

THE IMMUNE SYSTEM

We all get sick sometimes...but then we get better.

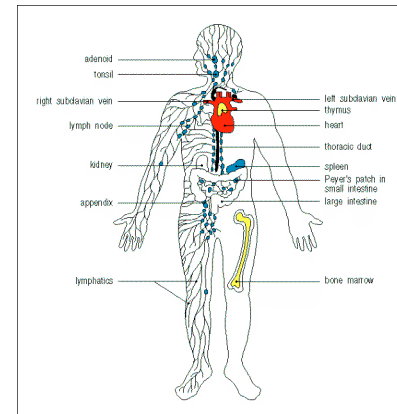
What happens when we get sick?

Why do we get better?

1

ANATOMY OF THE IMMUNE SYSTEM

2



The immune system is localized in several parts of the body

- immune cells develop in the **primary organs** - bone marrow and thymus (yellow)
- immune responses occur in the **secondary organs** (blue)

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ANATOMY OF THE IMMUNE SYSTEM

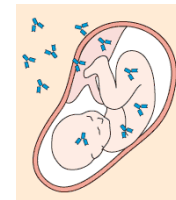
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- **Thymus** – glandular organ near the heart – where T cells learn their jobs
- **Bone marrow** – blood-producing tissue located inside certain bones
 - blood **stem cells** give rise to all of the different types of blood cells
- **Spleen** – serves as a filter for the blood
 - removes old and damaged red blood cells
 - removes infectious agents and uses them to activate cells called lymphocytes
- **Lymph nodes** – small organs that filter out dead cells, antigens, and other “stuff” to present to lymphocytes
- **Lymphatic vessels** – collect fluid (lymph) that has “leaked” out from the blood into the tissues and returns it to circulation

PASSIVE IMMUNITY

4

While your immune system was developing, you were protected by immune defenses called **antibodies**. These antibodies traveled across the placenta from the maternal blood to the fetal blood.

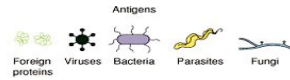


Antibodies (Y) are also found in breast milk.

The antibodies received through passive immunity last only several weeks.

YOUR ACTIVE IMMUNE DEFENSES

5



Innate Immunity
 - invariant (generalized)
 - early, limited specificity
 - the first line of defense

Adaptive Immunity
 - variable (custom)
 - later, highly specific
 - “remembers” infection

INNATE IMMUNITY

6

When you were born, you brought with you several mechanisms to prevent illness. This type of immunity is also called **nonspecific immunity**.



Innate immunity consists of:

- **Barriers**
- Cellular response
 - phagocytosis
 - inflammatory reaction
 - NK (natural killer) and mast cells
- Soluble factors

INNATE IMMUNITY

7

Barriers

- Physical
 - skin
 - hair
 - mucous
- Chemical
 - sweat
 - tears
 - saliva
 - stomach acid
 - urine

INNATE IMMUNITY

8

Cellular response

- nonspecific - the same response works against many pathogens
- this type of response is the same no matter how often it is triggered
- the types of cells involved are **macrophages**, **neutrophils**, **natural killer cells**, and **mast cells**
- a soluble factor, **complement**, is also involved

9

Phagocytic cells include:

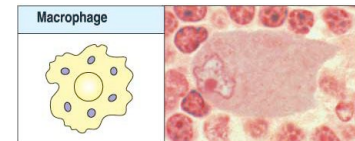
Macrophages engulf pathogens and dead cell remains

Neutrophils release chemicals that kill nearby bacteria

- pus = neutrophils, tissue cells and dead pathogens

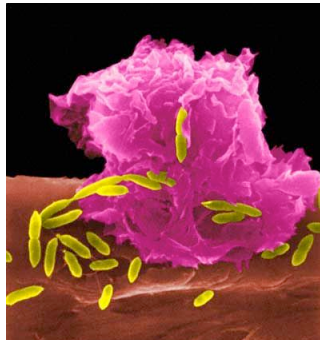
Macrophages (MØ)

