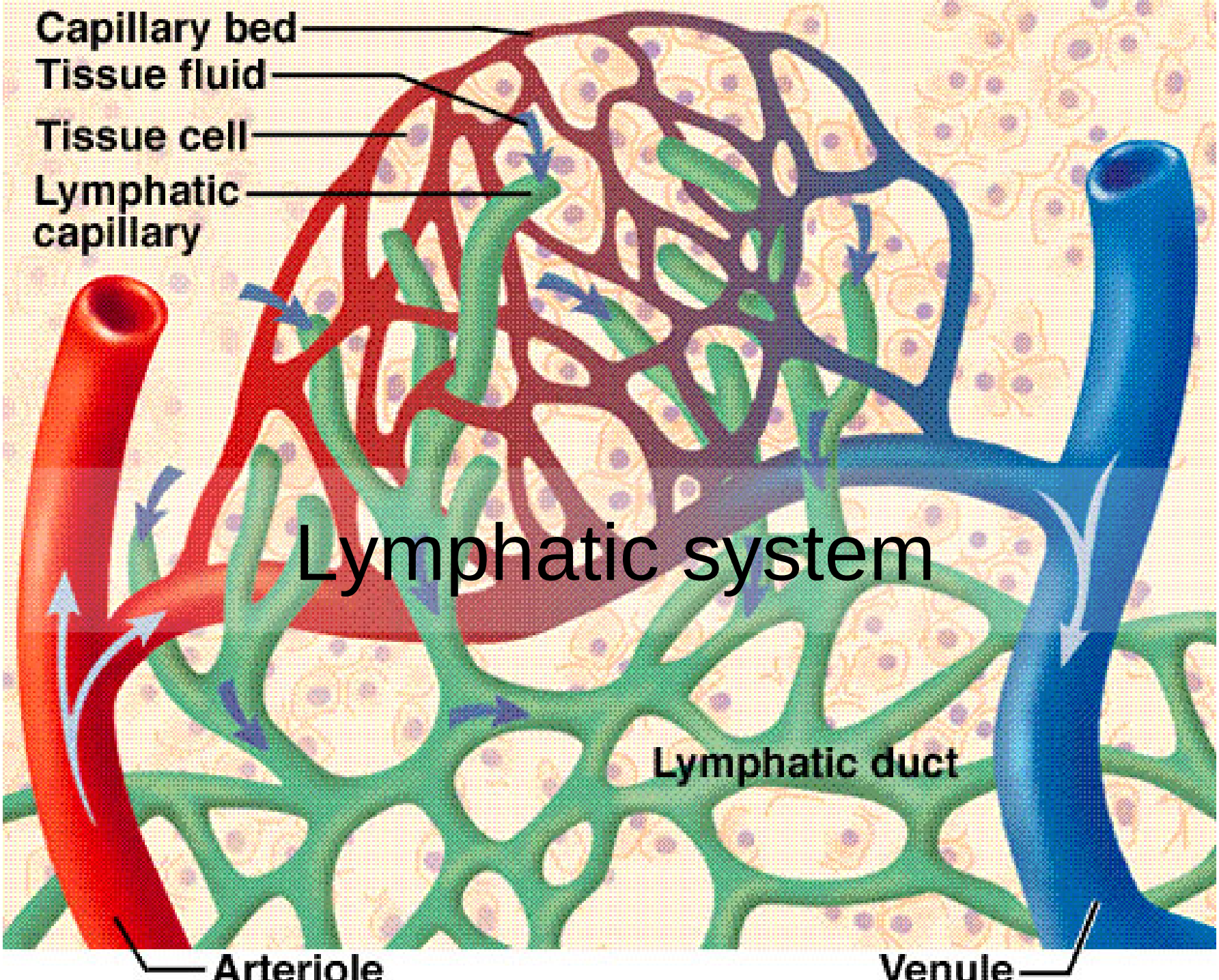

Capillary bed
Tissue fluid
Tissue cell
Lymphatic capillary
Lymphatic system
Lymphatic duct
Arteriole
Venule

Functions of the lymphatic system

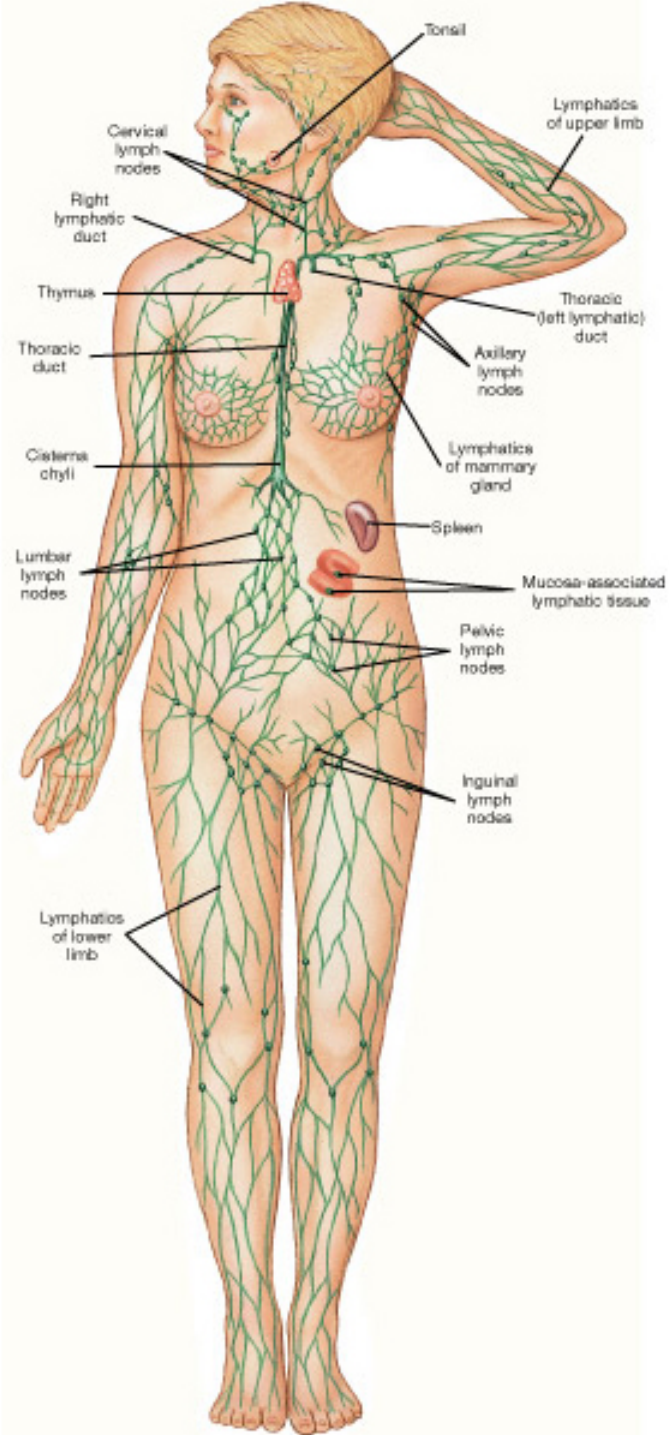
- Production & circulation of lymphocytes
- Protection against pathogens (leukocytes)
- Return of ‘fluid’ from the interstitial space to the rt. atrium of the heart
- Aids in absorption/transport of dietary lipids lipid-soluble vitamins (A,D,K and E)

