LYMPHATIC SYSTEM

- lymphocytes
- Lymphoid tissue + organs
- Lymphatic vessels

LYMPHATIC ORGANS

Primary (central) organs

- Production and maturation of lymphocytes
- Incorporation of proteins in cell membrane of lymphocytes —> will later become receptors (for T and B lymphocytes to recognise pathogens)
- Naive cells mature here
    - They then migrate to secondary (peripheral) lymphatic organs
- 2 primary lymphatic organs
    - **Bone marrow**
        - Haematopoiesis
        - Maturation of B lymphocytes
    - **Thymus**
        - Maturation, multiplication and selection of T lymphocytes

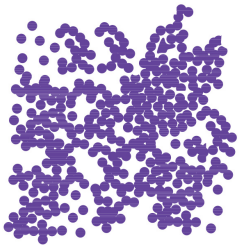
Secondary (peripheral) organs

- sites where immune cells migrate to and carry out their functions
- Can be :
    - Encapsulated : Covered by a fibrous capsule
        - **Spleen**
        - **Lymph nodes**
    - Partially encapsulated : part epithelium, part dense connective tissue
        - **Tonsils**
    - Not encapsulated : accumulation of lymphoid tissue near epithelium of organs (in mucosa)
        - **MALT** (mucosa associated lymphoid tissue)

Structure :

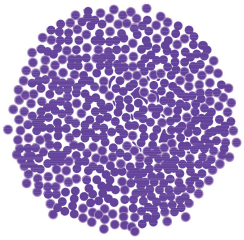
Parenchyma :

- functional tissue
- Storage of cells
    - Lymphocytes (including precursors and effectors)
    - Antigen presenting cells (monocytes, macrophages, follicular dendritic cells, dendritic cells)
    - Plasma cells
    - Granulocytes
- Arrangement of cells may be :
    - Diffused
        - **T** cells **diffusely** distributed between stroma (in parenchyma surrounded by stroma)
            - Thymus
            - Lymph nodes (paracortex)
            - Spleen



Diffuse arrangement of the lymphoid parenchyma

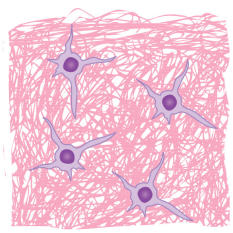
- Nodular (follicular) arrangement :
  - **B** cells form **clusters** (lymphoid nodules)
    - Lymph nodes (cortex)
    - Spleen (white pulp)
    - Tonsils
    - MALT
  - Primary non activated follicles (nodules) :
    - Poppy seed like structure
    - All dark
  - secondary activated follicles (nodules) :
    - Mantle zone : Peripheree - poppy seed like structure, dark
    - Germinal centre due to development of centroblasts to centrocytes



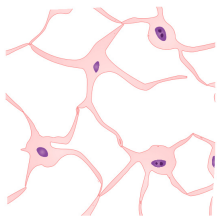
Nodular arrangement of the lymphoid parenchyma

Stroma

- scaffold like structure that supports the storage of cells in parenchyma
- Reticular fibres
- Reticular cells
- ***Exception :*** *reticular epithelium in the thymus*



Reticular cells surrounded by reticular fibers



Reticular epithelium

CELLS

Epithelial reticular cells

- Only in thymus
- Stellate shape
- Ovoid nucleus - high in euchromatin
- Eoisnophilic
- Cytokeratin intermediate filaments
- derived from endoderm / ectoderm

- Type 1 : form continuous subcortical layer (processes)
- Type 2 : wrap lymphocytes into aggregates (processes)
- Type 3 and 4 : contribute to blood thymus barrier (processes) + secrete substances that regulate proliferation and maturation of T lymphocytes
- Type 5 : development of self tolerance
- Type 6 : form hassalls corpuscles

Thymus

- 2 lobes
- Larger in children
- Decreases in size by age and is replaced by adipose tissue
- Has only efferent lymphatic vessels (doesn't filter lymph)

STRUCTURE :

