



Immunology Introduction and Overview

Fundament of Immunology

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- Immunology is a science that involves the immunological **defense**, immunological **homeostasis**, and immunological **surveillance**, covering the areas of the composition and function of immune systems.
- With the immunological theoretical and technical interactions with other disciplines, such as molecular biology, cellular biology,

genetics and biochemistry etc, immunology has developed rapidly over last 50 years, and **become one of the fastest growing disciplines.**

Medical immunology is located at the cutting edge of the life science and is closely intertwined with all the disciplines of clinical medicine in the 21 Century.

The immunological theory and techniques have been extensively applied to many other



areas of life science and medicine.

Immunology is also an important basic and applied discipline to many other disciplines, such as biology, basic medicine, clinical medicine, preventive medicine and veterinary science, etc.

- **In School of Medicine, Southeast University, immunology is an academic degree course, and contains **48 hours of theoretical lectures****

that will be lectured in classroom, as well as **16 hours of technical experiments** that will be learned in laboratory. You can receive **3.5 credits** after you have finished the study of medical immunology and passed through the examination.



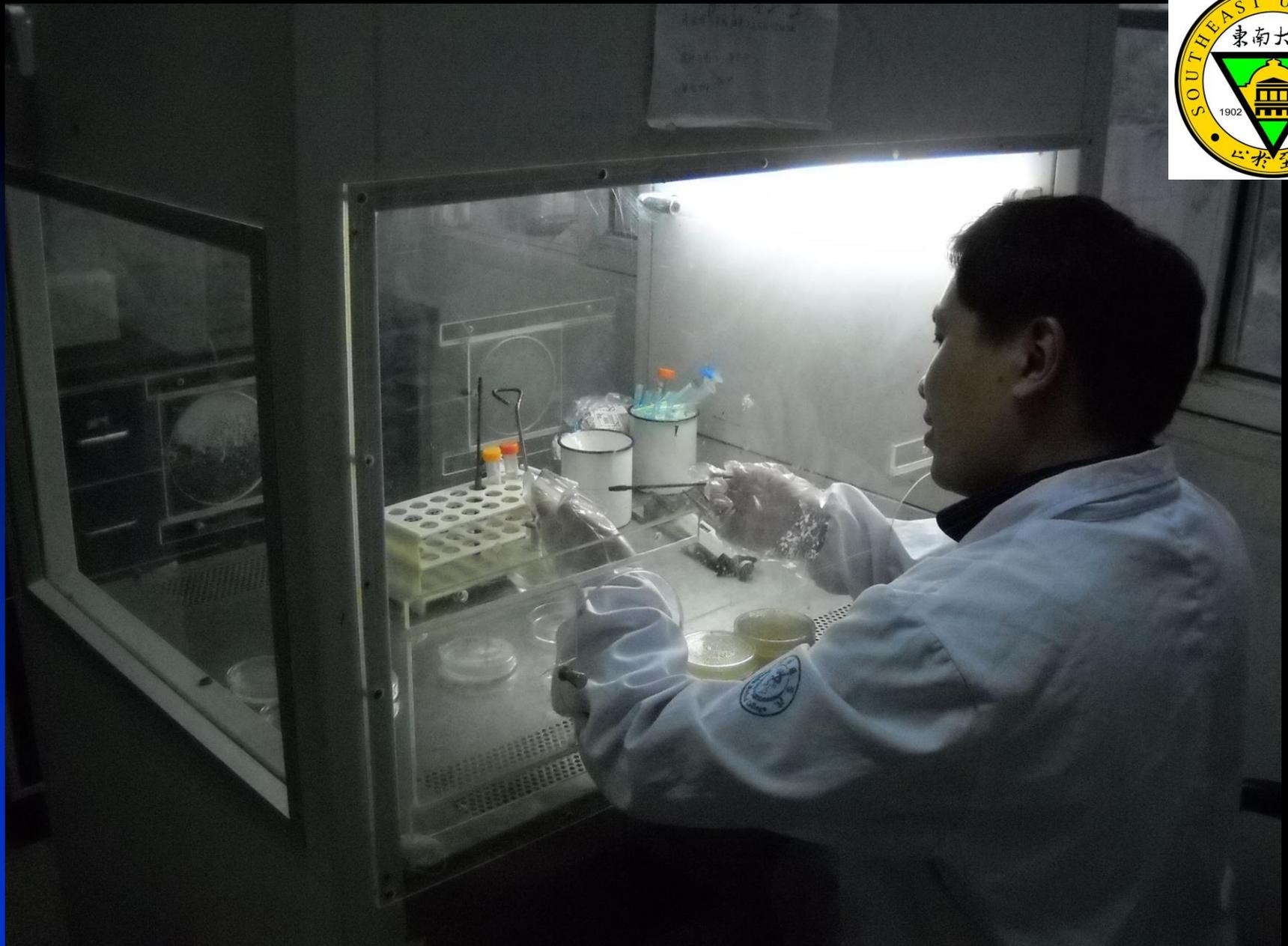
Laboratory

07/07/2013



Laboratory

07/07/2013



2020/5/6

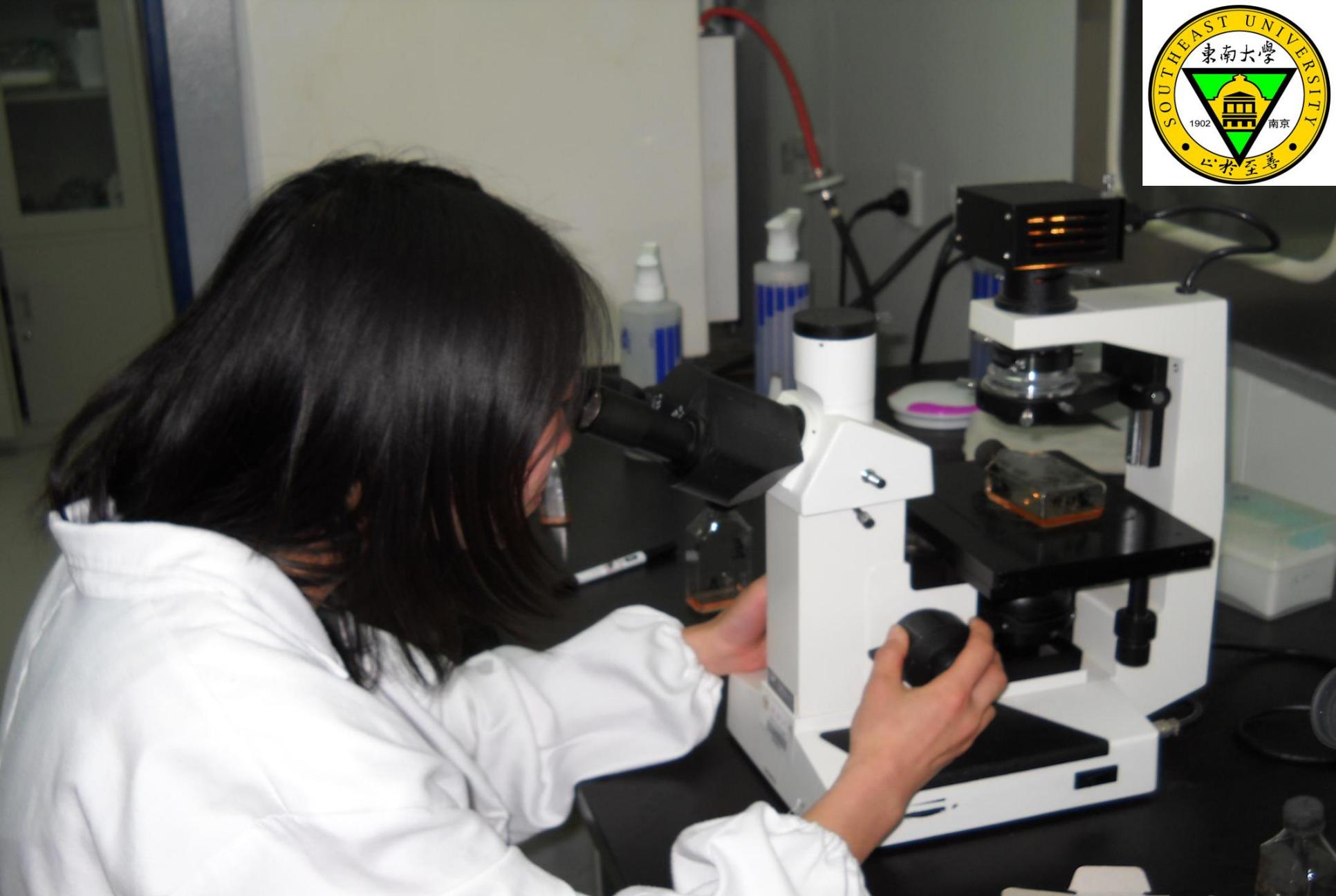
Super clean bench in clone room



Ultra cold freezer in cold room

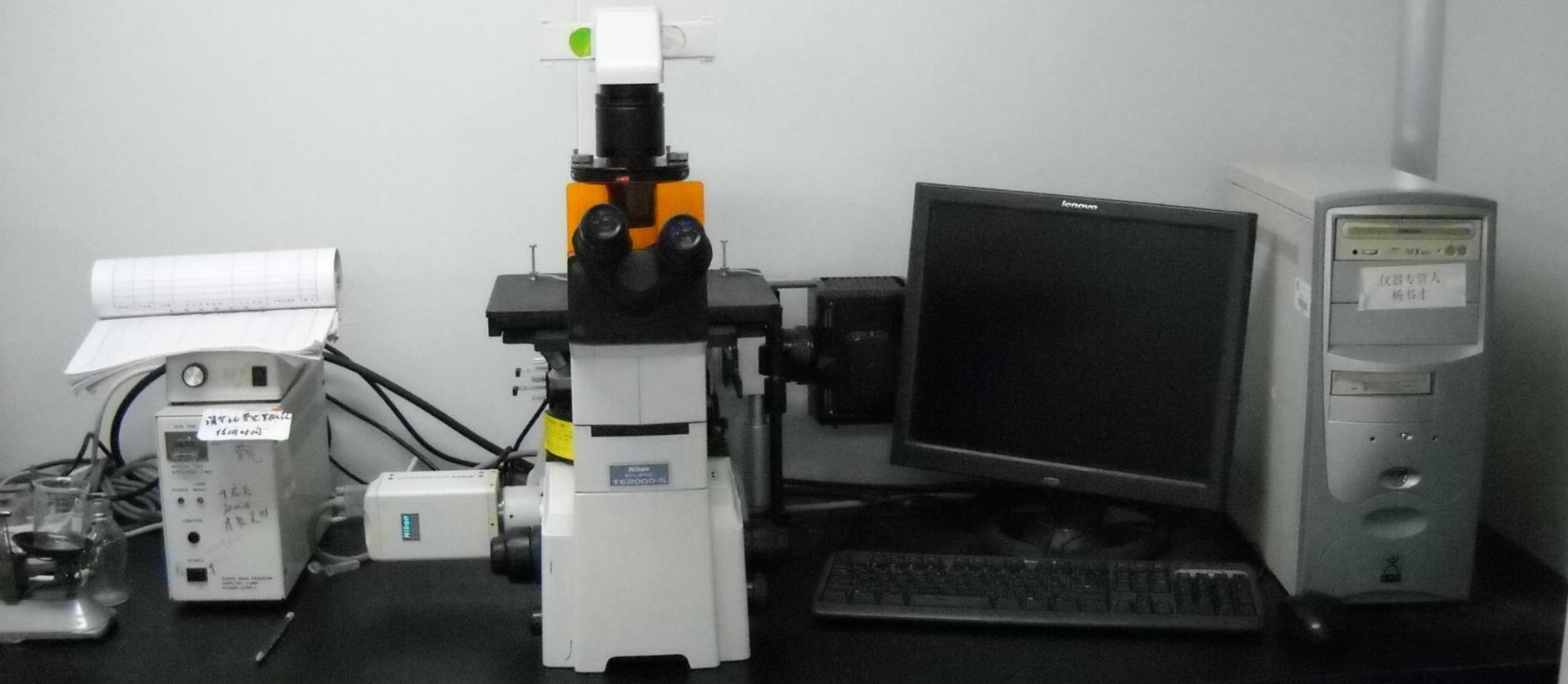


Super clean bench in cell culture room



2020/5/6

Inverted microscope



Immuno-flourescence microscrope



Super centrifuge





Ultrasonic desintegration device



Odyssey scanning instrument



Quantitative PCR instrument

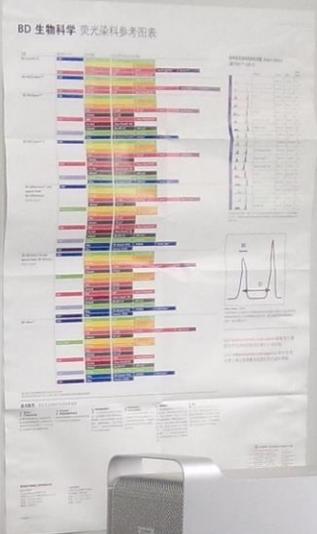


FACSCalibur开机程序

1. 打开气泵
2. 检查气
3. 打开 FACSCalibur 模式选择
4. 检查鞘液
5. 检查鞘液流量
6. 检查鞘液流量是否稳定

FACSCalibur 关机程序

1. 关闭气泵
2. 检查气
3. 检查鞘液
4. 检查鞘液流量
5. 检查鞘液流量是否稳定



Flow Cytometry



Bio-safety Cabinet



■ **Medical Immunology**

■ **Brief Introduction**

- **This book is intended as an introductory text for use in immunology courses of curriculums of medicine, biology and other relevant fields. The content of this textbook consists of basic and clinical immunology. The basic immunology discusses four important aspects of knowledge, involving innate immunity, adaptive immunity, immune regulation and immune tolerance.**



- These knowledge are embodied in four different parts which are
- **General Introduction**
- **Immune Molecules**
- **Immune Cells**
- **Immune Response**
- The immune-related diseases, diagnosis and therapy in clinic are described in **Clinical Immunology.**

- **This textbook synthesizes materials representing the most recent development in innate immunity to fill the gap between innate immunity and adaptive immunity.**
- **Another character of this book is emphasis on both the classical knowledge and cutting-edged advance in immunology simultaneously.**



Immunology

Immunity

- ◆ **Resistance to a pathogen or invading material.**
- ◆ **Or protection from certain diseases, particularly infectious diseases.**



Immunology

- ◆ **The study of the processes that promote health and combat disease.**
- ◆ **Or the study of the ways in which the body defends itself from infectious agents and other foreign substances in its environment.**
- ◆ **Self vs nonself discrimination.**
- ◆ **Maintain identity of self.**

- **What is the role of the immune system?**
Eliminate foreign (dangerous) substance (tissue, cell or molecule), Accept or tolerate self (useful) substance.
- **What happens when the immune system doesn't work properly?**
- **Infectious disease, cancer, autoimmunity, hypersensitivity etc.**



Immune System Discrimination

Infectious (dangerous) non-self (microbial pathogens)

Non-infectious non-self (different kind of food etc.)

Infectious self (latent virus)

Non-infectious self (normal tissue)

Microbial non-self

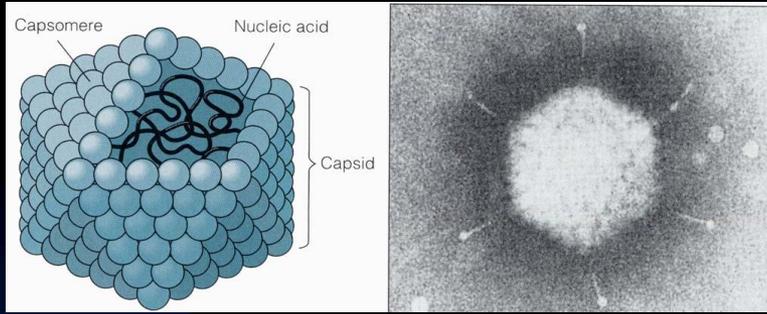
Induced or Altered Self.



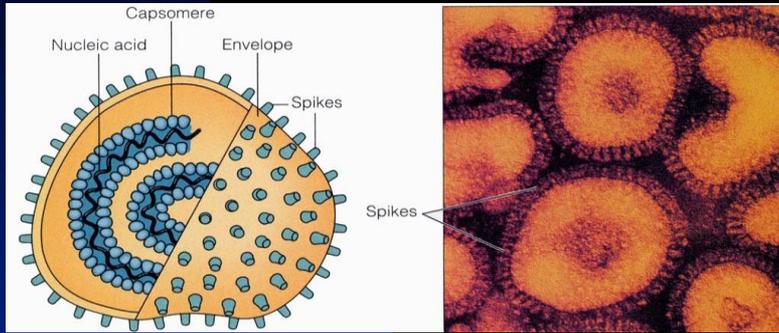
Self-Non-self Discrimination is a Fundamental Biological Principle.

All organisms (entities) exhibit the ability to distinguish between self and non-self.

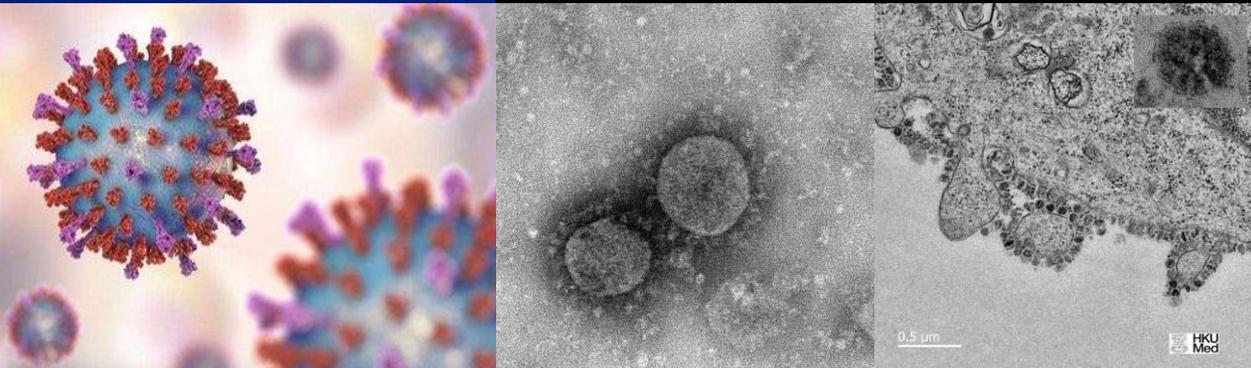
- **Viruses**
- **Bacteria**
- **Plants**
- **Sponges**
- **Humans**
- **Species**



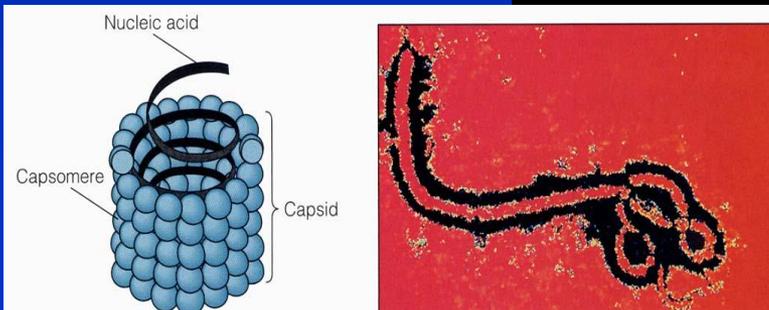
Polyhedral virus
- adenovirus



Enveloped virus
- influenza virus

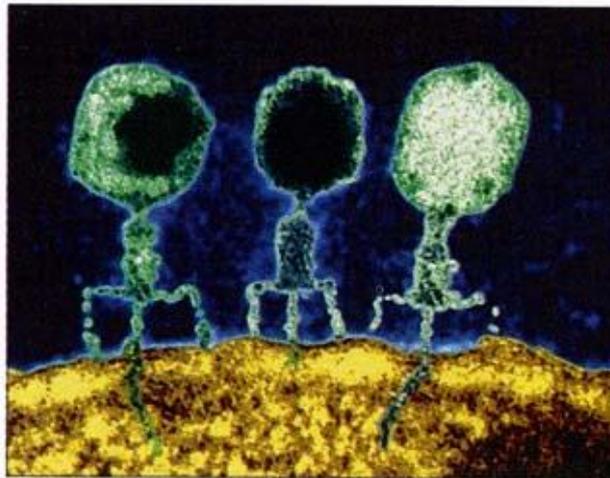
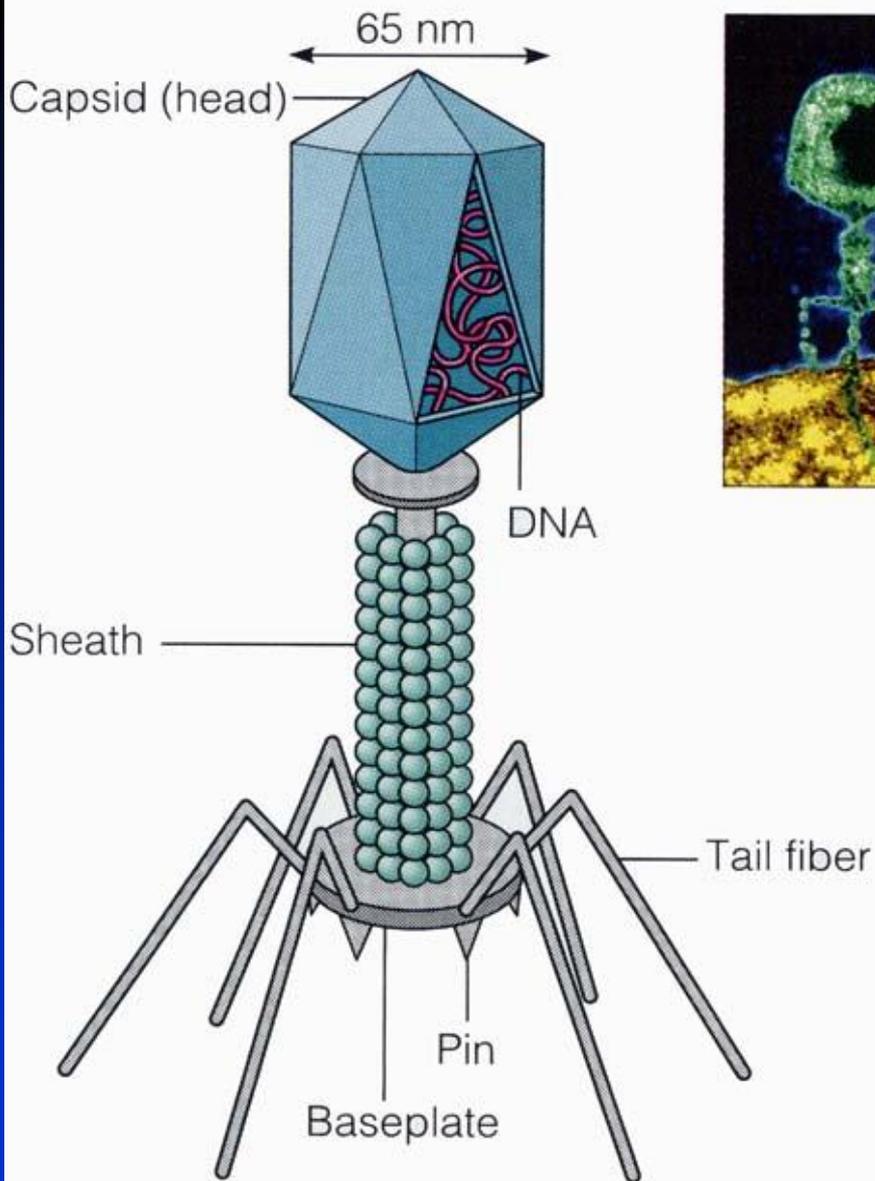


