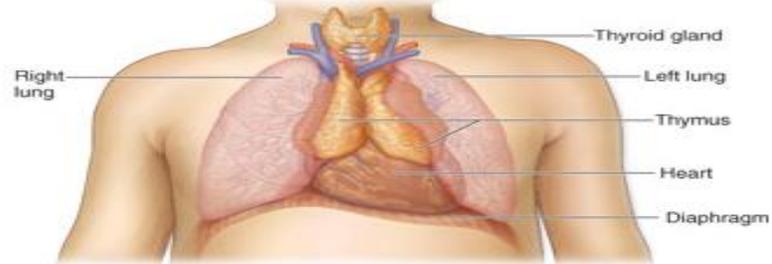


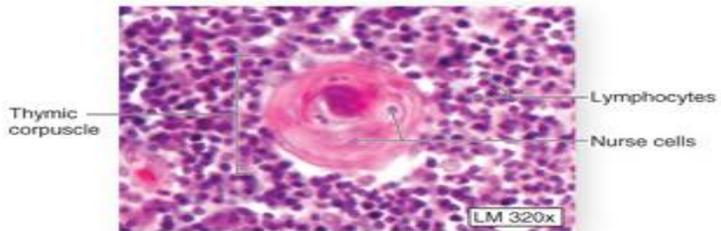
# *In the name of God*



(a)



(b)



(c)

*Lymphatic tissue*

# *Lymph Tissue*

## ▶ 3 types

### ▶ Diffuse lymphatic tissue

- ▶ No capsule present
- ▶ Found in connective tissue of almost all organs

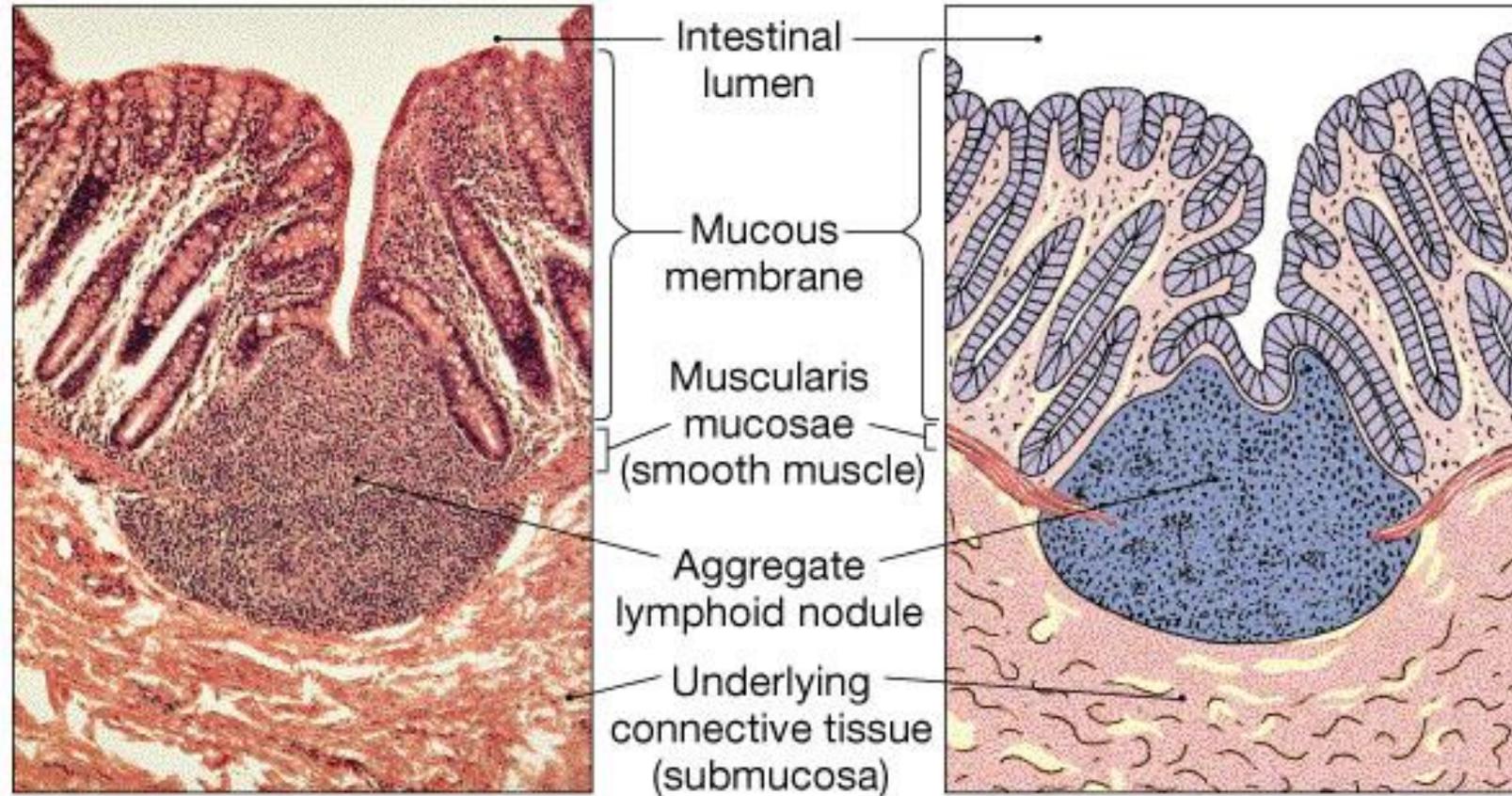
### ▶ Dense lymphatic tissue

- ▶ No capsule present
- ▶ Oval-shaped masses
- ▶ Found singly or in clusters
- ▶ Tonsils , Peyer's patches , Appendix

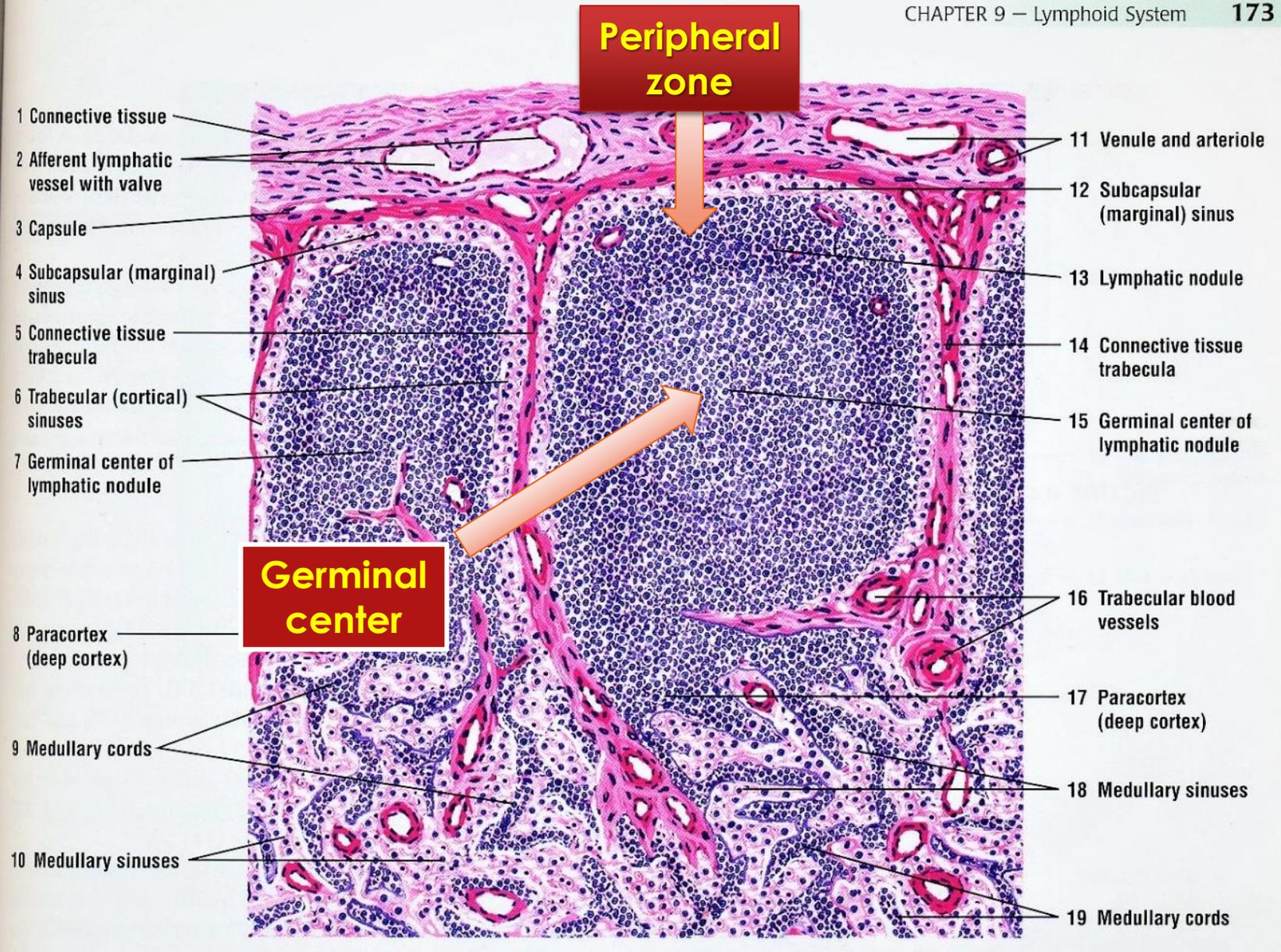
### ▶ Capsulated lymphatic organs

- ▶ Capsule present
- ▶ Lymph and hemal nodes, spleen, thymus gland

# Lymph Nodules



**(a) Lymphoid nodule**



- 1 Connective tissue
- 2 Afferent lymphatic vessel with valve
- 3 Capsule
- 4 Subcapsular (marginal) sinus
- 5 Connective tissue trabecula
- 6 Trabecular (cortical) sinuses
- 7 Germinal center of lymphatic nodule
- 8 Paracortex (deep cortex)
- 9 Medullary cords
- 10 Medullary sinuses

- 11 Venule and arteriole
- 12 Subcapsular (marginal) sinus
- 13 Lymphatic nodule
- 14 Connective tissue trabecula
- 15 Germinal center of lymphatic nodule
- 16 Trabecular blood vessels
- 17 Paracortex (deep cortex)
- 18 Medullary sinuses
- 19 Medullary cords

**Peripheral zone**

**Germinal center**

# Peyer's Patches

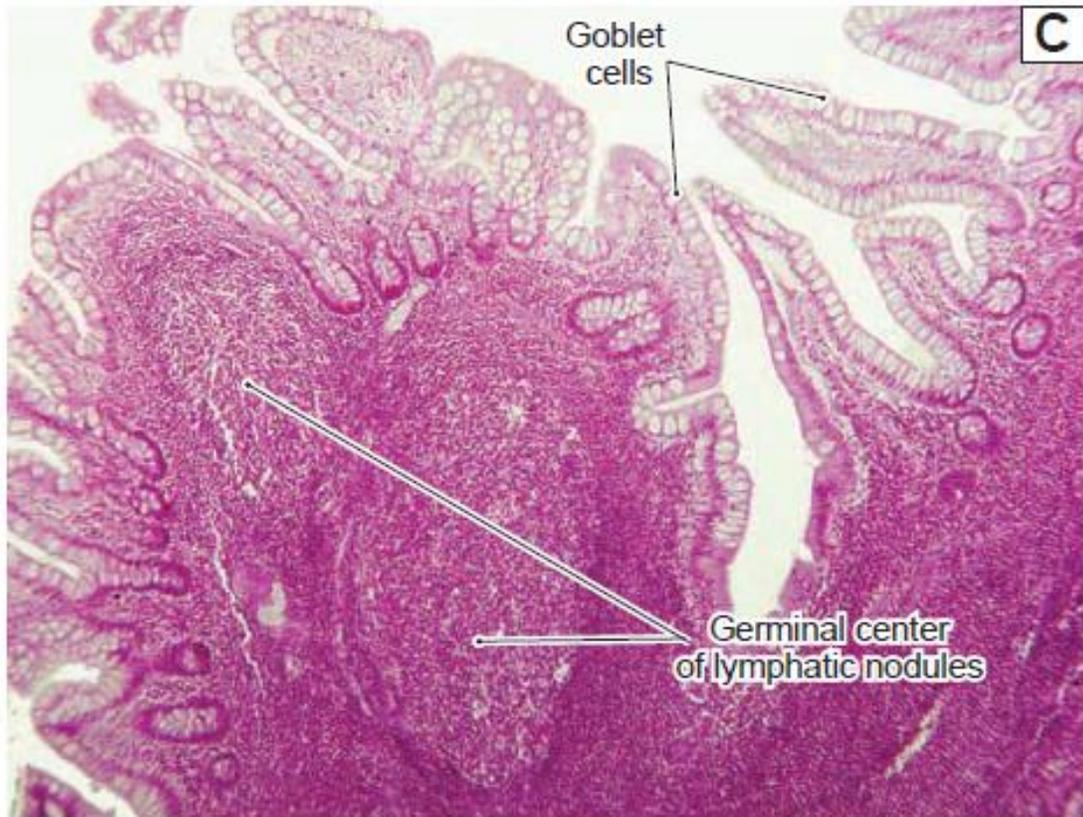
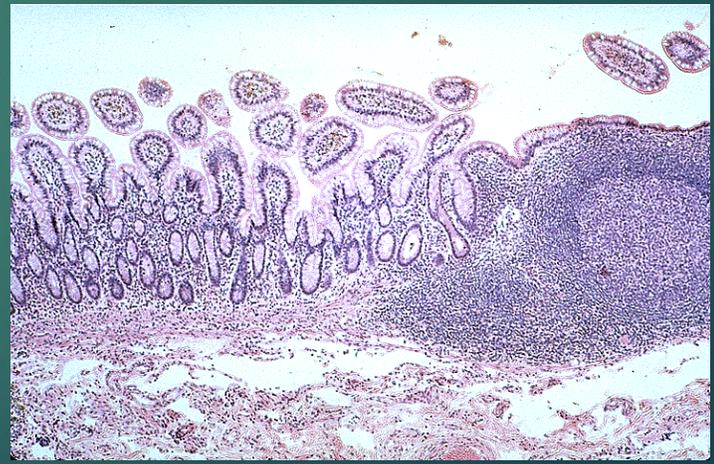
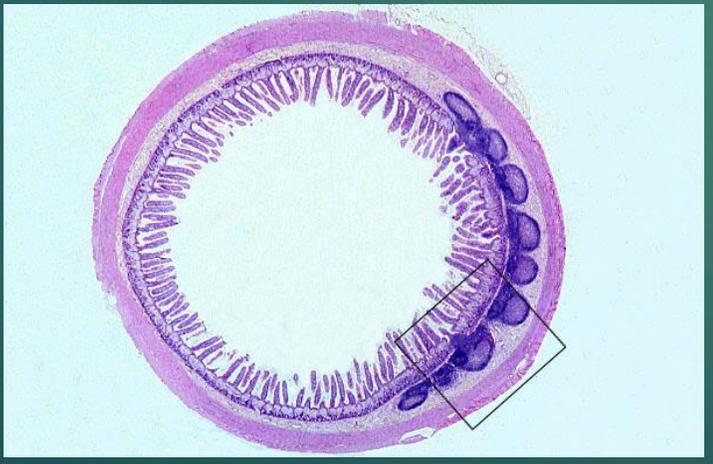
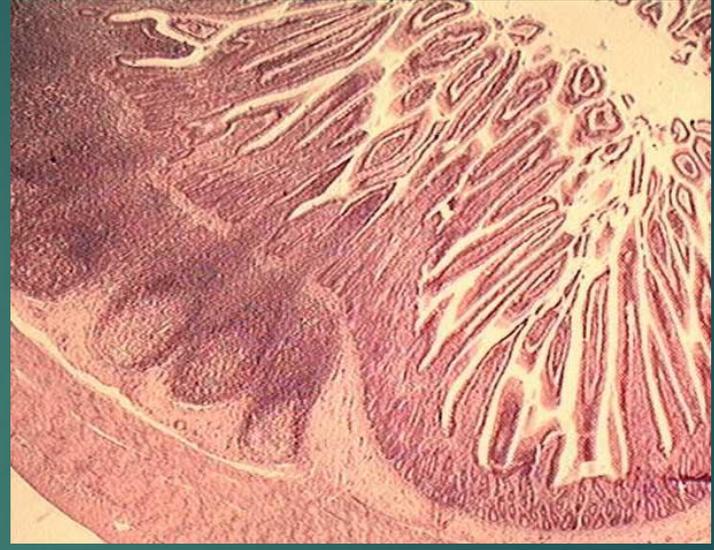


Figure 15-15C. Mucosa of the ileum, small intestine. H&E,  $\times 68$

Here is an example of the mucosa of the ileum showing numerous goblet cells in the surface epithelium. In this section, two lymphatic nodules are located in the lamina propria. These lymphatic nodules have germinal centers and are, therefore, secondary lymphatic nodules. These nodules may extend into the submucosa (Fig. 15-15B). The lymphatic nodules and Peyer patches are locations where lymphocytes can interact with antigens and, therefore, play important roles in immunological function. Naive B cells (B lymphocytes) within these lymphoid patches are primed and awaiting exposure to unique epitopes. When stimulated by a specific antigen from the intestinal mucosa, they differentiate into plasma cells and memory B cells. In response, the plasma cells produce large quantities of immunoglobulins ([Ig] antibodies), especially IgA to combat mucosal infection. The memory B cells live on in the Peyer patches to retain immunity to a specific antigen.