Capsule

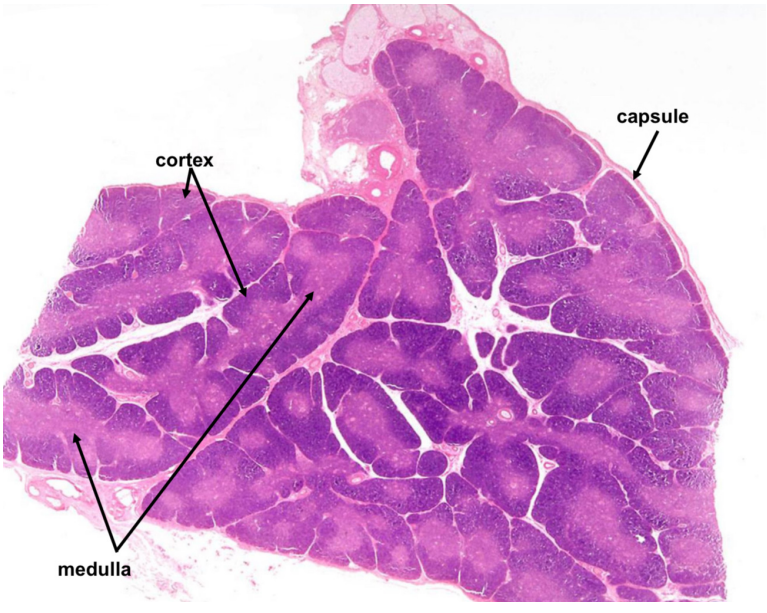
- dense irregular connective tissue (type I)
    - Septa corticali thymi
        - Connective tissue septa (trabeculae) extending from capsule
        - Divide parenchyma into pseudolobules
        - Contain large blood vessels

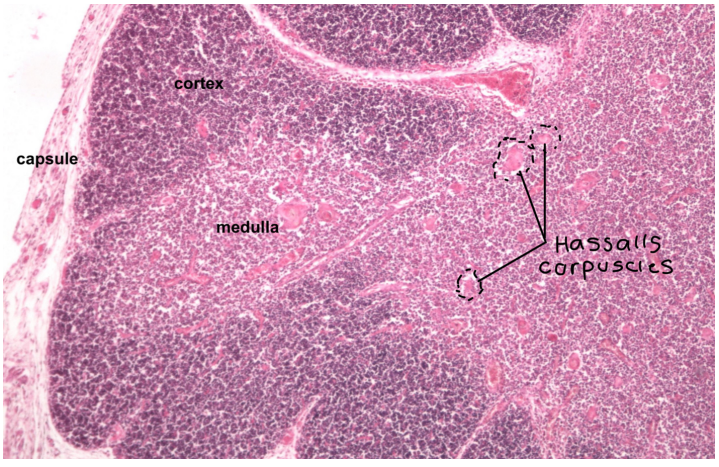
Cortex

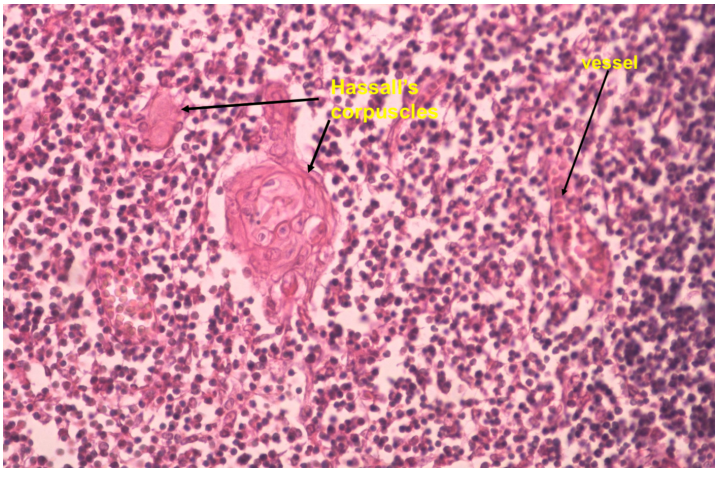
- Peripheral part
- darker in staining - due to T lymphocytes (diffuse arrangement)
    - Parenchyma : **developing** T lymphocytes (thymocytes) + macrophages
    - Internal Stroma : epithelial reticular cells
        - Cover blood vessels with their processes —> **blood thymus barrier**

