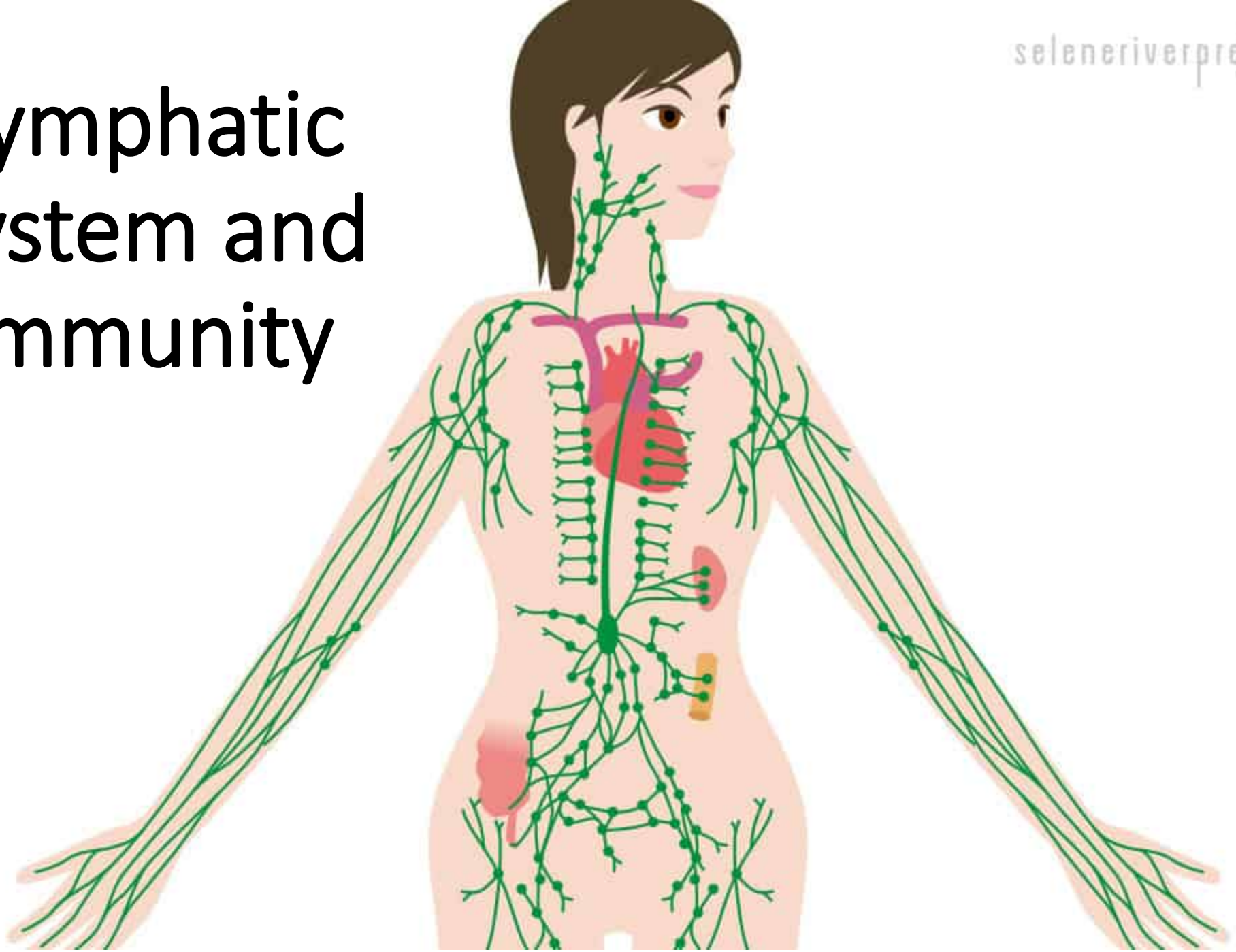
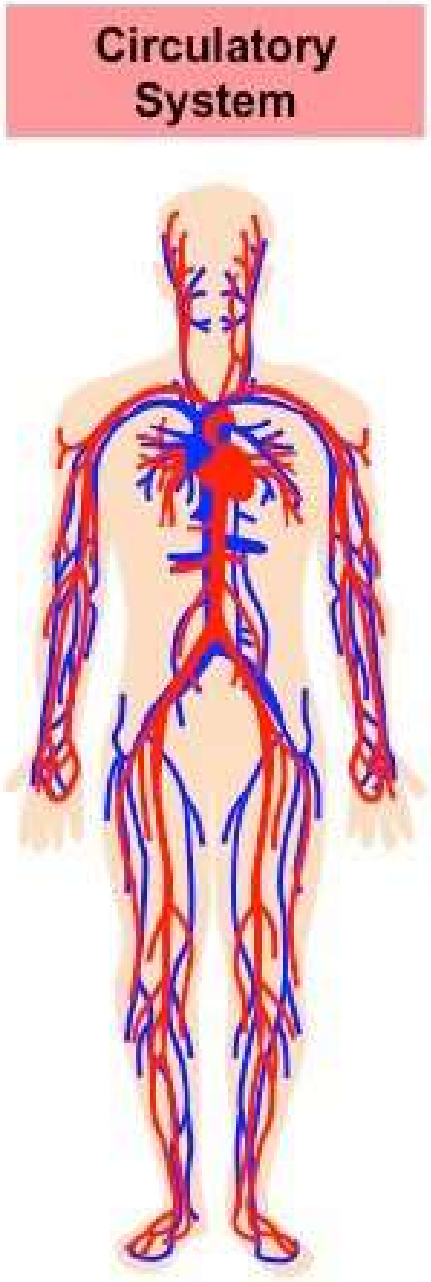
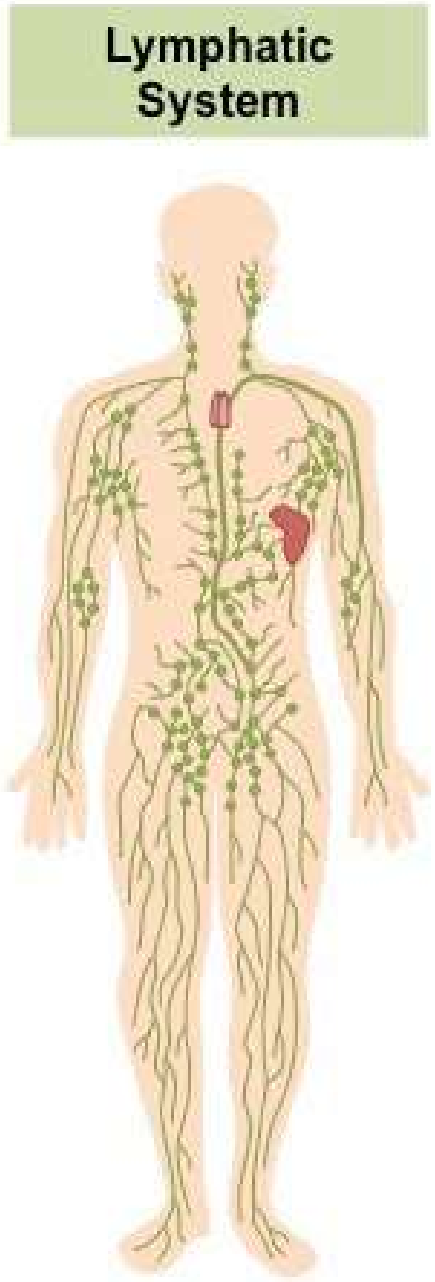
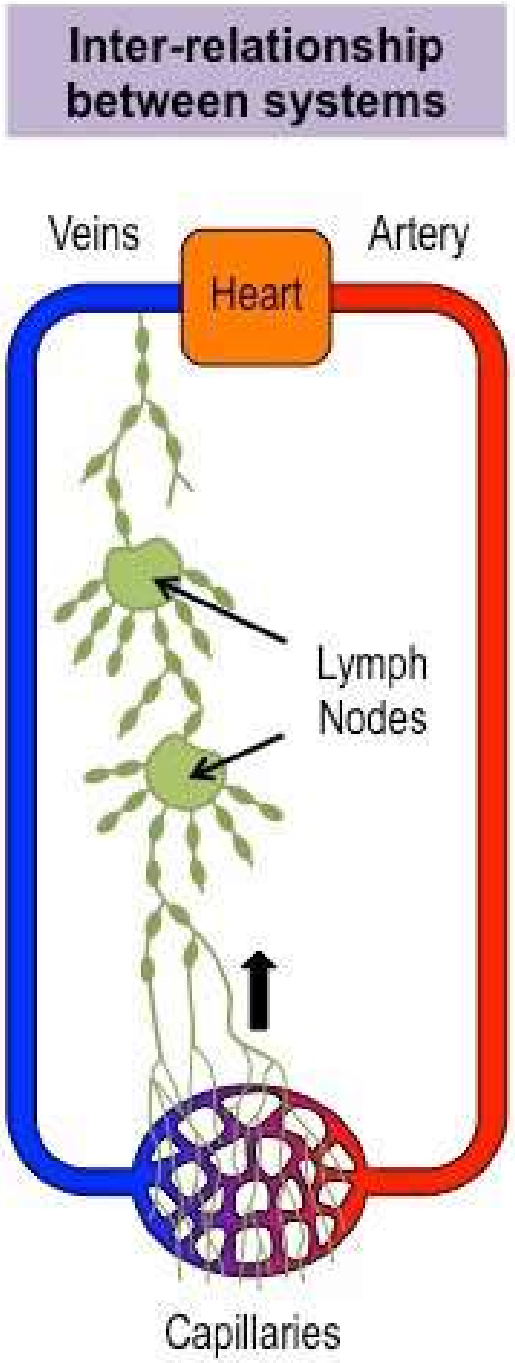
Lymphatic System and Immunity



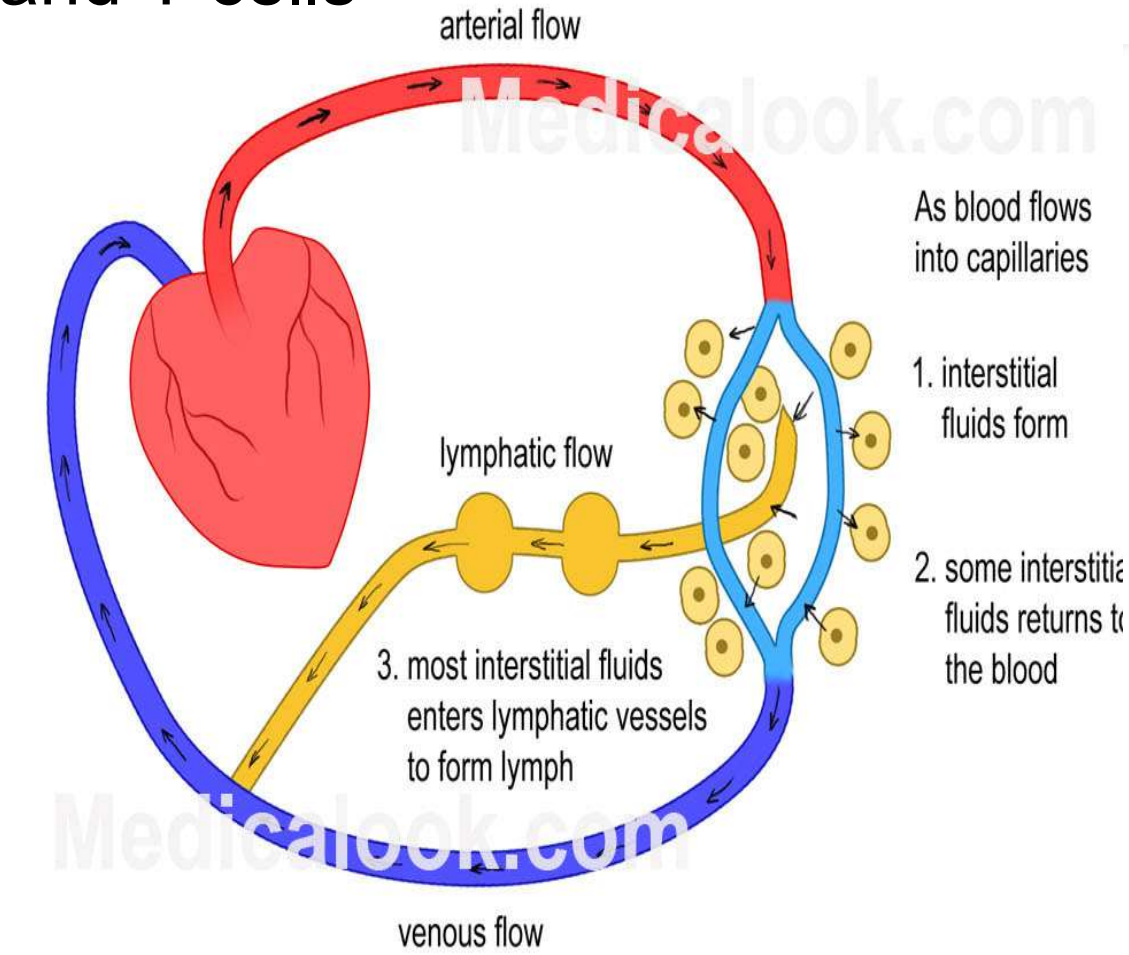
Lymphatic System - the other circulatory system

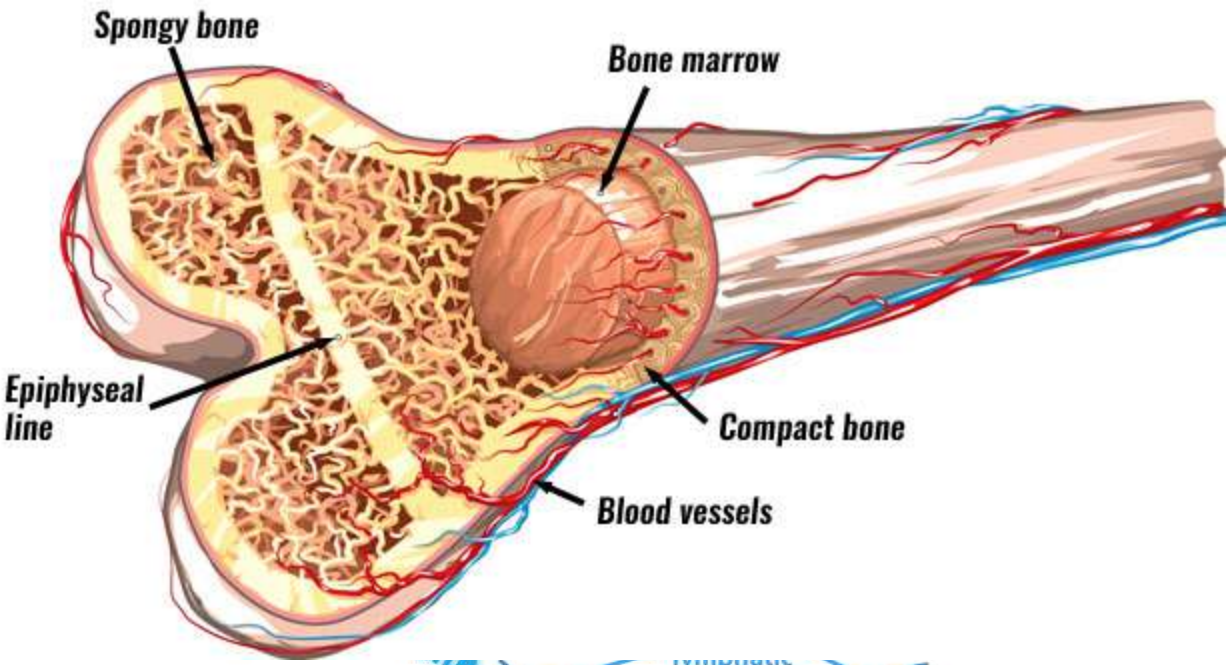


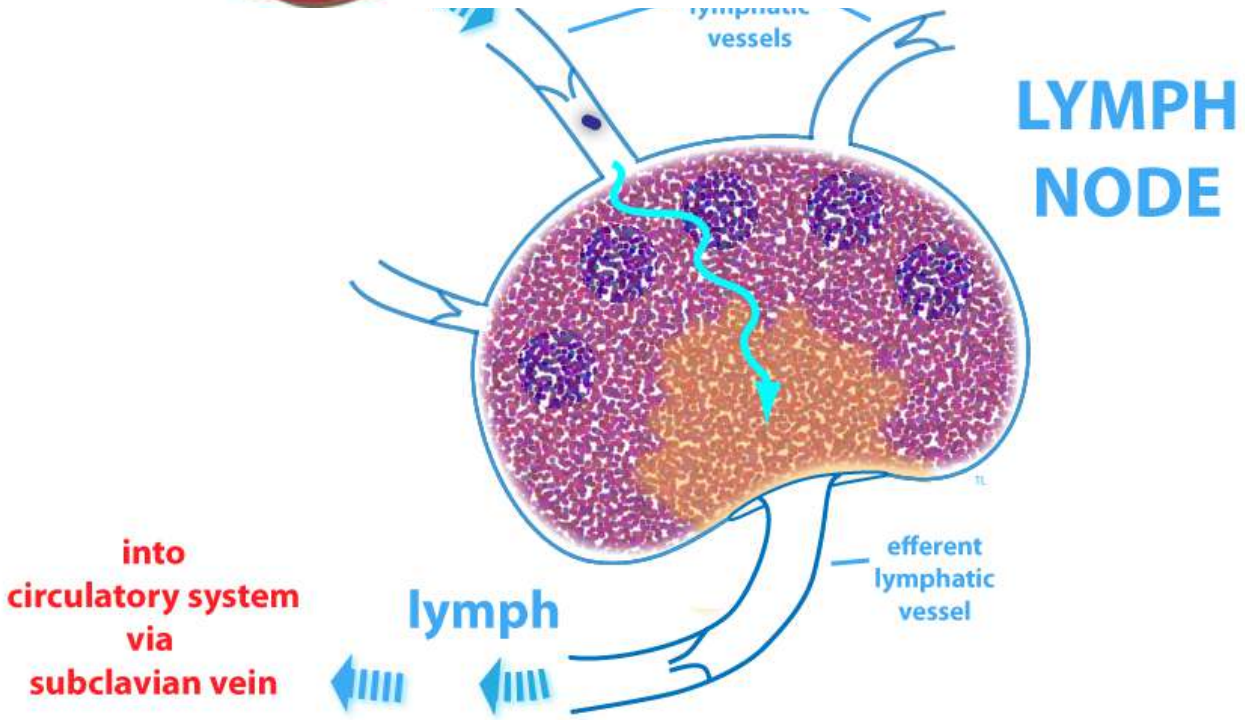




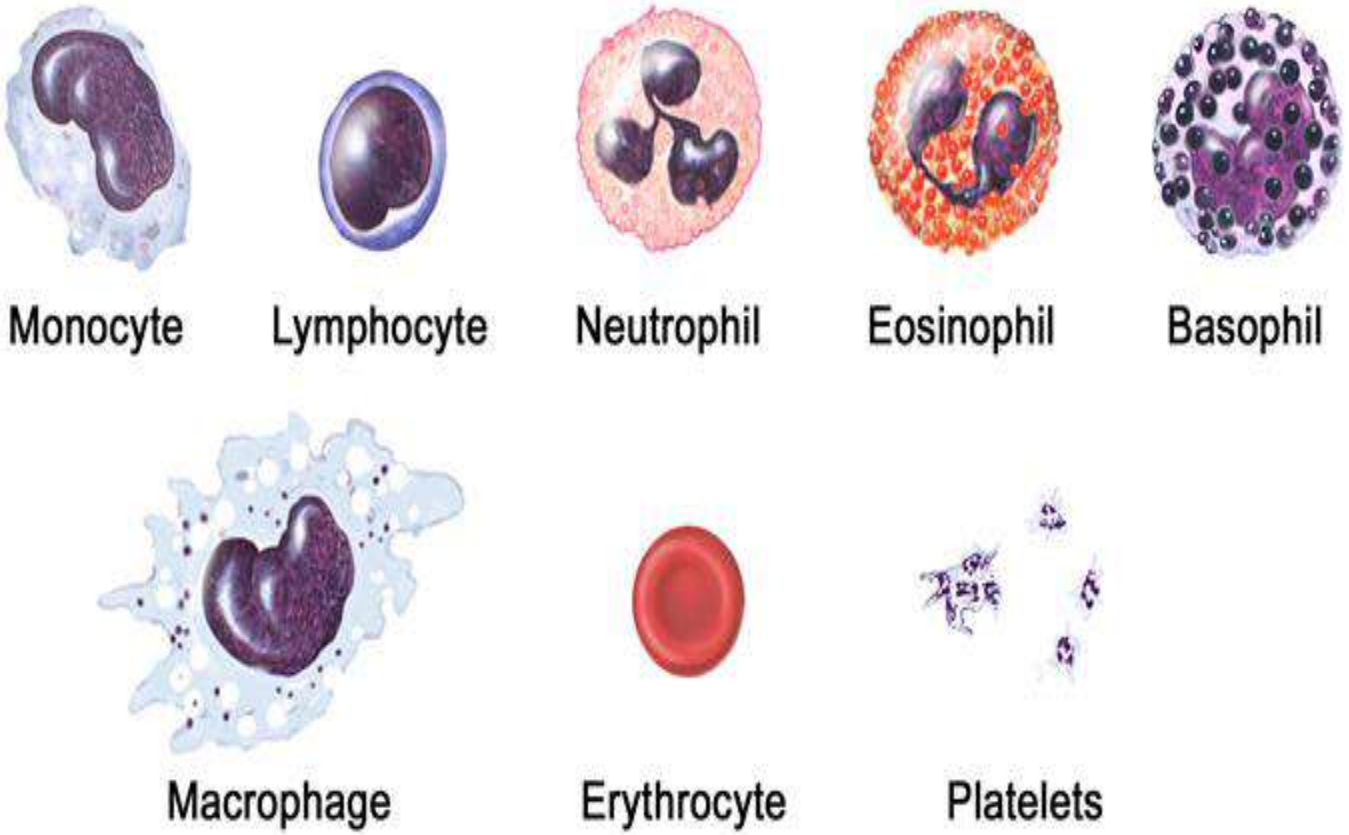
A. Structures - lymph fluid, lymph vessels, lymph tissue, red bone marrow - makes the WBC, lymphocytes - makes B and T cells

