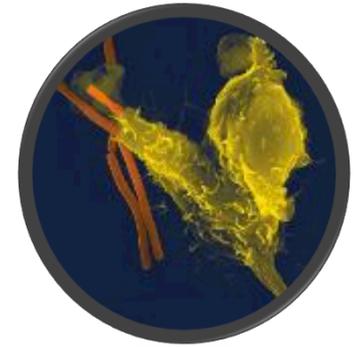
RBC (*left*)

platelet (*center*)

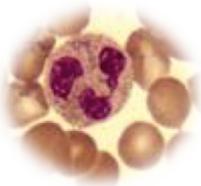
leukocyte (*right*)

Leukocytes > Granulocytes

Category of white blood cells characterized by presence of **granules** in their cytoplasm.



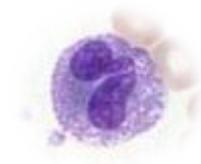
3 types:



Neutrophils - Most abundant white blood cell. Predominant cells in pus, accounts for its whitish appearance. Respond quickly following tissue injury. Hallmark of acute inflammation.

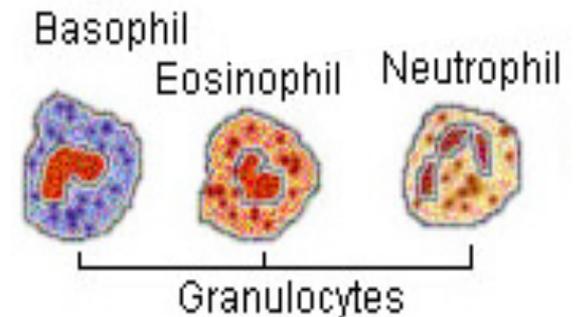


Basophils - Least common granulocyte. When activated, release histamine and other inflammatory chemicals.



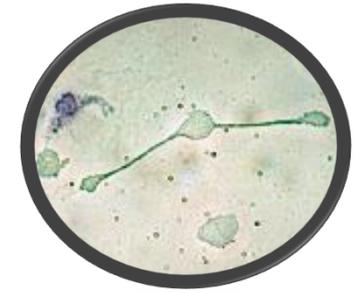
Eosinophils - Main effector cells in allergic responses & asthma. Also fight helminth (worm) colonization.

Neutrophils and **eosinophils** can *phagocytize* pathogens.

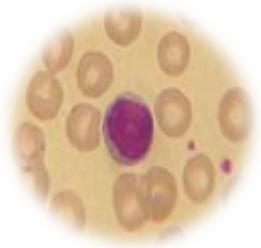


Second Line of Defense

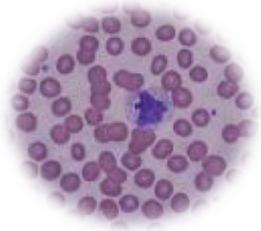
Leukocytes > Agranulocytes



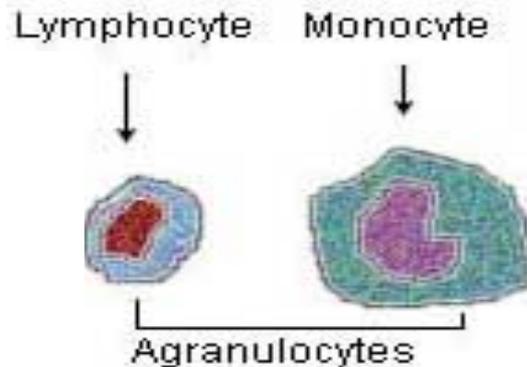
2 types:



Lymphocytes - most involved in specific immunity
(3rd line of immune defense),



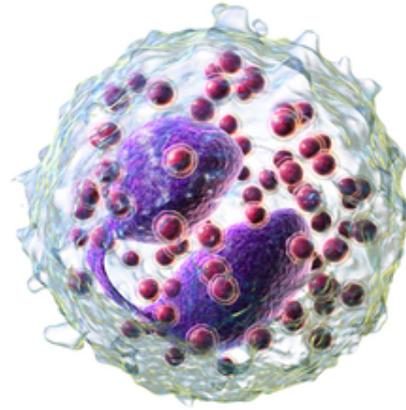
Monocytes - leave the blood and mature into **macrophages** (phagocytic cells of the second line of defense).