Enveloped virus
- novel coronavirus
(2019-nCoV/SARS-CoV-2)



Filamentous virus
- Ebola virus

Bacterial viruses



TEM 100 nm

“Tadpole like”



Types of Immunity

Innate versus **Adaptive** or **Acquired**

Humoral versus **Cellular**

Innate Immunity



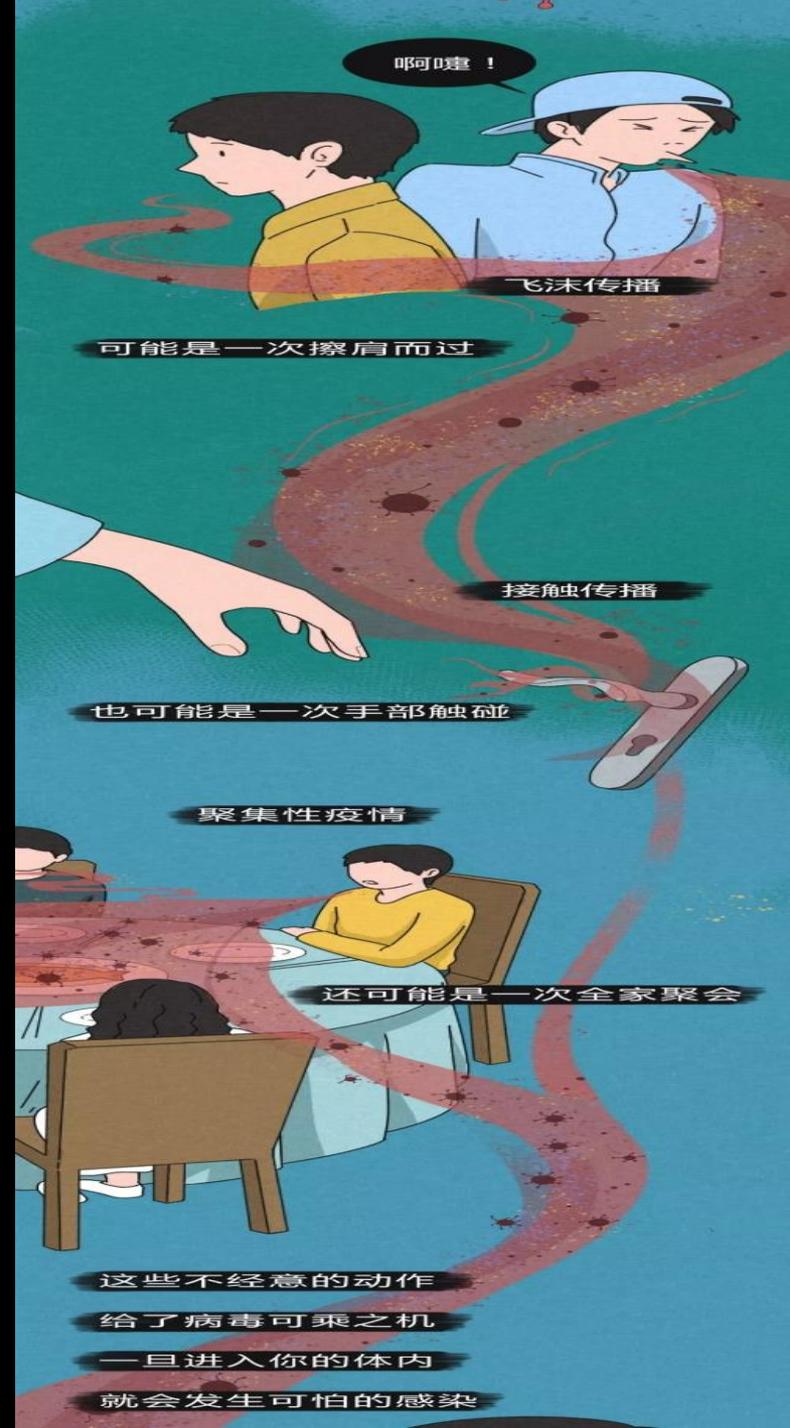
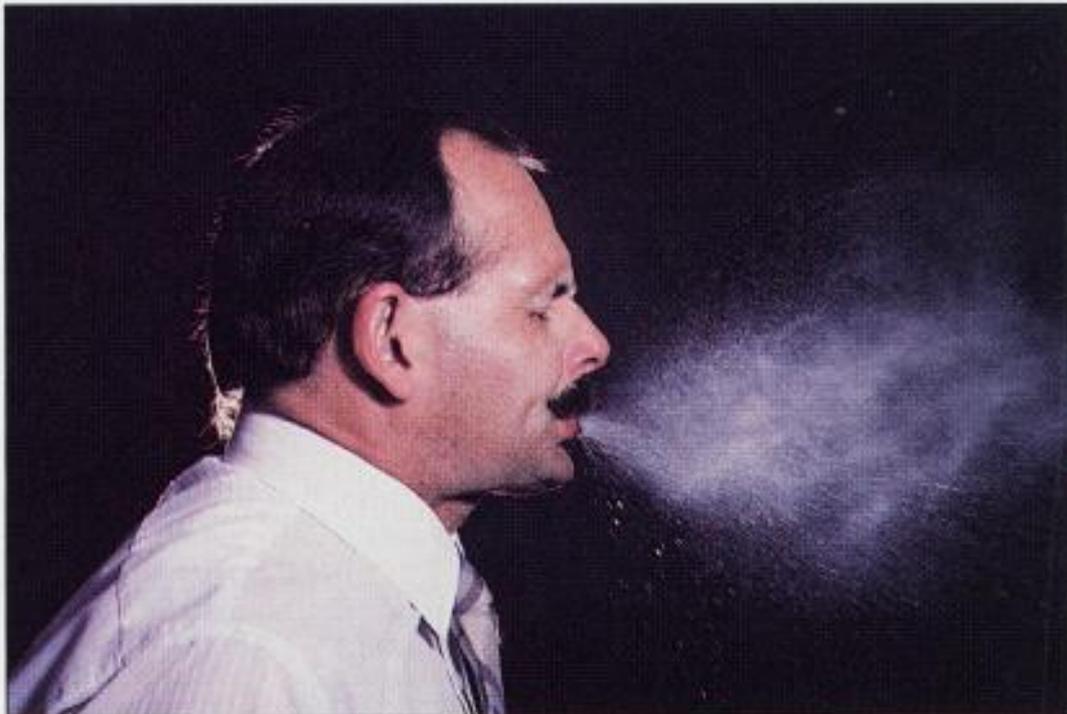
■ **Anatomic:**

◆ Skin (epidermis/dermis), sebum (lactic acid and fatty acids), cilia, fluid flow(such as tears, gastric fluid, saliva) **cough, sneeze**, antimicrobial peptides in skin, mucous, local cytokines and chemokines, **Normal flora etc.**

■ **Physiologic:**

◆ Temperature/fever, gastric acid, lysozyme interferon, complement etc.

Coughs and sneezes spread diseases- enough said. For example, the novel coronavirus in Dec. 2019 (2019-nCoV/SARS-CoV-2)



Callaway E, Cyranoski D. **Nature**. 2020 Jan;577:605-607

China coronavirus: Six questions scientists are asking

New China virus: Five questions scientists are asking

(Ewen Callaway & David Cyranoski. Update:28 JAN. 2020)



Medical staff at a hospital in Wuhan, China, where most cases of the viral infection have occurred.

2020/5/6

1. **How does the virus spread?**
2. **How deadly is the virus?**
3. **Where did the virus come from?**
4. **What can we learn from the virus's genetic sequence?**
5. **Can a drug be developed to treat the coronavirus?**



innate

1. Possessed at birth; inborn.
2. Possessed as an essential characteristic; inherent.
3. Of, or produced by the mind or body **or genes rather than** learned through experience.

immunity

Inherited, acquired, or induced resistance to infection by a **specific** pathogen.

immune

Of, relating to, or having resistance to infection by a **specific** pathogen.



Inflammation

Barriers Created By The Inflammatory Response.

- **Inflammation:** Latin names rubor (redness), tumor (swelling), calor (heat), dolor (pain).
- **Vasodilation:**
 - Increased vascular permeability
 - Lymphoid cells arrive via adherence (margination), crossing endothelium (diapedesis or extravasation).
 - Chemotaxis and chemokinesis.
 - **Dead cells, digested matter = pus.**



Self versus Nonself Discrimination

Function of the immune system:

Maintain self identity, niche, fidelity of genome

Threats:

Infectious disease, tumors, toxins, trauma

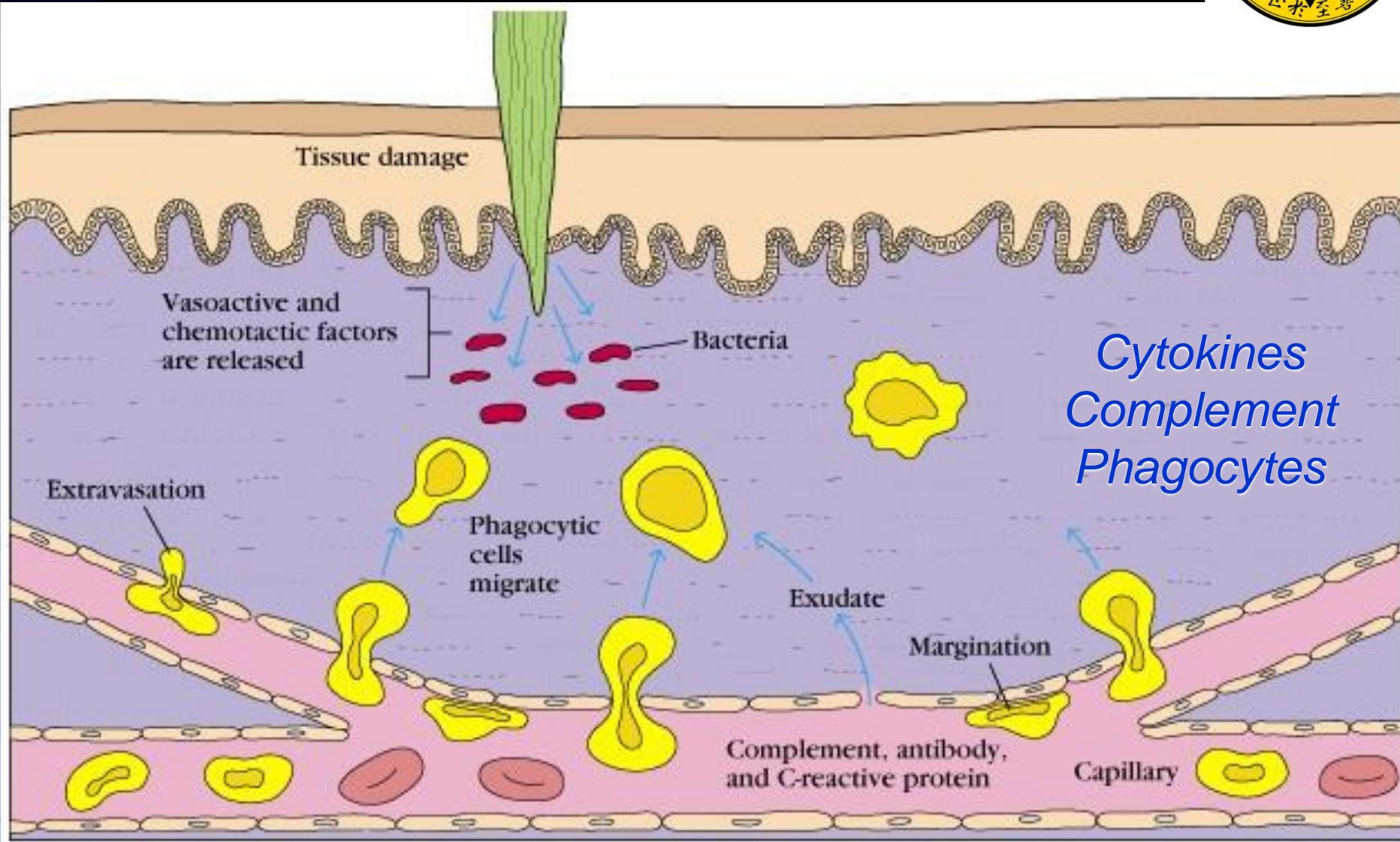
Defenses:

Out, detox, kill, hyperplasia, symbiosis (treaty)

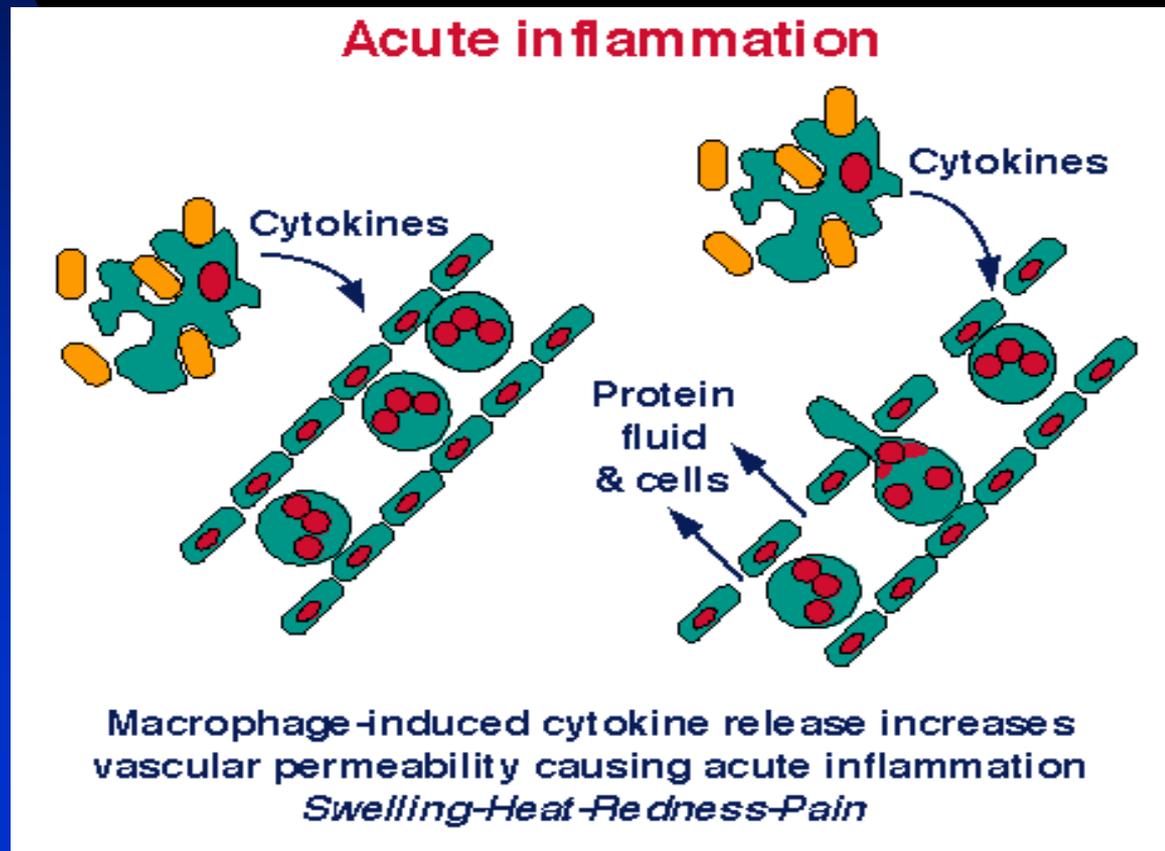
CNS analogy:

Throughout body, patrol and defend, sensory, action for survival, immune system less “hard-wired” than CNS.

Perception of Invasion and Inflammation



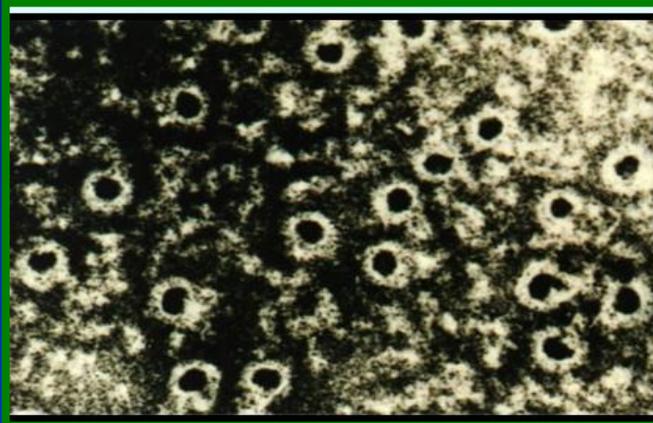
- **Cytokine:** Any of several regulatory proteins, such as the interleukins and lymphokines, that are released by cells of the immune system and act as intercellular mediators in the generation
- of an immune response



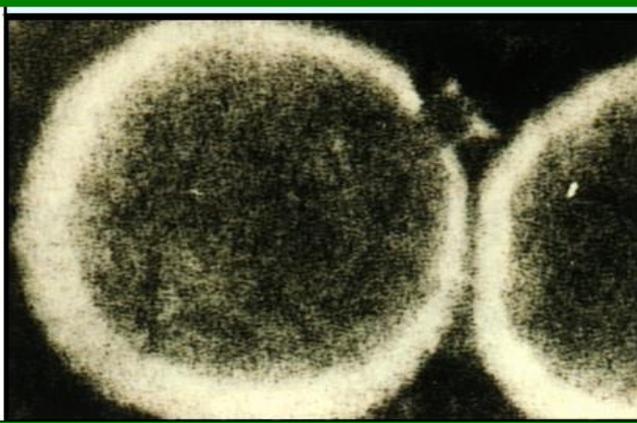
■ Complement

- A complex system of proteins found in normal blood plasma that combines with antibodies to destroy pathogenic bacteria and other foreign cells.

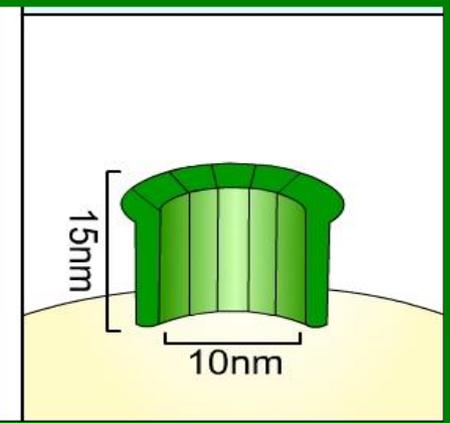
Damaged cell membrane



damaged cell membrane



transmembrane pore



Phagocyte /endocytic cells

A cell, such as a white blood cell, that **engulfs** and **absorbs** waste material, harmful microorganisms, or other foreign bodies in the bloodstream and tissues.

Professional phagocytes; neutrophils, macrophages (**M ϕ**) . Find, eat, kill, digest.

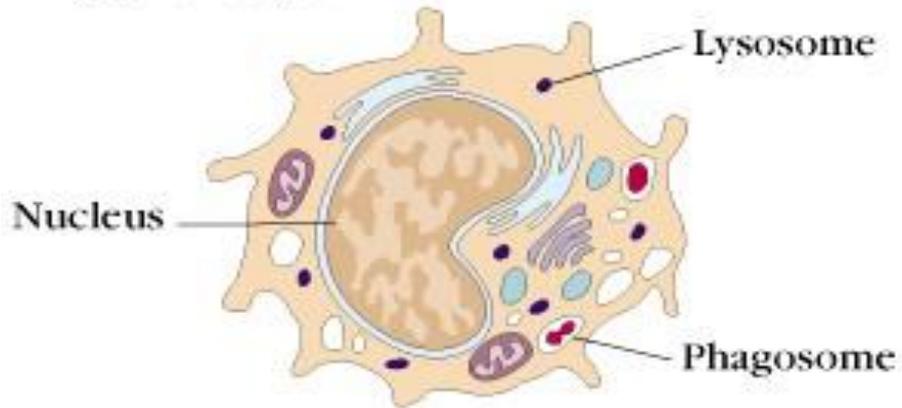
■Others

- ◆ NK cells, NKT cells
- ◆ Anything **not** involving **antibody** or TCR.