Medulla

- central part
- lighter in staining - more epithelial cells (more cytoplasm)
    - Parenchyma : **mature** T lymphocytes
    - Internal stroma : epithelial reticular cells (more)
        - Don't fully cover vessels with their processes —> **no blood thymus barrier** (cells have already encountered antigen)
    - Hassals corpuscles : onion like structure
        - Eoisinophilic
        - Increase size with age
        - May calcify







Lymph node

- Totally encapsulated secondary lymphatic organ
- Ovoid / kidney / bean like shape
- Embedded into the course of the lymphatic vessels
- Function : **immunological filters,** defence against microorganisms and against spread of cancer cells
    - Purifies lymph from foreign particles before entering blood
        - *Lymph : enters lymphatic capillaries from interstitial fluid, is filtered by lymph nodes and and enters blood through main duct*
- Approx 500 lymph nodes present
- Afferent lymphatic vessel : brings lymph to lymph node
- Efferent lymphatic vessel : carries lymph away from lymph node
- Lymph node covered by adipose tissue

STRUCTURE

Capsula fibrosa

- *note : remember we said lymph nodes are encapsulated completely*

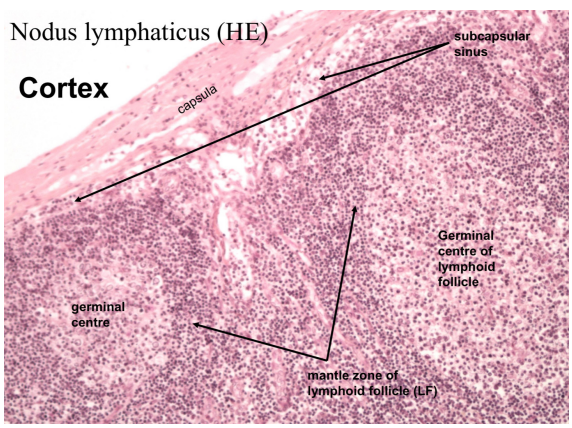
- connective tissue capsule
    - Trabeculae extends from it
- lymphatic sinuses

Internal Stroma :

- reticular connective tissue
- Structural support
- Compartmentalisation
    - Divides parenchyma into cortex, paracortex and medulla

Cortex :

- located directly under the capsule
- Contains pseudolobules formed by stroma
    - Contain **lymphoid nodules :** accumulation of B lymphocytes in follicular arrangement
- site where APCs present antigens to B naive cells



Paracortex :

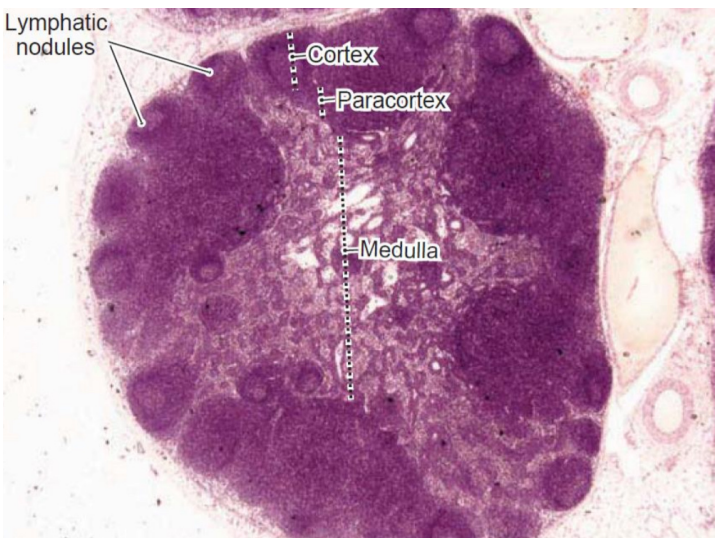
- deeper to cortex
- Layer of sparse lymphocytes - in diffuse arrangement
    - No lymphoid nodules
- contains T lymphocytes,
- Site where APC's present their antigens to naive T lymphocytes