# Tonsils

Multiple groups of large lymphatic nodules  
Location – mucous membrane of the oral and pharyngeal cavities

Palatine tonsils

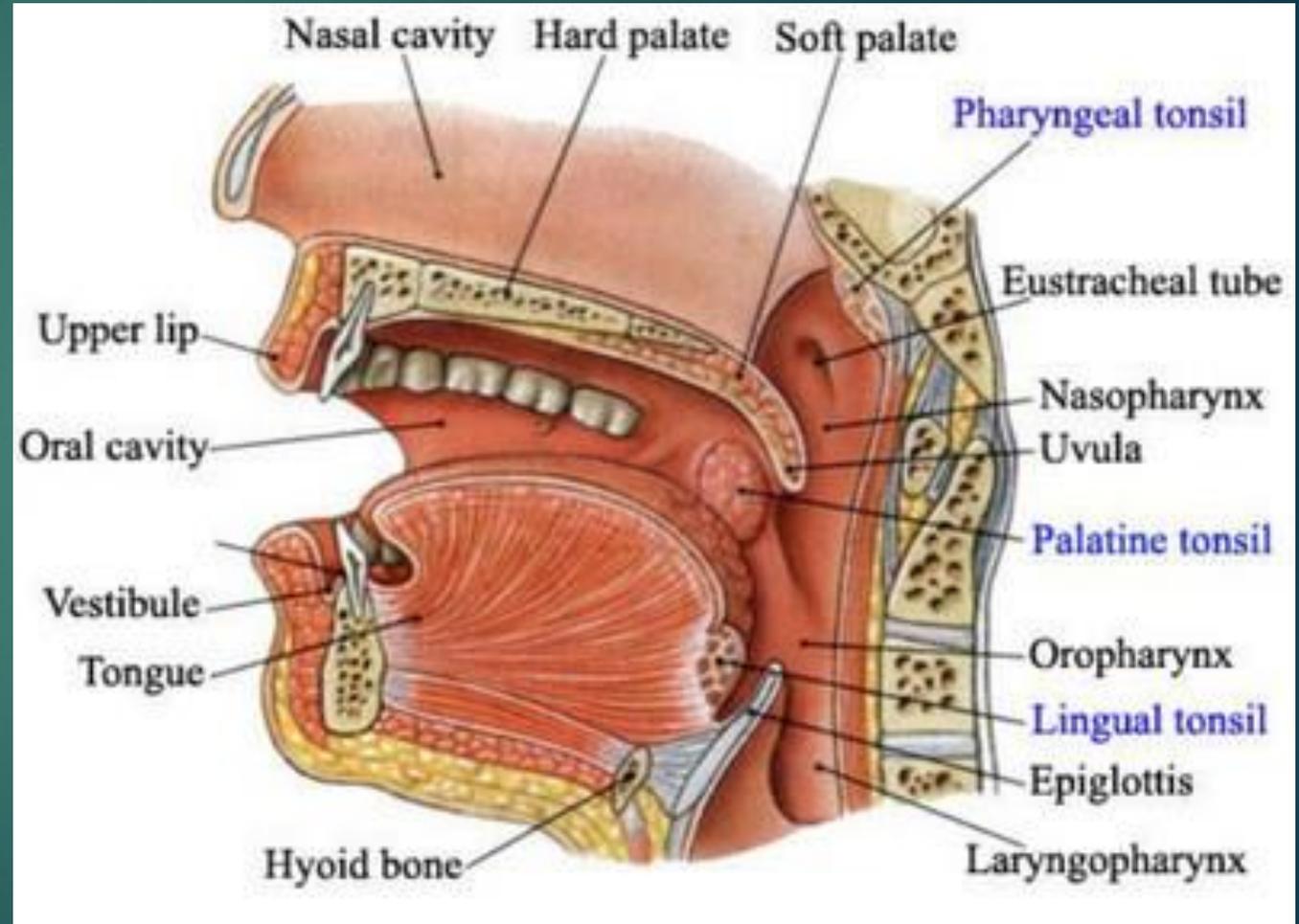
Posterior-lateral walls of the oropharynx

Pharyngeal tonsil

Posterior wall of nasopharynx

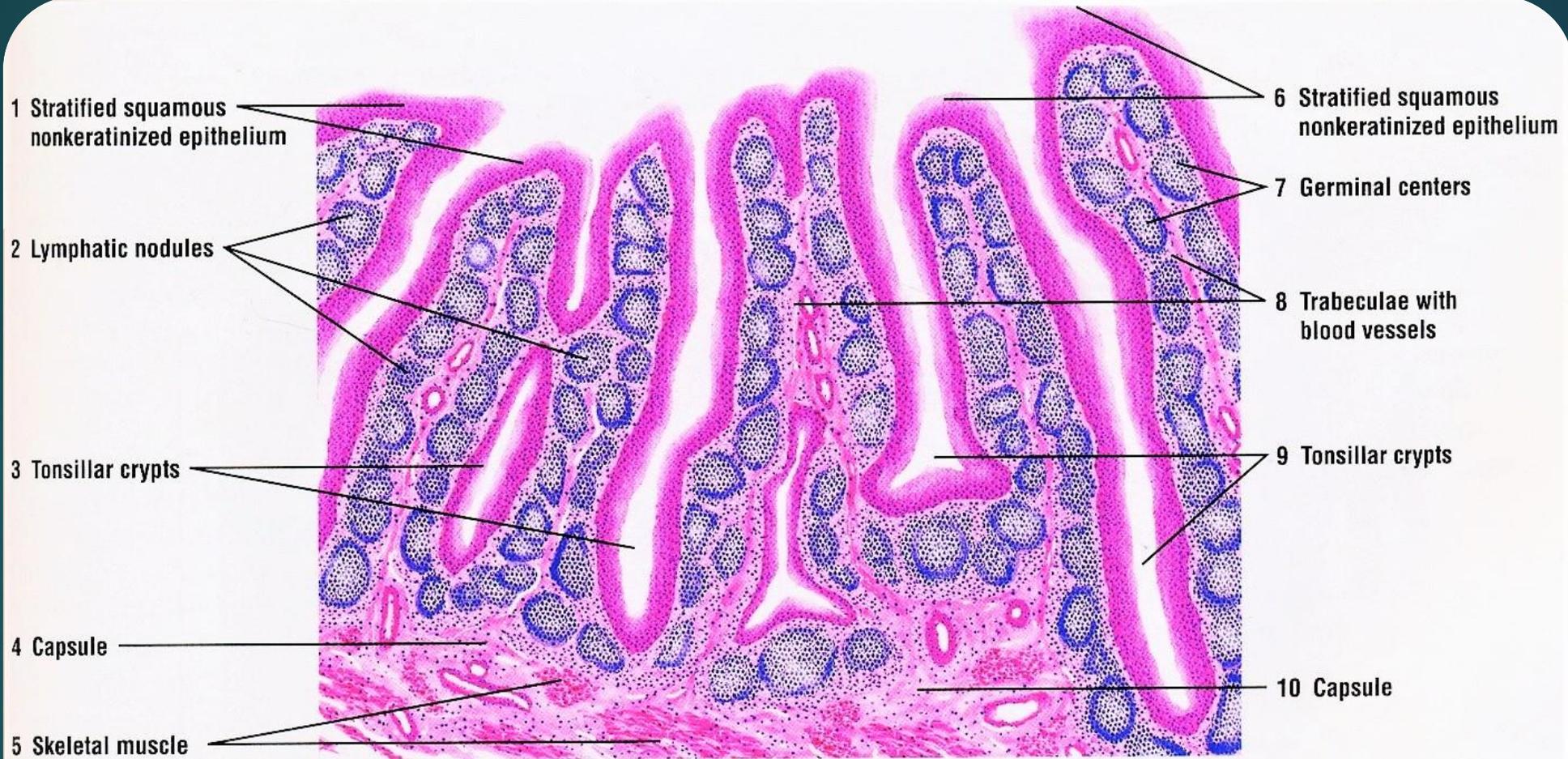
Lingual tonsils

Base of tongue



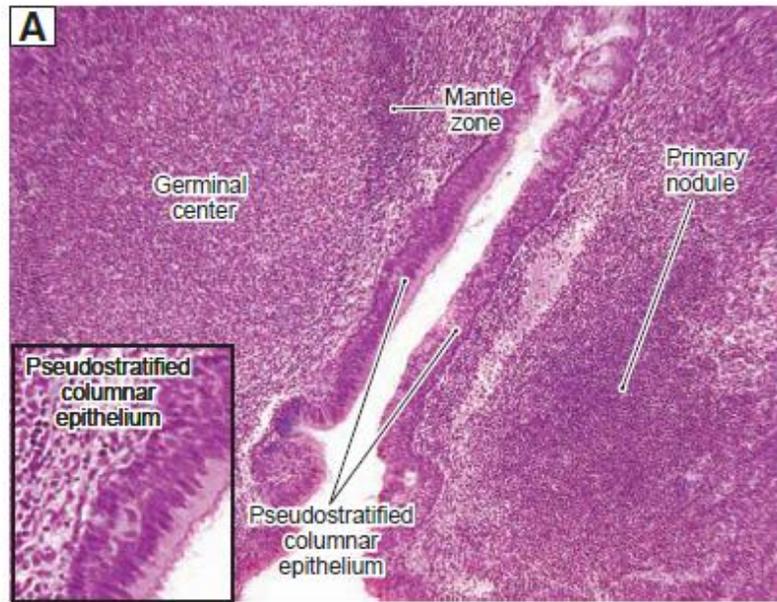
**TABLE 10-1** Tonsils

Name	Location	Epithelial Covering	Crypts	Capsule	Lymphatic Nodules (Follicles)
Palatine tonsils (2)	Posterolateral walls of the oral cavity	Stratified squamous epithelium (nonkeratinized)	Yes, deep and branched crypts divide tonsil into lobules	Thick, incomplete connective tissue capsule; partially covered by epithelium	Each lobule contains numerous lymphatic nodules, most having a germinal center
Pharyngeal (adenoid) tonsil (1)	Posterior roof of the nasopharynx	Pseudostratified ciliated columnar epithelium	No, only epithelial invagination	Thin, incomplete connective capsule; partially covered by epithelium	Mostly diffuse lymphoid tissues and some lymphatic nodules
Lingual tonsils (2)	Posterior floor of the mouth (surface of the posterior third of the tongue)	Stratified squamous epithelium (nonkeratinized)	Yes, wide nonbranched crypt; duct of mucous gland opens into the crypt	No capsule; partially covered by epithelium	Rows of lymphatic nodules supported by connective tissue septa



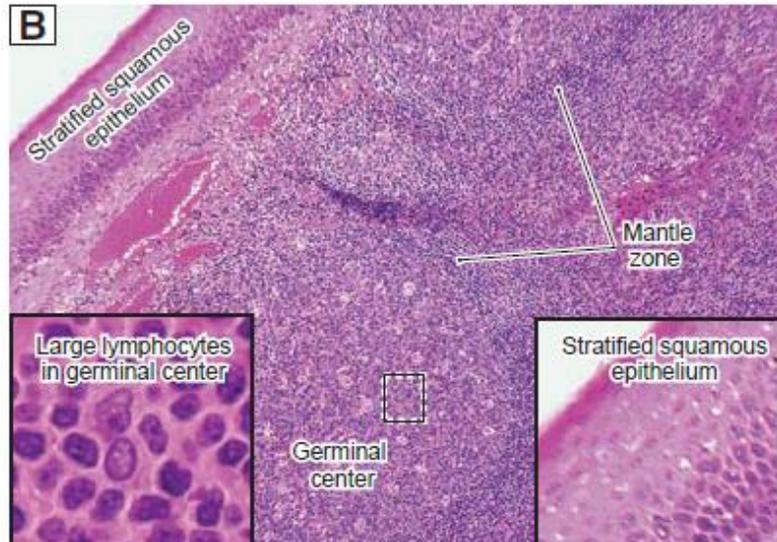
**FIGURE 9.12** ■ Palatine tonsil. Stain: hematoxylin and eosin. Low magnification.

**FIGURE 9.12** ■ Palatine tonsil. Stain: hematoxylin and eosin. Low magnification.



**Figure 10-8A.** Pharyngeal tonsil, MALT. H&E,  $\times 76$ ; inset  $\times 184$

MALT refers to diffuse lymphatic tissues or aggregate lymphatic nodules in the mucosa of the digestive, respiratory, and genitourinary tracts. Comparable tissue is GALT in the gut and BALT in the respiratory system. Tonsils are composed of aggregate lymphatic nodules and belong to MALT. Tonsils include pharyngeal, palatine, and lingual tonsils. The pharyngeal tonsil is located in the roof of the nasopharynx (Fig. 10-6). It has epithelial invaginations, but no crypts, and is covered by pseudostratified columnar epithelium. The pharyngeal tonsil traps bacteria and viruses and is one of the lymphoid organs that provides an environment for lymphocytes to meet antigens. It mostly consists of secondary nodules and a few primary nodules. A secondary nodule is composed of a germinal center and mantle zone. Activated B cells are found mainly in the germinal centers of secondary nodules and inactivated B cells primarily in primary nodules.



**Figure 10-8B.** Palatine tonsil, MALT. H&E,  $\times 83$ ; inset  $\times 750$  (left);  $\times 197$  (right)

Palatine tonsils are paired and are located in the posterior and lateral portions of the oral cavity. They have 10 to 20 crypts and the portion facing the oral cavity is covered by stratified squamous epithelium. The nodules usually lie as a row beneath the epithelium and surround each crypt. They safeguard the entrance of the respiratory and digestive tracts against microbe invasion. They also function in the recirculation of lymphocytes and provide sites for the lymphocyte to interact with antigens. The germinal center of a nodule contains large-sized B cells and antigen-presenting cells where B cells encounter antigens and continue to proliferate and develop into plasma cells. The mantle zone of the nodule contains mostly small inactive B cells. The peripheral region of the nodule contains mostly T cells.



**15.28** Tonsil (dog). (1) Stratified squamous epithelium. (2) Dense aggregation of lymphoid tissue in the lamina propria. H & E.  $\times 20$ .