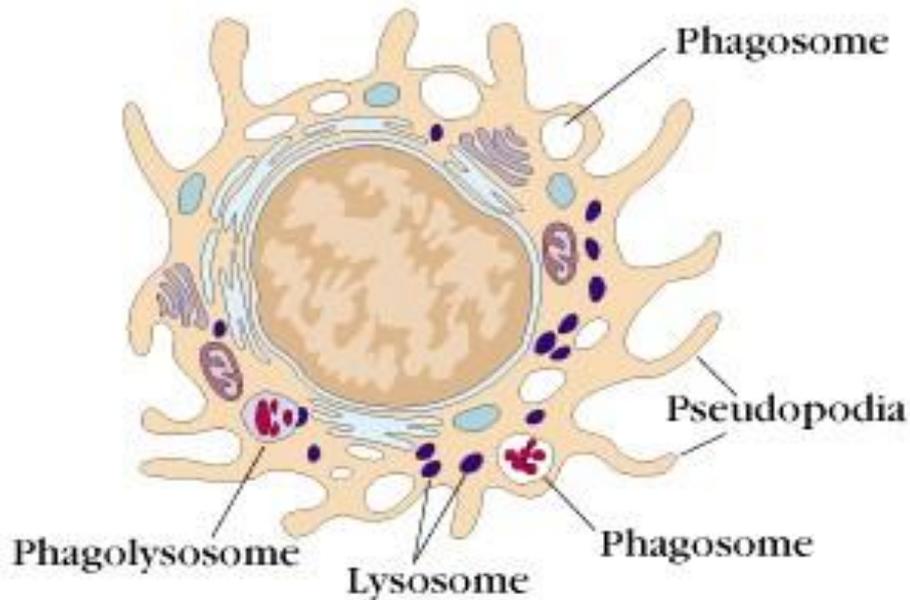


Myeloid Cells

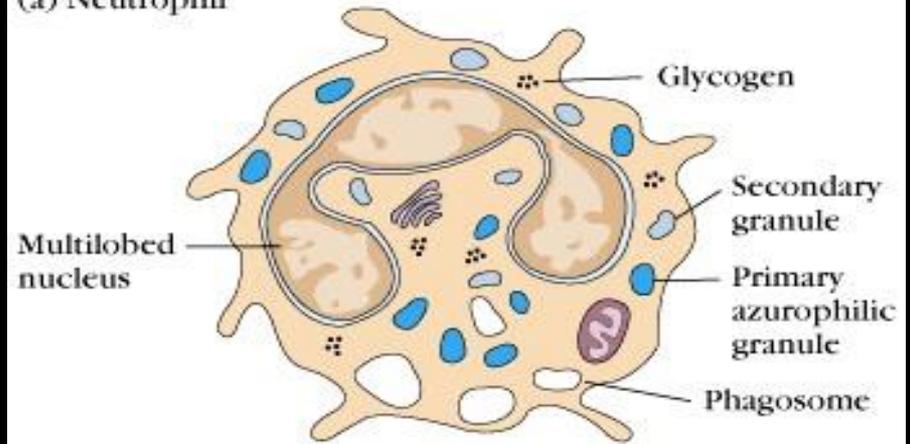
(a) Monocyte



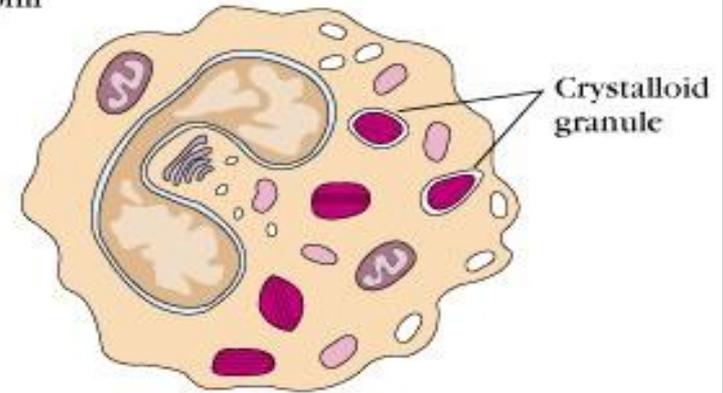
(b) Macrophage



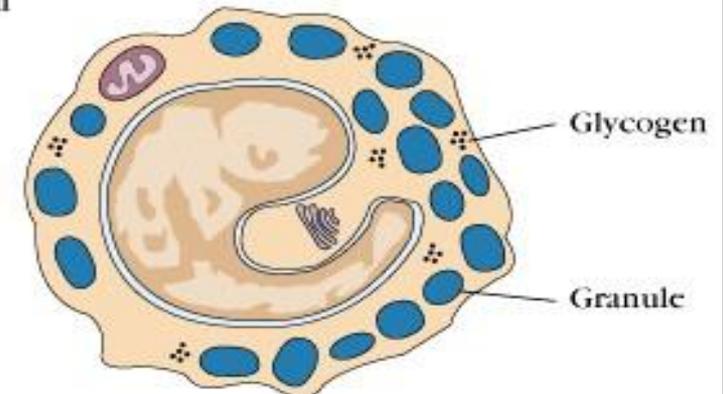
(a) Neutrophil



(b) Eosinophil



(c) Basophil





Specific - Acquired Immunity

- Immunity that develops **after** antigen exposure
 - ★ **Historic: Survivors of infection don't get sick again**
 - ★ **Childhood mortality from infections**
- **Primary versus secondary Immune response**
- **Communication among lymphoid & myeloid cells**
- **Memory and specificity.**
- **Receptors for antigen on lymphocytes**
- **Clonal Selection.**



Humoral and Cellular immunity

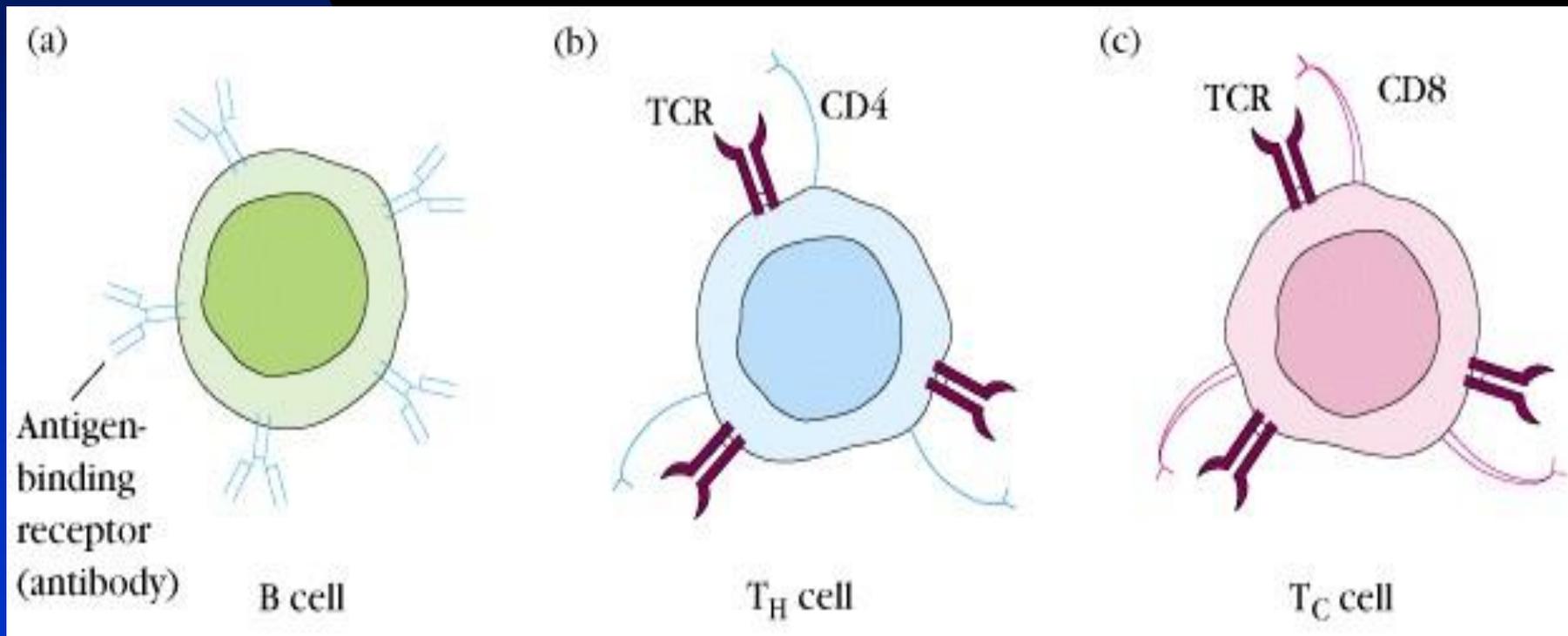
■ **Humoral immunity -**

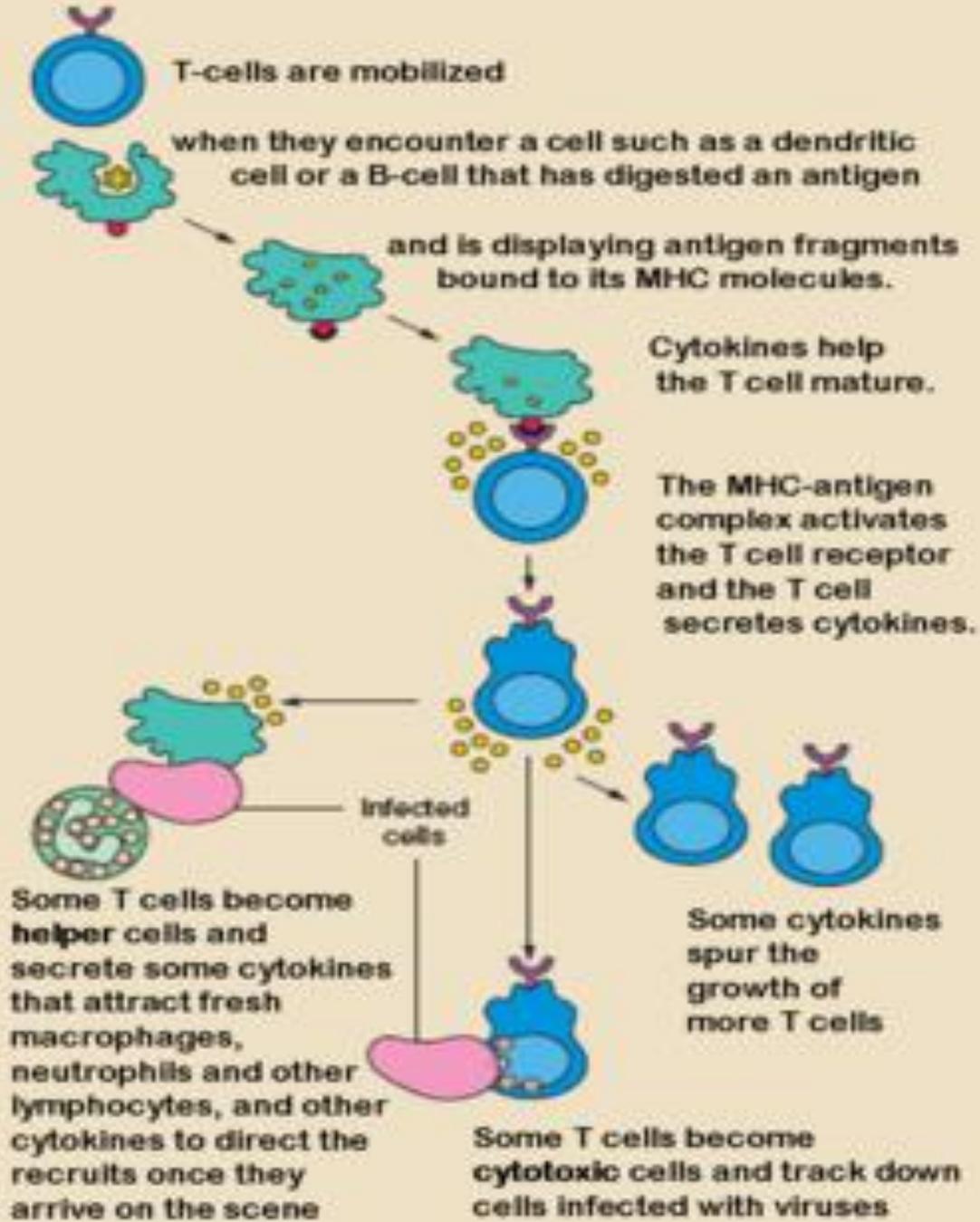
- ◆ Secreted products of B lymphocytes
- ◆ Antibodies or Immunoglobulins (Ig)

■ **Cellular immunity -**

- ◆ T lymphocytes. T cell receptor
- ◆ Cytokines and cell-cell contact

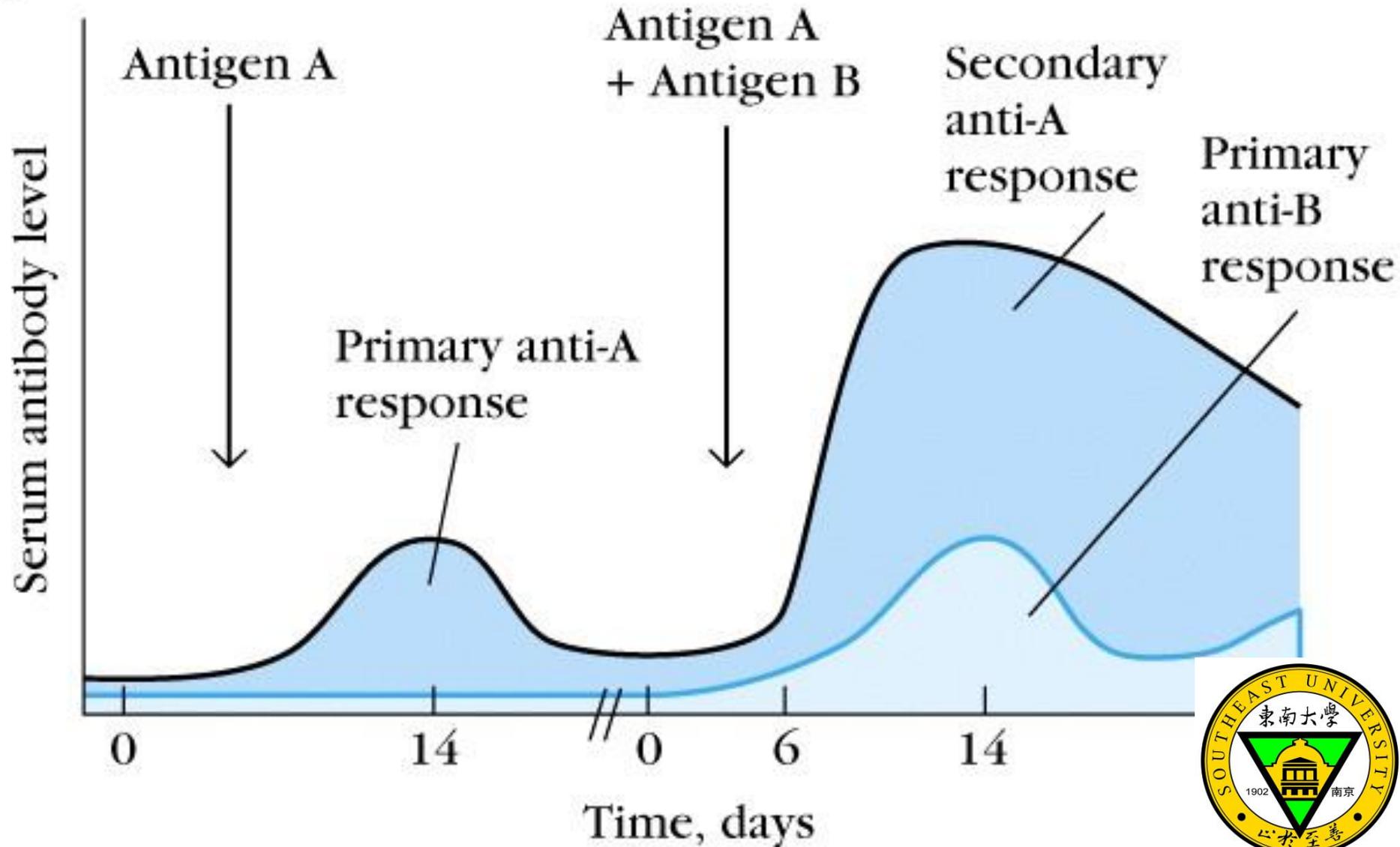
Recognition of Antigen by Lymphocytes (B cells and T cells)

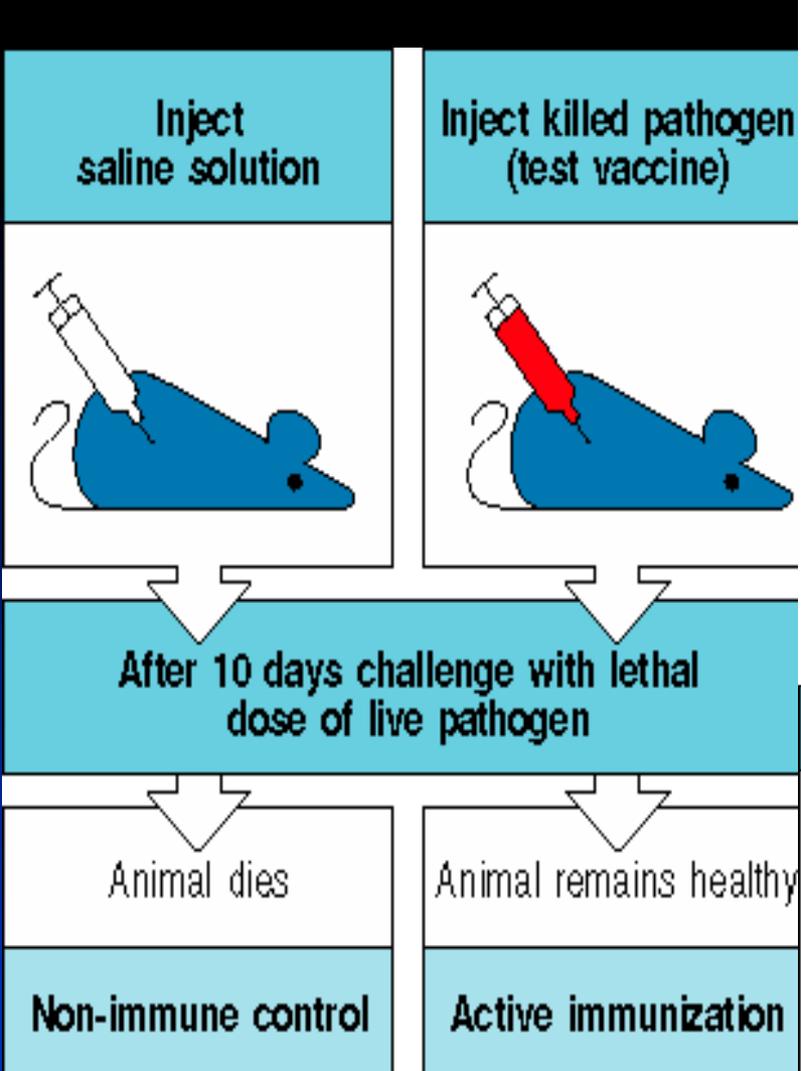




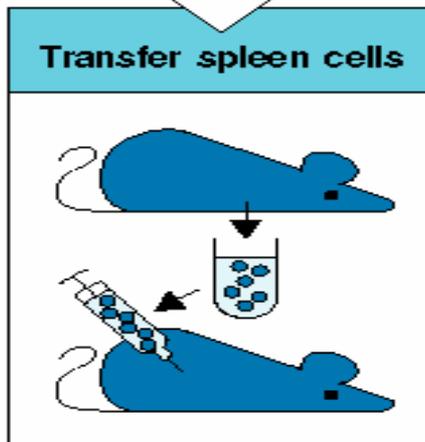
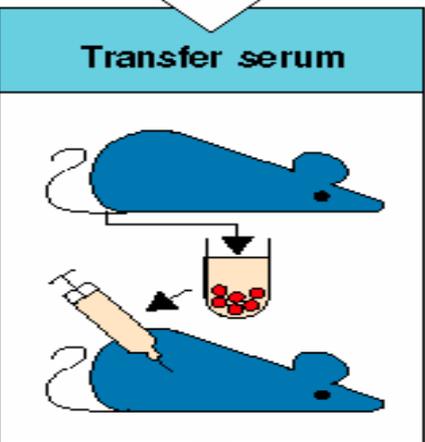
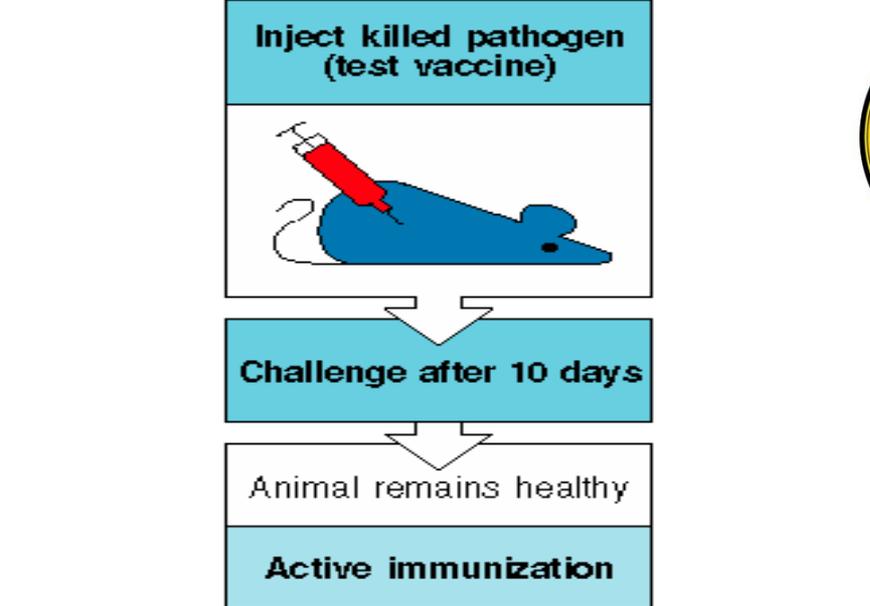
Primary and Secondary Responses. Specific Adaptive or Acquired Immunity.