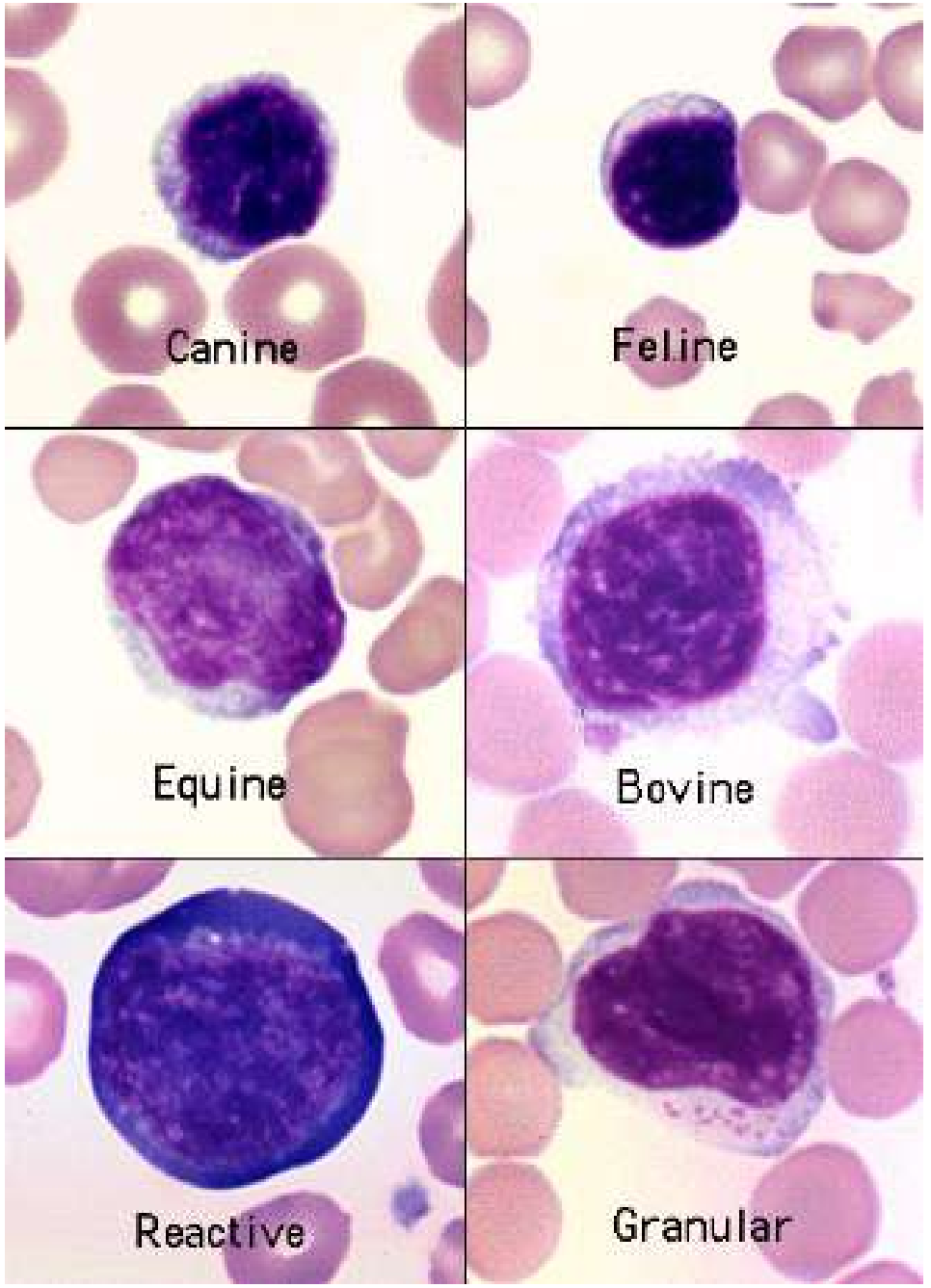


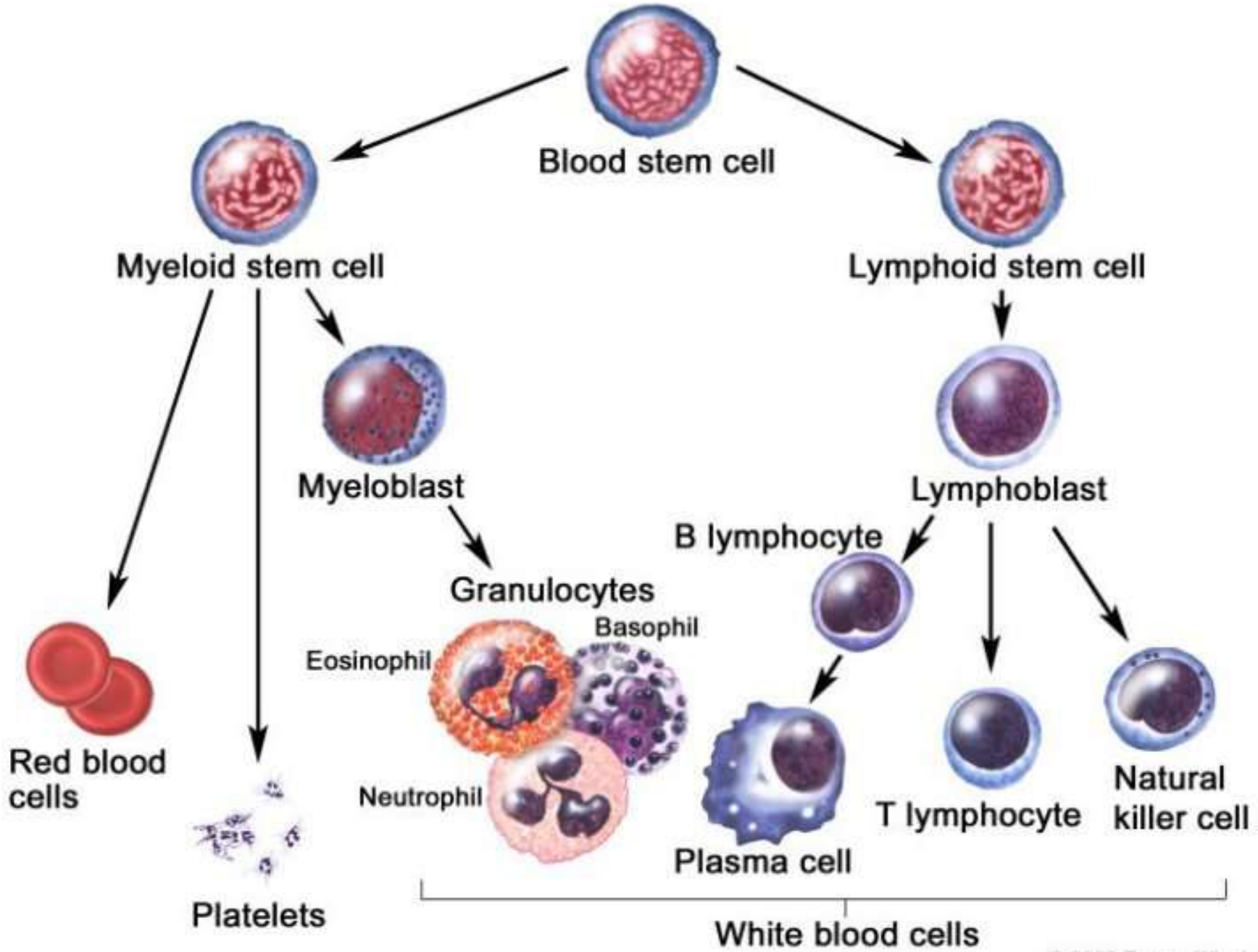


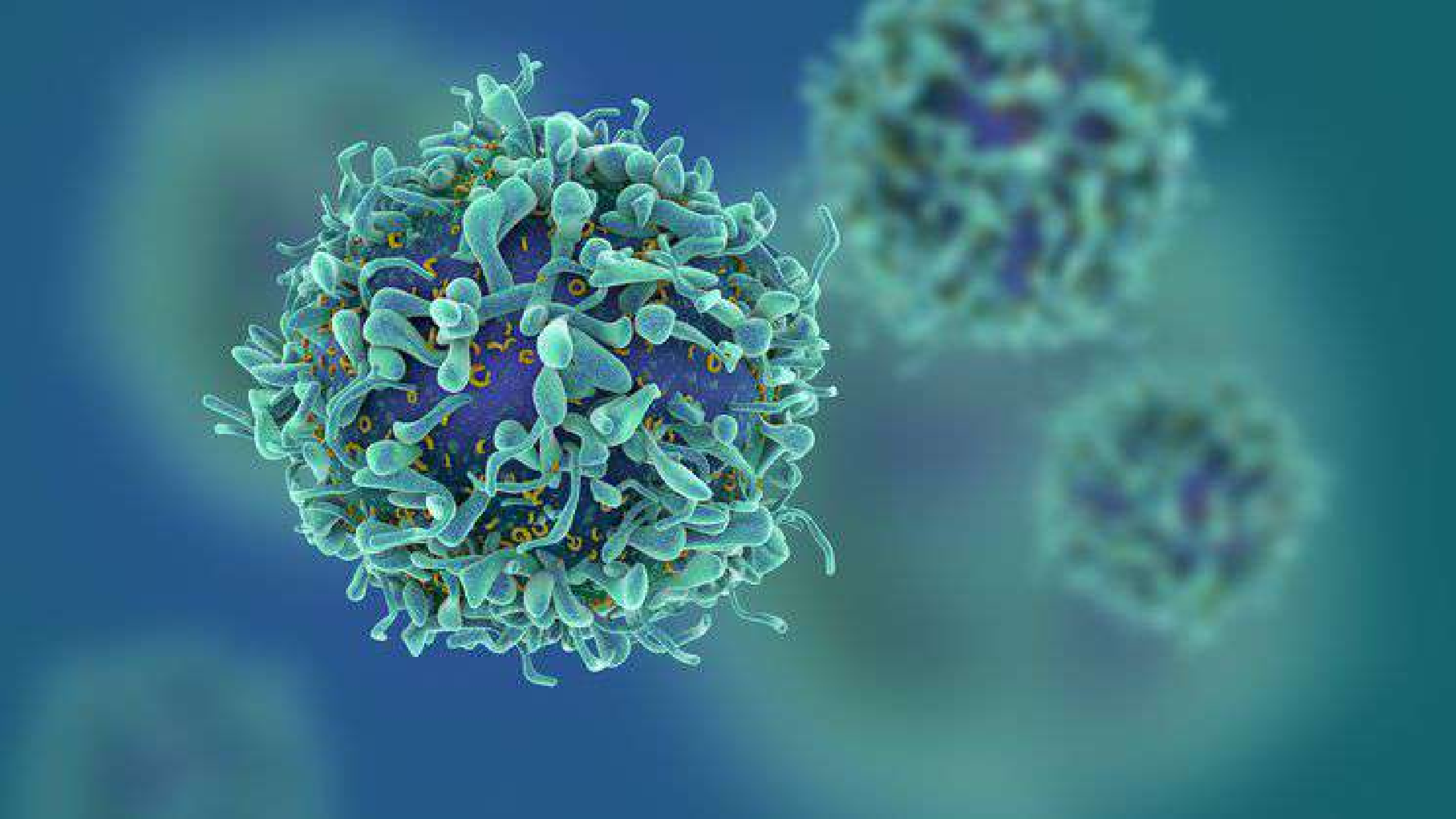


Blood Cells



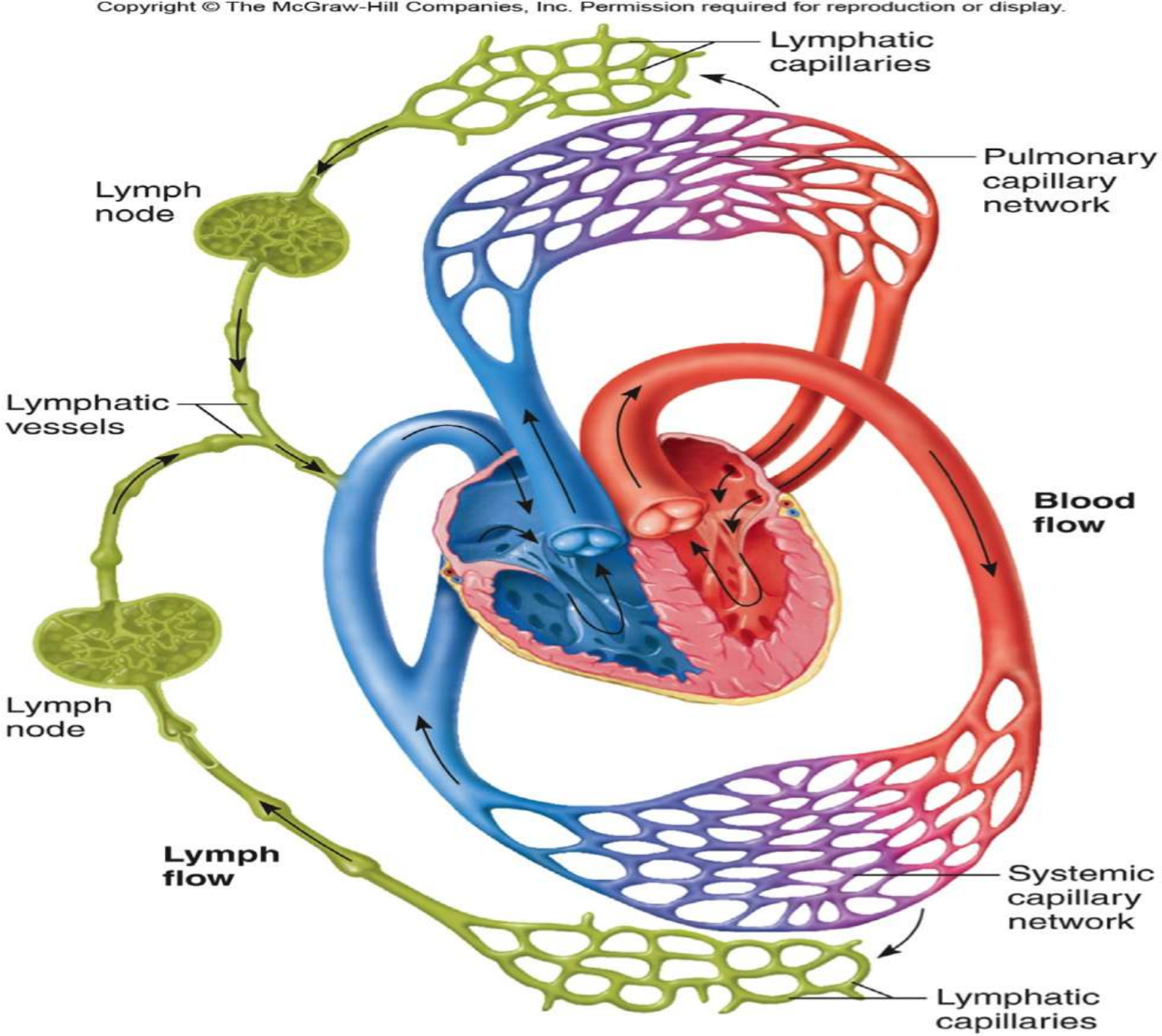




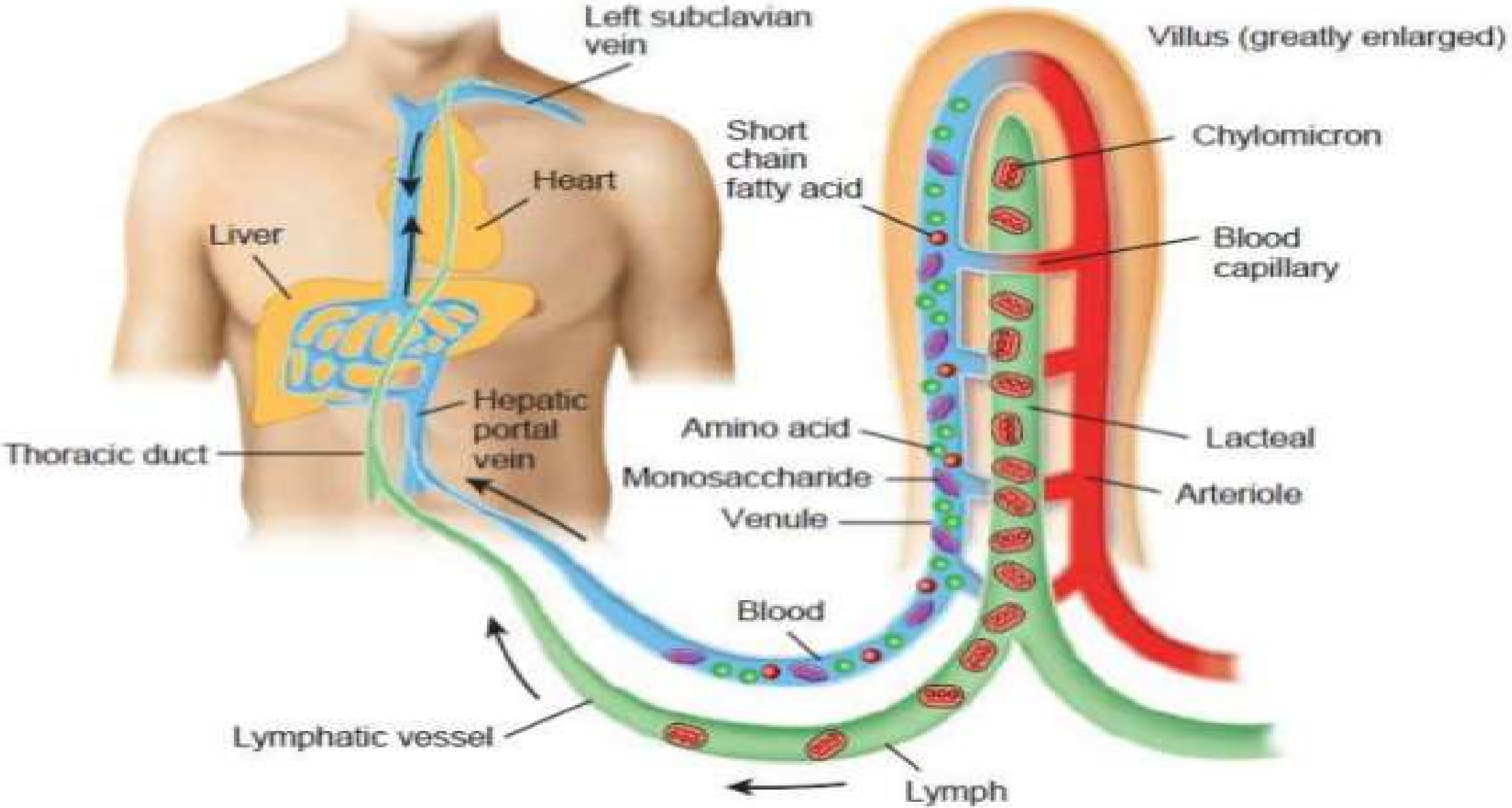


B. Functions

1. Drains interstitial fluid returns to circulatory system
2. Transports lipids, vitamins from GI tract to blood



Transport of lipids

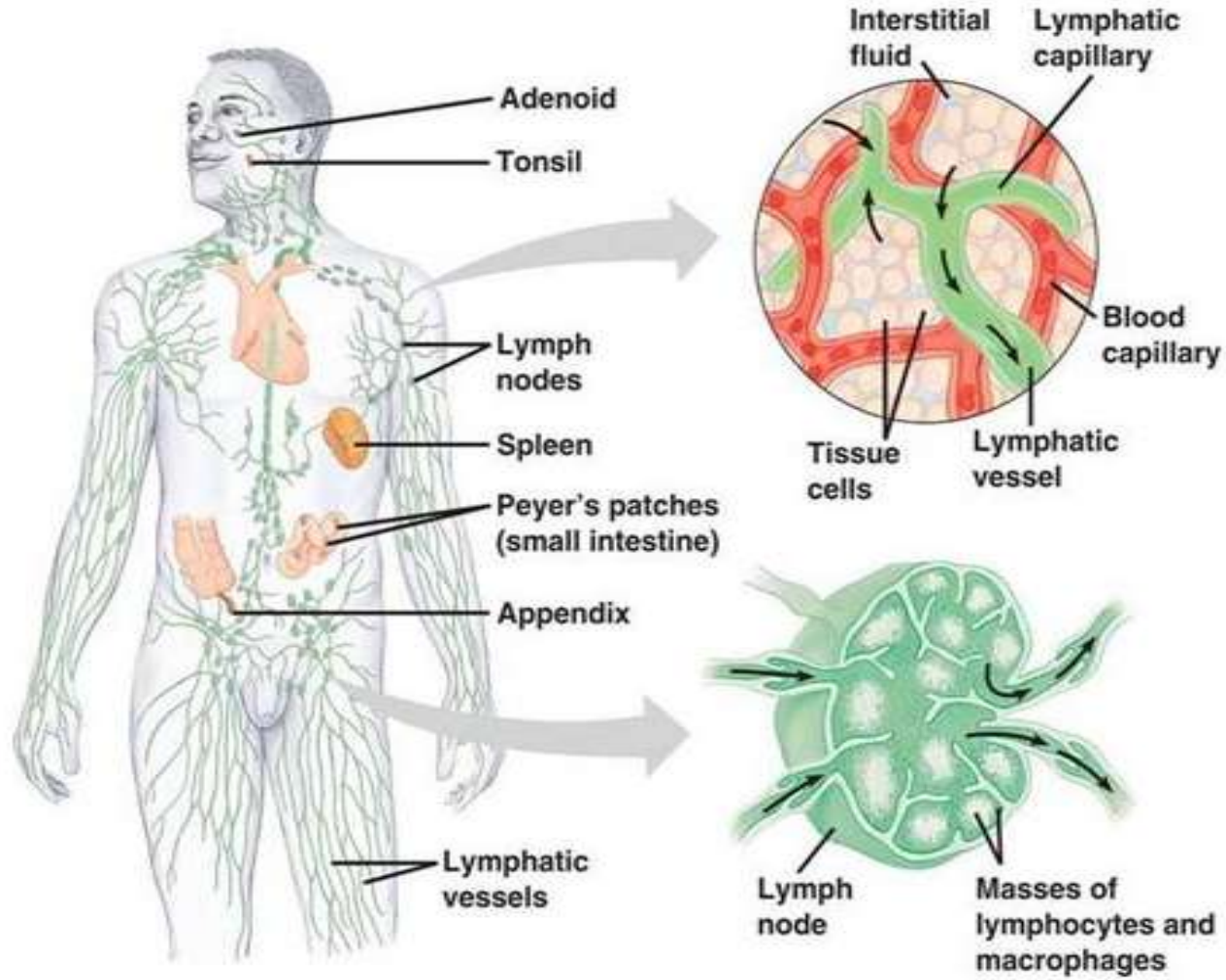


B. Functions

1. *Drains interstitial fluid returns to circulatory system*
2. *Transports lipids, vitamins from GI tract to blood*
3. Protection - uses lymphocytes, lymph organs

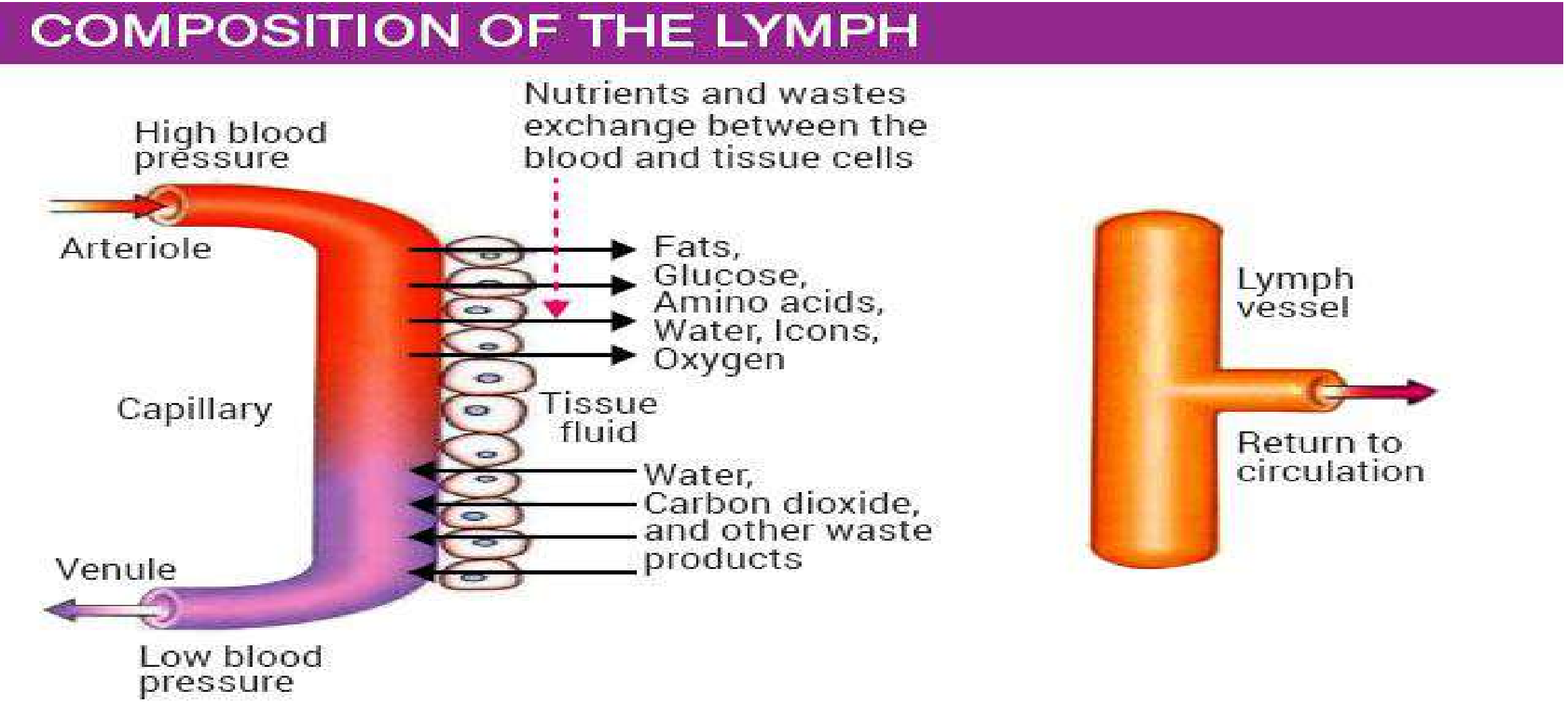
How lymphatic functions occur?

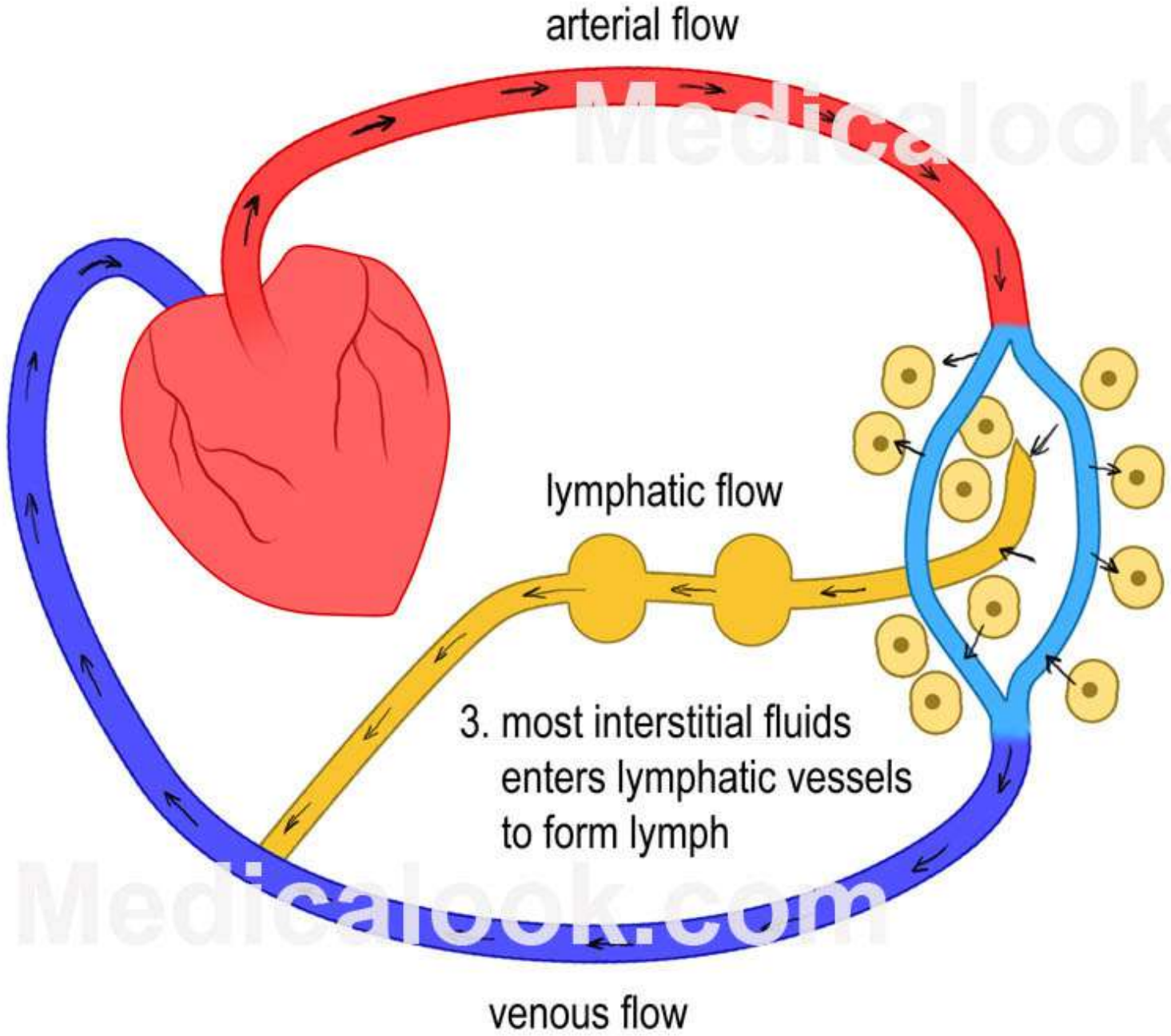
- 1. ***protect from invading organisms***
  - The lymphatic system does this in 3 ways:
    - Lymph nodes filter microorganisms and other foreign substances from the lymph
    - The spleen filters the blood
    - Lymph cells attack and destroy microorganisms



C. Lymph vs. interstitial fluid

1. Same chemical composition (like plasma - less protein), different location.
2. Lymph is in lymph vessels, interstitial is between cell