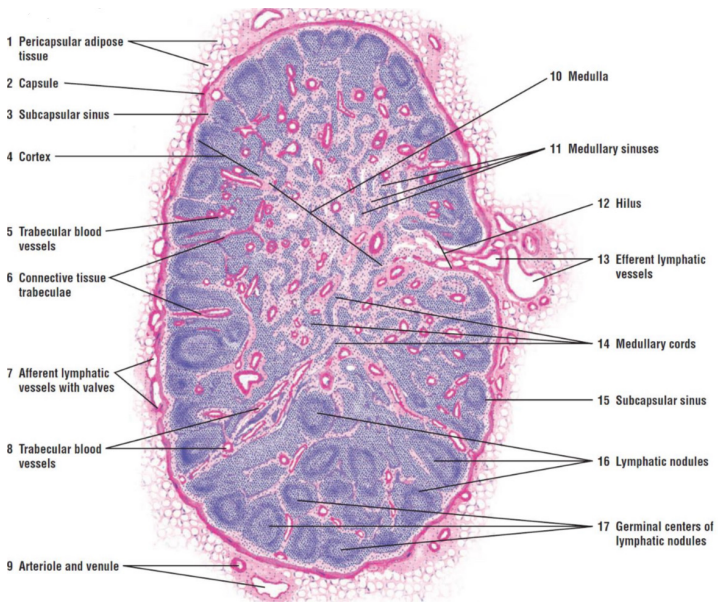
- High endothelial venules : facilitate entry of lymphocytes into the node

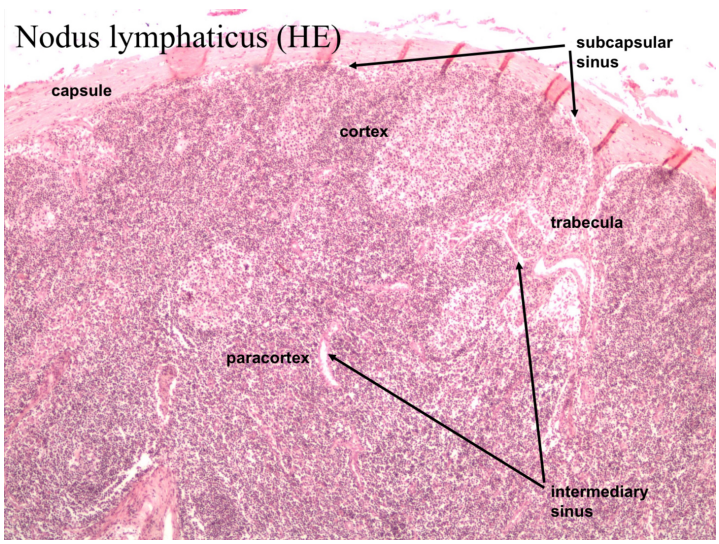
Medulla :

- Inner part of lymph node
- Network of medullary sinuses leading to efferent lymphatic vessel
- Medullary sinuses : for lymph
- medullary chords : between medullary sinuses, contains T cells, plasma cells, LYMPHOCYTES
    - Site of antibody production

- macrophages and APC's found throughout whole lymph node







FLOW OF LYMPH :

- afferent lymphatic vessel - brings lymph to lymph node
- Subcapsular sinus - beneath capsule
- Intermediary sinus
- Medullary sinus
- Efferent lymphatic vessel

Spleen :

- secondary lymphoid organ
- Largest accumulation of lymphatic tissue
- functions
    - Immune defence
    - Blood filtration
    - Foetal haematopoiesis
- encapsulated

STRUCTURE

Tunica serosa

- visceral layer of peritoneum (because its in abdomen)
- loose collagenous connective tissue + mesothelium