(a)



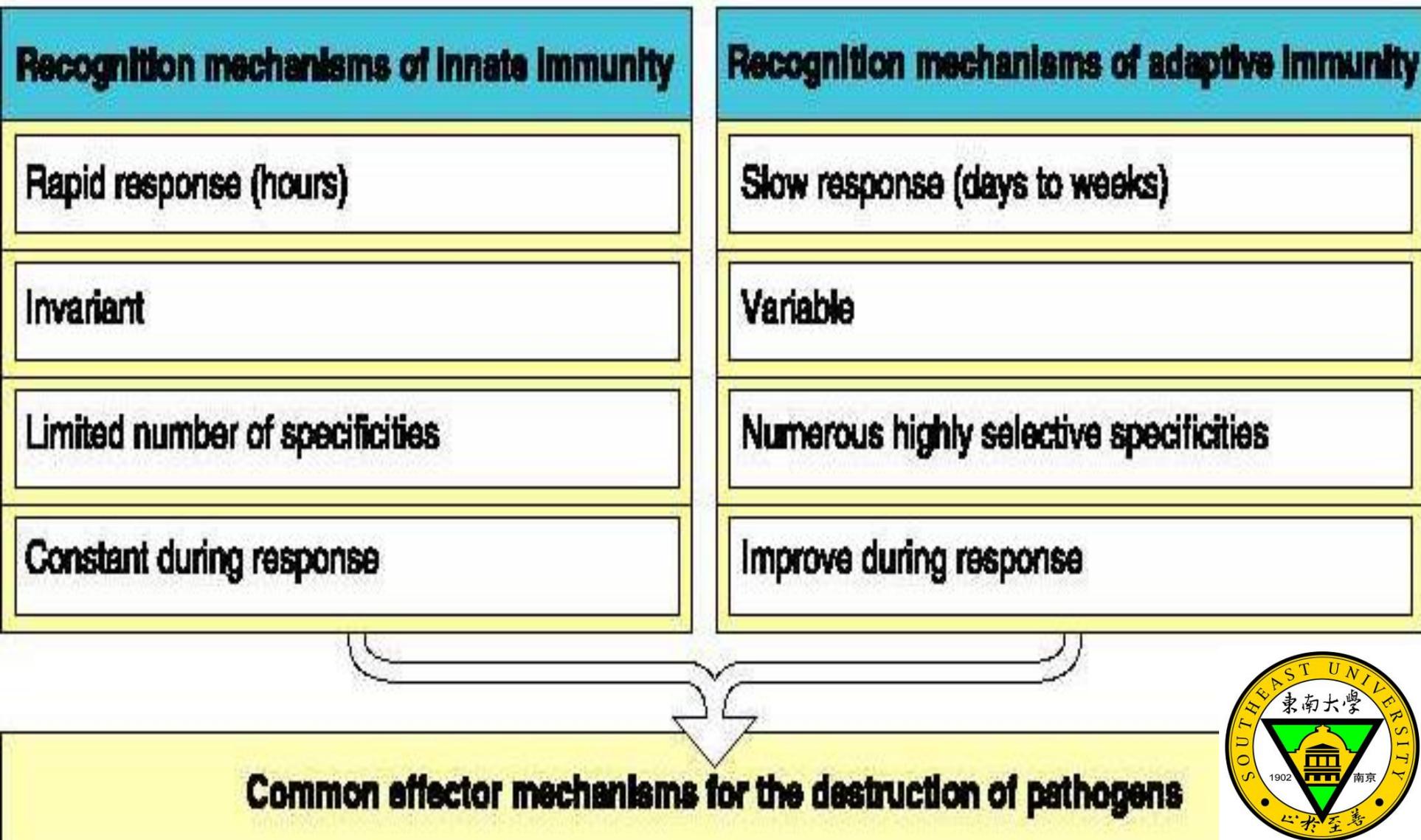


Humoral Immunity



Cellular Immunity

Comparison of Innate Versus Adaptive Immunity



Two Arms of Host Defense

- Innate immunity

- Adaptive immunity

Innate

Adaptive

- Non-specific

- Widely present in nature



The Immune System

Tissues

Cells

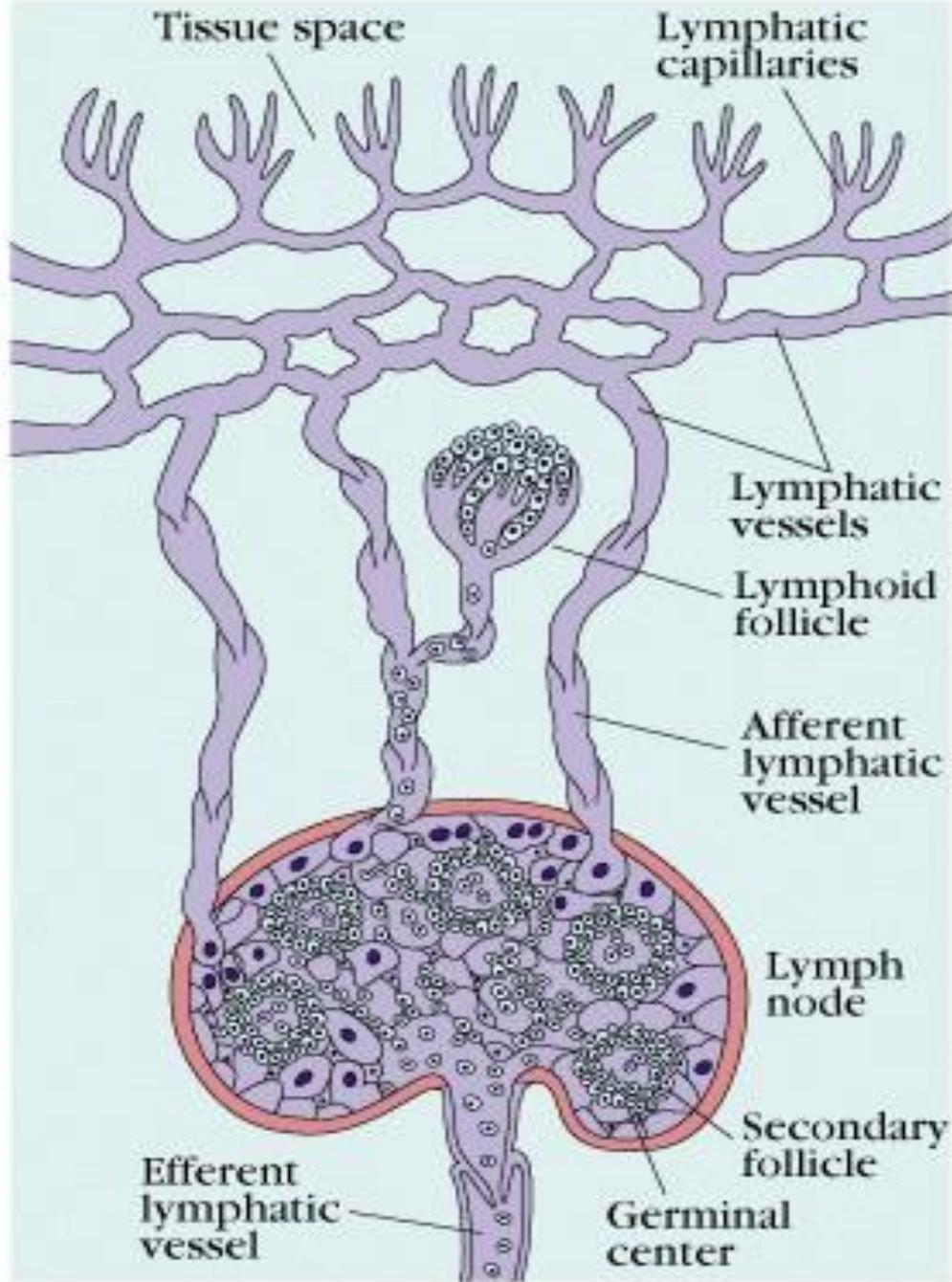
Molecules



Tissues

- **Thymus and bone marrow**
- **The lymphatic system**
- **Lymph nodes**
- **Spleen**
- **MALT**
 - ◆ **GALT (Gut-associated lymphoid tissue)**
 - ◆ **Peyer's Patches**

Lymphatics. The Drainage System

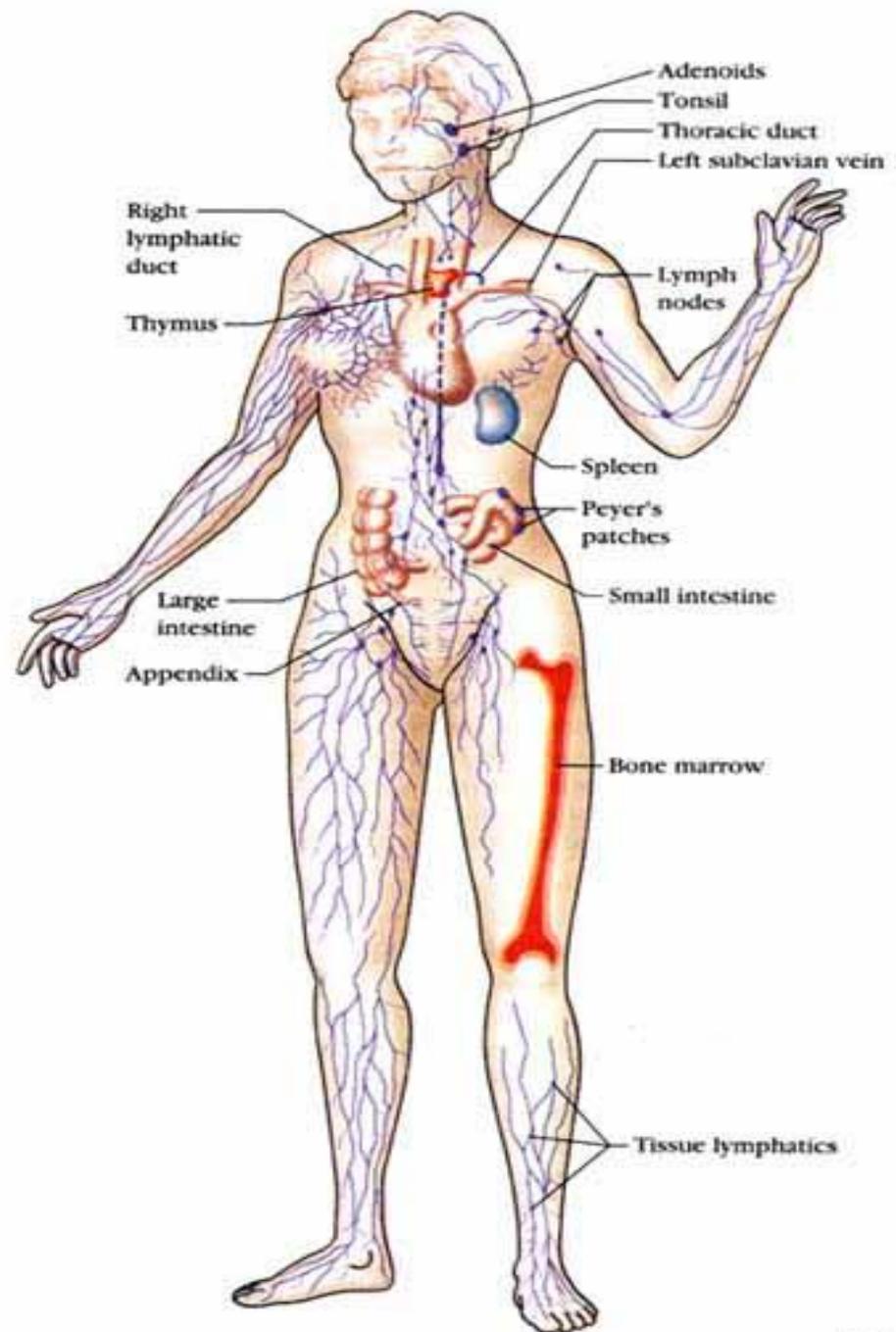


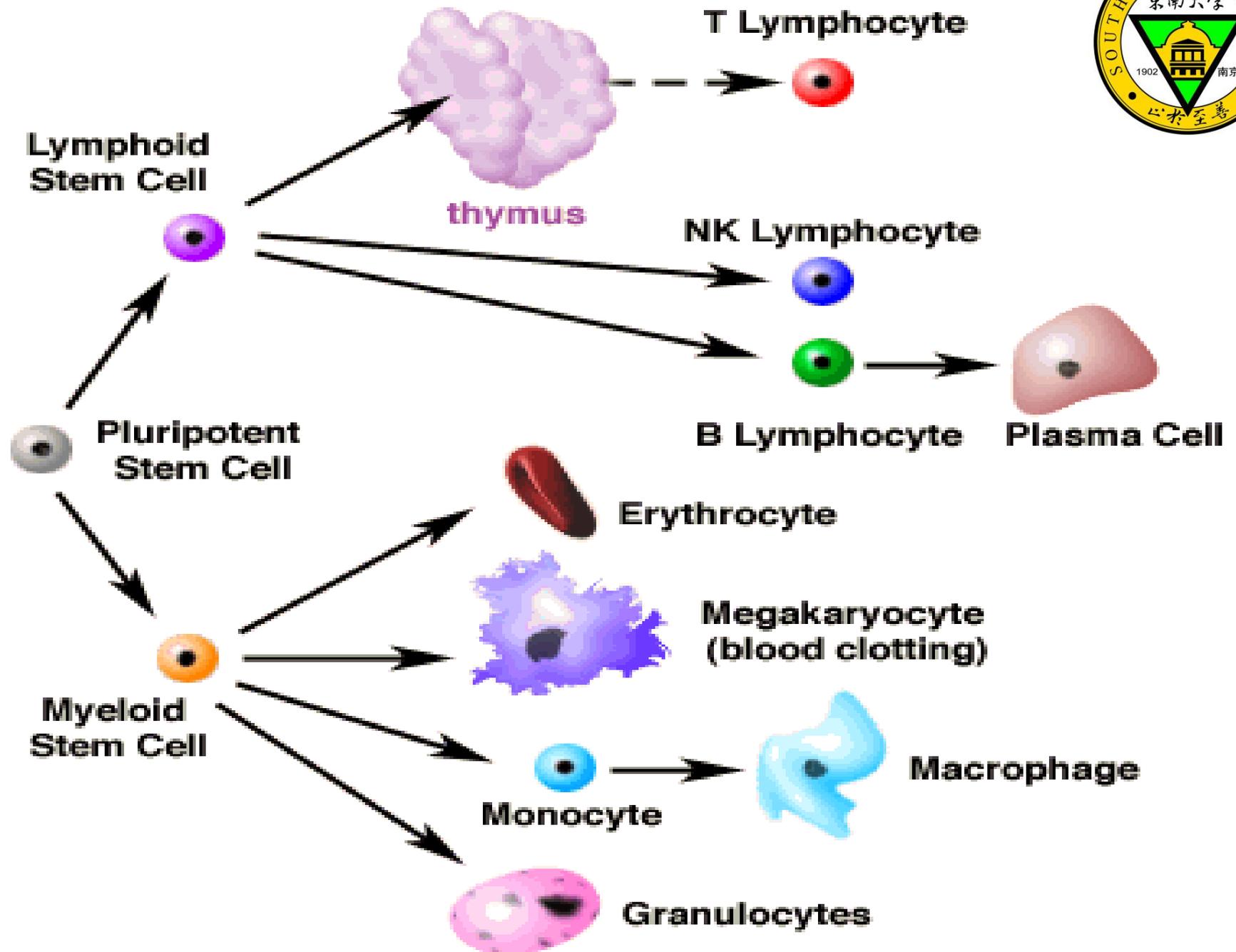
filariae



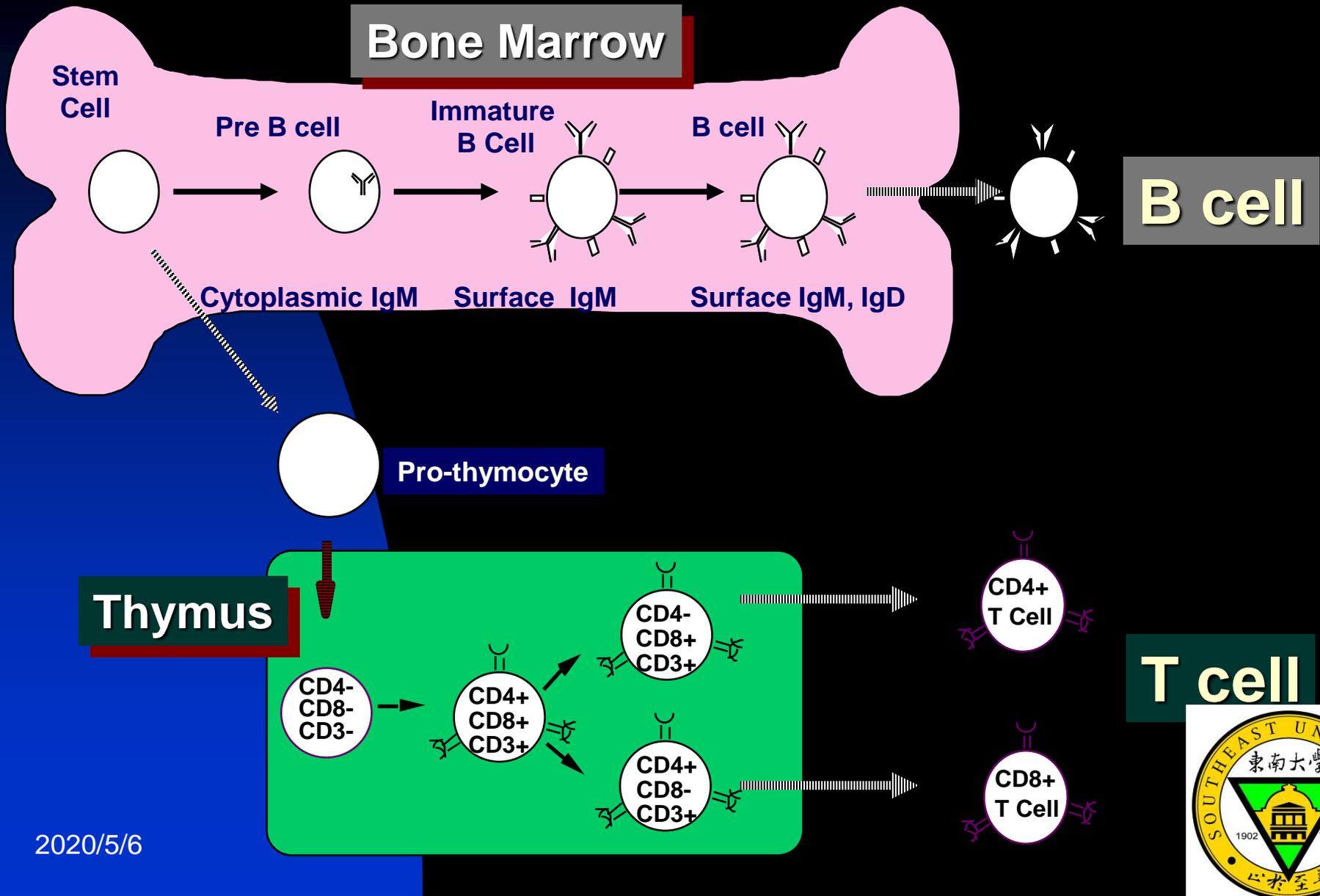
Lymphoid Organs

- **Primary Lymphoid Organs (Development)**
 - ◆ Bone Marrow
 - ◆ Thymus
- **Secondary Lymphoid tissues**
 - ◆ Lymph nodes
 - ◆ spleen
 - ◆ Peyer's patches

