

Overview of the Immune System

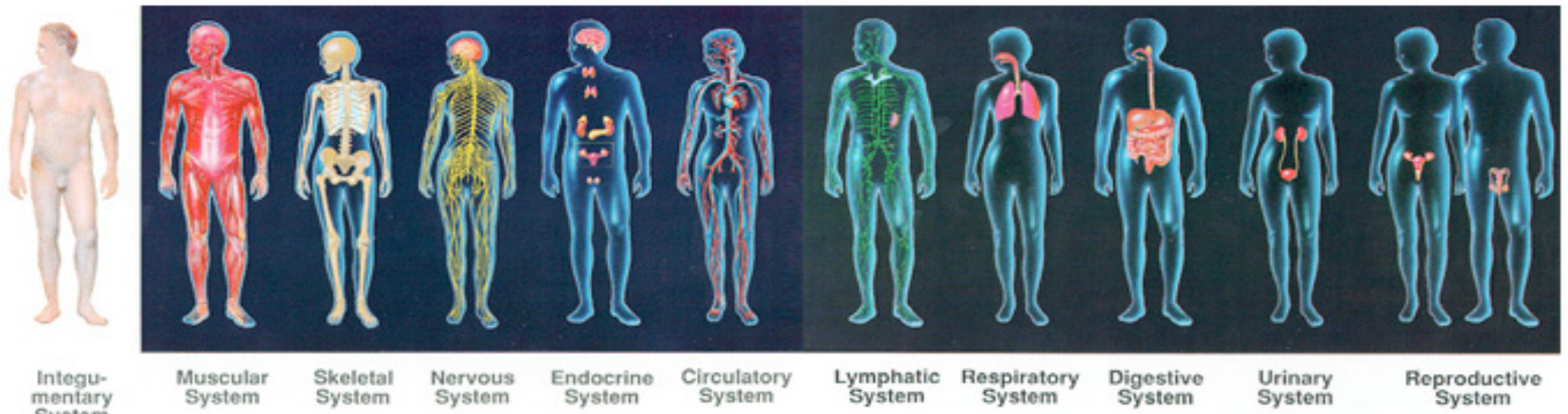
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Learning Objectives

By the end of this lecture you will be able to:

- ① Recognize the cells and organs of the immune system
- ② Understand the basic concepts of immunity
- ③ Differentiate between innate and adaptive immune responses
- ④ Appreciate the significance of immunology studies and research

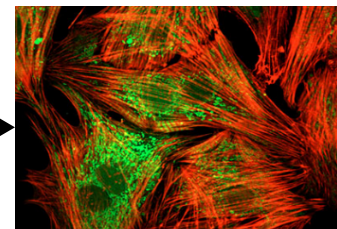
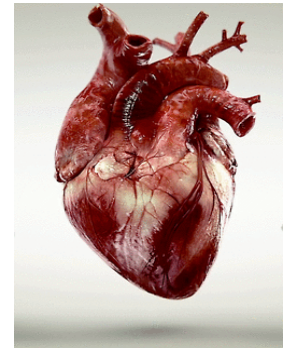
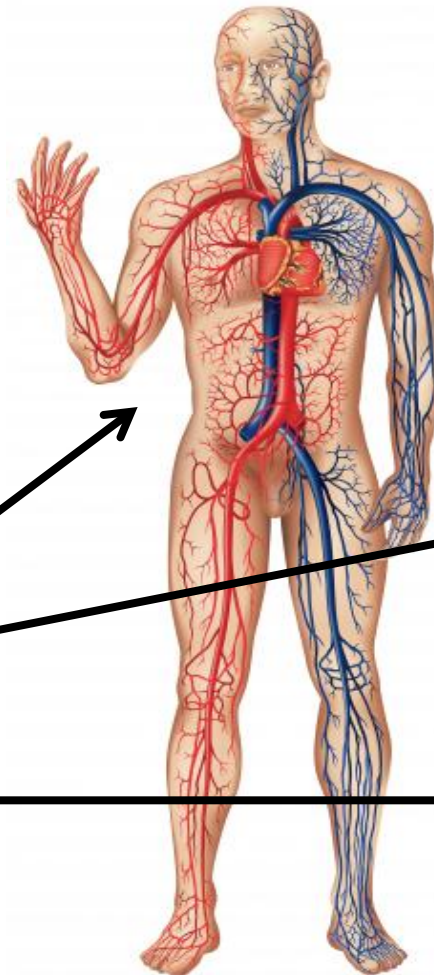
Where is the Immune System?



The immune system is located
throughout your body

Cells and Organs of the Immune System

- Each **system** in the body consists of **cells** and **organs**:
- For example:
 - Endocrine **system**
 - Pancreas (**organ**)
 - Beta cells (**cells**)
 - Cardiovascular **system**
 - Heart (**organ**)
 - Myocardocytes (**cells**)



Cells and Organs of the Immune System

- Similarly the immune **system** in the body consists of **cells** and **organs**:

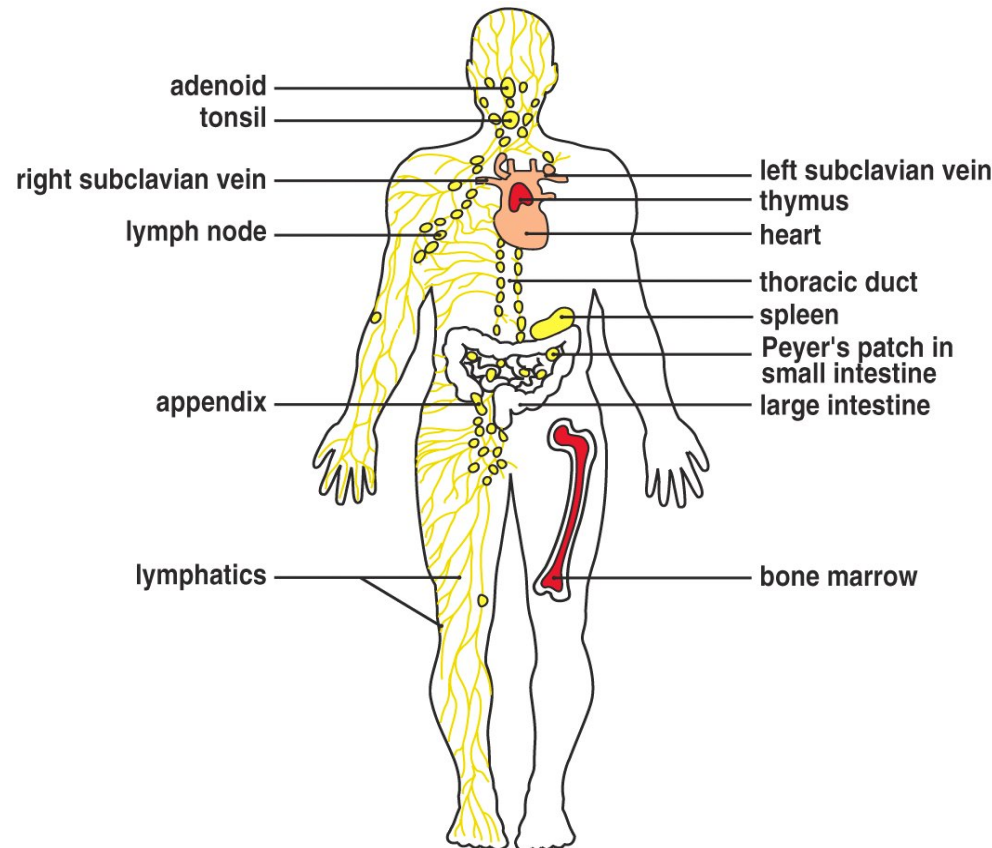


Figure 1-15 The Immune System, 2/e (© Garland Science 2005)

Cells and Organs of the Immune System

- Similarly the immune **system** in the body consists of **cells** and **organs**:

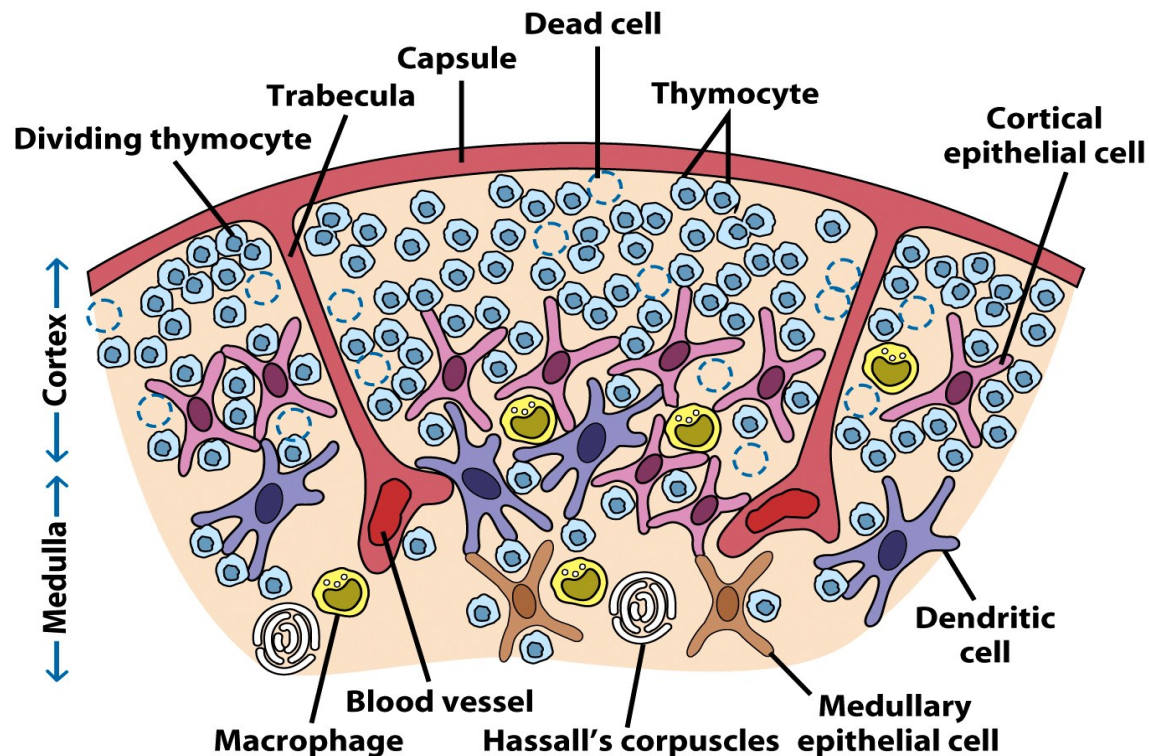


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Cells and Organs of the Immune System

- Similarly the immune **system** in the body consists of **cells** and **organs**:

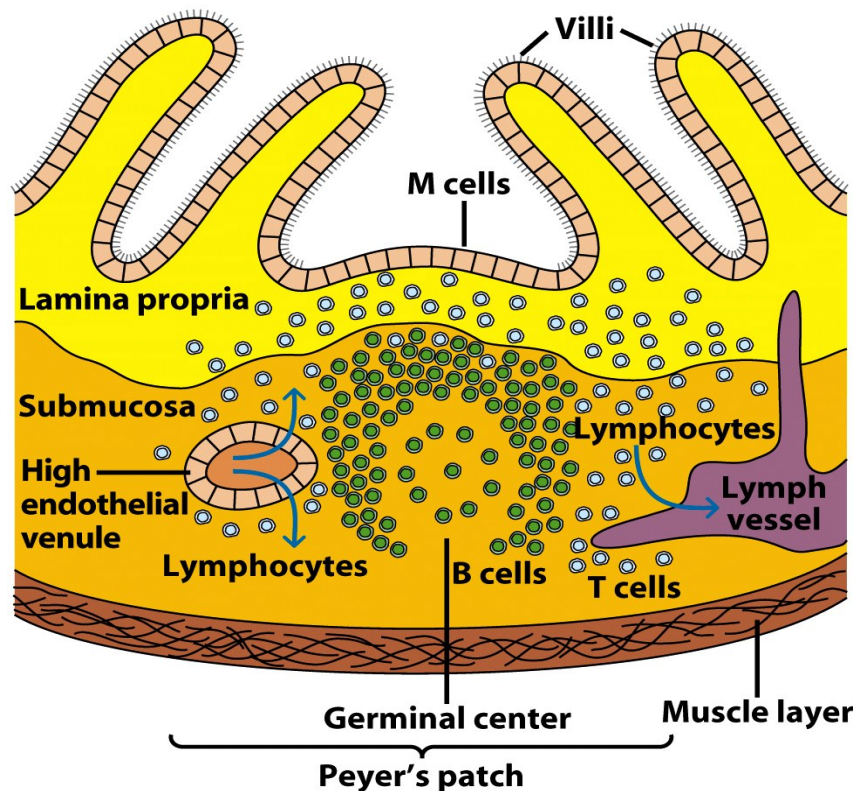


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Functions of the Immune System