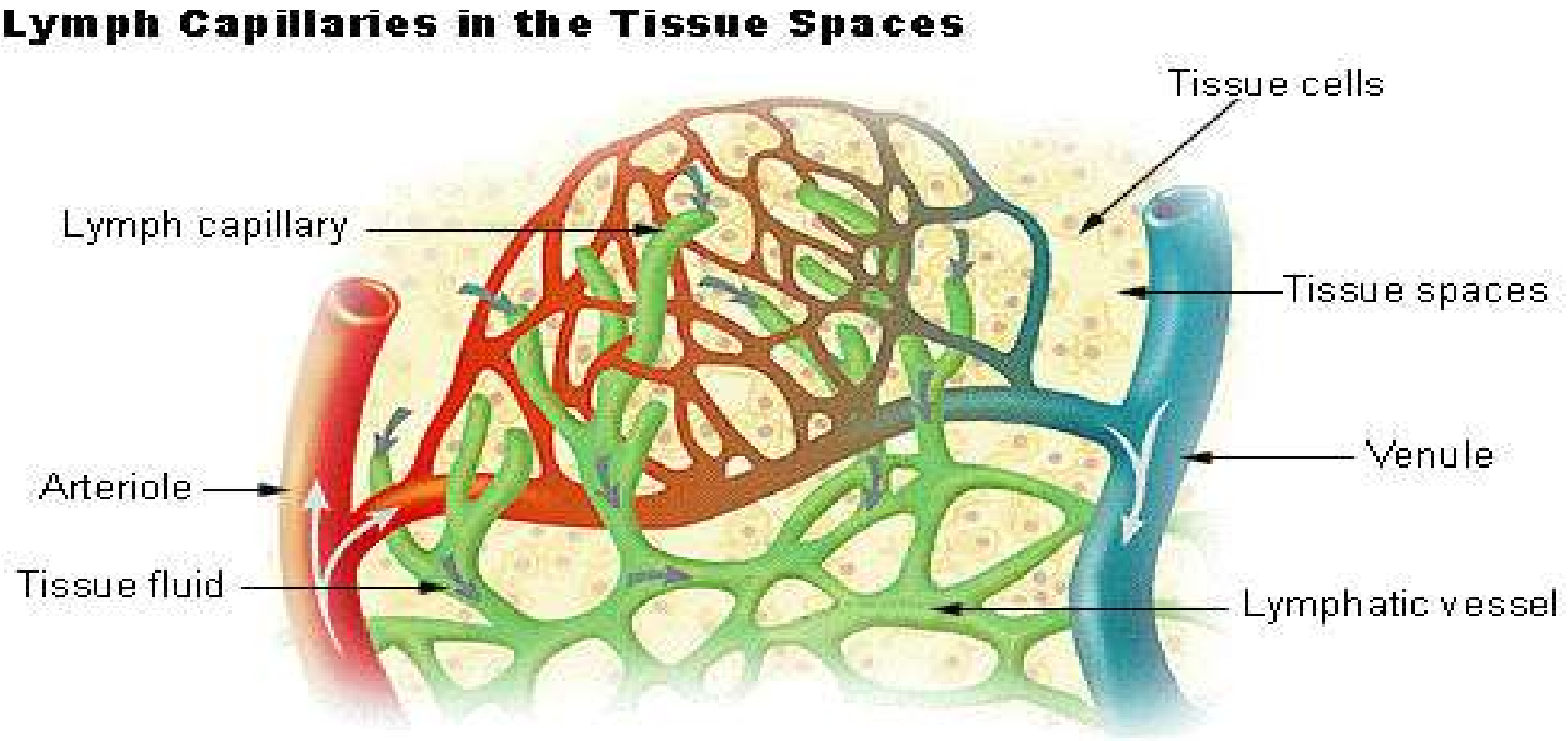
As blood flows into capillaries

1. interstitial fluids form

2. some interstitial fluids returns to the blood

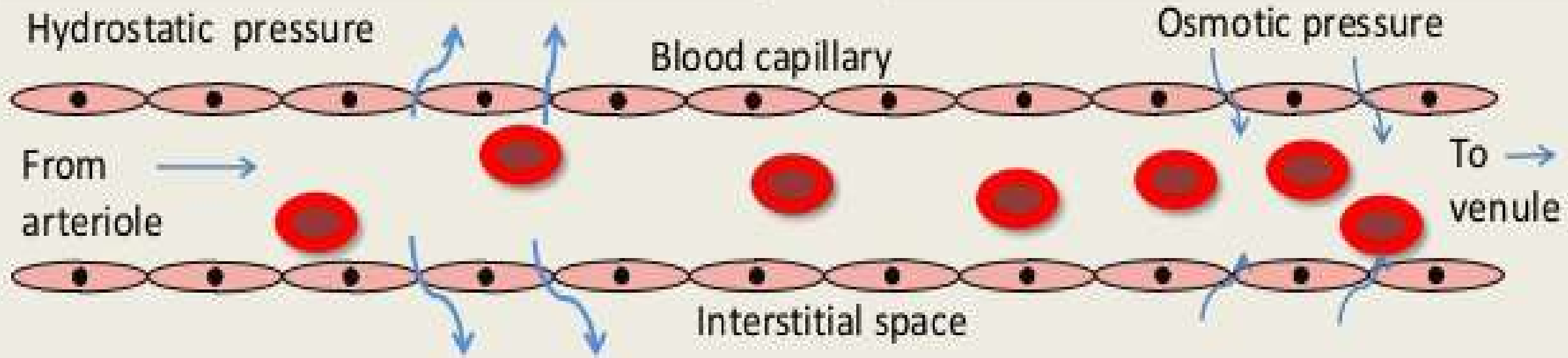
D. **Lymphatic vessels**

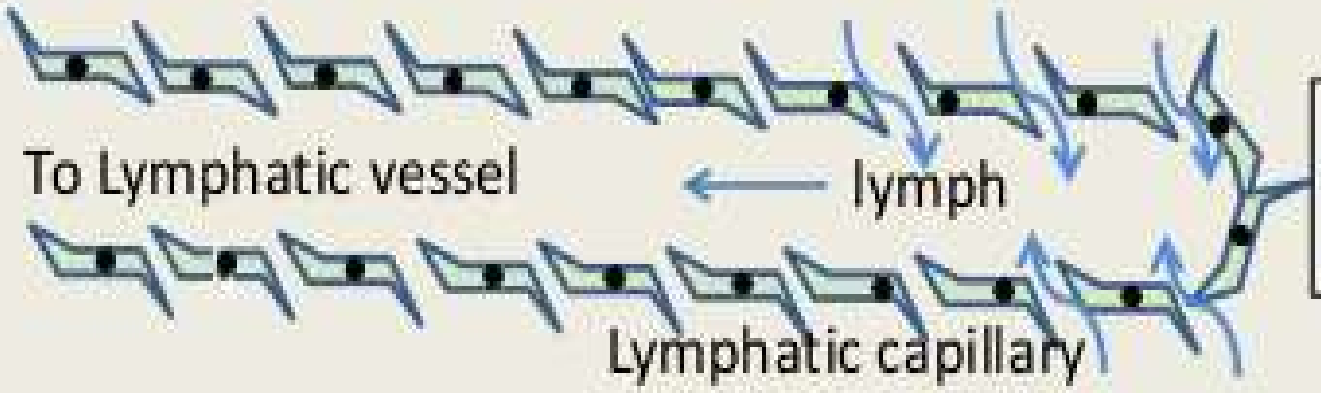
1. Lymphatic capillaries between blood capillaries
2. Interstitial fluid flows into lymphatic capillaries due to a pressure gradient and then, due to an overlapping of the capillary walls, cannot escape



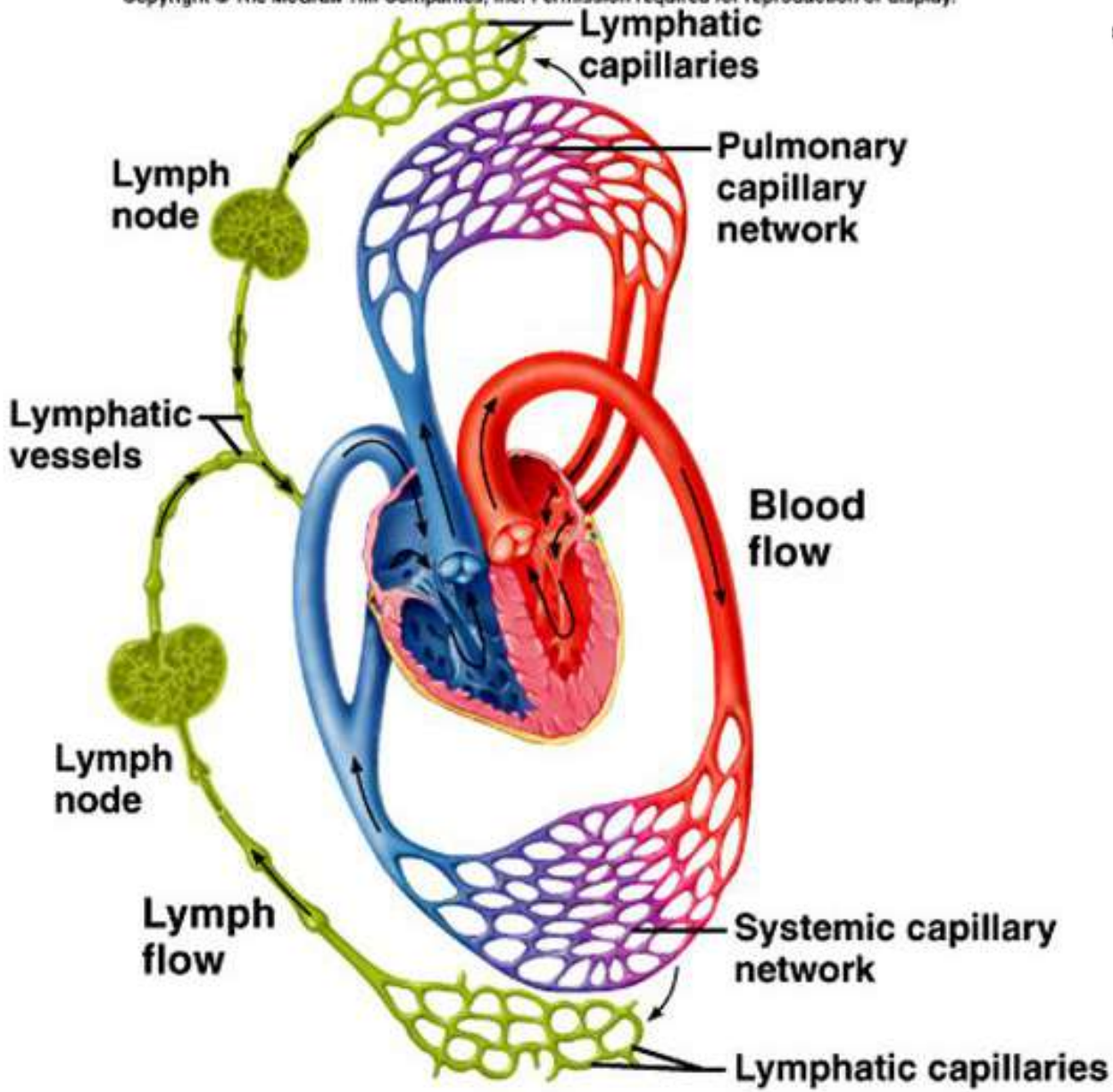
Hydrostatic pressure moves plasma out of blood capillaries into the interstitial space.

Osmotic pressure only reabsorbs some of the lost fluid from interstitial space.





Excess fluid enters through one-way valves



Lymphatic capillary

↓

Lymphatic vessel

↓

Lymph node

↓

Lymphatic vessel

↓

Lymphatic trunk

↓

Collecting duct

↓

Subclavian vein

Know this sequence

D. **Lymphatic vessels**

1. *Lymphatic capillaries between blood capillaries*
2. *Interstitial fluid flows into lymphatic capillaries due to a pressure gradient and then, due to an overlapping of the capillary walls, cannot escape*
3. Lymphatic capillaries contain valves like veins

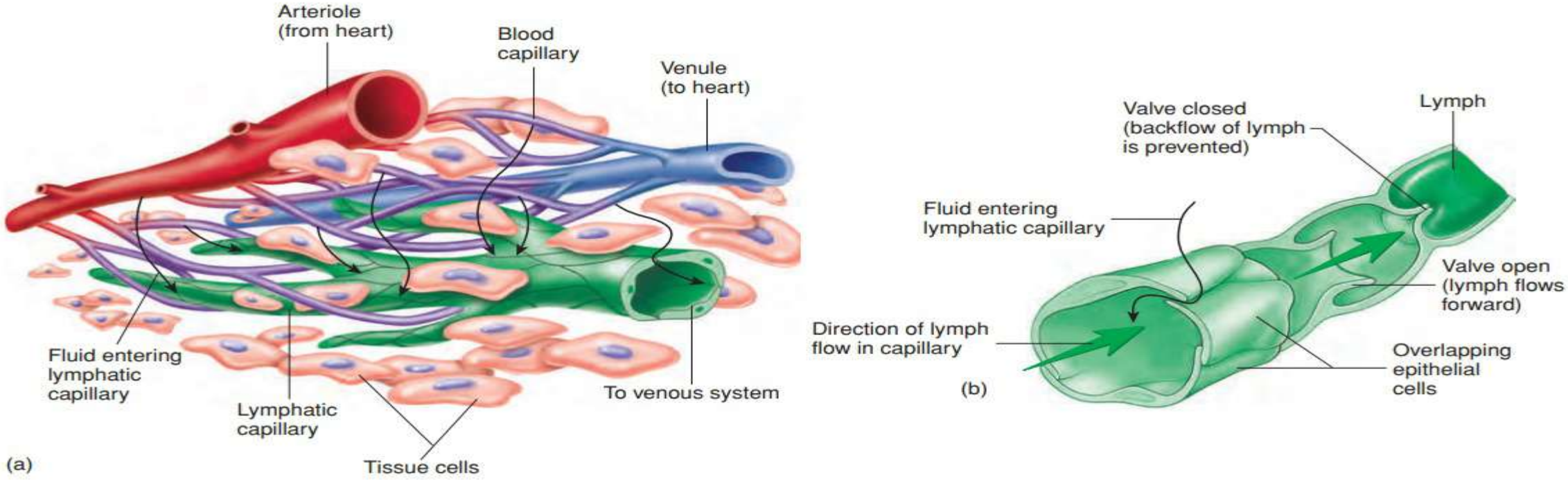
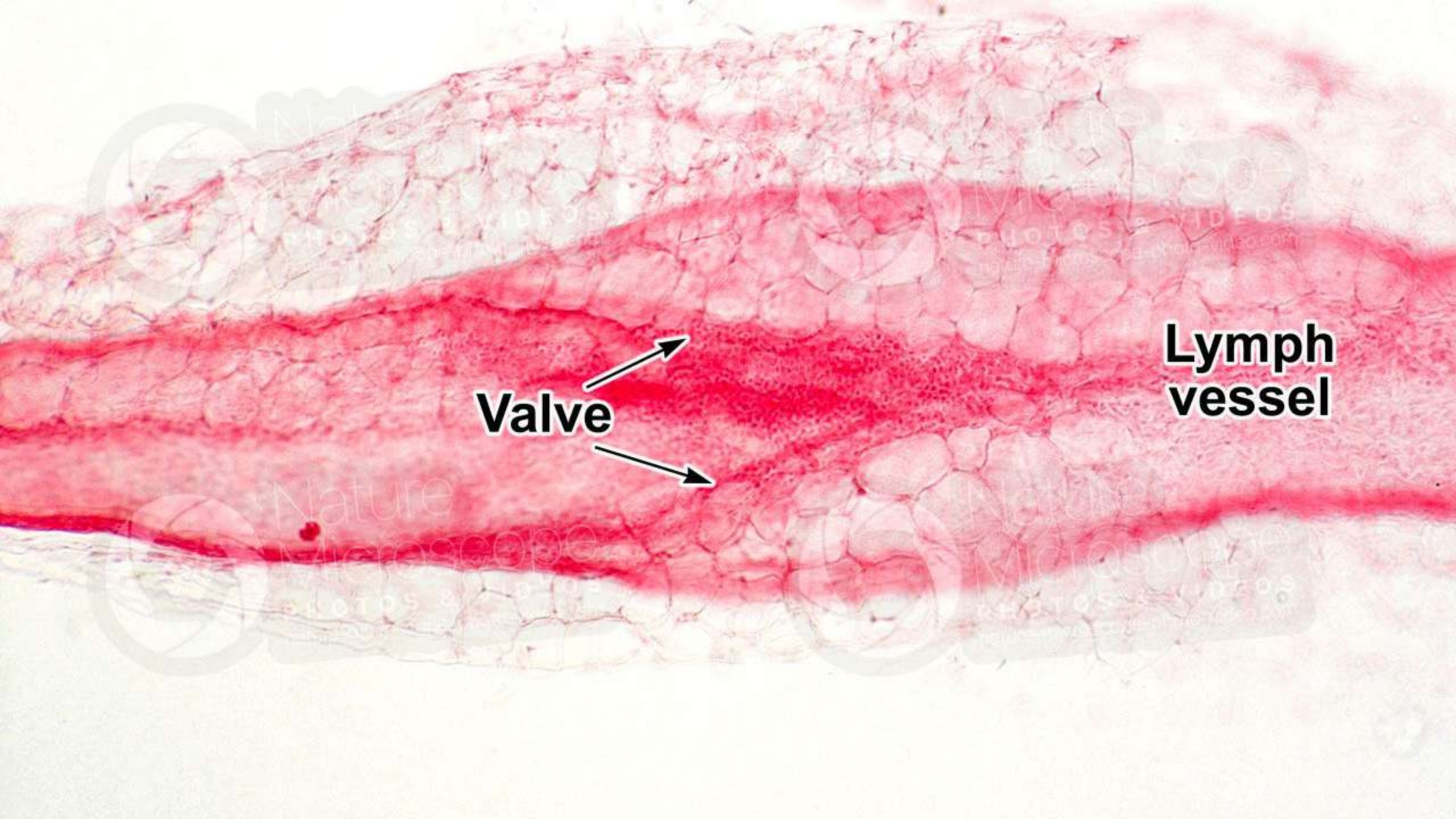
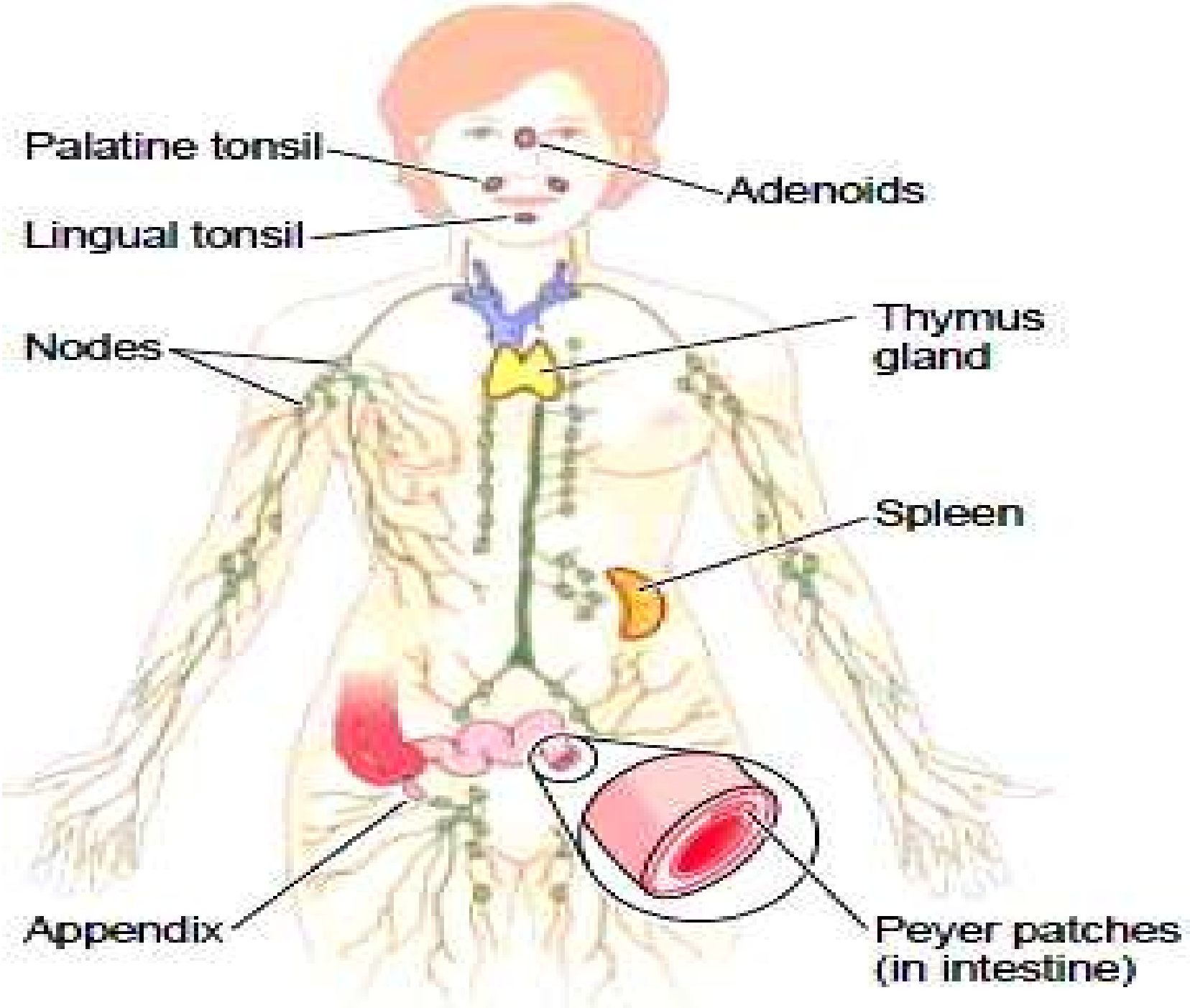


Figure **Lymph Formation and Movement**

(*a*) Fluid moves from blood capillaries into tissues and from tissues into lymphatic capillaries to form lymph. (*b*) The overlap of epithelial cells of the lymphatic capillary allows fluid to enter easily but prevents it from moving back into the tissue. Valves, located farther along in lymphatic vessels, also ensure one-way flow of lymph.


Valve
Lymph vessel

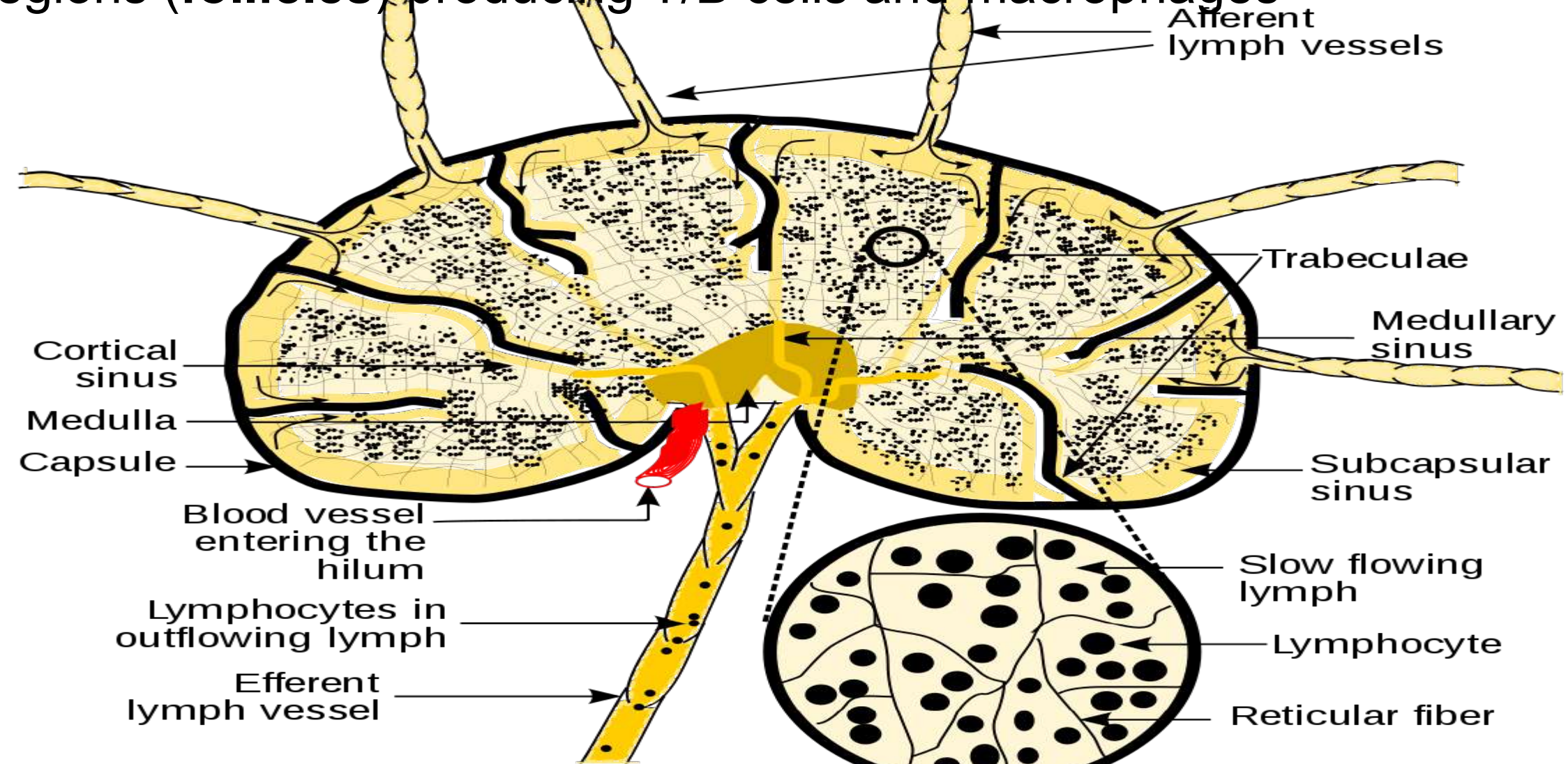
E. Lymphatic tissue
   1. Lymph nodes
   2. Tonsils
   3. Spleen
   4. Thymus



E. Lymphatic tissue

1. **Lymph nodes**

a. Oval shape surrounded by a capsule and divided interiorly into regions (**follicles**) producing T/B cells and macrophages