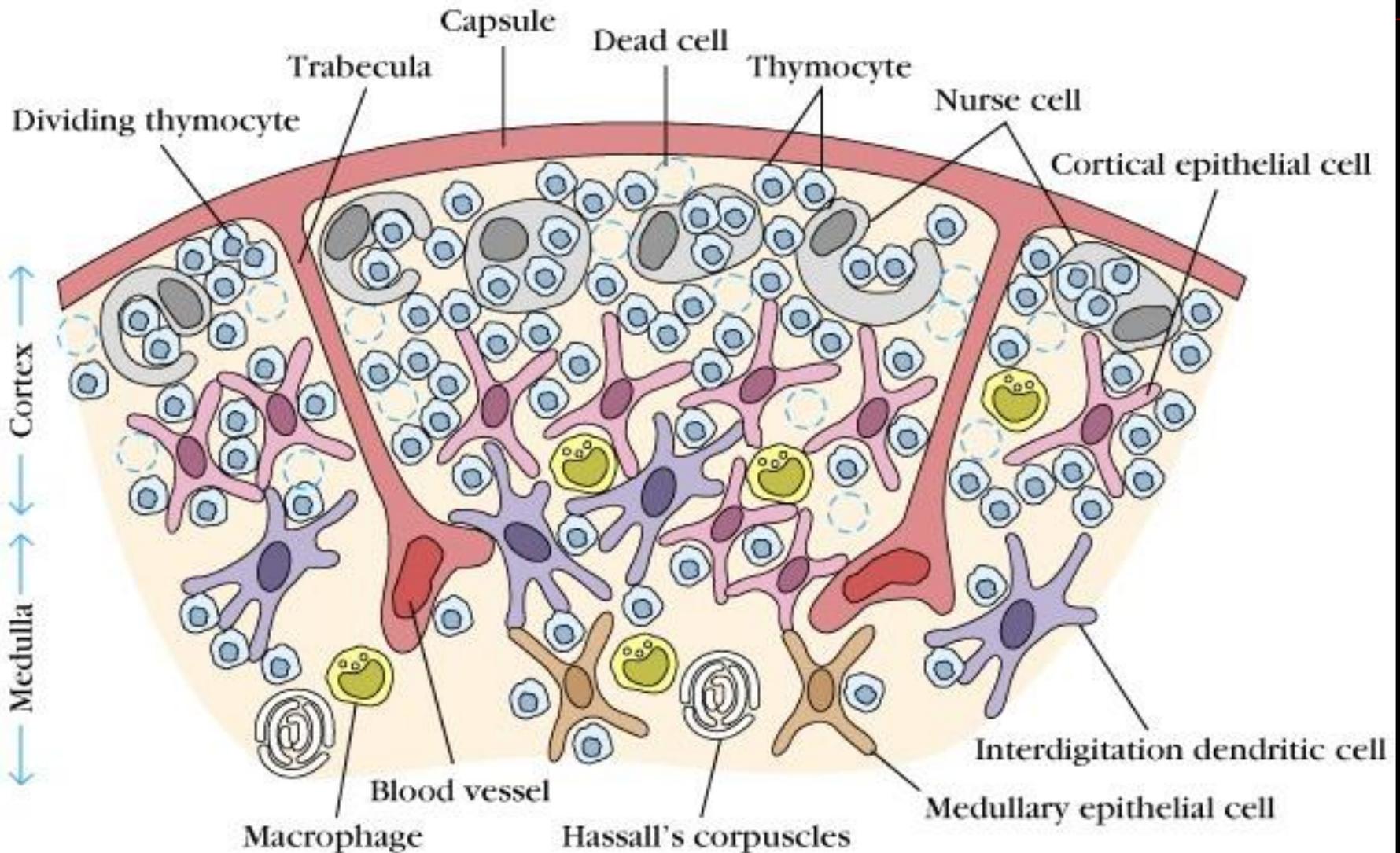




Lymphocyte Development in Primary Lymphoid Organs



Thymus



Lymph Node

- **Cortex - outer layer consisting of B cells and macrophages**

- **Paracortex - contains T cells and dendritic cells. lots of action**

- **Medulla - T and B cells / plasma cells**

- **Follicles - tightly packed lymphocytes**

 - ◆ **Primary - resting**

 - ◆ **secondary - active**

 - ★ **germinal center**

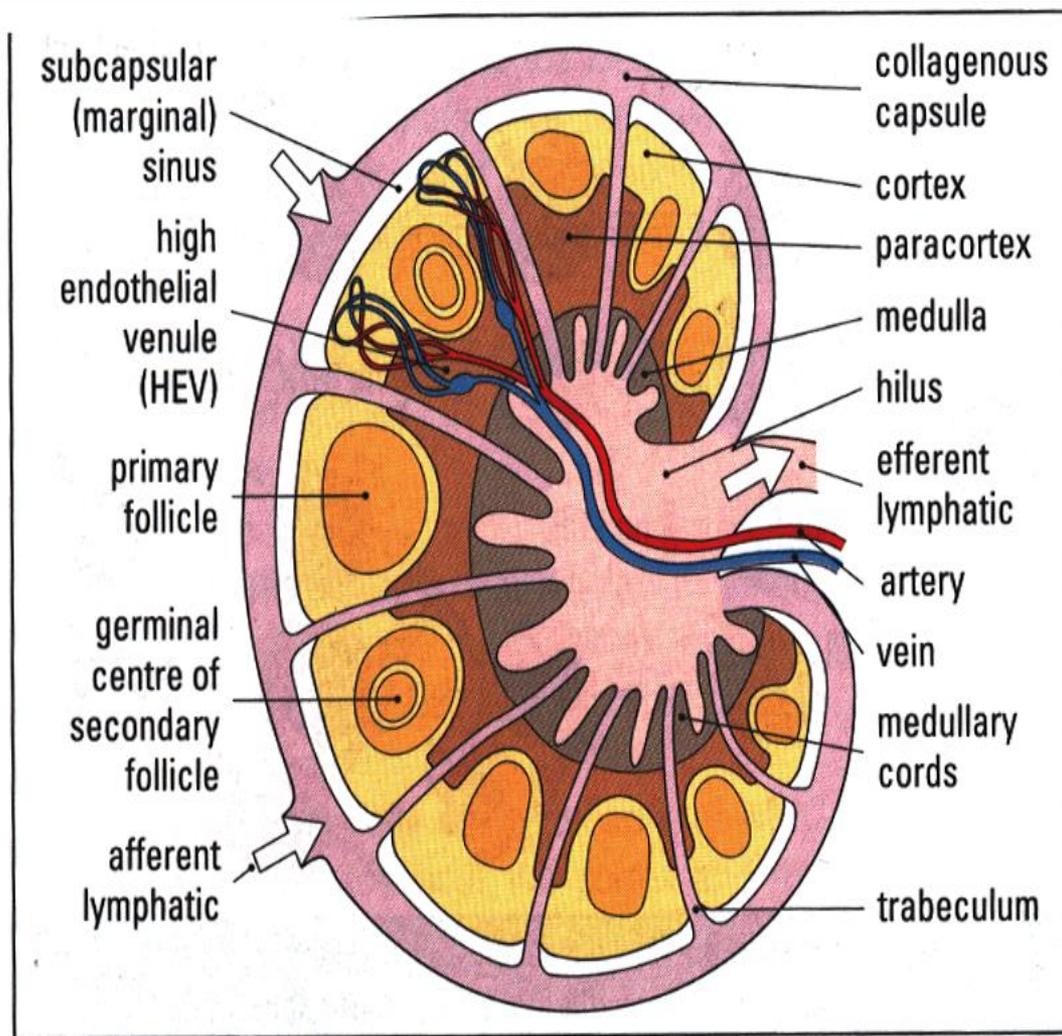
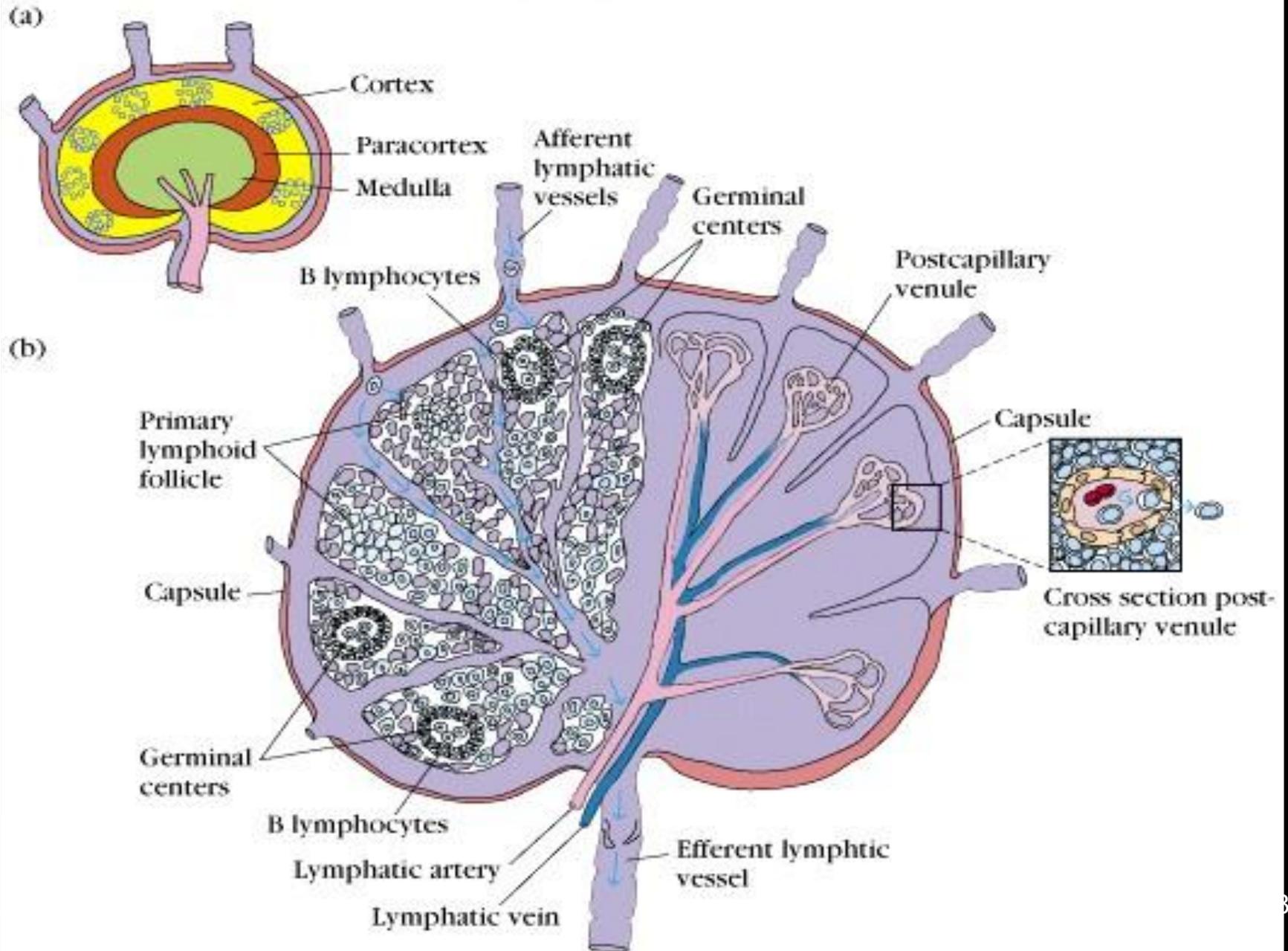
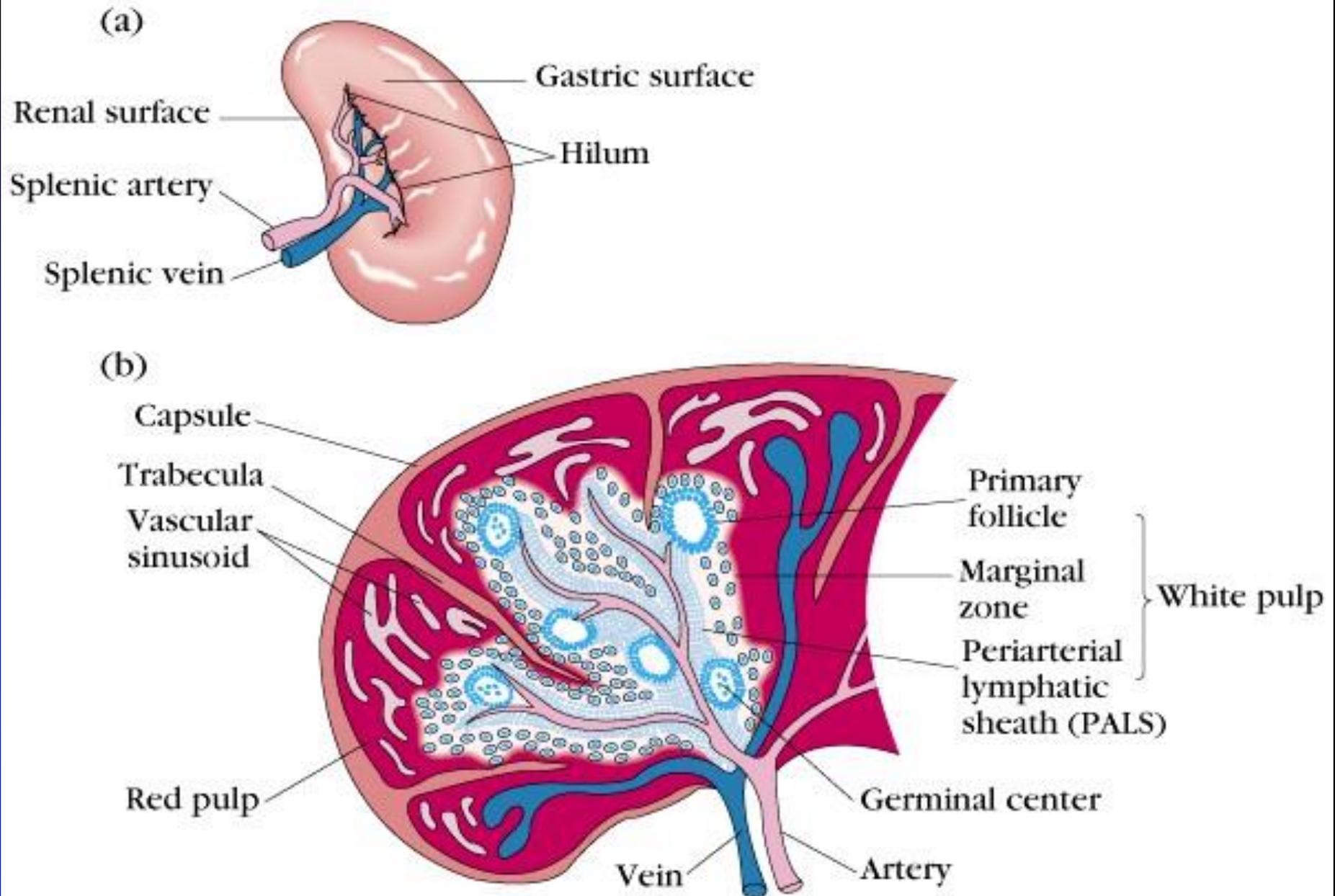


Fig. 1.13 The structure of a lymph node.

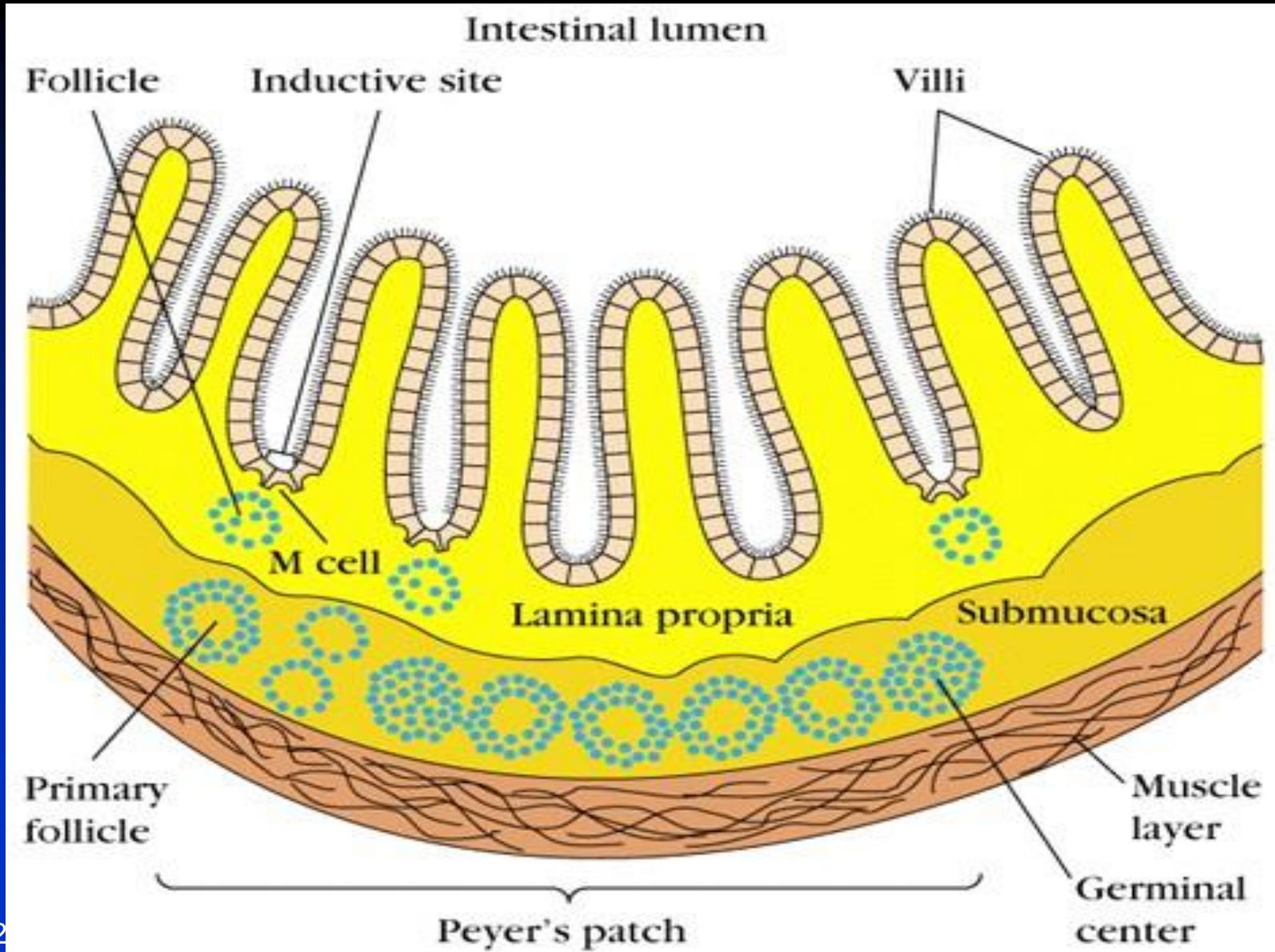
Lymph Node



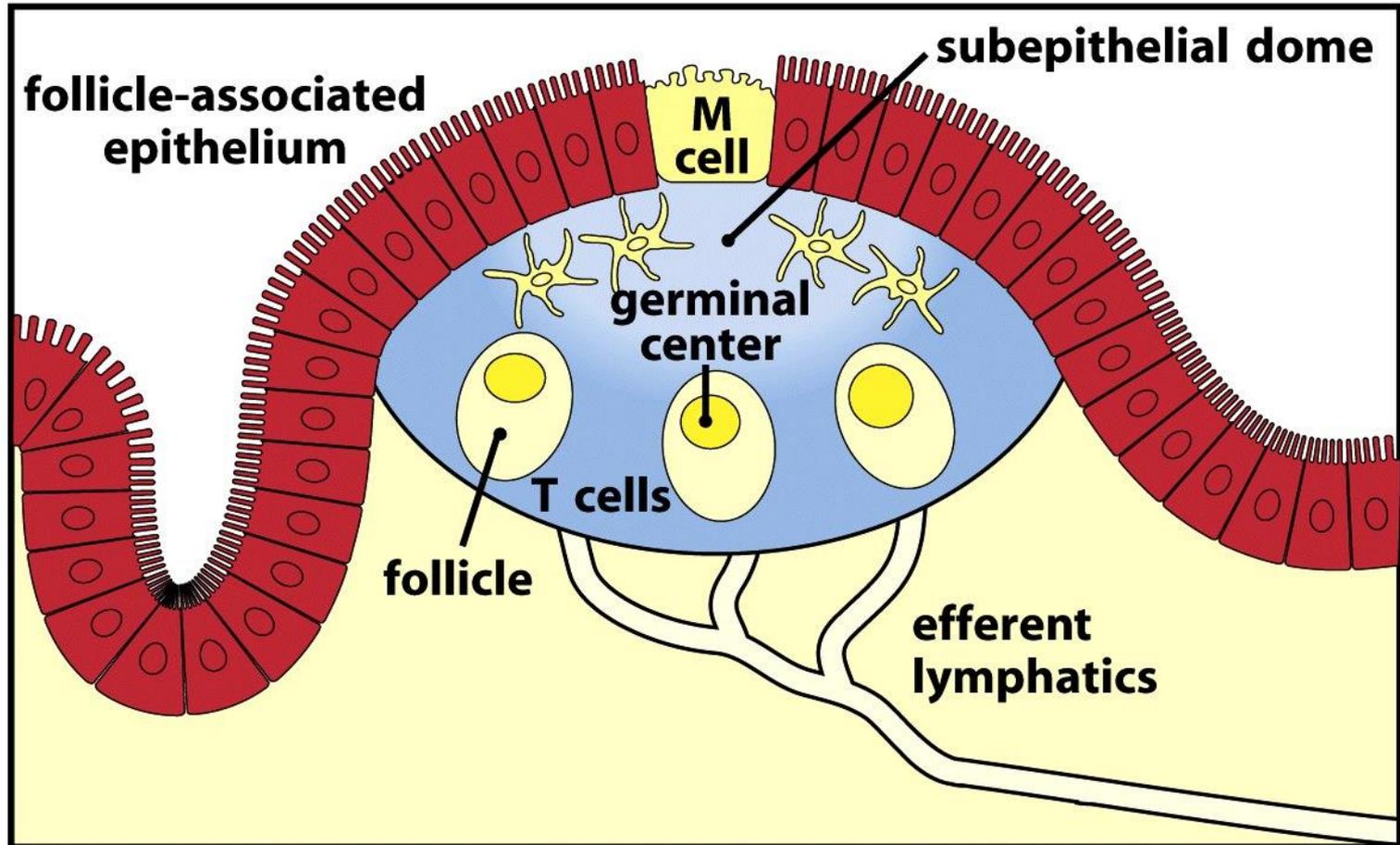
Spleen



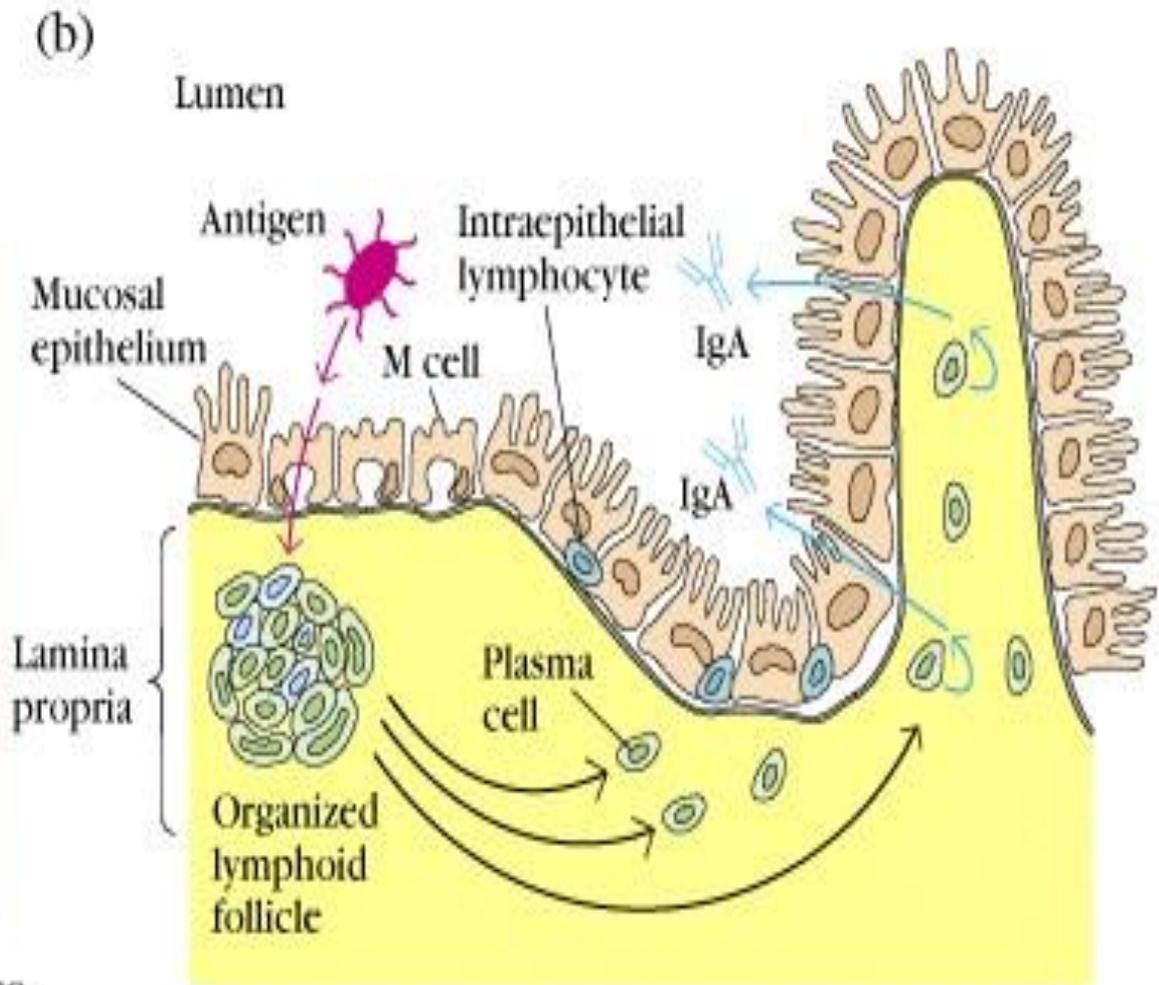
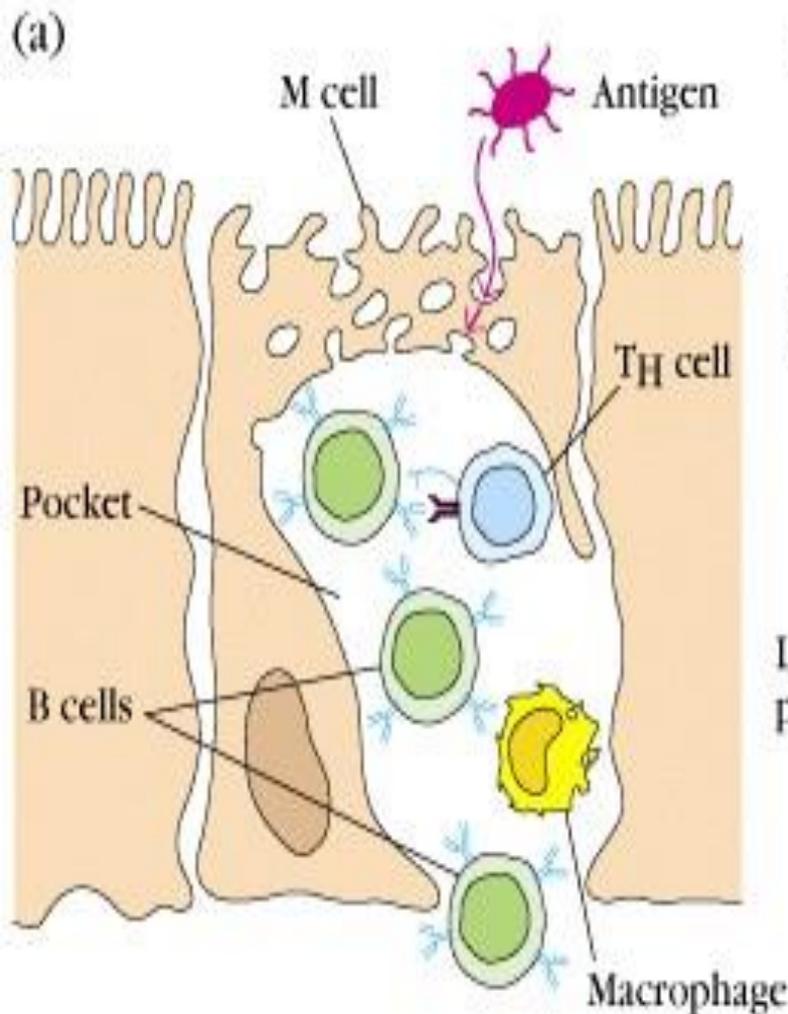
Gut Associated Lymphoid Tissue



Peyer's patches are covered by an epithelial layer containing specialized cells called M cells which have characteristic membrane ruffles