Capsula fibrosa (coarse stroma)

- Dense collagenous connective tissue capsule
- splenic trabeculae : extend from capsule
    - Trabecular arteries : branches of splenic artery running in the trabeculae

Internal stroma

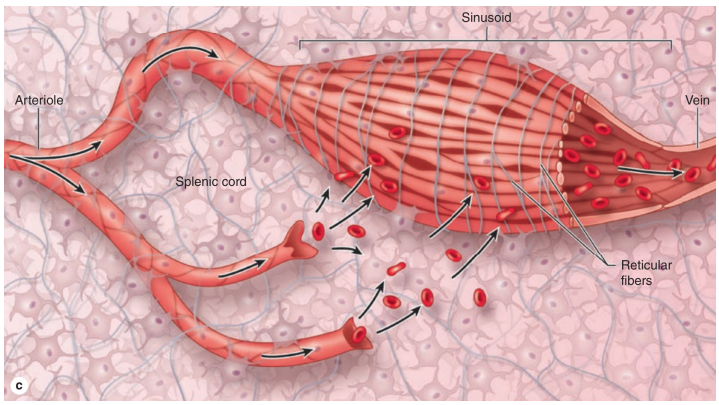
- reticular fibres and cells

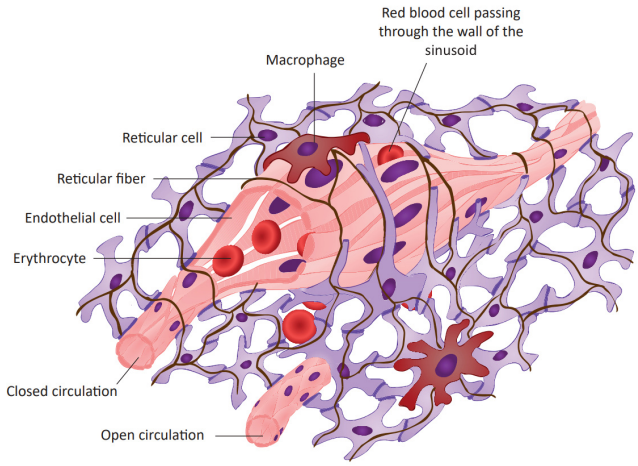
Parenchyma

- **note : not divided into cortex, medulla etc… and no lobules**
- **White pulp :**
    - Malpighian bodies
        - lymphatic nodules embedded in red pulp
        - Aggregation of WBC (mainly B cells)
    - periarteriolar lymphoid sheath **(PALS)**
        - Around central arterioles
        - T cells
        - Typical feature of spleen
    - marginal zone
        - Around follicles
        - More macrophages and dendritic cells at the expense of lymphocytes
    - perifollicular zone
        - Expansions around follicle, blood enters into it
- **Red pulp :**
    - makes up majority of spleen
    - Splenic chords of Billroth
        - Reticular cells
        - Immune cells : WBC + RBC
        - Site that blood is emptied into = open circulation

- Older RBC cannot pass from chords to sinusoids due to their degenerating elasticity
  - Remain in spleen and taken up by macrophages

- Venous sinusoids
  - Dilated capillaries with wide sinusoids
  - Enable the exchange between blood and pulp
  - Endothelium : stave cells