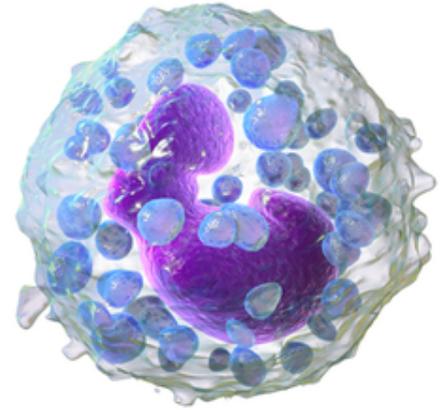
Second Line of Defense



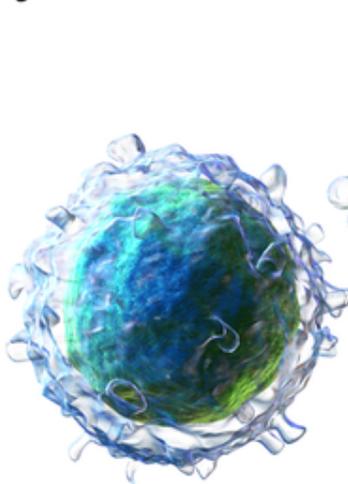
Monocyte



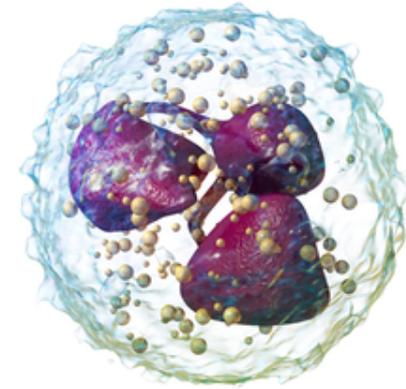
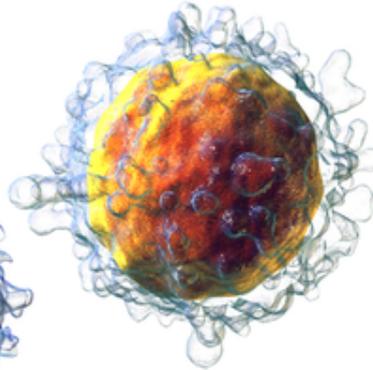
Eosinophil