Components of the lymphatic system

- Spleen
- Thymus
- 5 Tonsils
- Lymph nodes (distributed all over the body)
- Lymphatic vessels
- Peyer’s patches
- lacteals

Fig

23.1


Tonsil
Lymphatics of upper limb
Cervical lymph nodes
Right lymphatic duct
Thymus
Thoracic (left lymphatic) duct
Thoracic duct
Axillary lymph nodes
Cisterna chyli
Lymphatics of mammary gland
Spleen
Lumbar lymph nodes
Mucosa-associated lymphatic tissue
Pelvic lymph nodes
Inguinal lymph nodes
Lymphatics of lower limb

Lymphocytes

- A type of leukocyte
- Function in specific immunity
- Destroy pathogens
- Travel thru the cardiovascular & lymphatic systems

Types of lymphocytes

- Three types:
  - T cells (thymus-dependent)
  - B (bone marrow derived) cells
  - NK cells (natural killer)

T cells

- 80% of the circulating lymphocytes
- Directly attack pathogens- Cytotoxic T cells
- Control activity of B cells- Helper T cells Suppressor T cells
- Memory T cells-after the primary infection they are on reserve until the same antigen appears in the body
- Effected by Human Immunodeficiency Virus

B cells

- 10-15% of the circulating lymphocytes
- Production of antibodies/immunoglobulins
- Anti bodies bind to antigens (associated with a pathogen)

NK cells

- 5-10% of the circulating lymphocytes
- Destroy pathogens, infected/cancerous cells

Lymphopoiesis

- Occurs in bone marrow and thymus

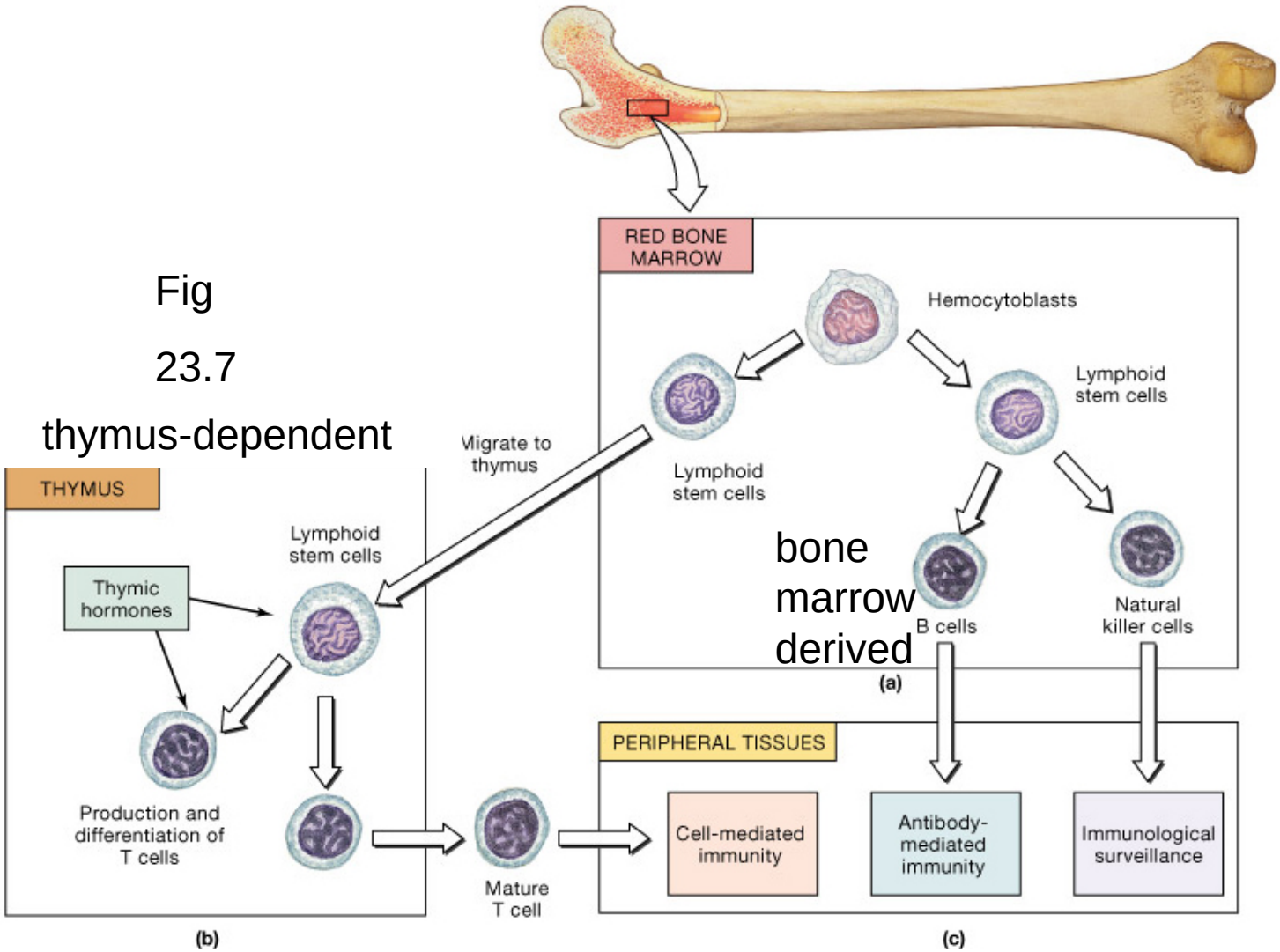


Fig 23.7

thymus-dependent

bone marrow derived

Lymph

- Lymph is the fluid that circulates thru the lymphatic system
- Lymph is similar to plasma of the blood
  - Differences are in the ionic and protein concentrations
- Fluid in the cardiovascular system-plasma
- Fluid in the lymphatic system is-lymph
- Fluid surrounding cells-interstitial fluid