The immune system protects against four classes of pathogens		
Type of pathogen	Examples	Diseases
Extracellular bacteria, parasites, fungi	<i>Streptococcus pneumoniae</i> <i>Clostridium tetani</i> <i>Trypanosoma brucei</i> <i>Pneumocystis carinii</i>	Pneumonia Tetanus Sleeping sickness <i>Pneumocystis pneumonia</i>
Intracellular bacteria, parasites	<i>Mycobacterium leprae</i> <i>Leishmania donovani</i> <i>Plasmodium falciparum</i>	Leprosy Leishmaniasis Malaria
Viruses (intracellular)	Variola Influenza Varicella	Smallpox Flu Chickenpox
Parasitic worms (extracellular)	<i>Ascaris</i> <i>Schistosoma</i>	Ascariasis Schistosomiasis

Functions of the Immune System

- The main features of the immune system include:
 - ① Protection of the body by two related activities: **recognition** and **response**
 - ② Distinguishing foreign invaders from self components (**self-nonself discrimination**)
 - ③ Recognition of host cells that are altered (neoplasm)

Functions of the Immune System

- The main features of the immune system include:
 - ④ Converting initial recognition into a variety of **effector responses** (elimination, neutralization, etc.)
 - ⑤ Generation of **memory response** characterized by more rapid and heightened response
 - ⑥ Education and orientation toward disease prevention or treatment by **vaccination**

The Immune Systems

- There are two immune systems in the body:

① **Innate** immune system:

- The less specific immune component
- First line of defense against infection

② **Adaptive** immune system:

- The highly specific immune component
- Capable of recognizing, eliminating, and remembering specific pathogens

Innate Immune System

- Most components of the innate immune system are present before the onset of infection

Neutrophil

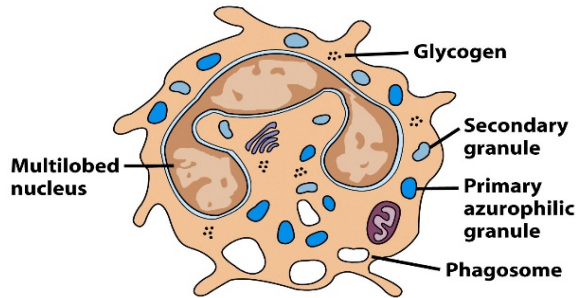


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Eosinophil

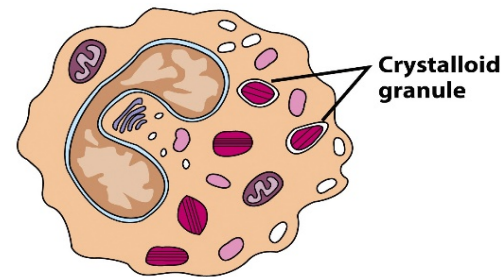


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Basophil

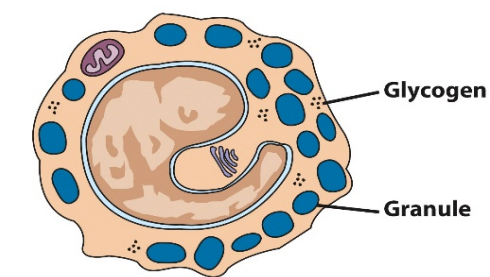
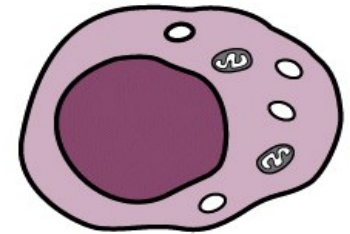


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NK cell

Monocyte

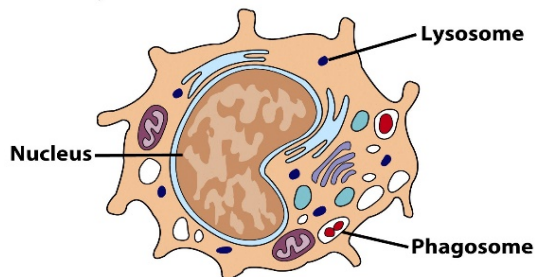


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Macrophage

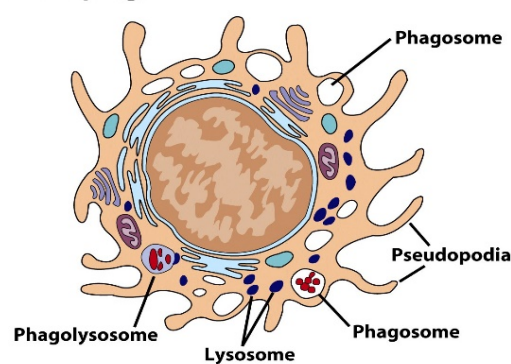
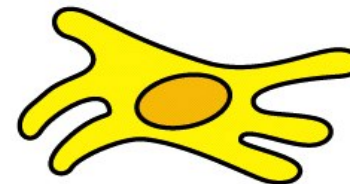
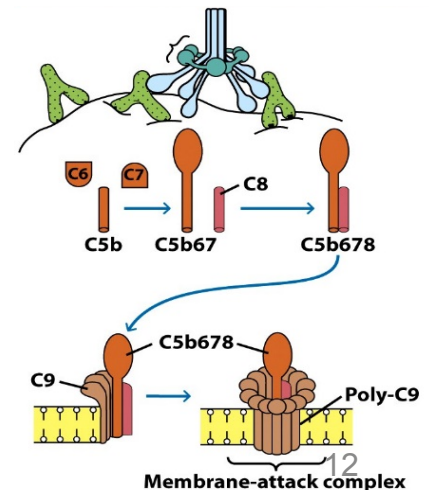


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Dendritic cell

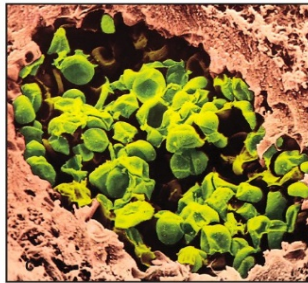


Innate Immune System

- It is not specific to a particular pathogen



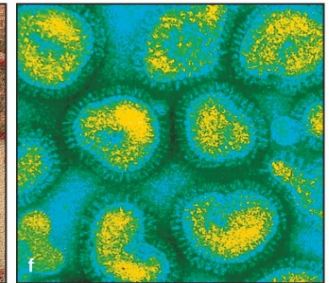
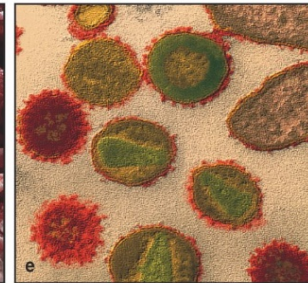
Figure 1-3 part 1 of 4 The Immune System, 2/e (© Garland Science 2005)



worms



Figure 1-3 part 2 of 4 The Immune System, 2/e (© Garland Science 2005)



viruses

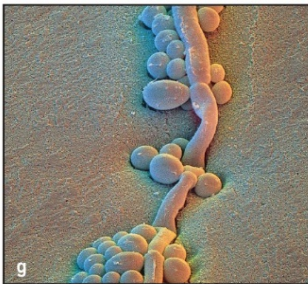
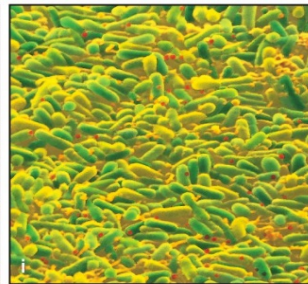
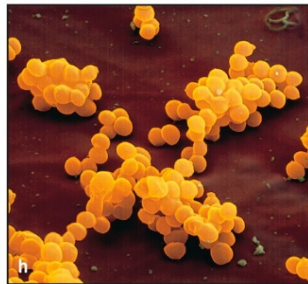


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fungi

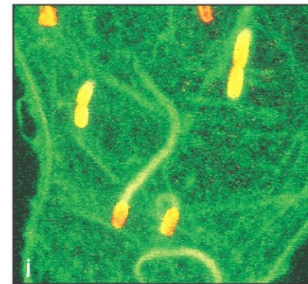
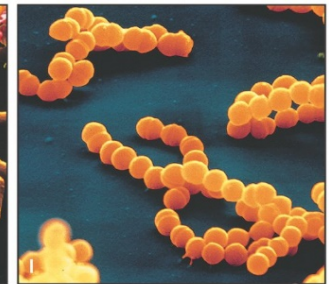
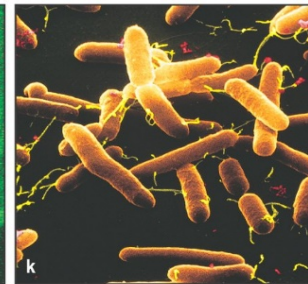


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bacteria

Innate Immune System

- The first hurdle for a pathogen includes host anatomical and physiological barriers
- The importance of these barriers becomes obvious when they are breached