Basophil



Lymphocytes

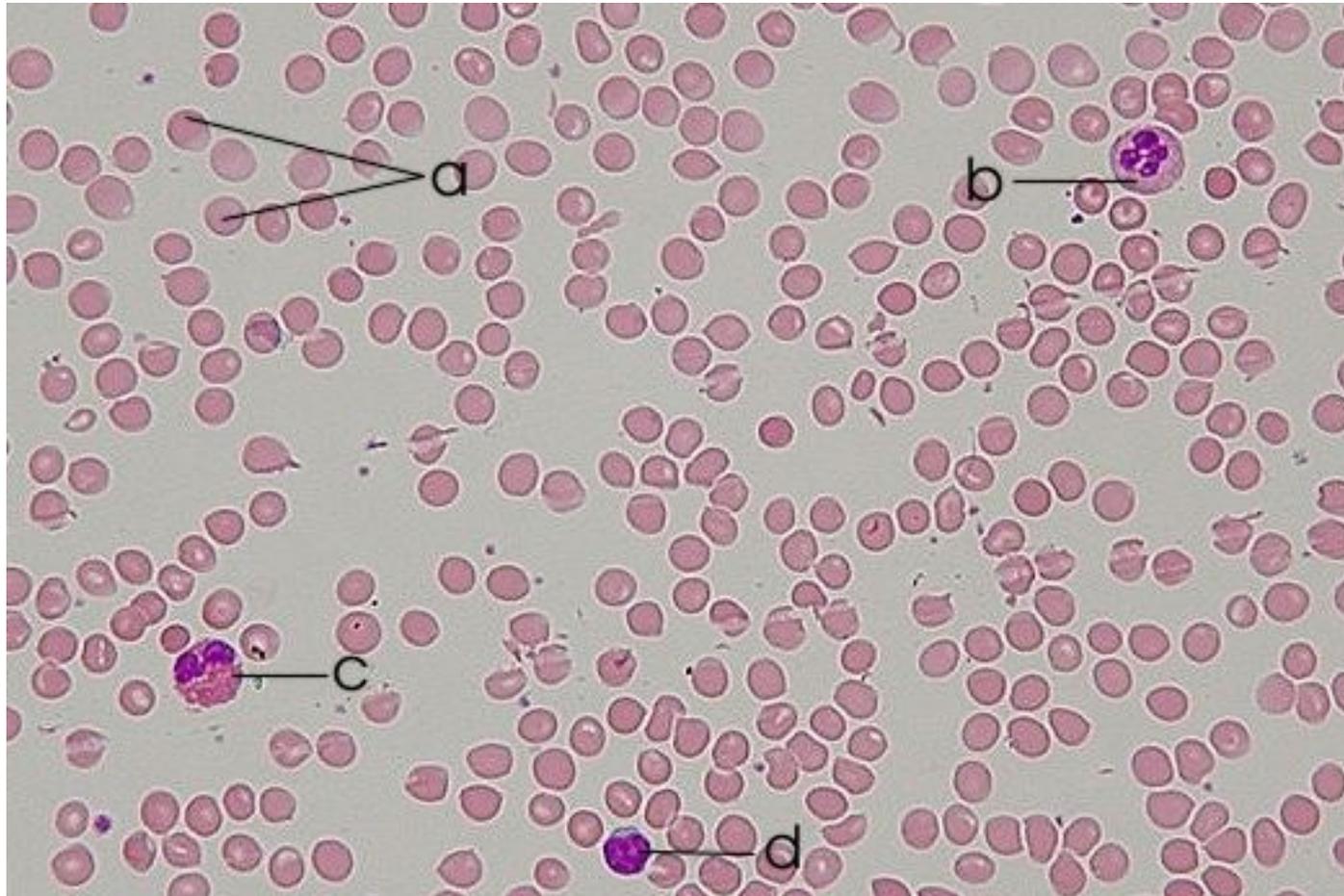


Neutrophil

White Blood Cells

See [Lymphocytes](#) on Wikipedia for more images of WBC's