Gut Associated Lymphoid Tissue



➤ Gut-associated lymphoid tissue, GALT

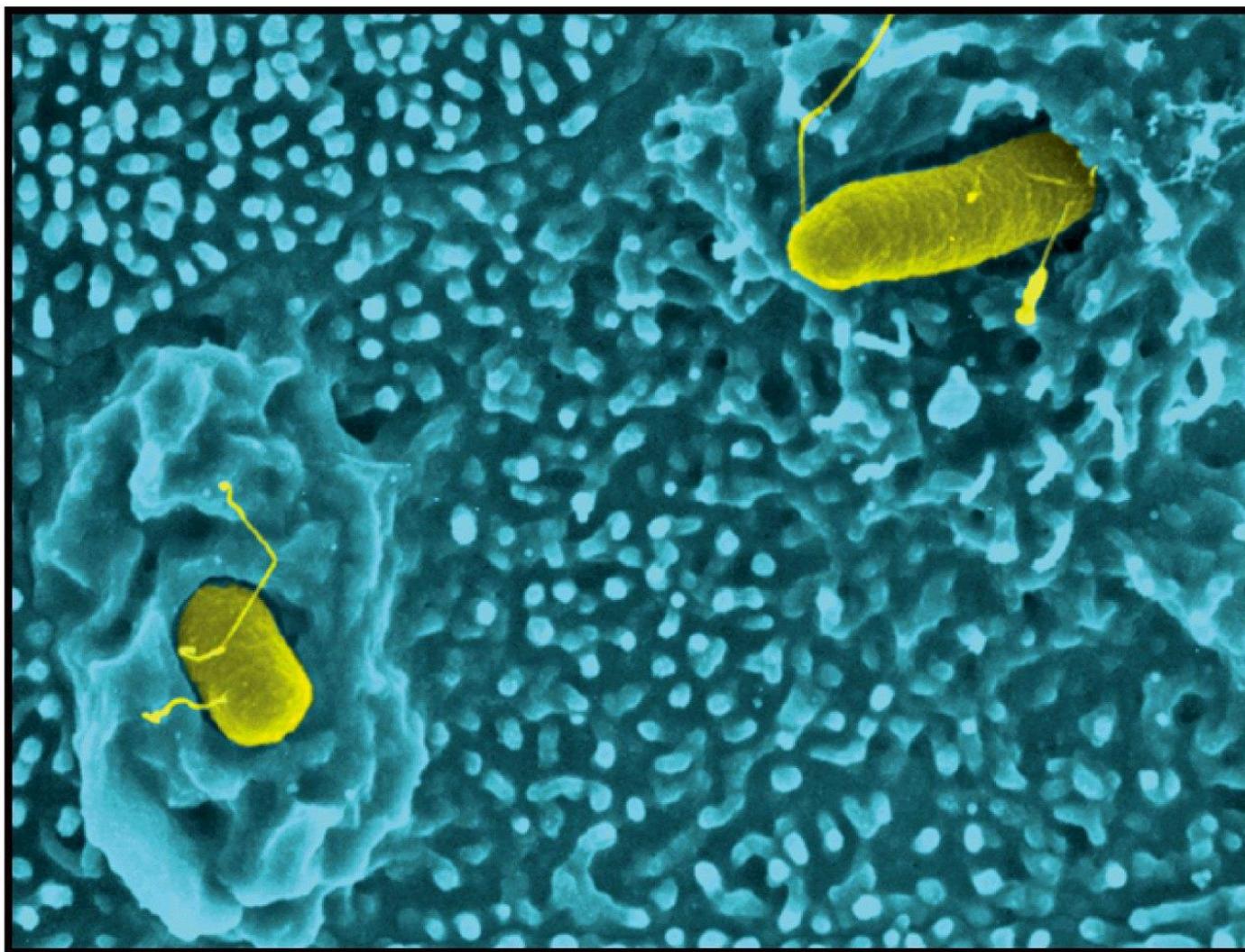
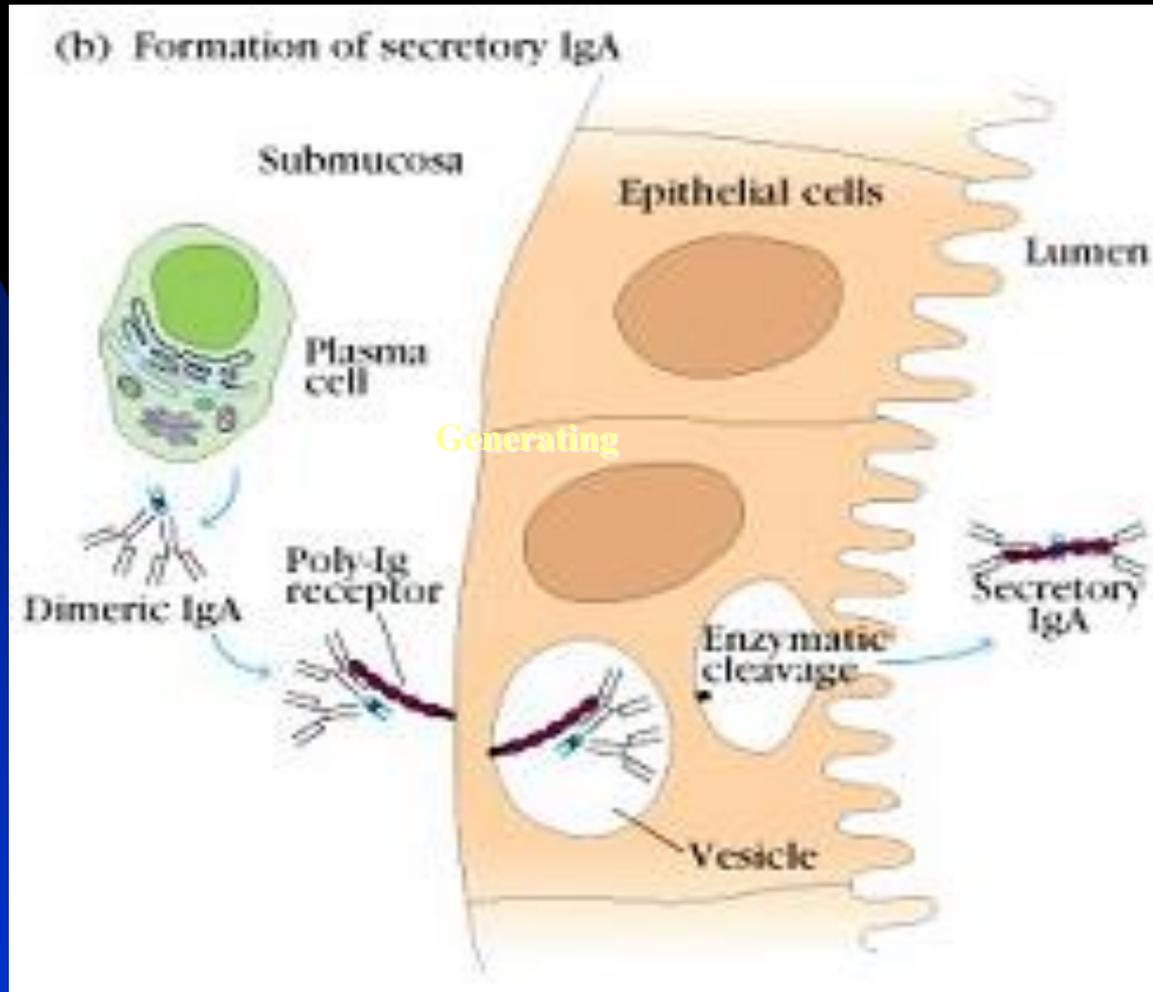


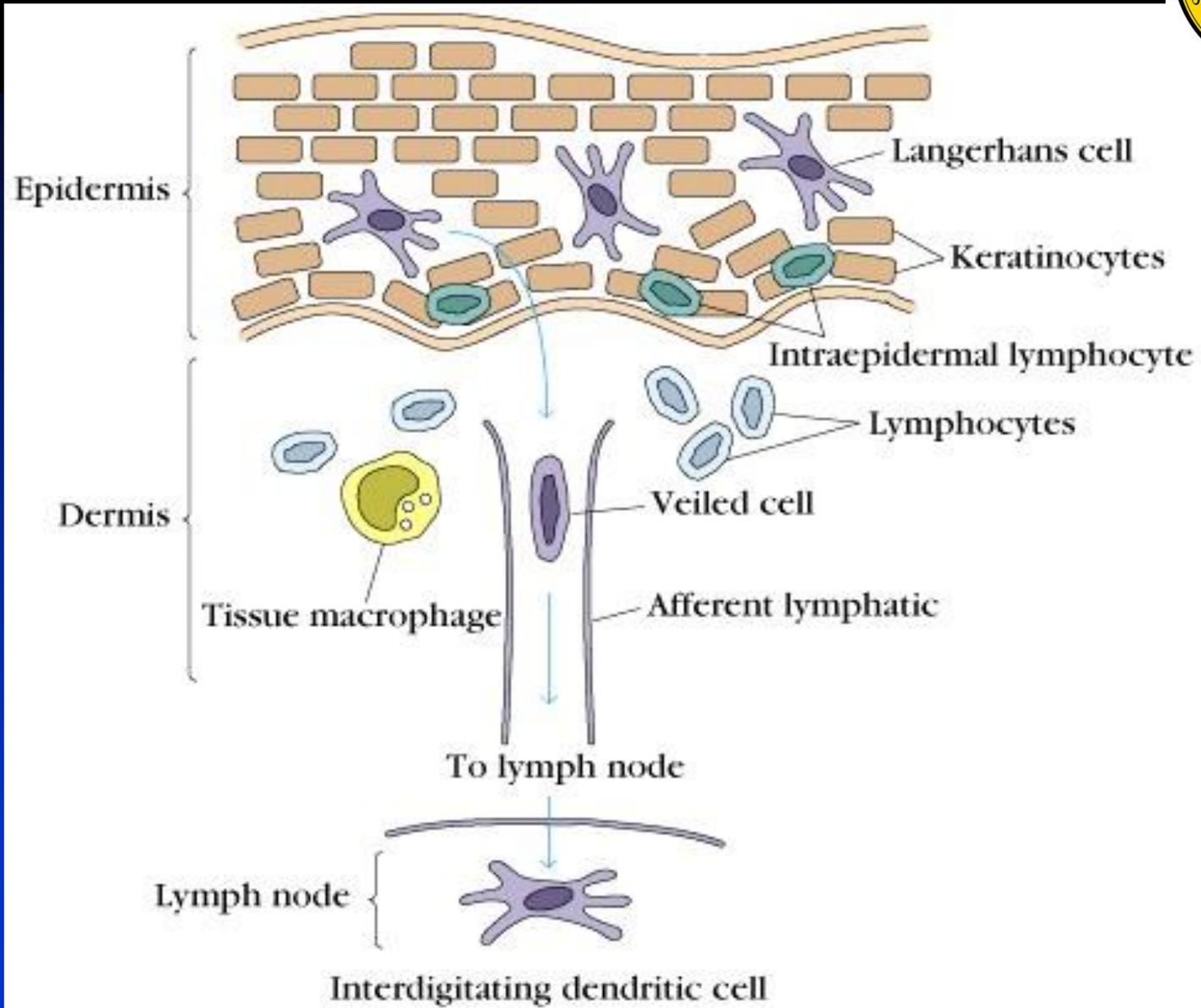
Figure 2-13 Immunobiology, 6/e. (© Garland Science 2005)

2020/5/6 **Salmonella** winking their way in through M cells

Mucosal lymphoid system, MIS



Skin Associated Lymphoid Tissue

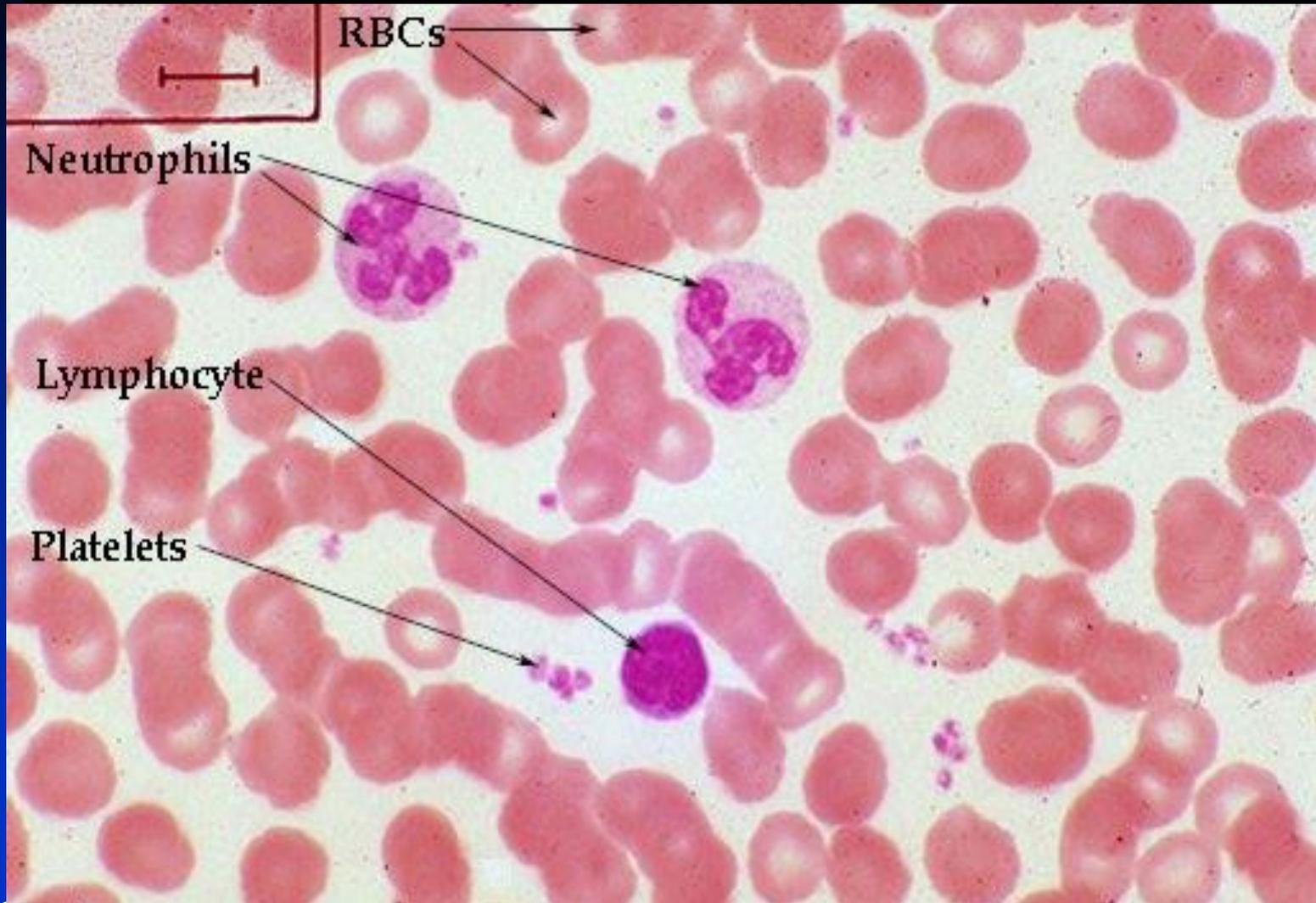


Cells

TABLE 2-3 NORMAL ADULT
BLOOD-CELL COUNTS

Cell type	Cells/mm ³	%
Red blood cells	5.0×10^6	
Platelets	2.5×10^5	
Leukocytes	7.3×10^3	
Neutrophil		50–70
Lymphocyte		20–40
Monocyte		1–6
Eosinophil		1–3
Basophil		<1

Human Blood Cells



Cell	Activated function
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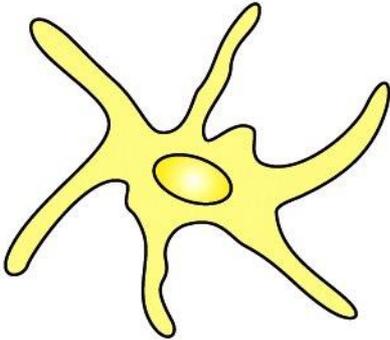
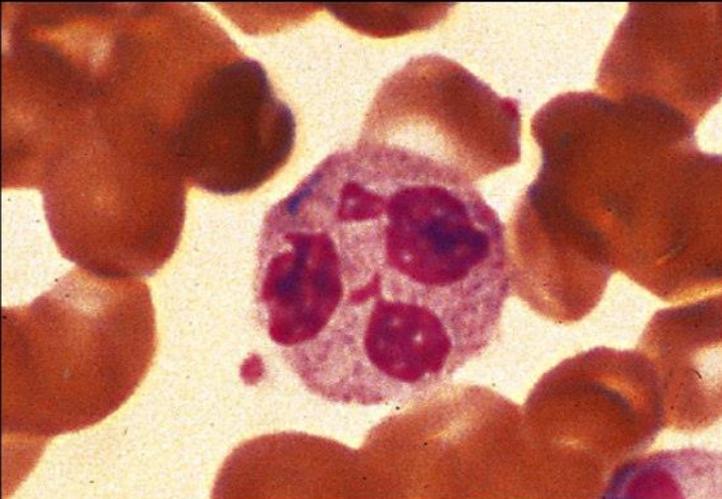
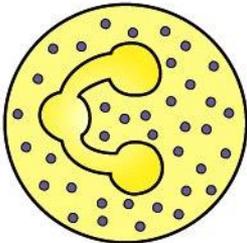
Dendritic cell		<p>Antigen uptake in peripheral sites</p> <p>Antigen presentation</p>
		

Figure 1-4 part 2 of 6 Immunobiology, 7ed. (© Garland Science 2008)

Cell	Activated function
------	--------------------

Neutrophil		<p>Phagocytosis and activation of bactericidal mechanisms</p>
		

Cell	Activated function
------	--------------------

Eosinophil



Killing of antibody-coated parasites

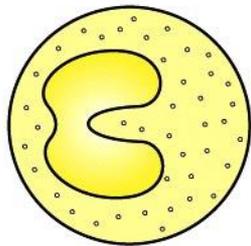
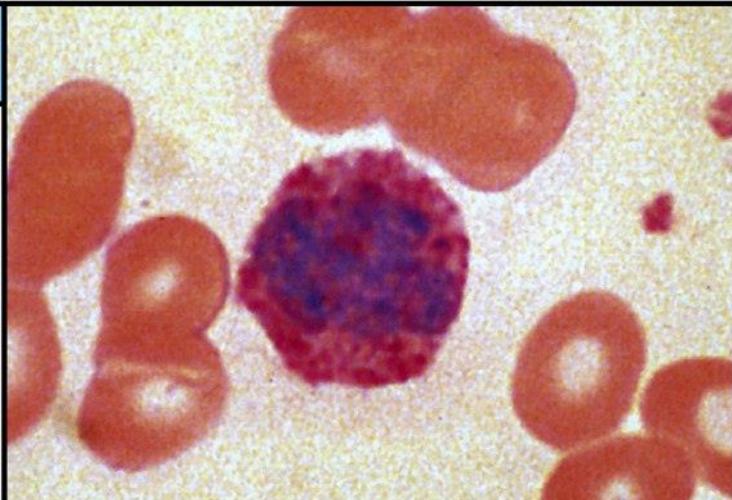


Figure 1-4 part 4 of 6 Immunobiology, 7ed. (© Garland Science 2008)

Cell	Activated function
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Basophil



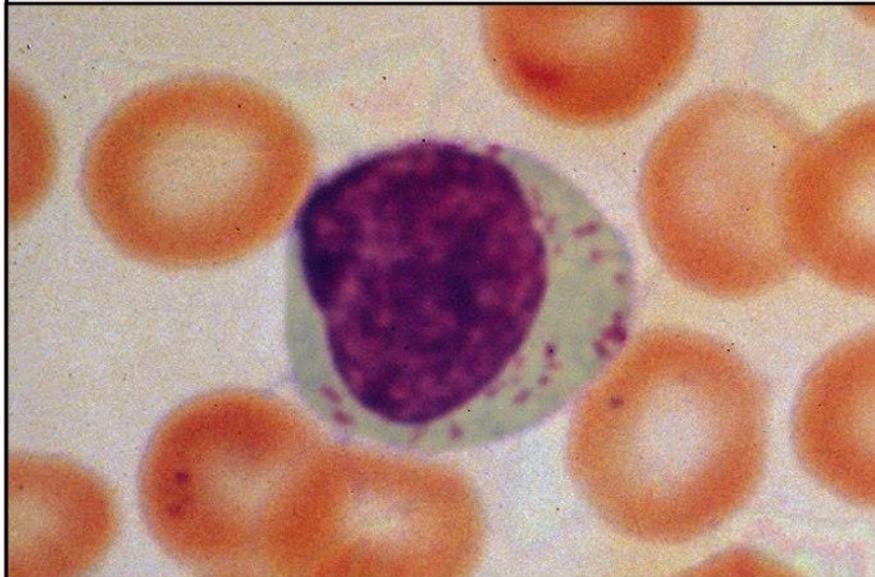
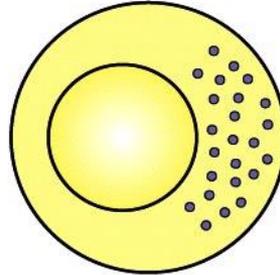
Unknown



Cell	Activated function	
Mast cell	 <p>A light micrograph showing several mast cells. The most prominent cell is centrally located, featuring a large, dark purple, granular cytoplasm that obscures the nucleus. The nucleus is pushed to the periphery, appearing as a thin, dark purple ring. Other smaller, less distinct cells are visible in the background.</p>	<p>Release of granules containing histamine and active agents</p>

