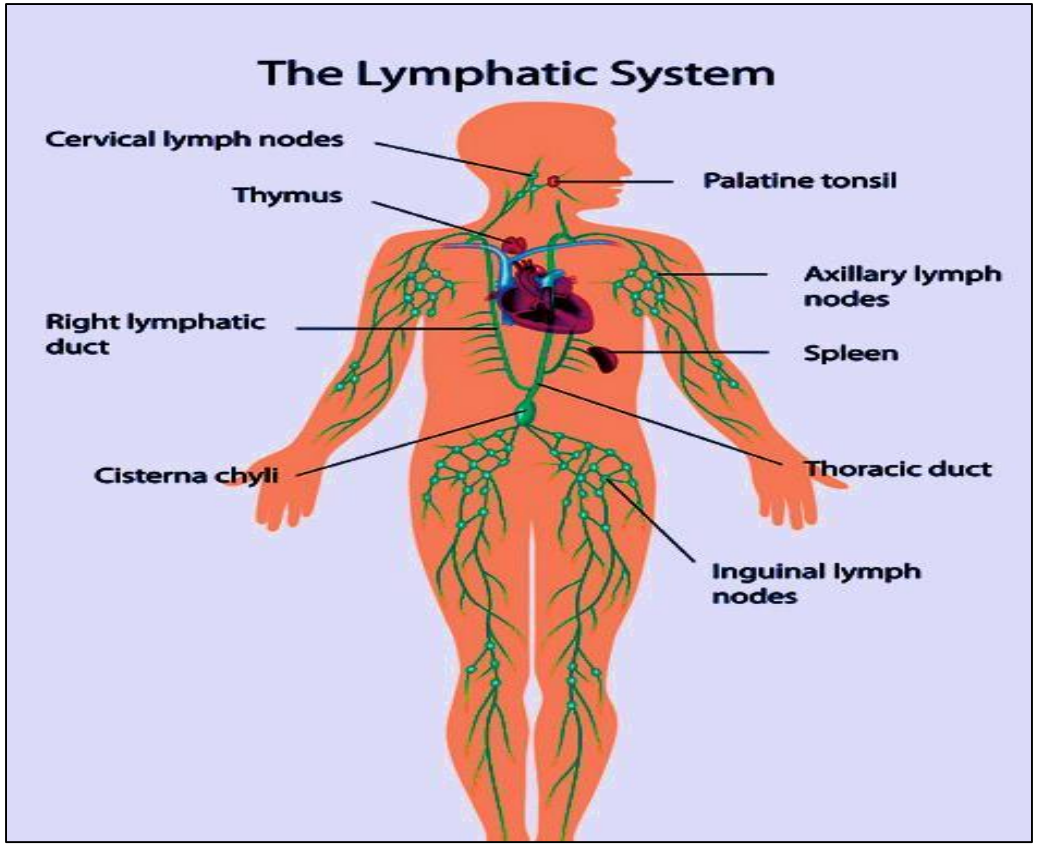
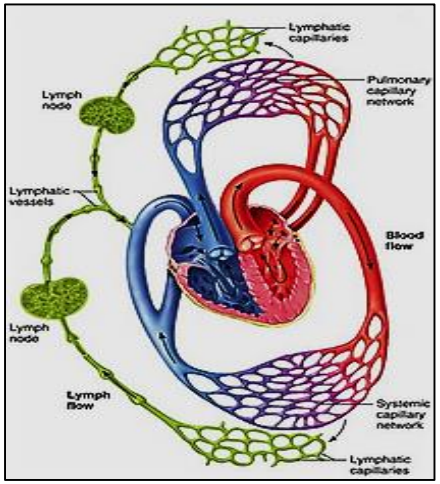
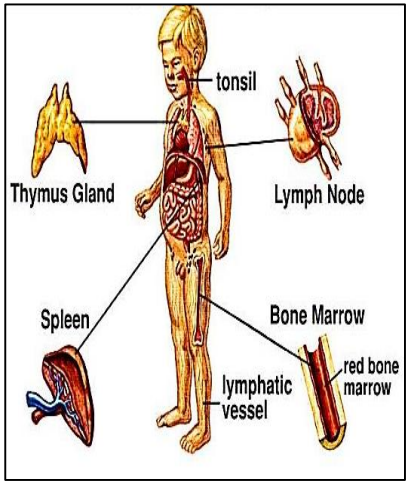
The lymphatic system
(Part I)
Professor Dr Hala El-mazar



The lymphatic system





Lymphatic vessels

Lymphatic tissues & organs

Immunity: is body's ability to resist or eliminate potentially harmful foreign materials or abnormal cells

- Includes the following activities:
  - Defense against invading pathogens (viruses & bacteria)
  - Removal of 'worn-out' cells (e.g., old RBCs) & tissue debris (e.g., from injury or disease)
  - Identification & destruction of abnormal or mutant cells (primary defense against cancer)
  - Rejection of 'foreign' cells (e.g., organ transplant)
  - Other responses:
    - **Allergies - response to normally harmless substances**
    - **Autoimmune diseases**

The immune system

The immune system has 2 components:

- **The innate immune system** : non-specific, acts rapidly & has no immunological memory

  its contents are:

  physical : skin barrier , **chemical** : Complement proteins C1 –C9, acid in stomach, **cellular** : mast cells, eosinophils, neutrophils, macrophages, & natural killer cells

- **The adaptive immune system**: specific, last long, able to distinguish self from non-self, has memory, specificity & diversity

  Its contents are : T & B lymphocytes & APCs

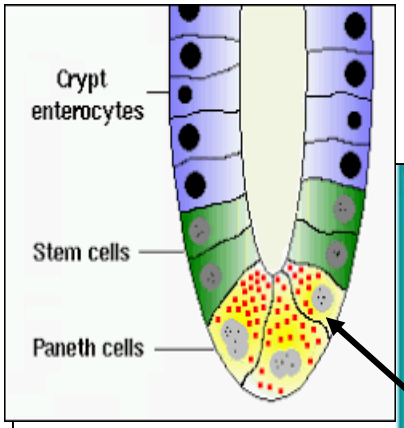
They communicate with each other through signaling molecules called **cytokines** & **cell surface markers**

The Adaptive immune system functions to defend the body by:

- **Humoral immunity** **B cells**→ Against antigens→ therough production of antibodies

- **Cell mediated immunity** **T cells** → Against tumor, transplant cells, virus infected cells & microorganisms

immune response



INNATE IMMUNITY
Rapid responses to a broad range of microbes

ACQUIRED IMMUNITY
Slower responses to specific microbes

External defenses

Internal defenses

- Skin
- Mucous membranes
- Secretions
- Phagocytic cells
- Antimicrobial proteins
- Inflammatory response
- Natural killer cells
- Complement
- Humoral response (antibodies)
- Cell-mediated response (cytotoxic lymphocytes)

Invading microbes (pathogens)

The structure of the Lymphatic tissue & lymphopoiesis

The basic structure of the lymphatic tissue is mainly **lymphocytes (T & B),** other cells also found such as plasma cells & macrophages.

Pluripotent hemopoietic stem cell

↓

Lymphoid progenitor cell

↓

Lymphoblast

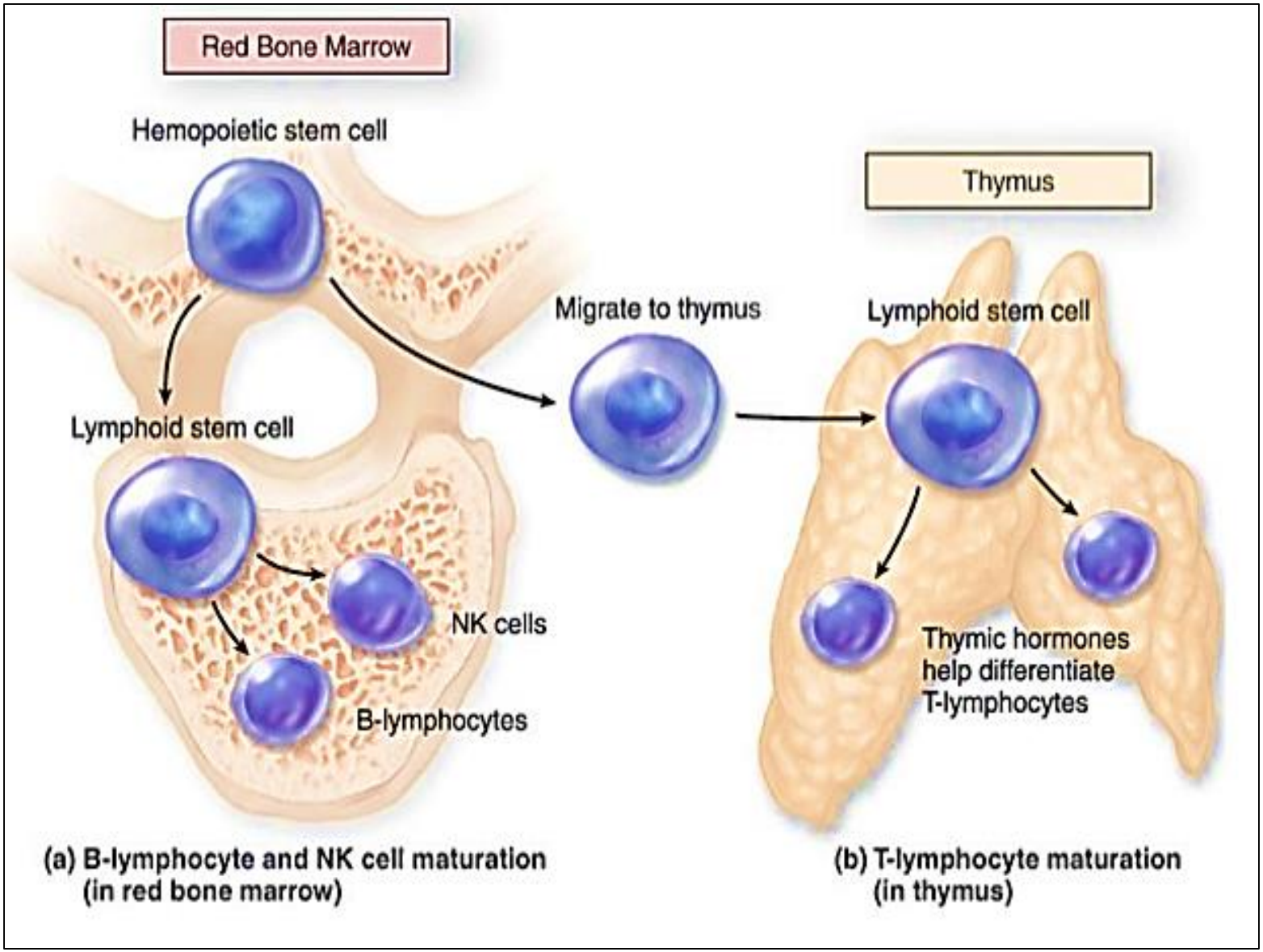
↓

Prolymphocytes: have one of three different fates:

↓

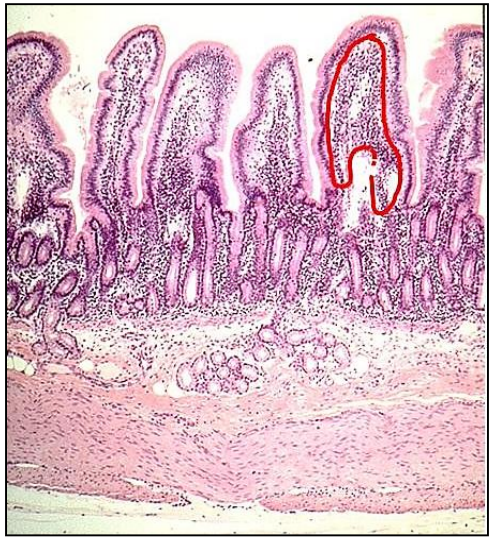
- **Remain in bone marrow & give B lymphocytes**
- **Migrate to thymus and give T lymphocytes**
- **Give rise to NK cells which enter blood directly**

Bone marrow


Red Bone Marrow
Hemopoietic stem cell
Lymphoid stem cell
NK cells
B-lymphocytes
(a) B-lymphocyte and NK cell maturation
(in red bone marrow)
Migrate to thymus
Thymus
Lymphoid stem cell
Thymic hormones
help differentiate
T-lymphocytes
(b) T-lymphocyte maturation
(in thymus)

The lymphatic tissue

The lymphatic tissue present in 2 forms:

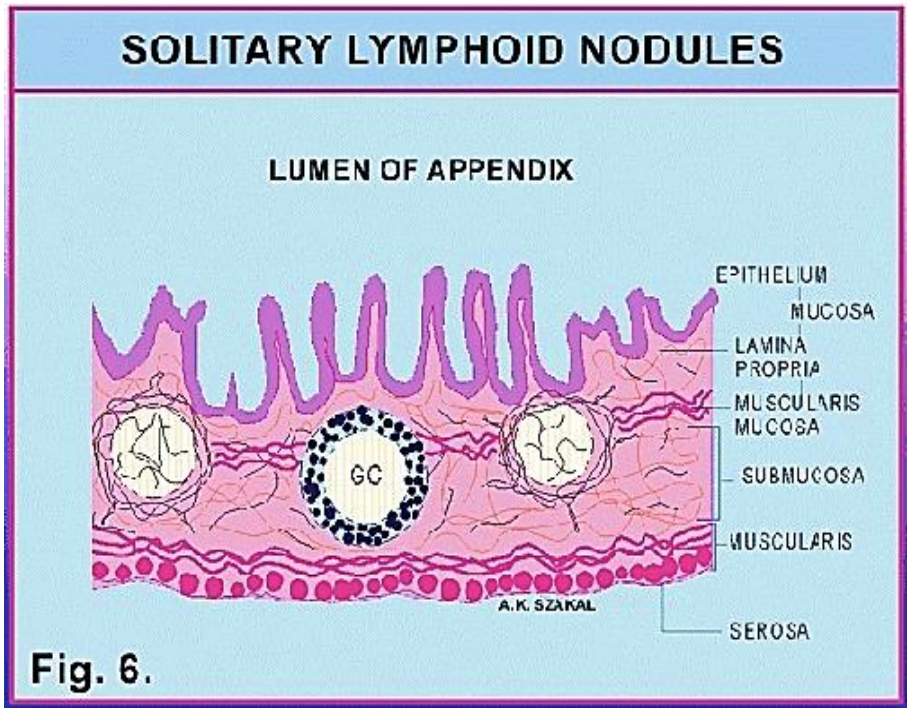


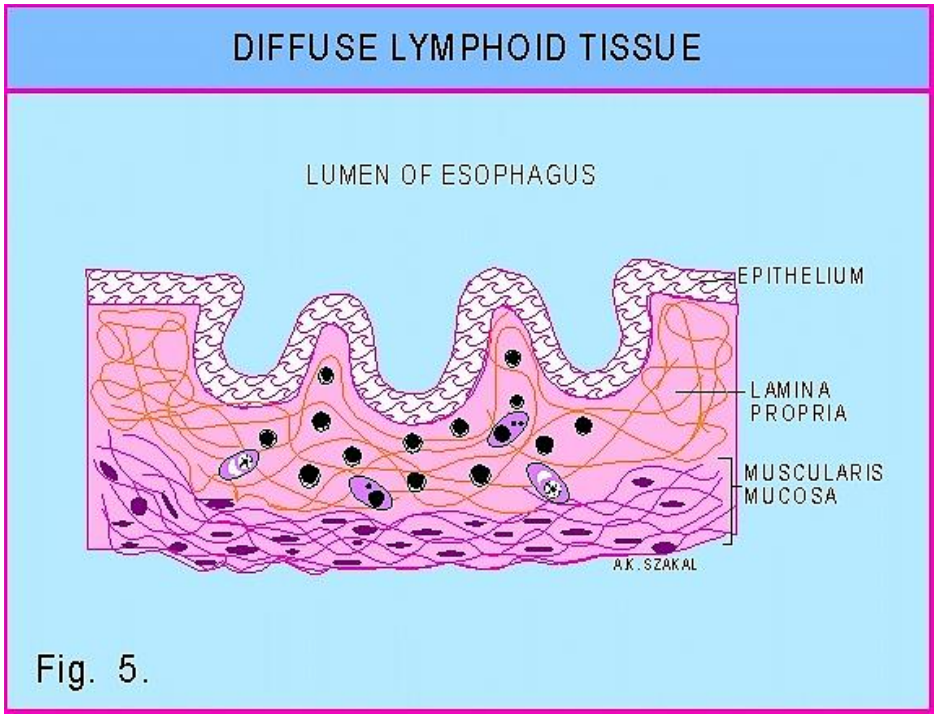
- Diffuse lymphatic tissue

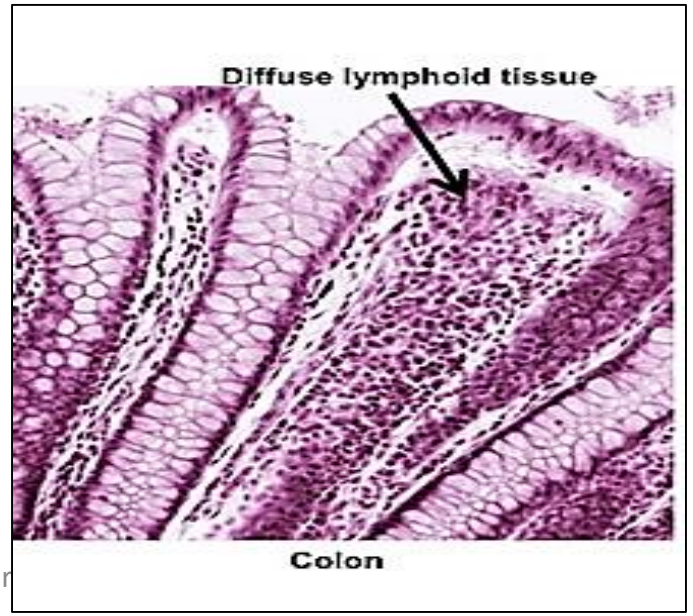
No capsule present, scattered lymphocytes
Found in CT (LP)of almost all organs

- Noduler lymphatic tissue

No capsule present
Oval-shaped masses
Found single or in groups

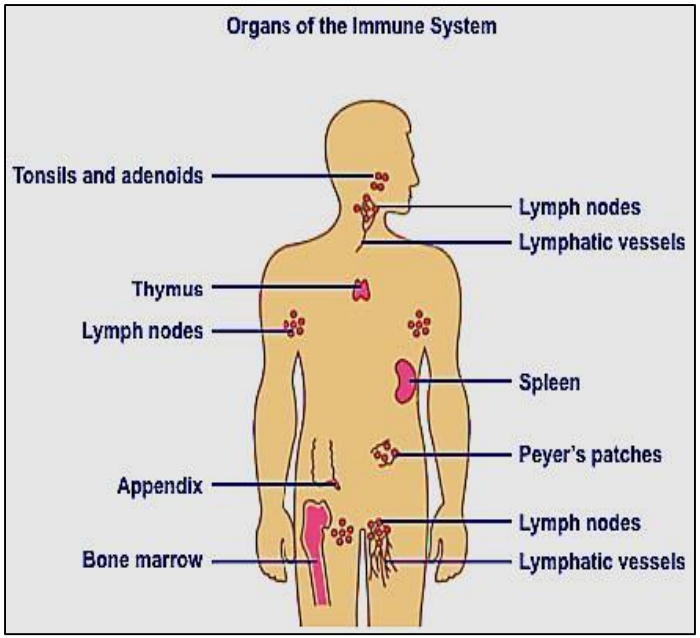

SOLITARY LYMPHOID NODULES
LUMEN OF APPENDIX
EPITHELIUM
MUCOSA
LAMINA PROPRIA
MUSCULARIS MUCOSA
SUBMUCOSA
MUSCULARIS
SEROSA
GC
A.K. SZAKAL
Fig. 6.

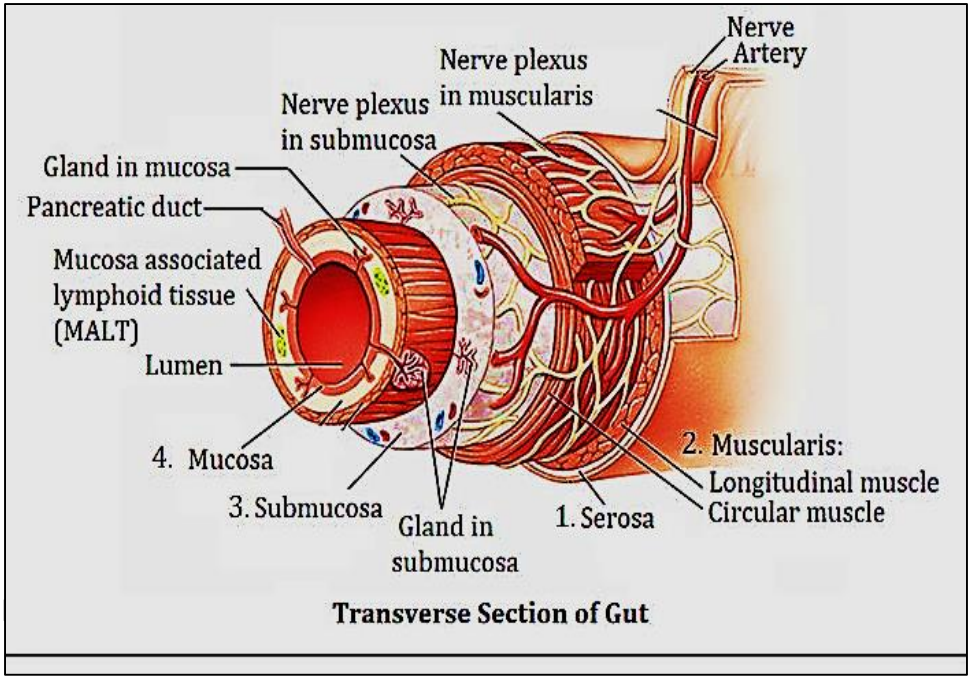

DIFFUSE LYMPHOID TISSUE
LUMEN OF ESOPHAGUS
EPITHELIUM
LAMINA PROPRIA
MUSCULARIS MUCOSA
A.K. SZAKAL
Fig. 5.


Diffuse lymphoid tissue
Colon

Distribution of The diffuse and /or nodular forms in the lymphatic organs:

- Bone marrow : diffuse form only
- Thymus: diffuse only
- Lymph node
- Tonsils
- Spleen
- MALT mucosa associated lymphatic tissue



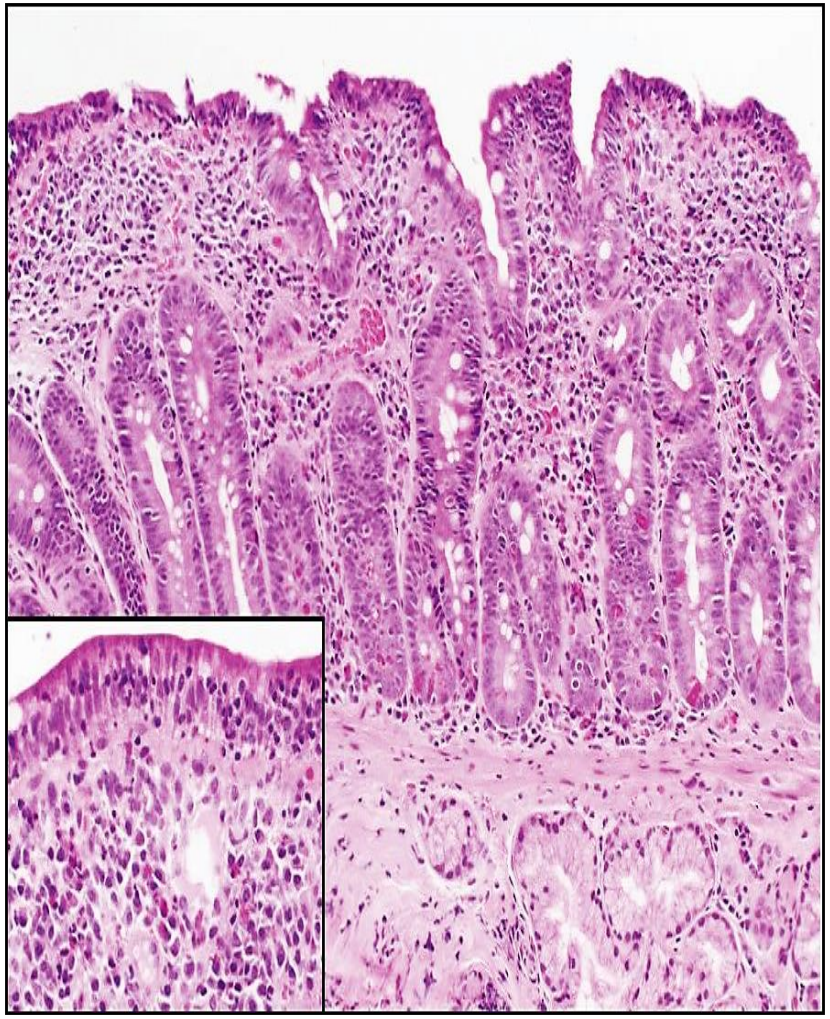


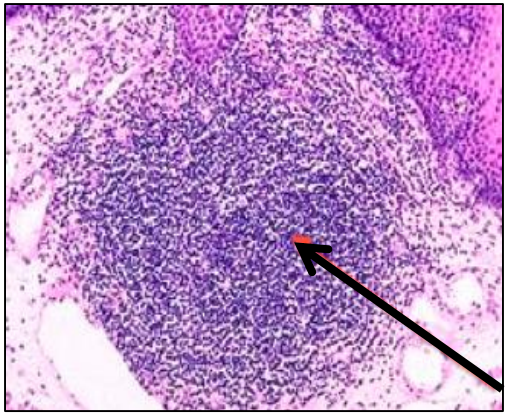
Diffuse lymphatic tissue

- Lymphocytes in lamina propria & submucosa of many organs (RS, GIT, UT, RT)

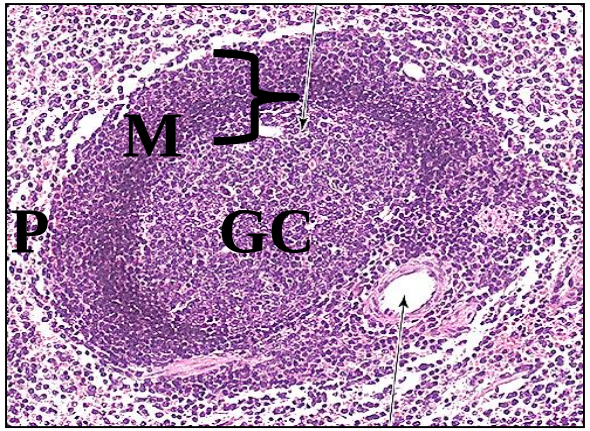
- Also called mucosa associated lymphatic tissue (MALT)

- Appear as scattered dark stained nuclei within C.T.