Skin

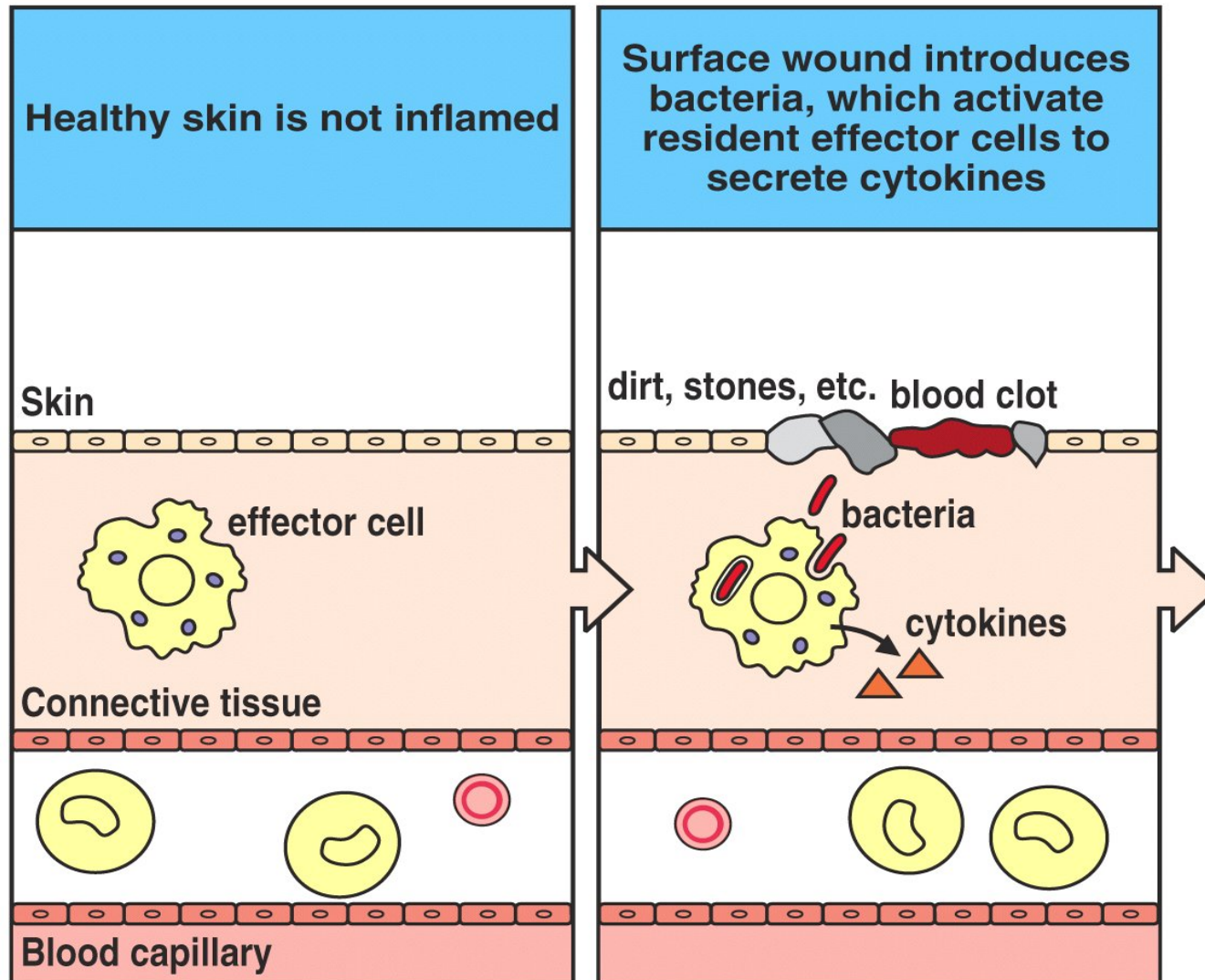


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Skin

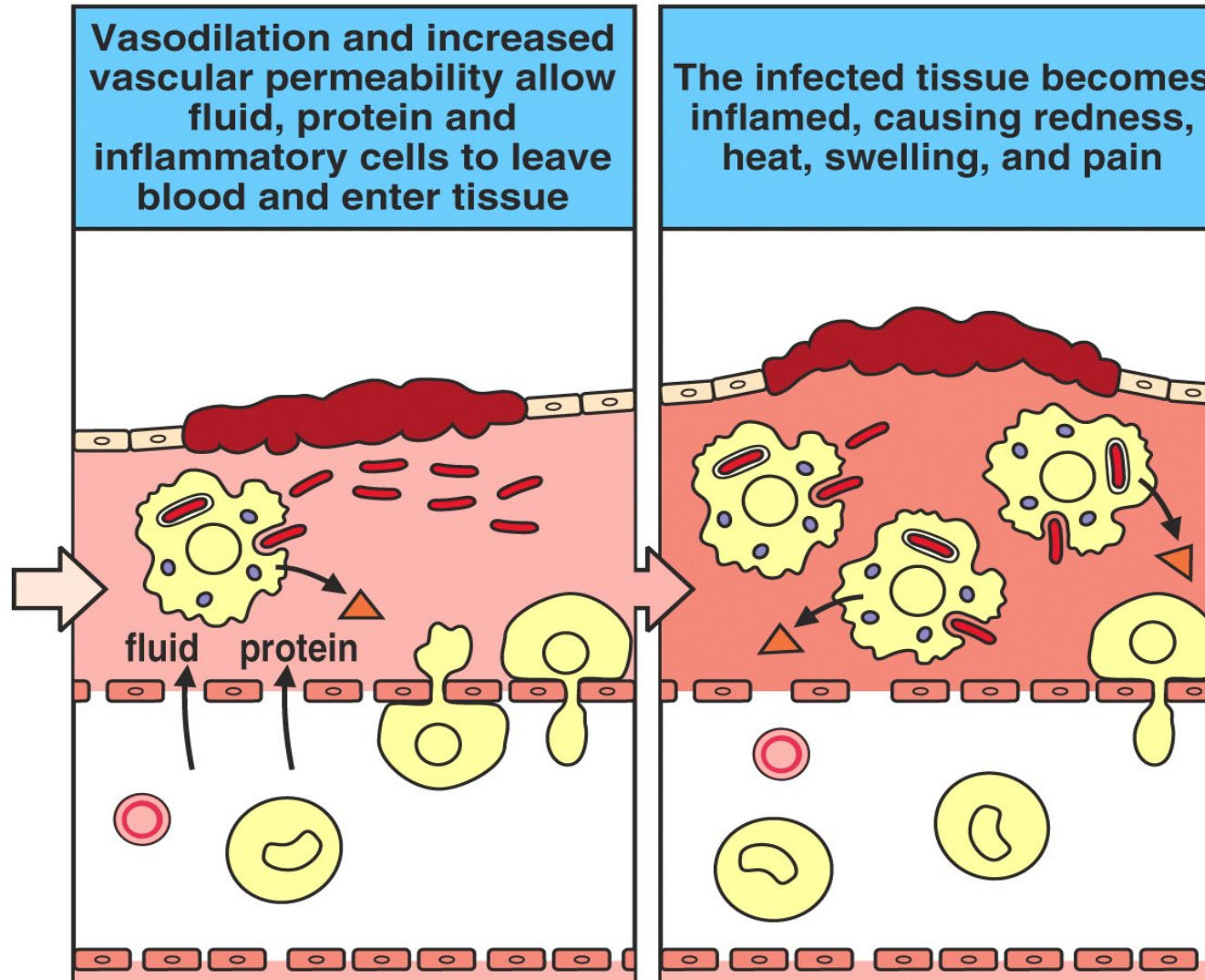
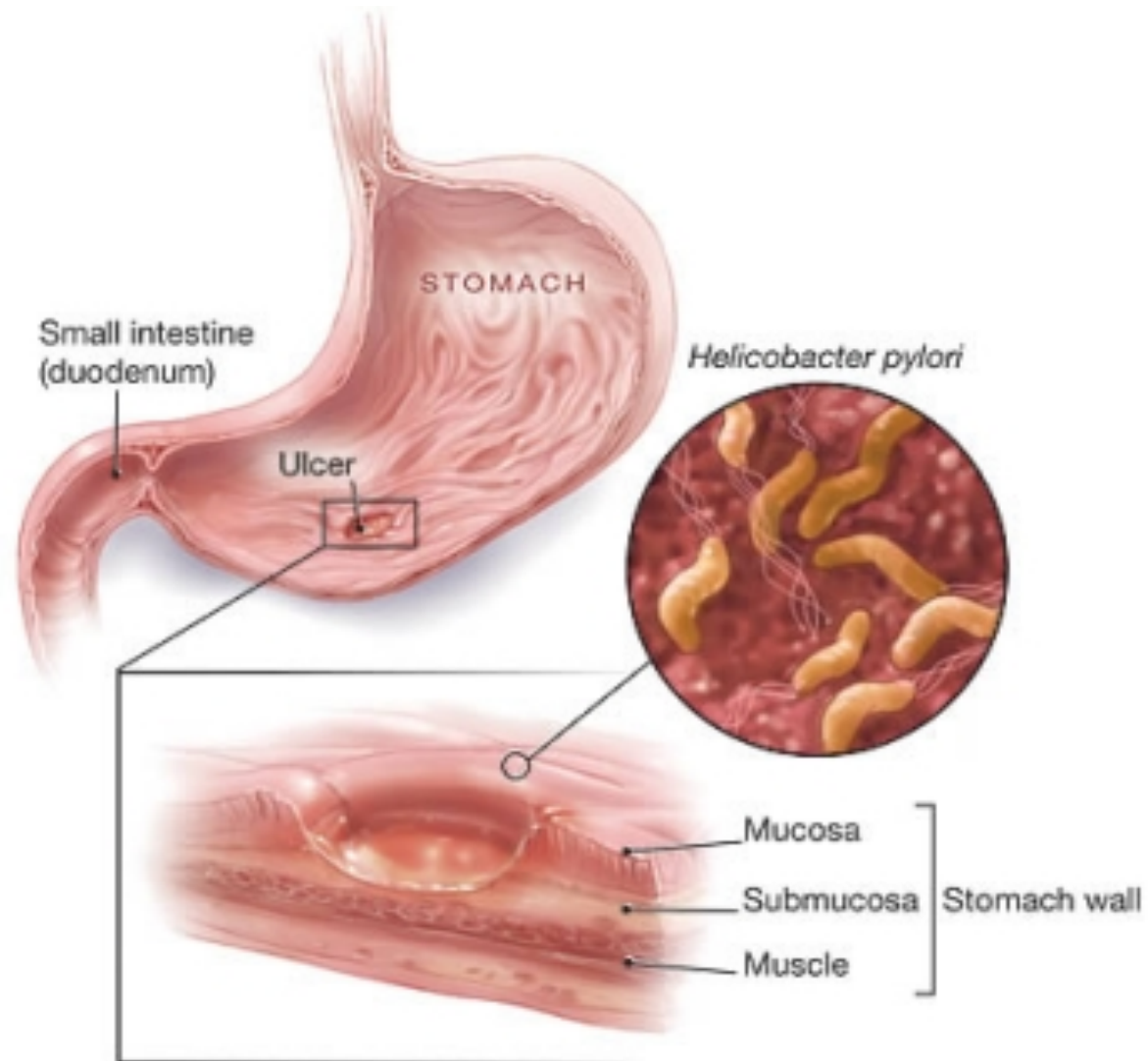


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Acidic pH



Innate Immune System

- Beyond the primary barriers, innate immunity includes a host of cells such as the **phagocytic cells** and **antimicrobial soluble molecules** synthesized by the host that can **recognize** and **neutralize** invaders.

