

## The Immune System

The molecules, cells, and tissues of the human body that protect against microorganisms and viruses

#### Tasks of the immune system

- Recognize
- Respond
- Regulate
- Remember



# Defense levels of the immune system

#### Non-specific First Line of Defense

- Physical barriers
- Chemical barriers
- Biological mechanisms
  Innate Immune System
- Phagocytes
- Natural Killer Cells
- Complement System
- Adaptive Immune System
- B-lymphocytes
- T-lymphocytes
- Antibodies



### The first layer

#### Non-Specific Components

- Physical Barriers
- Chemical Barriers
- Biological Mechanisms



## Blood

10% of your body weight

- $_{\circ}$  ~ 5 quarts of blood in adults
- 60,000 miles of blood vessels
- It takes only 20-60 seconds for a red blood cell to travel through the body

Highway system of the body

- Arteries carry oxygen and nutrients to cells
- Veins carry carbon dioxide and waste from cells

#### Defense/Immunity

Cells, antibodies, clotting factors

## The lymphatic system and blood system

The lymphatic system is connected to the blood system. This complex connected vessel system allows cells of the immune system an efficient way to travel around to all parts of the body to seek out and destroy "foreign invaders" such as viruses, bacteria and parasites



#### What is in blood?



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#### **Red blood cells**



**Platelets** 



#### White blood cells





## The second layer

Innate Immunity

- Protects against broad categories of pathogens
- Immediate
- Non-Specific

#### Components of Innate Immunity

- Phagocytes
- Pattern Recognition Receptors
- Complement System
  - Membrane Attack Complex



#### Macrophages

Scavengers that Roam looking for "bacteria food"

- Phagocyte= cell eater, engulfs bacterial and cell debris
- Found in blood and tissues
- Alerts other cells of the immune system by releasing cytokines





Master General that alerts of foreign microbes and orchestrates immune response

- Phagocyte
- Found in blood and tissues
- Once it has ingested a foreign microbe/particle it travels to the lymphoid tissues to alert other cells of the immune system
- Presents foreign proteins "antigens" to T-cells, thus activating them



The third layer

Adaptive immunity

- Highly specific antibodies
- Immunological memory
- Slow (the first time)
- Differentiates between self and non-self
- Natural body's own response
  - Active exposure  $\rightarrow$  protection
  - Passive biological transfer
- Artificial intentionally stimulated
  - Active vaccination with attenuated virus
  - Passive Injection of antibodies





## Adaptive immunity: the major players

T Cells:

Mature in the <u>T</u>hymus Cell-mediated immune response



B Cells:

Mature in the <u>B</u>one Marrow Antibody production Memory



### B cells

#### B Cells make antibodies

- Antibodies stop ("neutralize" viruses from being able to infect the cells of your body
- Antibodies help macrophages eat viruses faster





complement cascade or by the liver and spleen.

## T cells

#### Helper T cells

 Release cytokines to help activate the immune response system

## Cytotoxic T cellsKill infected cells



### Antigens and antibodies

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Provide molecular tags that tell other cells in the body Ο to destroy the invader

### Basic immunological concepts

- The immune system can distinguish between "self" and "non-self"
- Immune cells circulate in the blood and lymphatic systems searching for foreign microbes
- Communication between immune cells is vital
  - Macrophages and dendritic cells engulf invaders
  - B cells produce protective antibodies
  - T cells kill infected cells
- Memory
  - B and T cells can live for years as "memory cells" so that the immune system can respond quickly to a future infection by the same microbe



#### Stop and think:

- How can you tell if someone has been infected with a pathogen
- How do vaccines work?



#### Vaccination

- Vaccines are weakened or killed pathogens that are introduced to the body.
- AFTER vaccination, the body can recognize the pathogen and it can fight when the REAL pathogen shows up.
- Edward Jenner used this approach for smallpox. In 1980, smallpox was eradicated.



#### Vaccines work!

CDC statistics demonstrate dramatic declines in vaccine-preventable diseases when compared with the pre-vaccine era

DISEASE	PRE-VACCINE ERA ESTIMATED ANNUAL MORBIDITY <sup>1</sup>	MOST RECENT REPORTS OR ESTIMATES OF U.S. CASES	PERCENT DECREASE
Diphtheria	21,053	12	>99%
H. influenzae (invasive, <5 years of age)	20,000	40 <sup>2,3</sup>	>99%
Hepatitis A	117,333	3,473 <sup>4</sup>	98%
Hepatitis B (acute)	66,232	19,764 <sup>4</sup>	70%
Measles	530,217	667 <sup>2</sup>	>99%
Meningococcal disease	2,8865	433 <sup>2</sup>	85%
Mumps	162,344	1,223²	>99%
Pertussis	200,752	32,971 <sup>2</sup>	84%
Pneumococcal disease (invasive, <5 years of age)	16,069	1,9006	88%
Polio (paralytic)	16,316	O <sup>2</sup>	100%
Rotavirus (hospitalizations, <3 years of age)	62,500 <sup>7</sup>	12,500 <sup>s</sup>	80%
Rubella	47,745	62	>99%
Congenital Rubella Syndrome	152	12	99%
Smallpox	29,005	0 <sup>2</sup>	100%
Tetanus	580	25 <sup>2</sup>	96%
Varicella	4,085,120	151,149 <sup>9</sup>	96%

1. CDC. JAMA November 14, 2007; 298(18):2155-63.

2. CDC. MMWR September 18, 2015; 64 (36):1019-33. 3. An additional 11 cases of Hib are estimated to have

- 7. CDC. MMWR, February 6, 2009; 58(RR-2):1-25. 8. CDC. New Vaccine Surveillance Network, 2013 data
- (unpublished); U.S. rotavirus disease now has a biennial pattern. occurred among the 204 reports of Hib (<5 years) with
  - 9. CDC. Varicella Program, 2014 data (unpublished). Calculation based on the percent decline from 4 states that have continuously reported varicella cases to CDC.
- 4. CDC. Viral Hepatitis Surveillance United States, 2013. 5. CDC. MMWR October 6, 1995; 43(53):1-98.

unknown serotype.

6. CDC. Active Bacterial Core Surveillance, 2013 data (unpublished).

Technical content reviewed by the Centers for Disease Control and Prevention



Saint Paul, Minnesota • 651-647-9009 • www.immunize.org • www.vaccineinformation.org

www.immunize.org/catg.d/p4037.pdf • Item #P4037 (1/16)

## Activity1: ELISA

Enzyme-linked Immunosorbent Assay

## Activity 2: Crime Scene Investigators

Agglutination Reactions using simulated blood and antibodies