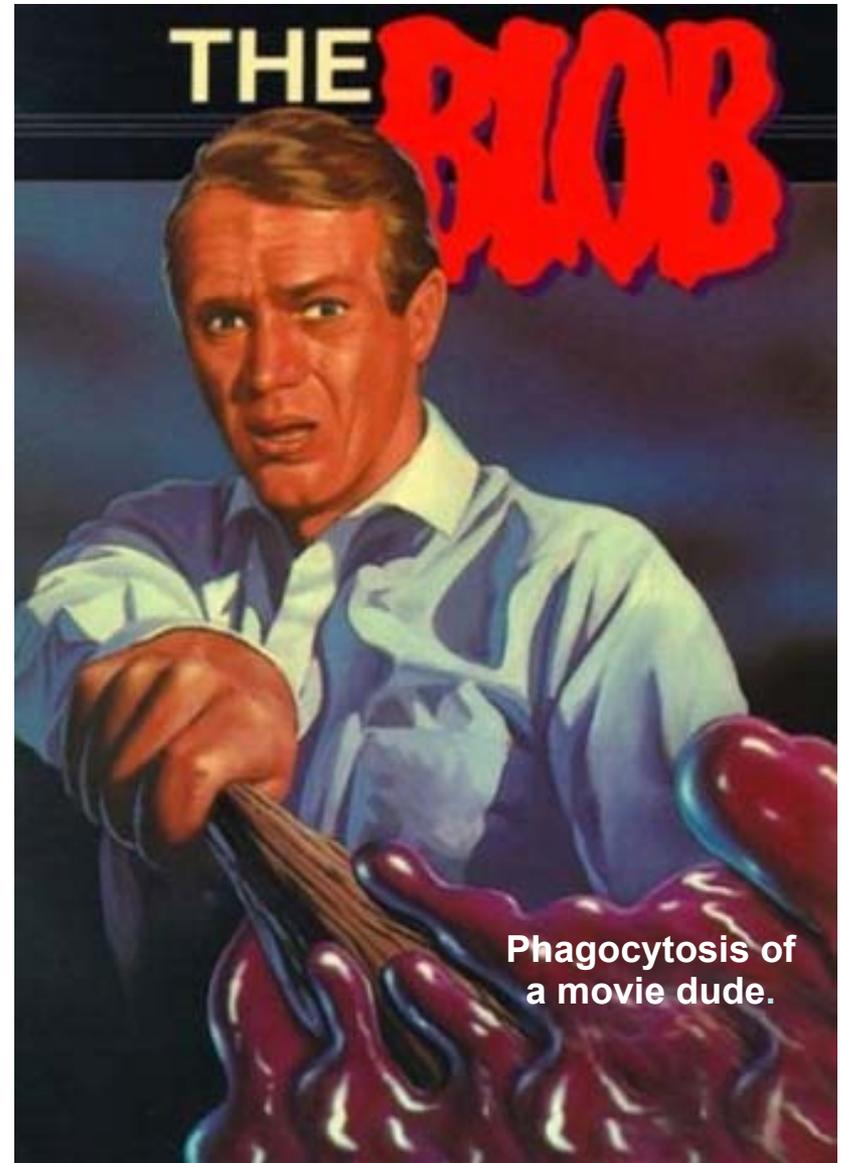
Formed Elements in Blood Smear



a. erythrocyte, b. neutrophil, c. eosinophil, d. **Q:** What is d?