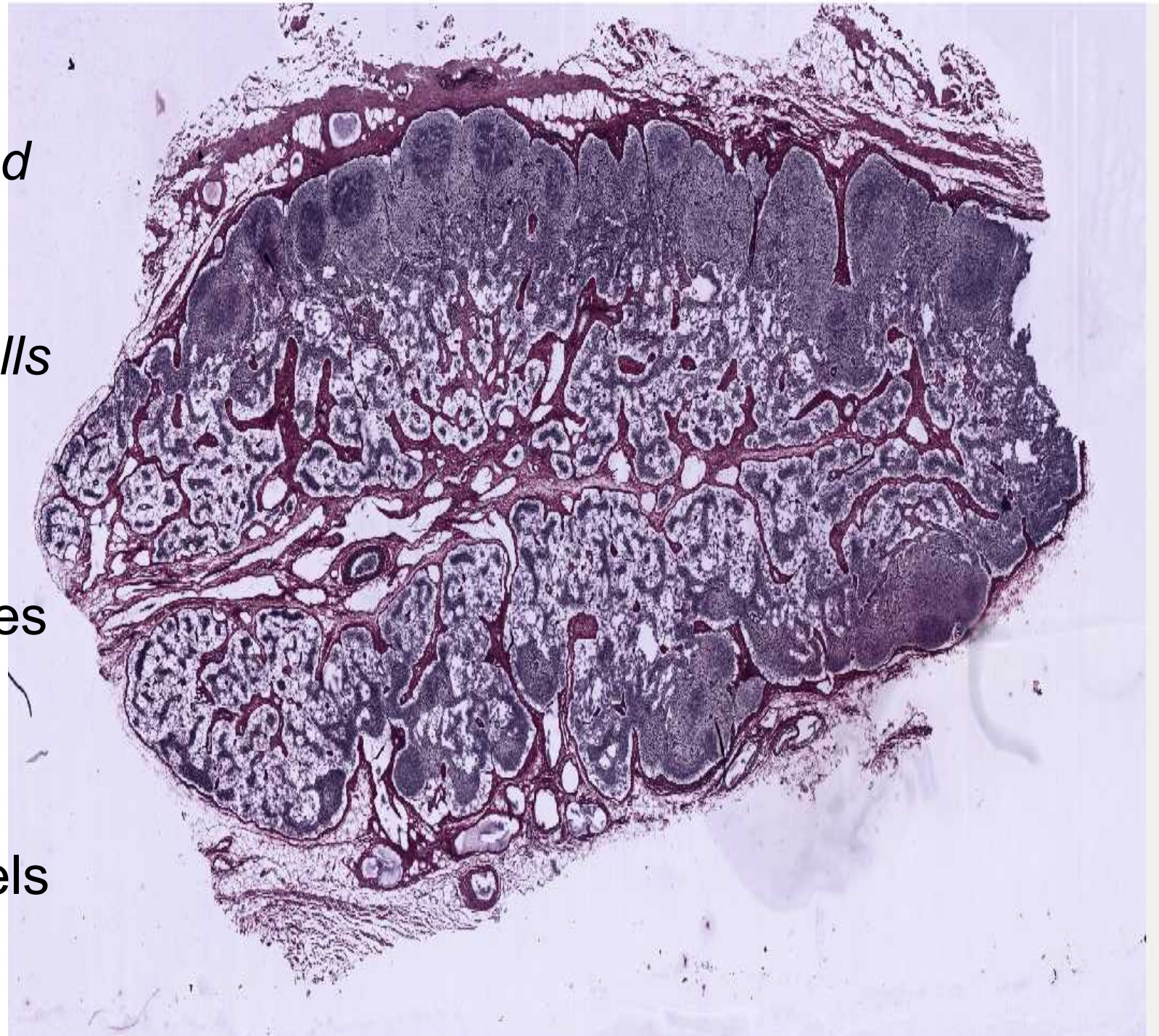
E. Lymphatic tissue

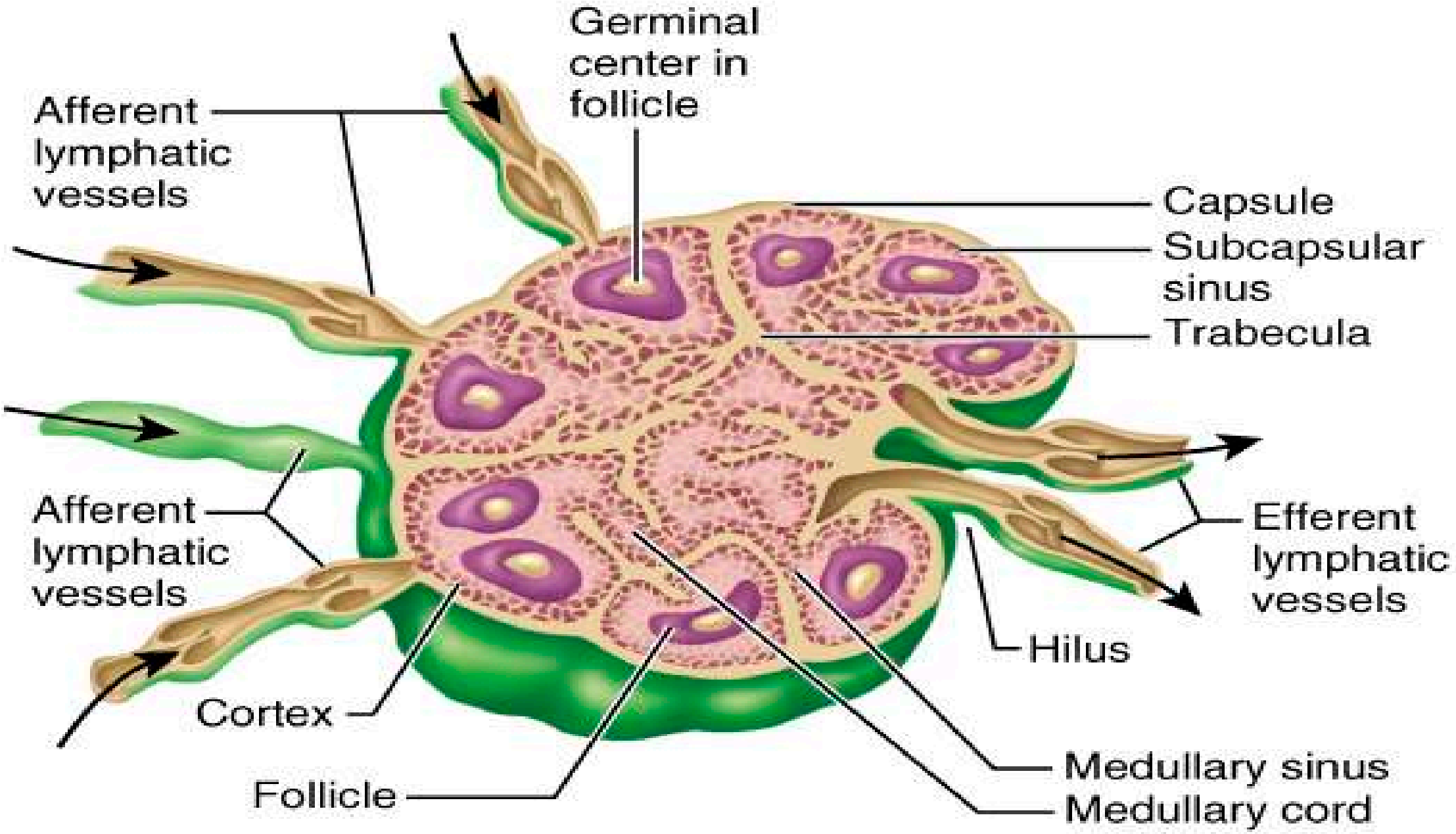
1. **Lymph nodes**

*a. Oval shape surrounded by a capsule and divided interiorly into regions (**follicles**) producing T/B cells and macrophages*

b. Lymph nodes filter the lymph being returned to the blood. Fibers trap substances and the T/B cells or macrophages destroy them

c. Lymph flows into the node through afferent vessels and leaves through efferent vessels





(a)

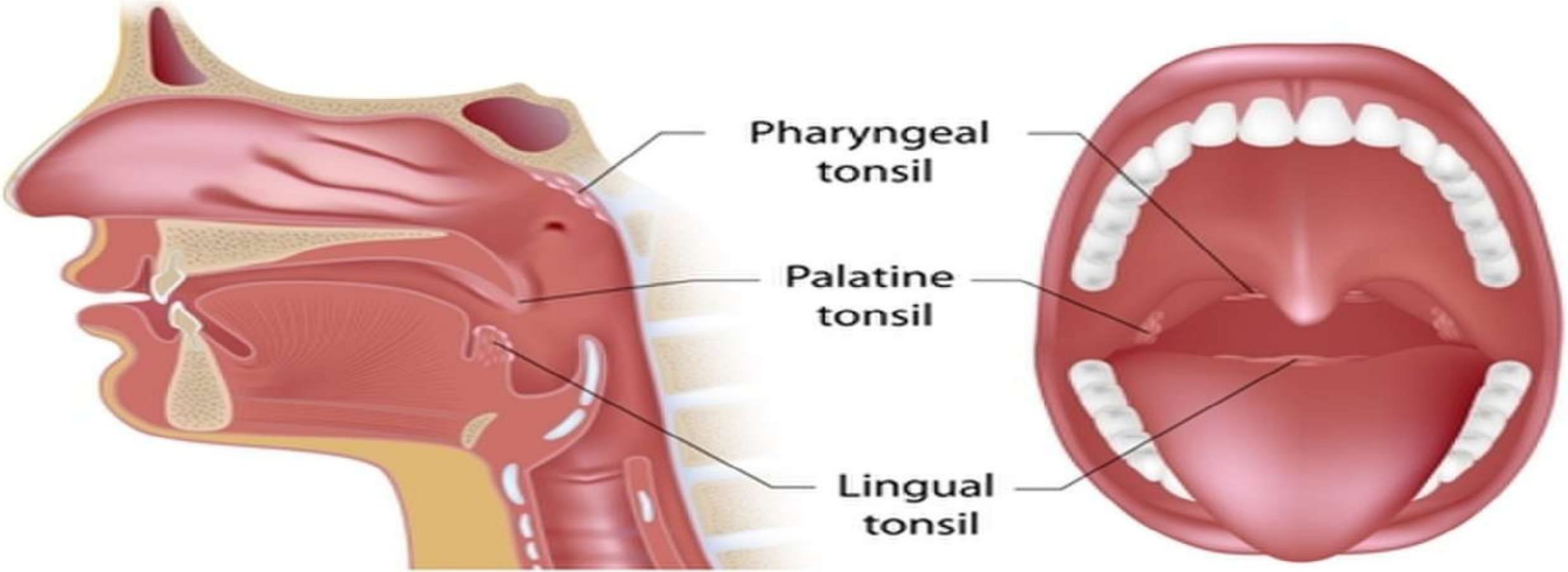
E. Lymphatic tissue

2. **Tonsils**

a. Lymphatic nodes near pharynx

b. Positioned to interpret foreign substances inhaled or swallowed.

c. Contain T/B cells



Tonsils

-Capsule+Trabecula:

Dense connective tissue

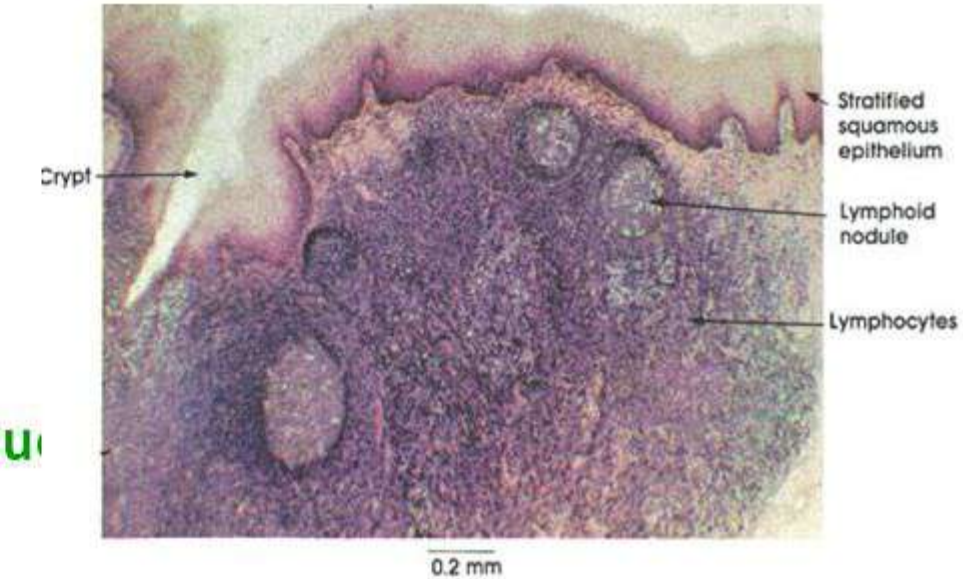
incomplement capsule =
organ Epithelium ,crypt

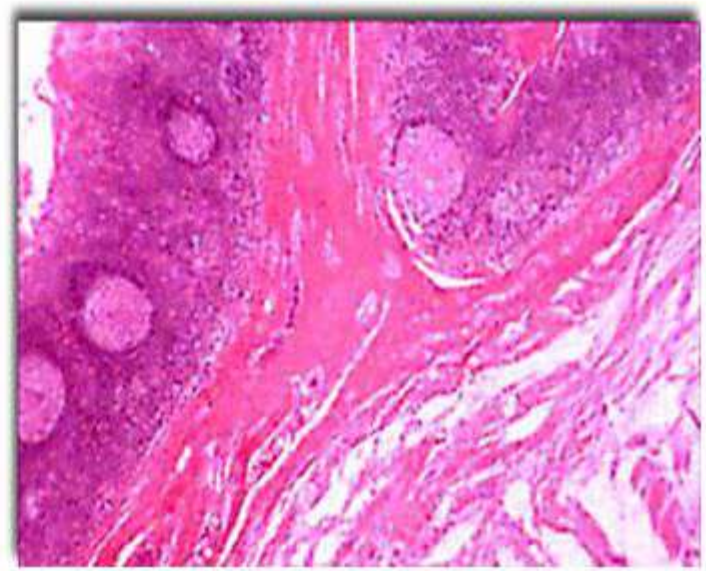
Stoma: Reticular connective tissu

Lymphocyte:

T-cell(Diffuse)

B-cell (lymphoid follicle)

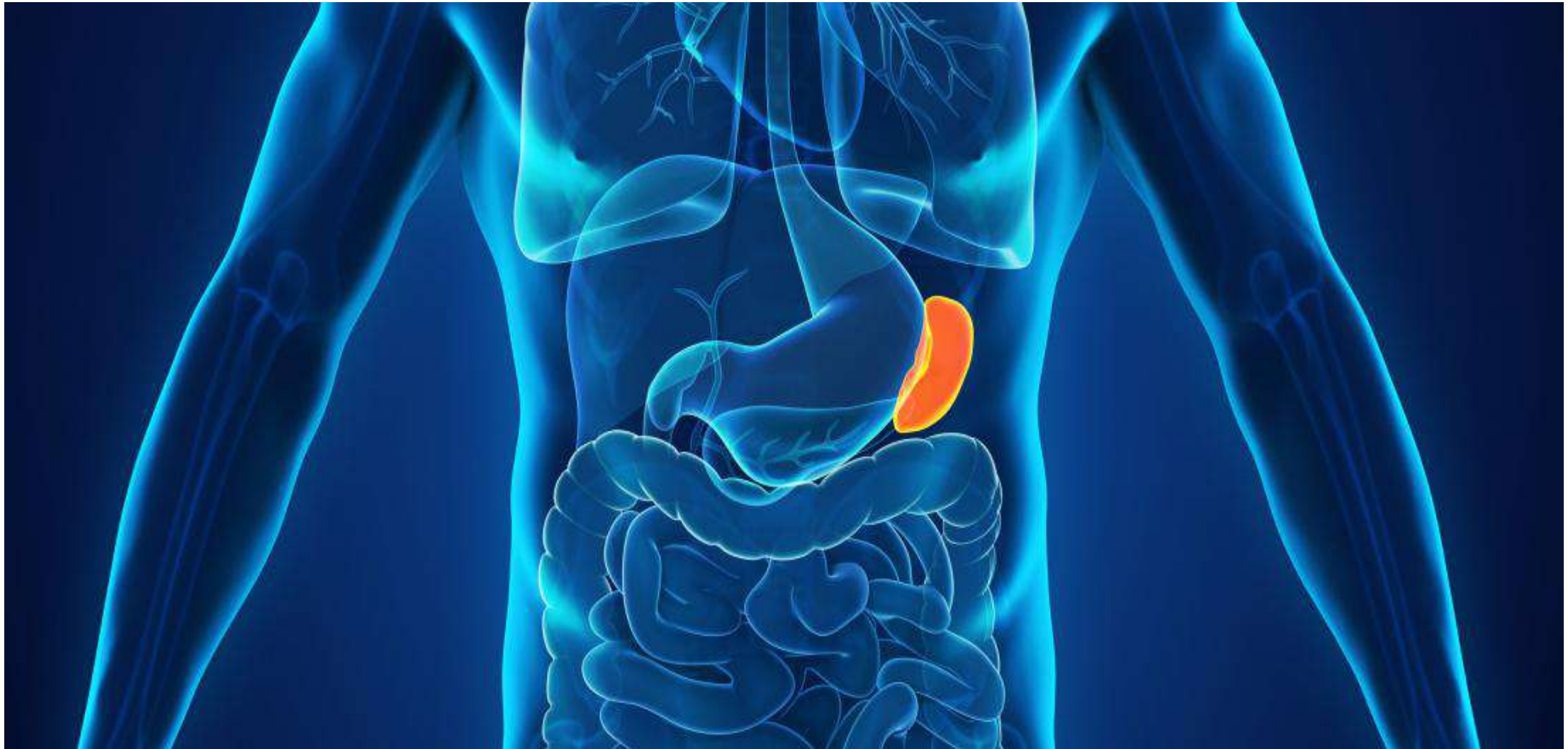




E. Lymphatic tissue

3. **Spleen**

a. Lies between stomach and diaphragm contains plasma cells, RBC, macrophages and leukocytes



Structure of the spleen

White pulp(20%)

Reticular stroma that contains next parenchimatous elements - lymphocytes, monocytes, plasma cells and macrophages, which are forming :

- 1. Periarterial lymphatic sheath.
- 2. Lymphoid nodules.
- 3. Ellipsoids.

Red pulp(80%)

Reticular stroma that contains that contains next parenchimatous elements :

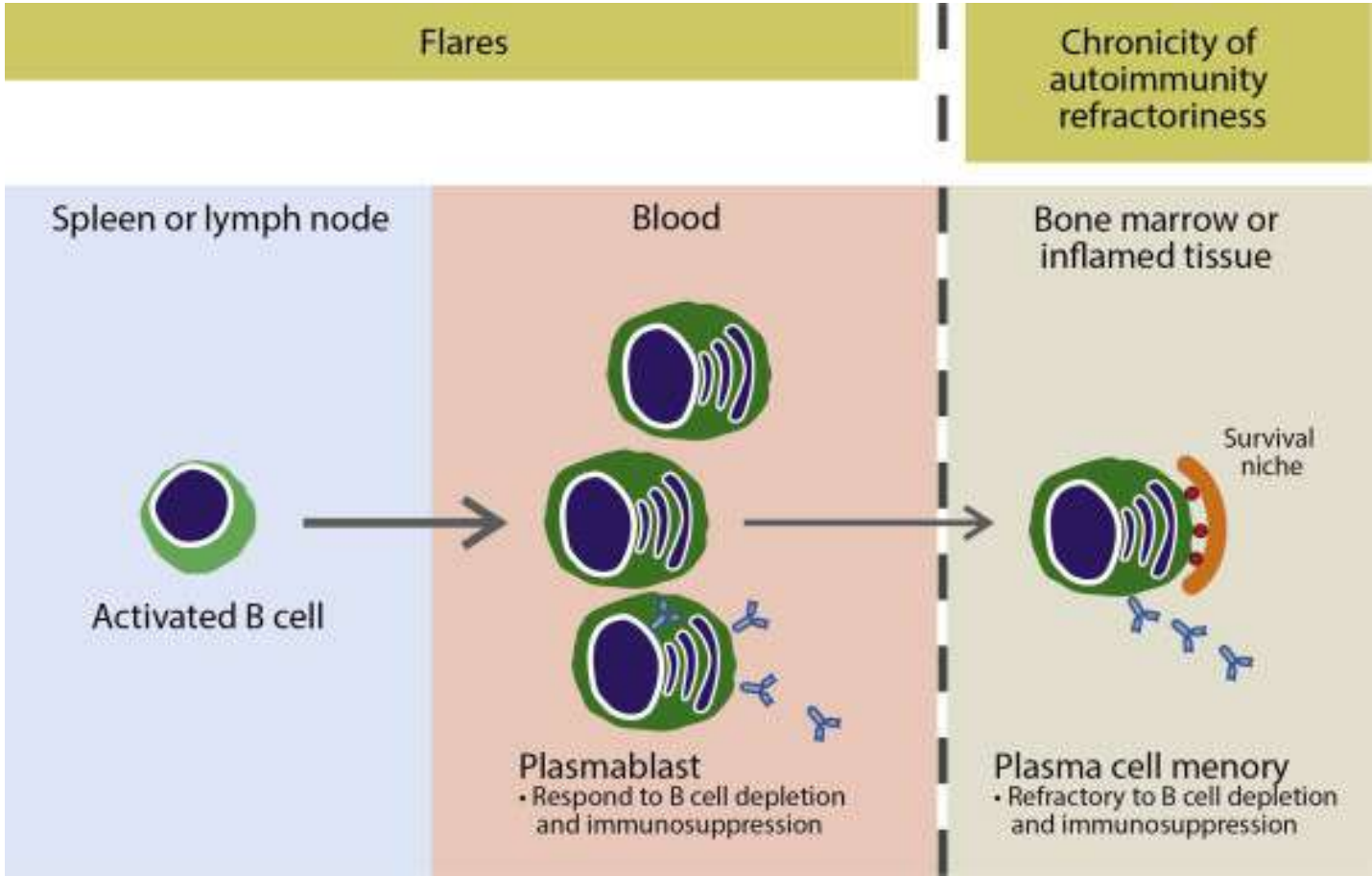
- Red blood cells, white blood cells, lymphocytes.
- Large number of macrophages.
- Plasma cells.
- Vascular system of sinuses.

E. Lymphatic tissue

3. **Spleen**

a. Lies between stomach and diaphragm contains plasma cells, RBC, macrophages and leukocytes

b. Does not filter lymph. Site of B cell proliferation into antibody producing plasma cells



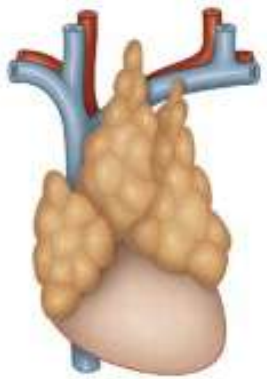
E. Lymphatic tissue

4. **Thymus**

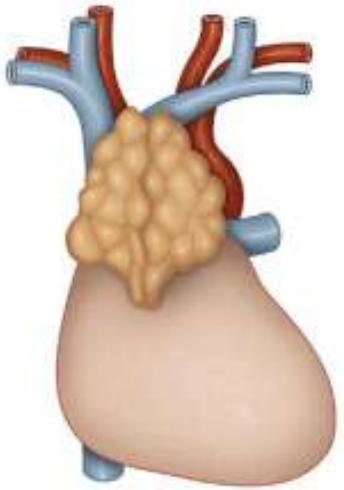
a. Behind sternum, between lungs contains T cells, macrophages

b. Grows until puberty, then atrophies

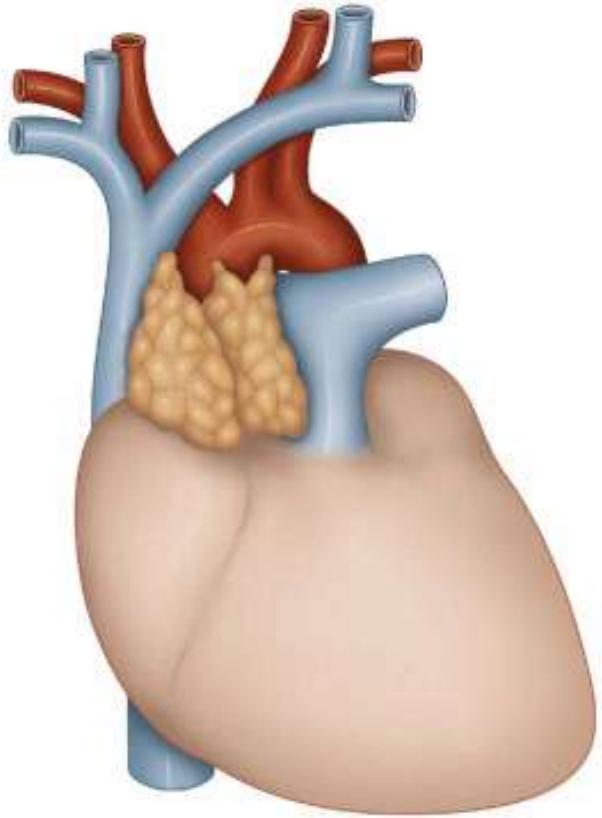
c. Produces and distributes T cells



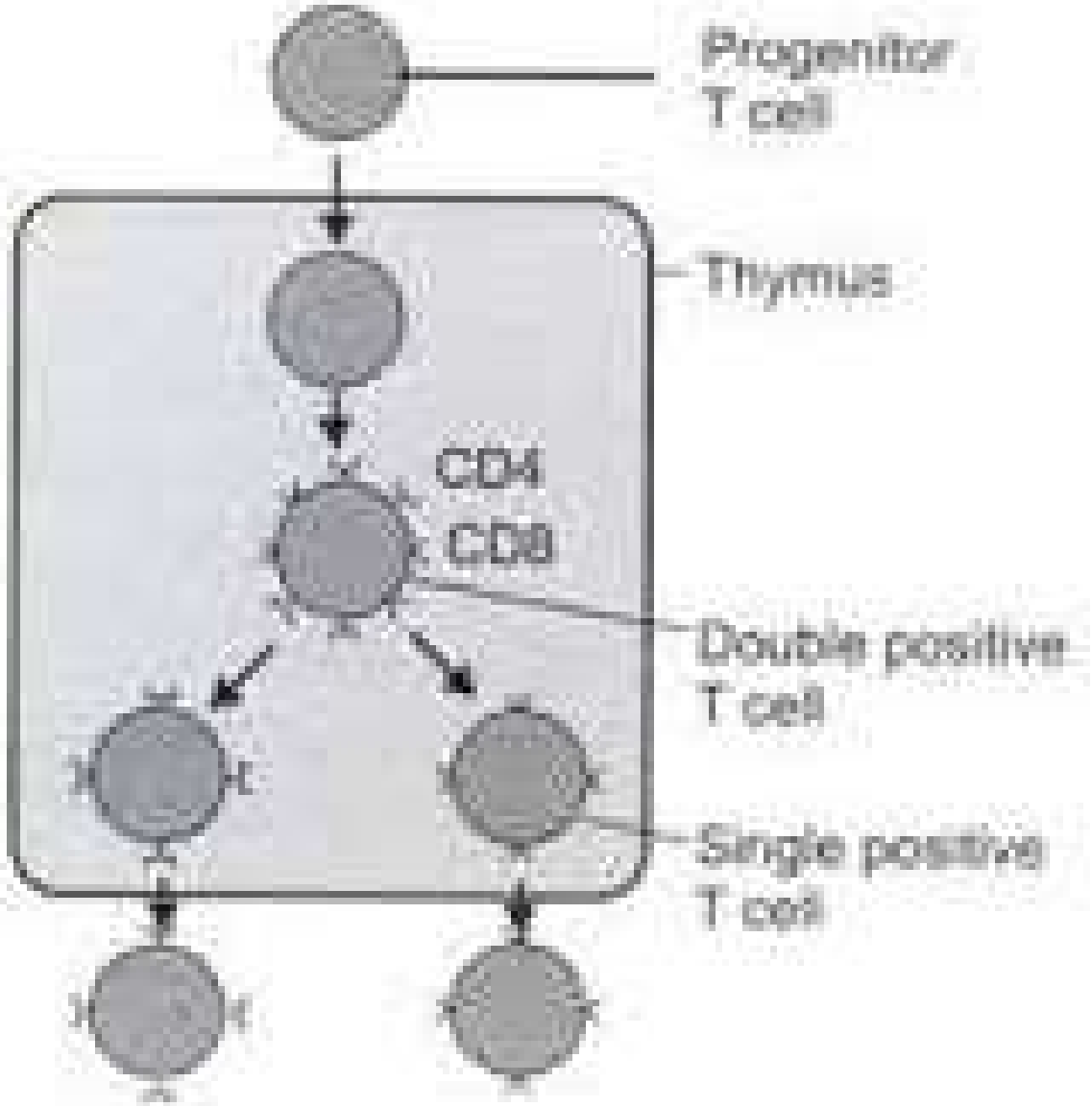
Thymus in a newborn.