- WBCs that ingest bacteria, viruses, dead cells, dust
- most circulate in the blood, lymph and extracellular fluid
- Produce cytokines/chemokines (initiate inflammation)
- they are attracted to the site of infection by chemicals given off by dying cells
- after ingesting a foreign invader, they “wear” pieces of it called antigens on their cell membrane receptors
 - this tells other types of immune system cells what to look for
 - Is an antigen presenting cell



11

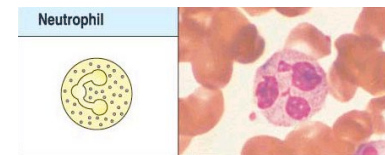
Macrophage and *E. coli*



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Neutrophils

- WBCs – are phagocytic, like macrophages
- Also called polymorphonuclear cells (PMNs)
- neutrophils also release toxic chemicals that destroy everything in the area, including the neutrophils themselves



Phagocytosis (MØ & PMN)

- Active process initiated by binding to pathogen
- Pathogen is surrounded and then internalized

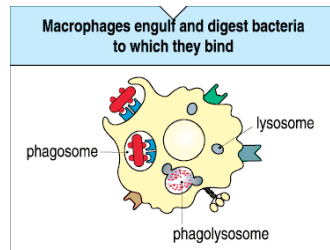


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INNATE IMMUNITY Cellular response

Complement

- complement is not a cell but a group of proteins
- these proteins circulate in the blood
 - help to recruit phagocytes to site of inflammation and activate them
 - bind to receptors on phagocytes, helping to remove agent of infection
 - form pores in the invader or infected cell's membrane (like the NKs do)
 - activate mast cells to release histamine and other factors
- complement plays a role in inflammatory responses of both the innate and adaptive immune responses

INNATE IMMUNITY Cellular response

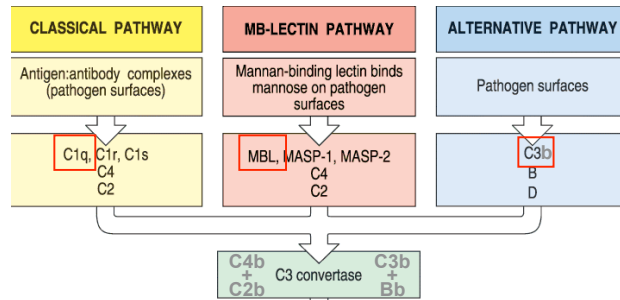
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The Complement (C') System

- Complement system is activated by innate immunity
- Recognition by Complement receptors (CR)
 - CR1, CR2, CR3, CR4, C5a, C3a
- Comprised of plasma proteins that when activated forms a triggered enzyme cascade
 - Zymogens – activated by the cleavage of other proteases
 - Precursor enzymes
- Function
 - Facilitates the uptake & destruction of pathogens by phagocytes
 - Induces inflammatory responses

Activation of C' System



INNATE IMMUNITY Cellular response

Inflammatory response (cont'd)

The release of histamine and prostaglandin causes local vessel dilation resulting in:

- more WBCs to site
- increased blood flow → redness and warmth
- increased capillary permeability
- phagocytes move out of vessels into intracellular fluid (ICF)
- edema (swelling) due to fluids seeping from capillaries

INNATE IMMUNITY Cellular response

Inflammatory response

- chemical and cell response to injury or localized infection
- eliminates the source of infection
- promotes wound healing

Step 1. Circulation to the site increases → tissue warm, red and swollen

Step 2. WBCs leak into tissues → phagocytes engulf and destroy bacteria

INNATE IMMUNITY Cellular response

Inflammatory response (cont'd)

Fevers have both positive and negative effects on infection and bodily functions

POSITIVE

- indicate a reaction to infection
- stimulate phagocytosis
- slow bacterial growth
 - increases body temperature beyond the tolerance of some bacteria
 - decreases blood iron levels

NEGATIVE

- extreme heat → enzyme denaturation and interruption of normal biochemical reactions
 - > 39° C (103°F) is dangerous
 - > 41° C (105°F) could be fatal and requires medical attention