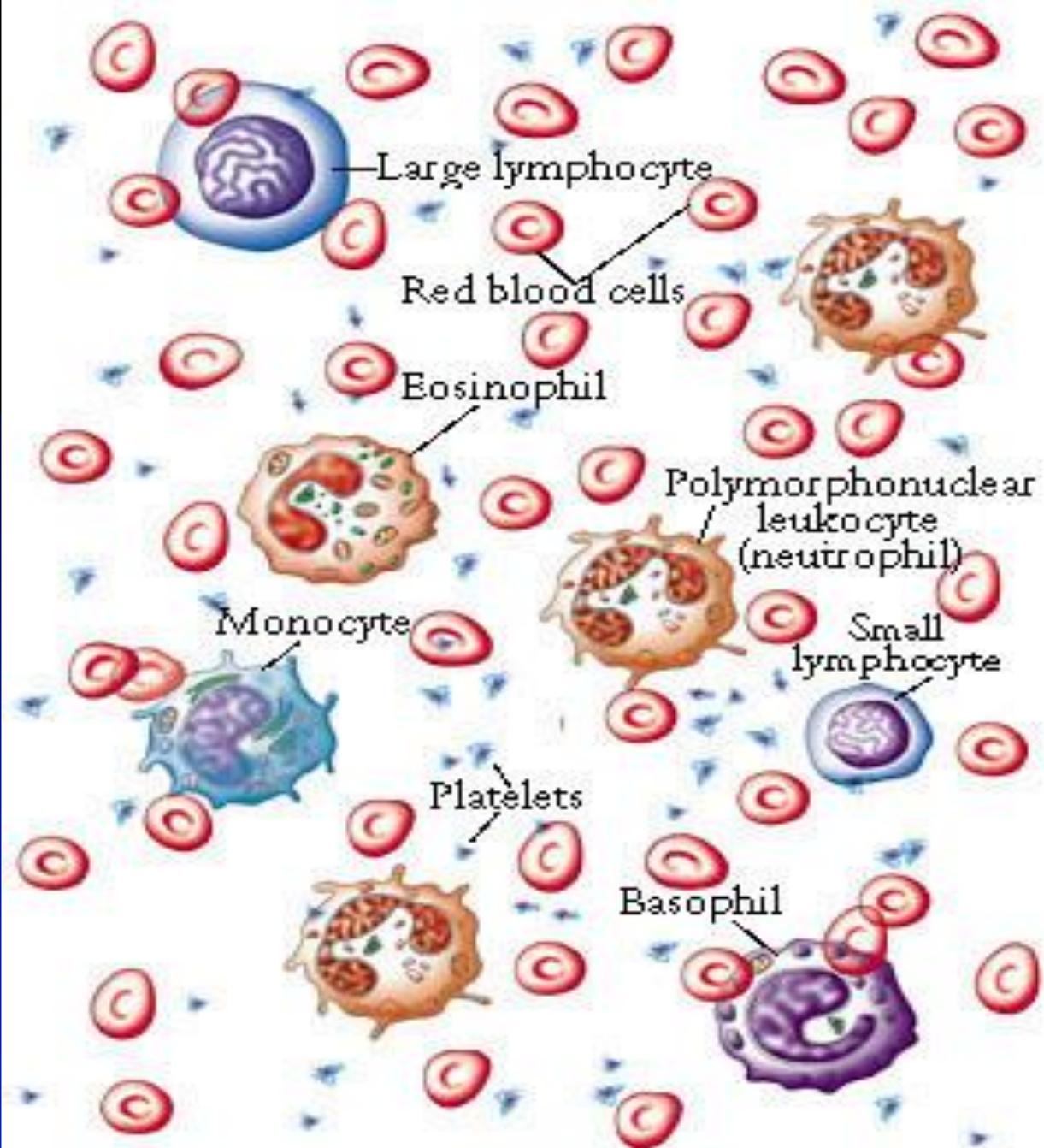
Figure 1-4 part 6 of 6 Immunobiology, 7ed. (© Garland Science 2008)

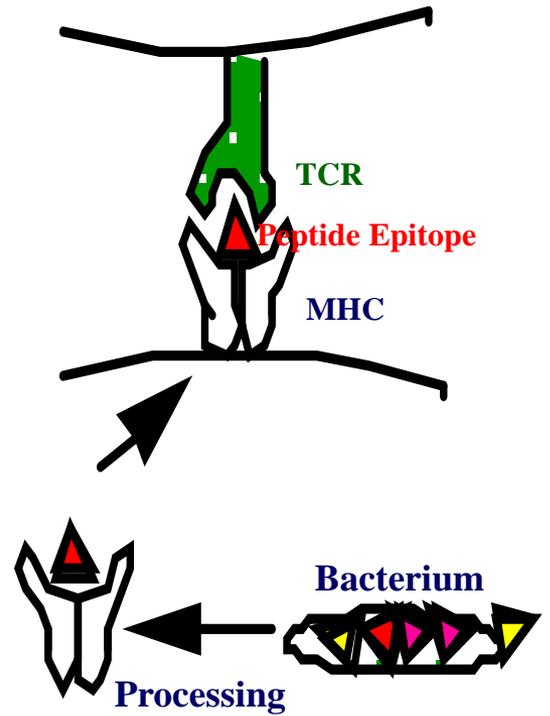
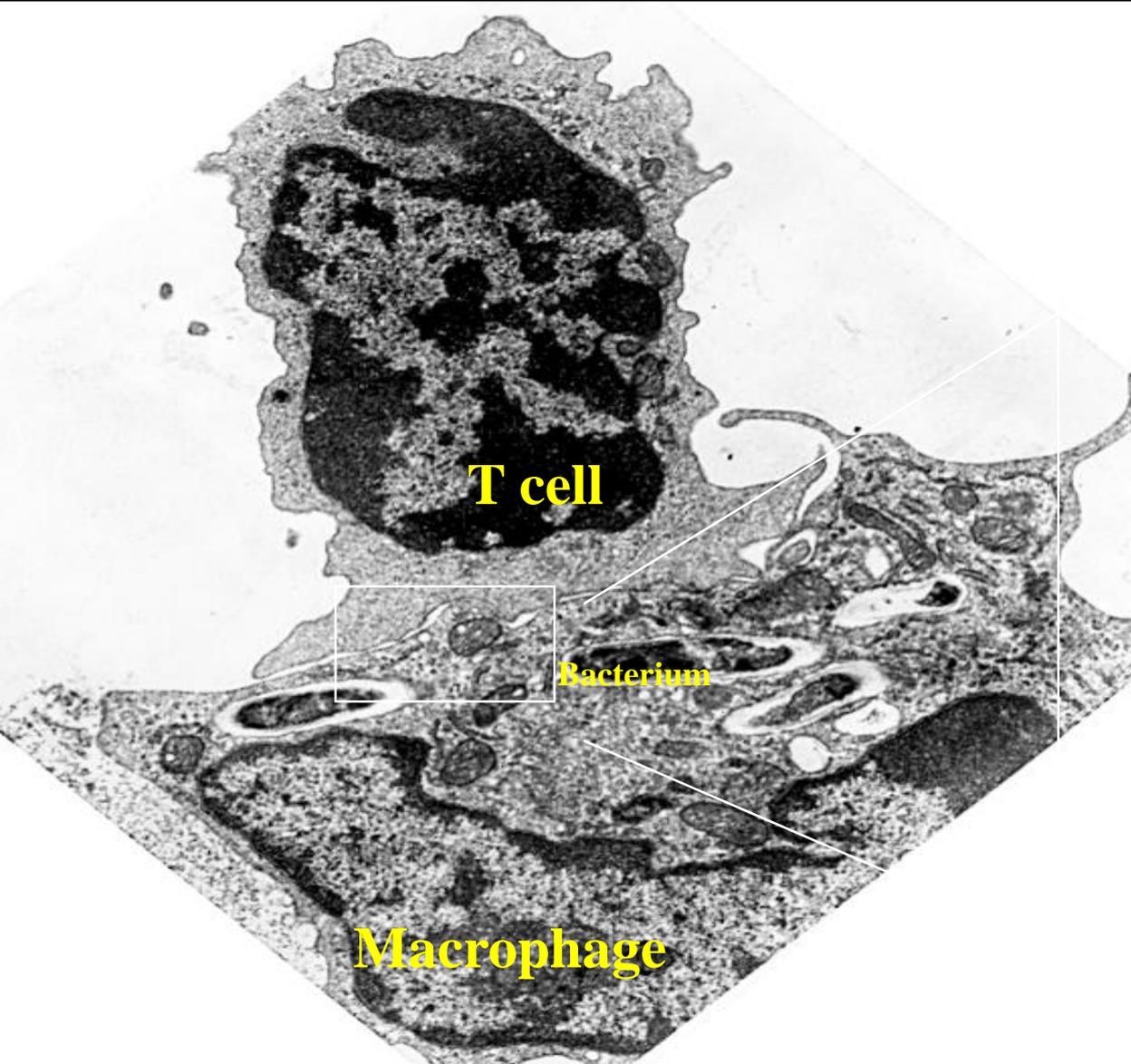
Natural killer (NK) cell



**Releases lytic granules that kill
some virus-infected cells**

Figure 1-5 Immunobiology, 7ed. (© Garland Science 2008)





■ **Antigen Processing Cells**

Unless otherwise stated, the term antigen (Ag) presentation cell (APC) refers to cells that constitutively express class II MHC molecules and present Ag to helper T cells. That is a “**professional**” APC.

Dendritic cells(DC), Macrophages (M ϕ), B cells

Each has unique properties that make it important for particular aspects of the immune response.

Professional APCs:

Find

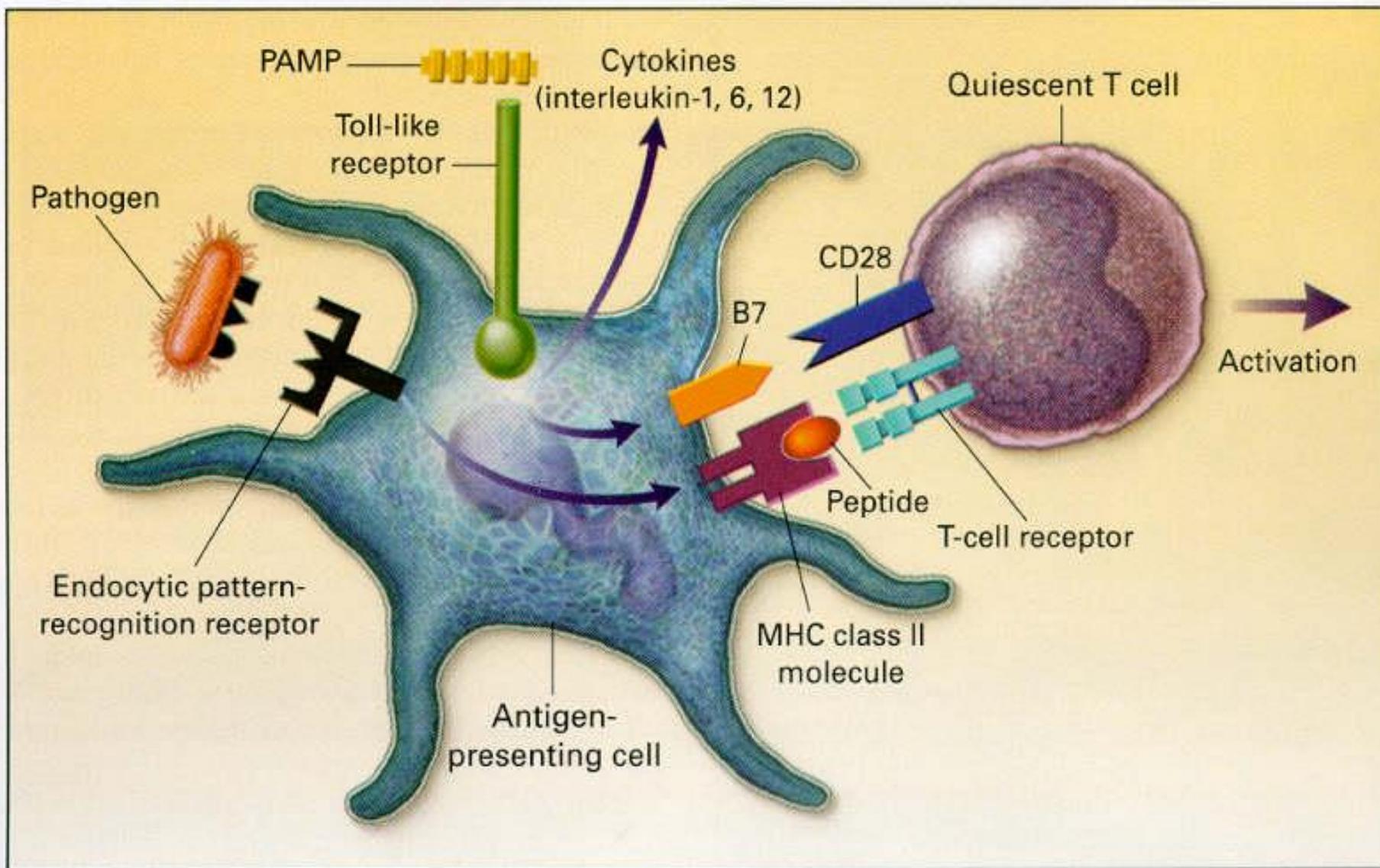
Eat

Kill

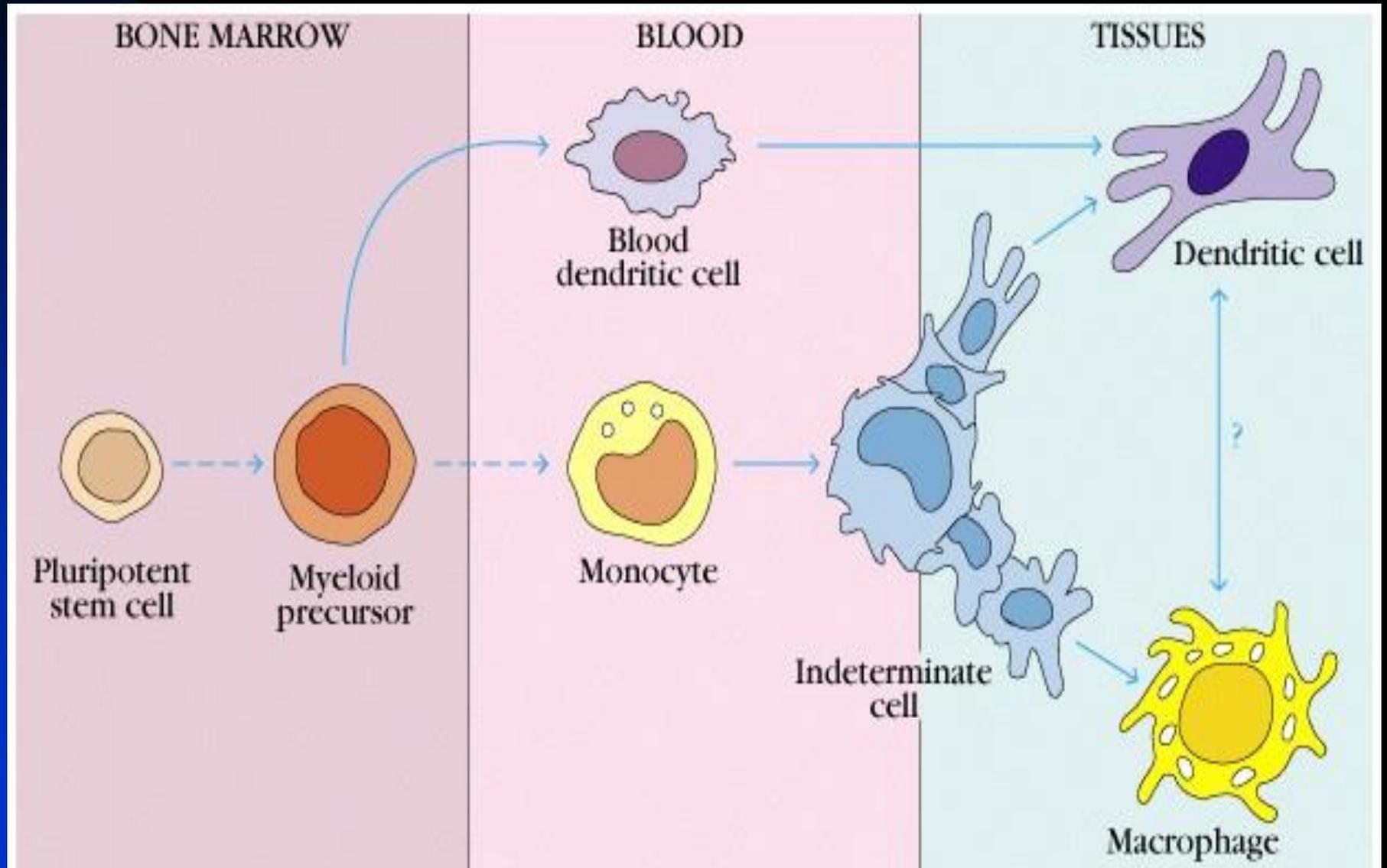
Process

Present.

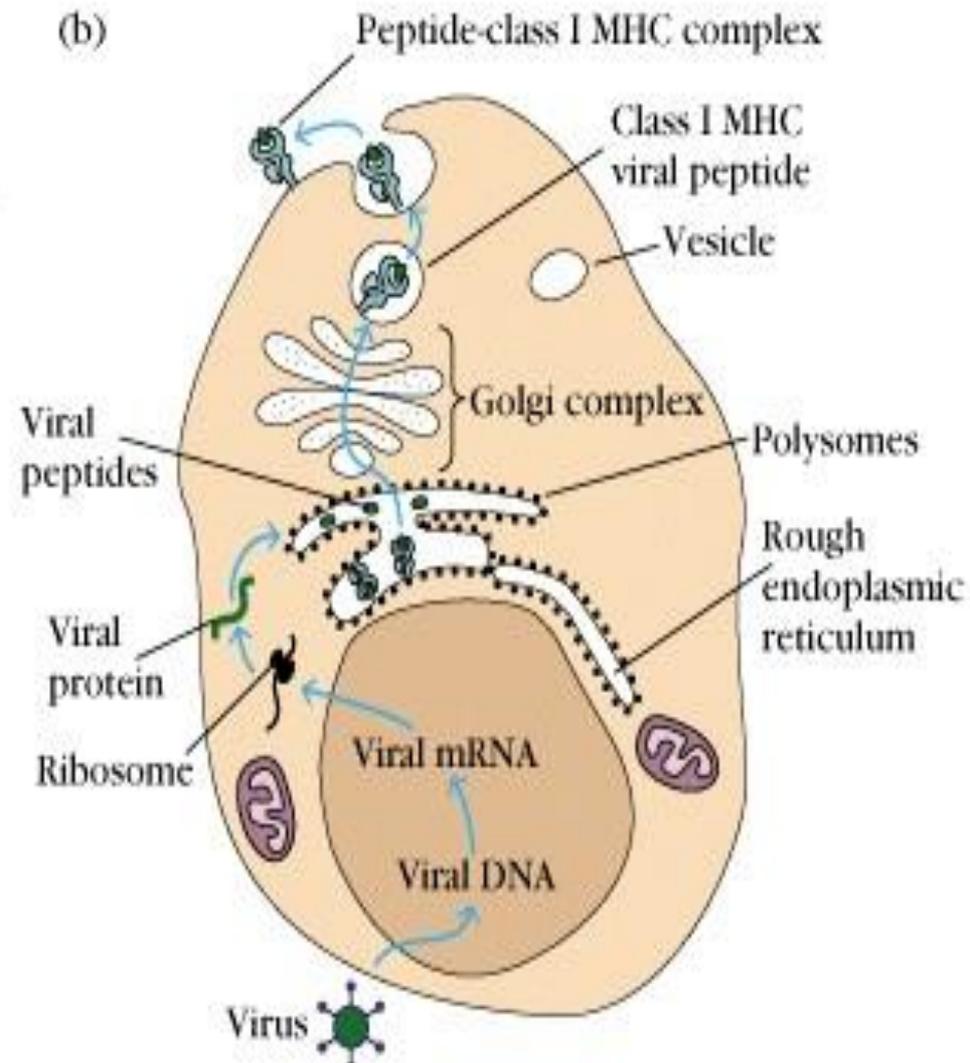
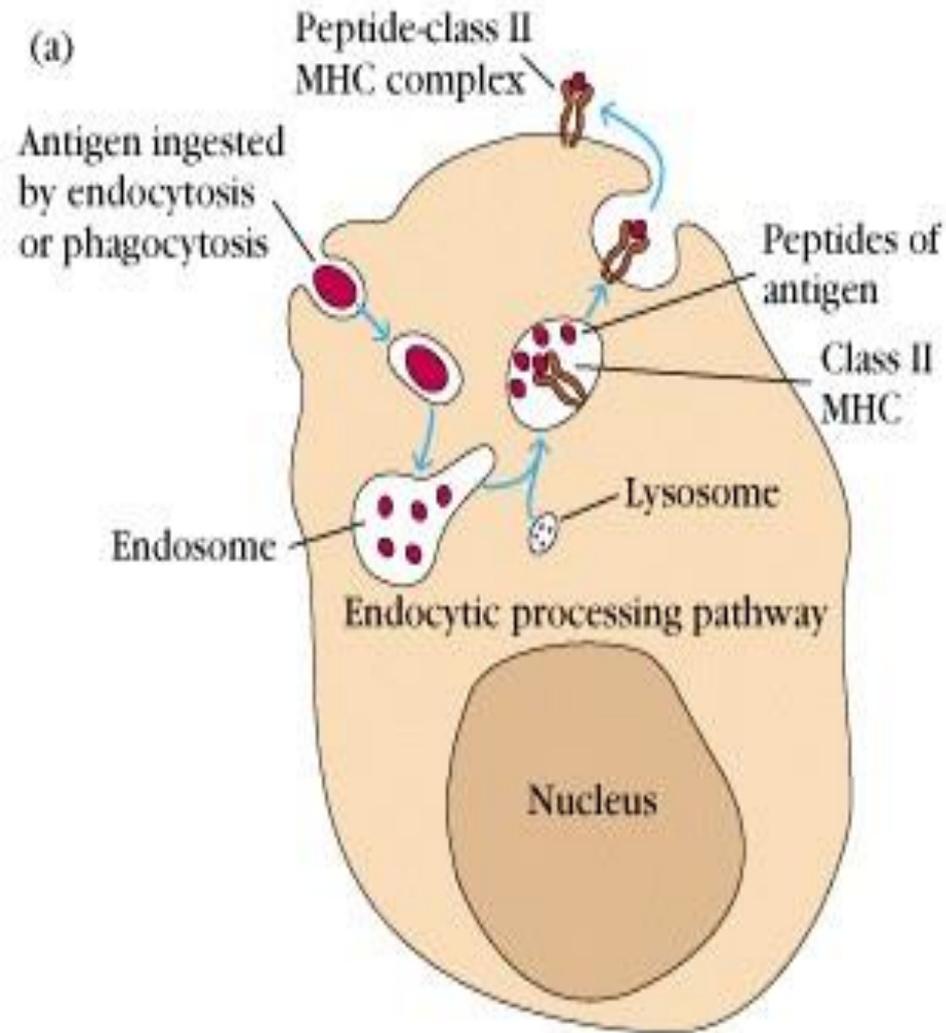
Early Innate Inflammatory Reactions Can Dictate Later Developing Specific Acquired Immune Response Via Effects on Antigen Presenting Cells and Cytokine Production