Lymphatic capillaries

- Absorb:
  - Interstitial fluid & dissolved solutes
  - Viruses & bacteria
- Located in most organs the body
  - (not in the skeletal & central nervous system)
- Lacteal-lymphatic capillaries in the intestines that absorb lipids

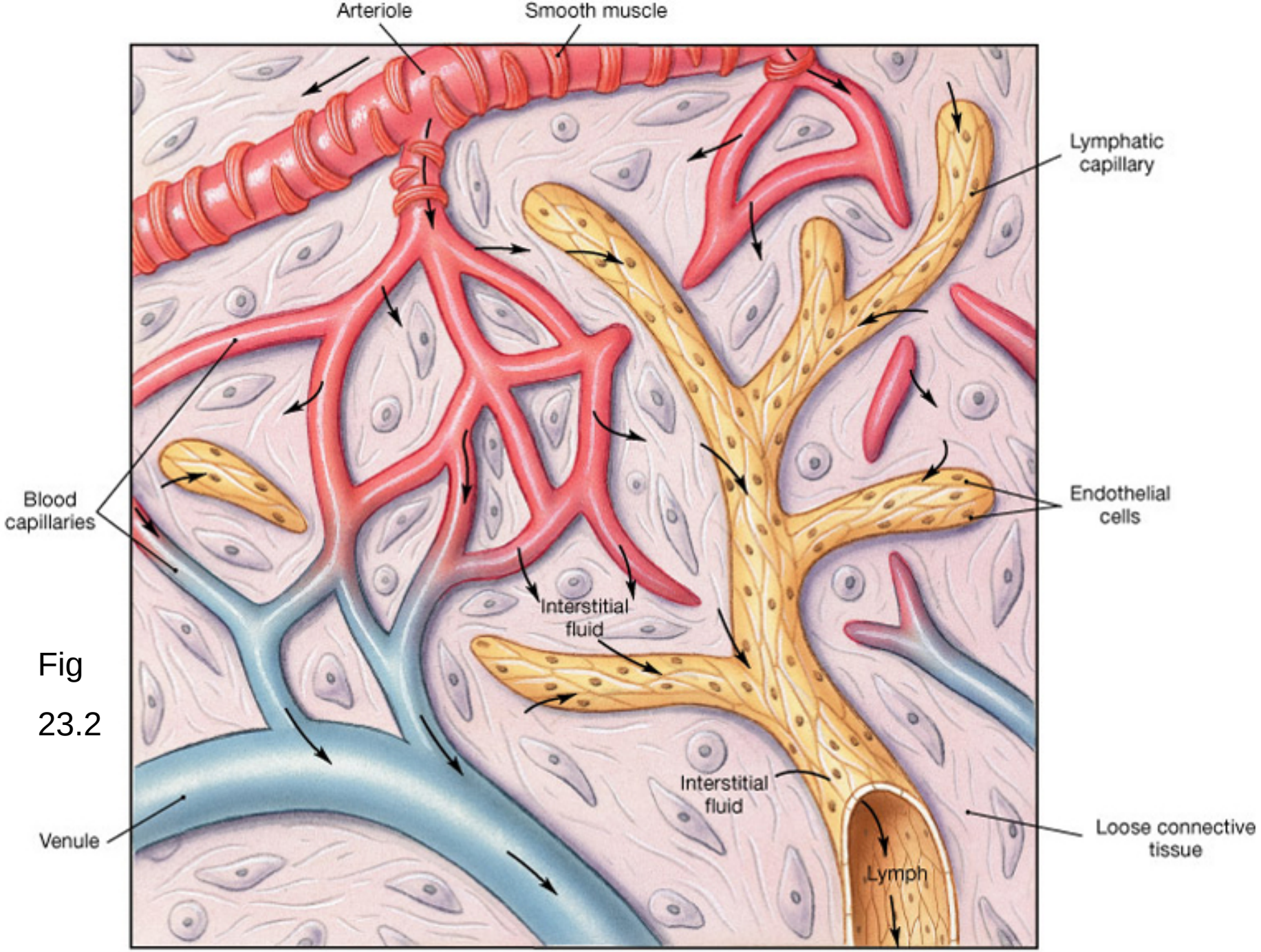


Fig 23.2

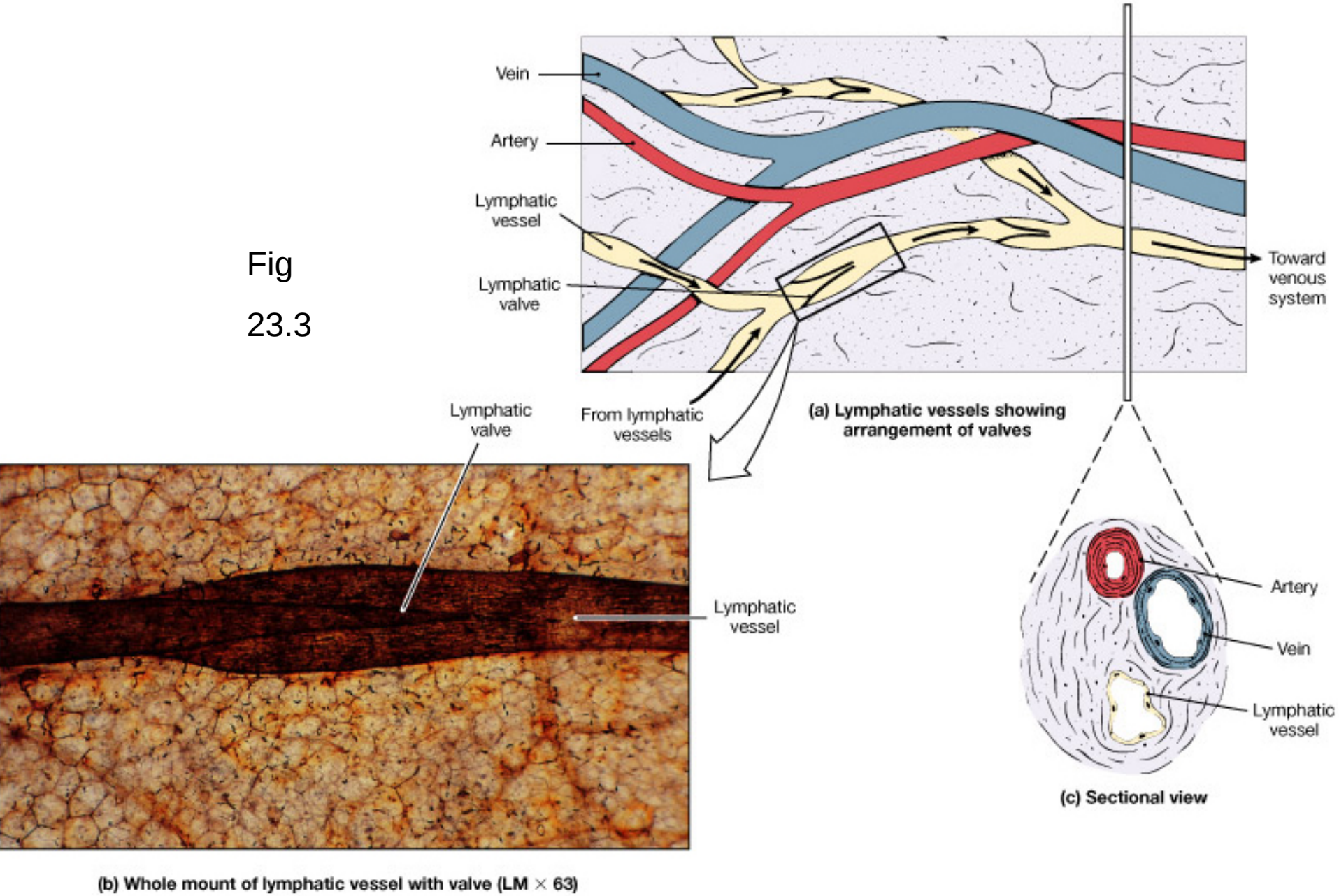
(a) Association of blood capillaries, tissue, and lymphatic capillaries

Lymphatic vessels

- They are similar to veins in the:
  - Layers of the walls (tunics)
  - Internal valves
  - Moving lymph to the heart
    - Skeletal muscle pump
    - Thoracoabdominal (respiratory) pump
    - Internal valves
    - Contraction of lymphatic vessels

Fig

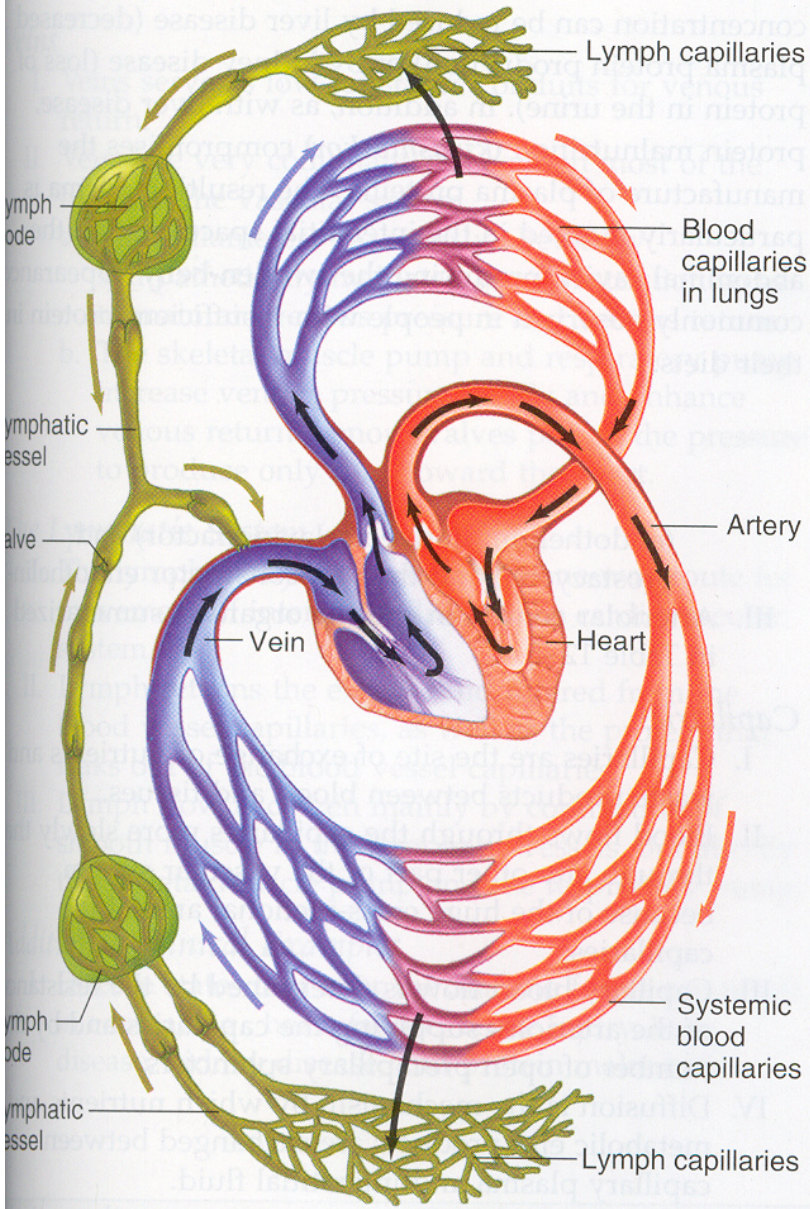
23.3


Vein
Artery
Lymphatic vessel
Lymphatic valve
Toward venous system
From lymphatic vessels
(a) Lymphatic vessels showing arrangement of valves
Lymphatic valve
Lymphatic vessel
Artery
Vein
Lymphatic vessel
(c) Sectional view
(b) Whole mount of lymphatic vessel with valve (LM × 63)

Major lymph-collecting vessels

- Thoracic (left lymphatic) duct-
- Collects lymph from areas inferior to the diaphragm & the left side superior to the diaphragm
- Right lymphatic duct-
- Collects lymph from areas on the right side superior to the diaphragm

- Thoracic duct & Right lymphatic duct empty lymph into the subclavian veins



IGURE 12–47

e lymphatic system (green) in relation to the cardiovascular
stem (blue and red). The lymphatic system is a one-way
stem from interstitial fluid to the cardiovascular system.