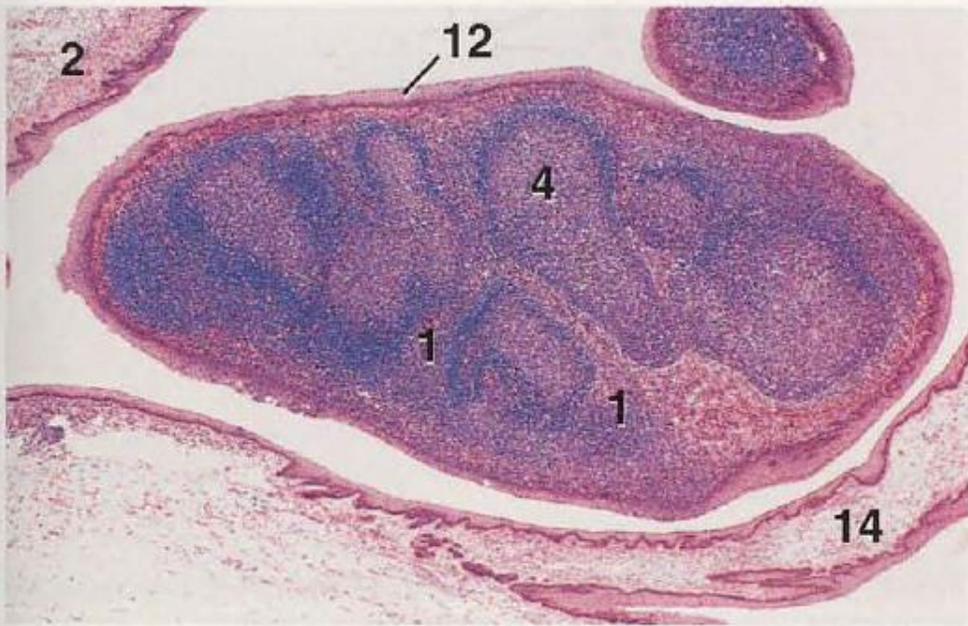


Figure 11.7

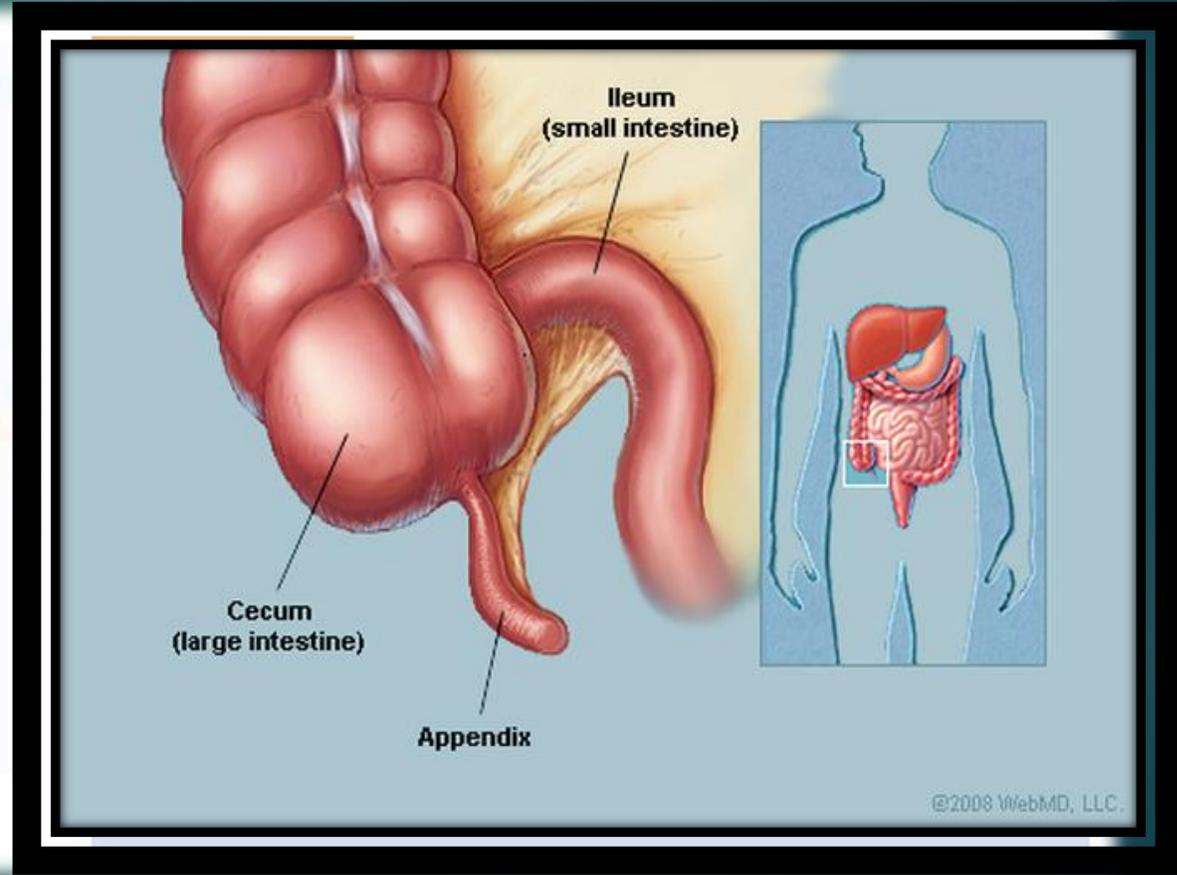
×12.5

#### KEY

- |                             |  |
|-----------------------------|--|
| 1. Diffuse lymphatic tissue | 10. Skeletal muscle                                |
| 2. Epiglottis               | 11. Stratified squamous epithelium, semilunar fold |
| 3. Fossa                    | 12. Stratified squamous epithelium, tonsil         |
| 4. Lymphatic nodule         | 13. Submucosa                                      |
| 5. Mucous acinus            | 14. Vestibular fold                                |
| 6. Muscularis externa       | 15. Villus   |
| 7. Salivary glands          |  |
| 8. Serous acinus            |  |
| 9. Serous demilune          |  |

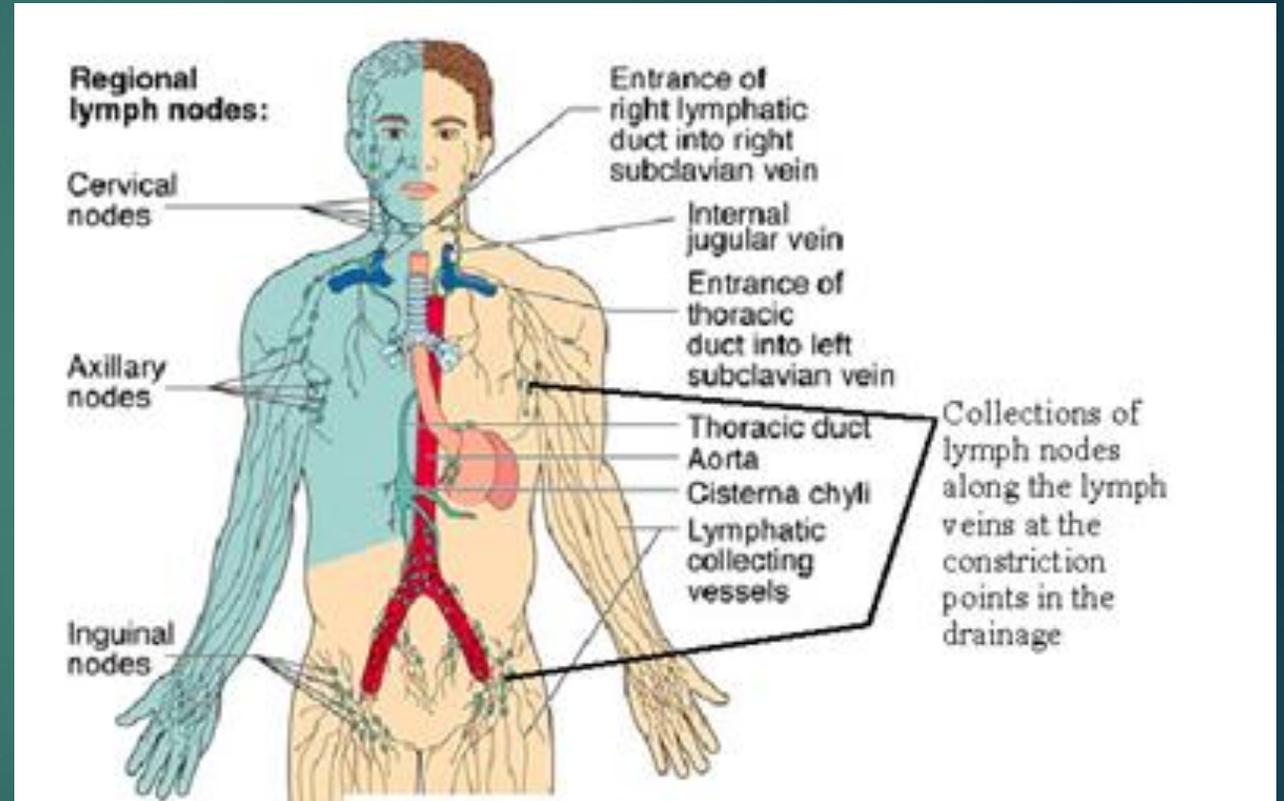
**Figure 11.7. Paraepiglottic Tonsil, Larynx, l.s., Cat.** In the cat an accumulation of lymphatic tissue in the lateral wall of the larynx, between the epiglottis and the vestibular fold, forms a tonsil without crypts.

# Appendix



# Lymph nodes

- Oval structures located along lymphatics
- Enclosed by a fibrous capsule
- Cortex = outer portion
  - Germinal centers produce lymphocytes
- Medulla = inner portion
  - Medullary cords
- Lymph enters nodes through afferent lymphatics, flows through sinuses, exits through efferent lymphatic



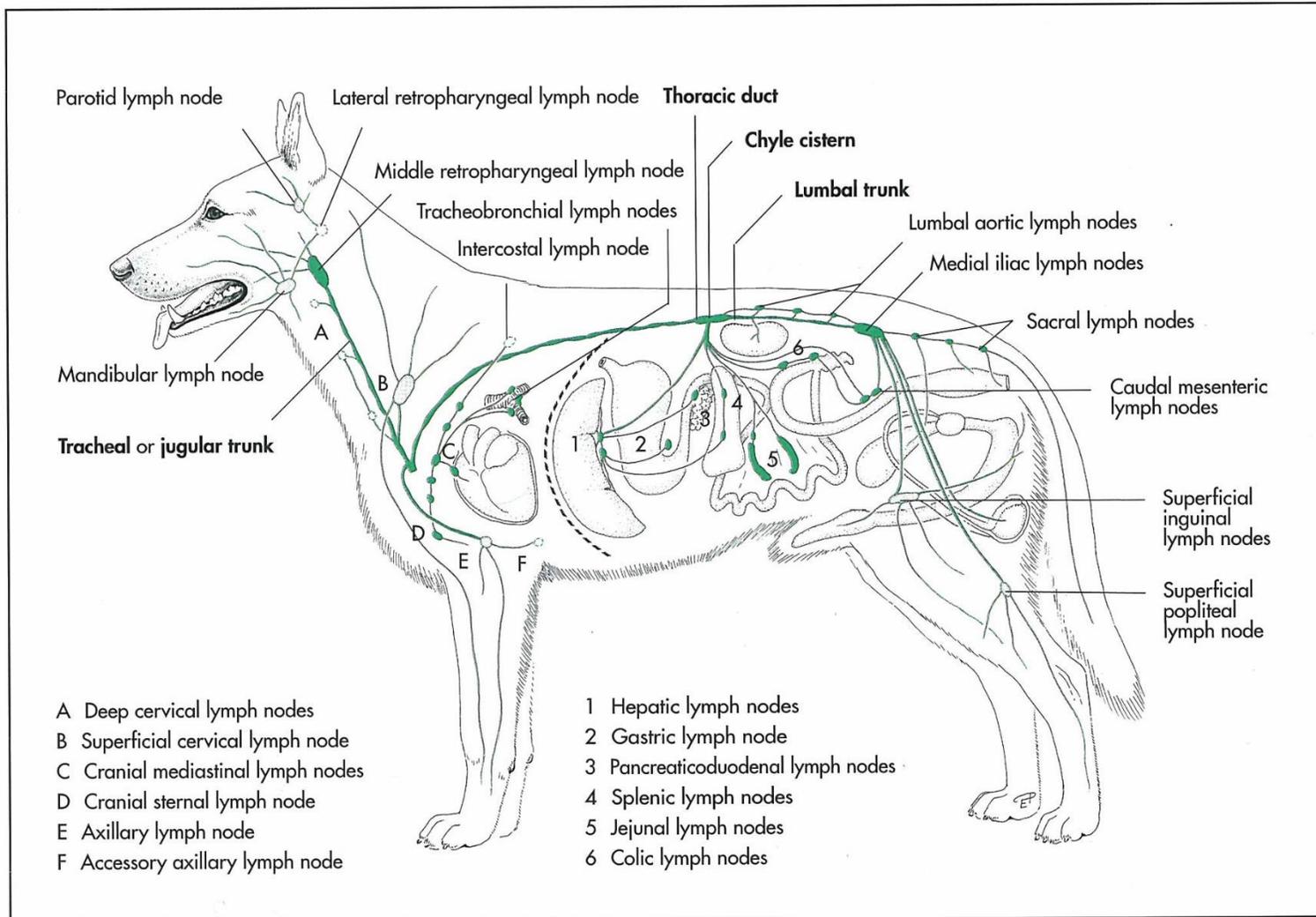
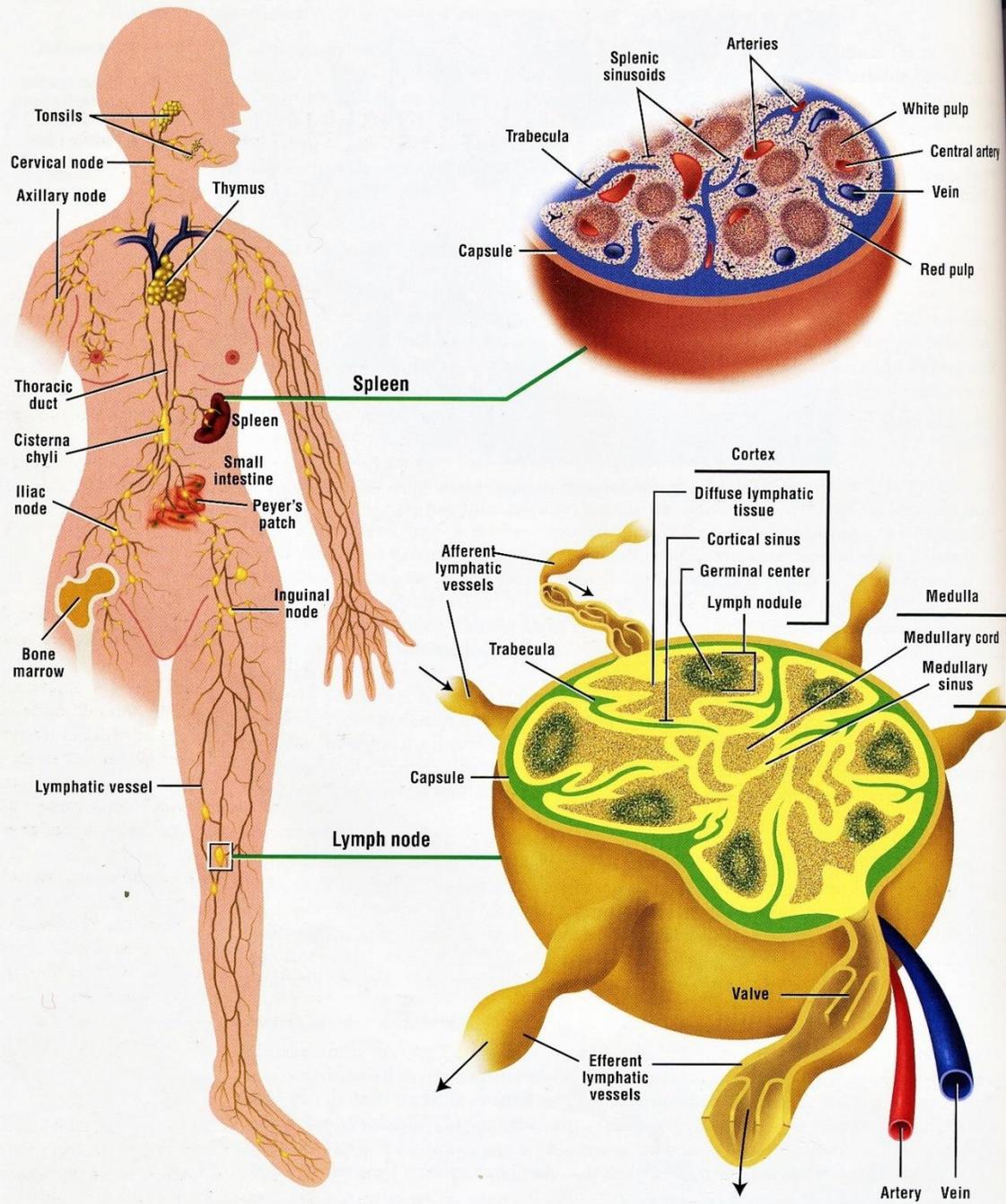
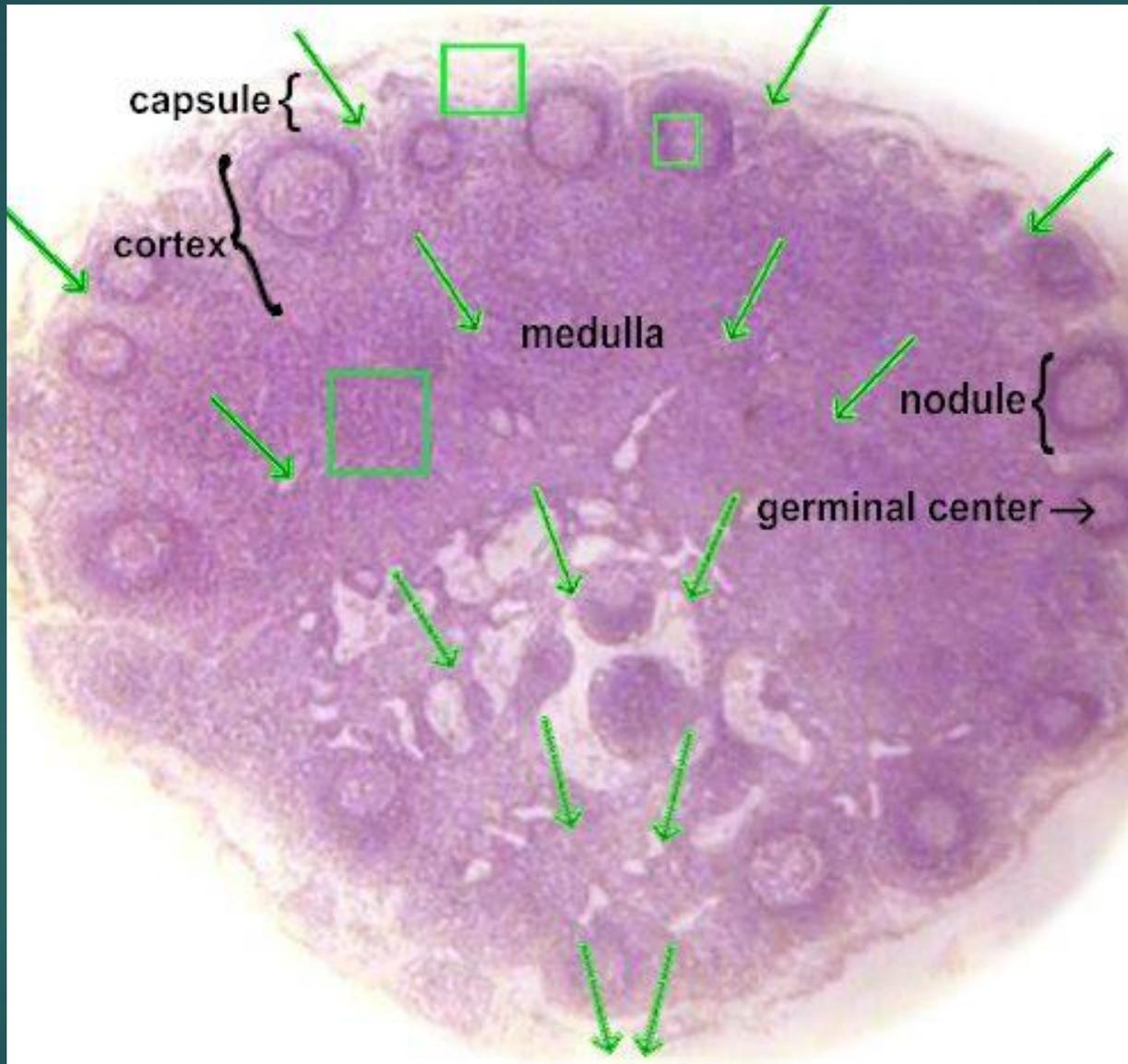
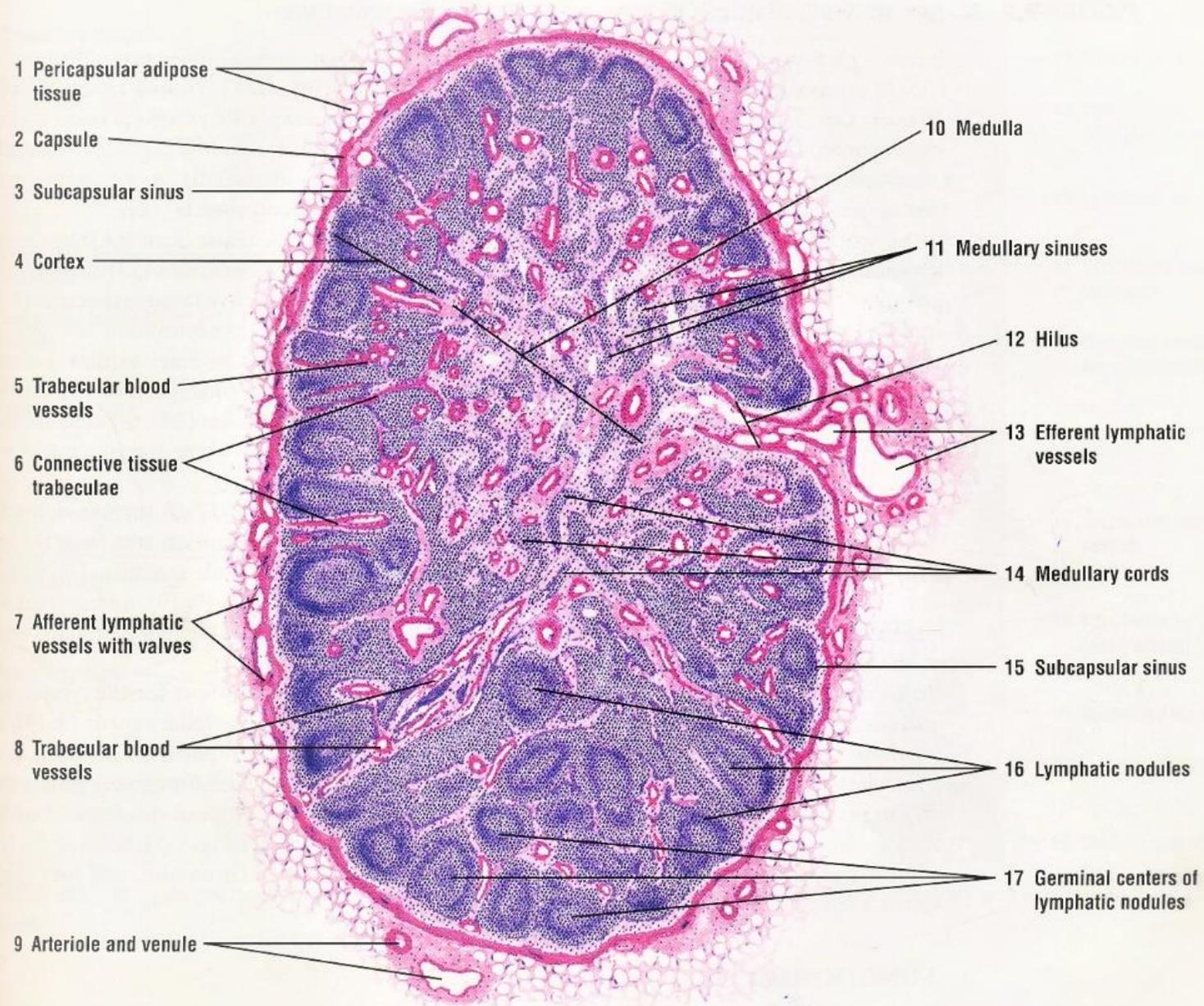