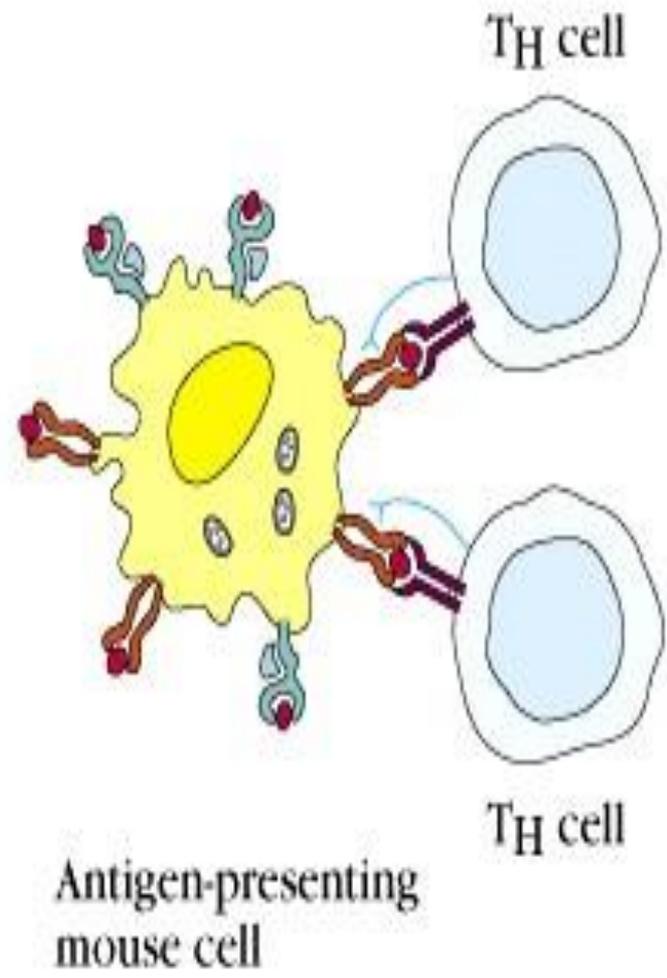
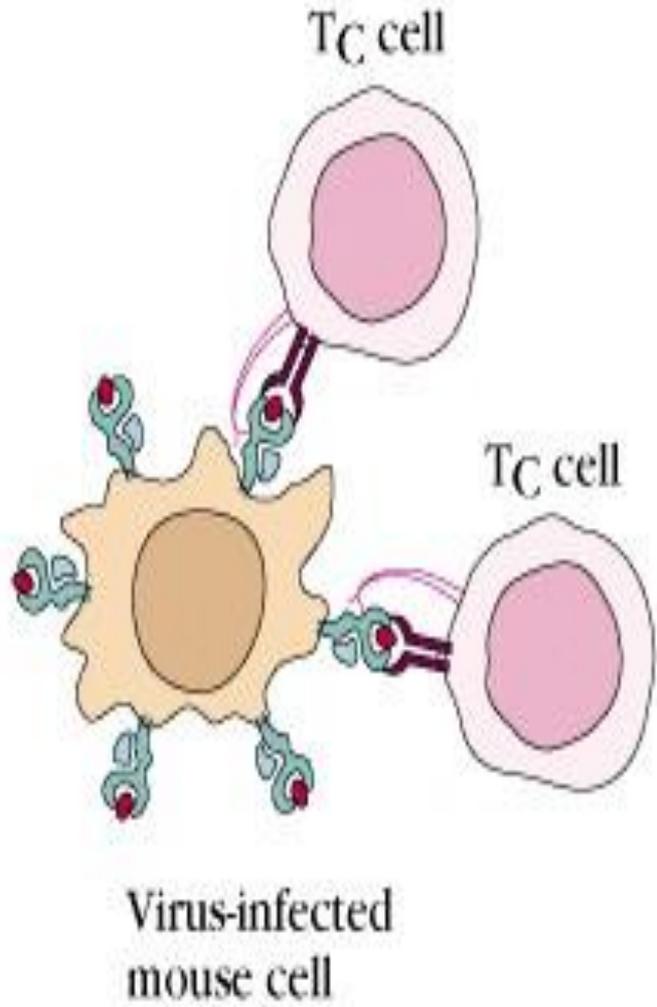
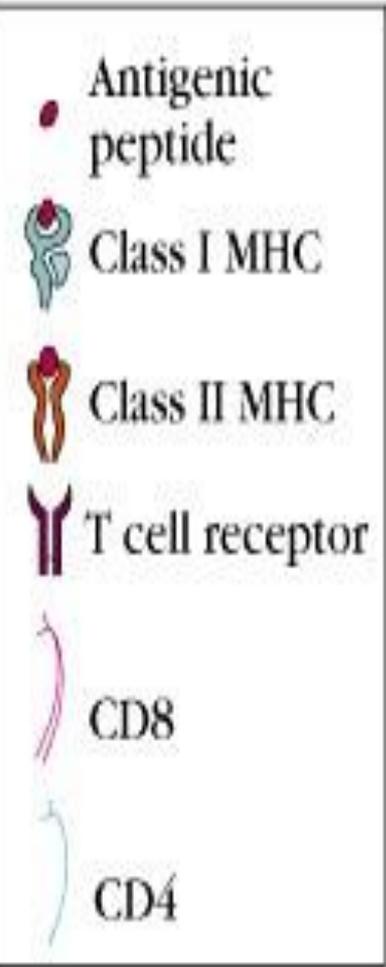


Macrophages and Dendritic Cells



Antigen Processing and Presentation





Specific Immunity: Molecules and Cells

- **The molecules :**
 - ◆ Immunoglobulin,
 - ◆ T cell receptor
 - ◆ class I MHC
 - ◆ class II MHC
 - ◆ Cytokines
 - ◆ CD molecules

■ The cells:

- ◆ B lymphocytes, B cells

- ◆ T lymphocytes, T cells

 - ★ CD4+ T cells vs. CD8+ T cells

 - ★ TH1 vs TH2 cells

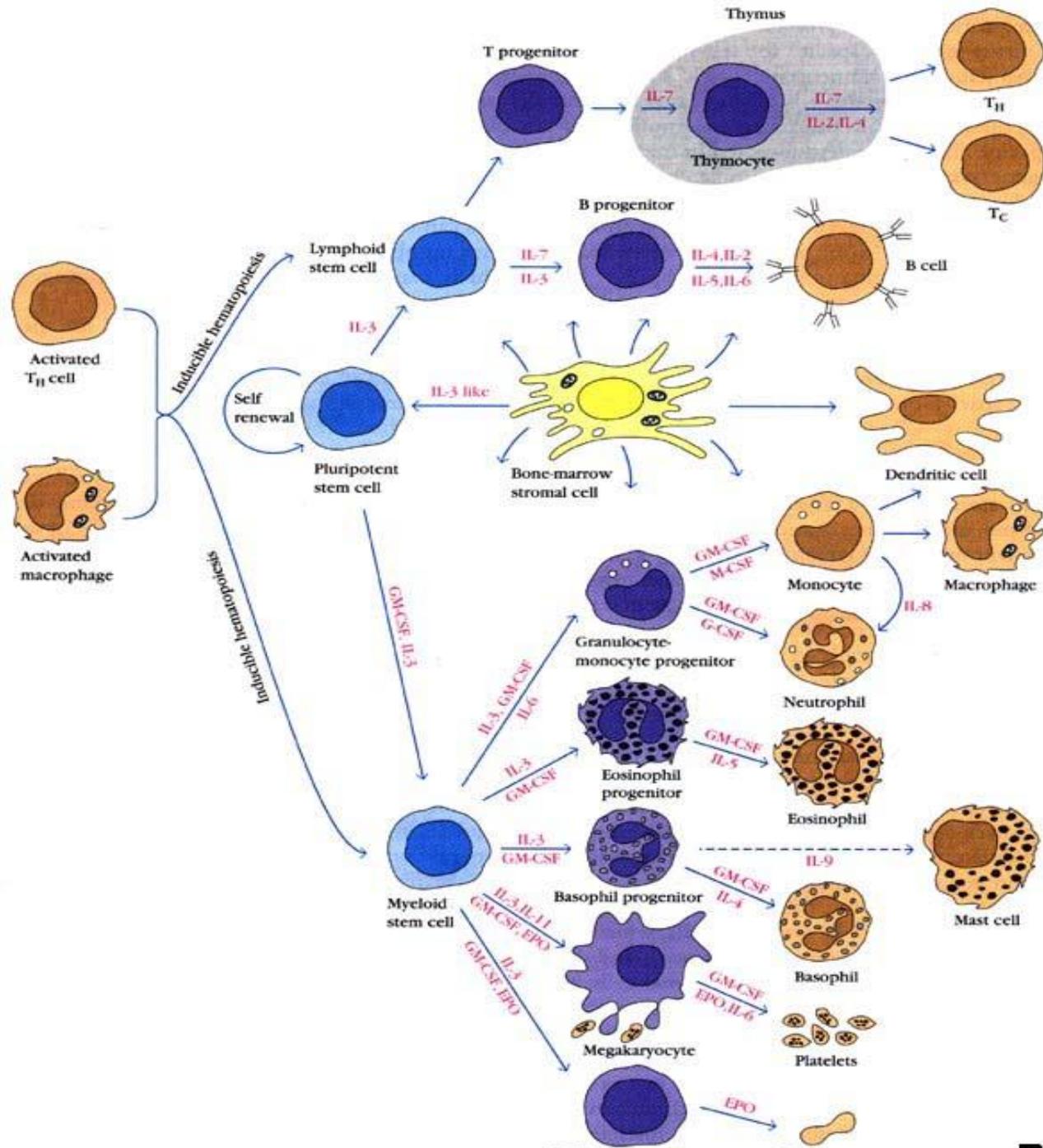
 - ★ Alpha/beta vs gamma/delta T cells

- ◆ APC

(Dendritic cells, Macrophages, B cells etc.)

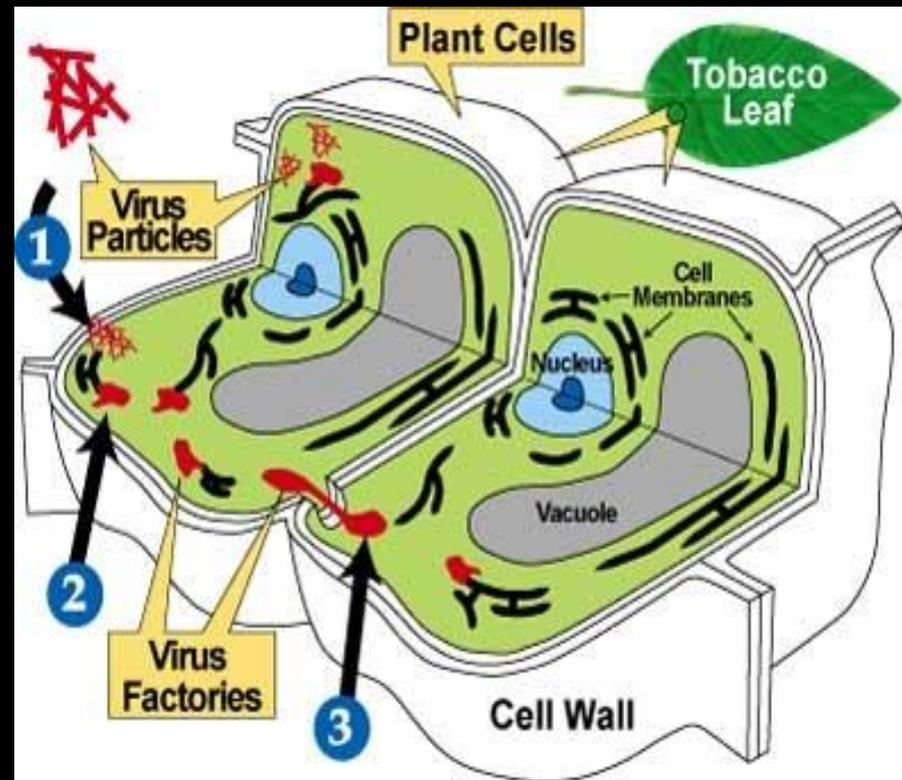
Formation of white blood cells.

Growth and differentiation



Pathogens

- Organism that produces a disease
 - ◆ Primary pathogen
 - ◆ Opportunistic pathogen
- Invasiveness = degree of spreading
- Infectivity = ability to establish a disease
- Toxigenicity = ability to produce toxins

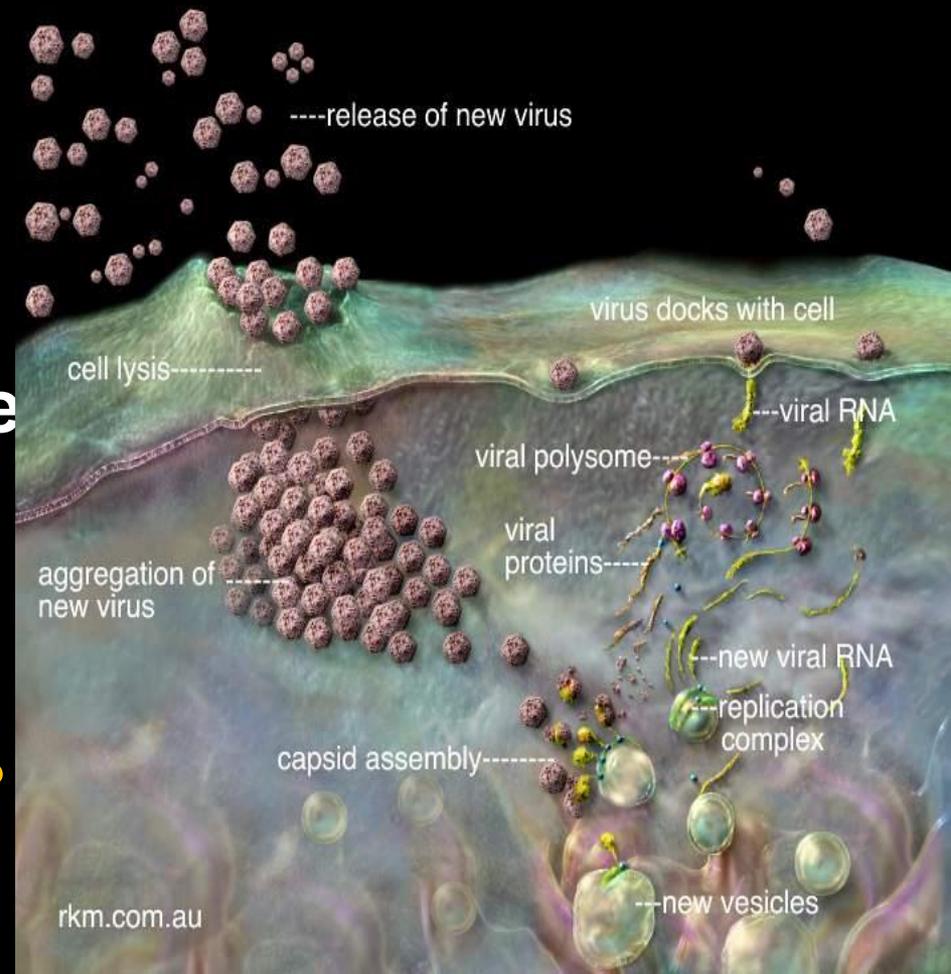


Pathogenesis of Viral Disease

- Enter host
- Entry into cell
- Replicate
- Spread
- Injury/damage
- Elicit immune response
- Outcome
- Shed

How about of 2019-nCoV?

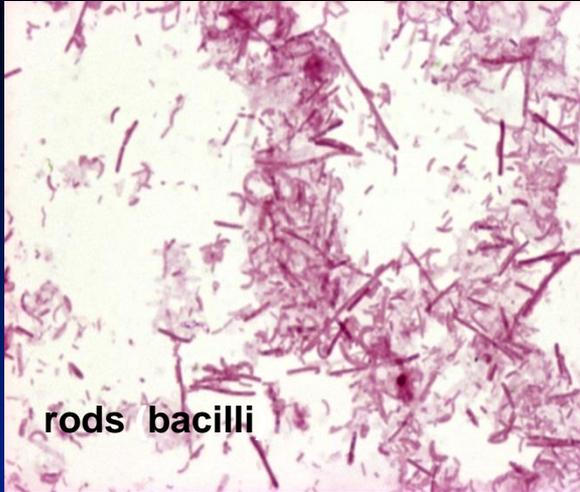
2020/5/6



Pathogenesis of Bacterial Disease

- **Invasion**
 - ◆ **Break into body through**
 - ★ **Scrapes, cuts, ulcers**
 - ★ **Arthropods**
 - ★ **Endocytosis, phagocytosis**
- **Multiply**
 - ◆ **Bacteremia**
 - ◆ **Septicemia**

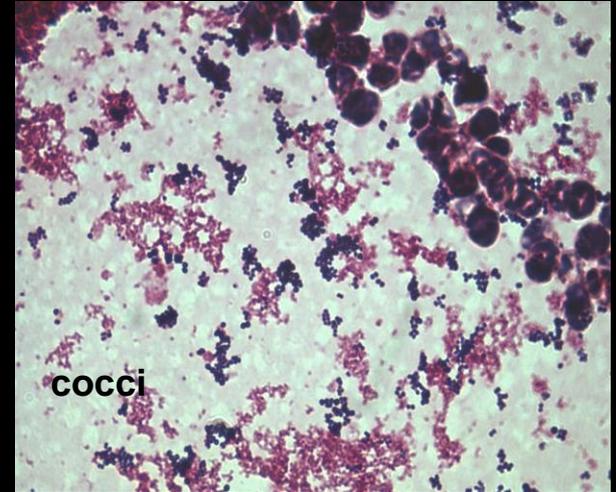
Prokaryotes



rods bacilli



spirals



cocci

Bacteria

Pathogenesis of Bacterial Diseases

■ Damage

◆ Exotoxin

Stimulate immune system

Cause fever

Enterotoxin

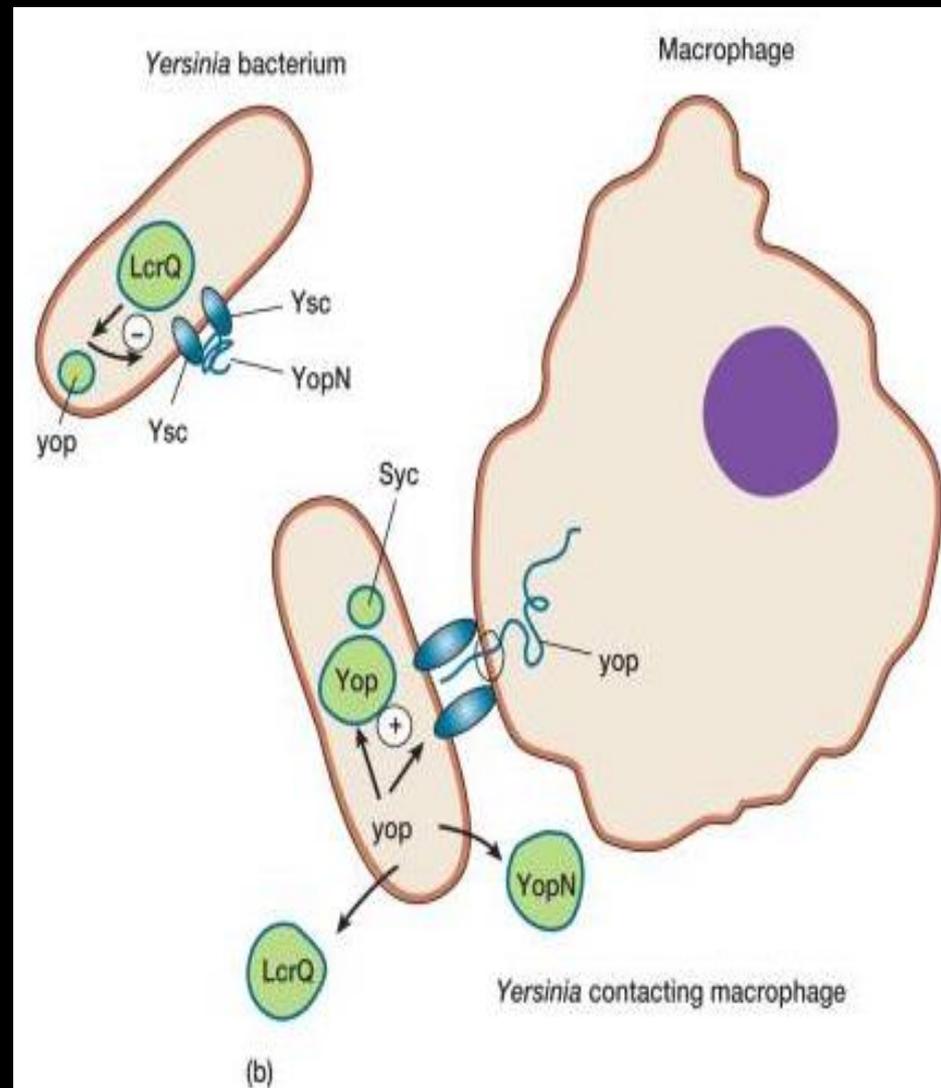
Neurotoxin

Cytotoxin

◆ Endotoxin

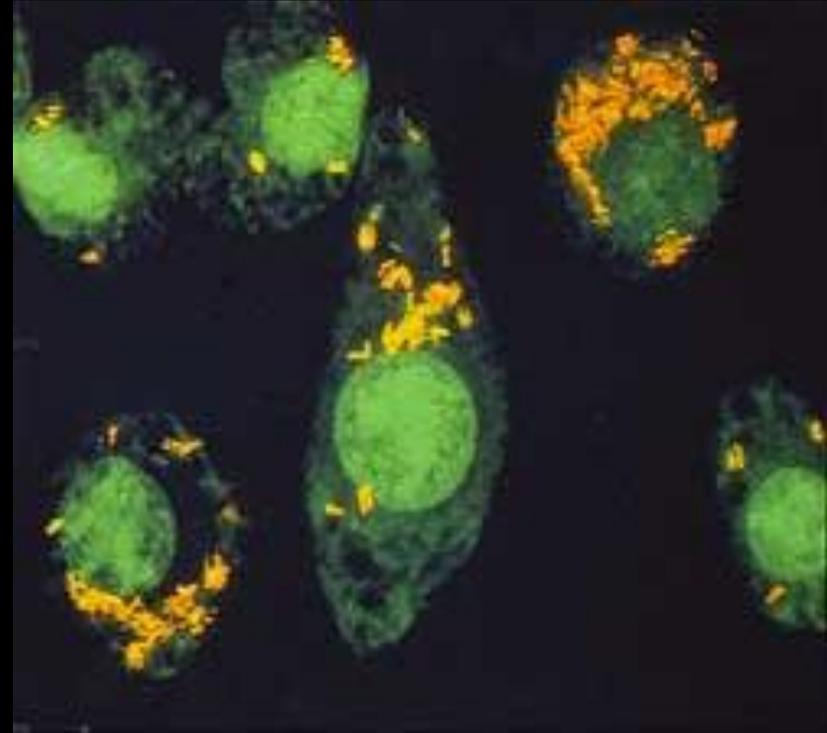
◆ LPS

2020/5/6



Pathogenesis of Bacterial Infections

- **Evasion of immune system**
 - ◆ **Phagocytosis**
 - ★ Capsules, slime layers, molecular mimicry
 - ◆ **Escape detection**
 - ★ Live inside cells
 - ◆ **Evade adaptive immunity**
 - Evolution of surface molecules
 - slgA proteases



Challenges of the immune system

1. System must be able to **recognize** an infinite variety of foreign substances.
2. System must **initiate** the appropriate response against each invader.
3. System must **shut off** when finished.
4. System must **avoid** responding to self.

Concepts:

- 1.GALT (Gut-associated lymphoid tissue)**
- 2.MIS (Mucosal lymphoid system)**
- 3.APCs**

Questions:

- 1.What is the role of the immune system?**
- 2.What happens when the immune system doesn't work properly?**
- 3. What is the innate immunity?**
- 4.What is the adaptive immunity?**
- 5.Comparison of Innate Versus Adaptive Immunity**
- 6.What is the peripheral lymphoid organs ?and concise answer their major function please.**
- 7.What is the Lymphocyte Traffic? and concise answer their major function please.**