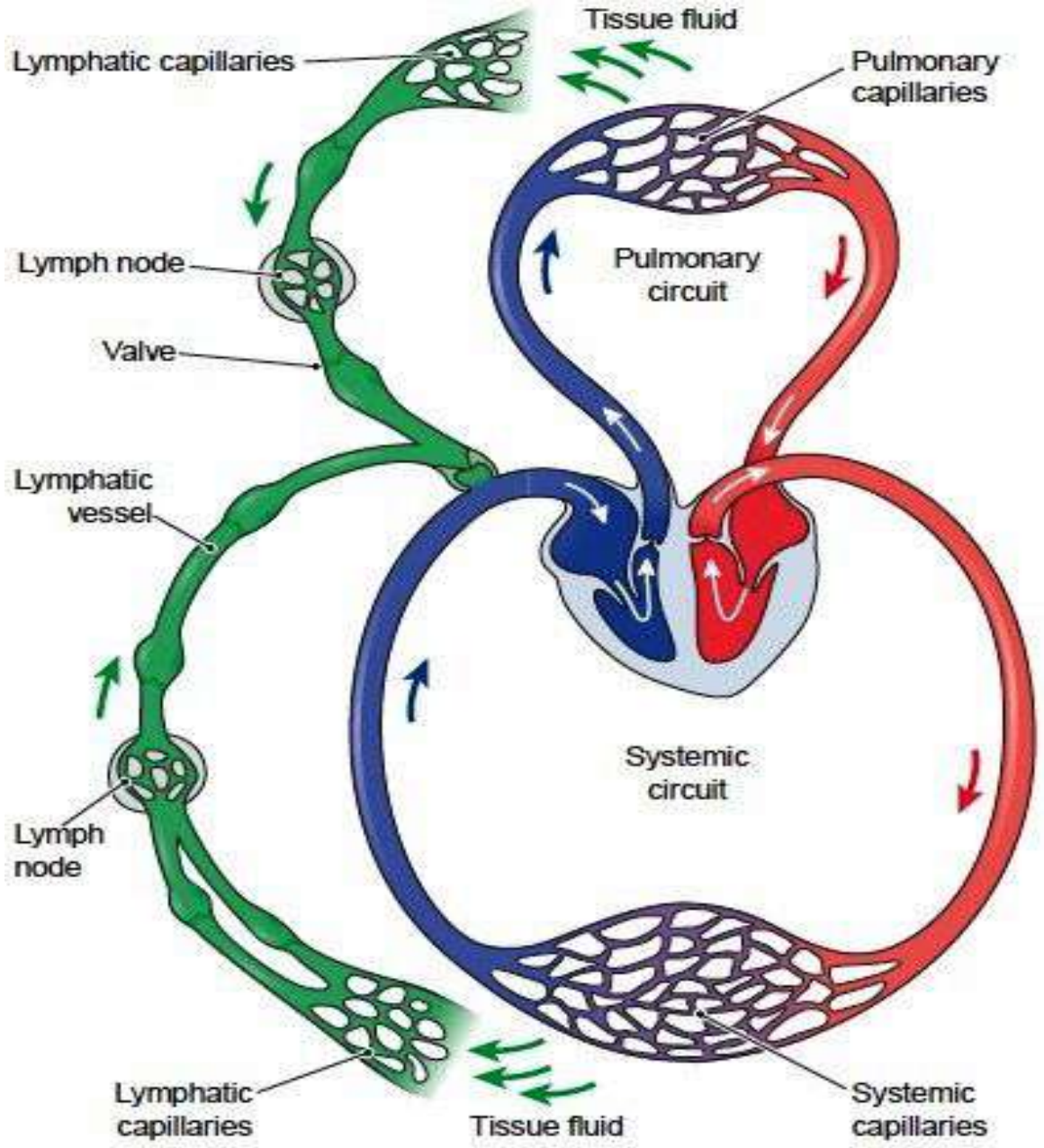
Thymus in a 2-year-old child.

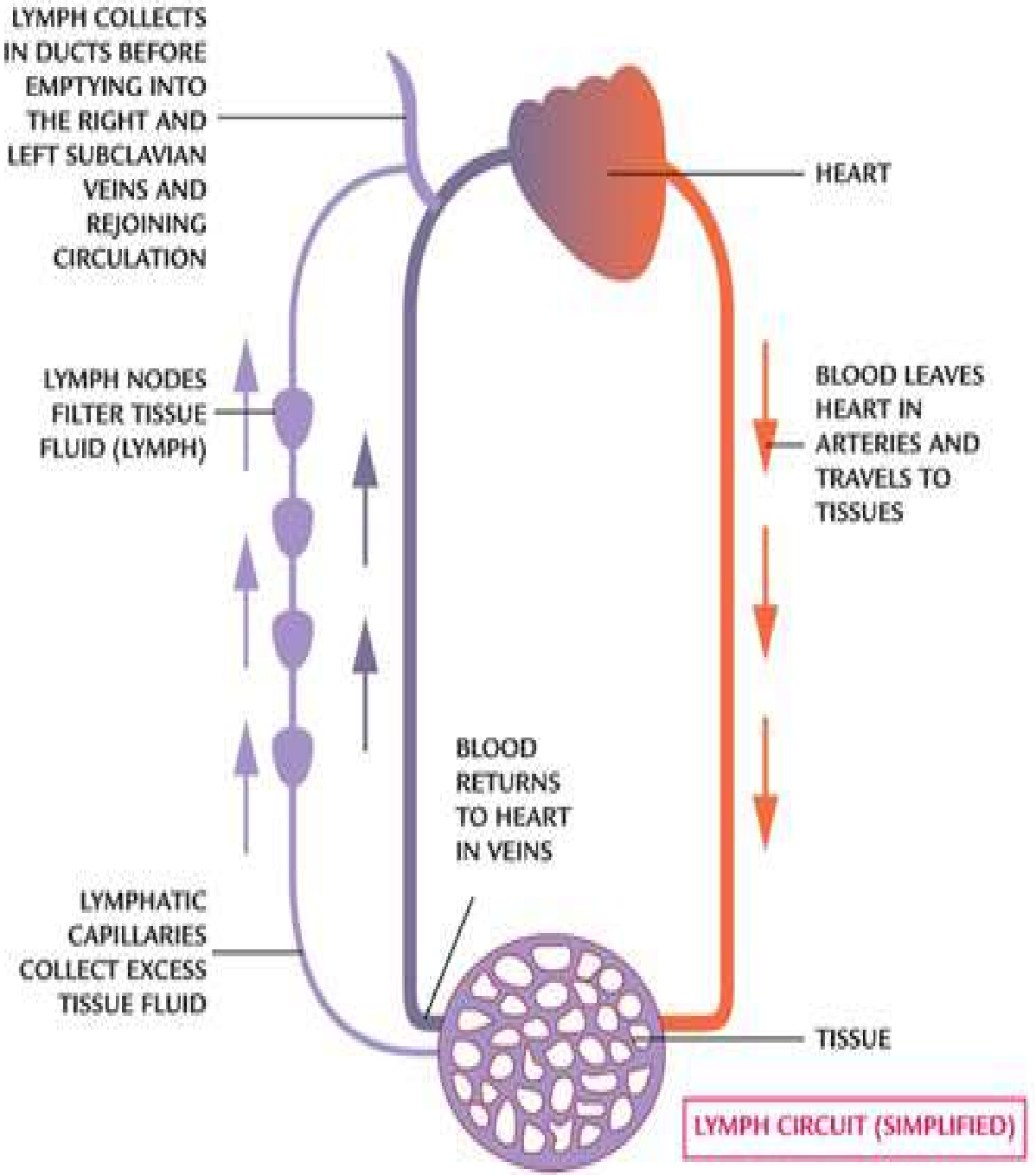


Thymus in an adult


Progenitor
T cell
Thymus
CD4
CD8
Double positive
T cell
Single positive
T cell
Mature CD4+ CD8−
T Cell (Helper T-cell)
Mature CD4− CD8+
T Cell (Cytotoxic T-cell)

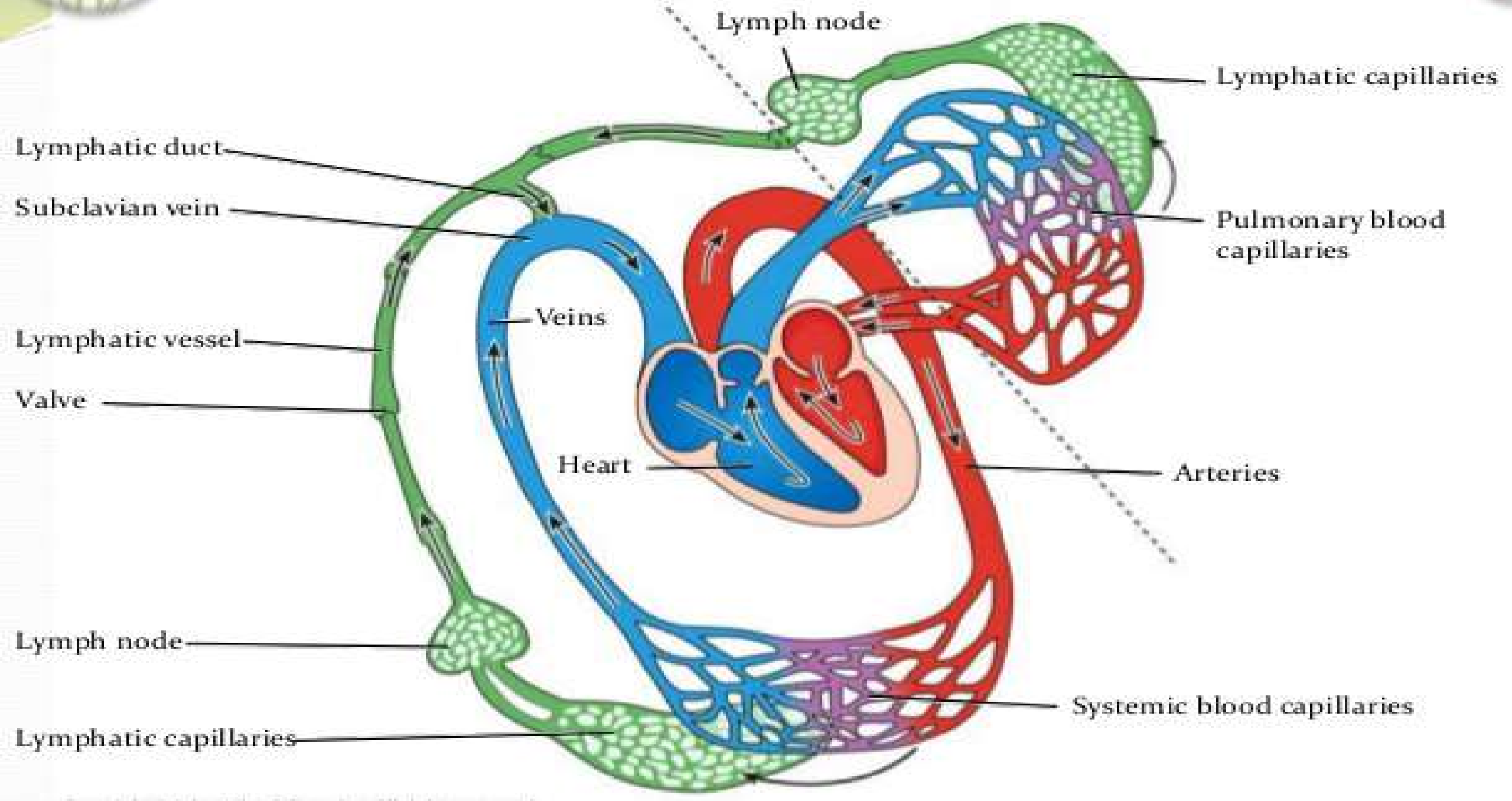
F. Lymph circulation





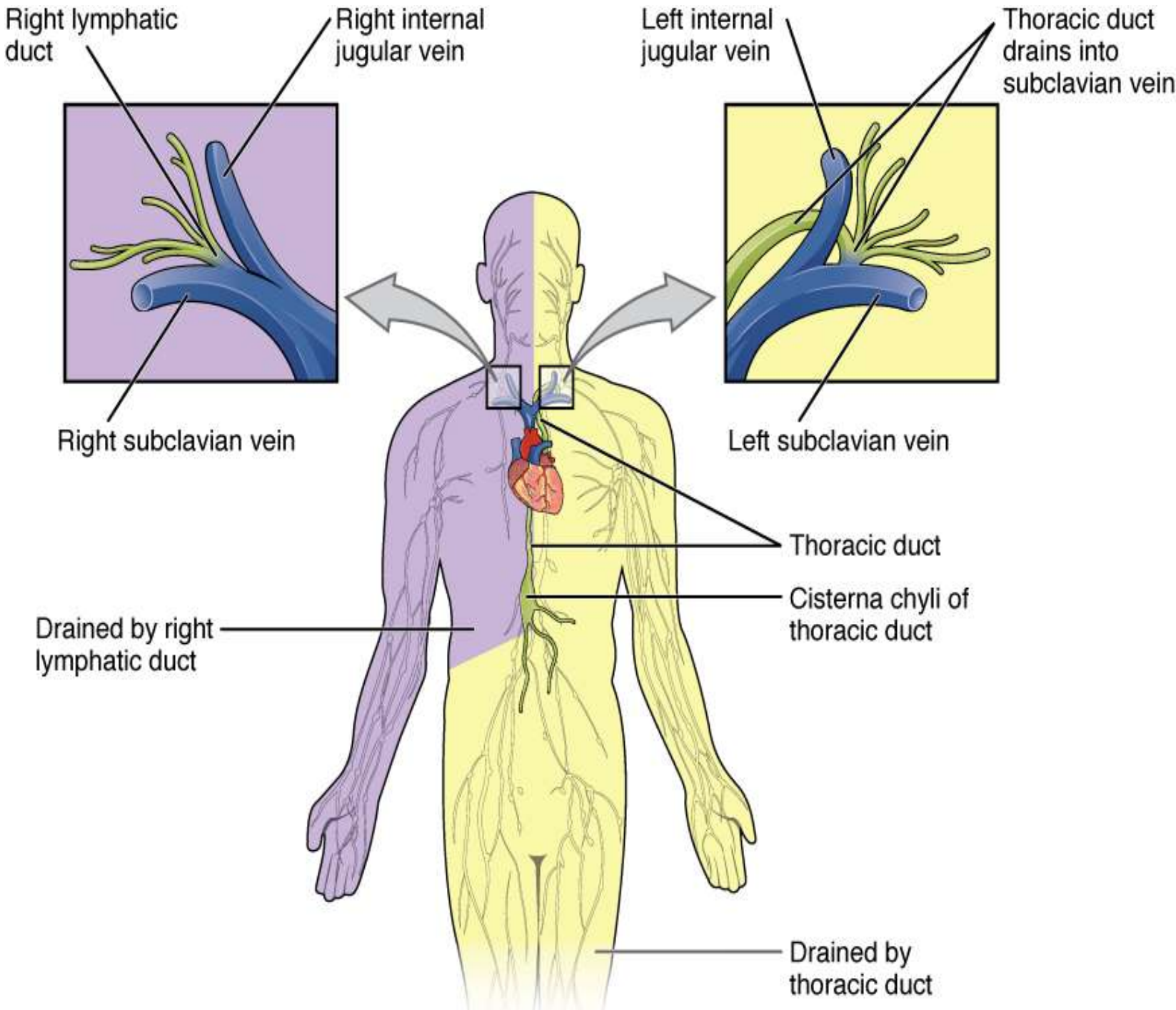
SYSTEMIC CIRCULATION

PULMONARY CIRCULATION



F. Lymph circulation

1. heart → artery → capillary → cells (interstitial fluid) → lymphatic capillaries → lymphatic vessels → lymph node → lymph trunks → **thoracic duct** (lymph from top left side/al lower body) → **Left jugular/subclavian** **OR** **right lymphatic duct** (right top side) → **right jugular/subclavian** → **superior vena cava** → heart



F. Lymph circulation

1. *heart → artery → capillary → cells (interstitial fluid) → lymphatic capillaries → lymphatic vessels → lymph node → lymph trunks →* ***thoracic duct*** *(lymph from top left side/all lower body)* ***→ Left jugular/subclavian*** *OR* ***right lymphatic duct*** *(right top side) →* ***right jugular/subclavian →*** ***superior vena cava → heart***

2. Flow is maintained by skeletal muscle movement and/or respiratory movement

G. Nonspecific resistance to disease

1. One function of the lymphatic system is protection against **pathogens** (disease producers). The ability to do so is called **resistance**. **Nonspecific resistance** is a general response by the body to counteract many pathogens.

Host Defenses

Nonspecific Resistance		Specific Resistance (Responses of the Immune System, Chapter 17)
First line of defense	**Second line of defense**	**Third line of defense**
• Intact skin • Mucous membranes and their secretions • Normal microbiota	• Phagocytic white blood cells • Inflammation • Fever • Antimicrobial substances	• Specialized lymphocytes: B cells and T cells • Antibodies

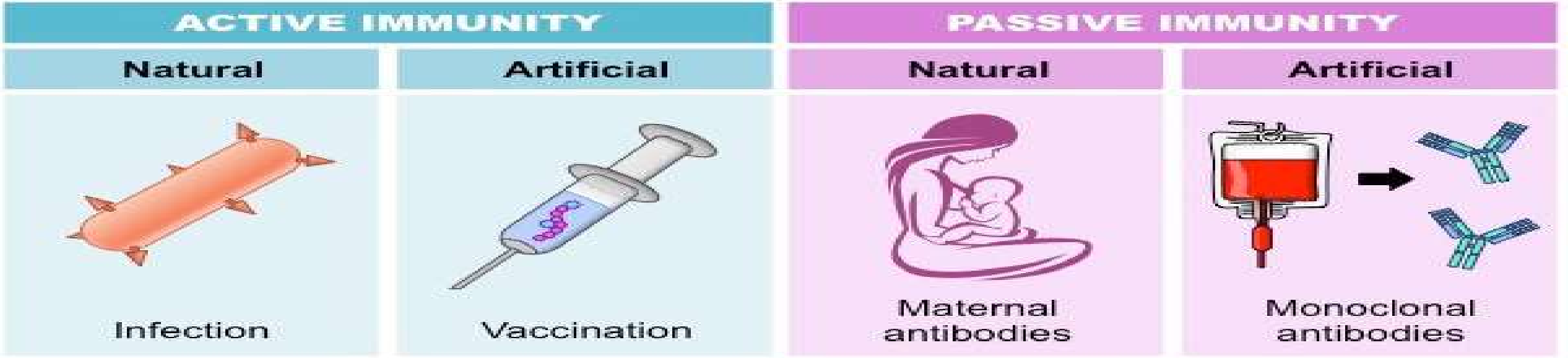
Exhibit 17.1 Summary of Nonspecific Resistance

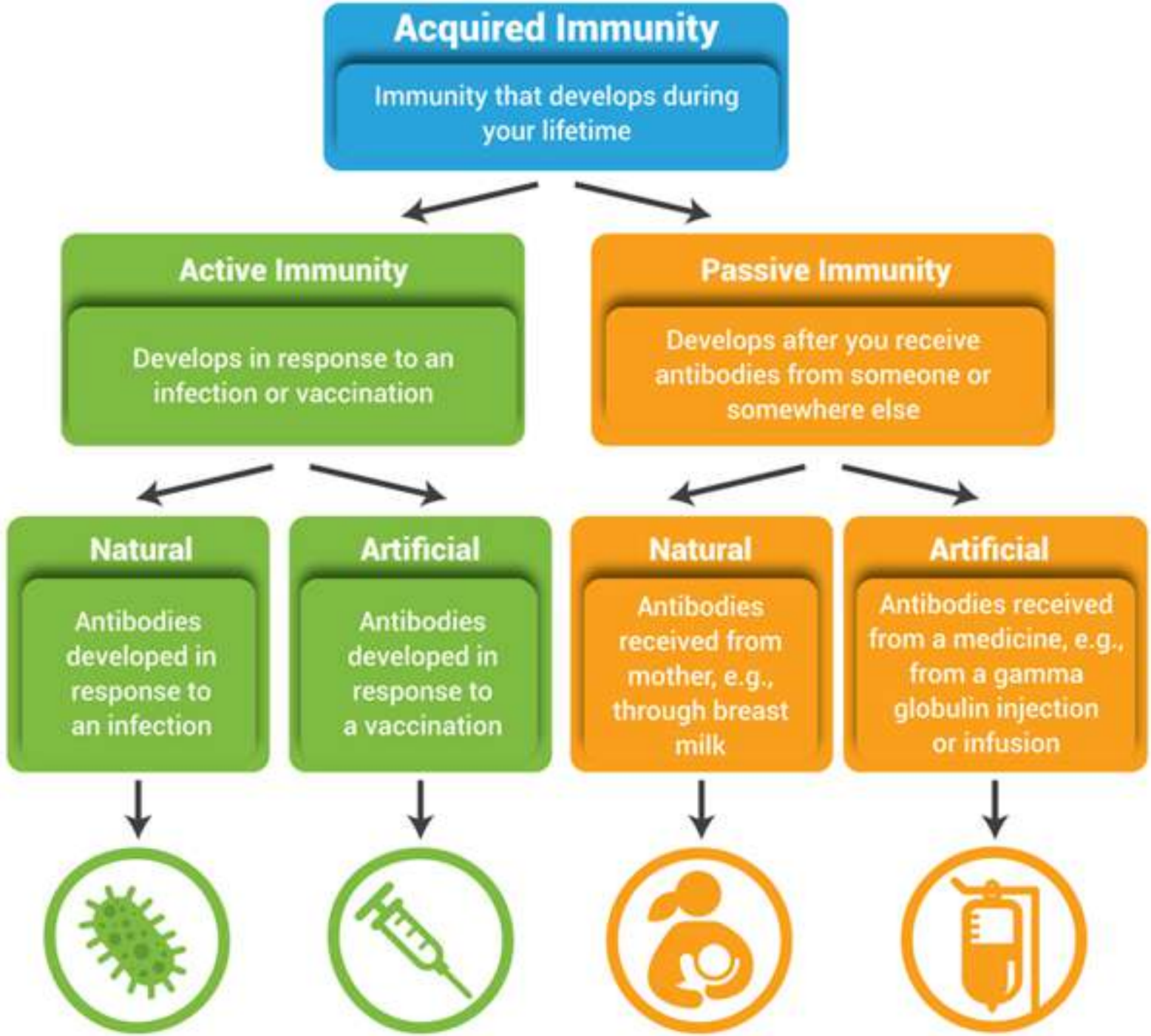
COMPONENT	FUNCTIONS
SKIN AND MUCOUS MEMBRANES	
MECHANICAL FACTORS	
Epidermis of skin	Forms a physical barrier to the entrance of microbes.
Mucous membranes	Inhibit the entrance of many microbes, but not as effective as intact skin.
Mucus	Traps microbes in respiratory and gastrointestinal tracts.
Hairs	Filter out microbes and dust in nose.
Cilia	Together with mucus, trap and remove microbes and dust from upper respiratory tract.
Epiglottis	Prevents microbes and dust from entering lower respiratory tract.
Lacrimal apparatus	Tears dilute and wash away irritating substances and microbes.
Saliva	Washes microbes from surfaces of teeth and mucous membranes of mouth.
Urine	Washes microbes from urethra.
Defecation and vomiting	Expel microbes from body.
CHEMICAL FACTORS	
Sebum	Forms protective oily film on skin.
Acid pH of skin	Discourages growth of many microbes.
Lysozyme	Antimicrobial substance in perspiration, tears, saliva, nasal secretions, and tissue fluids.
Vaginal secretions	Highly acidic secretions that discourage bacterial growth.
Gastric juice	Destroys bacteria and most toxins in stomach.
ANTIMICROBIAL SUBSTANCES	
Interferons (IFNs)	Protect uninfected host cells from viral infection.
Complement	Causes cytolysis of microbes, promotes phagocytosis, and contributes to inflammation.
NATURAL KILLER (NK) CELLS	Kill a wide variety of microbes and certain tumor cells.
PHAGOCYTOSIS	Ingestion of foreign matter by neutrophils and macrophages.
INFLAMMATION	Confines and destroys microbes and initiates tissue repair.
FEVER	Inhibits growth of some microbes and speeds up body reactions that aid repair.

Immunity - The response of the body to destroy a specific pathogen.