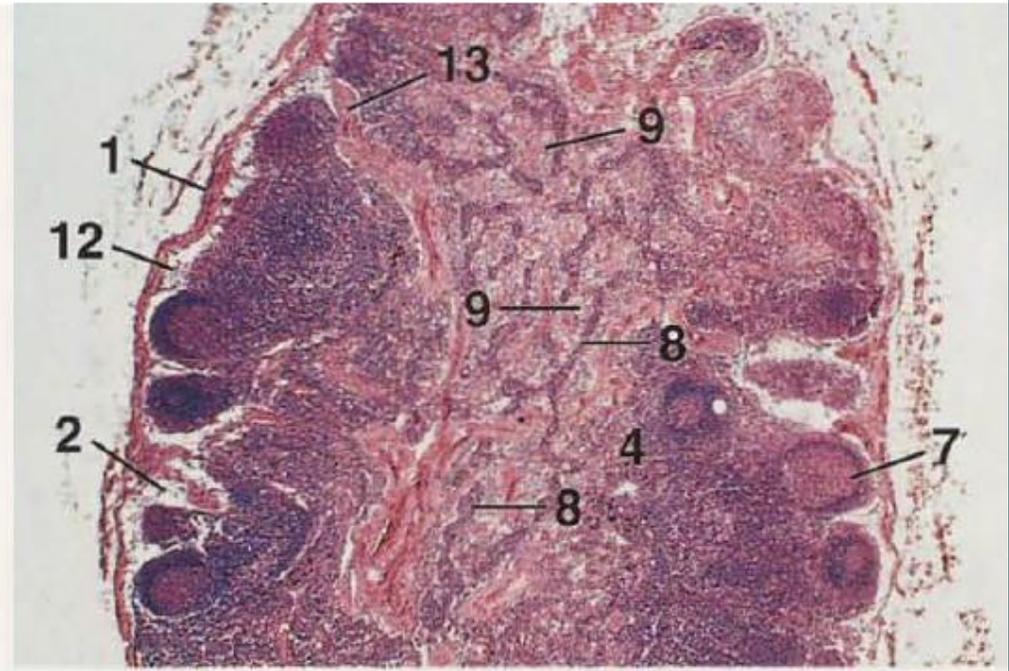
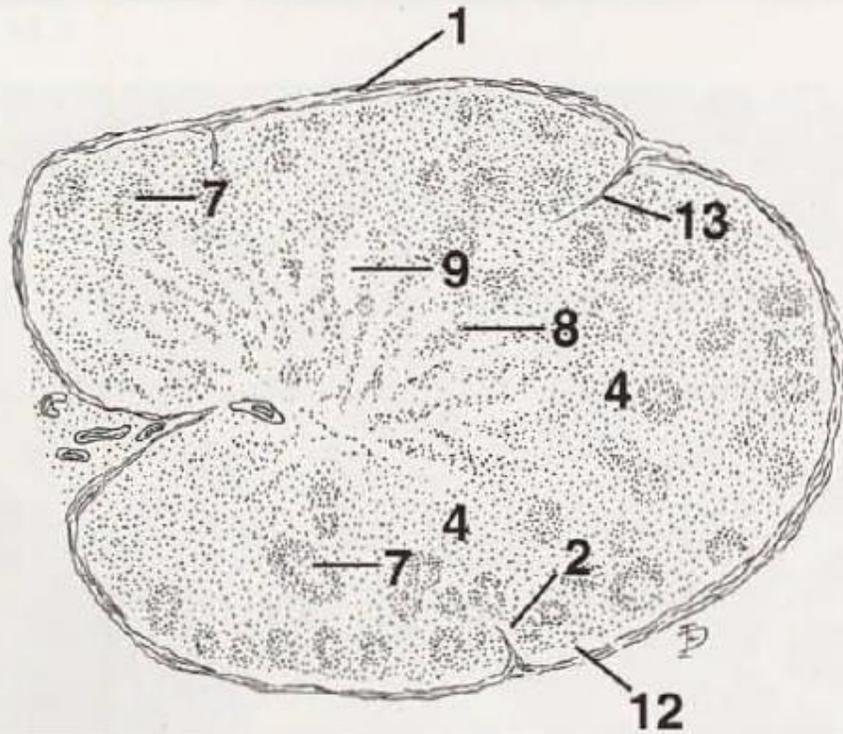
Fig. 13-12. Lymphatic system of the dog, schematic (Budras, Fricke and Richter, 1996).





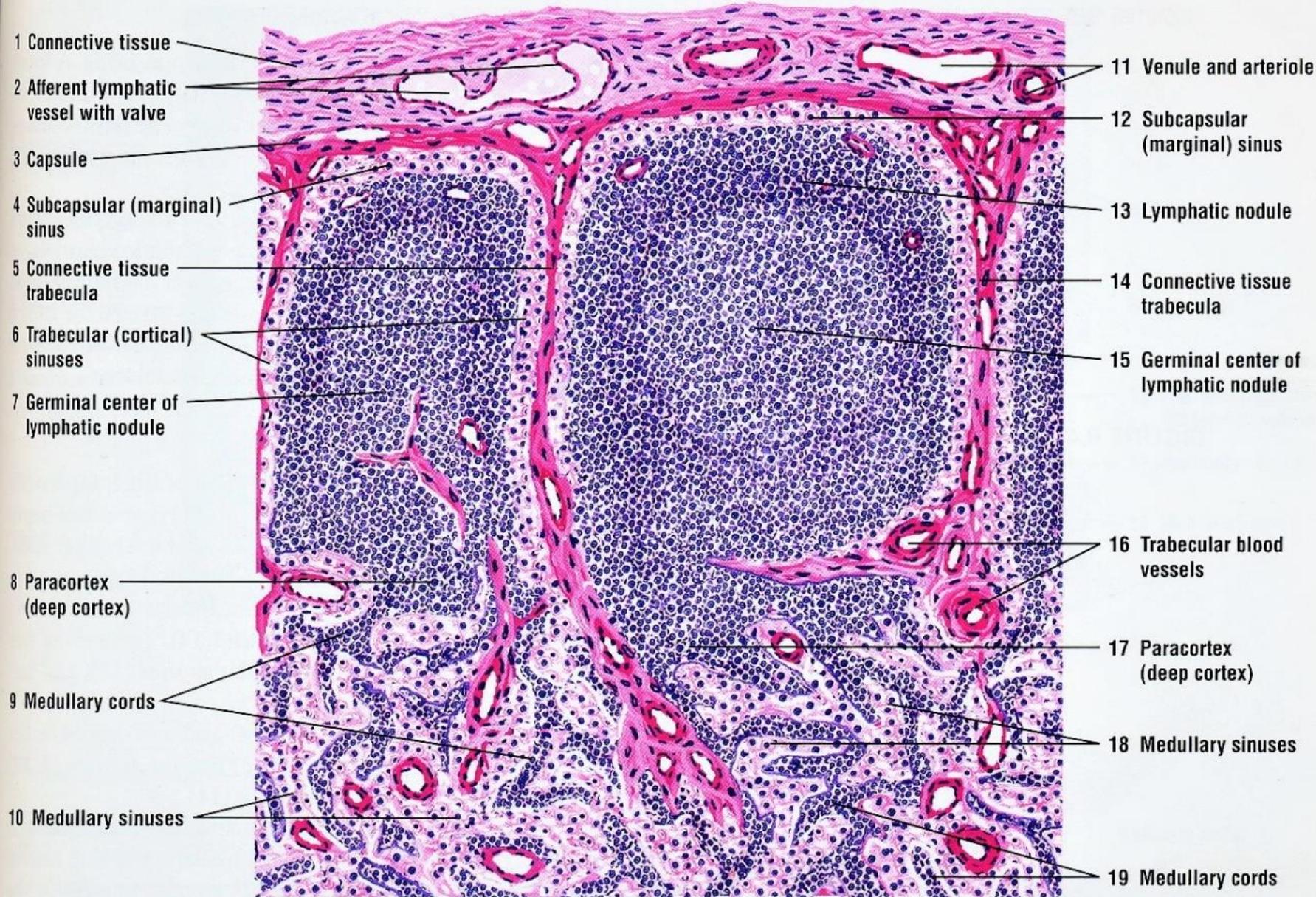


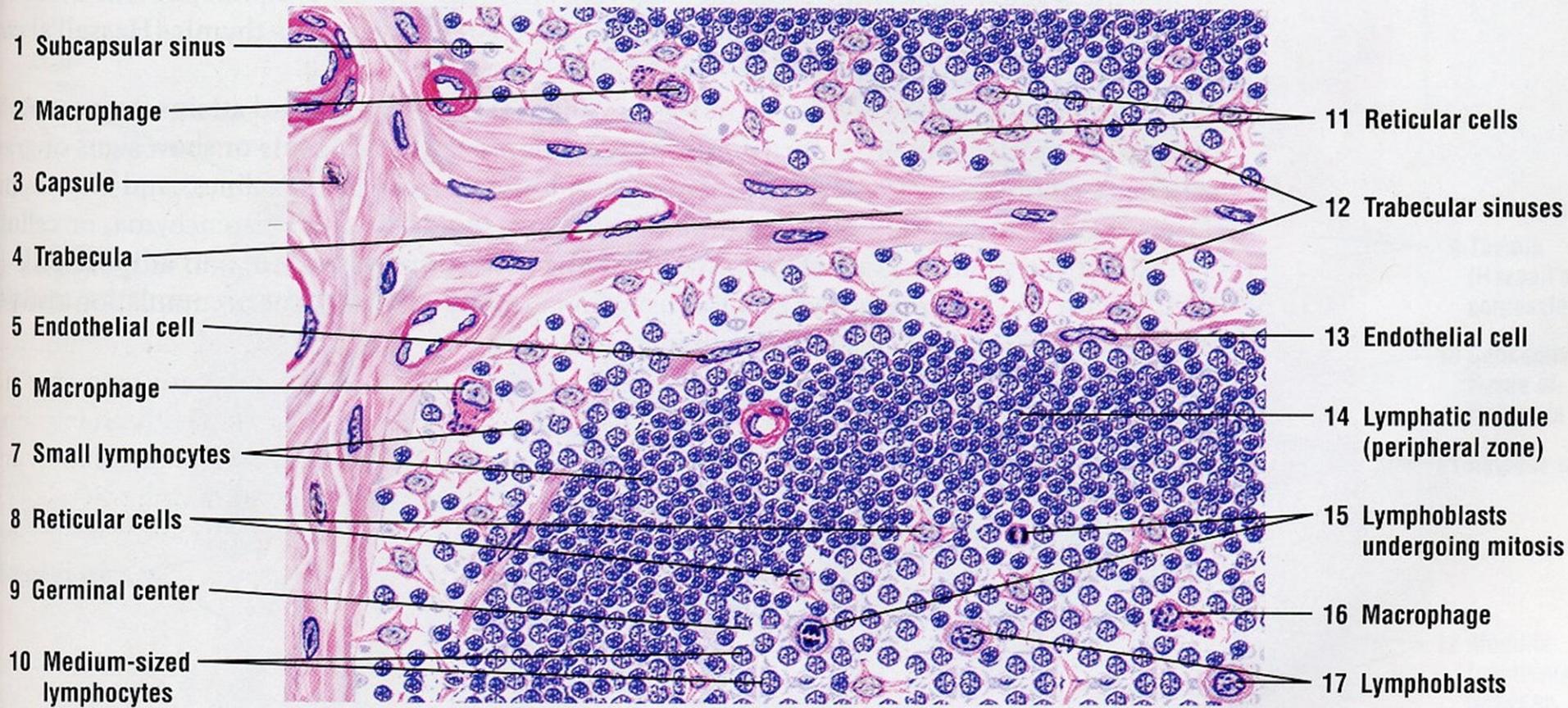
**FIGURE 9.1** ■ Lymph node (panoramic view). Stain: hematoxylin and eosin. Medium magnification.