Nodular Lymphatic tissue (follicle)



Primary
No germinal center

Secondary
With germinal center

Germinal center (GC)

Mantle zone (M)

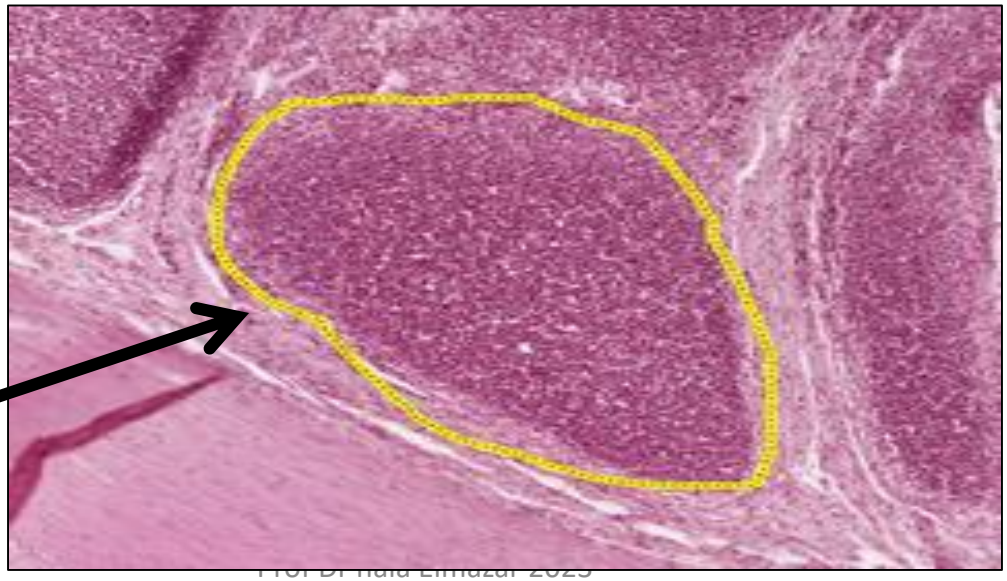
Peripheral zone (P)

Primary Lymphatic nodules

- Non capsulated collection of lymphocyte

- Found in all lymphoid organs **EXCEPT** **thymus & bone marrow.**

Primary nodule: has no germinal center **Only small B lymphocytes (not activated)**



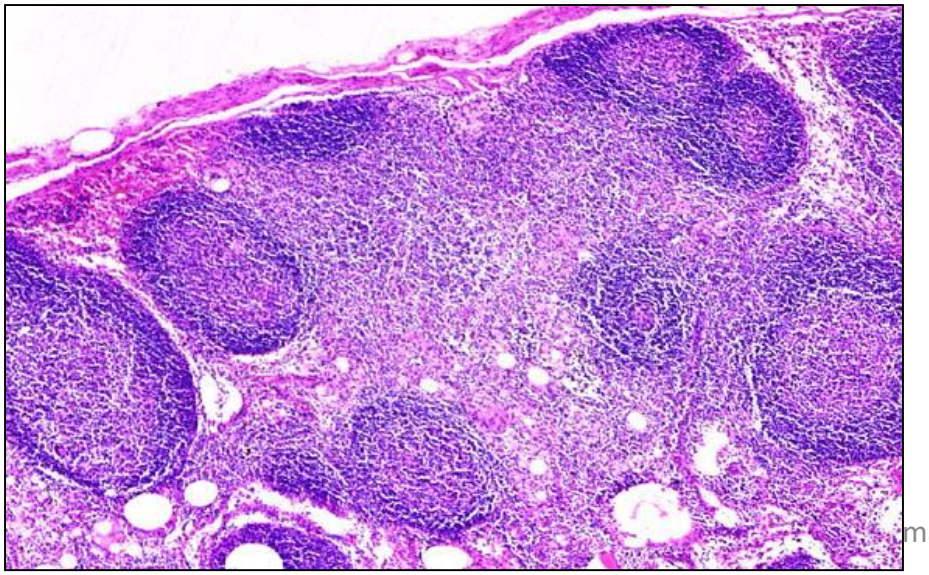
The Secondary lymphatic nodule

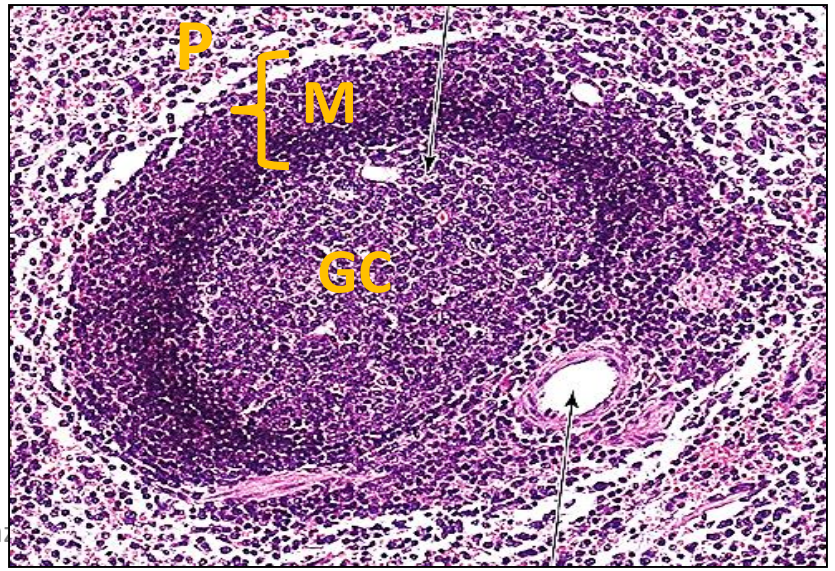
contains :

1- Pale germinal center: B lymphocytes actively divide as a result of Ag stimulation , plasma cells & dendritic cells

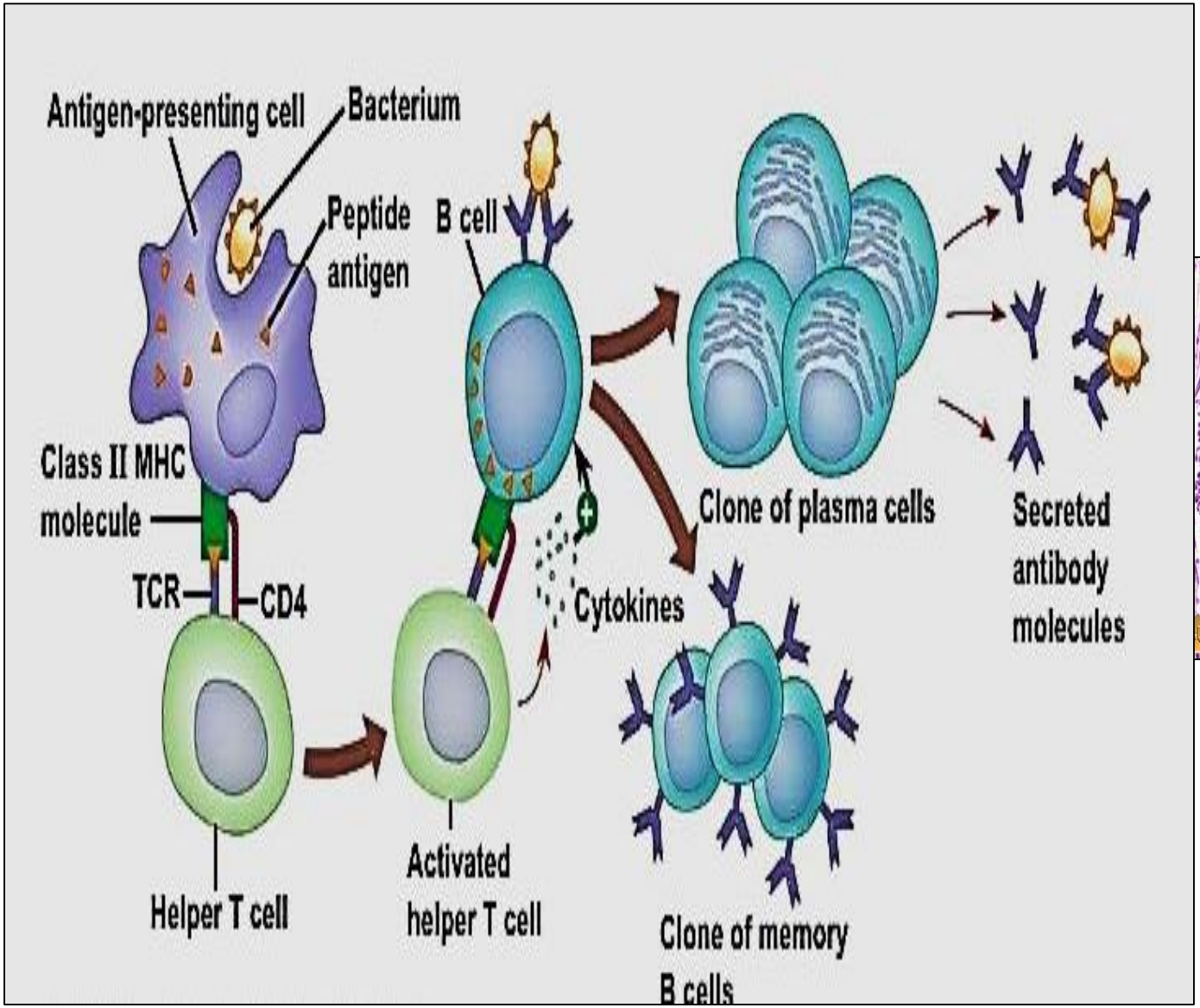
2- Mantle zone (corona): formed by dense population of resting & memory B lymphocytes (Mantel cell lymphoma)

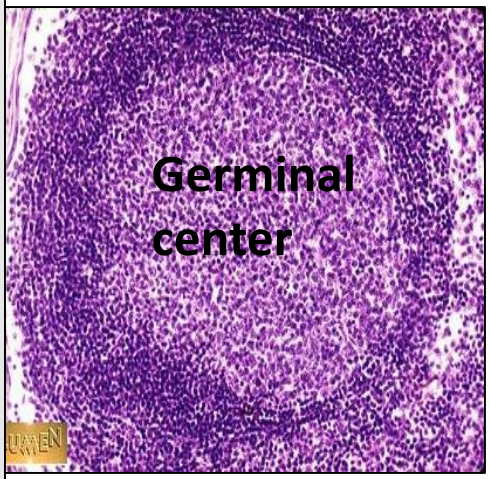
3- Peripheral zone: small B lymphocytes

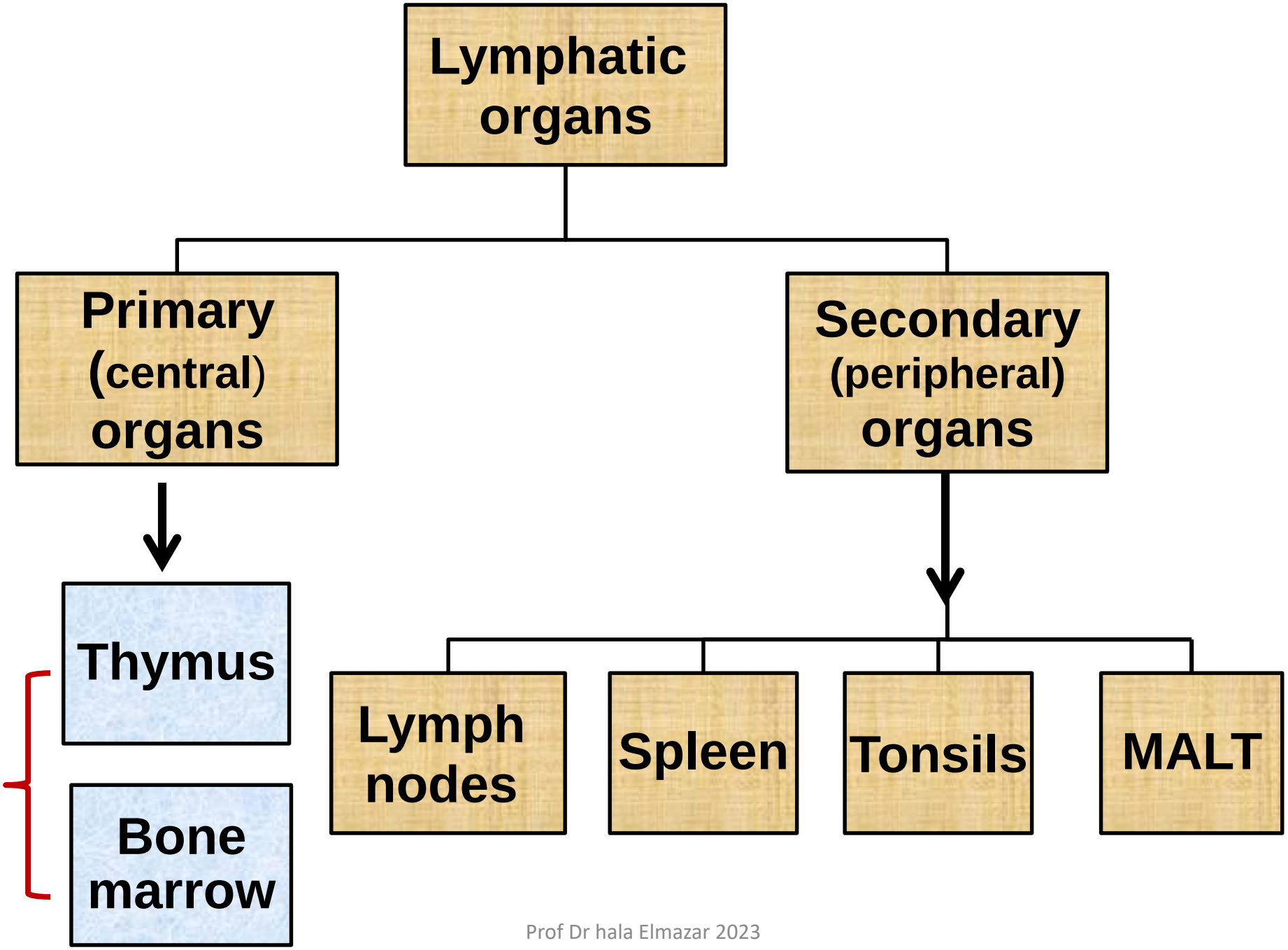




Activation of B cells & development of germinal center:






Lymphatic organs
Primary (central) organs
Secondary (peripheral) organs
Thymus
Bone marrow
Lymph nodes
Spleen
Tonsils
MALT

Primary Lymphoid Organs

- B & T lymphocytes arise from same stem cell in bone marrow

- are **initial** "education centers" of the immune system

- In these organs, lymphocytes (**T** /thymus, **B/**bone marrow) differentiate into **immunocomptent cells**

(i.e. they can recognize "self" vs. "non-self")

- This differentiation is said to be ***antigen-independent***
- ***The lymphocytes then enter the blood & lymph to reside in the 2nry lymphatic organs***

Secondary Lymphoid Organs

- The lymph nodes, MALT, tonsils, spleen

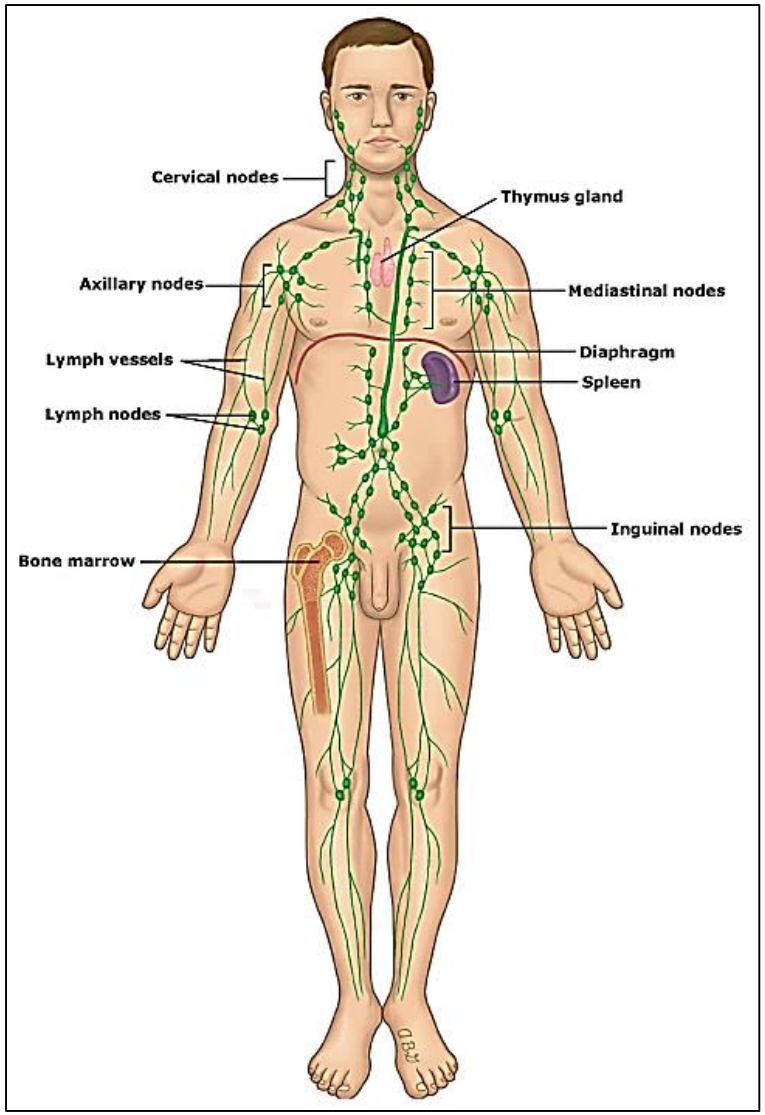
- Are **secondary** "education centers" of the immune system, where **most immune response occurs**

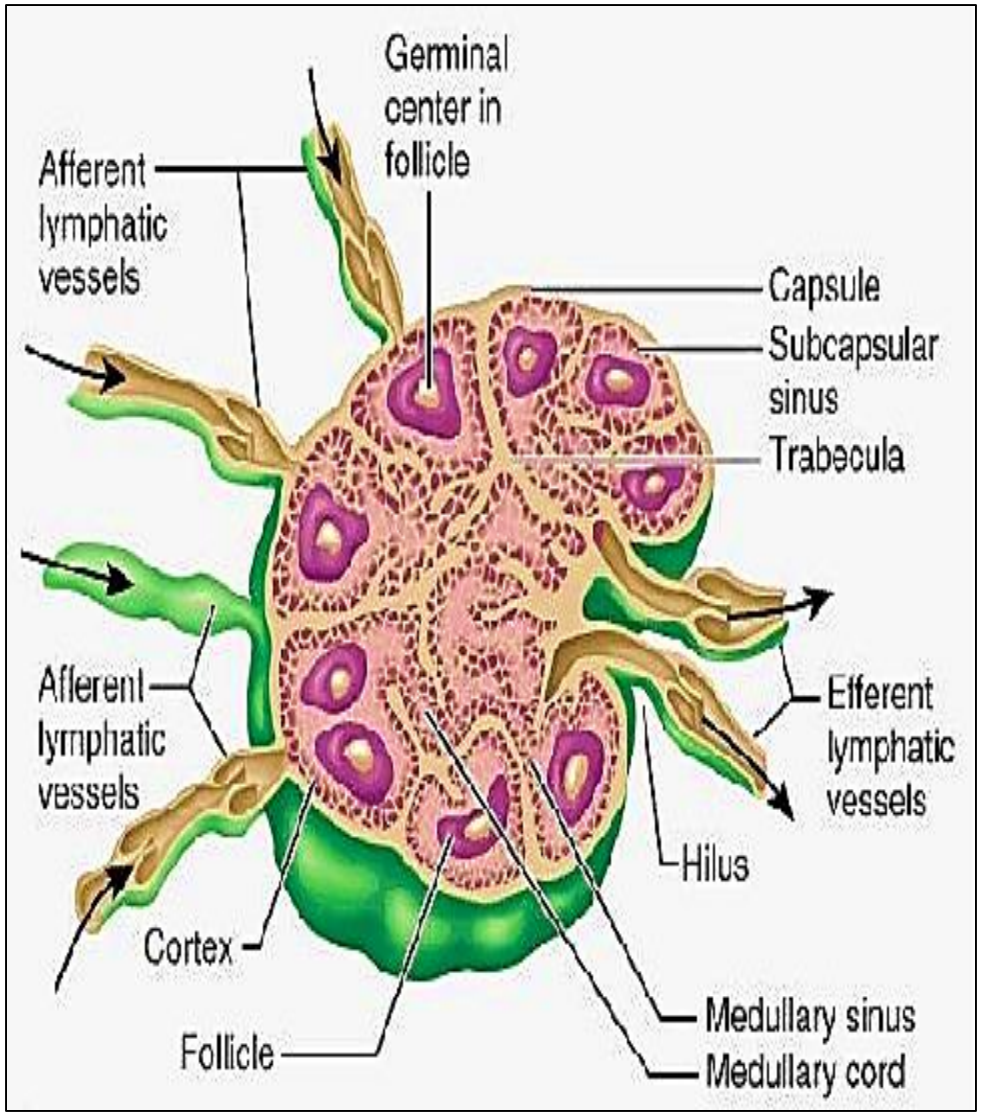
- In these organs, immuno-competent lymphocytes differentiate into **immune effectors** & **memory cells**

(The activation and proliferation is ***antigen-dependent***)

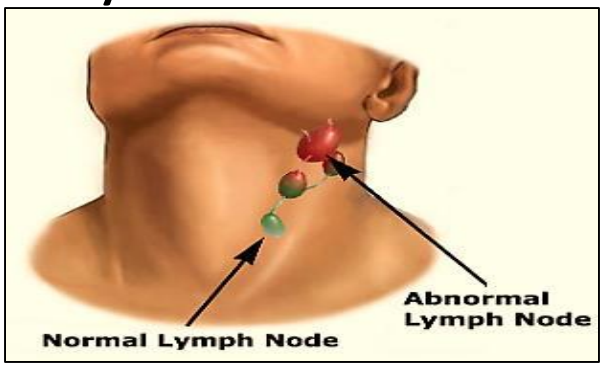
These lymphocytes then carry out their functions

Lymph nodes


Cervical nodes
Thymus gland
Axillary nodes
Mediastinal nodes
Lymph vessels
Diaphragm
Spleen
Lymph nodes
Inguinal nodes
Bone marrow


Germinal center in follicle
Afferent lymphatic vessels
Capsule
Subcapsular sinus
Trabecula
Afferent lymphatic vessels
Efferent lymphatic vessels
Hilus
Cortex
Medullary sinus
Follicle
Medullary cord

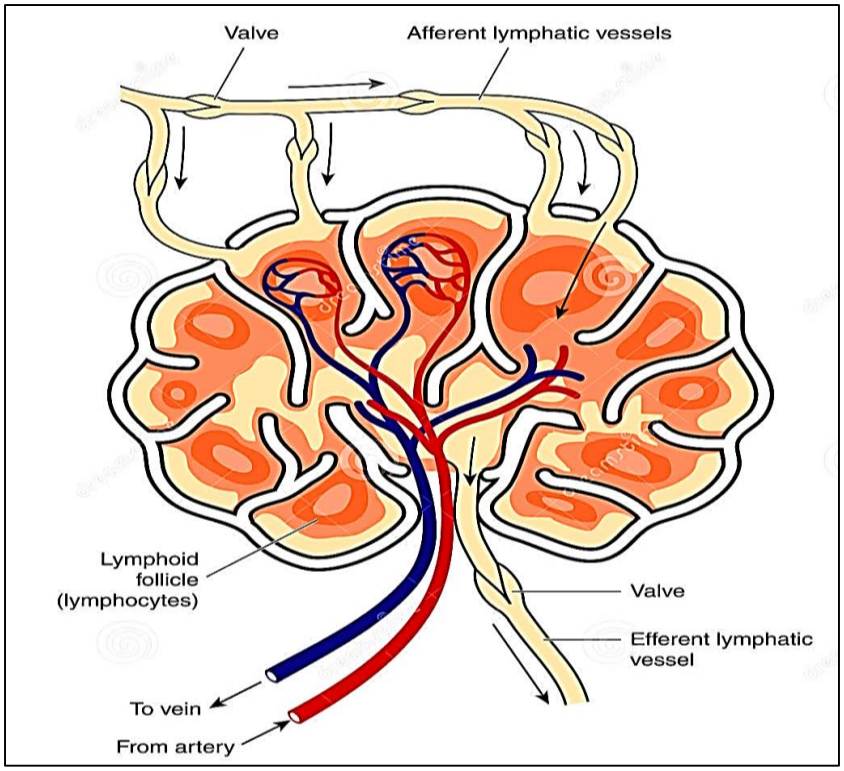
- Principal **2ry lymphoid organs** of the body