A. **Acquired immunity** - immunity granted to the body by prior contact with that pathogen

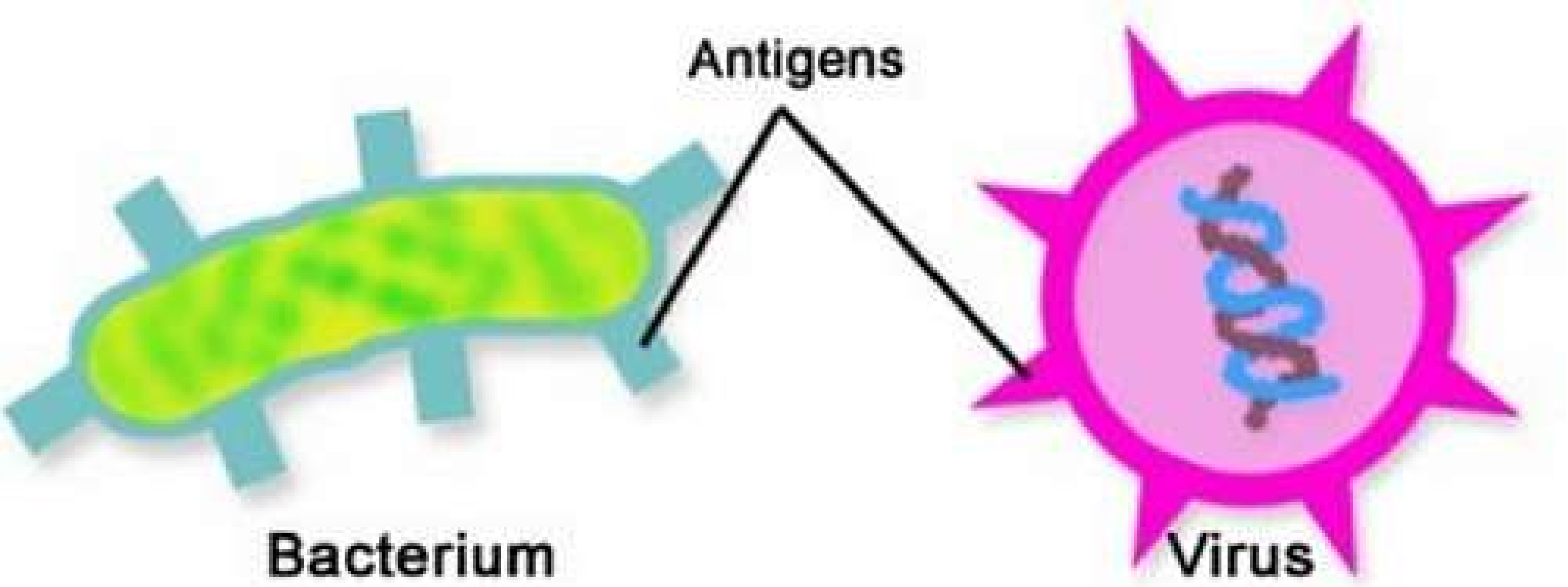
1. **Naturally acquired active immunity** person becomes sick and survives.
2. **N. acquired passive immunity** - immunity is passed from one person to another Ex - mother to child through placenta or breast milk.
3. **A. acquired active i**mmunity - from vaccination with the pathogen
4. **Artificially acquired passive immunity** - injection of antibodies



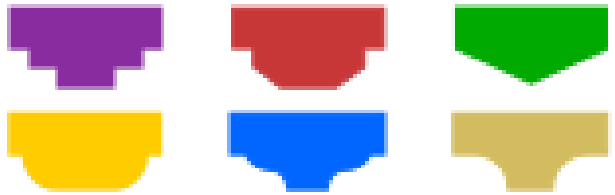

Acquired Immunity
Immunity that develops during your lifetime
Active Immunity
Develops in response to an infection or vaccination
Passive Immunity
Develops after you receive antibodies from someone or somewhere else
Natural
Antibodies developed in response to an infection
Artificial
Antibodies developed in response to a vaccination
Natural
Antibodies received from mother, e.g., through breast milk
Artificial
Antibodies received from a medicine, e.g., from a gamma globulin injection or infusion

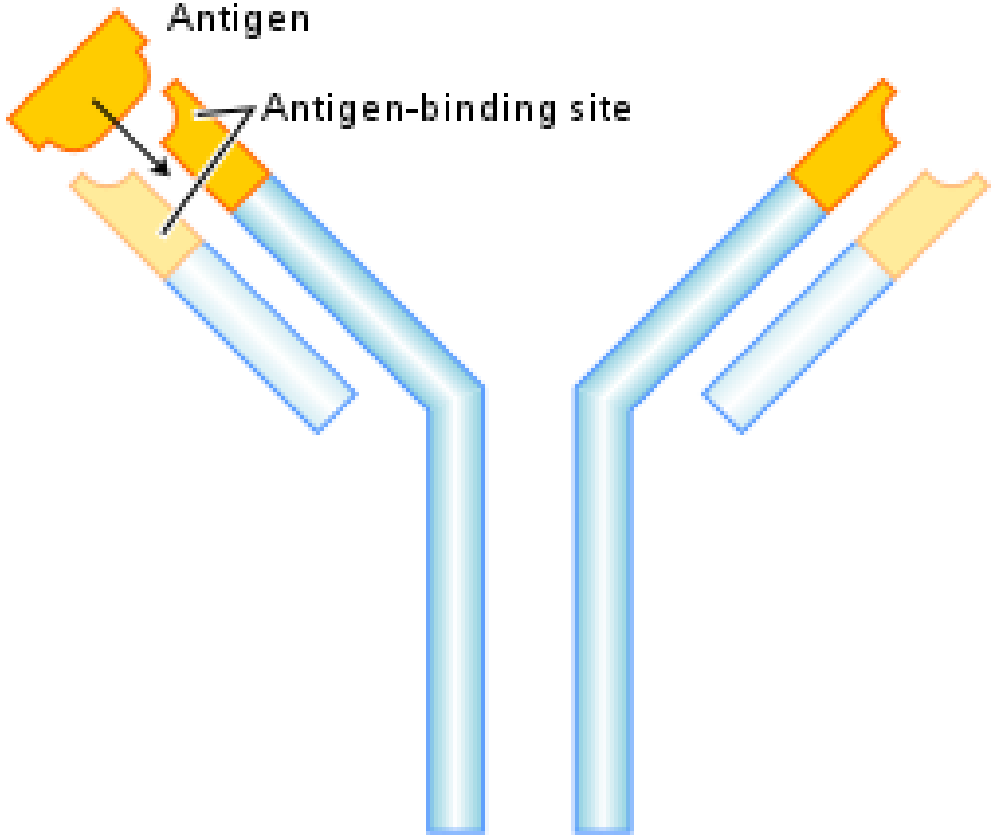
B. **Antigens** (Ag) - immunogens

1. This is any chemical substance that is not recognized by the body as self. It will lead to the production of specific antibodies and will react specifically with them.

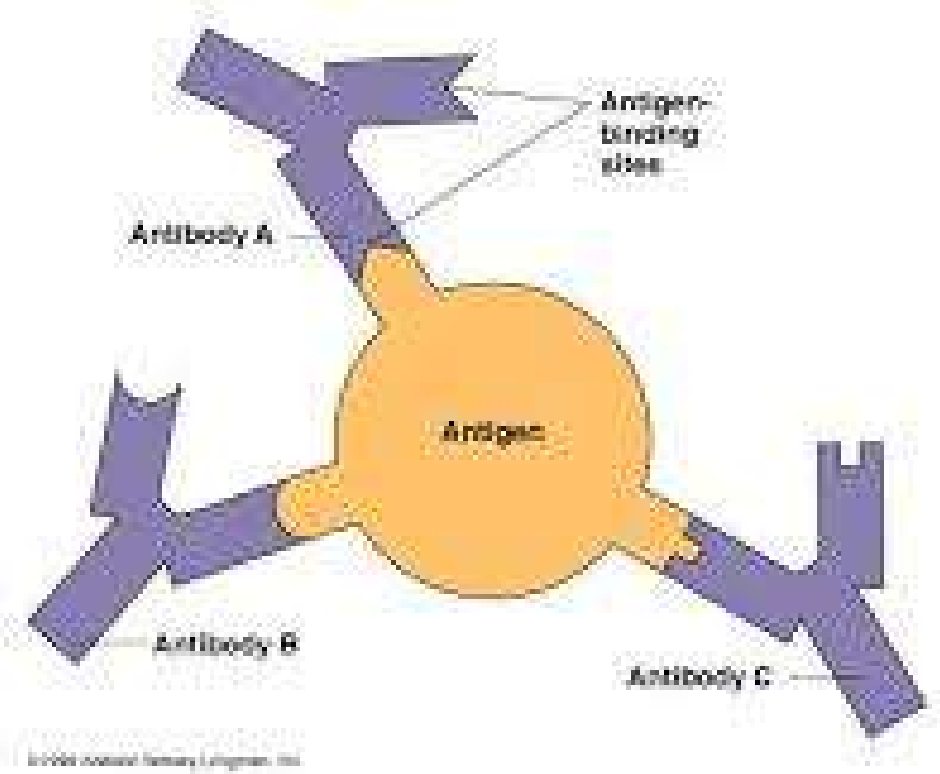


Antigens





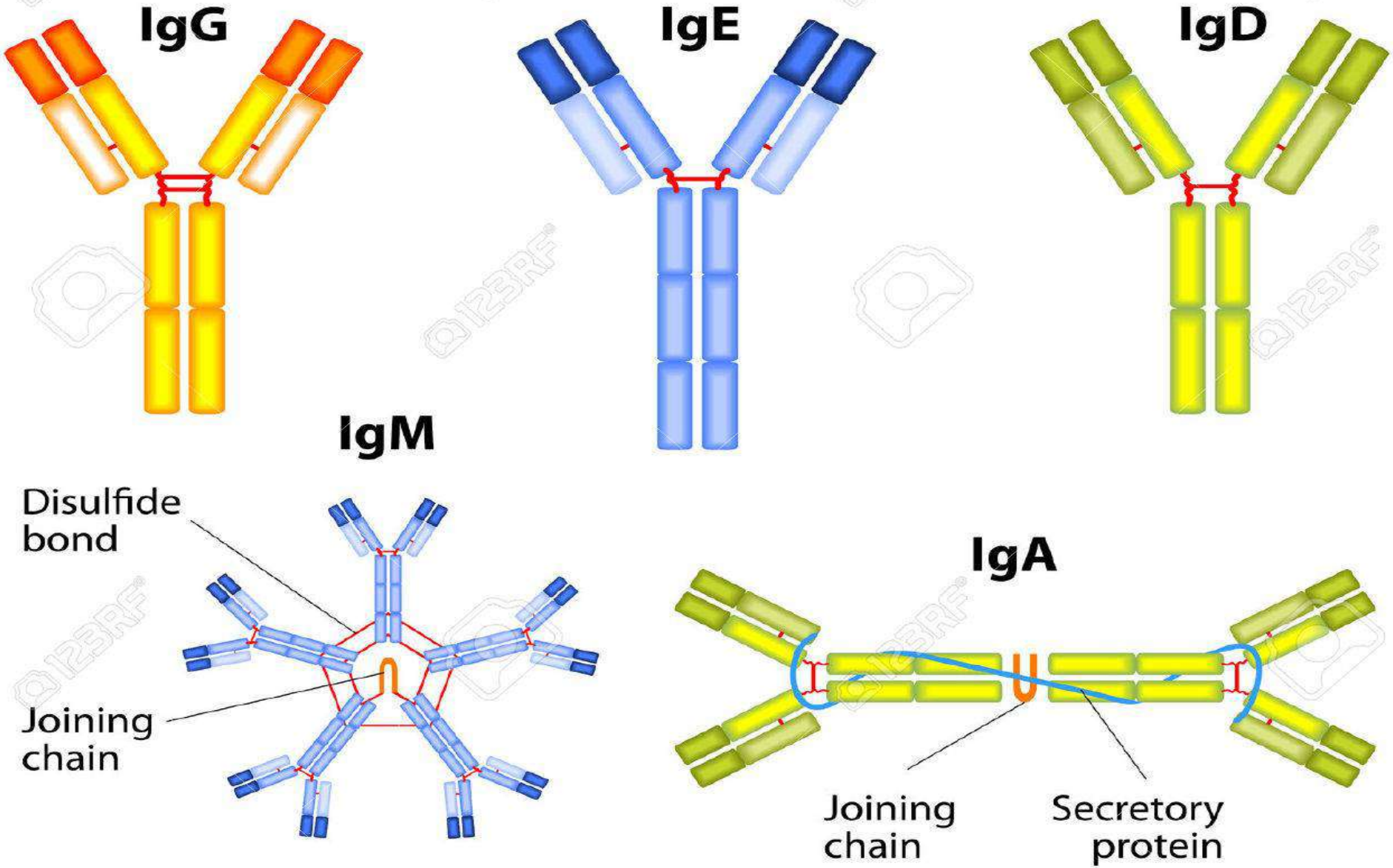
Antibody



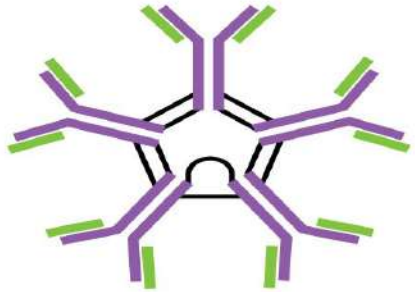
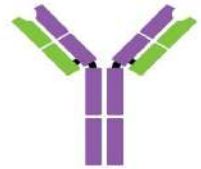
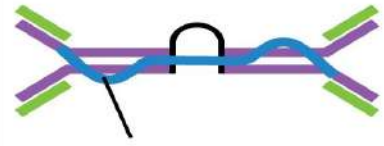
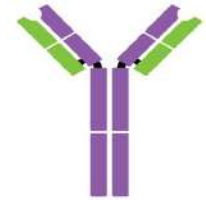
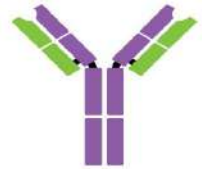
C. **Antibodies** (Abs)

1. These are produced by plasma cells and are specific for an antigen like a lock and key.
2. There are 5 classes of antibodies or immunoglobulins.

ANTIBODY CLASSIFICATION

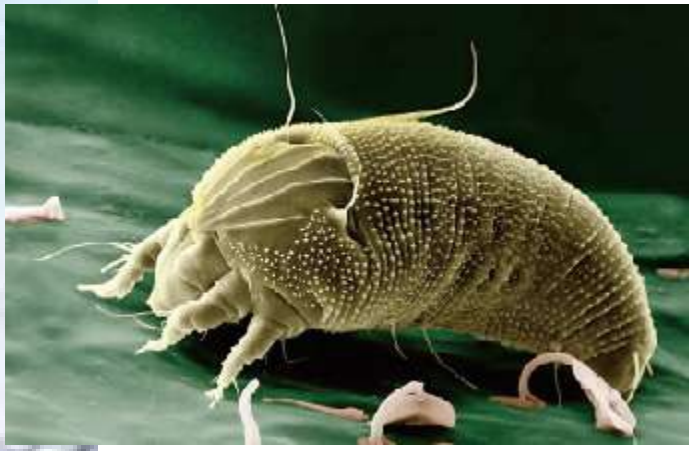


The Five Immunoglobulin (Ig) Classes

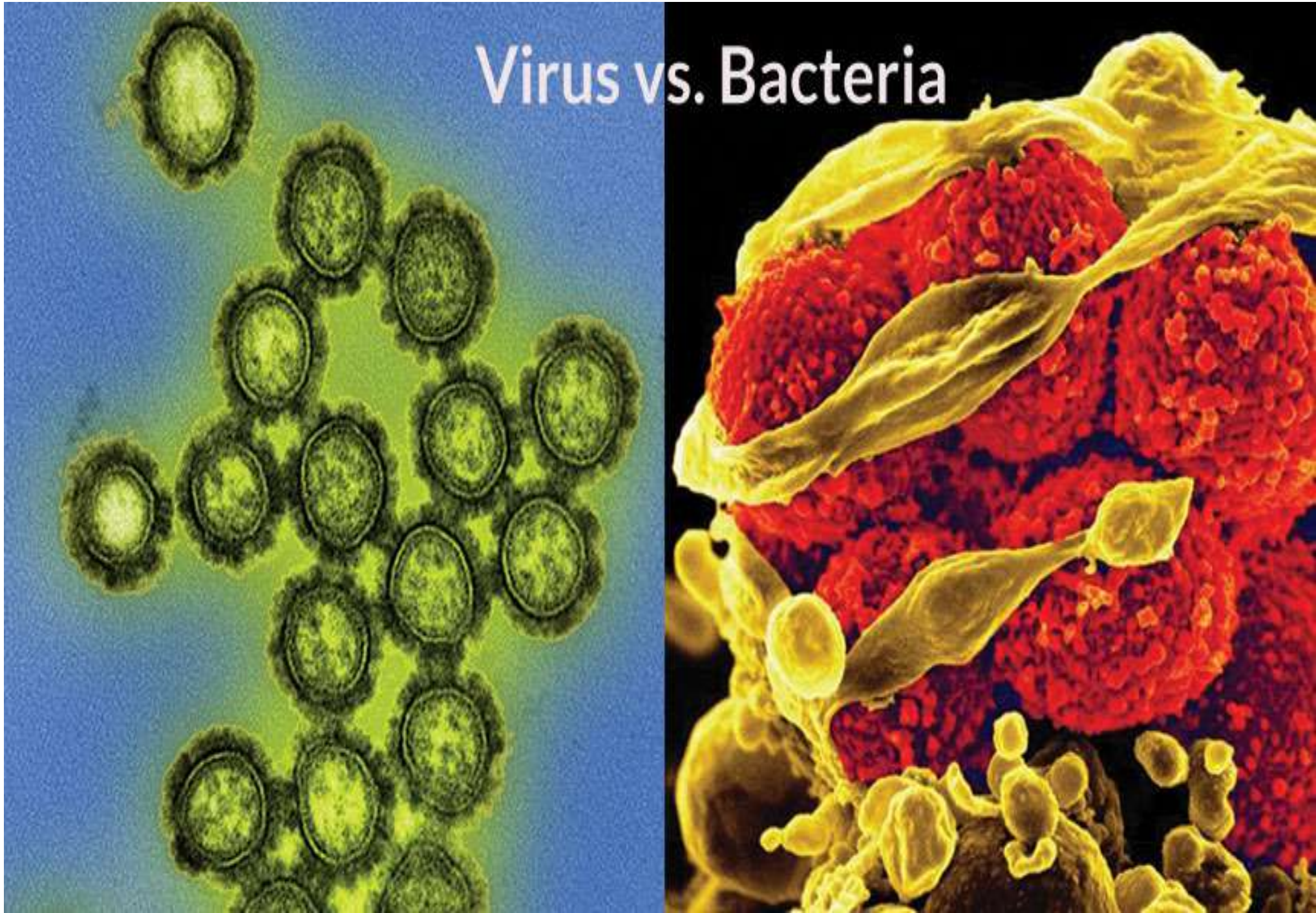
	IgM pentamer	IgG monomer	Secretory IgA dimer	IgE monomer	IgD monomer
					
Heavy chains	μ	γ	α	ε	δ
Number of antigen binding sites	10	2	4	2	2
Molecular weight (Daltons)	900,000	150,000	385,000	200,000	180,000
Percentage of total antibody in serum	6%	80%	13%	0.002%	1%
Crosses placenta	no	yes	no	no	no
Fixes complement	yes	yes	no	no	no
Fc binds to		phagocytes		mast cells and basophils	
Function	Main antibody of primary responses, best at fixing complement; the monomer form of IgM serves as the B cell receptor	Main blood antibody of secondary responses, neutralizes toxins, opsonization	Secreted into mucus, tears, saliva, colostrum	Antibody of allergy and antiparasitic activity	B cell receptor

D. Methods of destroying antigens

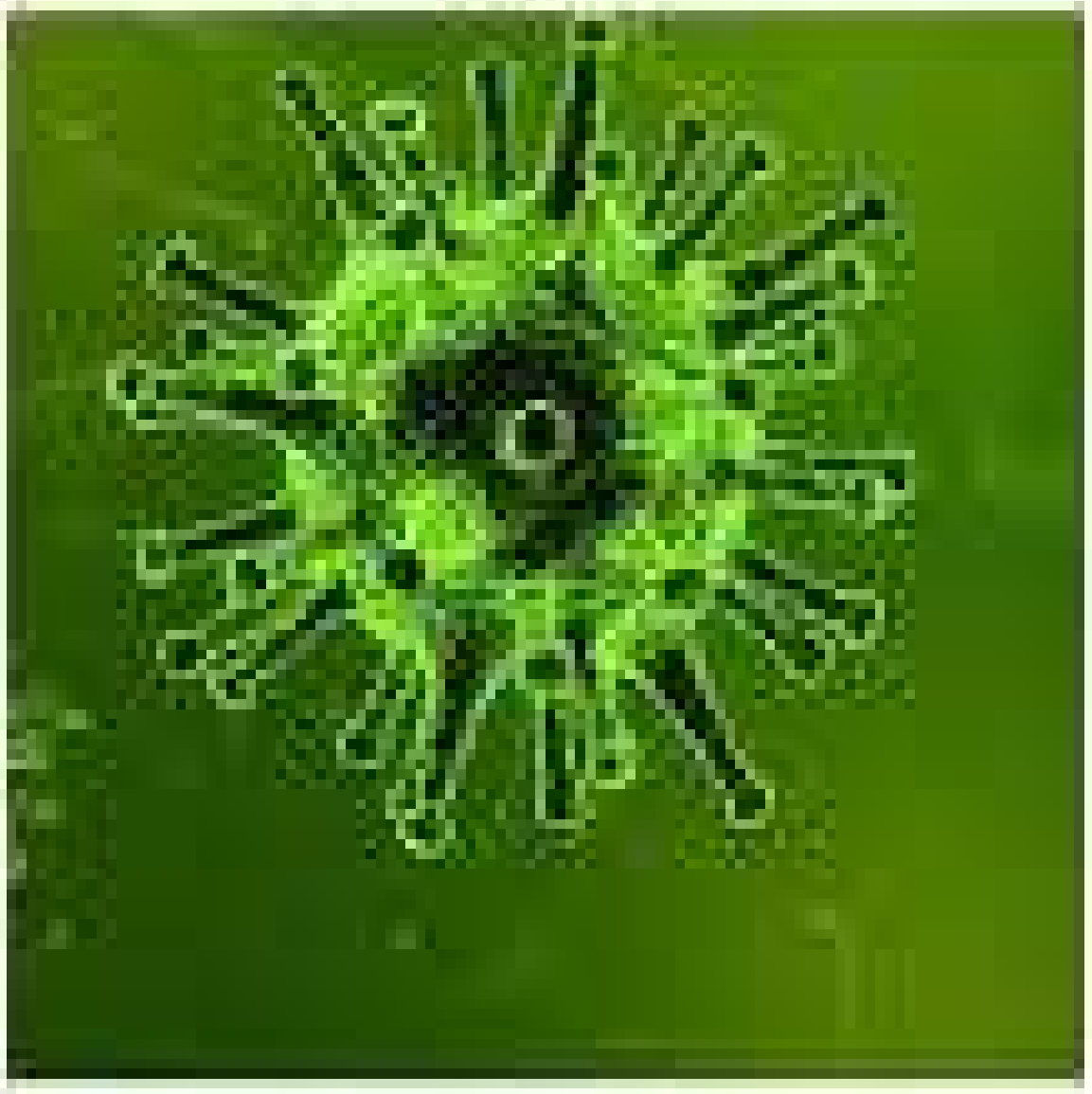
1. Cell mediated immunity - uses T cells which directly attack and destroy. Mostly used for antigens like fungus, parasites, etc (not bacteria/viruses)



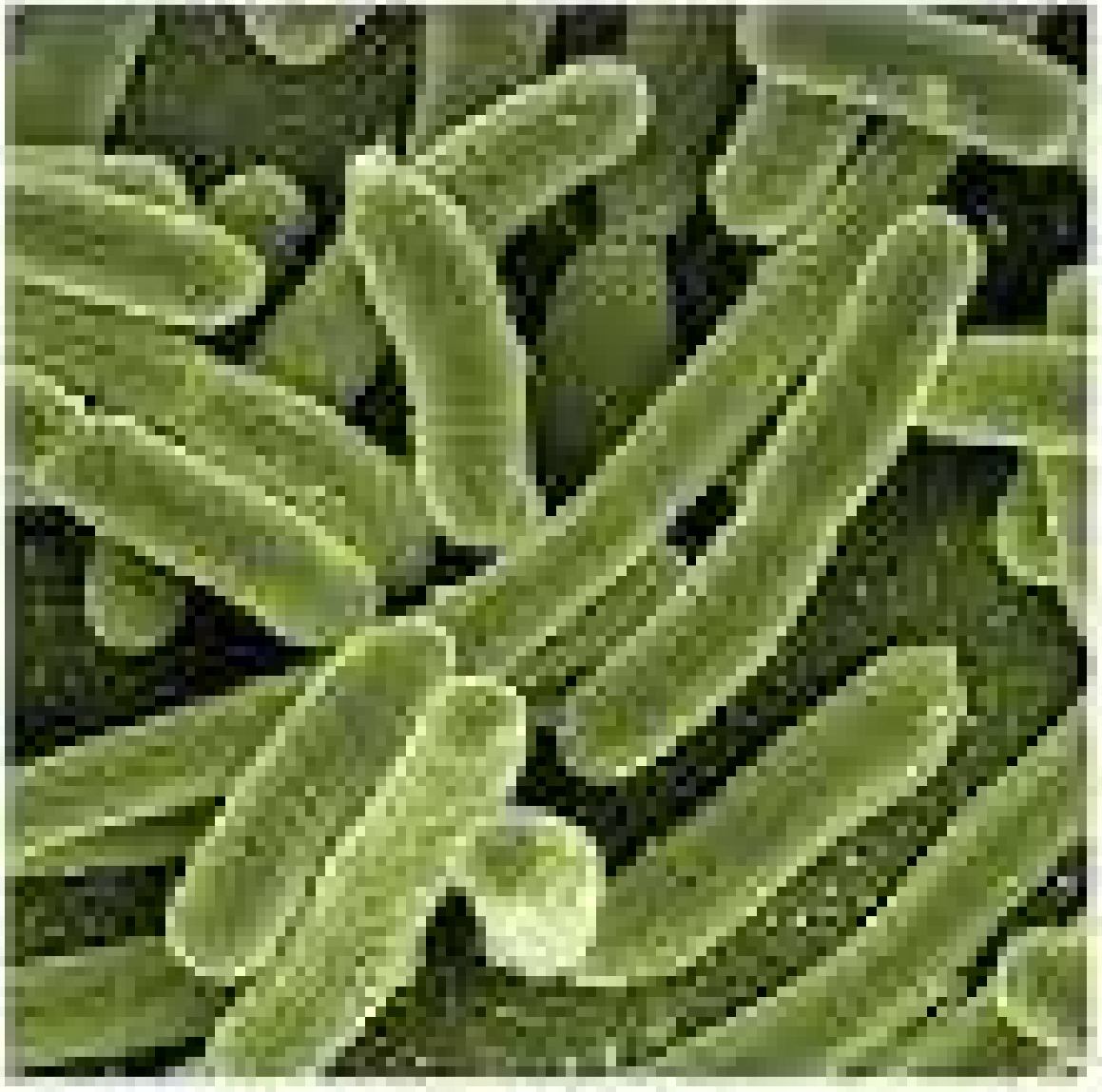
2. Antibody mediated immunity - uses B cells which produce antibodies. Used against bacteria and viruses