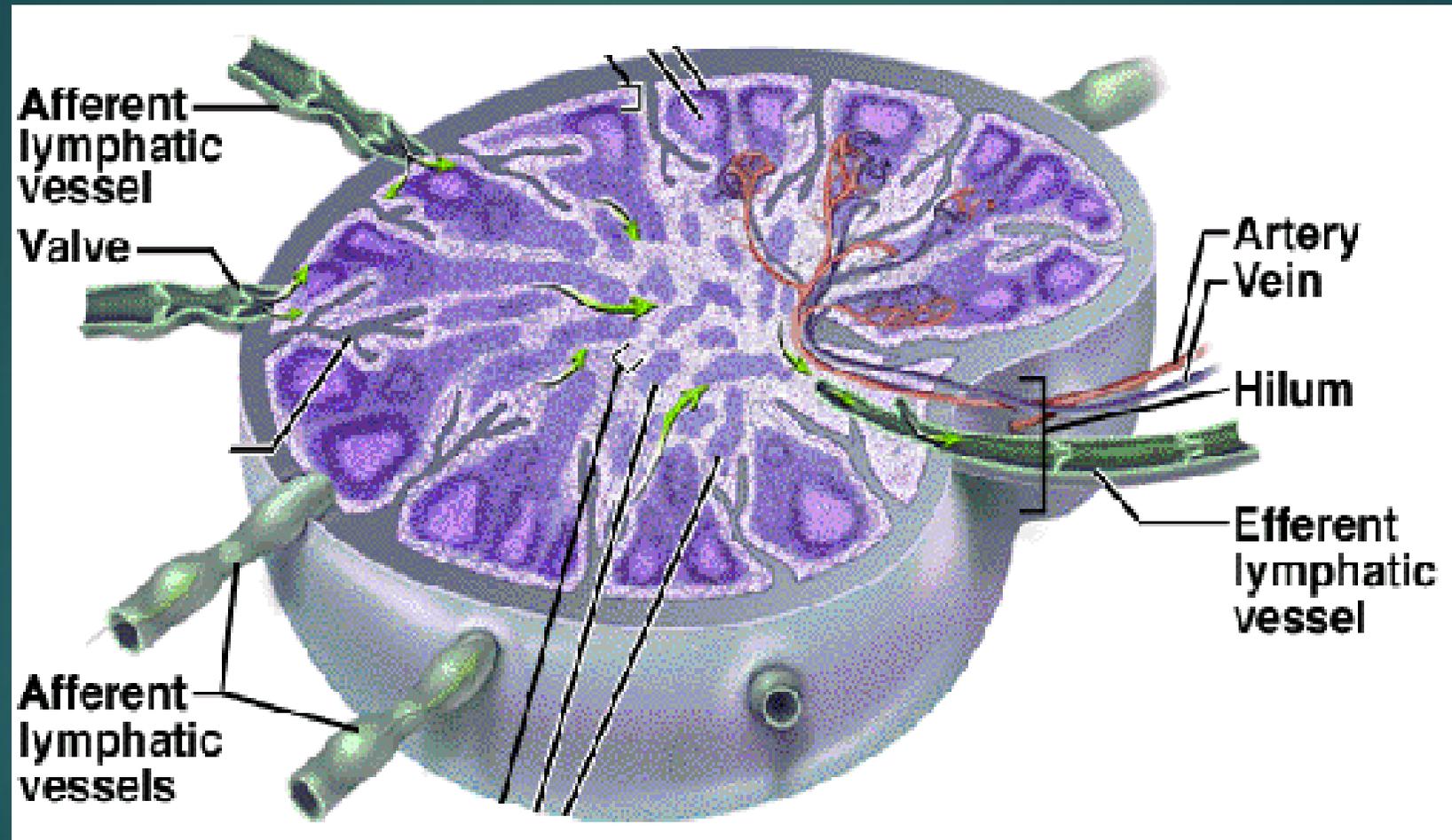
#### KEY

- |                             |                                    |
|-----------------------------|------------------------------------|
| 1. Capsule                  | 8. Medullary cord                  |
| 2. Cortical sinus           | 9. Medullary sinus                 |
| 3. Crypt                    | 10. Salivary glands, mucous        |
| 4. Deep cortex              | 11. Stratified squamous epithelium |
| 5. Diffuse lymphatic tissue | 12. Subcapsular sinus              |
| 6. Leukocyte infiltration   | 13. Trabecula                      |
| 7. Lymphatic nodule         |                                    |

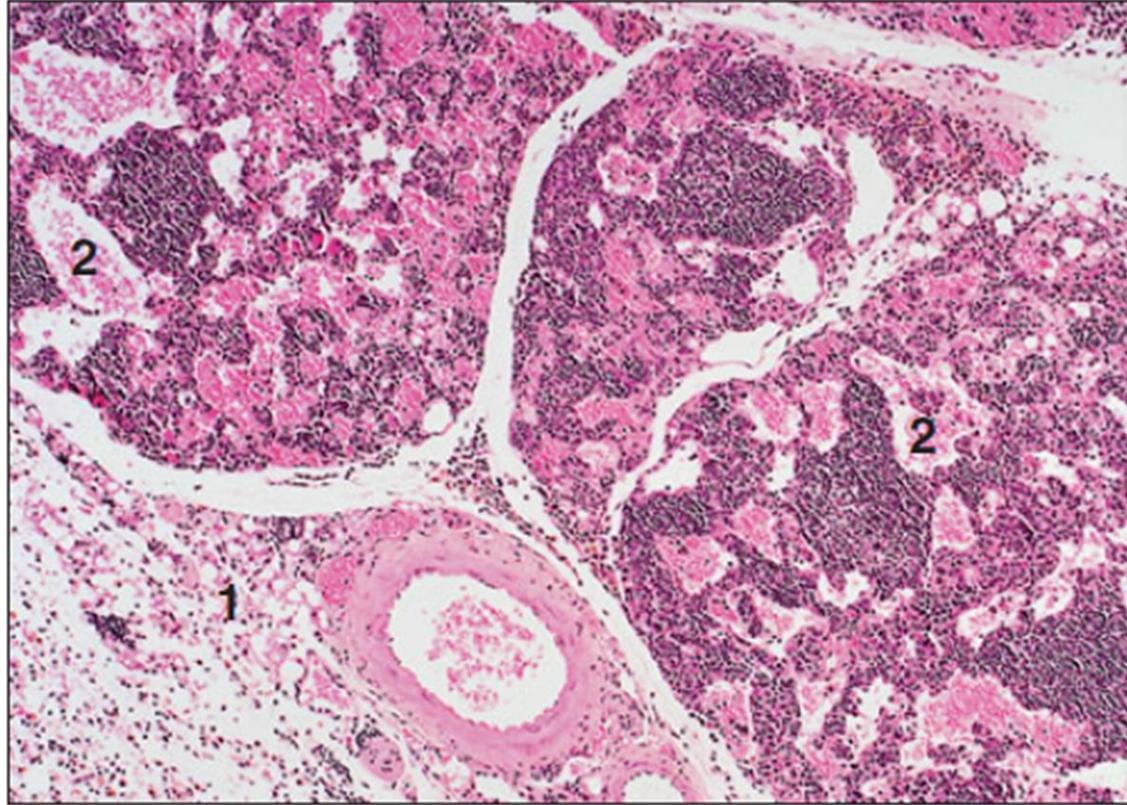




**FIGURE 9.4** ■ Lymph node: subcortical sinus and lymphatic nodule. Stain: hematoxylin and eosin. High magnification.



# Haemal Node



**15.14** Haemal lymph node (ox). (1) Connective tissue capsule. (2) Blood filled sinusoids. H & E.  $\times 20$ .

# Thymus

Location – behind the sternum in the mediastinum

The capsule divides it into 2 lobes

Development

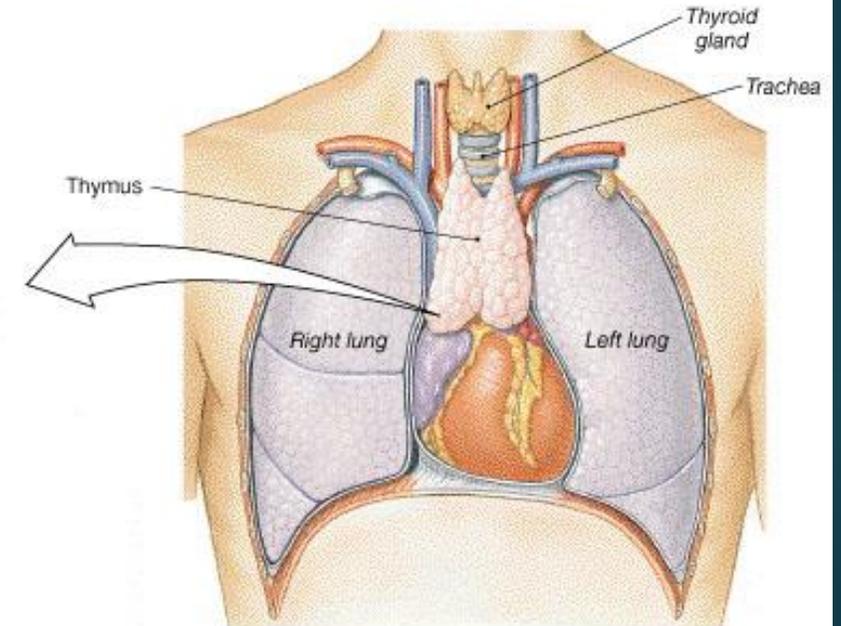
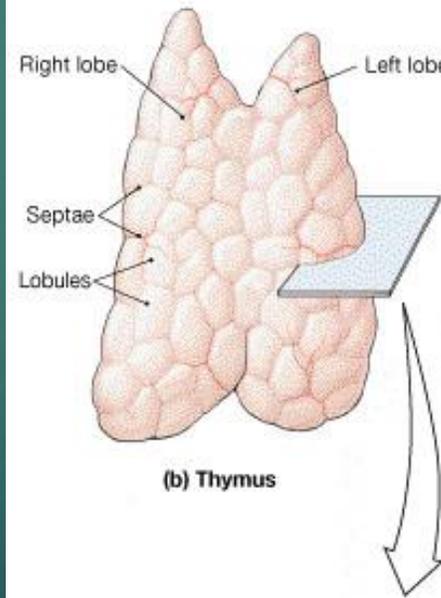
Infant – conspicuous

Puberty – maximum size

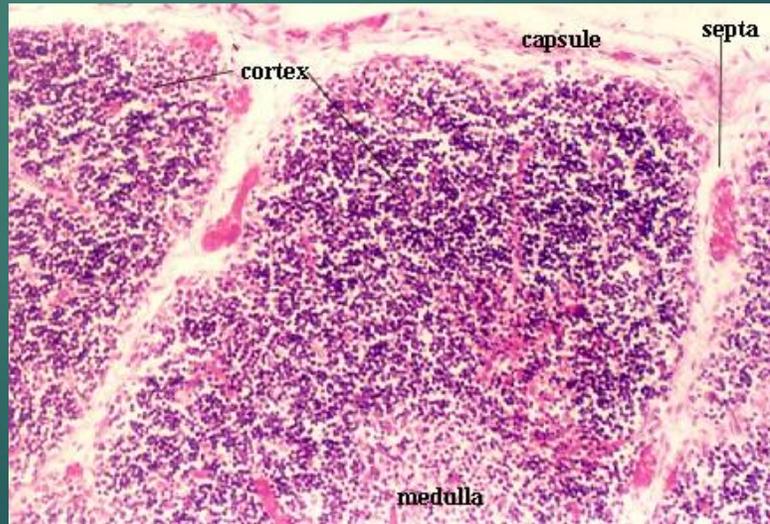
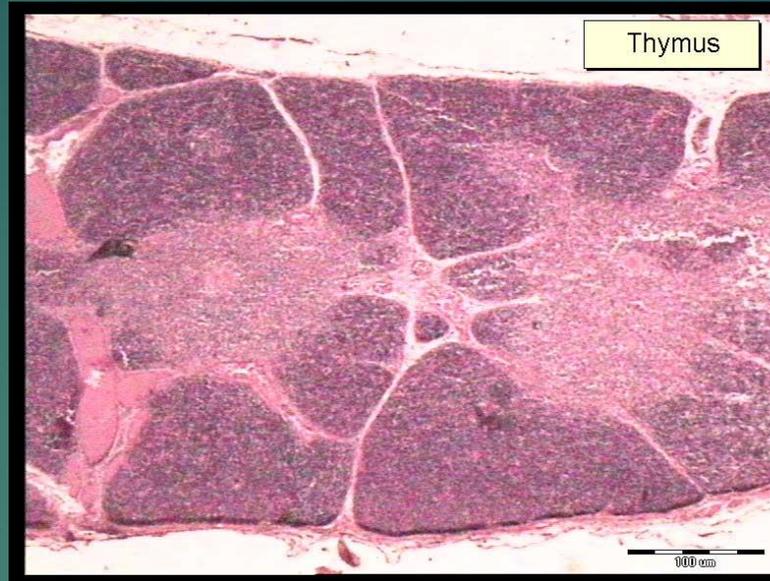
Maturity – decreases in size