Inflammatory Response

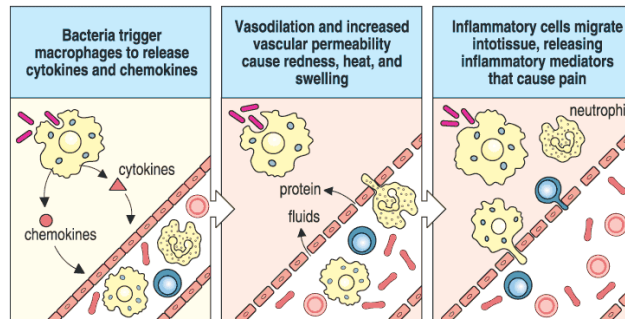


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The Inflammation Process

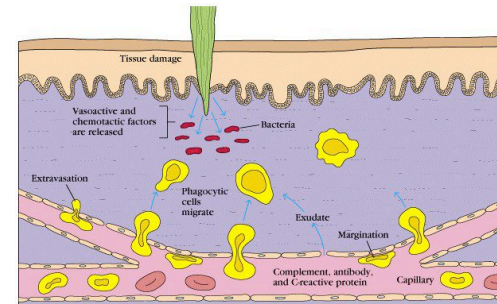


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Inflammatory Response

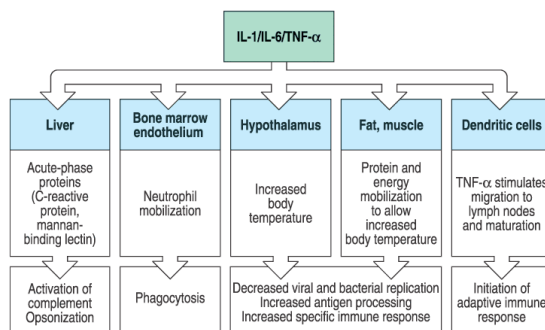


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Natural killer cells (NK cells)

- instead of attacking the invaders, they attack the body's own cells that have become infected by viruses
- they also attack potential cancer cells, often before they form tumors
- they bind to cells using an antibody "bridge", then kill it by secreting a chemical (perforin) that makes holes in the cell membrane of the target cell.
- With enough holes, the cell will die, because water rushing inside the cell will induce osmotic swelling, and an influx of calcium may trigger apoptosis.

25

NK cells and cancer

- **Experimental tumor models:**
 - **Depletion of NK increases metastases**
 - **Administration of activated NK cells results in tumor regression**

27

INNATE IMMUNITY – Soluble factors

- **Interferon**
 - a chemical (cytokine) produced by virus-infected cells that contributes to their death by apoptosis
- **Acute phase proteins**
 - proteins in the plasma that increase during infection and inflammation
 - can be used diagnostically to give an indication of acute inflammation

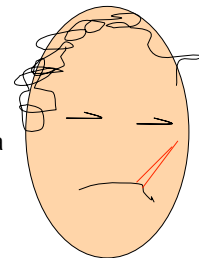
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Mast cells

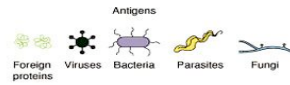
- are found in tissues like the skin, near blood vessels.
- are activated after antigen binds to a specific type of antibody called IgE that is attached to receptors on the mast cell.
- activated mast cells release substances that contribute to inflammation, such as histamine.
- mast cells are important in allergic responses but are also part of the innate immune response, helping to protect from infection.

28

- Your mom's antibodies were effective for just a short time at birth, but your innate immune system can be activated quickly. It is always your first line of defense during an infection, but it can't always eliminate the germ.
- When this happens, your body initiates a focused attack against the specific pathogen that is causing the infection. This attack may lead to long-term protection against that pathogen.
- This type of immunity is called **adaptive immunity**, the customized second line of defense.



YOUR ACTIVE IMMUNE DEFENSES



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1. Barriers - skin, tears
2. Phagocytes - neutrophils, macrophages
3. NK cells and mast cells
4. Complement and other proteins