VIRUS



BACTERIA

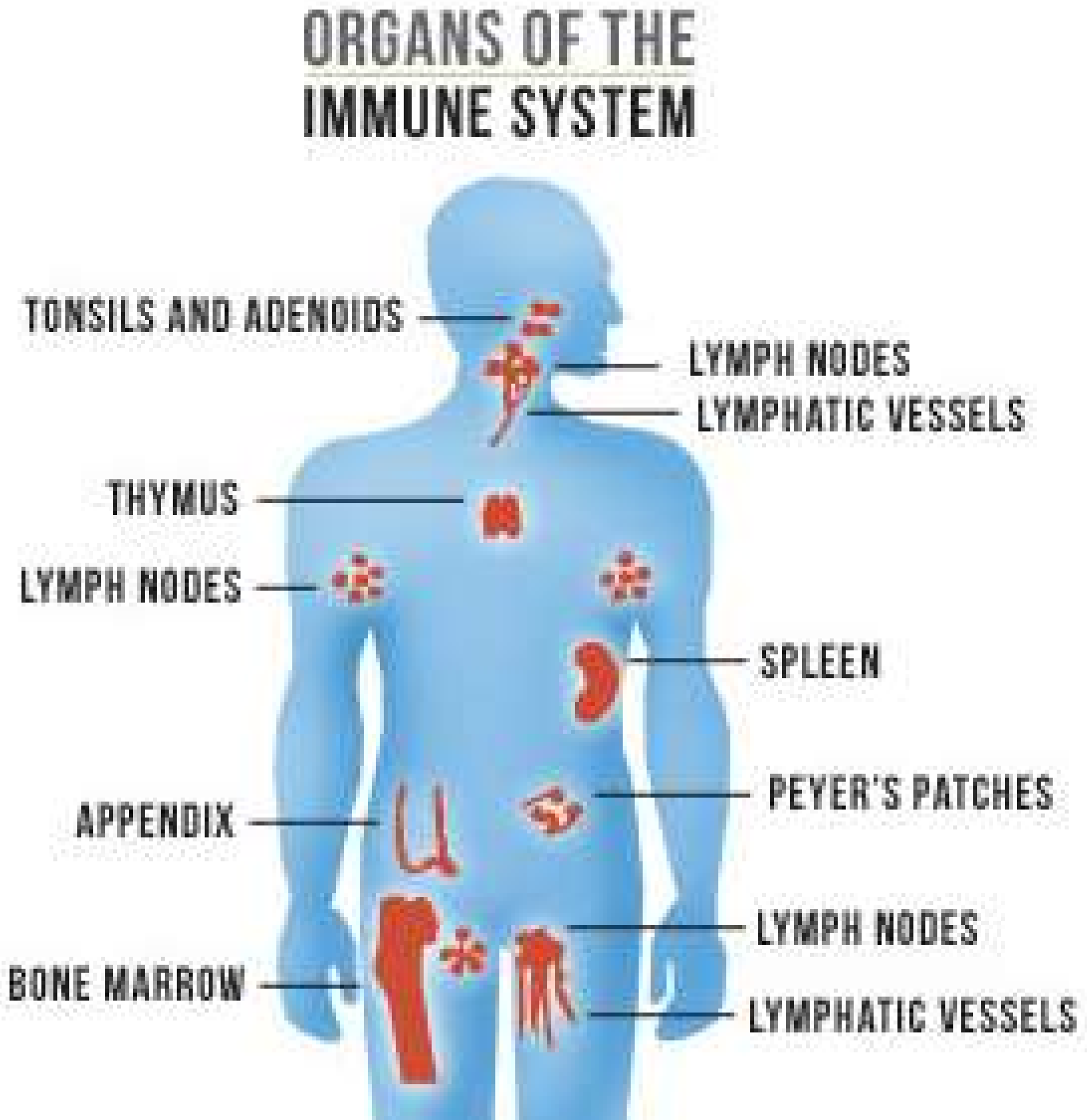


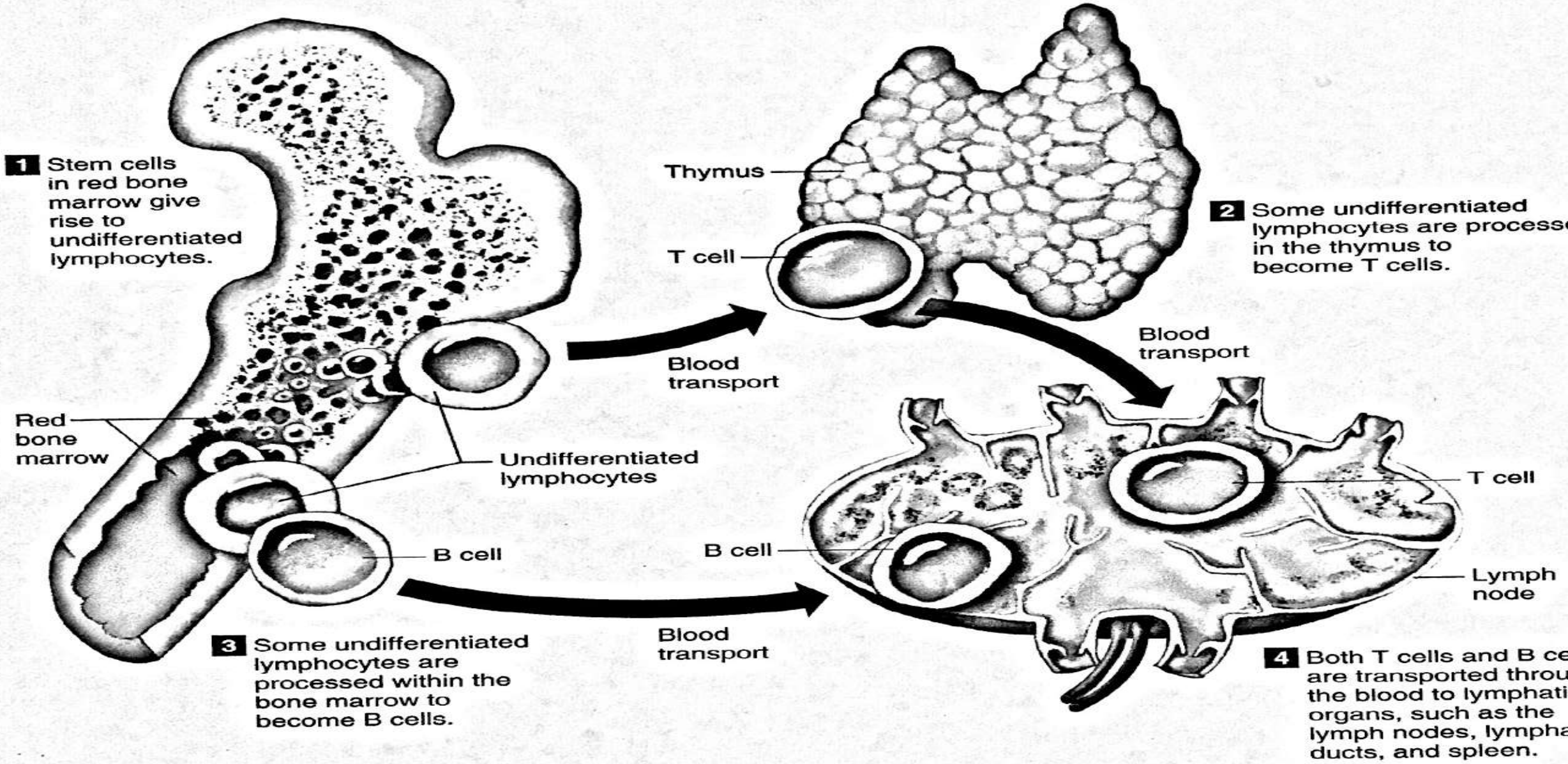
D. Methods of destroying antigens

1. Cell mediated immunity - uses T cells which directly attack and destroy. Mostly used for antigens like fungus, parasites, etc (not bacteria/viruses)

2. Antibody mediated immunity - uses B cells which produce antibodies. Used against bacteria and viruses

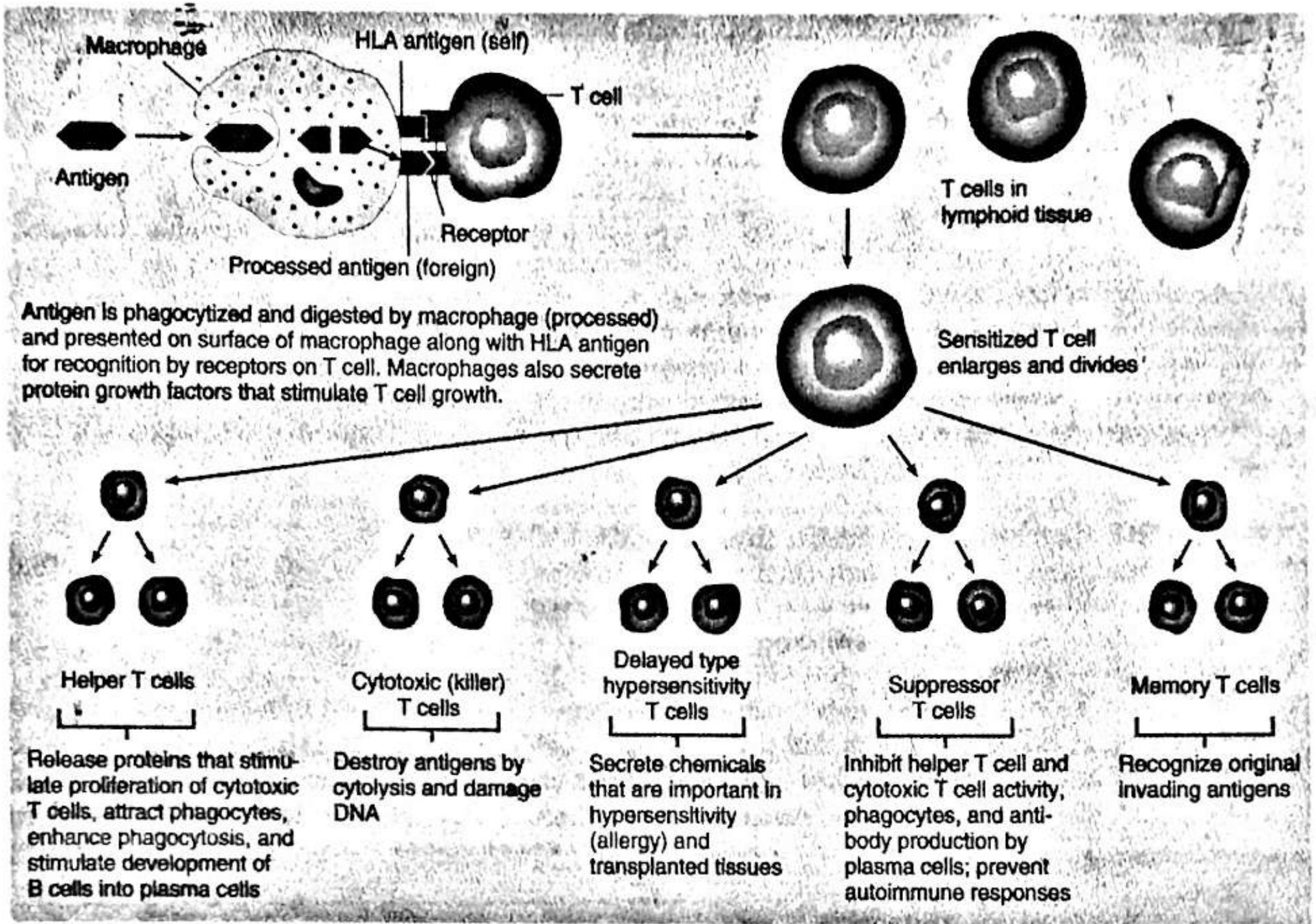
3. The cells used by each are produced by lymph nodes, spleen, GI tract, red bone marrow





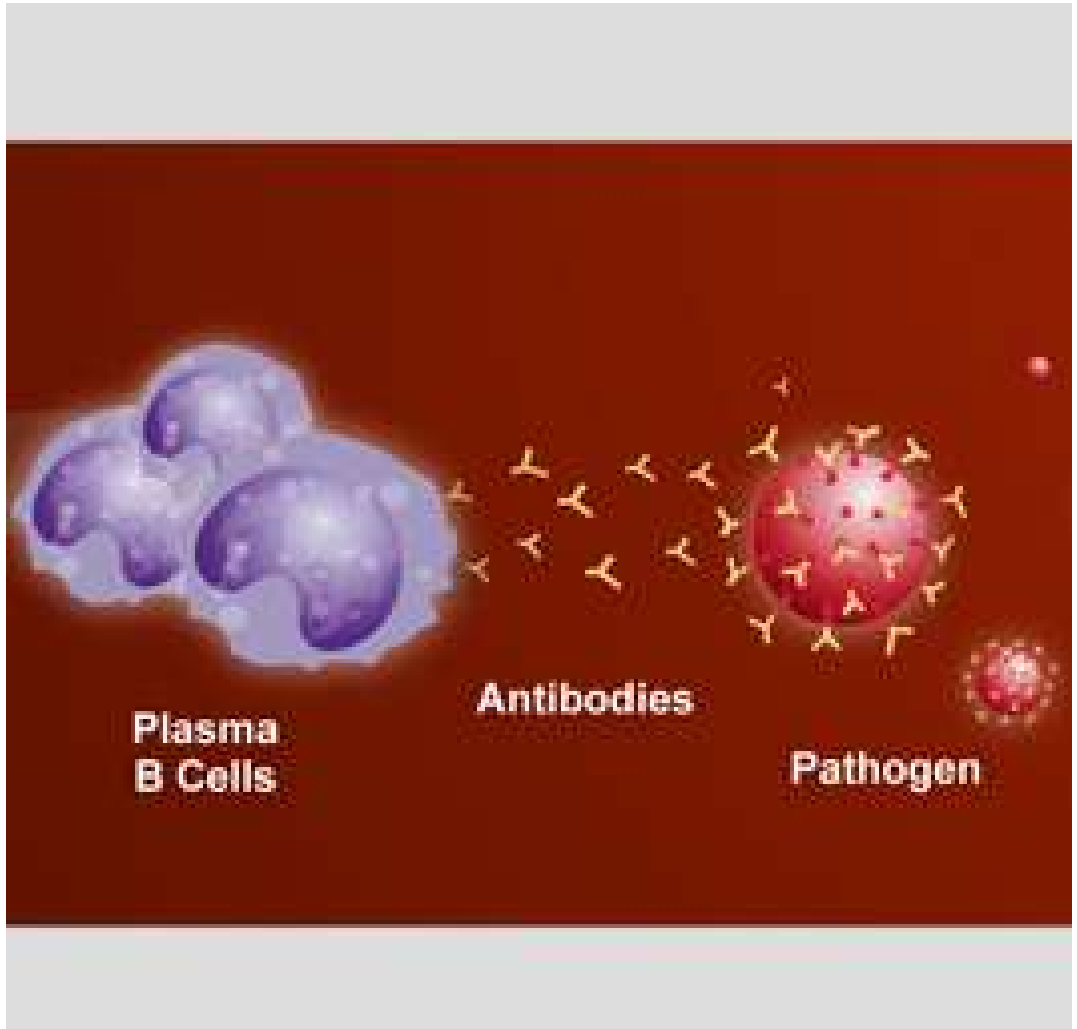
B cell and T cell origins
Figure 14.11

E. **Cell mediated immunity**


Macrophage
HLA antigen (self)
T cell
Antigen
Receptor
Processed antigen (foreign)
T cells in lymphoid tissue
Antigen is phagocytized and digested by macrophage (processed) and presented on surface of macrophage along with HLA antigen for recognition by receptors on T cell. Macrophages also secrete protein growth factors that stimulate T cell growth.
Sensitized T cell enlarges and divides
Helper T cells
Release proteins that stimulate proliferation of cytotoxic T cells, attract phagocytes, enhance phagocytosis, and stimulate development of B cells into plasma cells
Cytotoxic (killer) T cells
Destroy antigens by cytolysis and damage DNA
Delayed type hypersensitivity T cells
Secrete chemicals that are important in hypersensitivity (allergy) and transplanted tissues
Suppressor T cells
Inhibit helper T cell and cytotoxic T cell activity, phagocytes, and antibody production by plasma cells; prevent autoimmune responses
Memory T cells
Recognize original invading antigens

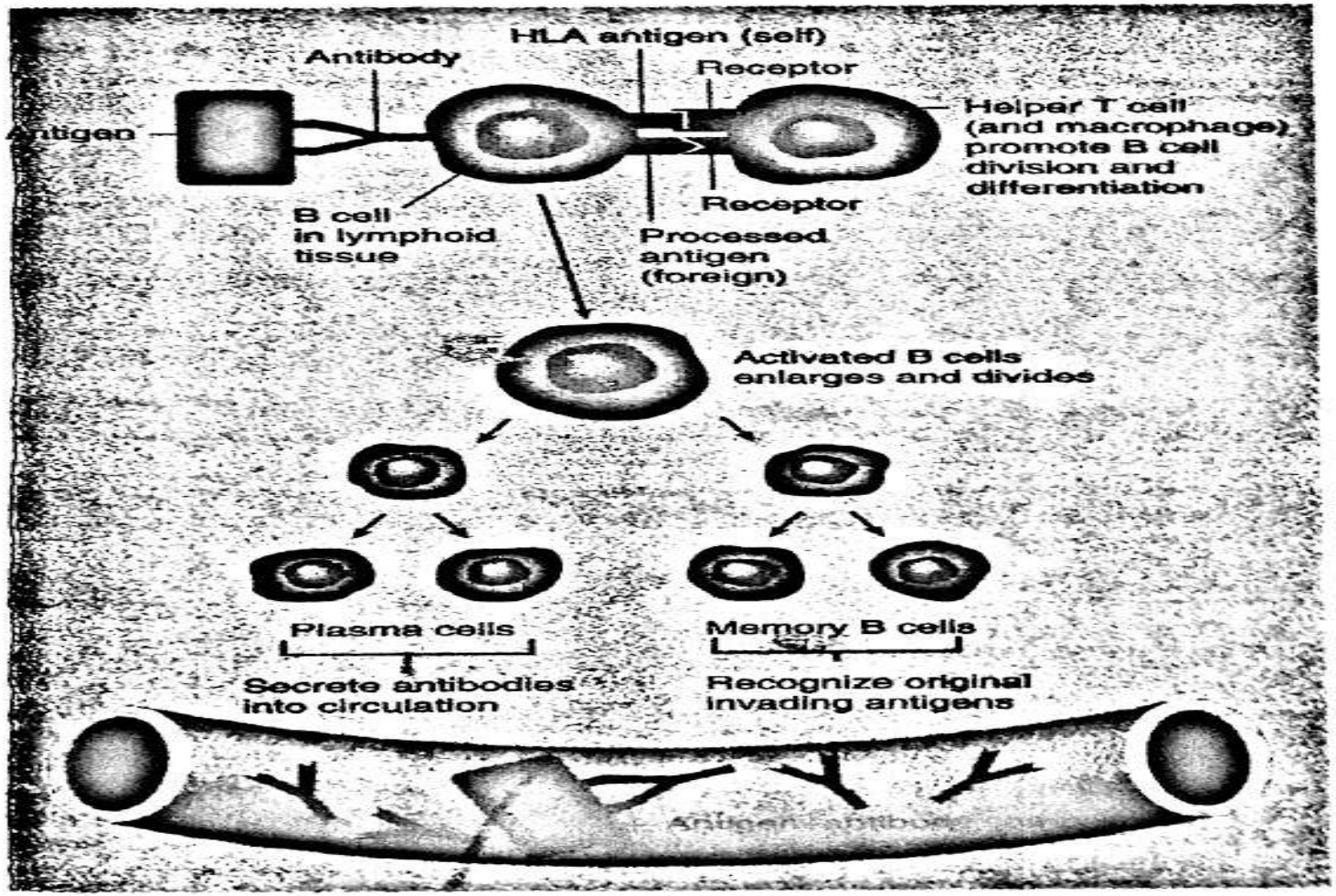
F. **Antibody mediated immunity**

1. Sensitized T cells travel to the tonsils, lymph nodes and spleen to activate the immobile B cells. The B cells produce the antibodies which are then free to circulate and kill and the memory B cells.



gure 17.9 Role of B cells in antibody-mediated immunity.

B cells develop into antibody-producing plasma cells.



What substances stimulate B cells to develop into plasma cells?

immunization, yo
the pathogen aga
your body respon
However, booste
periodically, to m
tection against th

Actions of Anti

The five classes o
what (see Exhibit

1. **Neutralizin**
   antigen blo
   prevents at

Figure 17.10 Secr
sure) and secondar
antigen.

***The secondar
tion by vacci***

***Which antib
response?***

Red Bone Marrow

stem cells

thymus

tonsils/lymph node

T cells → circulate

thoracic duct

Spleen

★ Cell mediated starts it all.

Antigen enters lymph system → lymph node - gets picked up by a macrophage who presents it to a T cell who becomes sensitized

Then the T cell

Memory T cells (stay in lymph tissue)

Delayed hypersensitized T cells - recruit more macrophages

Suppressor T cells

Helper T cells

stimulate

Cytotoxic killer T cells - cytolysis of antigen, damage DNA

stem cells

lymph node / tonsils

thymus

Spleen

B cells (~~cannot circulate~~)

memory B cells

plasma cells

antibodies (circulate)

stimulate

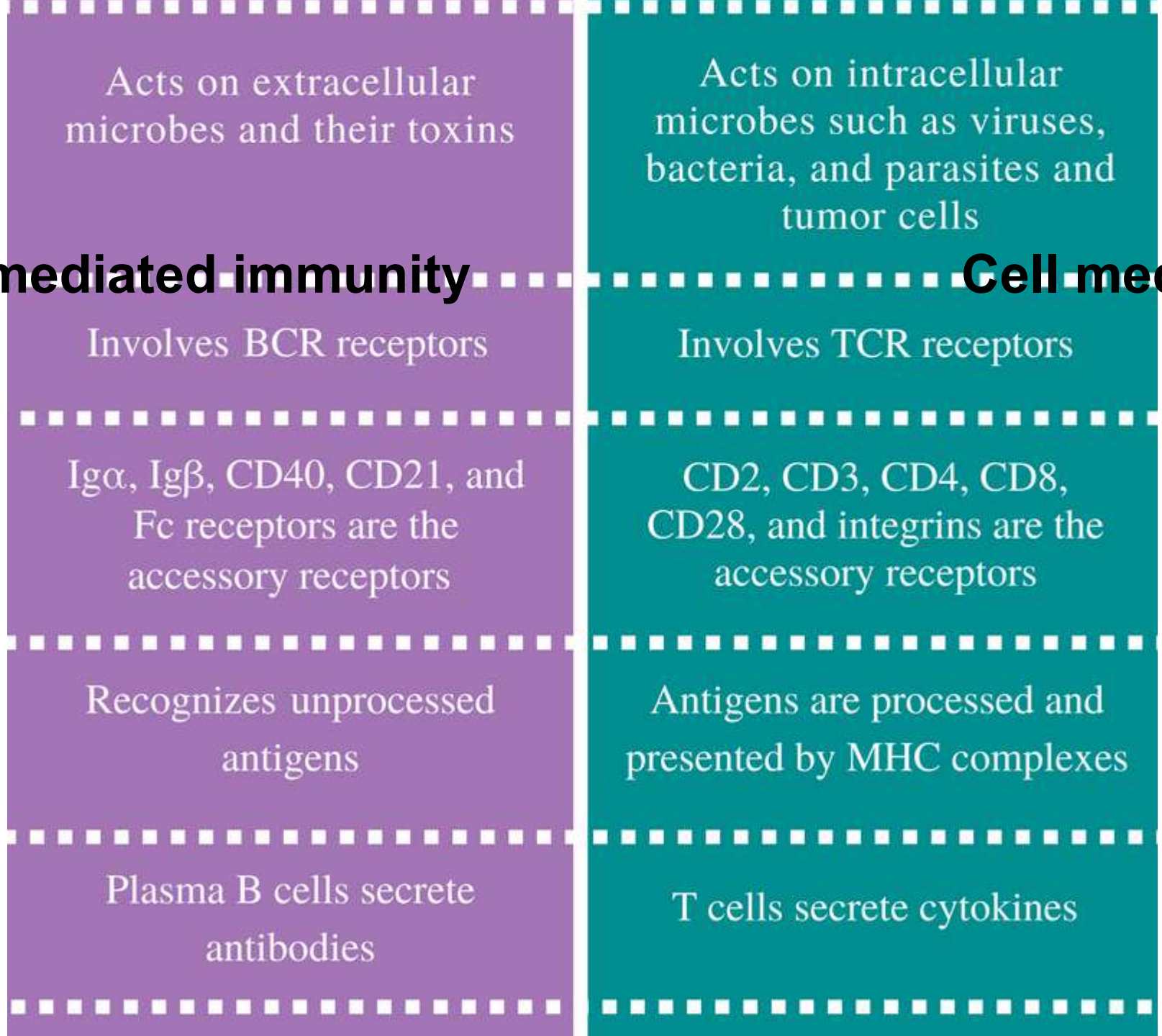
CELL	FUNCTIONS
Macrophage	Phagocytosis; processing and presentation of foreign antigens to T cells; secretion of protein growth factors that stimulate T cell growth and division of T cells to form a large population of sensitized T cells.
Helper T cell	Activates cytotoxic T cells, attracts phagocytes, enhances phagocytosis; and stimulates development of B cells into plasma cells.
Cytotoxic (killer) T cell	Releases chemicals that cause cytolysis of target cells and damage target cell DNA; attracts macrophages, enhances their phagocytic activity and prevents them from leaving the site of actions.
Delayed type hypersensitivity T cell	Attracts macrophages in response related to hypersensitivity (allergy) and tissue transplantation.
Suppressor T cell	Inhibits activity of helper T cells and cytotoxic T cells, inhibits phagocytosis, reduces antibody protection by plasma cells, and prevents autoimmune responses.
Memory T cell	Remains in lymphoid tissue and recognizes original invading antigens, even years after infection.
Natural killer (NK) cell	Destroys foreign cells by cytolysis.
B cell	Differentiates into antibody-producing plasma cell.
Plasma cell	Descendant of B cell; the plasma cell that produces antibodies.
Memory B cell	Ready to respond more rapidly and forcefully than initially should the same antigen challenge the bod in the future.