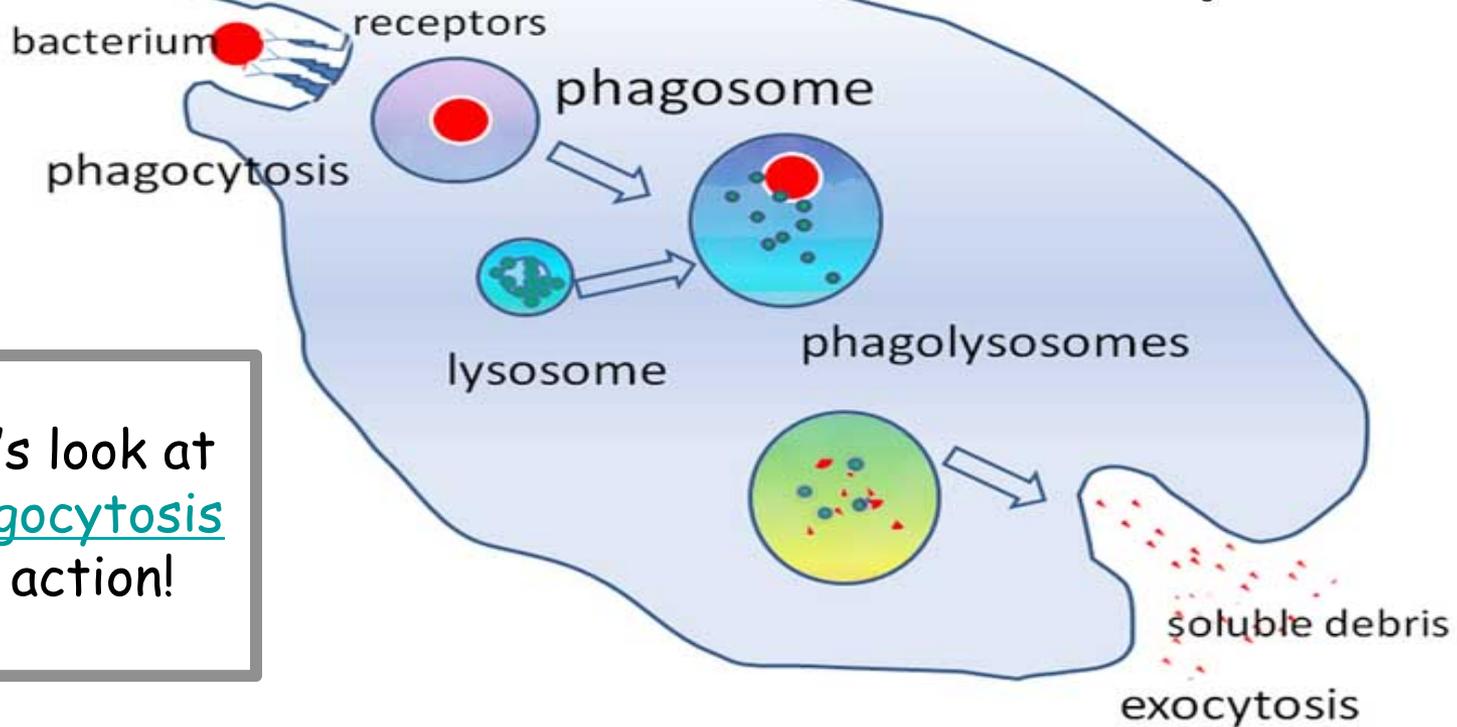
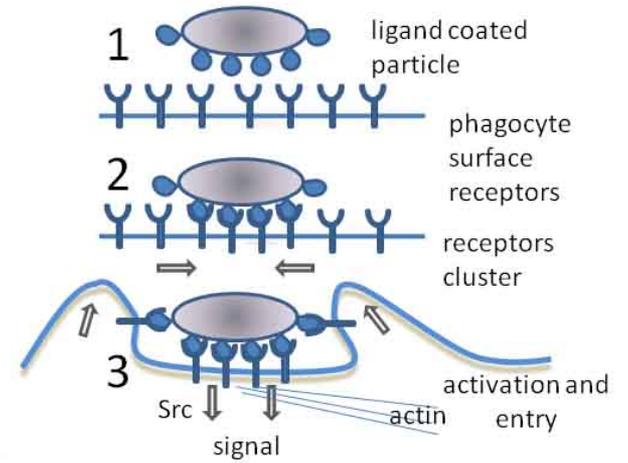
Components of the Second Line of Defense

- Leukocytes
 - **Phagocytosis**
How phagocytes ingest and destroy foreign matter such as microorganisms or debris.
 - Extracellular killing by leukocytes
- Nonspecific chemical defenses
- Inflammation
- Fever



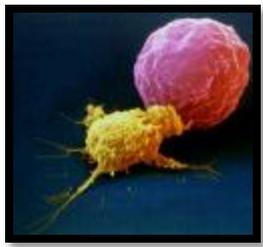
Second Line of Defense

Leukocytes: Phagocytosis



Let's look at phagocytosis in action!