Phagocytic Cells

- Specialized cells that have the ability of phagocytosis

Monocyte

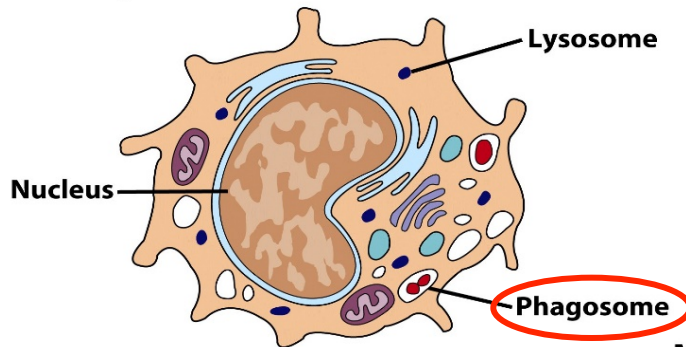


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Neutrophil

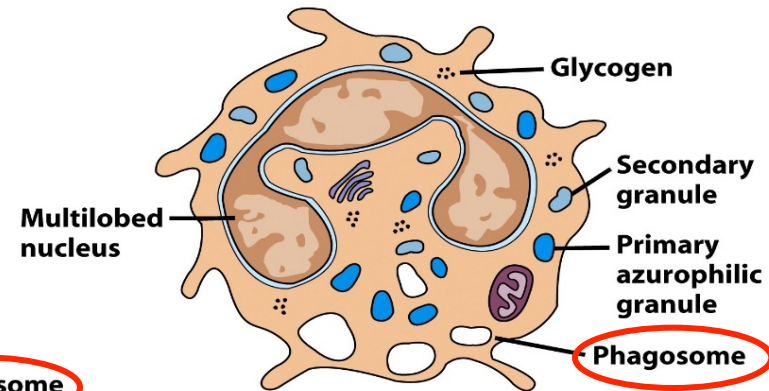


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Macrophage

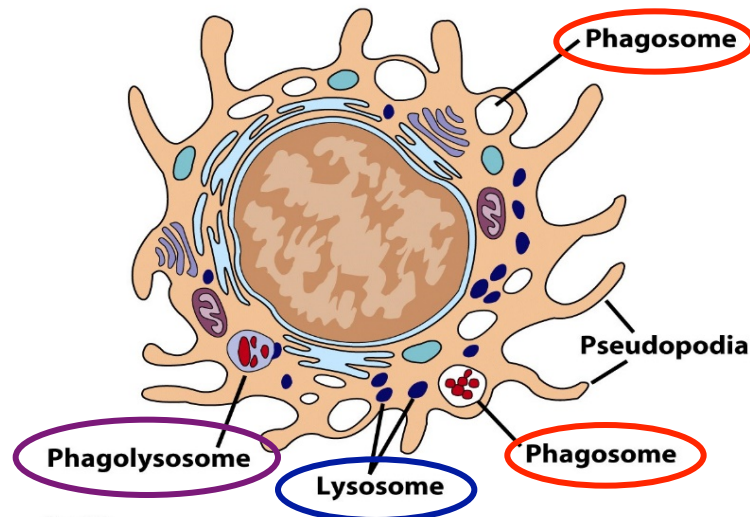
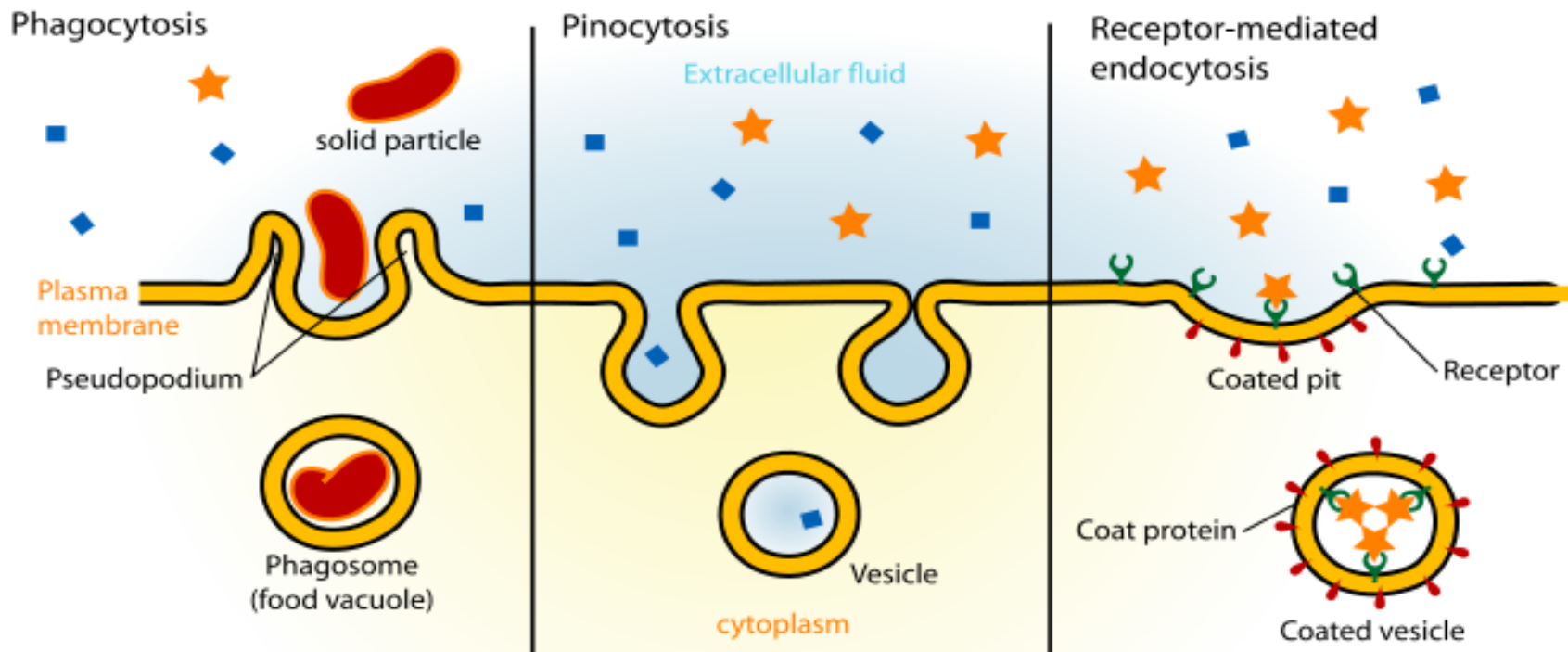


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Phagocytosis

- One type of **endocytosis**, in which cells expand their plasma membrane around a **particulate matter** e.g. microorganism.

Endocytosis



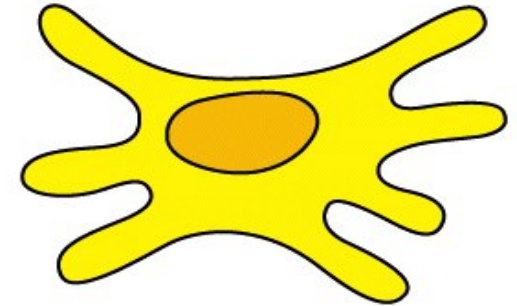
Phagocytic Cells



Neutrophils



Macrophages/ Monocytes



Dendritic cells

Cell type

Function

Phagocytosis
Reactive oxygen
and nitrogen
species
Antimicrobial
peptides

Phagocytosis
Inflammatory
mediators
Antigen presentation
Reactive oxygen and
nitrogen species
Cytokines
Complement proteins

Antigen presentation
Costimulatory
signals
Reactive oxygen
species
Interferon
Cytokines

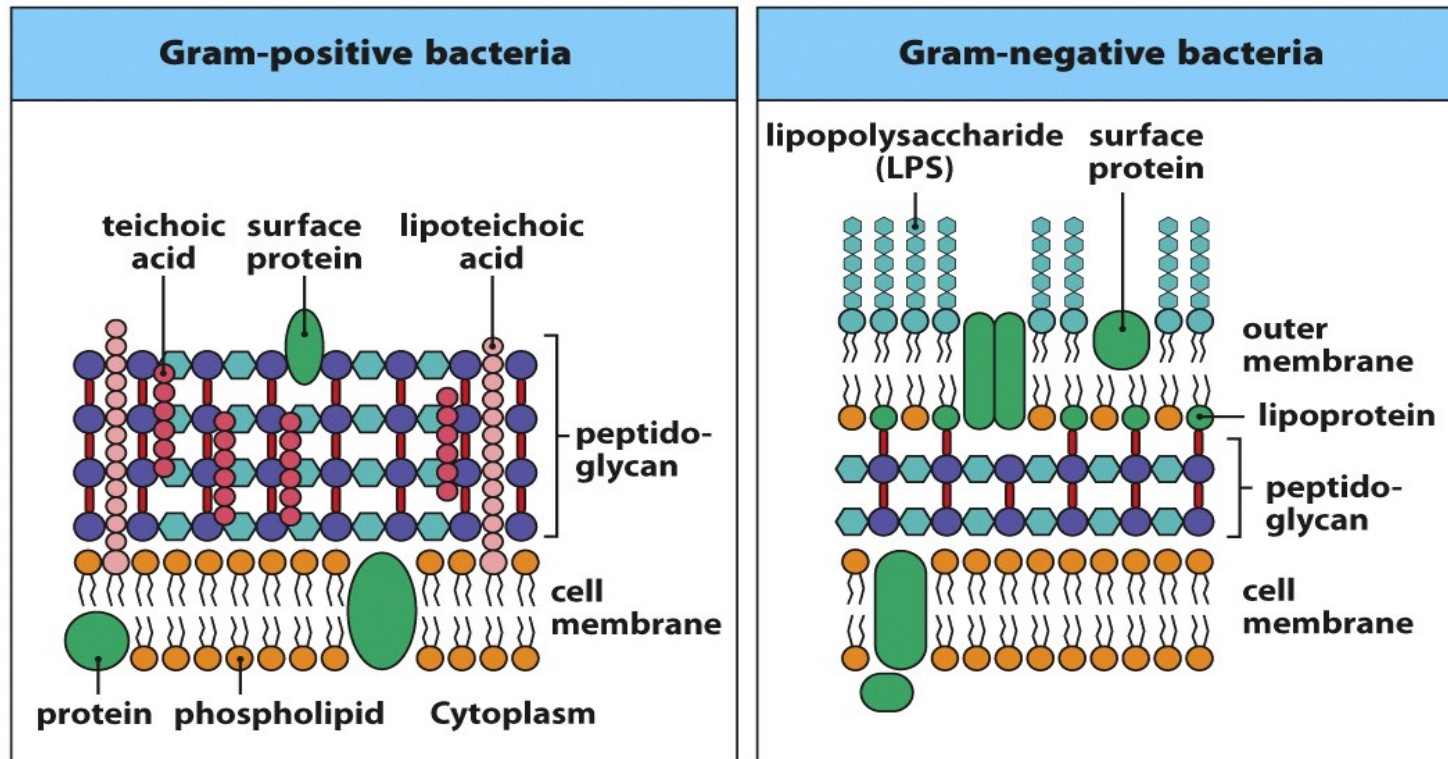
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Soluble molecules

- A variety of soluble molecules contribute to innate immunity such as:
 - ① Protein lysozyme
 - ② Interferon proteins
 - ③ Complement system

Protein lysozyme

- Hydrolytic enzyme present in mucous secretions and in tears, able to cleave the **peptidoglycan layer** of the bacterial cell wall



Protein lysozyme

- **Hydrolytic enzyme** present in mucous secretions and in tears, able to cleave the peptidoglycan layer of the bacterial cell wall

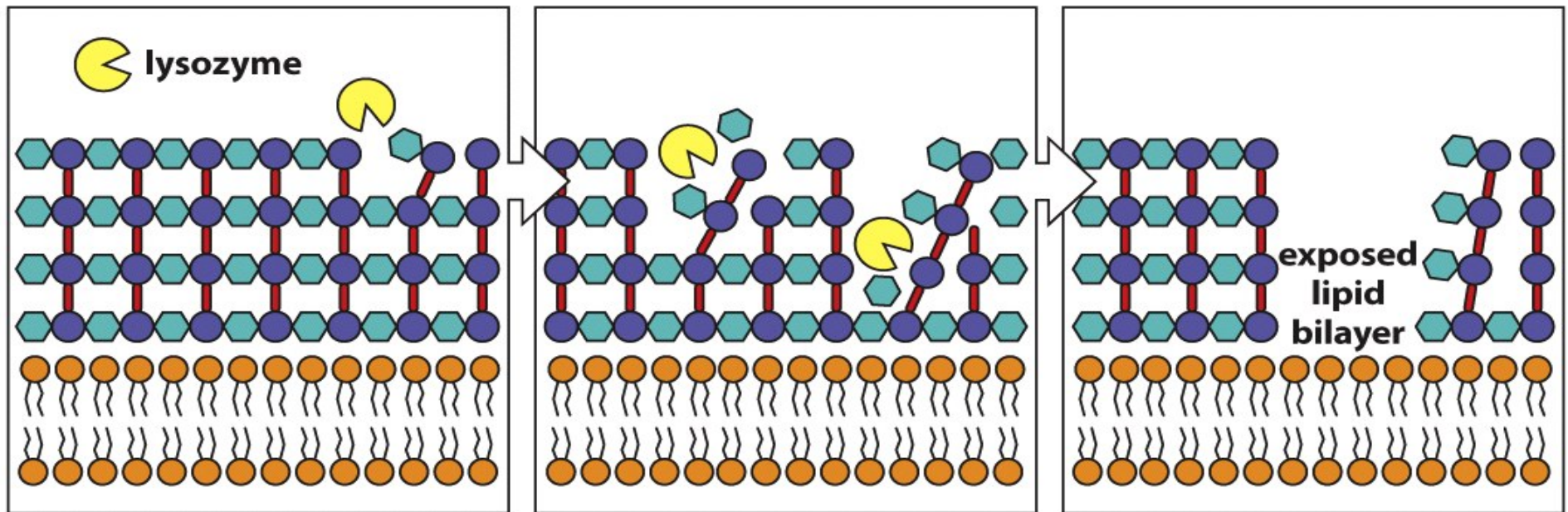
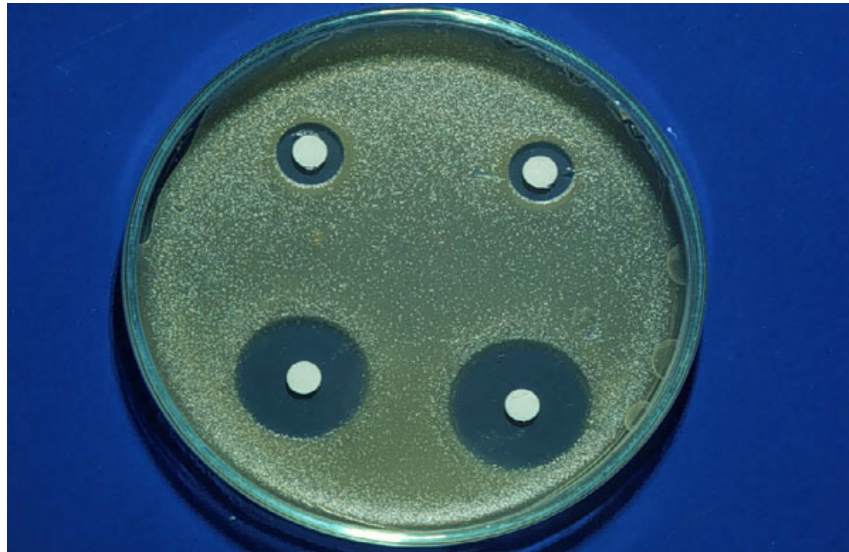