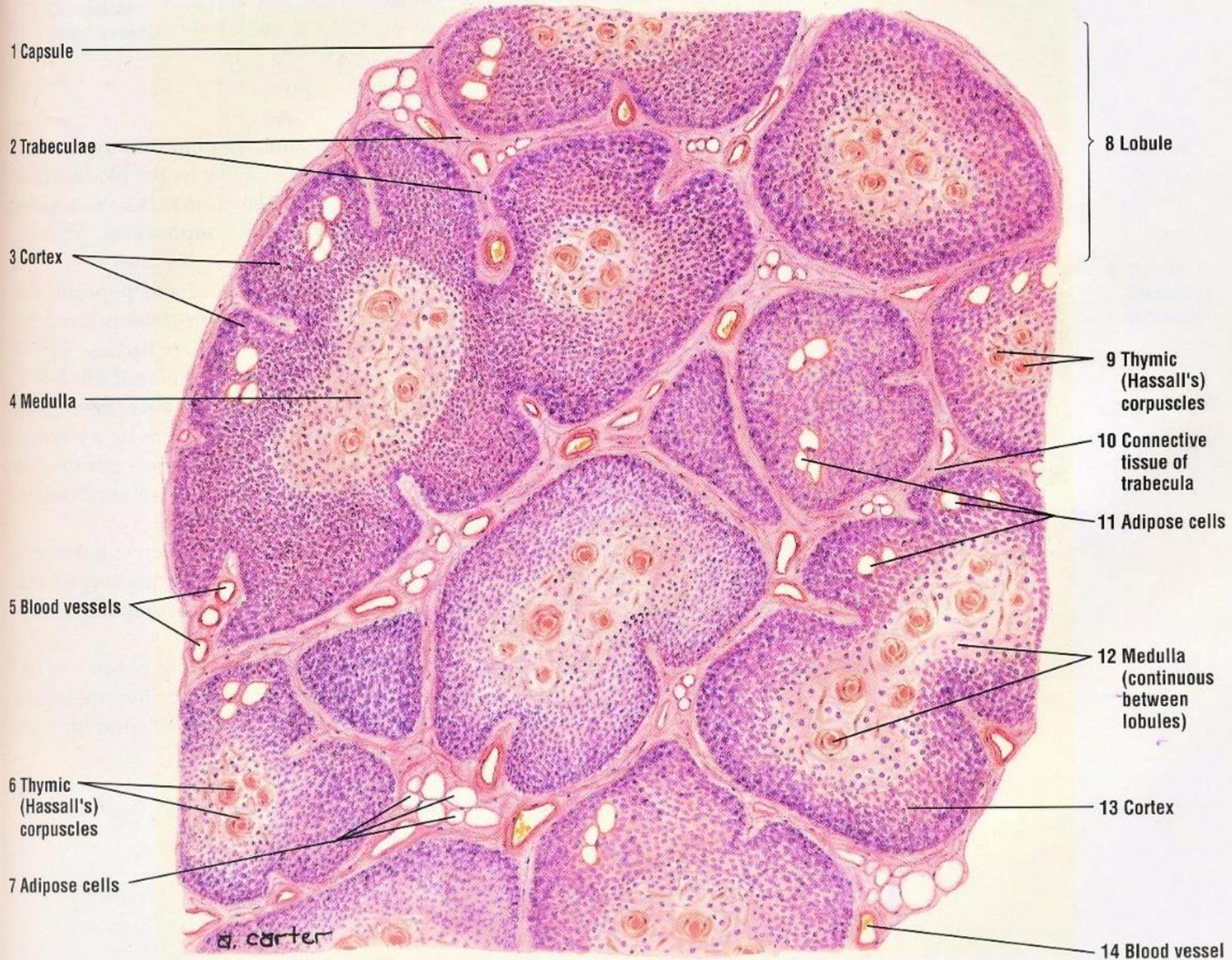
Function

Differentiation and maturation of T cells

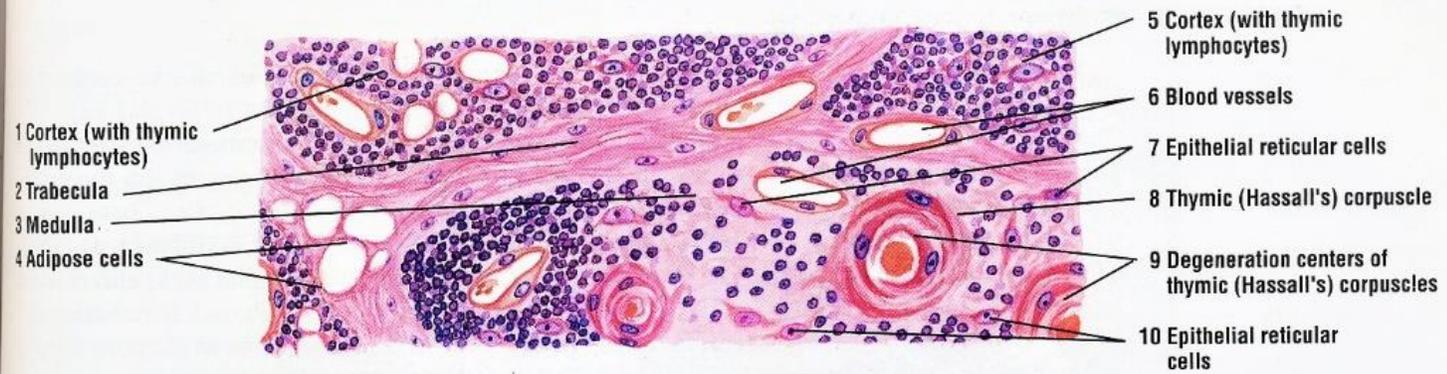


(a) Location of thymus within thoracic cavity

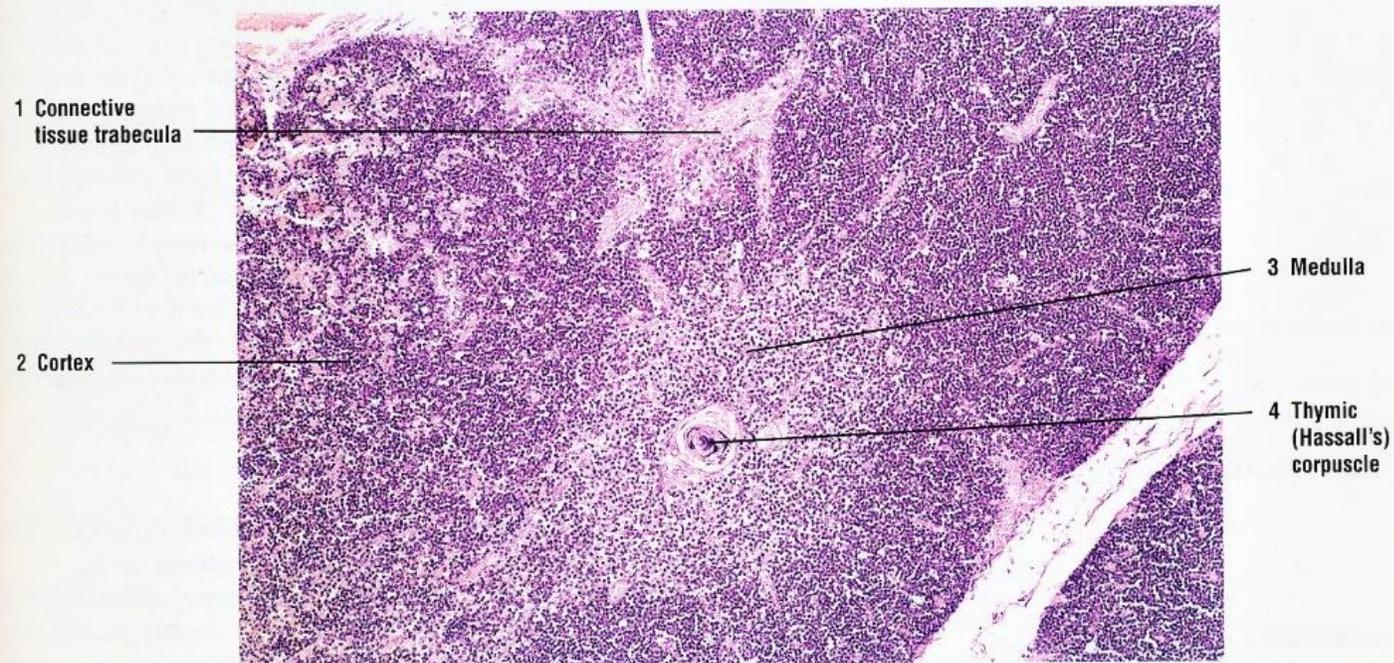




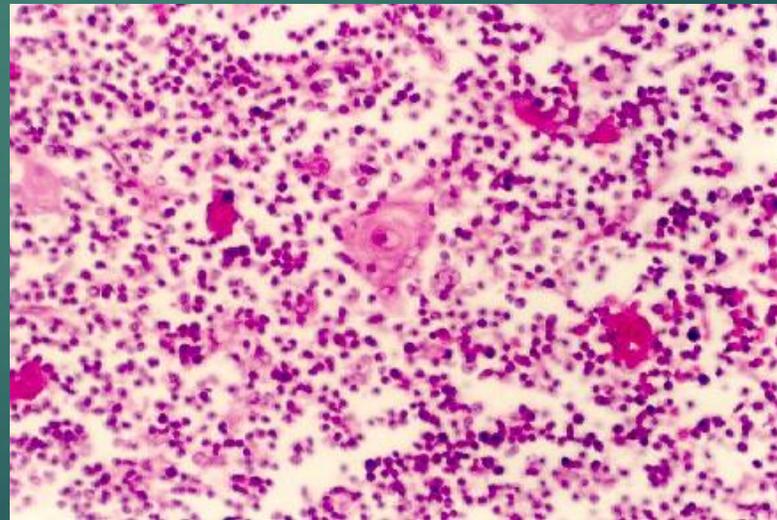
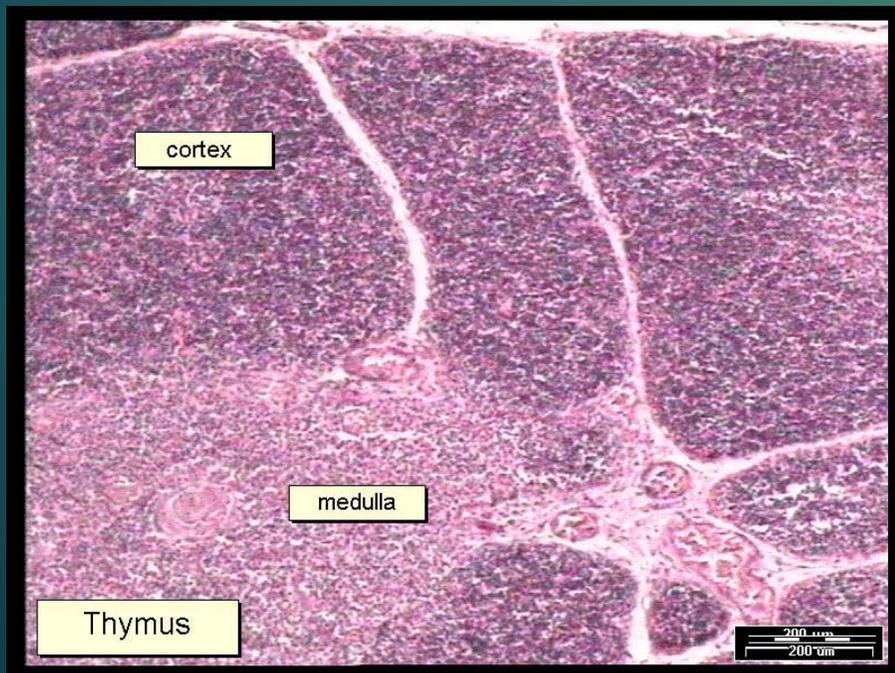
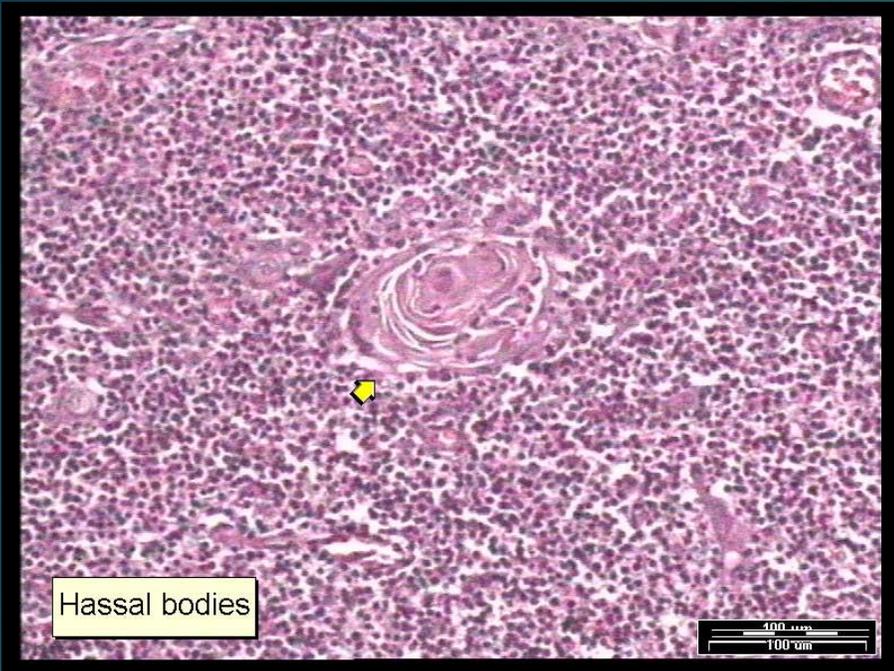
**FIGURE 9.6** ■ Thymus gland (panoramic view). Stain: hematoxylin and eosin. Low magnification.



**FIGURE 9.7** ■ Thymus gland (sectional view). Stain: hematoxylin and eosin. High magnification.



**FIGURE 9.8** ■ Cortex and medulla of a thymus gland. Stain: hematoxylin and eosin. 30×



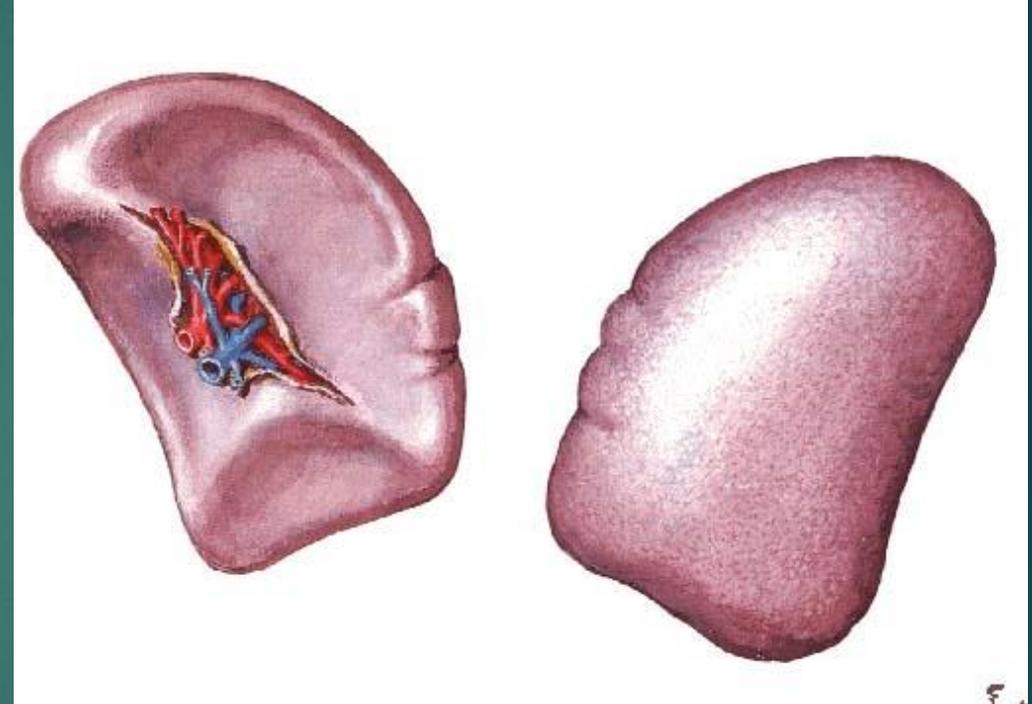
*Thymus Medulla*



## *Thymus Age Degeneration*

# Spleen

- Largest lymphatic organ
- Located between the stomach & diaphragm
- Structure is similar to a node
  - Capsule present
  - But no afferent vessels or sinuses
- Histology
  - Red pulp contains all the components of circulating blood
  - White pulp is similar to lymphatic nodules
- Functions
  - Filters blood
  - Stores blood





**FIGURE 9.9** ■ Spleen (panoramic view). Stain: hematoxylin and eosin. Low magnification.



**FIGURE 9.10** ■ Spleen: red and white pulp. Stain: hematoxylin and eosin. Medium magnification.

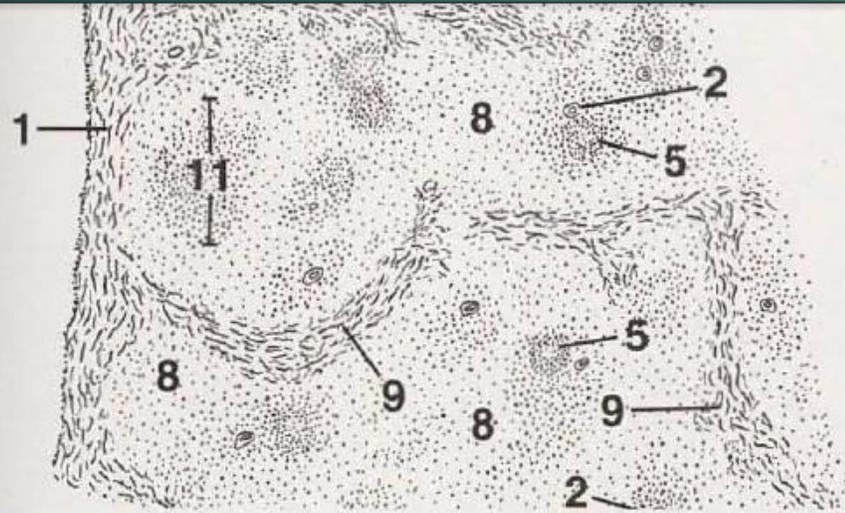


Figure 11.35

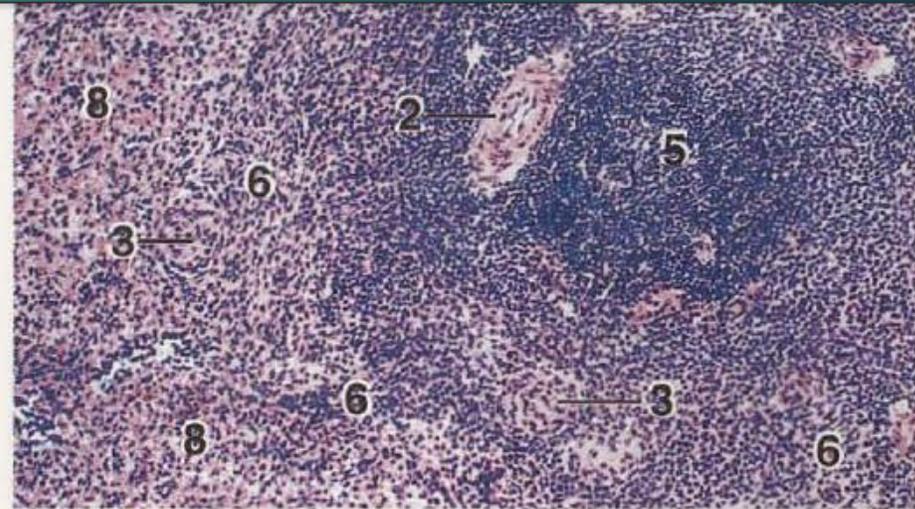
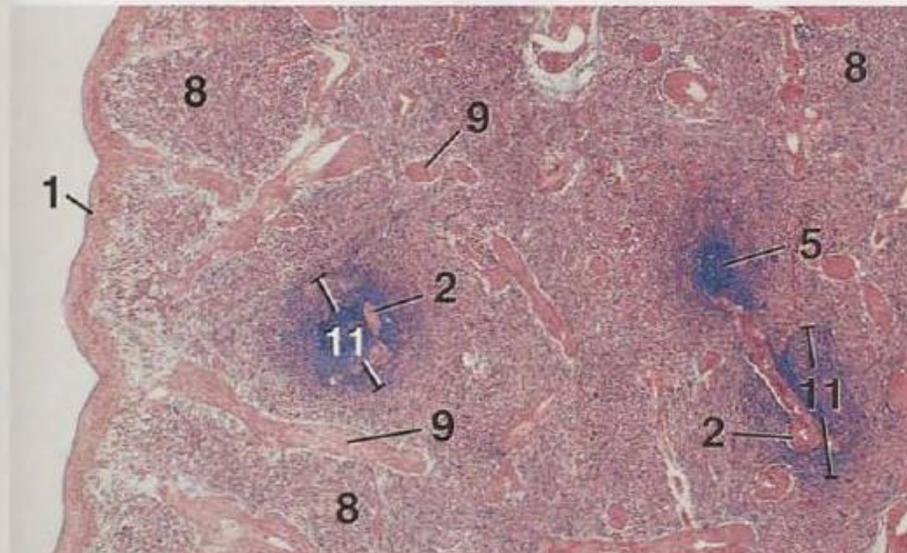


Figure 11.39

×62.5



KEY

- |                     |                  |
|---------------------|------------------|
| 1. Capsule          | 7. Mesothelium   |
| 2. Central artery   | 8. Red pulp      |
| 3. Ellipsoid        | 9. Trabecula     |
| 4. Endothelial cell | 10. Venous sinus |
| 5. Lymphatic nodule | 11. White pulp   |
| 6. Marginal zone    |                  |

Figure 11.35. Spleen, Dog. This drawing is of a small portion of the spleen.