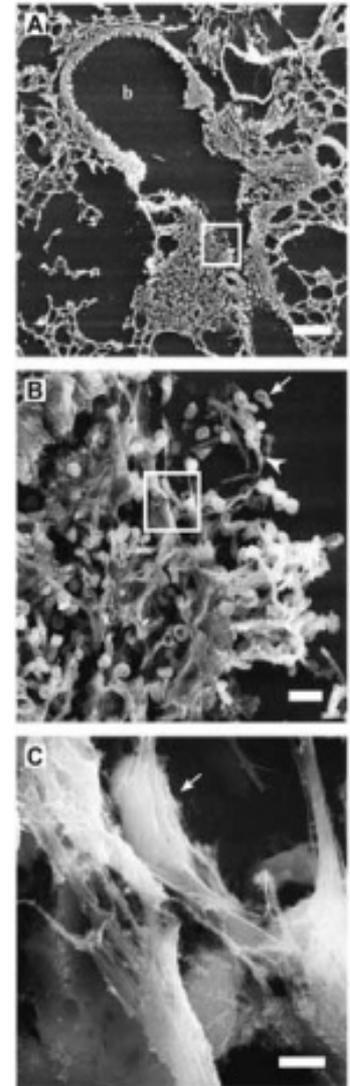
Second Line of Defense



Leukocytes: Extracellular Killing

3 Cell Types That Kill Extracellularly:

- **natural killer lymphocytes** (NK cells)
 - Secrete toxins onto surface of virally infected cells & tumors.
 - Differentiate normal body cells because they have membrane **proteins** similar to the NK cells.
- **eosinophils**
 - Mainly attack parasitic worms by attaching to their surface.
 - Secrete toxins that weaken or kill worm.
 - Elevated eosinophil levels, is often indicative of a helminth (parasitic worm) infection.
- **neutrophils**
 - Can create the active ingredient in bleach to kill nearby microbes.
 - Fibers called neutrophil extracellular traps (NETs) can ensnare and kill bacteria and fungi. Secrete antimicrobial proteins.

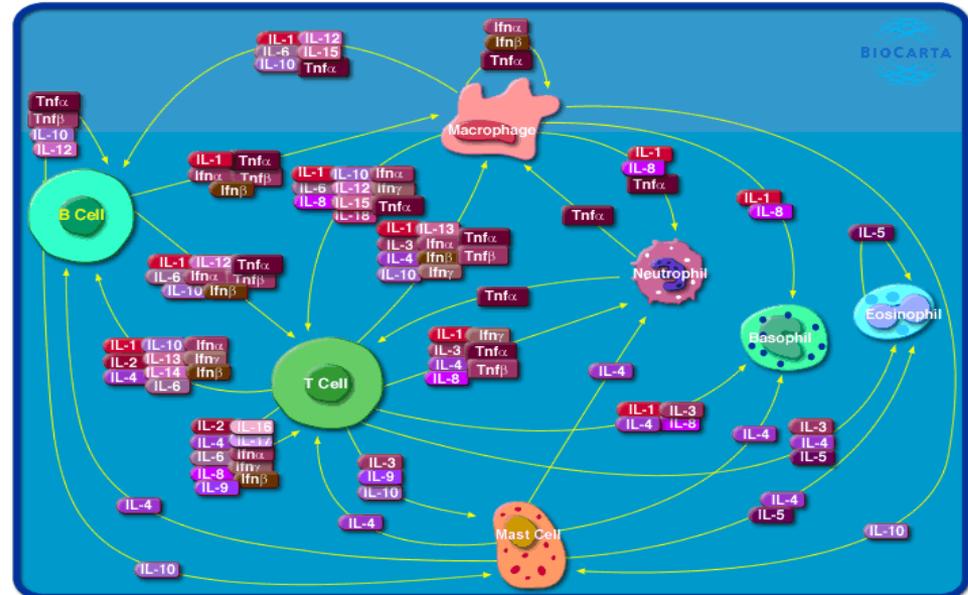
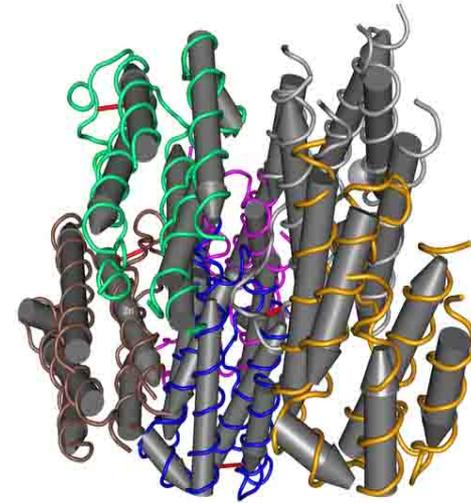


Second Line of Defense

Image: Natural killer cell (yellow) attacking a cancer cell (red), Dr. Rupert Handgretinger, University Hospital of Tübingen; Mouse lung cell **NETS** engulfing fungus PLoS.