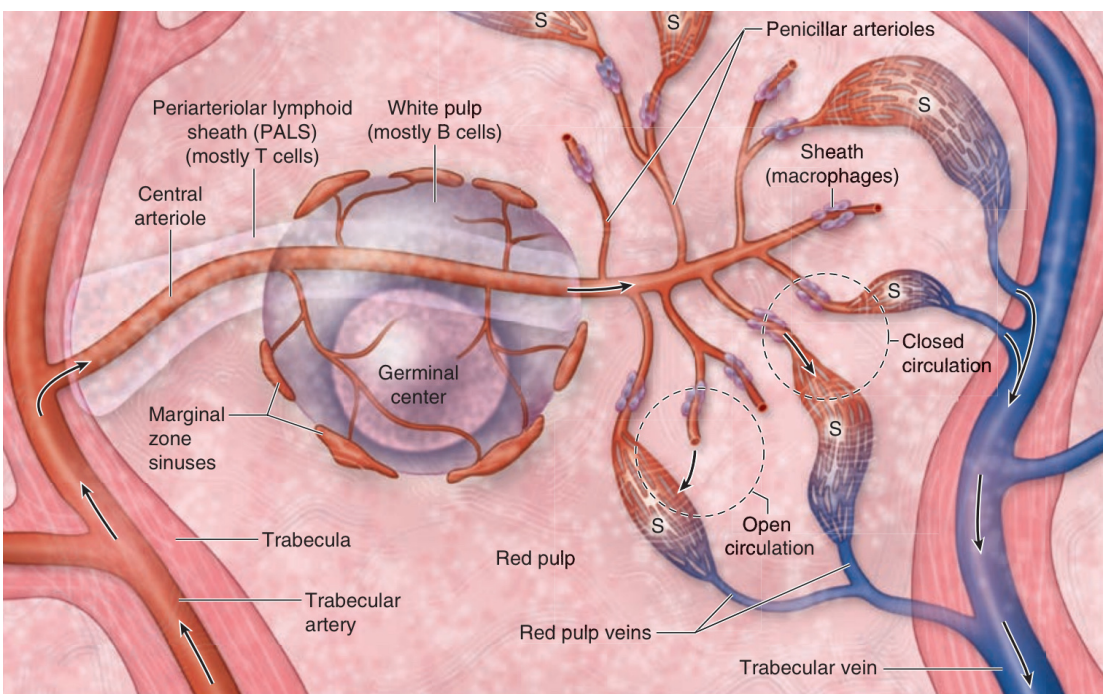




Open and closed blood circulation in the spleen

Blood flow in spleen

- **splenic** arteries
  - **Trabecular arteries**
    - **Central** arterioles
      - Covered by PALS
      - Give off follicular arterioles (send plasma to follicular)
        - **Penicillar** arterioles
          - **Sheathed capillaries** (sheathed by macrophages)
            - **Open circulation** : empties into splenic chord (majority)
              - Blood from open circulation passes through the openings of the sinusoids
            - **Closed circulation** : passes to sinusoids



Mucosa associated lymphoid tissue

- organised lymphoid tissue in lamina propria of hollow organs
- Peripheral non encapsulated lymphoid tissue

Structure

- lymphoid follicles
    - B cells
- interfollicular areas
    - T cells

Based on location

- GALT - gut
- BALT - bronchi
- NALT - nasal mucosa
- CALT - conjunctiva mucosa

Types :

- independent macroscopic structure - eg tonsil
- Thin layer in mucosa of hollow organs - eg appendix

Palatine tonsils

- one of the 4 types of tonsils
    - Lingual tonsil
    - **Palatine tonsils (paired)**
    - Tubal tonsils (paired)
    - Pharyngeal
        - Make up walleyes ring : entrance to the respiratory and GIT tract
- secondary lymphoid organs
- Partially encapsulated

STRUCTURE

Capsula fibrosa

- Connective tissue capsule with **septa**
- Only covers basal surface (in contact with skeletal muscle), doesn't cover surface

Surface epithelium

- luminal surface
- Stratified squamous non keratinised / pseudo stratified columnar with goblet cells and cilia
- Crypts
    - Deep grooves in epithelium
    - Colonies of microorganisms + cell debris