Figure 11.36. Spleen, Dog. The parenchyma of the spleen is organized into red pulp and white pulp (periarterial lymphatic sheaths and lymphatic nodules). Trabeculae extend inward from

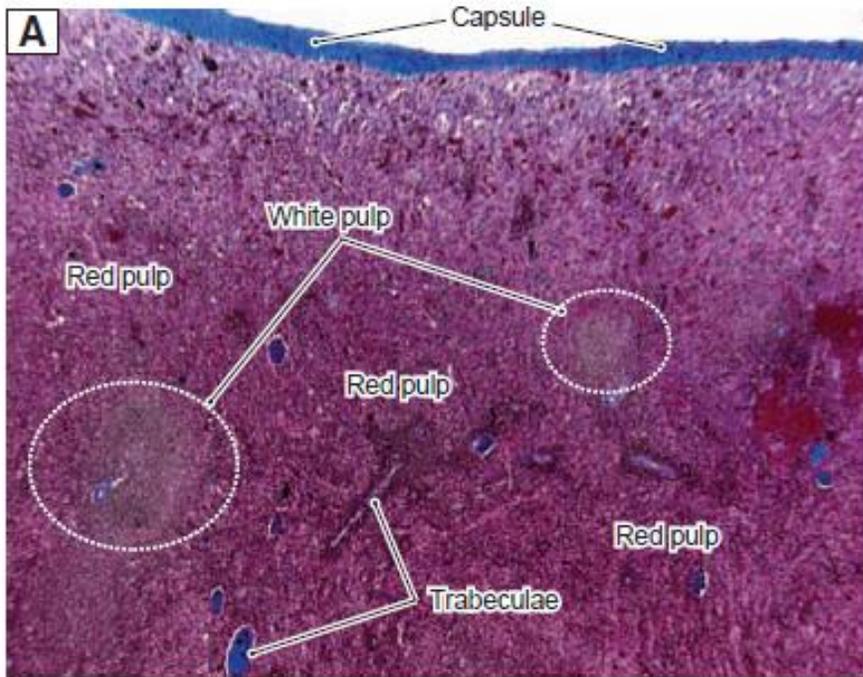


Figure 10-14A. Spleen. H&E,  $\times 60$

The spleen is a large lymphoid organ (about 140–180 g in humans) located in the left superior quadrant of the abdomen (Fig. 10-6). It is covered by a thick, dense connective tissue (capsule), which extends into the organ to form trabeculae. Trabeculae provide structural support for arteries and veins, which supply the compartments (white and red pulp) of the spleen. The spleen is not organized into a cortex and medulla as are lymph nodes and the thymus but is divided into white pulp associated with a central artery and red pulp associated with a vein and venous sinusoids. Functions of the spleen include (1) an immune component (white pulp) to activate lymphocytes and promote antibody production by plasma cells, (2) filtration of blood and destruction of aged erythrocytes in red pulp, and (3) serving as reservoir for erythrocytes and platelets.

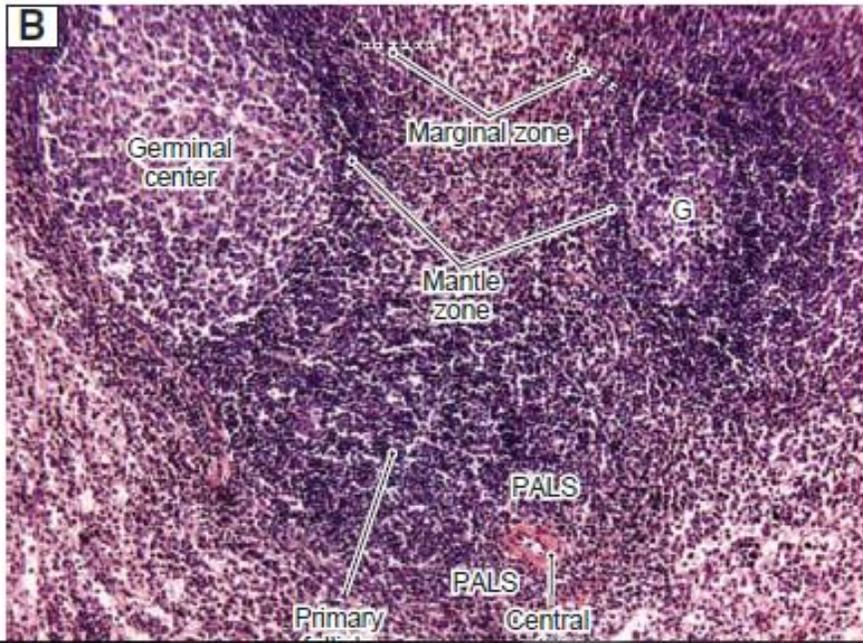
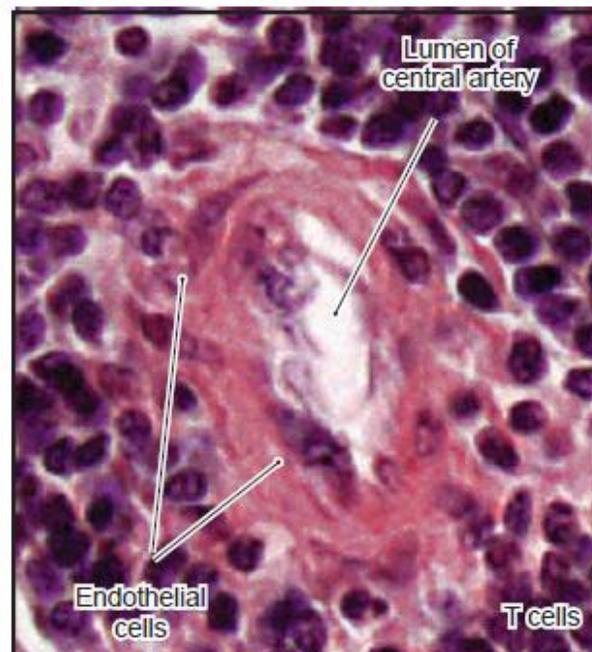
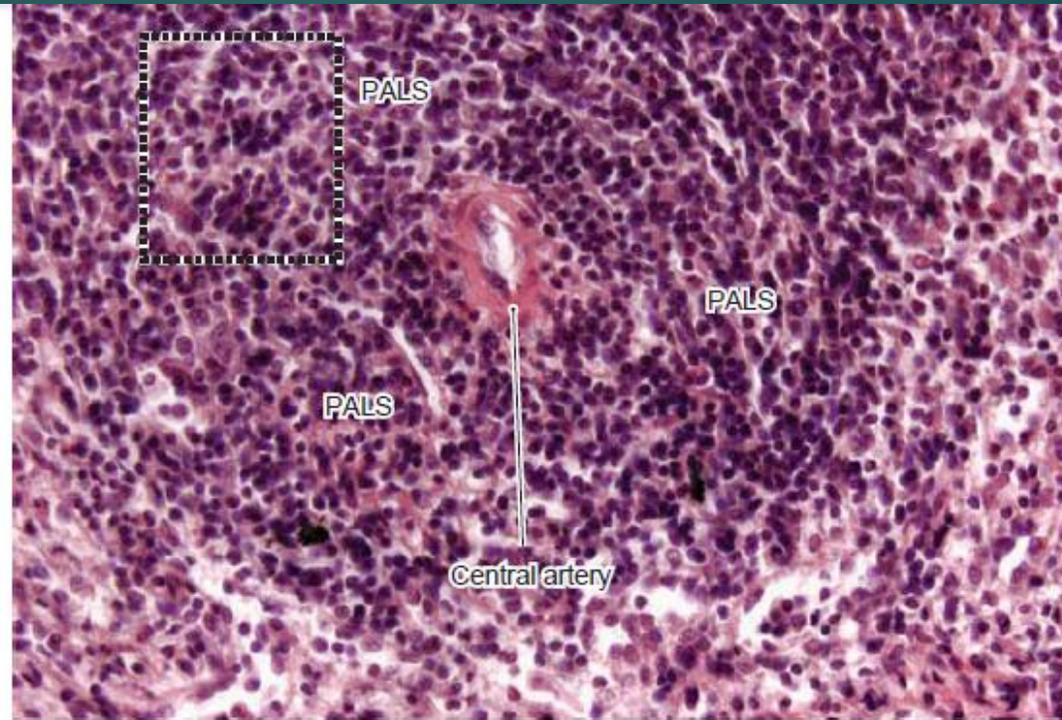


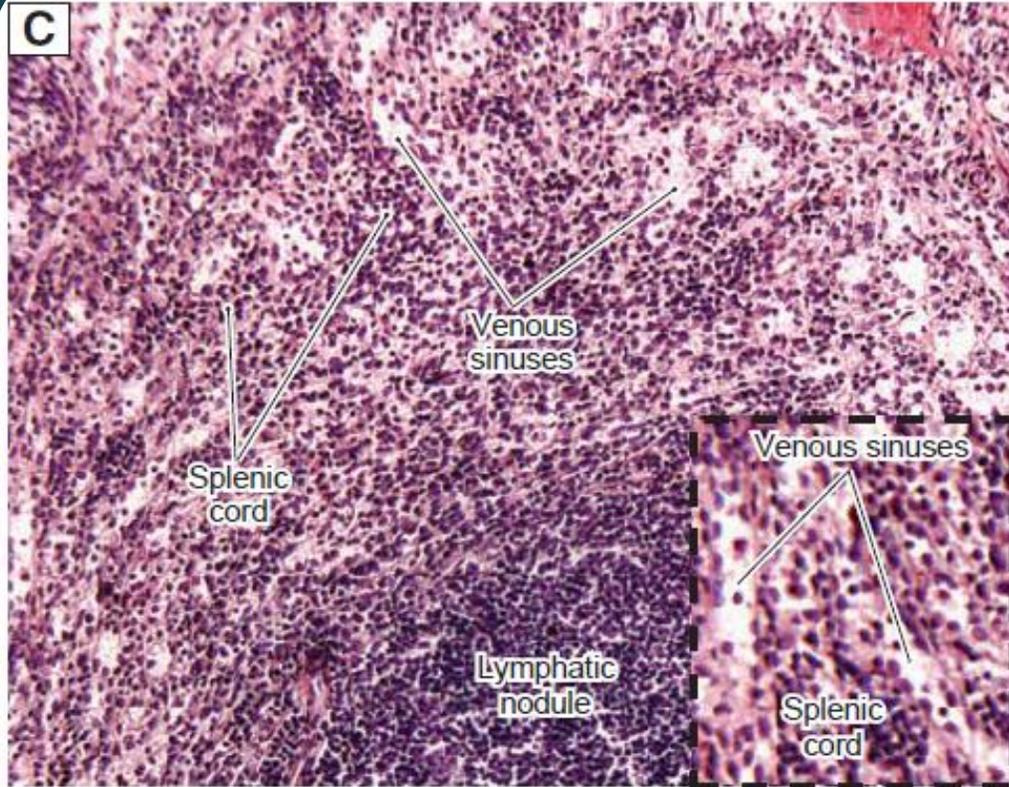
Figure 10-14B. White pulp, spleen. H&E,  $\times 194$ ; inset  $\times 748$

White pulp and red pulp are the two basic components of the spleen. White pulp is composed of a central artery, a PALS, and a lymphatic nodule. The nodules with germinal centers are secondary nodules (follicles) where B cells actively differentiate into large cells (lymphoblasts and lymphocytes). The dark ring region around the germinal center is the mantle zone where small inactive B cells are hosted. The mantle zone stains dark because of densely packed lymphocytes. The nodules without the germinal centers are primary nodules, which contain most of the inactive B cells. The region that surrounds the white pulp is the marginal zone, which contains marginal sinuses. (G, germinal center.)



**Figure 10-15B.** Periaarterial lymphatic sheath, spleen. H&E stain,  $\times 564$ ; insets  $\times 1,727$

The central artery, which helps to maintain the lymphatic sheath, continues through the white pulp and branches before supplying the marginal sinuses (capillaries). Its distal branches supply the red pulp. The central artery carries lymphocytes into the marginal sinuses in the marginal zone, where B cells encounter antigens. Naive B cells become memory B cells and plasma cells, which produce antibodies. T cells migrate to the central artery region and form multiple layers that surround that artery to form the PALS. T cells interact with antigen-presenting cells (*inset* shows a macrophage) and receive antigens. Active T cells undergo proliferation to increase their population (Fig. 10-5A).



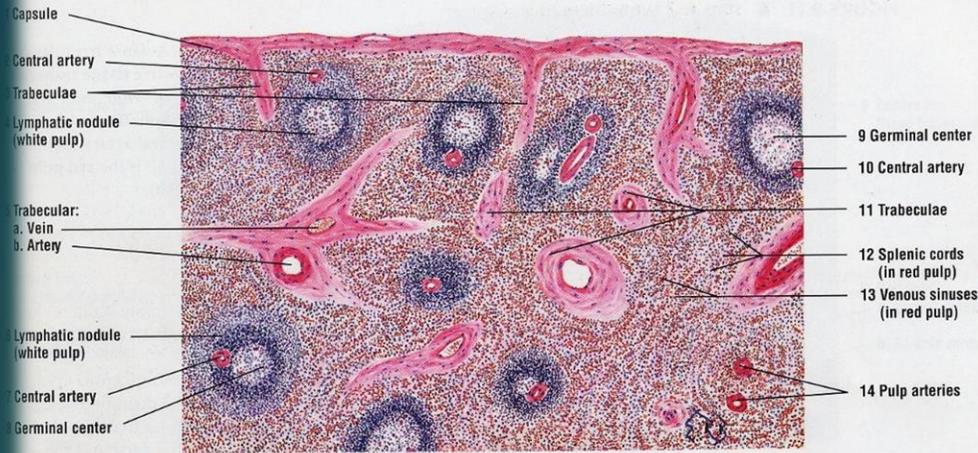
**Figure 10-14C.** Red pulp, spleen. H&E,  $\times 256$ ; inset  $\times 385$

Red pulp (red because it is rich in blood) stains light and contains splenic cords and venous sinuses that are filled with blood. Venous sinuses are discontinuous capillaries, which have large lumens, incomplete basal laminae, and gaps between endothelial cells. These special features allow blood cells to pass through the capillary wall (see Fig. 9-14A,B). The splenic cord is a framework of reticular tissue that contains B cells, T cells, plasma cells, macrophages, and other blood cells. Macrophages in the splenic cord often extend their processes into the lumen of the sinuses to reach and engulf foreign substances, microbes, and aged erythrocytes. The red pulp of the spleen also serves as a reservoir for platelets (Fig 10-16).

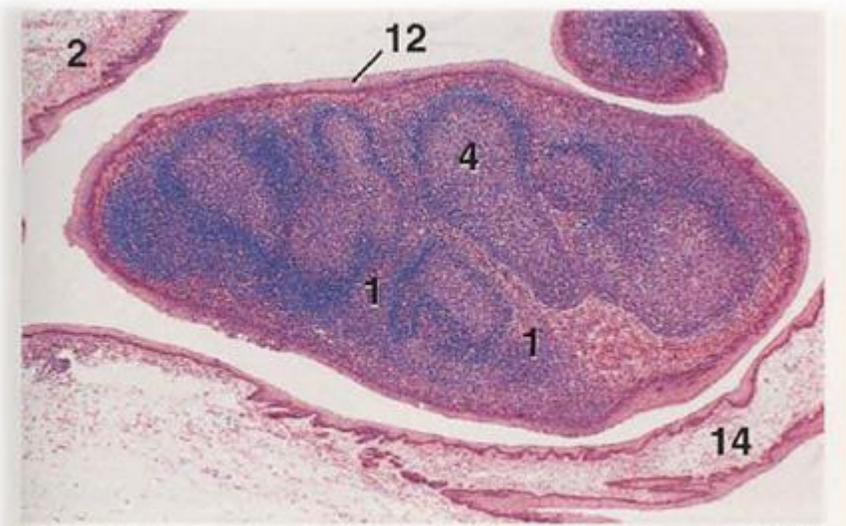


**TABLE 10-2** Lymphoid Organs

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	<ol style="list-style-type: none"> <li>1. Epithelial covering</li> <li>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</li> </ol>
Lymph nodes	Capsule (thin)	Cortex, paracortex, and medulla	Medullary cords and medullary sinuses	Primary and secondary nodules (most nodules are secondary); medullary cords	Paracortex	<ol style="list-style-type: none"> <li>1. Afferent lymphatic vessels and subcapsular sinuses</li> <li>2. Filter lymph and recirculate both B and T cells; provide place for lymphocytes to meet antigens and start immune response</li> </ol>
Thymus	Capsule (thin)	Cortex (without lymphatic nodules); medulla (with Hassall corpuscles)	No	No	Cortex and medulla	<ol style="list-style-type: none"> <li>1. Epithelial reticular cells and Hassall corpuscles; no lymphatic nodules</li> <li>2. Development and maturation of T cells</li> </ol>
Spleen	Capsule (thick)	No, arranged in white pulp and red pulp	Splenic cords and venous sinuses	Secondary nodules (splenic nodules)	PALS	<ol style="list-style-type: none"> <li>1. Central arteries and PALS</li> <li>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 proliferate, and initiate immune response</li> </ol>