Figure 2.7 Janeway's Immunobiology, 8ed. (© Garland Science 2012)

Protein lysozyme

- Hydrolytic enzyme present in mucous secretions and in tears, able to cleave the peptidoglycan layer of the bacterial cell wall

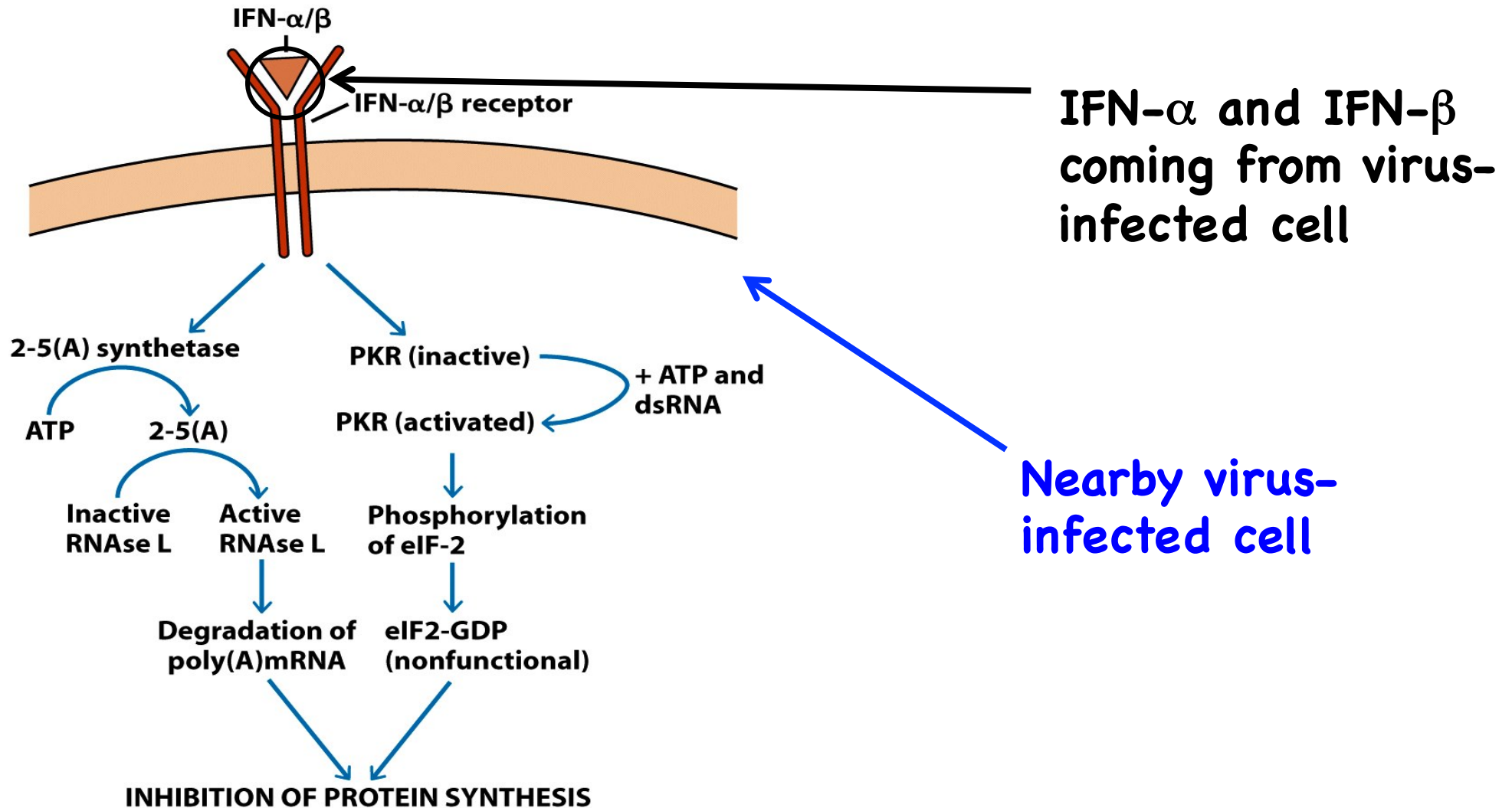


Antibiotic effects of lysozyme disc on bacterial culture

Interferon (IFN)

- A group of proteins (**cytokines**) produced by virus-infected cells, or some immune cells, that can induce generalized antiviral state.
- IFN- α and IFN- β (**type I interferons**), are produced by virus-infected cells as well as monocytes, macrophages, and fibroblasts.

Mechanism of IFN- α/β



Interferons (IFNs)

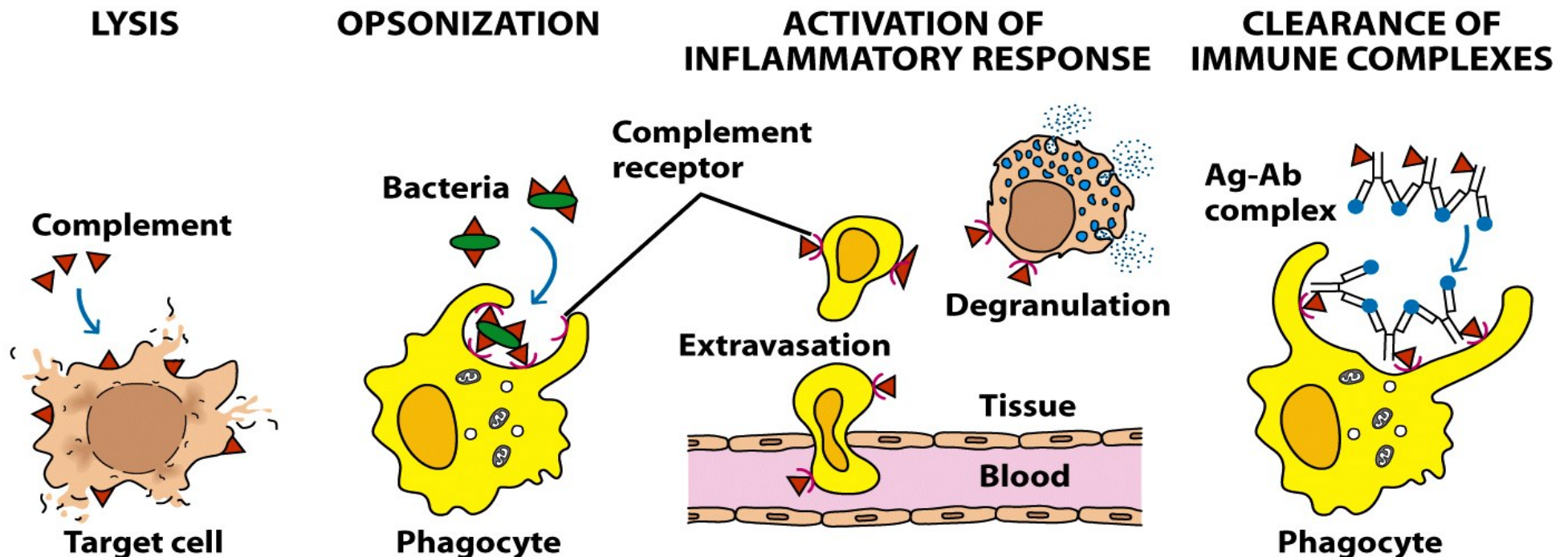
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- Binding of IFN- α and IFN- β to **natural killer (NK)** cells makes them very effective in killing virus-infected cells.

Interferons (IFNs)

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- Binding of IFN- α and IFN- β to **natural killer (NK)** cells makes them very effective in killing virus-infected cells
- IFN- γ (**type II interferons**) is involved more in adaptive immune response
- IFN- λ (**type III interferons**) plays a role in stimulating the immune system against viruses

Complements System

- Serum proteins that circulate in **inactive** state but when **activated** exert activities as such:



Adaptive Immune System

- Many molecules of the innate immune system have the ability for **pattern recognition** of unique components of the microbes
- The innate immune system then reacts with **inflammatory response**, which may result in priming an **adaptive immune response** against specific pathogens.