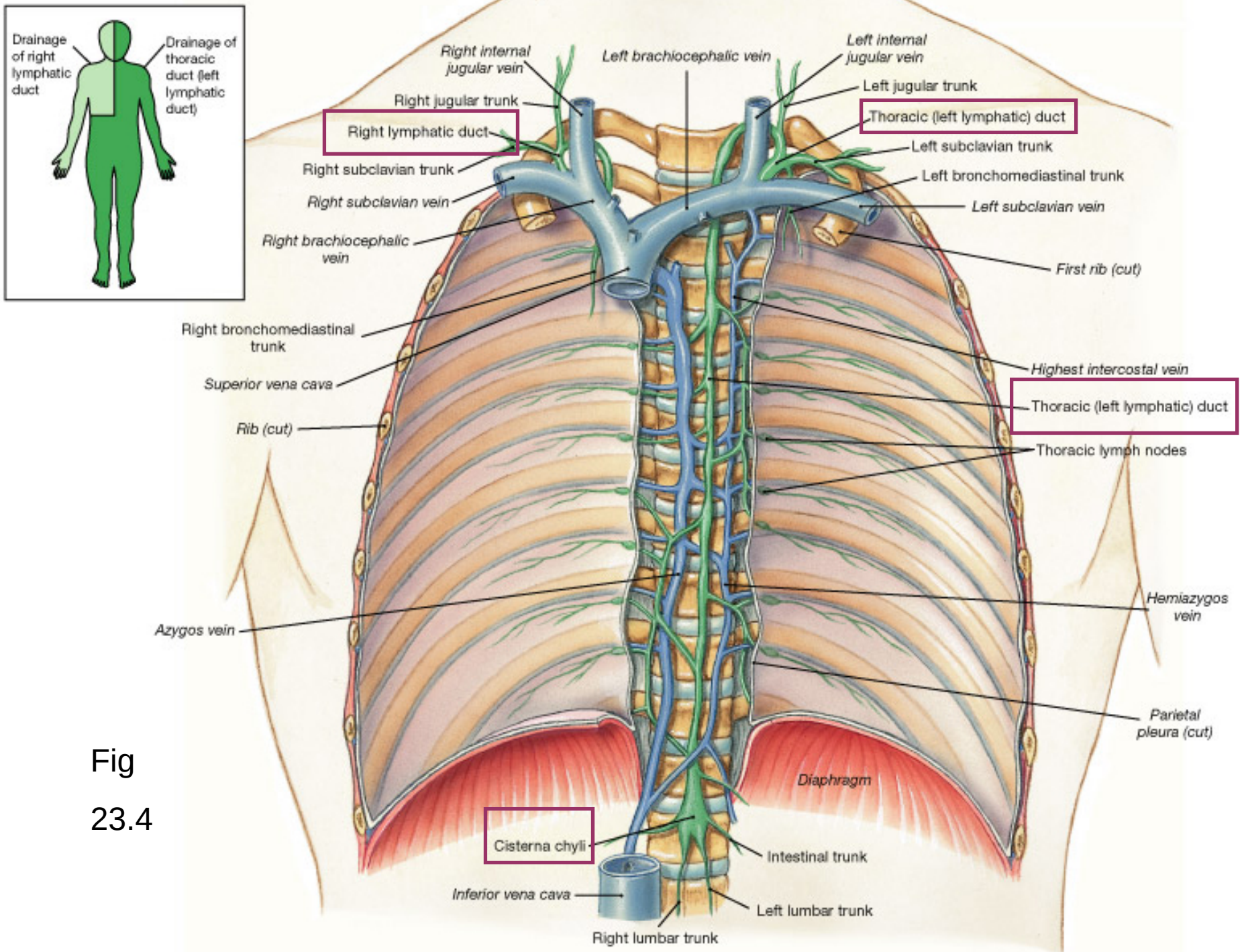

Drainage of right lymphatic duct
Drainage of thoracic duct (left lymphatic duct)
Right internal jugular vein
Left brachiocephalic vein
Left internal jugular vein
Right jugular trunk
Left jugular trunk
Right lymphatic duct
Thoracic (left lymphatic) duct
Right subclavian trunk
Left subclavian trunk
Left bronchomediastinal trunk
Right subclavian vein
Left subclavian vein
Right brachiocephalic vein
First rib (cut)
Right bronchomediastinal trunk
Highest intercostal vein
Superior vena cava
Thoracic (left lymphatic) duct
Rib (cut)
Thoracic lymph nodes
Azygos vein
Hemiazygos vein
Parietal pleura (cut)
Diaphragm
Cisterna chyli
Intestinal trunk
Inferior vena cava
Left lumbar trunk
Right lumbar trunk

Fig 23.4

- **Right upper half of the body** (right arm, right side of the torso, & right side of the head)
- Tissue (lymph from the interstitial fluid) – lymphatic capillaries-lymphatic vessels-lymph nodes-lymphatic vessels- (the lymph may enter a series of lymph nodes before continuing)—**right lymphatic duct-right subclavian vein-----heart**

- **Everywhere except the right upper half of the body**
- Tissue (lymph from the interstitial fluid) – lymphatic capillaries-lymphatic vessels-lymph nodes-lymphatic vessels- (the lymph may enter a series of lymph nodes before continuing)—**cisterna chili (lower limbs)- thoracic duct (left lymphatic duct) lt. subclavian vein-----heart**

- CV capillaries
  - Net filtration – net absorption = net out flow
- About 2 L/day collected by lymph vessels