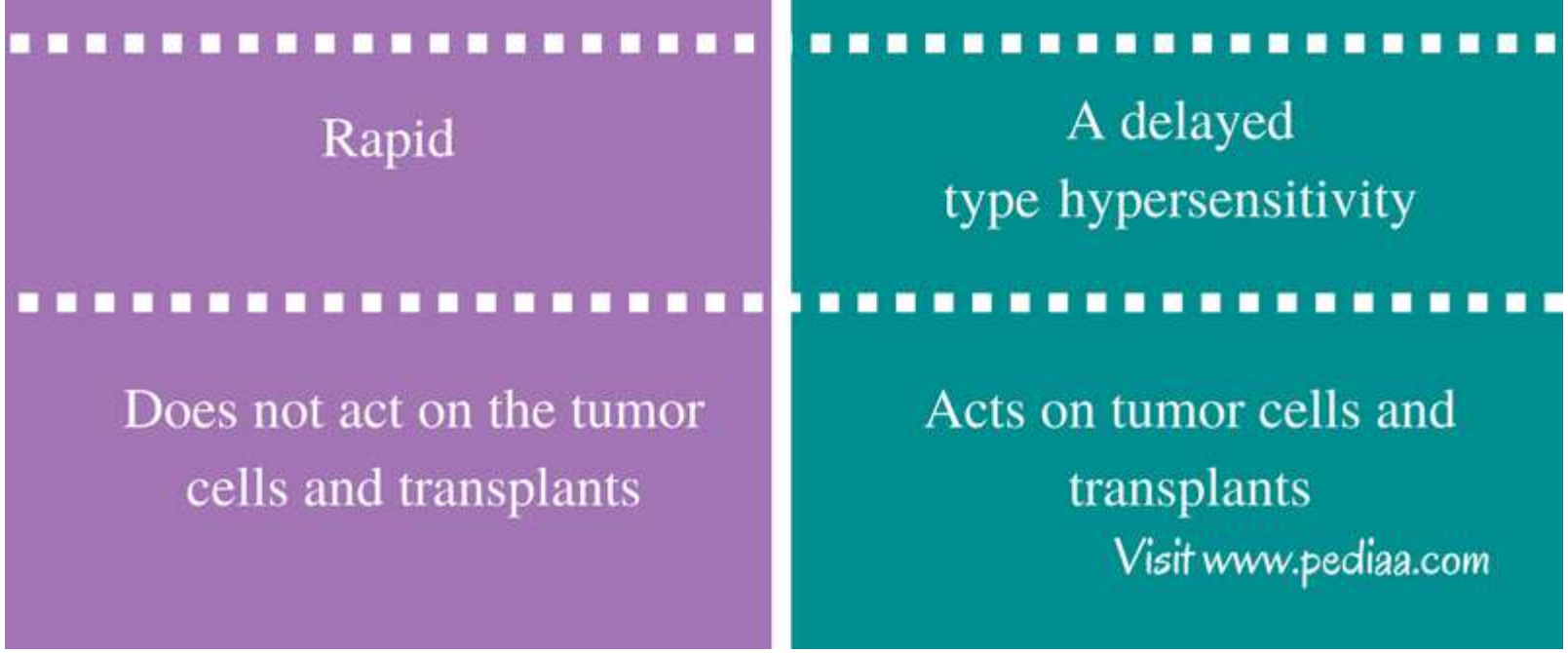
HUMORAL IMMUNITY

VERSUS

CELL MEDIATED IMMUNITY

HUMORAL IMMUNITY	CELL MEDIATED IMMUNITY
Humoral immunity refers to a component of the adaptive immunity where B cells secrete antibodies, which circulate in the blood as a soluble protein	Cell mediated immunity refers to the other component of the adaptive immunity, which is mediated by the activated, antigen-specific T cells
Mediated by B cells	Mediated by T cells
Mediated by T cells, B cells, and macrophages	Mediated by helper T cells, cytotoxic T cells, natural killer cells, and macrophages


Acts on extracellular microbes and their toxins
Acts on intracellular microbes such as viruses, bacteria, and parasites and tumor cells
Antibody mediated immunity
Cell mediated immunity
Involves BCR receptors
Involves TCR receptors
Igα, Igβ, CD40, CD21, and Fc receptors are the accessory receptors
CD2, CD3, CD4, CD8, CD28, and integrins are the accessory receptors
Recognizes unprocessed antigens
Antigens are processed and presented by MHC complexes
Plasma B cells secrete antibodies
T cells secrete cytokines



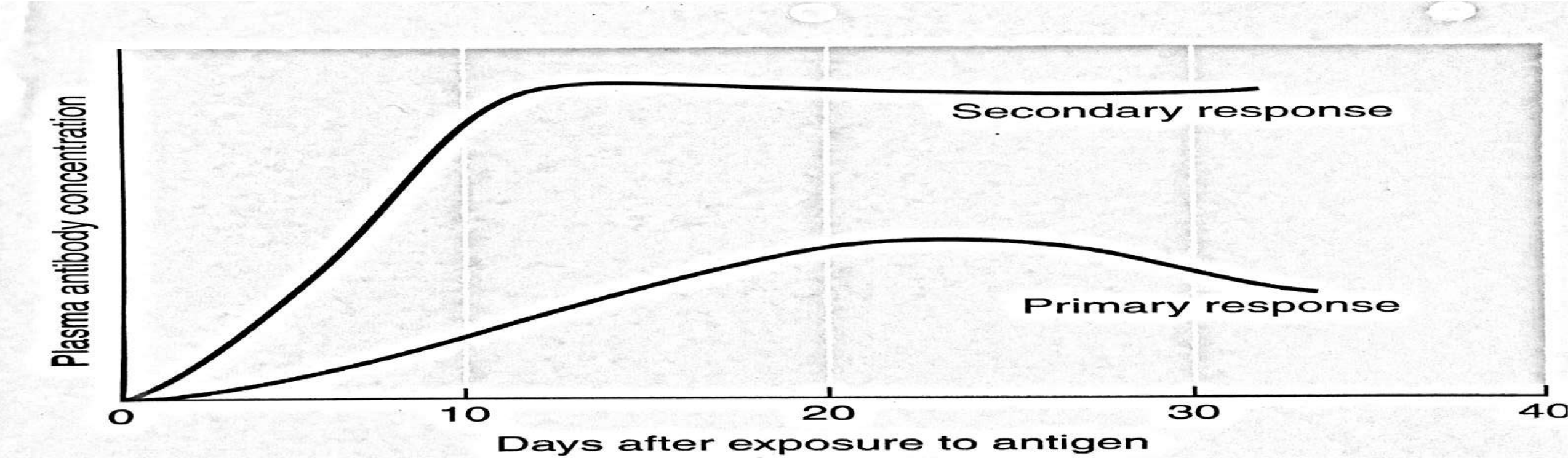
Antibody mediated immunity

Cell mediated immunity

F. **Antibody mediated immunity**

1. Sensitized T cells travel to the tonsils, lymph nodes and spleen to activate the immobile B cells. The B cells produce the antibodies which are then free to circulate and kill and the memory B cells.

2. There is a **primary** response (1st time infected - slow) and a **secondary** response (subsequent infections – quicker).



443 Primary immune response
Figure 14.16

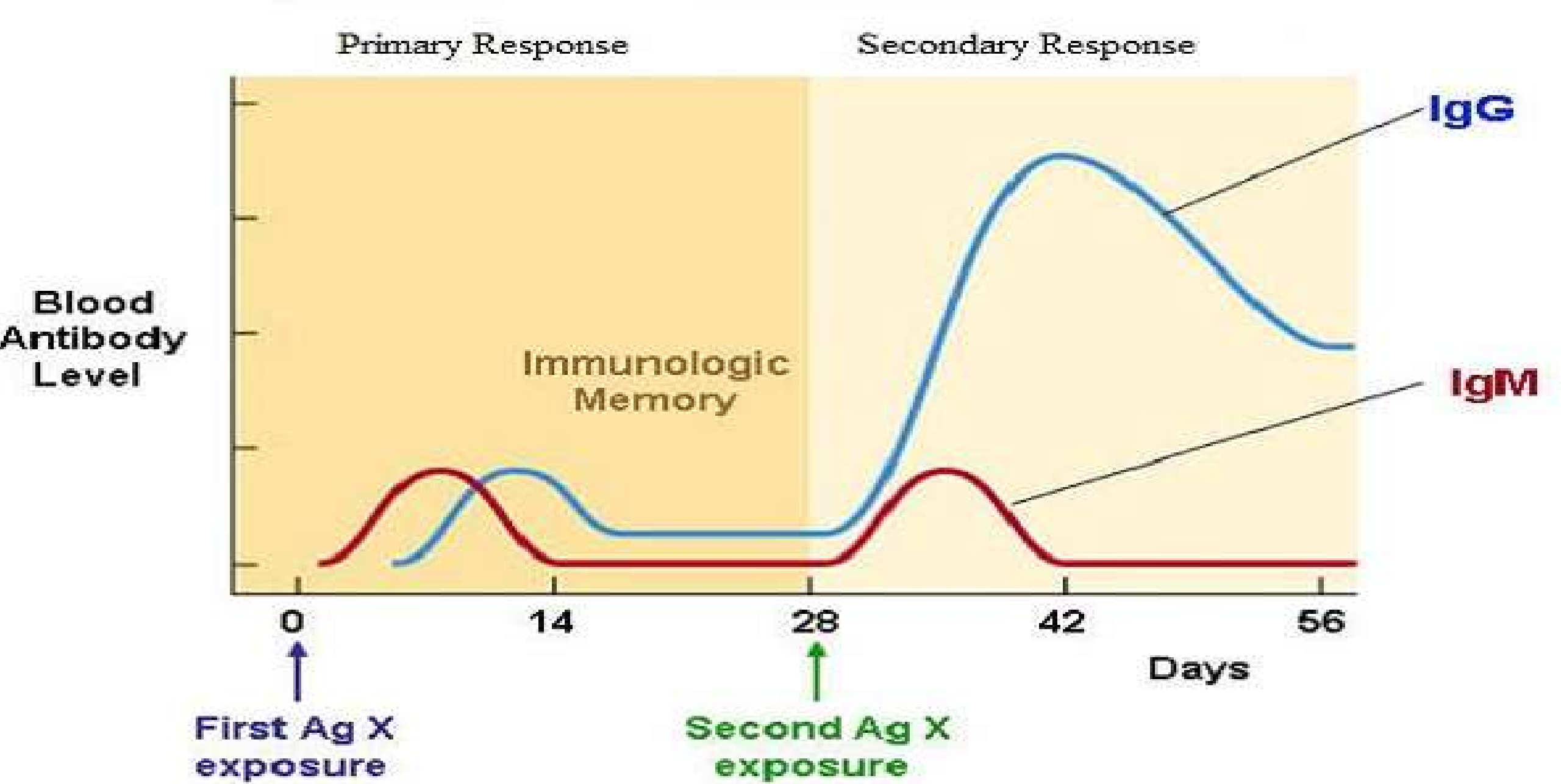


Fig. Immune Response and Secretion of antibodies

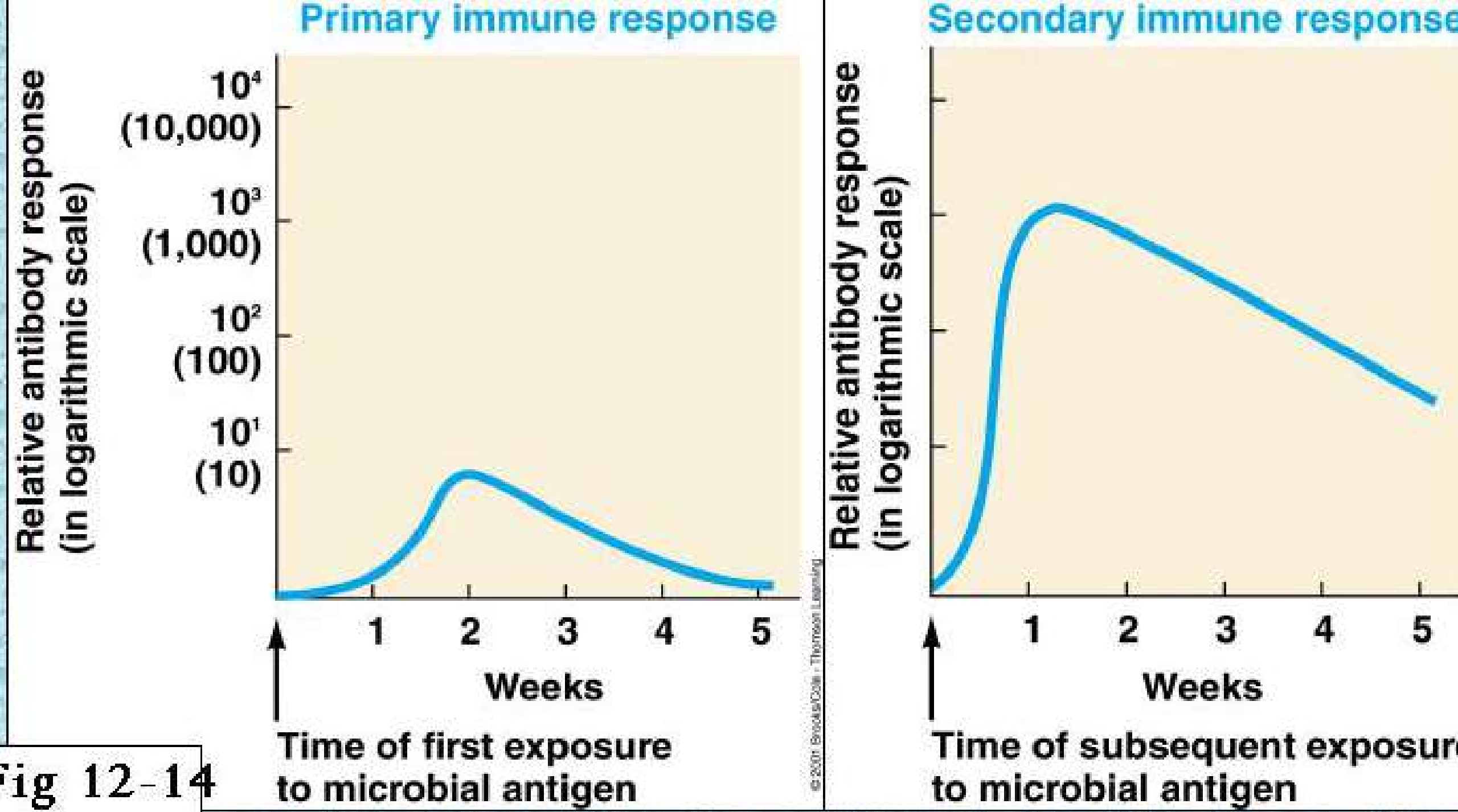

Primary immune response
Relative antibody response (in logarithmic scale)
10^4 (10,000)
10^3 (1,000)
10^2 (100)
10^1 (10)
1
2
3
4
5
Weeks
Time of first exposure to microbial antigen
Secondary immune response
Relative antibody response (in logarithmic scale)
1
2
3
4
5
Weeks
Time of subsequent exposure to microbial antigen
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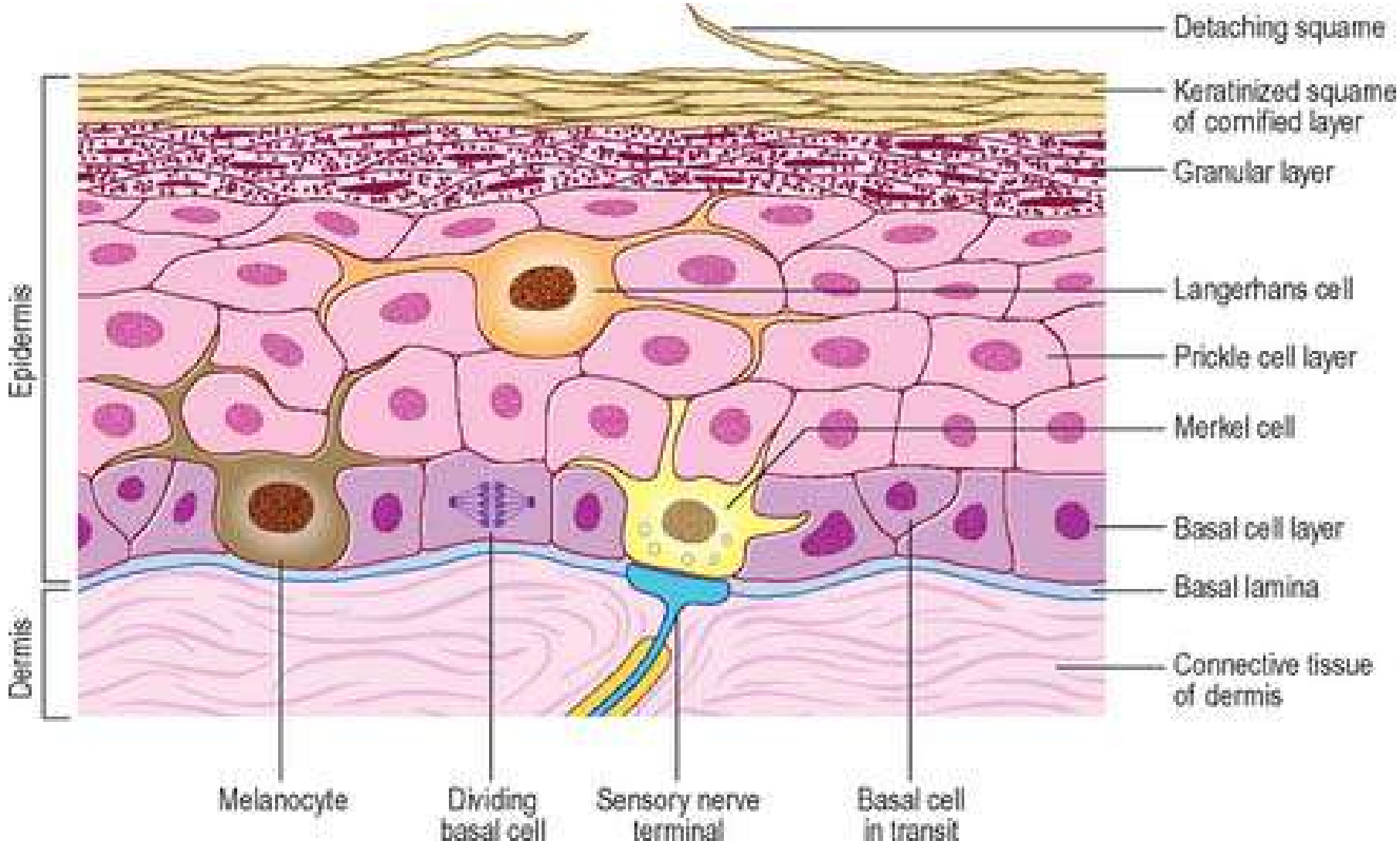
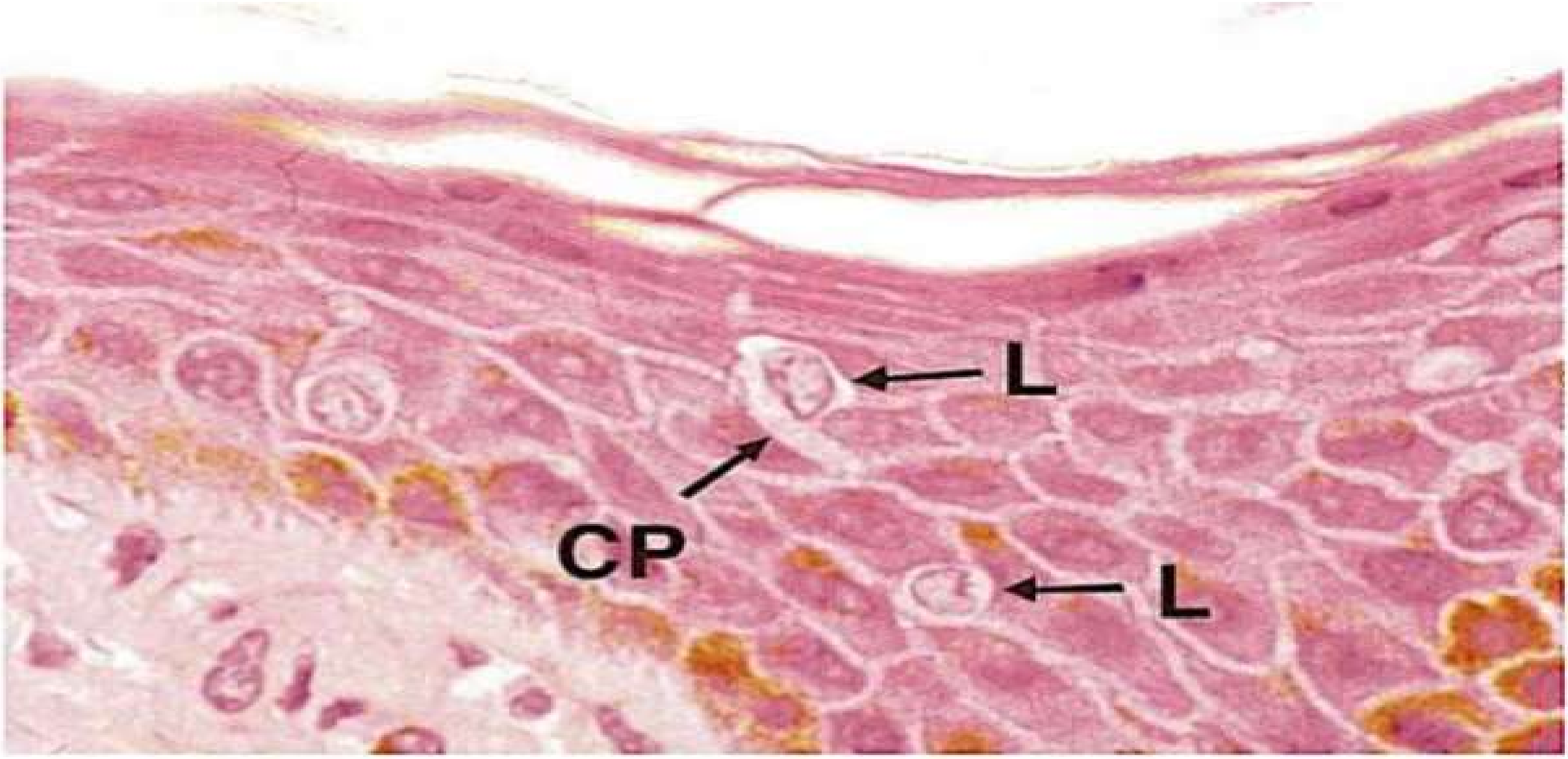
Fig 12-14

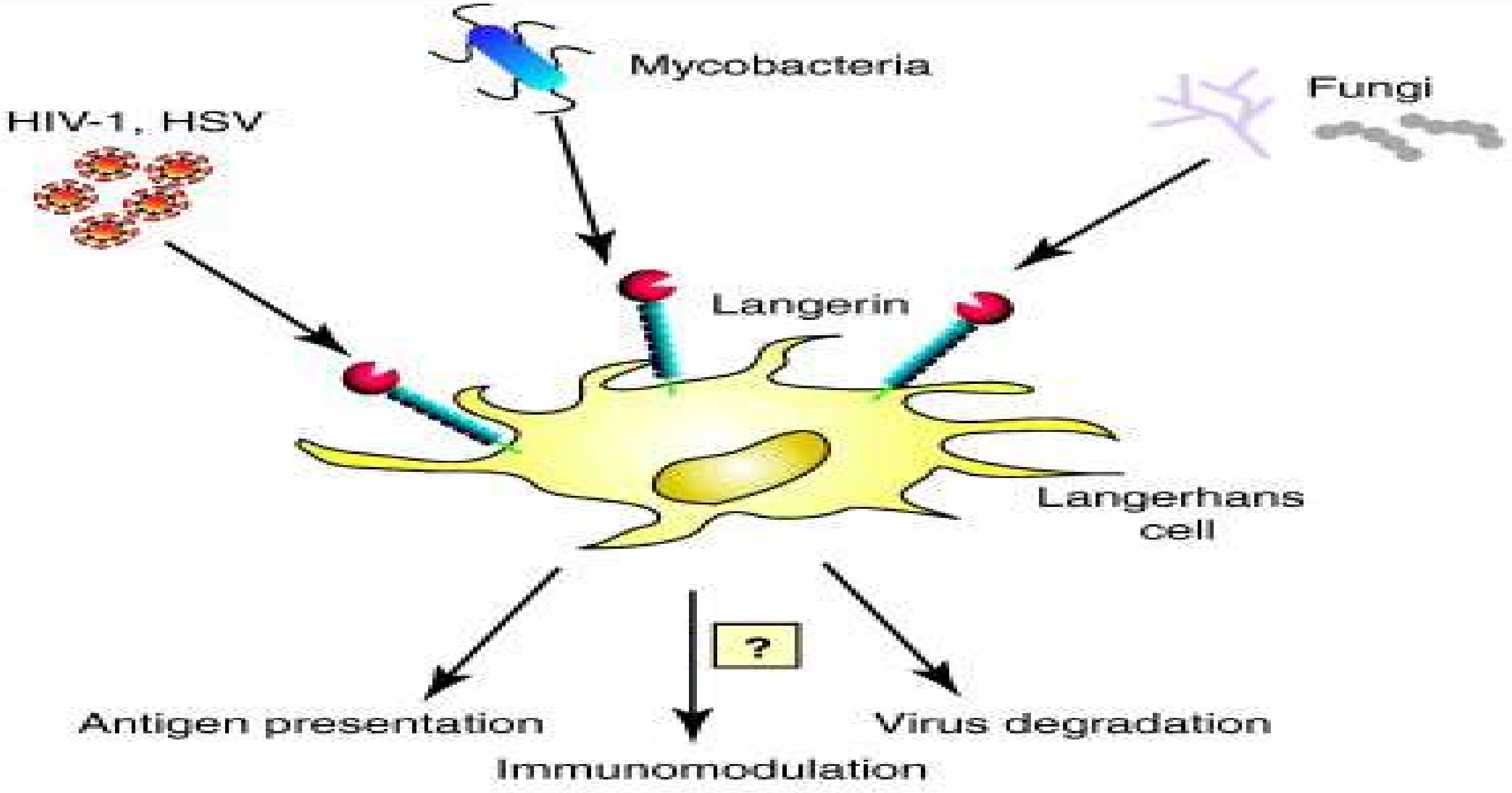
G. Skin

1. **Langerhans cells** in the skin will bind to the antigen and then present it to a helper T cell





Langerhans cell: dendritic processes; antigen presentation


Mycobacteria
HIV-1, HSV
Fungi
Langerin
Langerhans cell
?
Antigen presentation
Immunomodulation
Virus degradation
TRENDS in Immunology