Adaptive Immune System

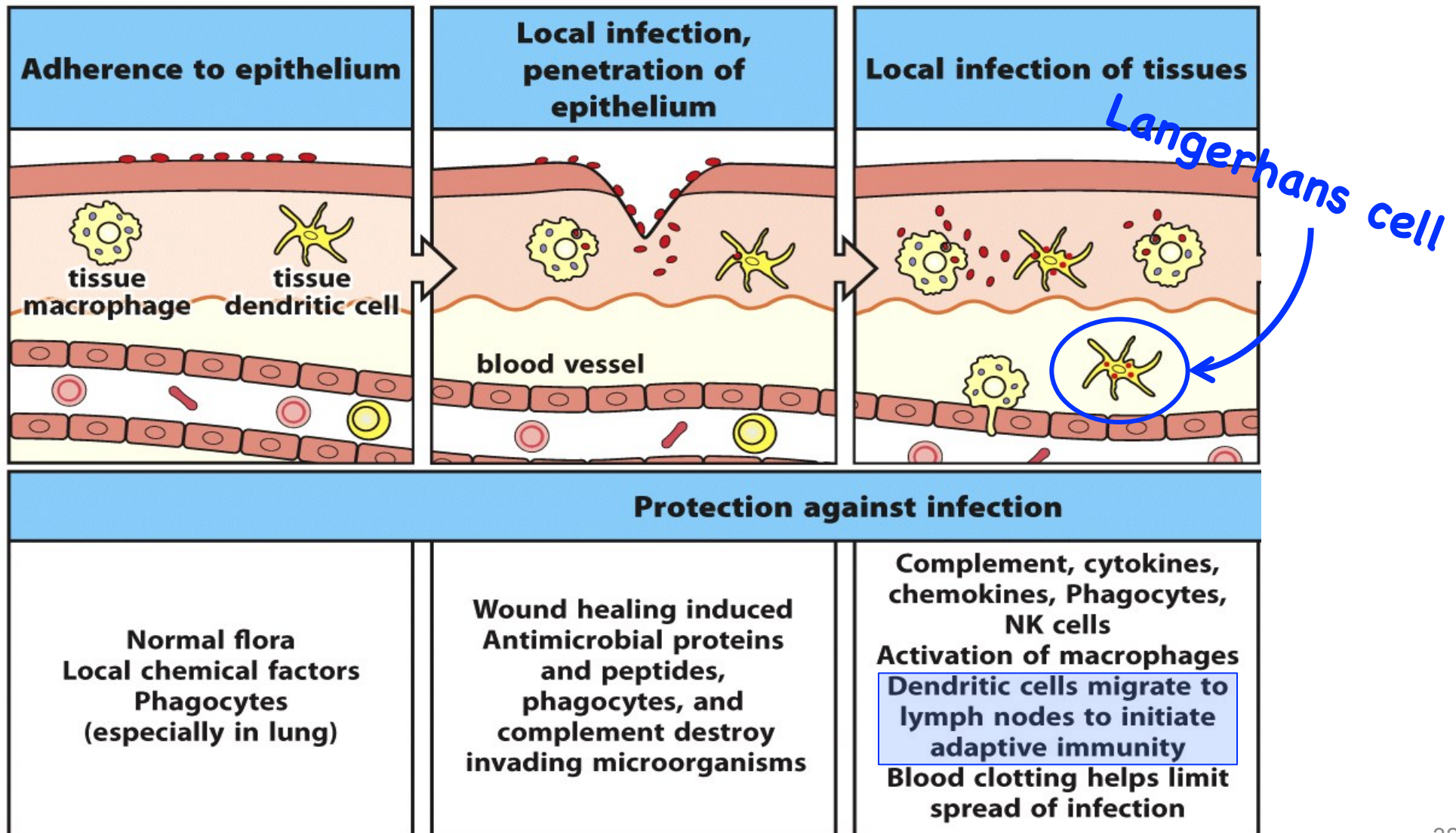
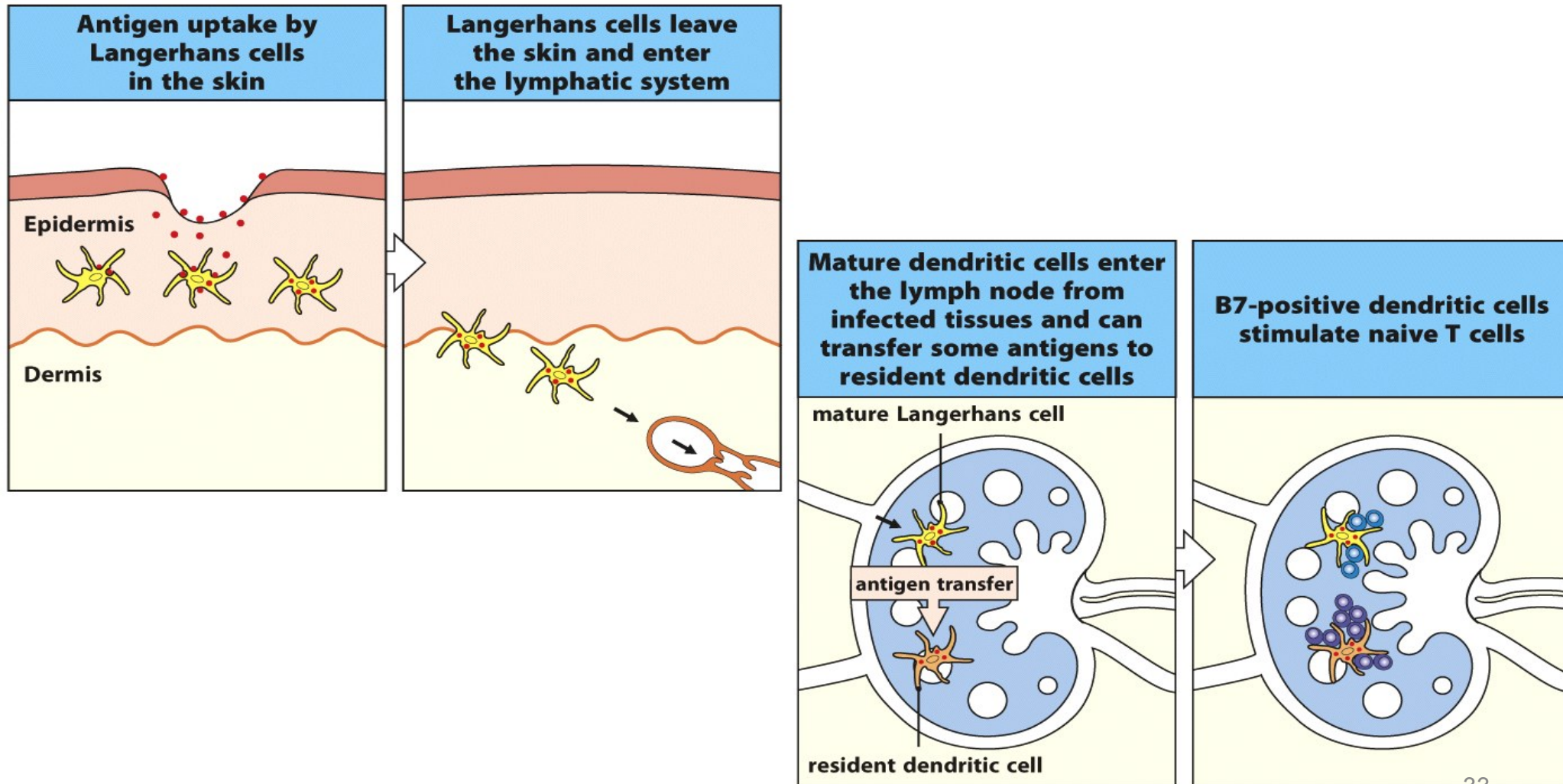


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Adaptive Immune System



Adaptive Immune System

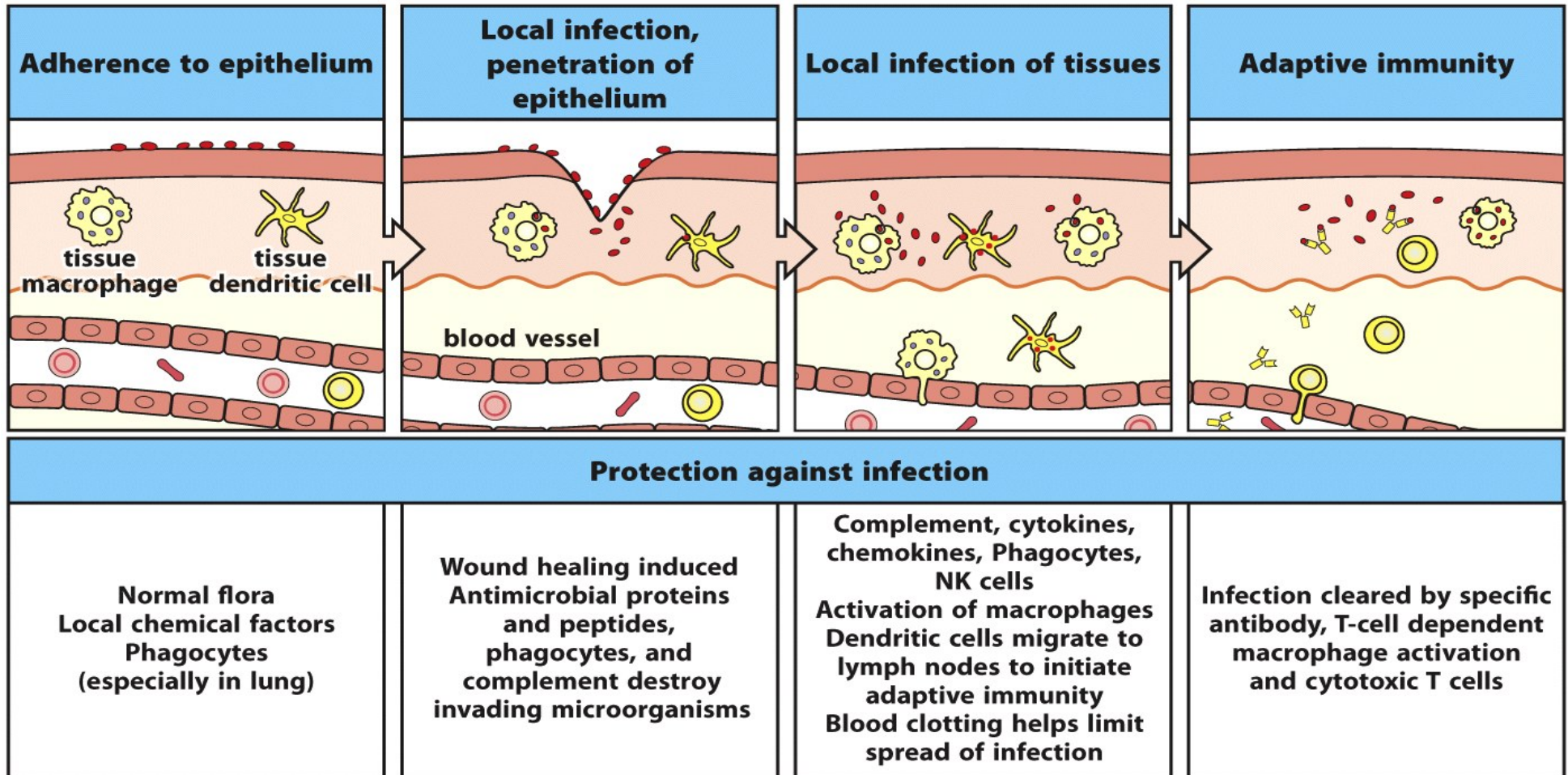


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Adaptive Immune System

- Effective Immune response involves 2 groups of cells:

① Lymphocytes

B cell

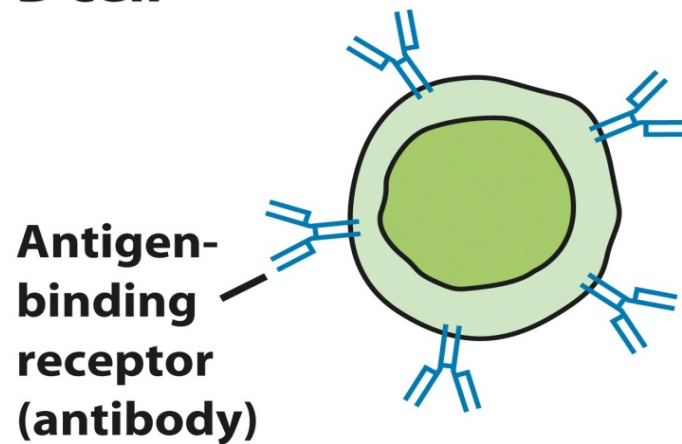


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T_C cell

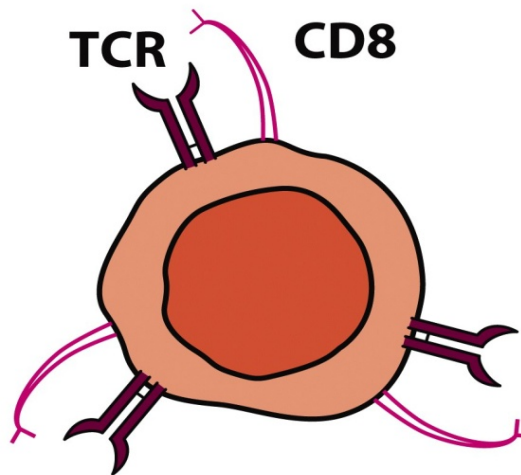


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T_H cell

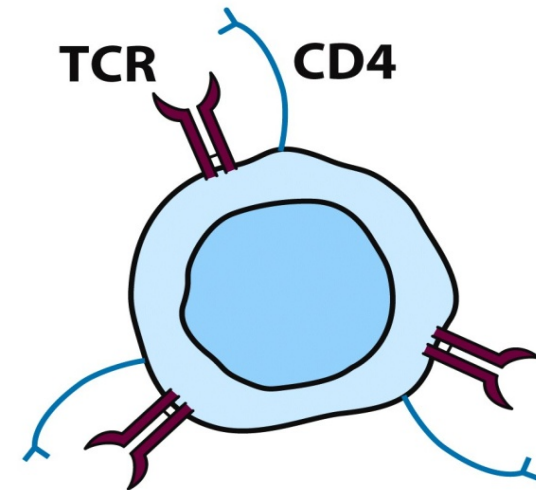
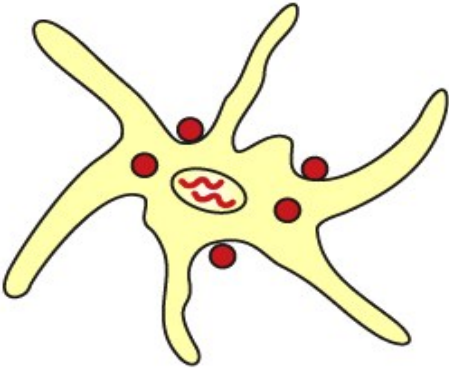
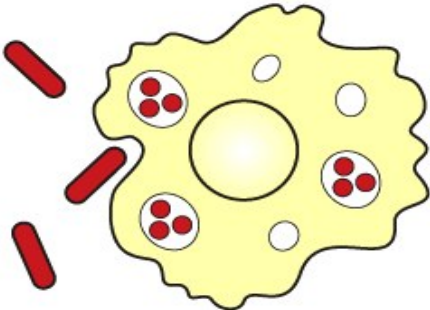
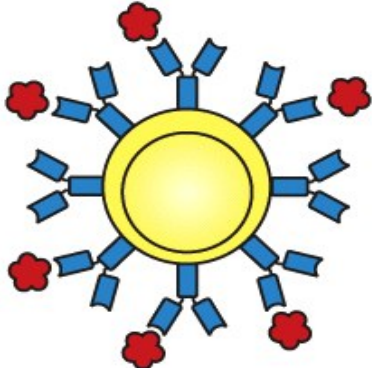