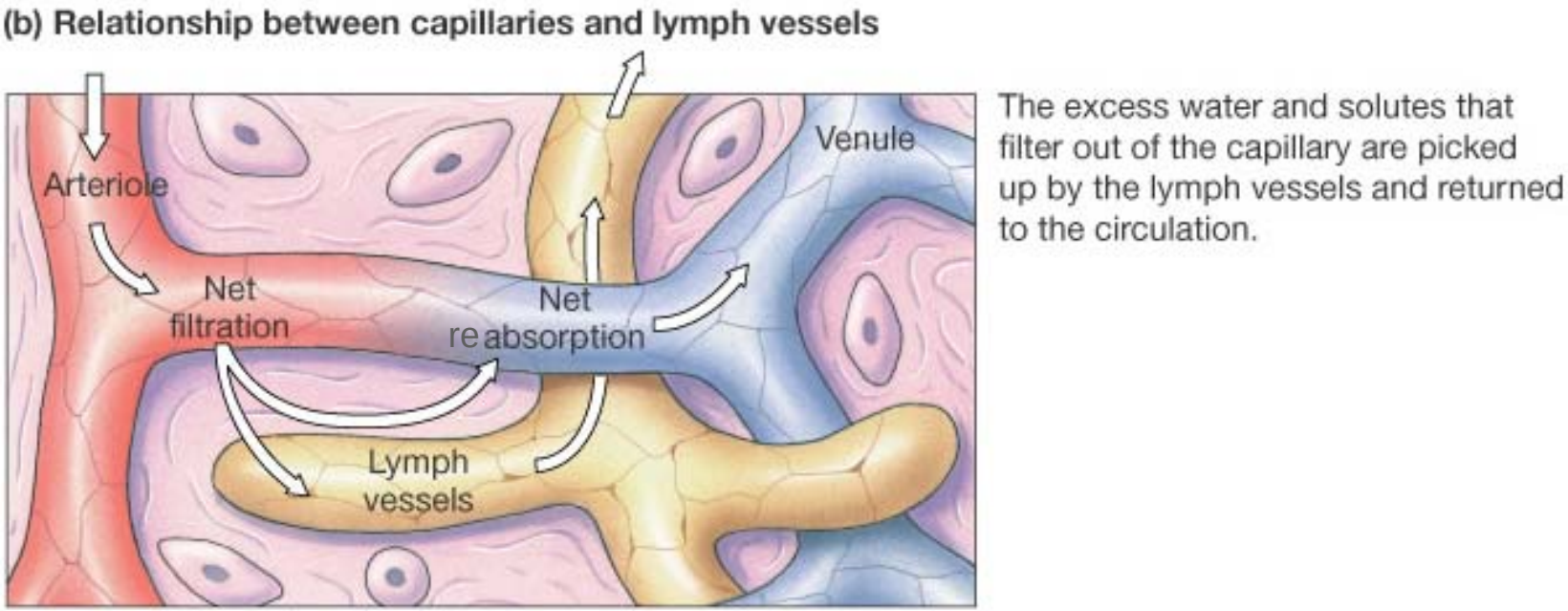
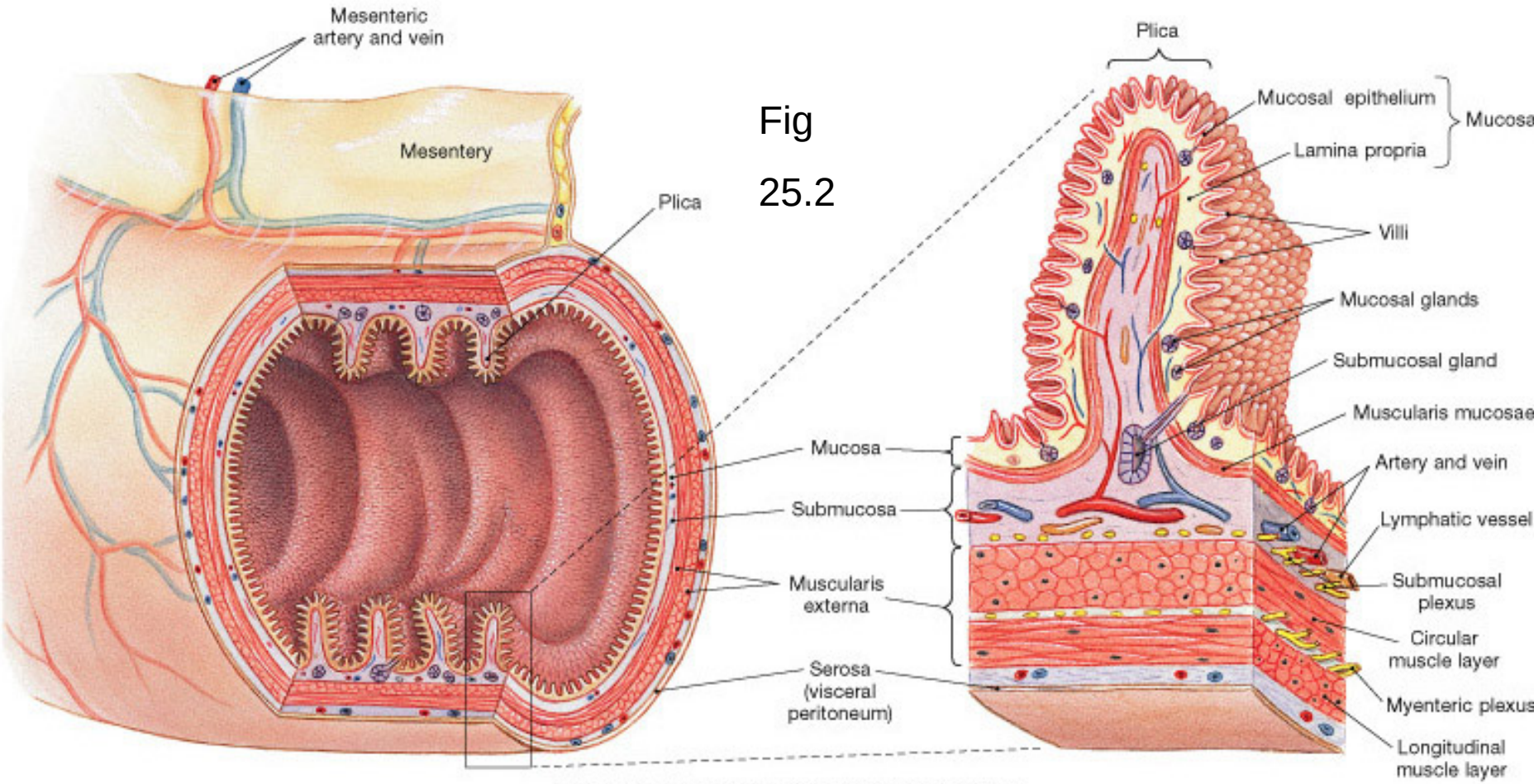