Components of the Second Line of Defense

- Leukocytes
 - Phagocytosis
 - Extracellular killing by leukocytes
- Nonspecific chemical defenses
 - Lysozyme, Defensins & Cytokines (including interferons and interleukins).
 - Augment phagocytosis
 - Some attack pathogens directly
 - Some enhance features of nonspecific resistance
- Inflammation
- Fever



Second Line of Defense

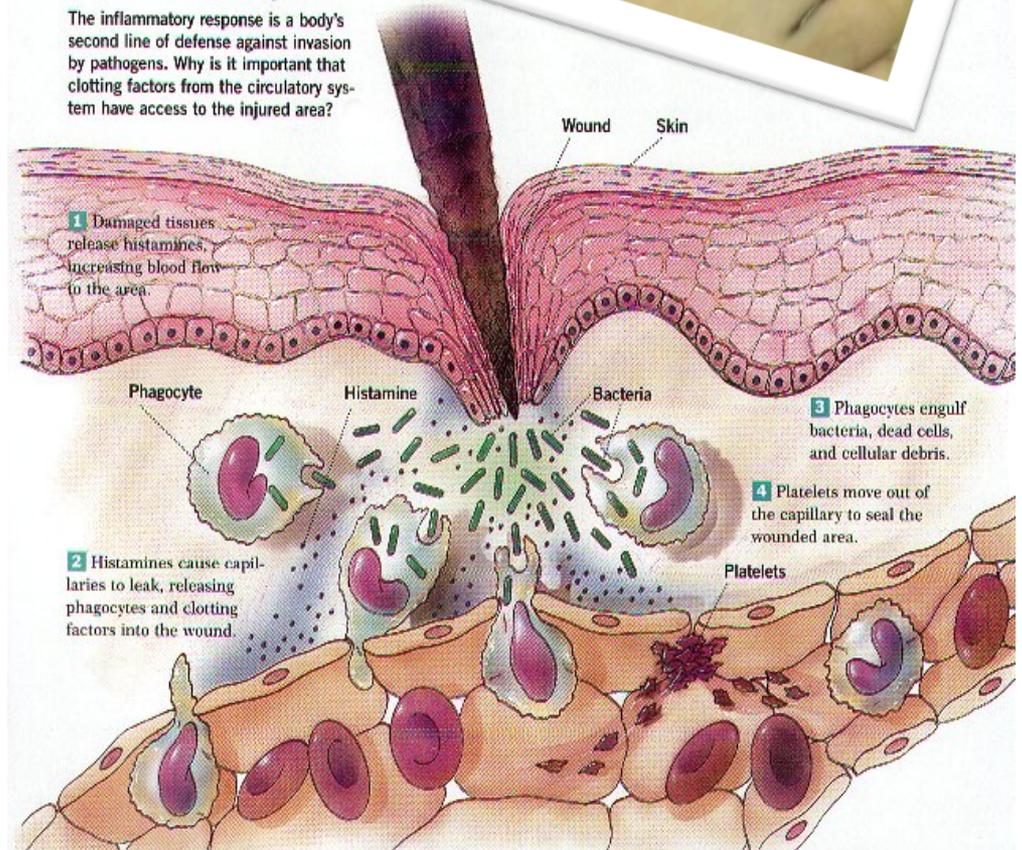
Components of the Second Line of Defense

- Leukocytes
 - Phagocytosis
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- Nonspecific Chemical Defenses
 - Ex. Lysozyme, Defensins & Cytokines
- Inflammation
 - Nonspecific response to tissue damage.
 - Damages cells release histamines which increase vasodilation.
 - Heat, swelling, pain
- Fever



Steps of the Inflammatory Response

The inflammatory response is a body's second line of defense against invasion by pathogens. Why is it important that clotting factors from the circulatory system have access to the injured area?