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Adaptive Immune System

- Effective Immune response involves 2 groups of cells:

② Antigen-presenting cells

Dendritic cells	Macrophages	B cells
		

Antigen Presentation

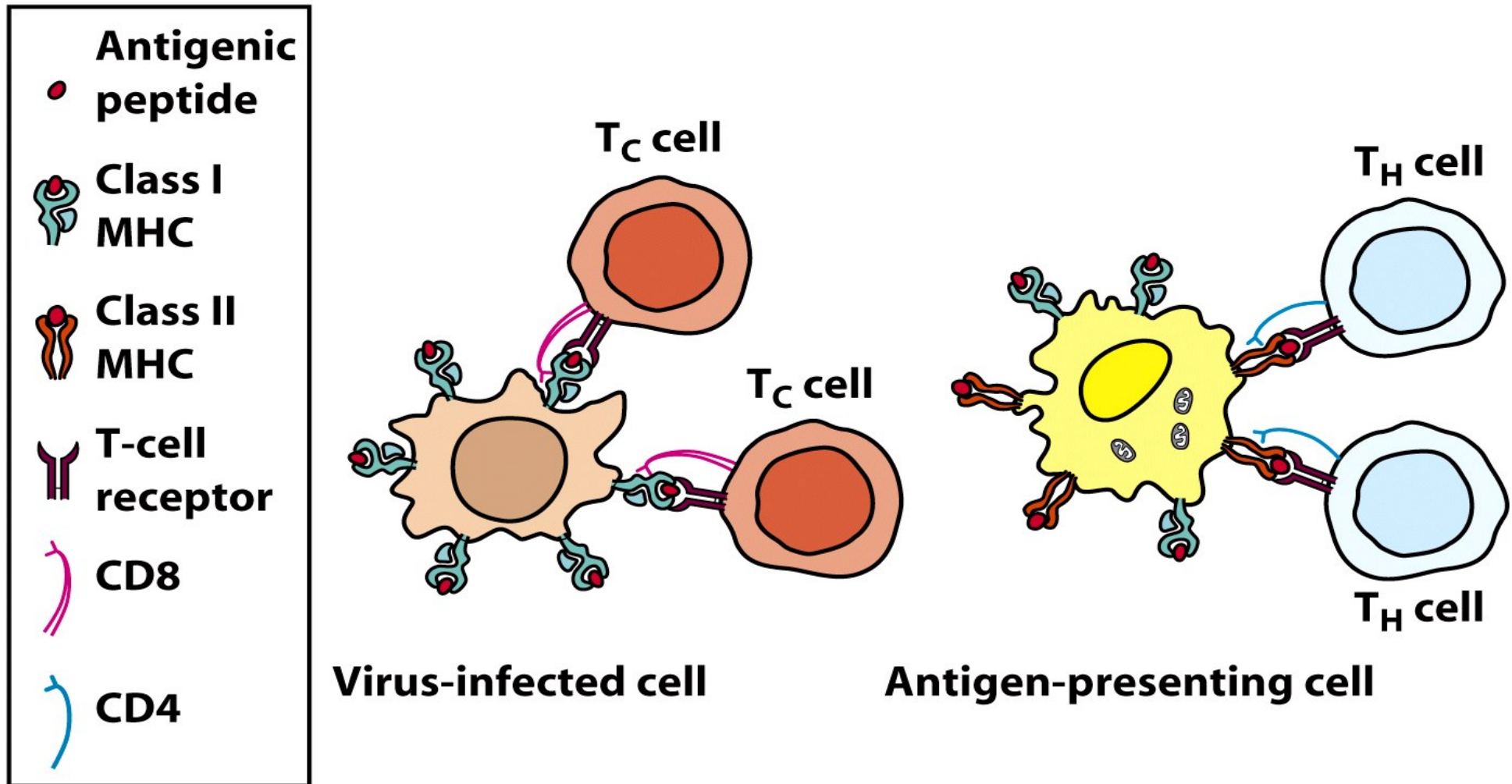


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Antigen Presentation

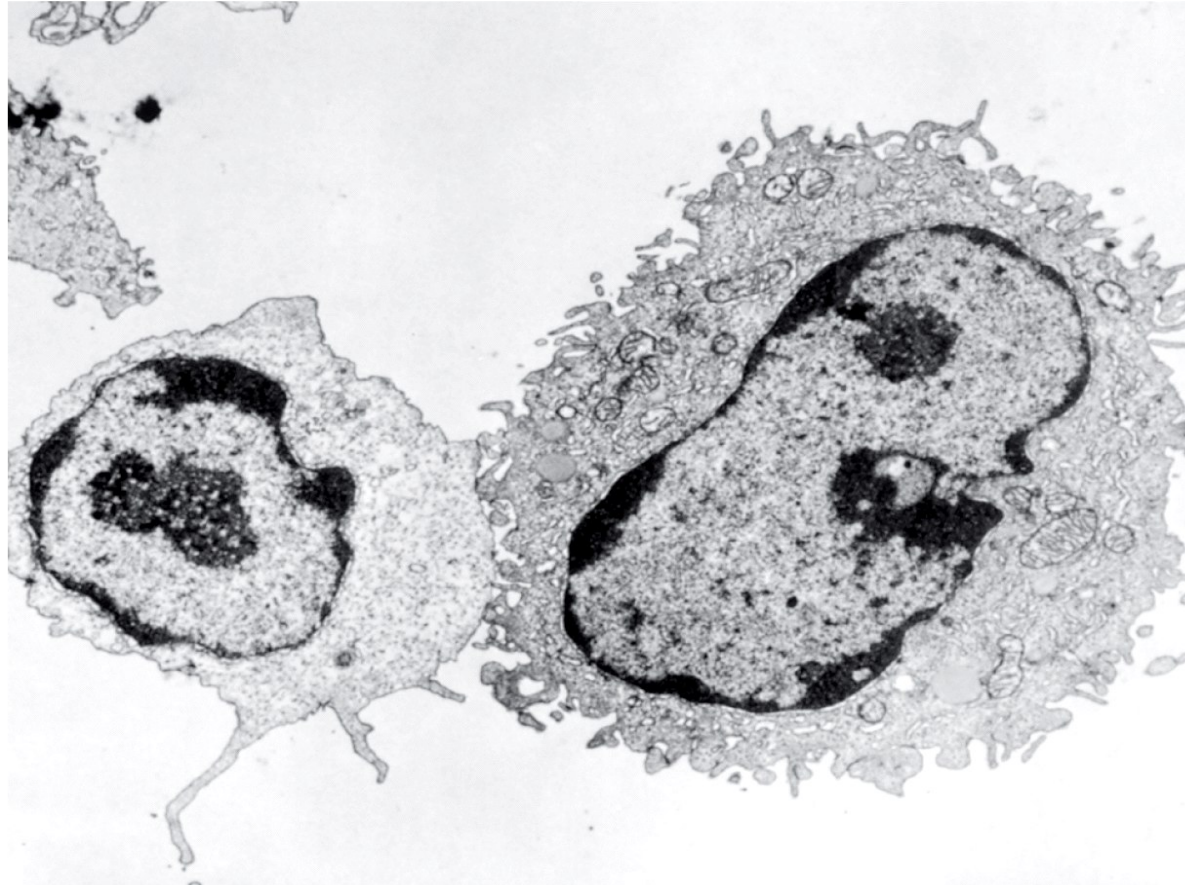
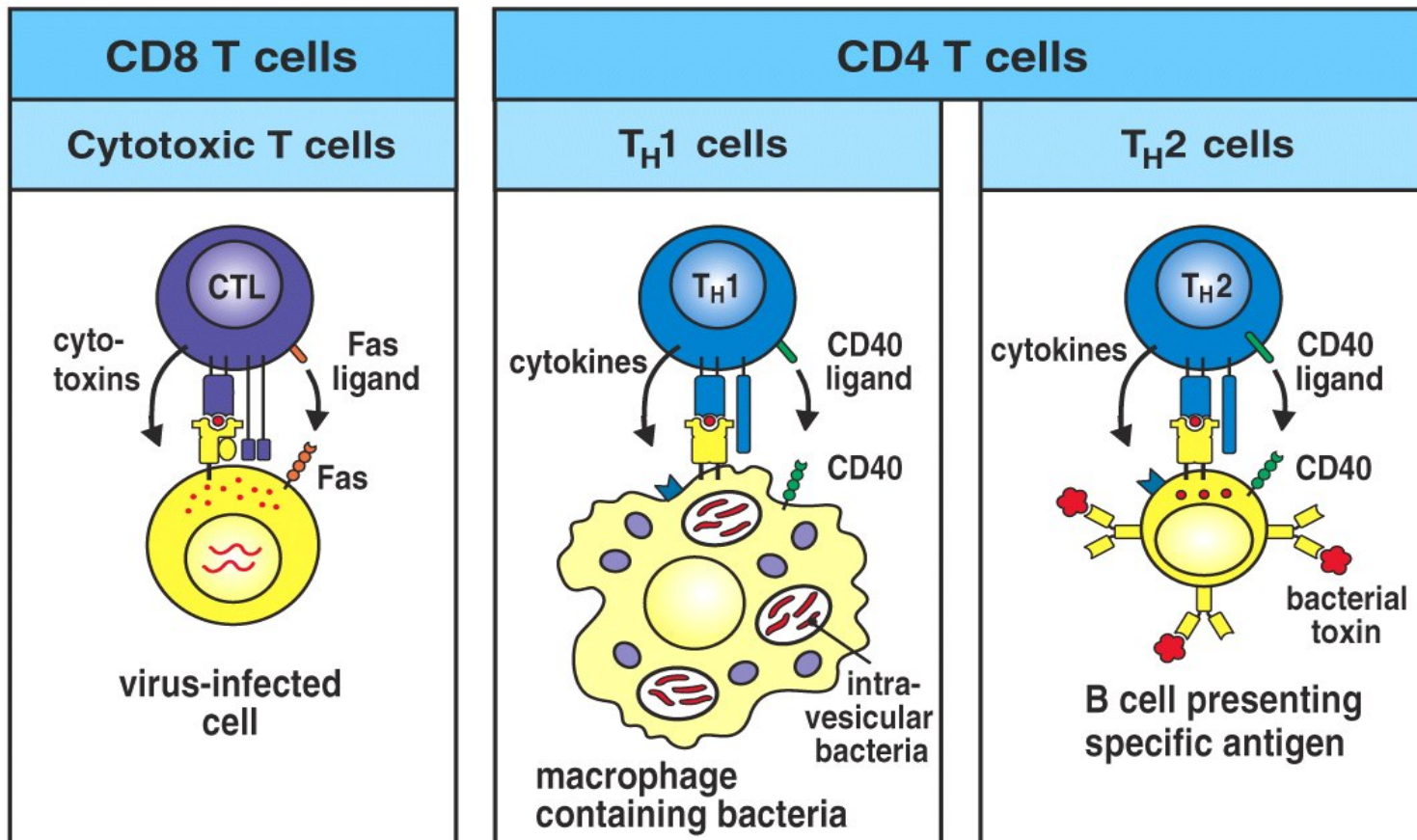