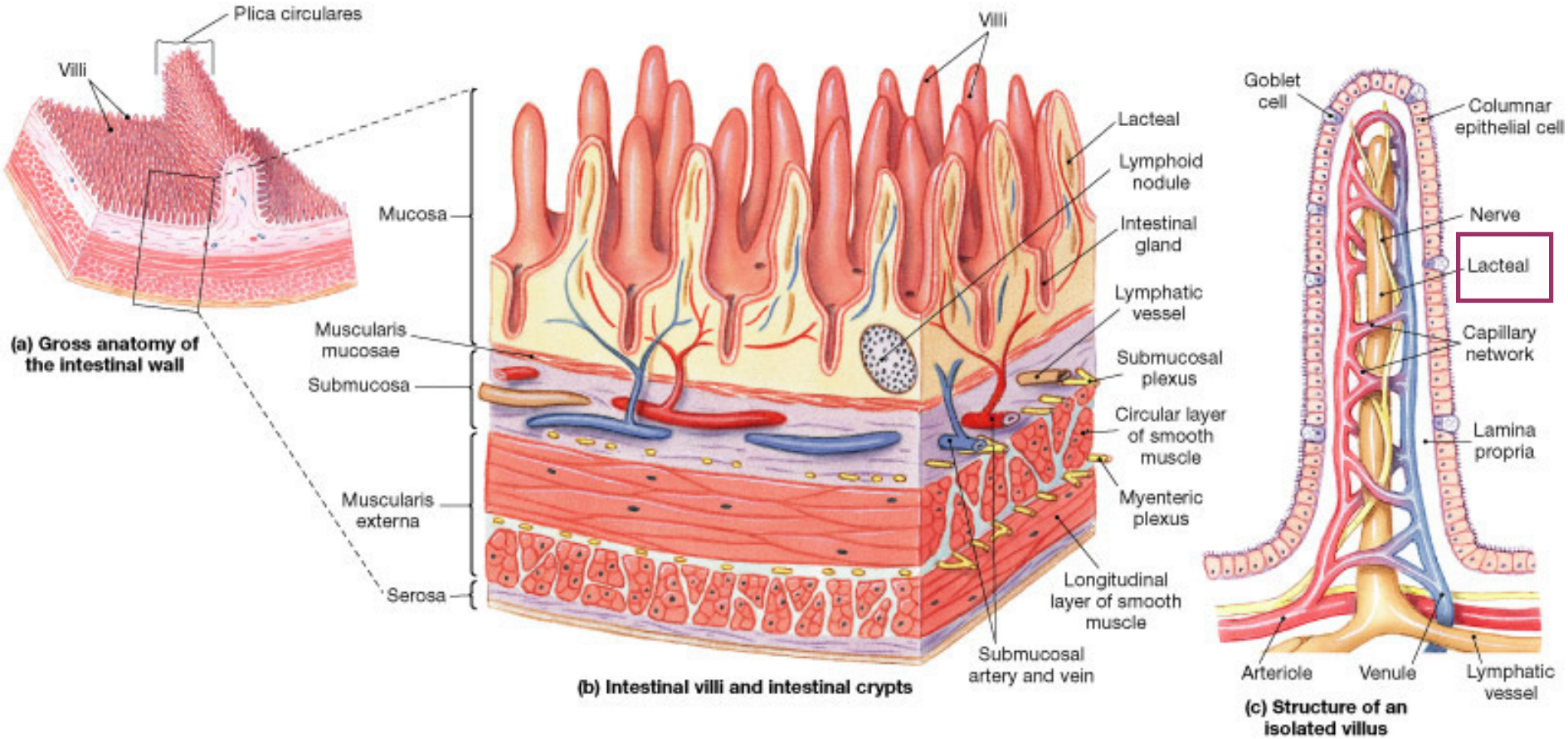
Fig 25.2

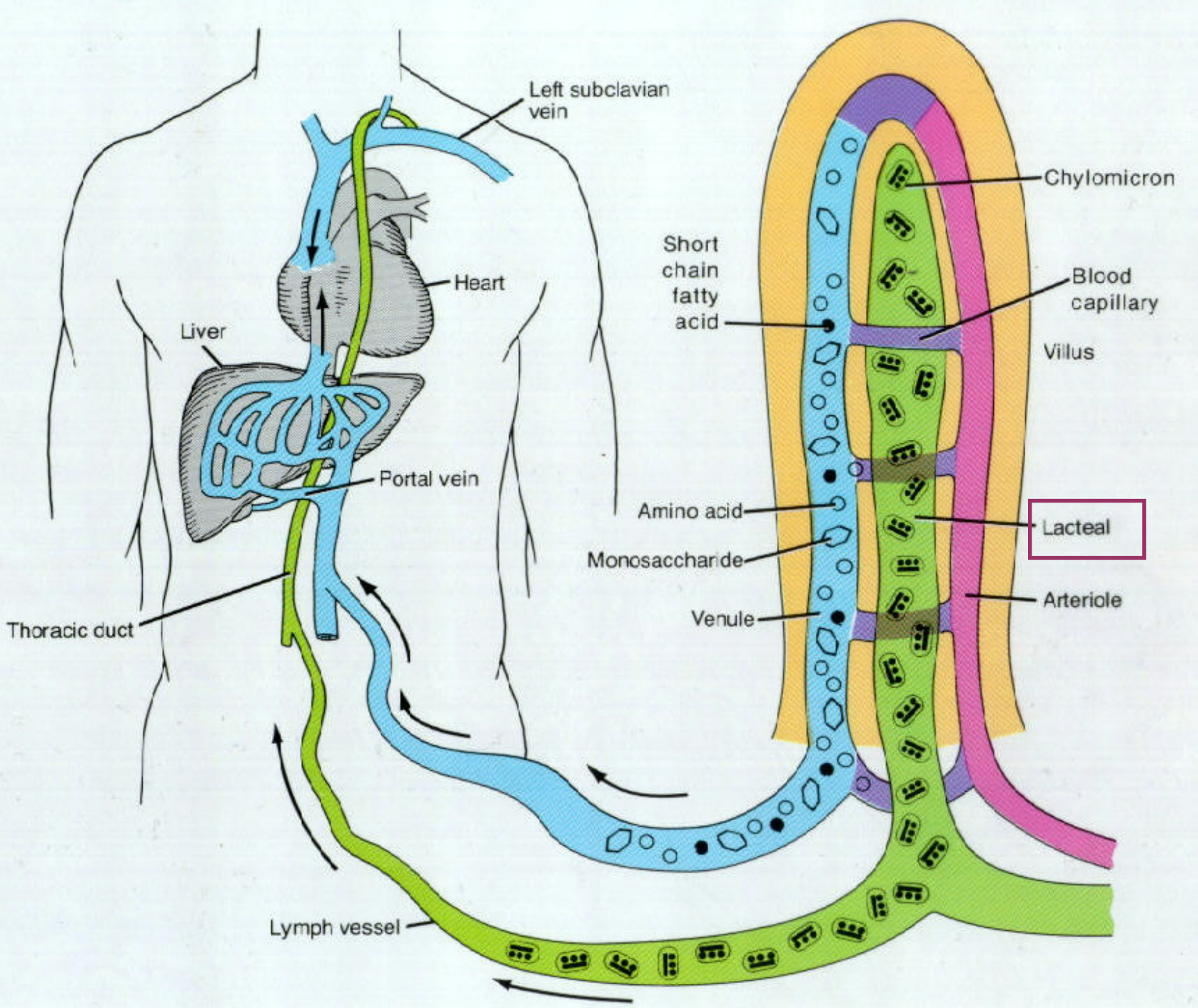


(a) Histological organization of the digestive tract

Fig

25.15


Plica circulares
Villi
(a) Gross anatomy of the intestinal wall
Mucosa
Muscularis mucosae
Submucosa
Muscularis externa
Serosa
Villi
Lacteal
Lymphoid nodule
Intestinal gland
Lymphatic vessel
Submucosal plexus
Circular layer of smooth muscle
Myenteric plexus
Longitudinal layer of smooth muscle
Submucosal artery and vein
(b) Intestinal villi and intestinal crypts
Goblet cell
Columnar epithelial cell
Nerve
Lacteal