Second Line of Defense

Components of the Second Line of Defense



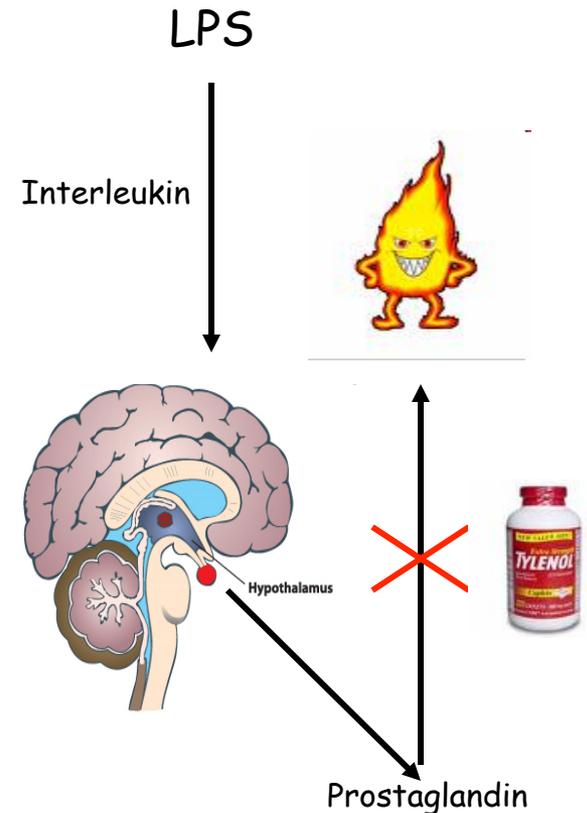
- Leukocytes
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 - Damages cells release histamines, which increase vasodilation.
 - Heat, swelling pain
- **Fever**

- ✓ Body temp above normal range of 36.5-37.5 °C (98-100 °F).
- ✓ Results when chemicals called pyrogens trigger the hypothalamus to increase body's core temperature.
- ✓ Various types of pyrogens
 - ❖ Bacterial toxins
 - ❖ Cytoplasm of bacteria released by lysis
 - ❖ Antibody-antigen complexes
 - ❖ Interleukin-I (IL-1 a cytokine)
- ✓ Benefits
 - ❖ Speed of immune system reaction increased
 - ❖ Inhibits growth of some temp sensitive microorganisms

Second Line of Defense

Fever Triggered by Gram- Bacteria

1. When infected with a Gram- bacteria...
2. 2nd line of defense responds with **phagocytes**.
3. Macrophages engulf invader in a vesicle called a **phagosome**.
4. The phagosome fuses with a **lysosome**. *Q: What happens to the bacteria when the phagosome and lysosome fuse?*
5. When the macrophage is **exposed to Lipid-A** (part of the LPS membrane that is a pyrogen) the **macrophage secretes interleukin** (a type of cytokine that is a pyrogen).
6. **Interleukin** is picked up by the blood and **transported to the brain**.
6. In the brain, interleukin stimulates the **hypothalamus to secrete prostaglandin**.
7. Prostaglandin attaches to receptors in the hypothalamus and cause it to **reset the thermostat → fever**.
8. **Ibuprophen** and **Acetaminophen** are **antiprostaglandins** (They temporarily remove the prostaglandin, interrupting the fever-generating process).



Confused?

Here are links to fun resources that further explain cellular respiration:

- [Innate Immunity Main Page](#) on the Virtual Cell Biology Classroom of [Science Prof Online](#).
- [Phagocytosis](#) animation and quiz by McGraw-Hill.
- [Immune System](#) “Who Wants to Be a Millionaire” game.
- [“Fever”](#), song by Peggy Lee.
- [Immune System Defender](#), online game from the Nobel Prize website. Use your force of white blood cells to destroy invading bacteria, before they overpopulate and cause disease.
- [“Osmosis Jones”](#) movie trailer. If you haven’t seen this movie yet, you must watch it immediately! It’s awesome!
- [Immune System Game](#), a collection of online fun and educational games about immunology.

Smart Links



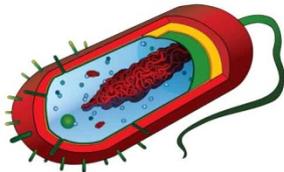
Are microbes intimidating you?



Do yourself a favor. Use the...

Virtual Microbiology Classroom (VMC) !

The VMC is full of resources to help you succeed,
including:



- practice test questions
- review questions
- study guides and learning objectives

You can access the VMC by going to the Science Prof Online website

www.ScienceProfOnline.com