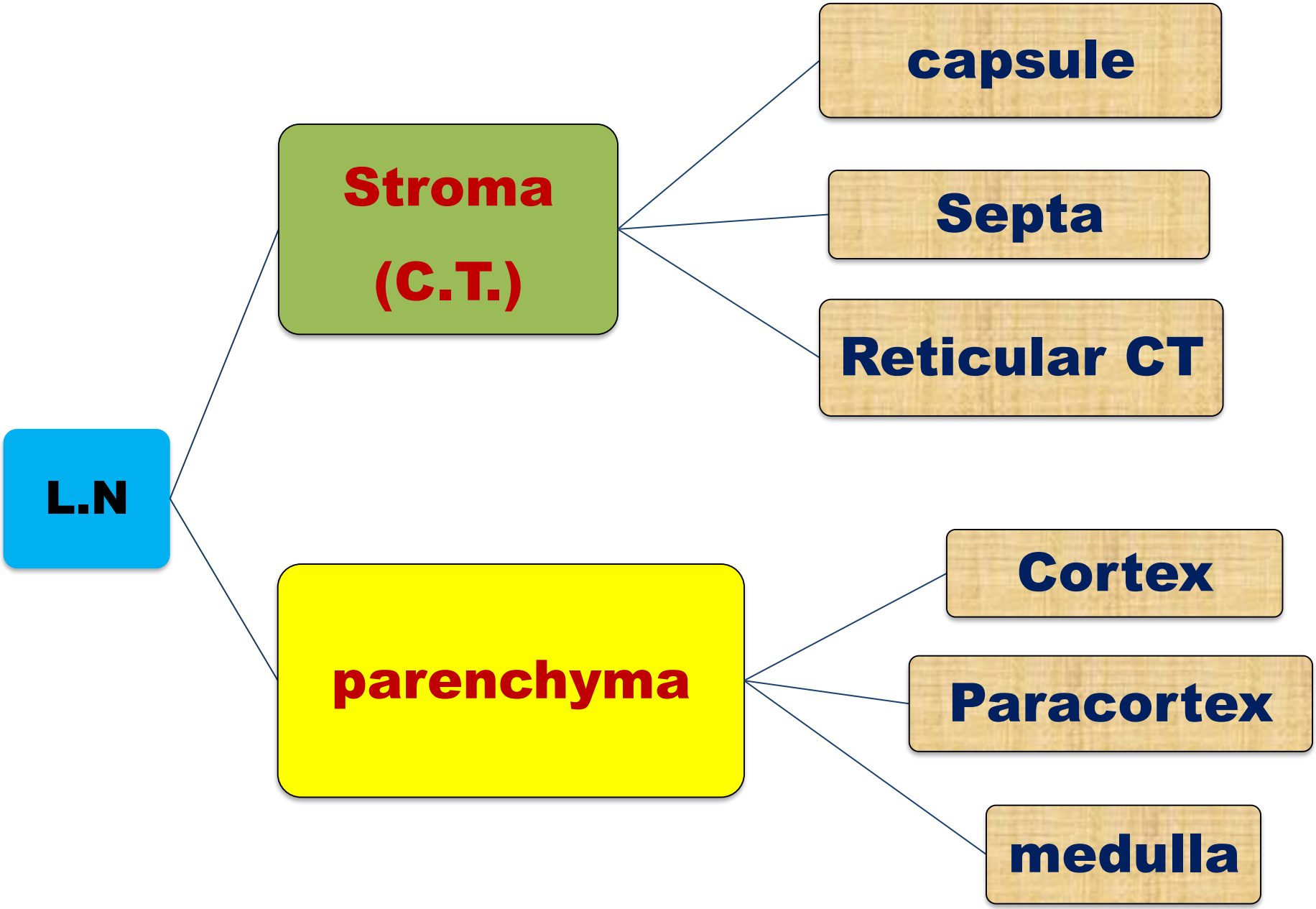


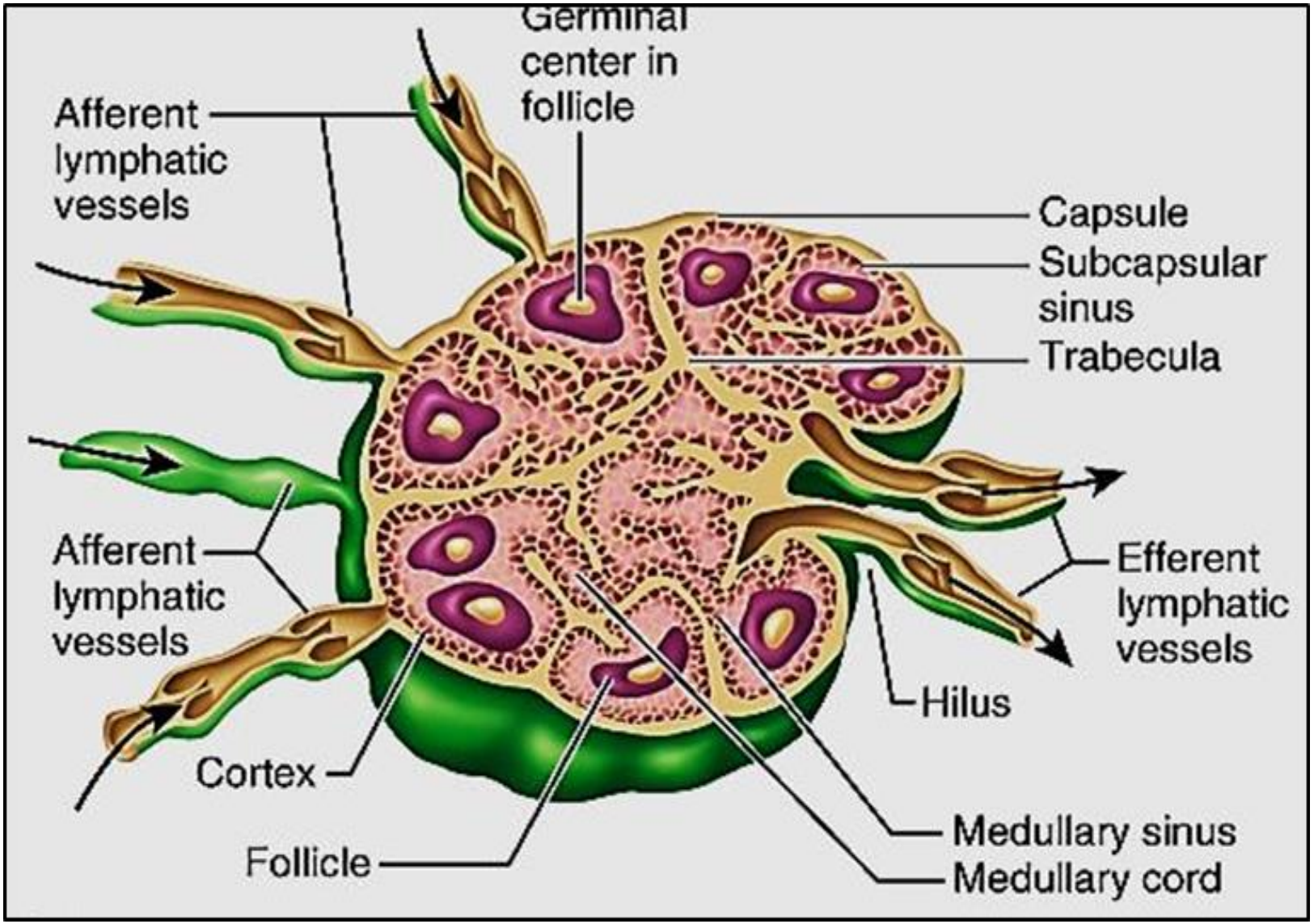
- Found along lymphatic vessels

- Oval or bean shaped /encapsulated organs

- Have convex surface where afferent lymphatic's enter the node & concave surface Where efferent lymphatic's, arteries &veins exit the node




L.N
Stroma
(C.T.)
capsule
Septa
Reticular CT
parenchyma
Cortex
Paracortex
medulla


Germinal center in follicle
Afferent lymphatic vessels
Capsule
Subcapsular sinus
Trabecula
Afferent lymphatic vessels
Efferent lymphatic vessels
Hilus
Cortex
Follicle
Medullary sinus
Medullary cord

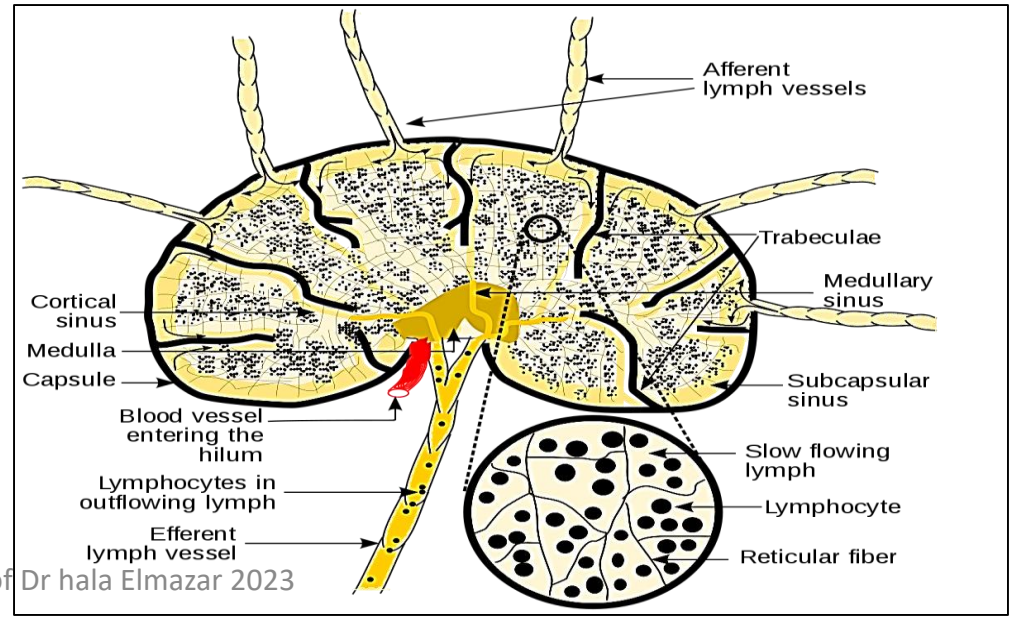
Lymph node

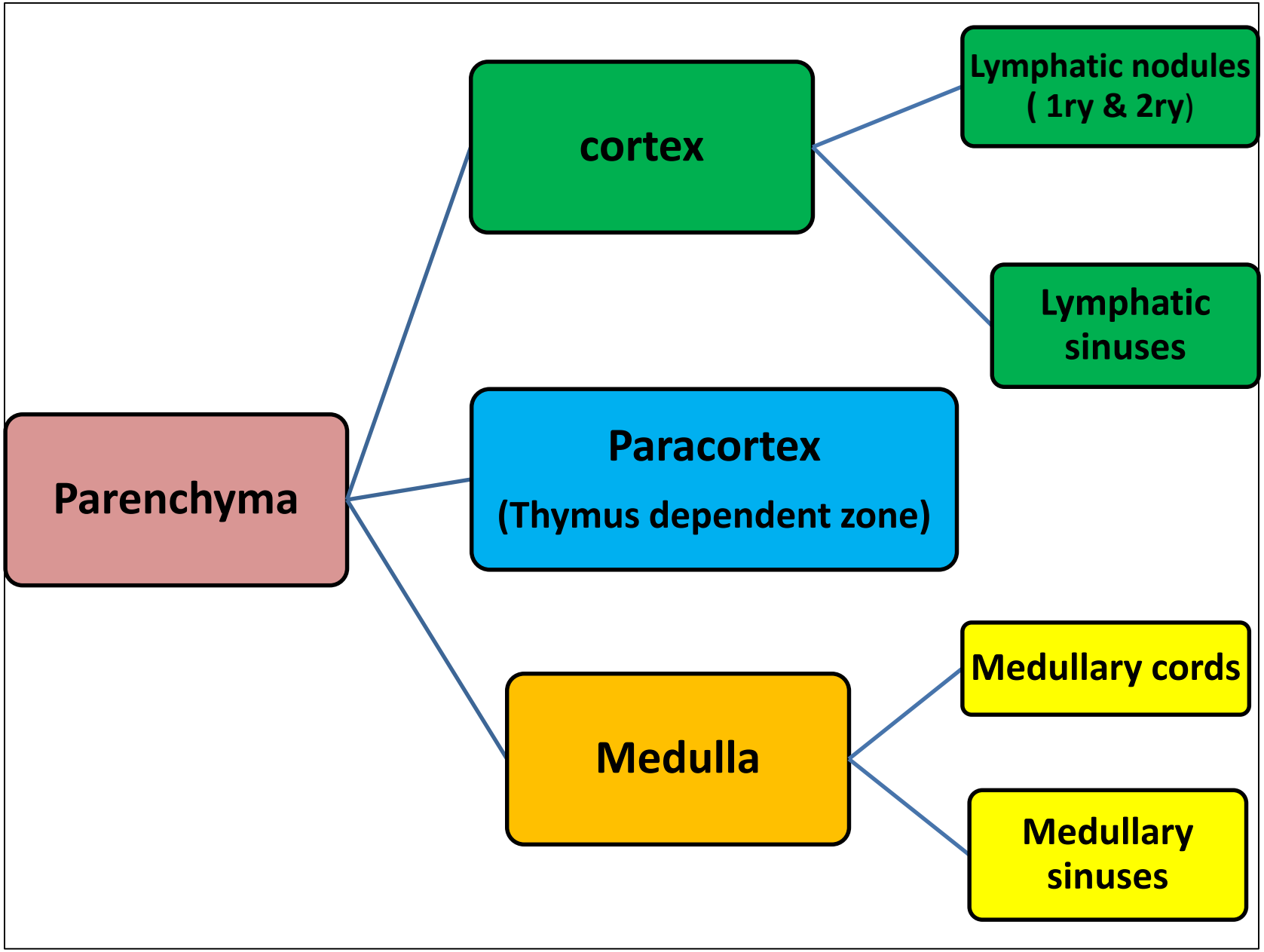
A- Stroma

Capsule: may contain smooth ms. & elastic fibers, capsule become thick at the hilum of the node

Septa (Trabeulae): extend from capsule and divide cortex into compartments

Reticular network: of reticular fibers form the background of the organ to support the parenchyma




Parenchyma
cortex
Lymphatic nodules
(1ry & 2ry)
Lymphatic
sinuses
Paracortex
(Thymus dependent zone)
Medulla
Medullary cords
Medullary
sinuses

B- Parenchyma

Is divides into 3 parts:

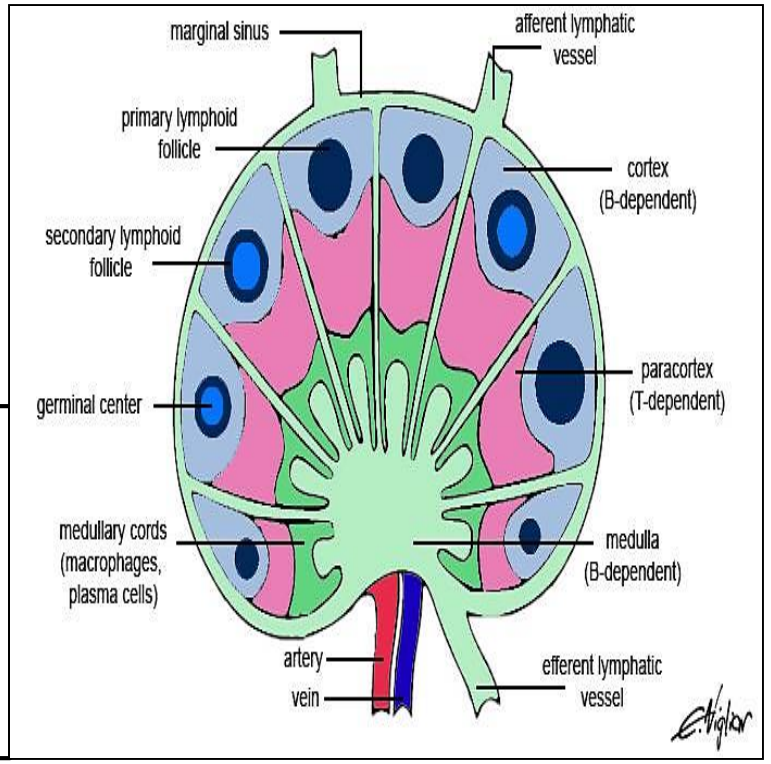
cortex, **paracortex ,** **medulla**

1- Cortex: outer zone under the capsule contains:

- A- lymphatic nodules (1ry & 2ry)

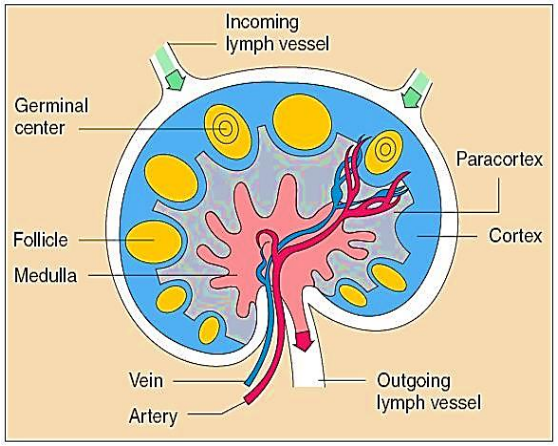
1ry: small B cells, APCs, reticular cells

2ry: activated B cells, Plasma cells, macrophages



- B- lymphatic sinuses (subcapsular & cortical): are spaces contains : **lymph**, B Lymphocytes, macrophages, few T-lymphocytes)

2- Paracortex:

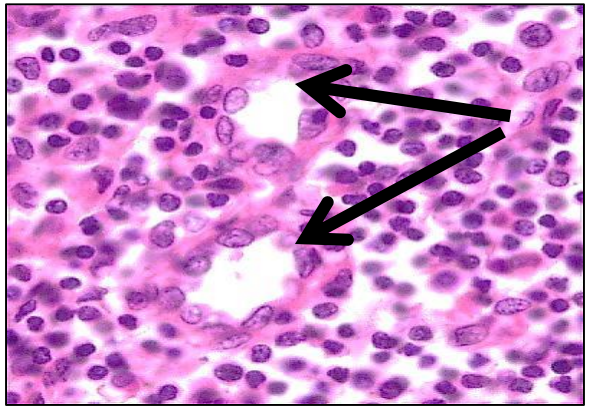


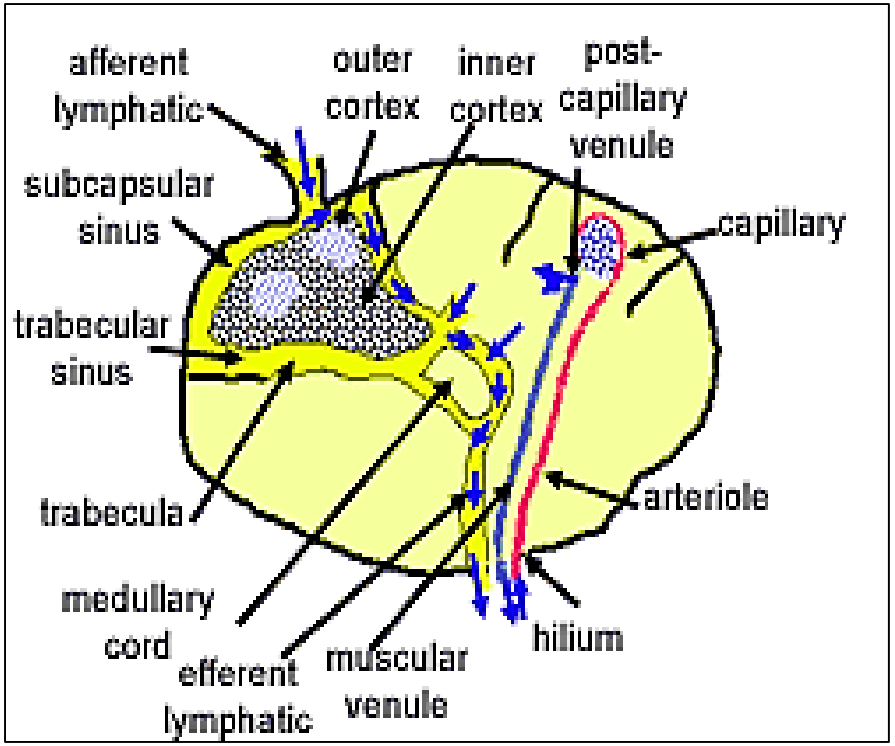
- between the cortex and medulla

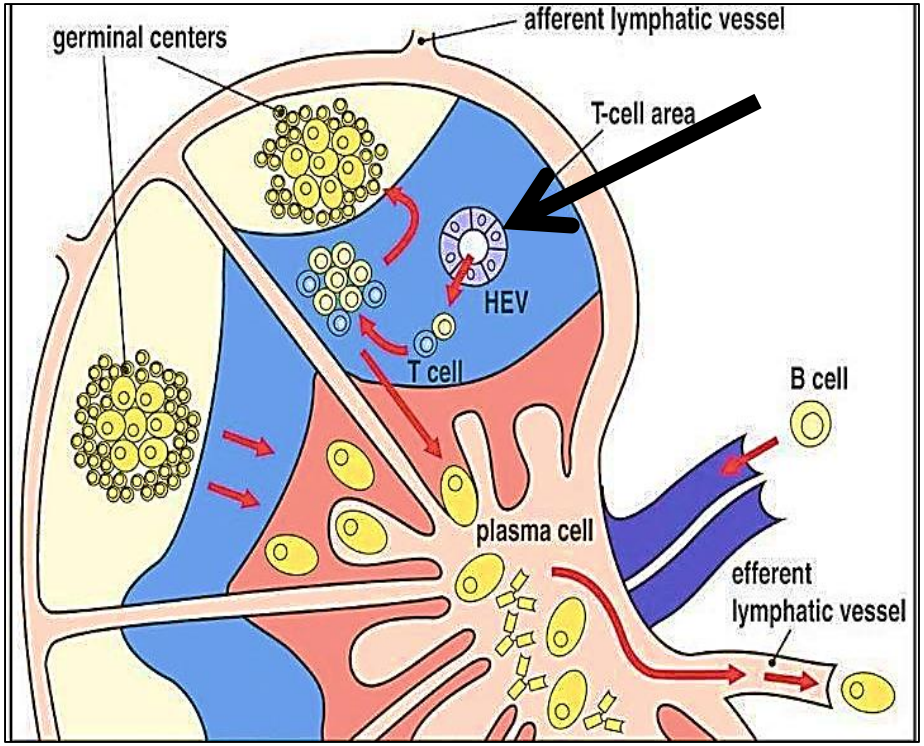
- Is called the **Thymus dependent zone** of the lymph node, contains **T cells** that have migrated from the thymus **[T lymphocytes + High endothelial venules (HEV)**

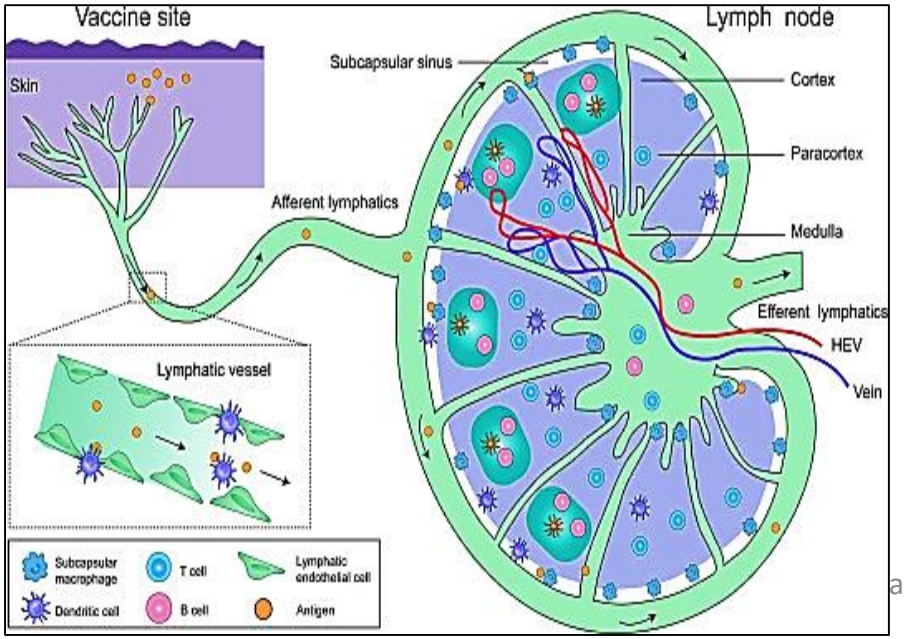
High endothelial venules(HEV): is a post- capillary venule

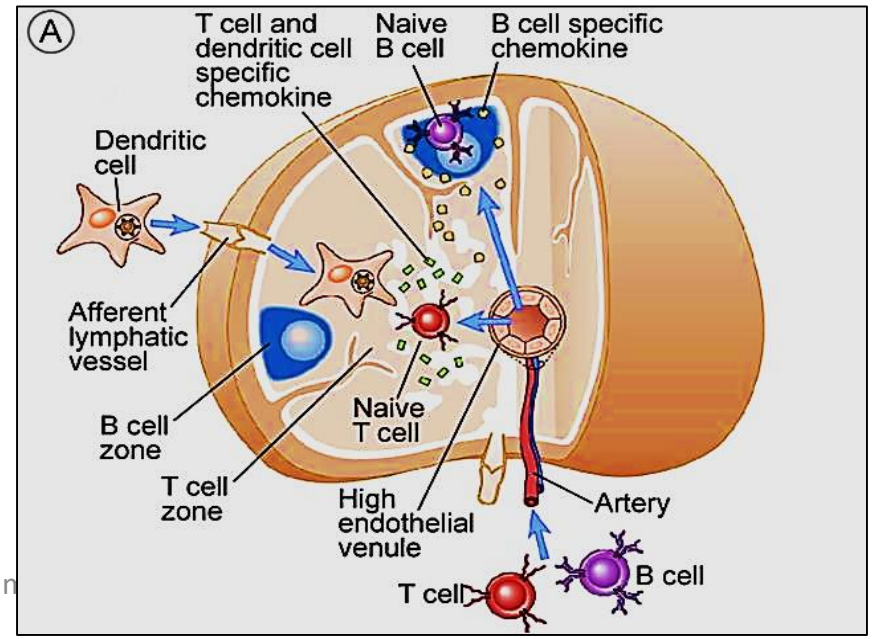
- is the point of entry of T cells from blood to lymph node
- its endothelial lining is unusual
- is cuboidal to facilitate movement of T cells into LN




afferent lymphatic
outer cortex
inner cortex
post-capillary venule
subcapsular sinus
capillary
trabecular sinus
trabecula
arteriole
medullary cord
efferent lymphatic
muscular venule
hilium


germinal centers
afferent lymphatic vessel
T-cell area
HEV
T cell
B cell
plasma cell
efferent lymphatic vessel


Vaccine site
Lymph node
Skin
Subcapsular sinus
Cortex
Paracortex
Afferent lymphatics
Medulla
Efferent lymphatics
HEV
Vein
Lymphatic vessel
Subcapsular macrophage
T cell
Lymphatic endothelial cell
Dendritic cell
B cell
Antigen


A
T cell and dendritic cell specific chemokine
Naive B cell
B cell specific chemokine
Dendritic cell
Afferent lymphatic vessel
B cell zone
T cell zone
Naive T cell
High endothelial venule
Artery
T cell
B cell

3- Medulla: contains

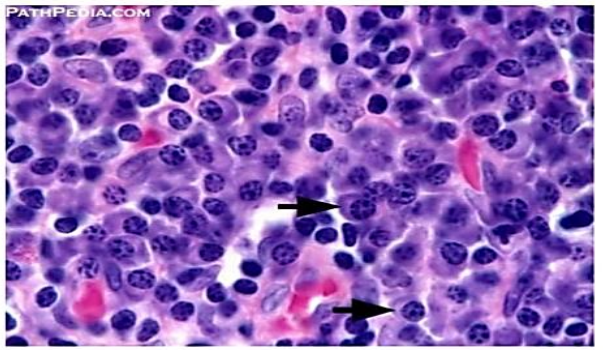
- Medullary cords:

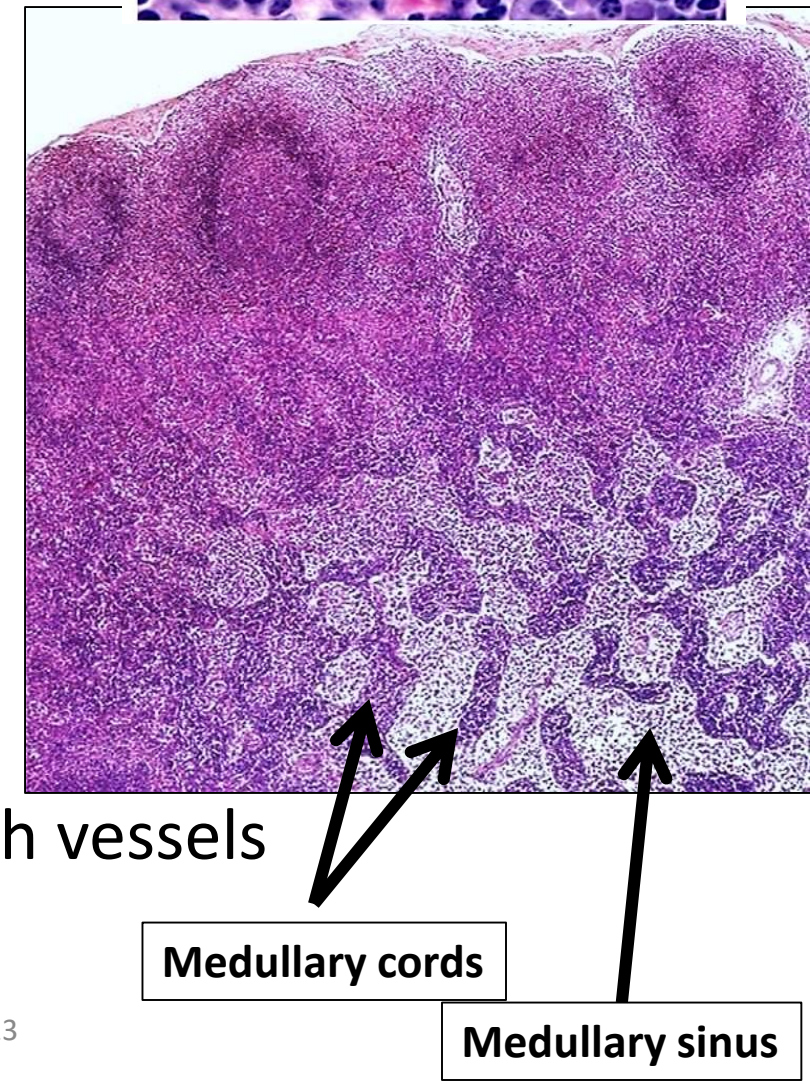
  * Cords of aggregated cells

  * Contains: B lymphocytes, Plasma cells , macrophages

- Medullary sinuses:

- Dilates spaces, continuous e cortical sinuses, & contains lymph, B cells, macrophages, they join at hilum → efferent lymph vessels





Flow of lymph:

Flows from Afferent lymphatic (valves) → lymph node

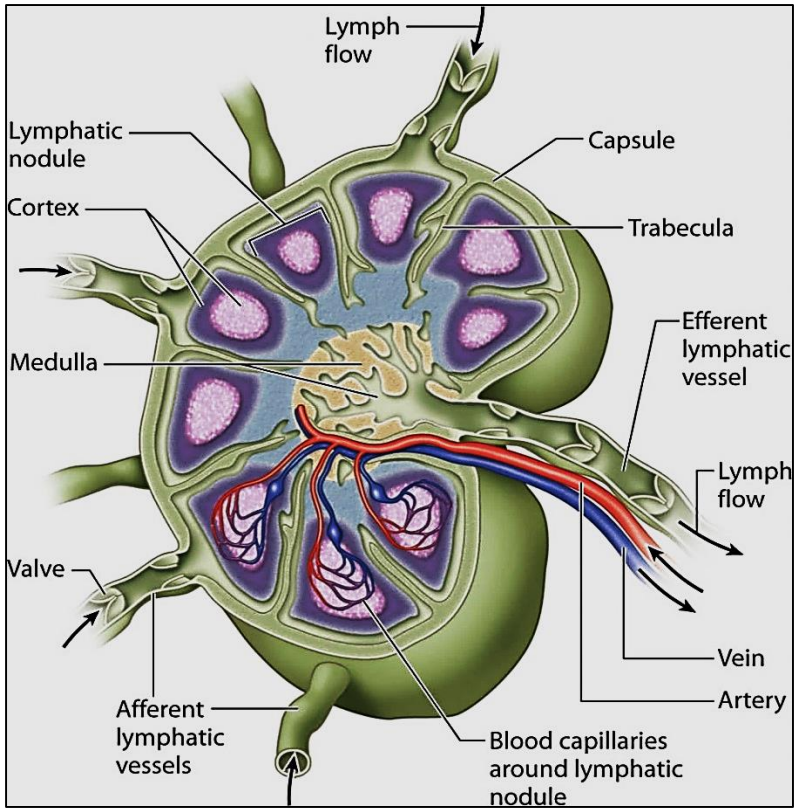
- → subcapsular sinus

  (contains B lymphocytes, macrophages & dendritic cells)
- → cortical sinuses

  (contains B cells)
- → paracortex

  (contains T cells)
- → medullary sinuses

  (B cells & plasma cells)
- → hilum → Efferent lymphatic



Functions of lymph nodes:

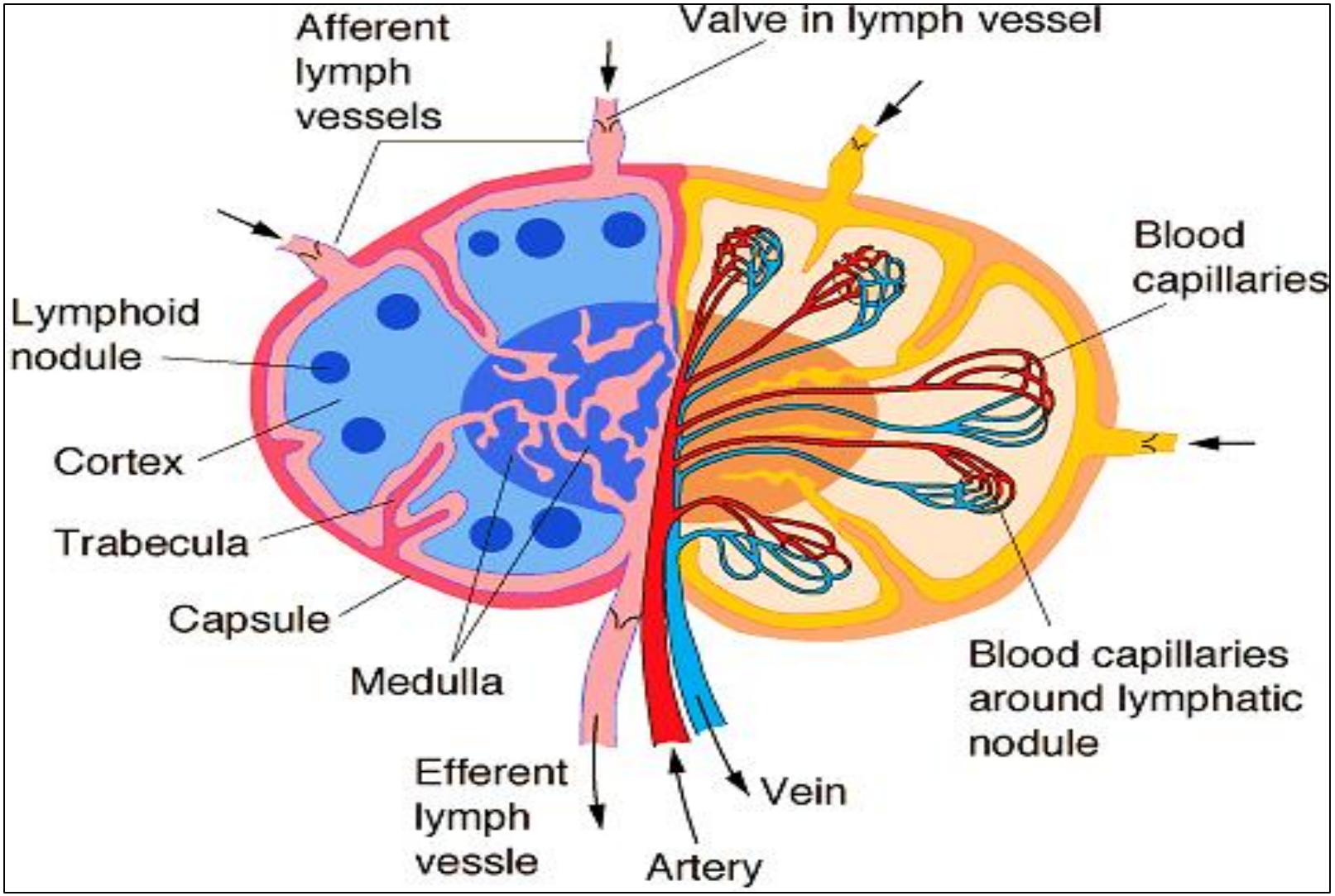
1- Filtration of lymph from microorganisms & particles before it reaches the general circulation.

2-Promote interaction of the circulating antigens in lymph with lymphocytes in nodes to initiate immune response *(antigen – dependent differentiation)*

3-Activation, proliferation of B lymphocytes and antibody production.

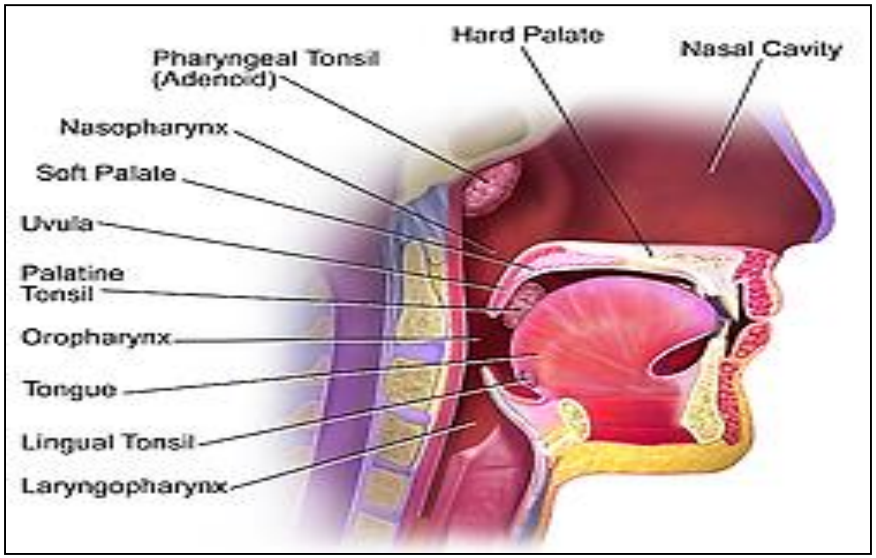
4-ActivationT lymphocytes into cytotoxic T cells

Lymph and blood supply of Lymph Node



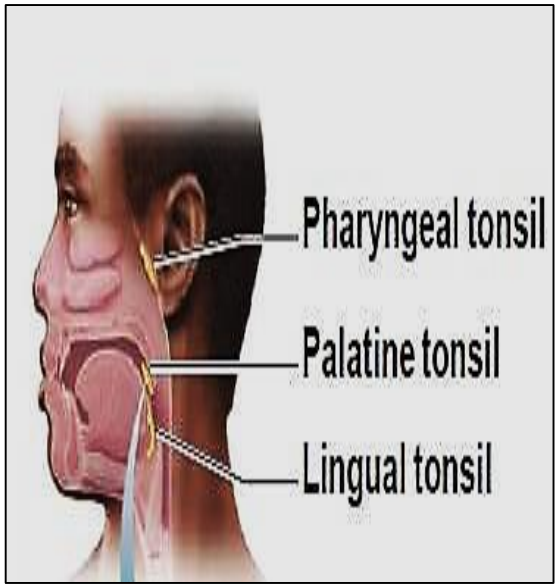
Tonsils

Masses of Lymphoid tissue **at entrance** of digestive and respiratory **under oral or respiratory epithelium** produce lymphocytes to guard against infections

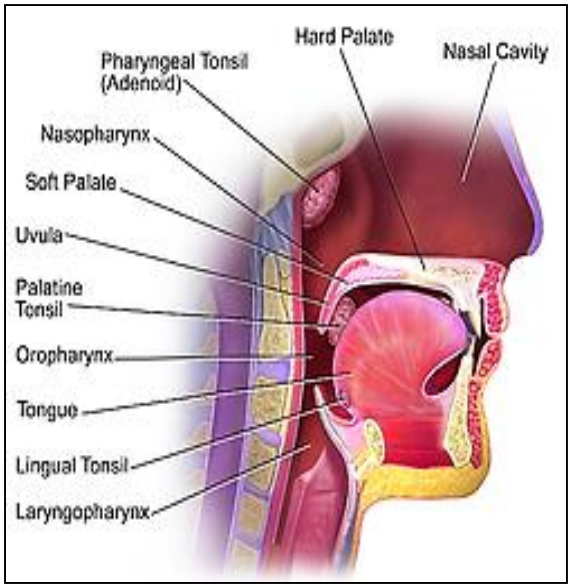


Characteristics of its lymphoid tissue:

- Covered by epithelium.
- Not situated along course of lymphatic vessels



Tonsils

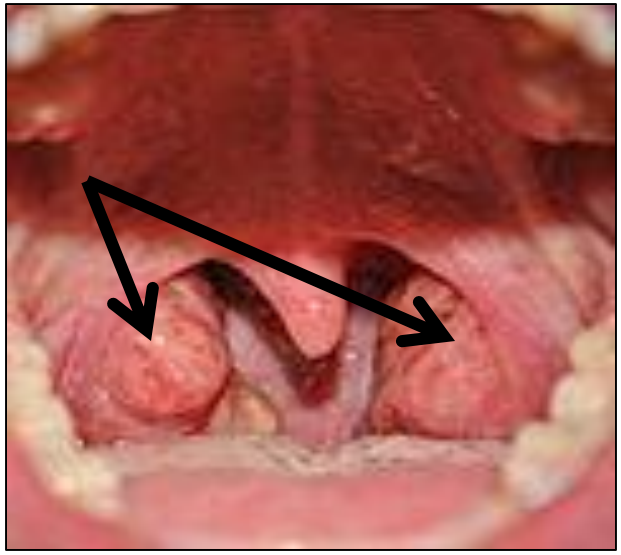


Palatine
Non keratinized stratified squamous epi

Pharyngeal
Pseudo-stratified Col. Ciliated

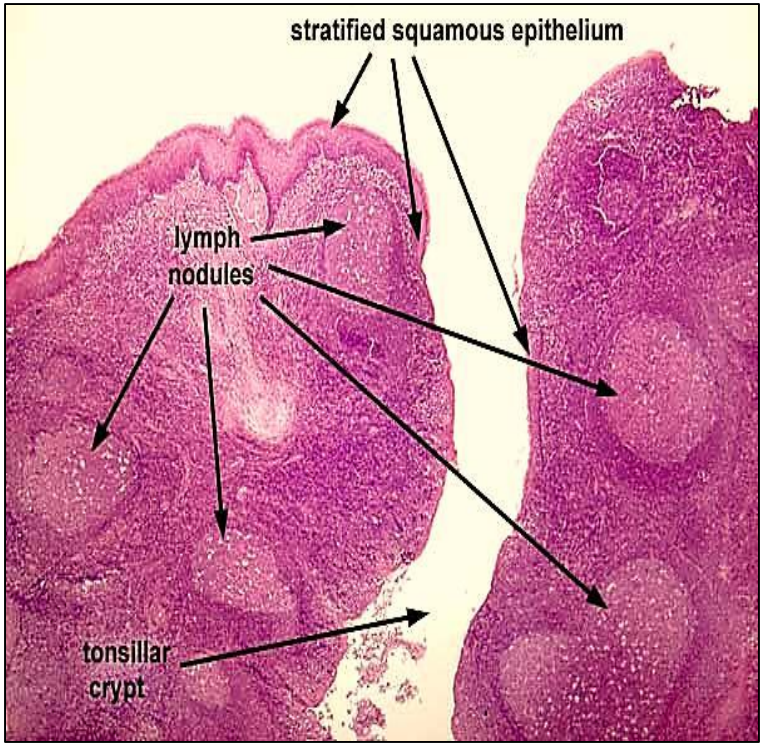
Lingual
Non keratinized stratified Squamous

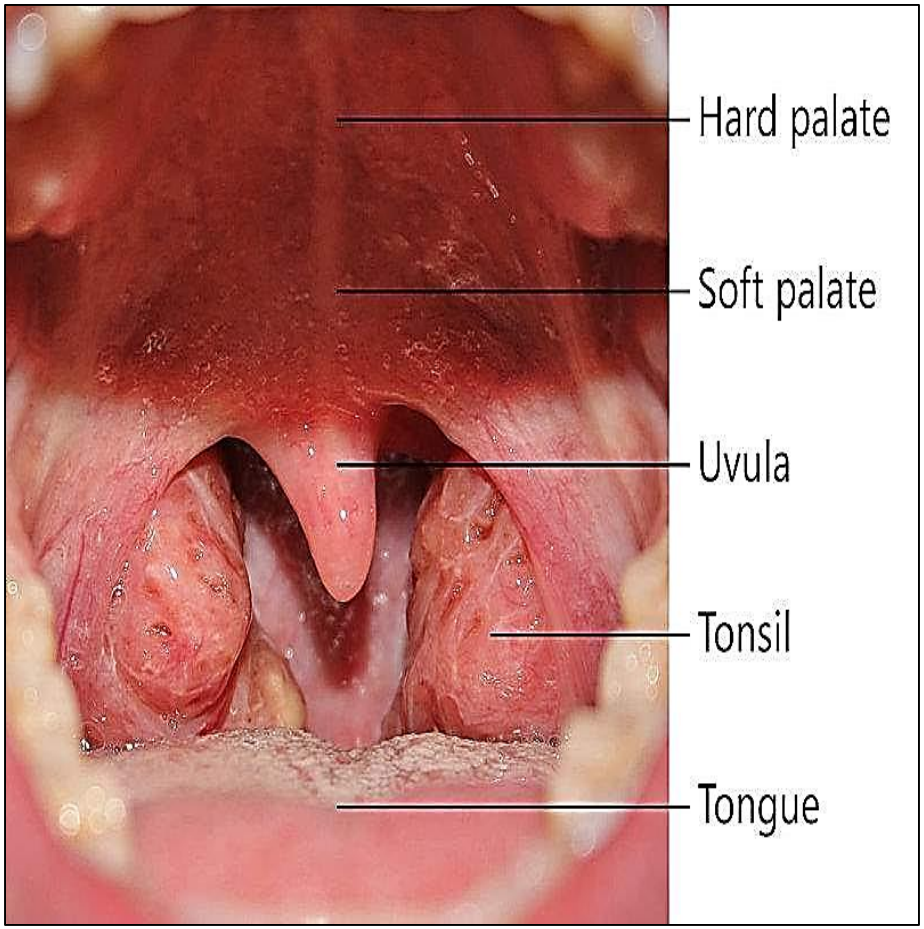
Palatine tonsils



2 tonsils located in the oral part of pharynx.

- **Stratified squamous epith:** Covers the free surface of the tonsil and lines the **crypts**.
- **Crypts:** Epithelial invaginations into the tonsil substance lined with surface epithelium.
- **Lymphoid tissue:** diffuse + nodular lymphatic tissue. May contain germinal centers.

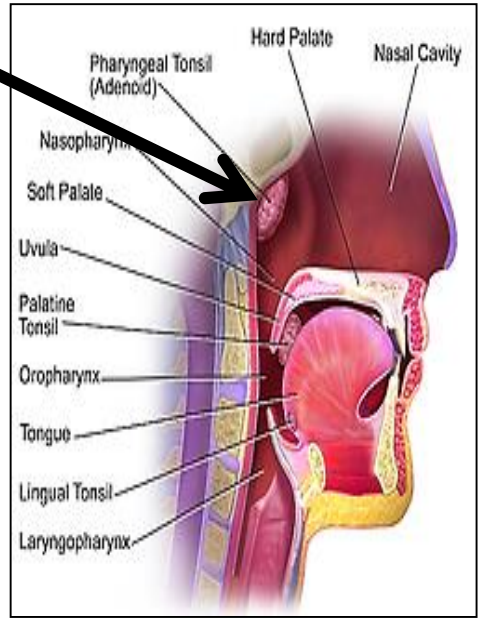




Palatine Tensile

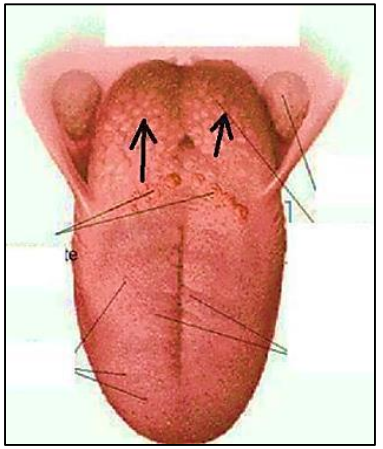
The lumen of the crypts contain lymphocytes, bacteria and desquamated epithelial cells.

Pharyngeal tonsil

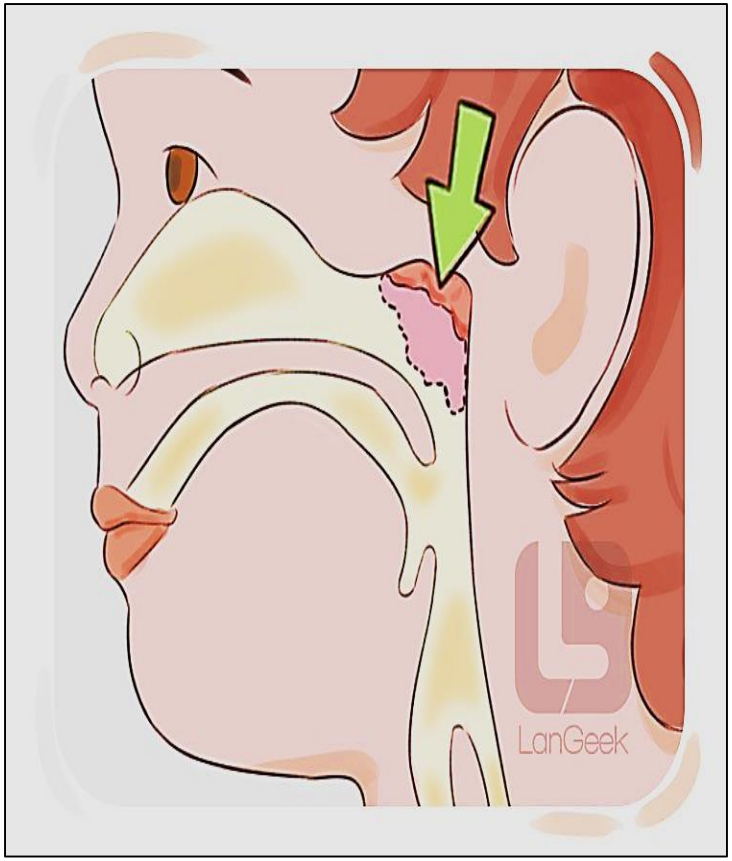


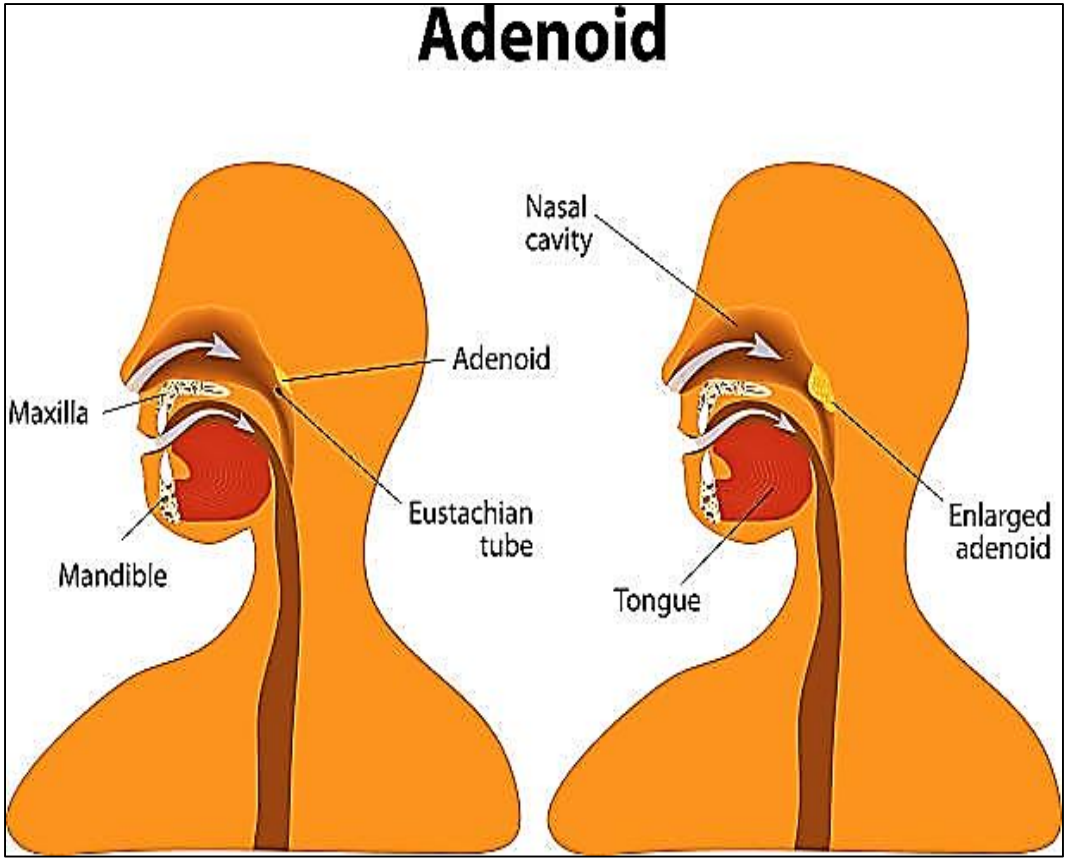
- **Single** mass of lymphoid T. in nasopharynx
- Covered by pseudo-st. columnar ciliated e goblet cells (**respiratory epithelium**)
- It has **No crypts** , underlying capsule is thin

Lingual tonsil



- The posterior 1/3 human tongue
- Covered e non - k. stratified squamous epith.
- **Contains crypts** mucus glands at the root of tongue drain through several ducts into the crypts secretions of these mucous glands keep the crypts clean and free of any debris.
- Tensile contains lymphoid nodules + diffuse lymphocytes.





Pharyngeal tonsil → Adenoids

Thank you