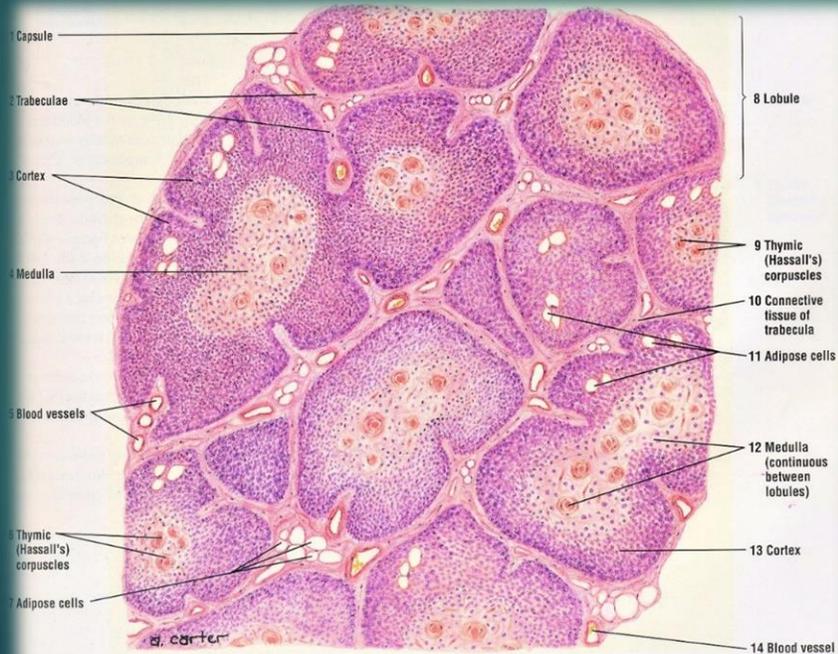


**FIGURE 9.9** ■ Spleen (panoramic view). Stain: hematoxylin and eosin. Low magnification.

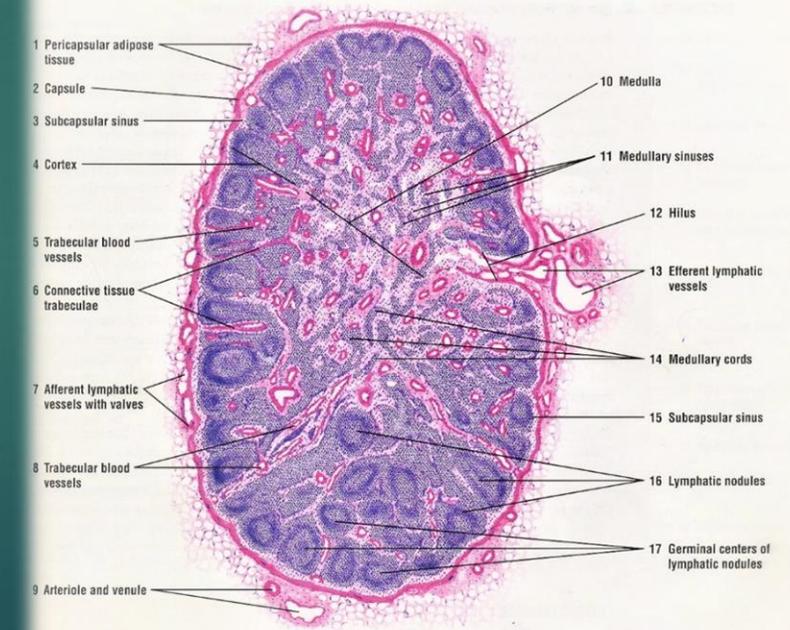


**Figure 11.7**

×12.5

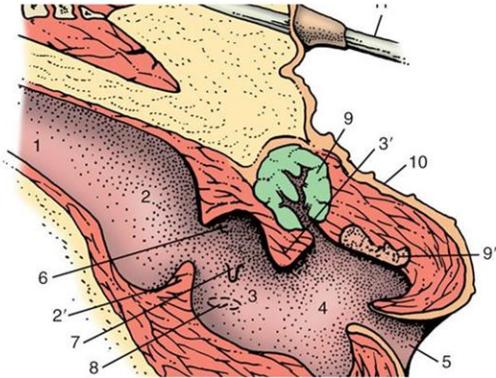
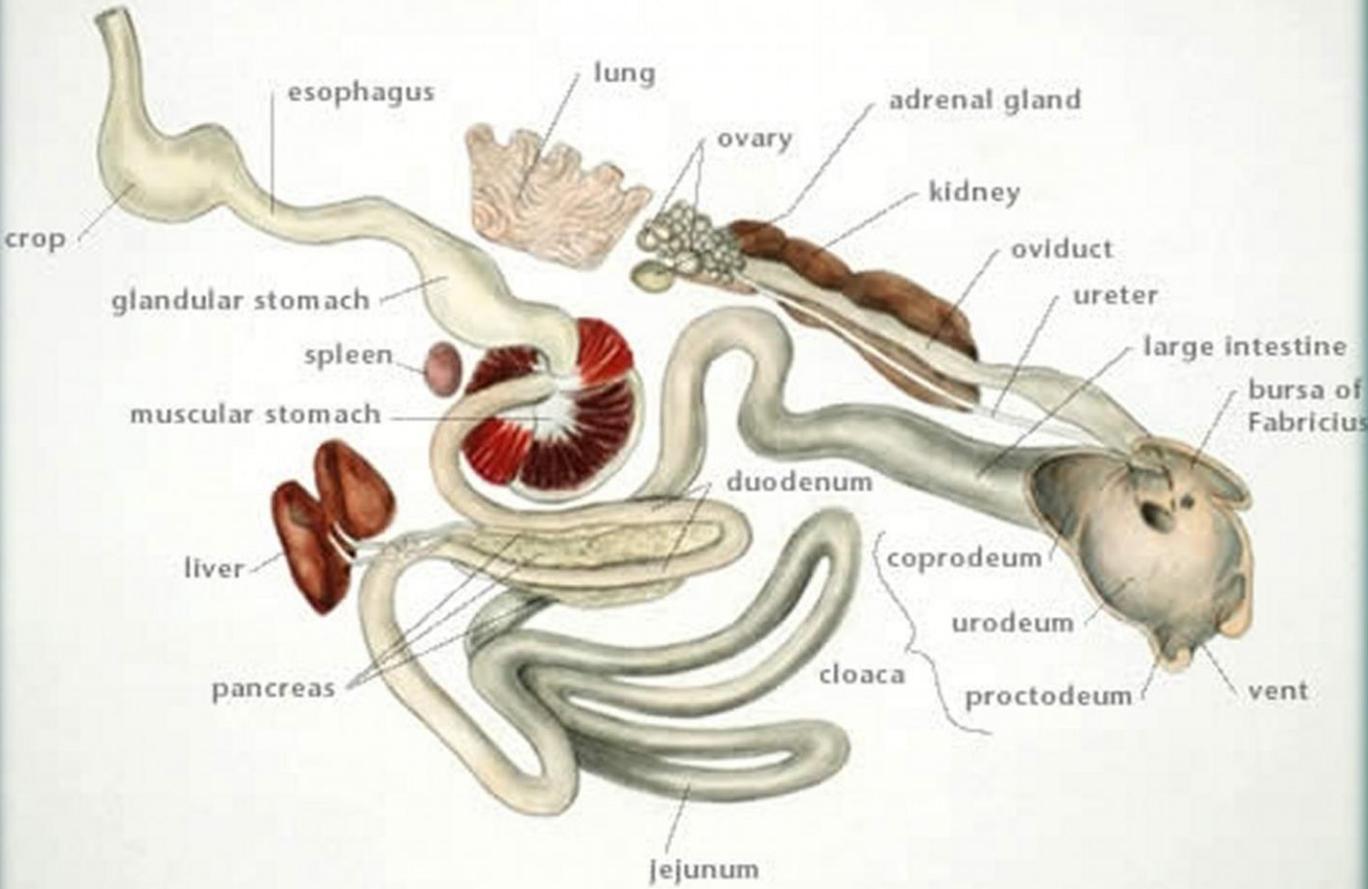


**FIGURE 9.6** ■ Thymus gland (panoramic view). Stain: hematoxylin and eosin. Low magnification.



**FIGURE 9.1** ■ Lymph node (panoramic view). Stain: hematoxylin and eosin. Medium magnification.

# Cloacal bursa

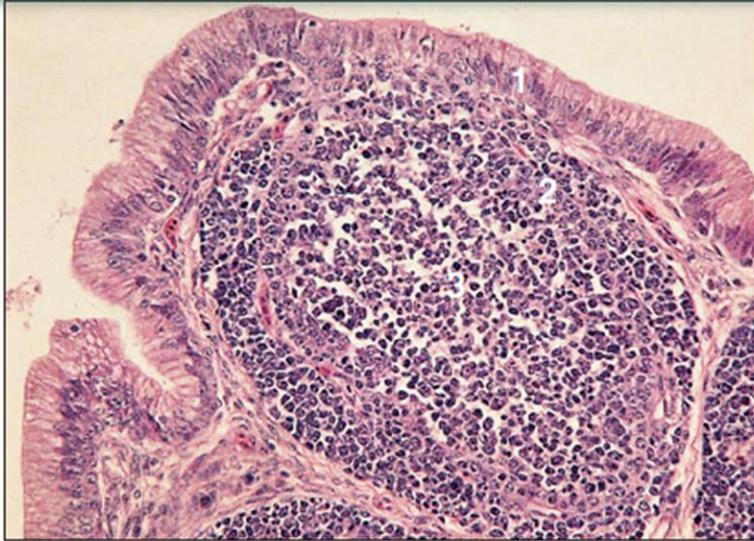


## Avian Cloaca

**Figure 37-22.** Median section of the cloaca, semischematic. 1, Colon; 2, coprodeum; 2', coprourodeal fold; 3, urodeum; 3', uroproctodeal fold; 4, proctodeum; 5, vent; 6, ureteric orifice; 7, papilla of deferent duct; 8, position of oviduct orifice (only on left side); 9, cloacal bursa; 9', dorsal proctodeal gland; 10, skin; 11, tail feather; 12, uropygial gland; 12', papilla of uropygial gland; 13, muscles surrounding caudal vertebrae.

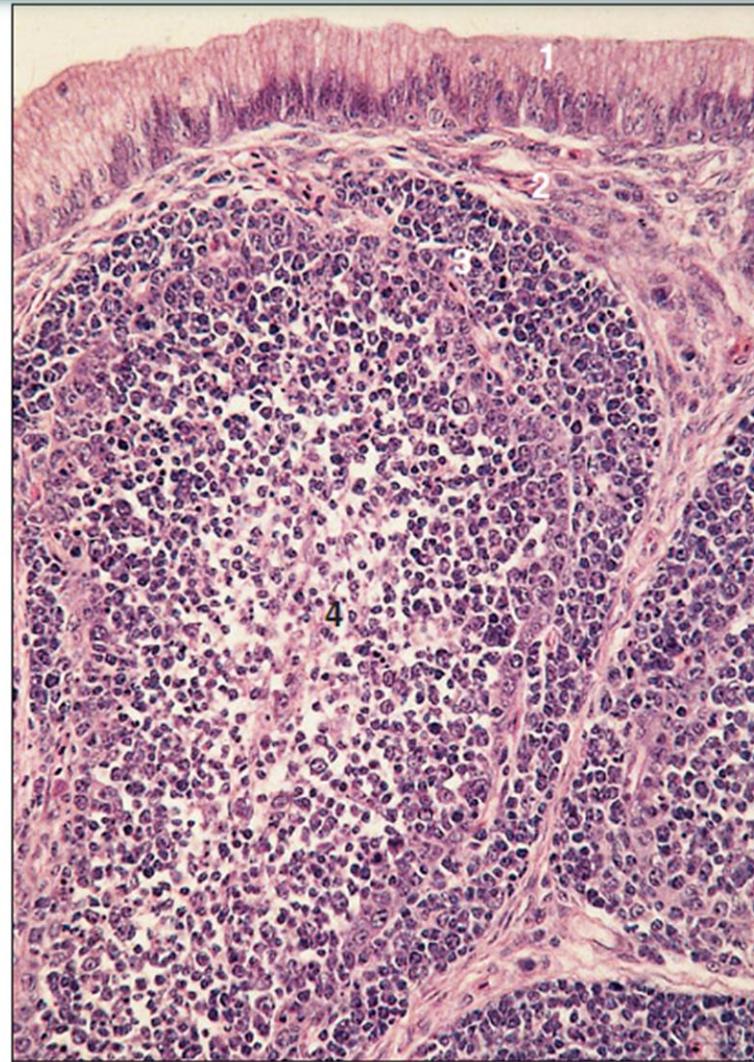


15.39



**15.39** Cloacal bursa (bird). (1) Simple columnar epithelium of the cloaca. (2) Cortical area of densely packed lymphocytes. (3) Sparsely populated medulla. H & E.  $\times 62.5$ .

15



**15.40** Cloacal bursa (bird). (1) Simple columnar epithelium of the cloaca. (2) Connective tissue lamina propria. (3) Cortex. (4) Medulla. H & E.  $\times 125$ .

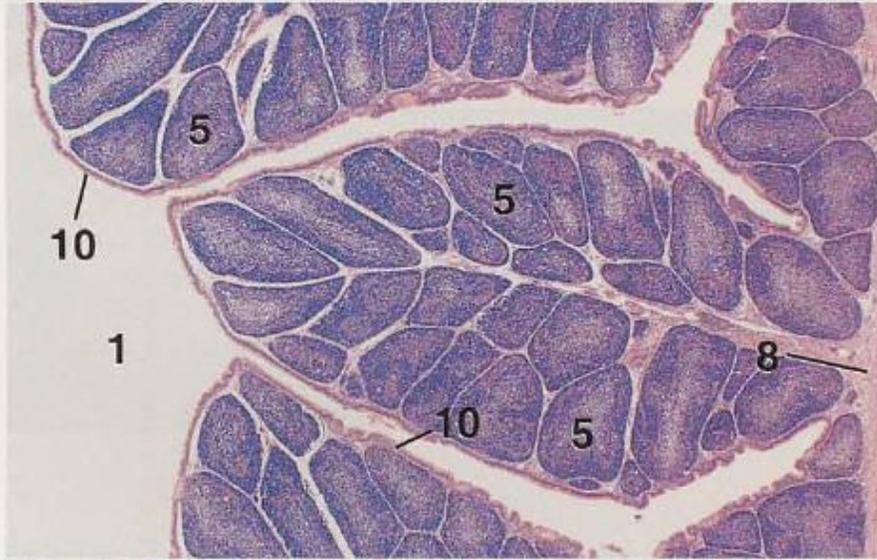


Figure 11.57

×12.5

**Figure 11.57. Bursa of Fabricius, Chicken.** Portions of the long mucosal folds (plicae) project into the lumen of the bursa. Numerous follicles, each composed of a cortex and medulla, fill the lamina propria of each fold.

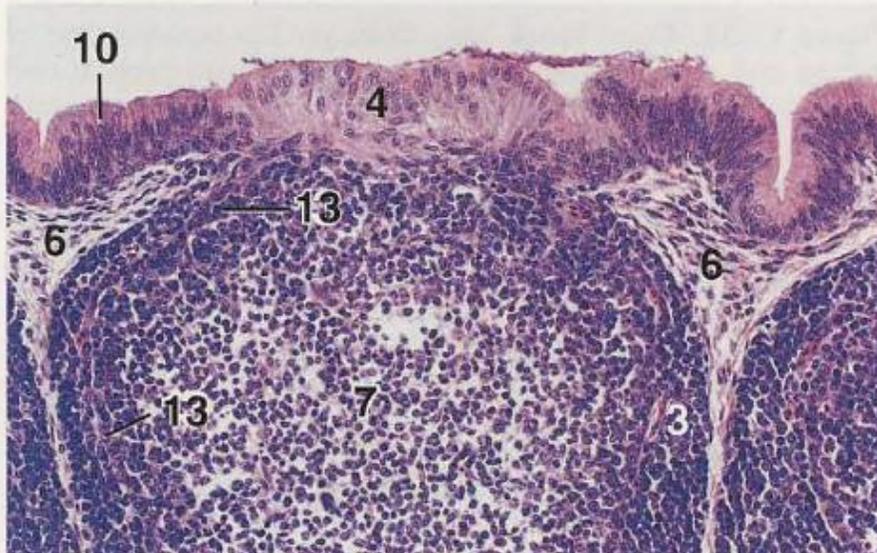


Figure 11.58

×125

**Figure 11.58. Bursa of Fabricius, Chicken.** Where the apex of a follicle contacts the epithelium, tall, pale columnar cells with apical nuclei form an epithelial tuft. Elsewhere, mucosal folds are covered by a pseudostratified columnar epithelium.

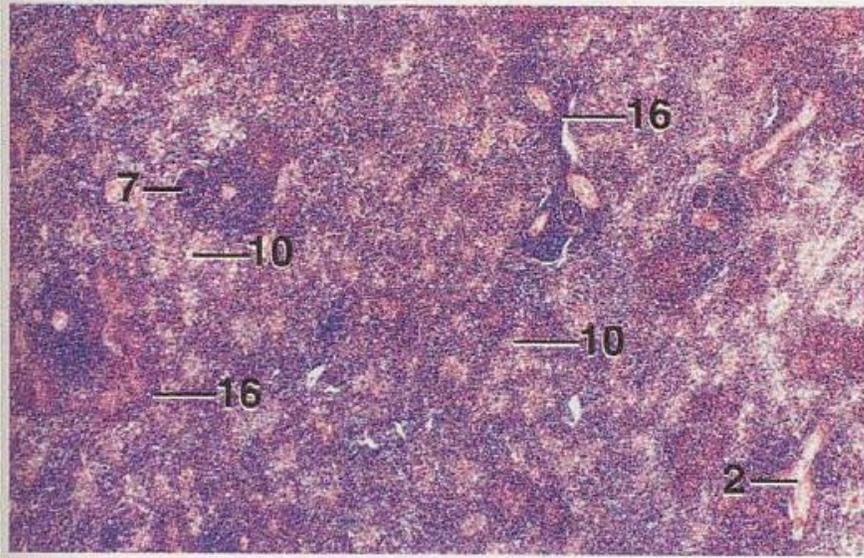


Figure 11.52

×25

#### KEY

- |                        |                              |
|------------------------|------------------------------|
| 1. Adipose tissue      | 9. Muscularis externa        |
| 2. Blood vessel        | 10. Red pulp                 |
| 3. Connective tissue   | 11. Reticular cell           |
| 4. Crypt of Lieberkühn | 12. Sheathed artery, lumen   |
| 5. Erythrocyte         | 13. Smooth muscle of capsule |
| 6. Granulocyte         | 14. Thymic tissue            |
| 7. Lymphatic nodule    | 15. Villus                   |
| 8. Mesothelium         | 16. White pulp               |

**Chicken spleen**