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Electron micrograph of an antigen-presenting Mφ (right) associating with a T lymphocyte (left)

Cell-Mediated Immunity



Humoral Immunity

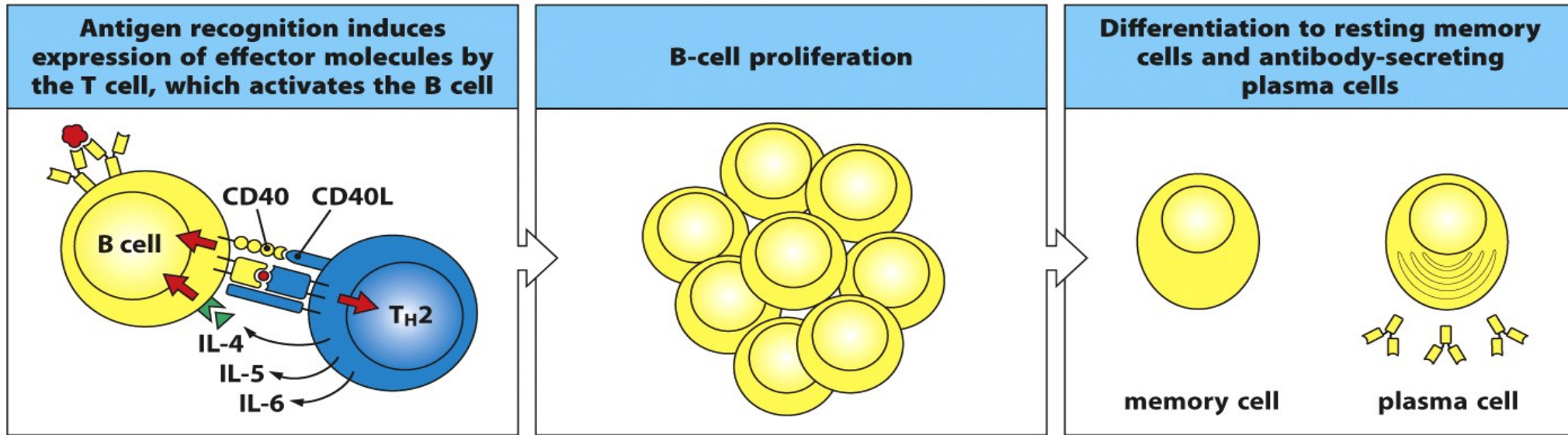


Figure 10.3 Janeway's Immunobiology, 8ed. (© Garland Science 2012)

Adaptive Immune System

- Displays 4 characteristic attributes:

- ① **Antigenic specificity**

- Distinguish subtle differences among antigens

- ② **Diversity**

- Recognitions of billions structures on foreign antigens

- ③ **Immunologic memory**

- Higher immune reactivity upon second encounter

- ④ **Self-Nonself recognition**

- Ability to respond only to foreign antigens

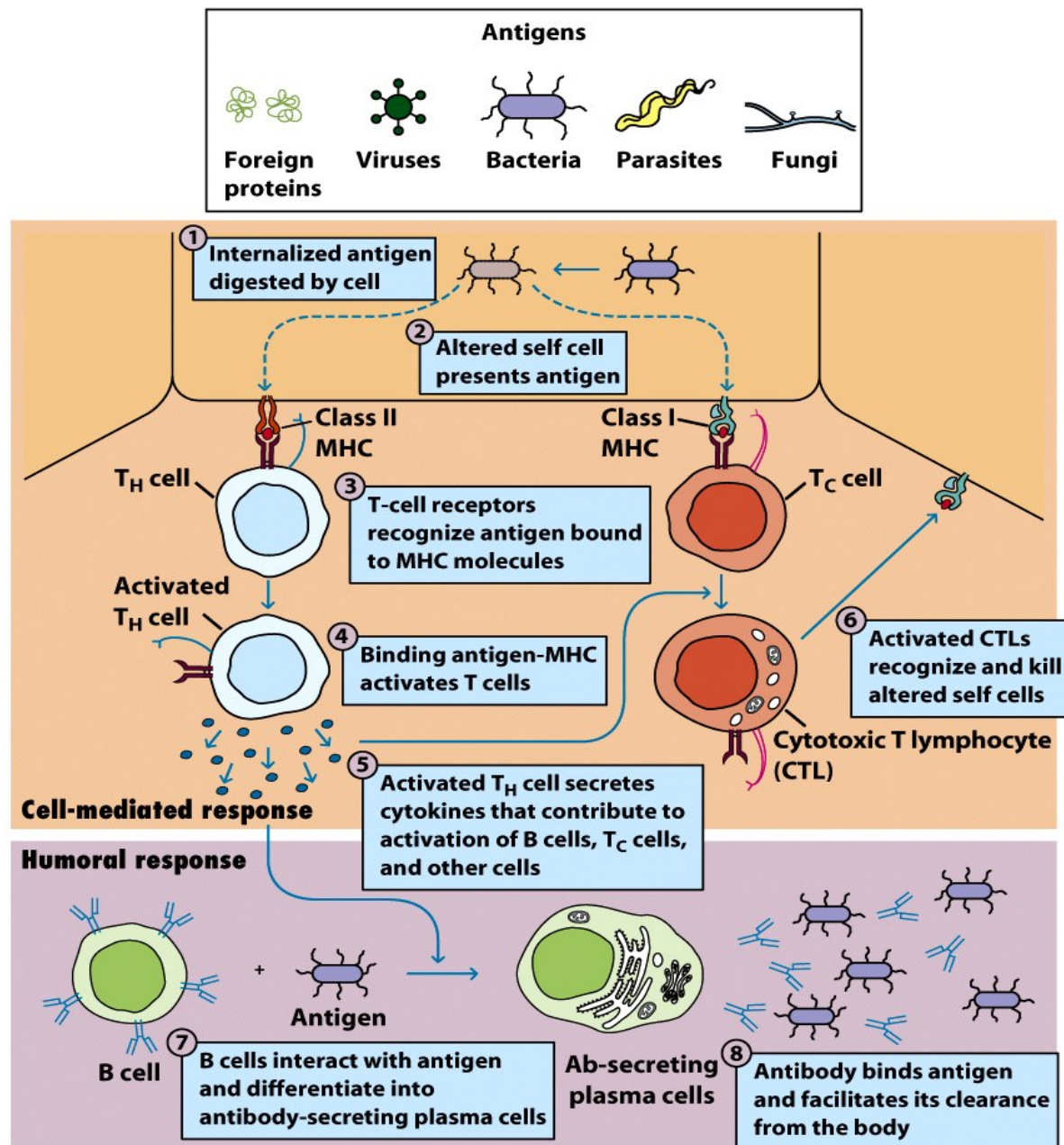


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Adaptive Immune System

- Typically, it takes about 5 to 6 days to develop an adaptive immune response against an antigen after the initial exposure
- Future exposure to the same antigen results in a **memory response**: more quicker, stronger, and effective in clearing pathogens

Adaptive Immune System

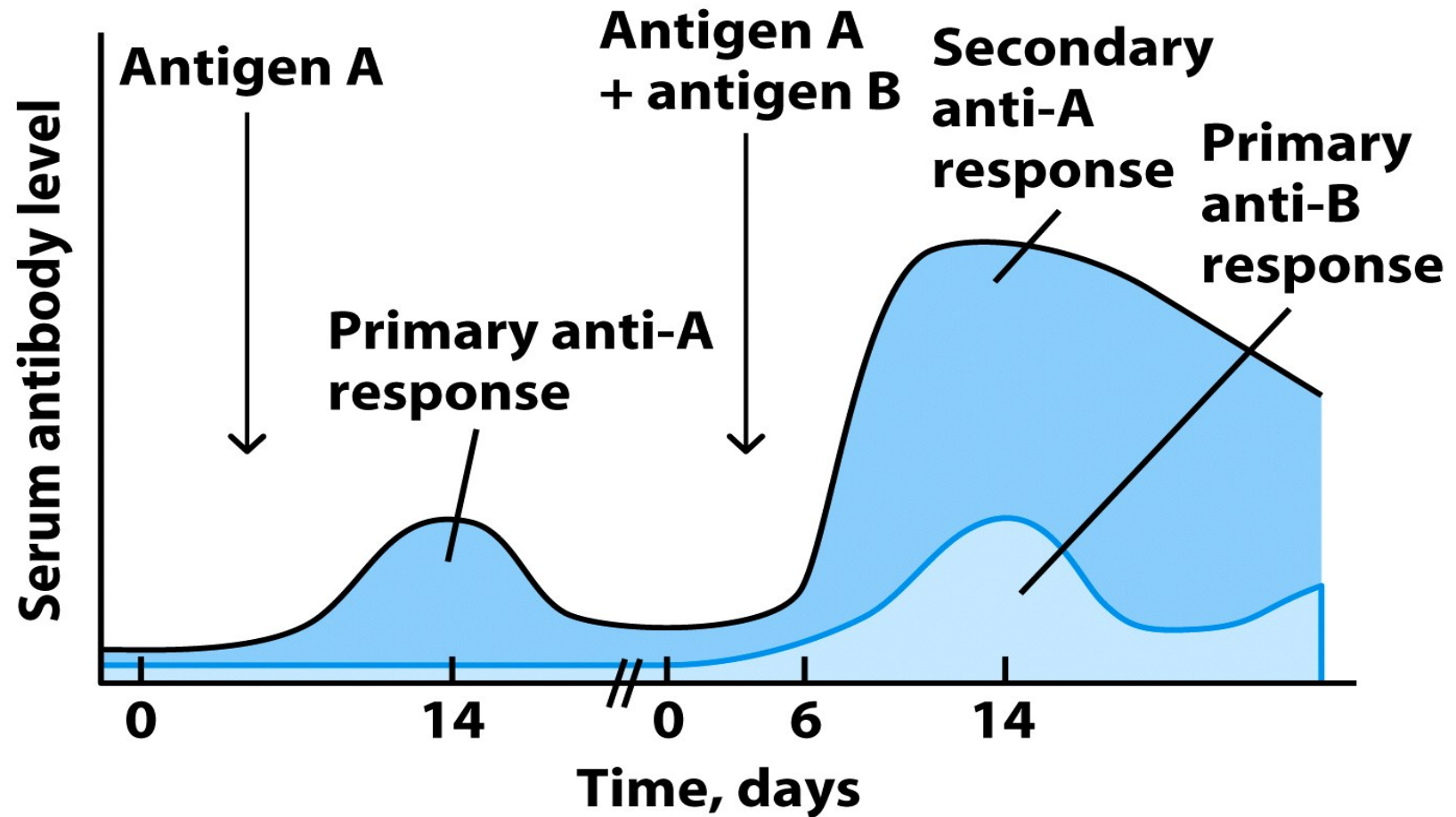


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Adaptive Immune System

- It is important to appreciate that innate and adaptive immune systems **DO NOT** operate independently
- They function as highly interactive and cooperative system, producing **combined response** more effective than either branch could produce by itself

TABLE 1-3**Comparison of innate and adaptive immunity**

	Innate	Adaptive
Response time	Hours	Days
Specificity	Limited and fixed	Highly diverse; improves during the course of immune response
Response to repeat infection	Identical to primary response	Much more rapid than primary response
Major components	Barriers (e.g., skin); phagocytes; pattern recognition molecules	Lymphocytes; antigen-specific receptors; antibodies

You are now able to:

- ✓ Recognize the cells and organs of the immune system
- ✓ Understand the basic concepts of immunity
- ✓ Differentiate between innate and adaptive immune responses
- ✓ Appreciate the significance of immunology studies and research