Stroma

- reticular fibres + cells

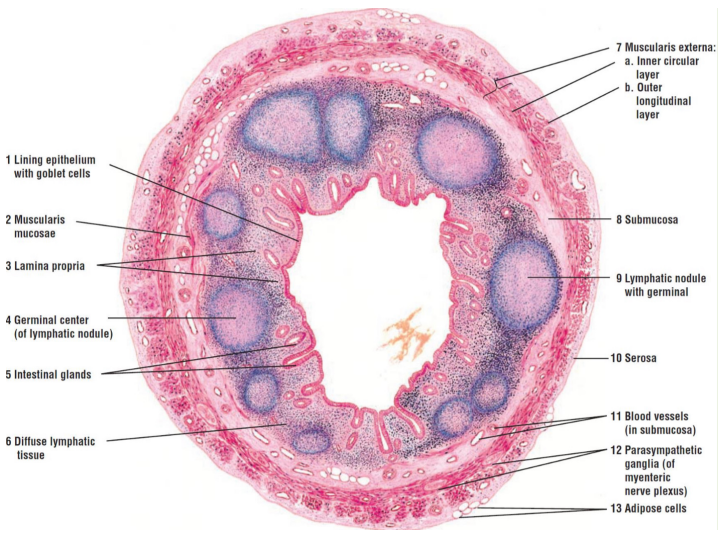
Lymphoid nodules

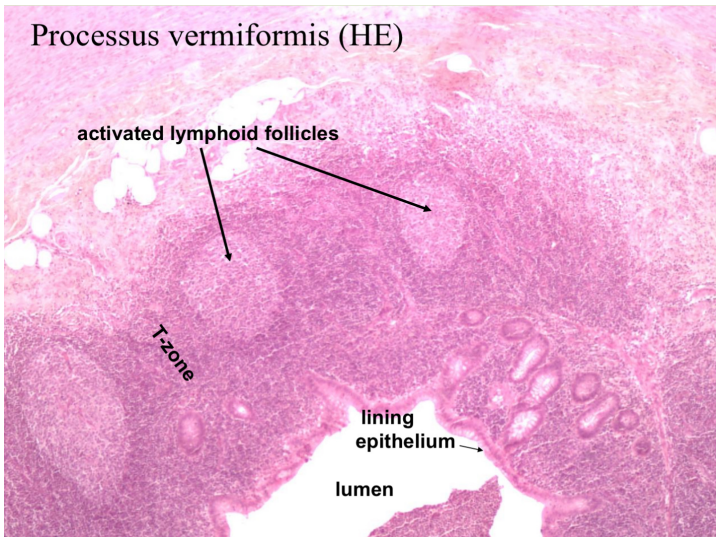
- primary and secondary lymphoid nodules
- t zone between them

Vermiform appendix

- **Mucosa**
  - epithelium
  - **Lamia propria**
    - Lymphoid follicles
  - Lamia muscularis mucosae

- **Submucosa**
- **Lamina muscularis external**
- **serosa**





- all same as caecum

Summary :

TABLE 10-2 Lymphoid Organs

Organ	Epithelium/ Capsule Covering	Cortex and Medulla	Cords and Sinuses	B-cell Main Region	T-cell Main Region	Special Features (1) and Functions (2)
Tonsils	Incomplete epithelium and capsule	No	No	Primary and secondary nodules	Outside of the lymphatic nodules	1. Epithelial covering 2. Promotes B cells to proliferate and to produce IgA; immune defense against upper respiratory infections, where B and T cells encounter foreign antigens and initiate immune response
Lymph nodes	Capsule (thin)	Cortex, paracortex, and medulla	Medullary cords and medullary sinuses	Primary and secondary nodules (most nodules are secondary); medullary cords	Paracortex	1. Afferent lymphatic vessels and subcapsular sinuses 2. Filter lymph and recirculate both B and T cells; provide place for lymphocytes to meet antigens and start immune response
Thymus	Capsule (thin)	Cortex (without lymphatic nodules); medulla (with Hassall corpuscles)	No	No	Cortex and medulla	1. Epithelial reticular cells and Hassall corpuscles; no lymphatic nodules 2. Development and maturation of T cells
Spleen	Capsule (thick)	No, arranged in white pulp and red pulp	Splenic cords and venous sinuses	Secondary nodules (splenic nodules)	PALS	1. Central arteries and PALS 2. Red pulp filters blood, removes aged erythrocytes, and acts as a reservoir for erythrocytes and platelets; the white pulp hosts B and T lymphocytes, where they meet antigens, mature and prolif-erate, and initiate immune response