Capillary network
Lamina propria
Arteriole
Venule
Lymphatic vessel
(c) Structure of an isolated villus


Left subclavian vein
Heart
Liver
Portal vein
Thoracic duct
Lymph vessel
Chylomicron
Short chain fatty acid
Blood capillary
Villus
Amino acid
Monosaccharide
Lacteal
Venule
Arteriole
(b)

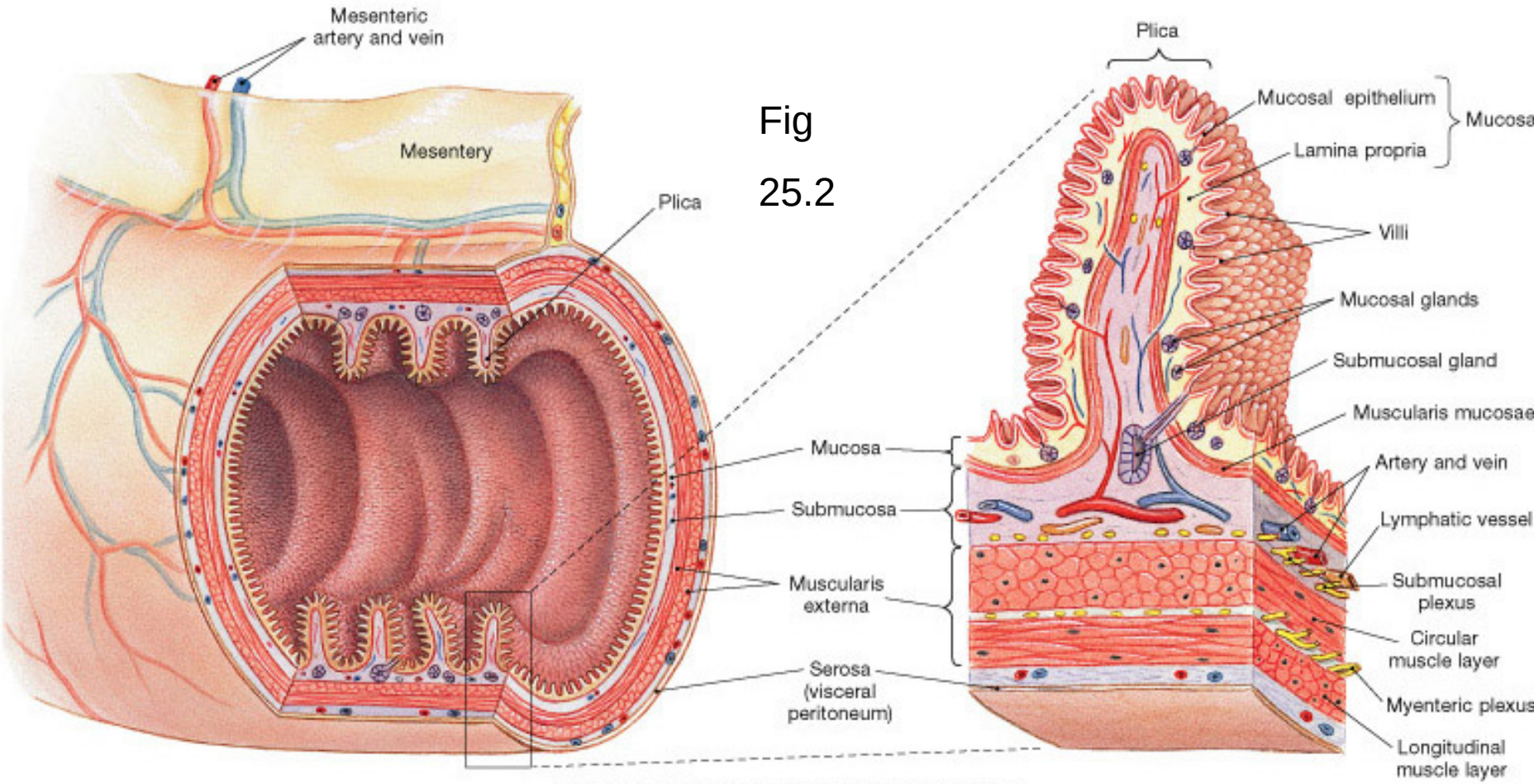
edema

Blockage of lymphatic capillaries

Lymphatic nodules

- Clusters of many lymphocytes within connective tissue
- Lymphatic nodules in the mouth are tonsils
- Five tonsils
- Lymphatic nodules in the intestinal wall are Peyer’s patches

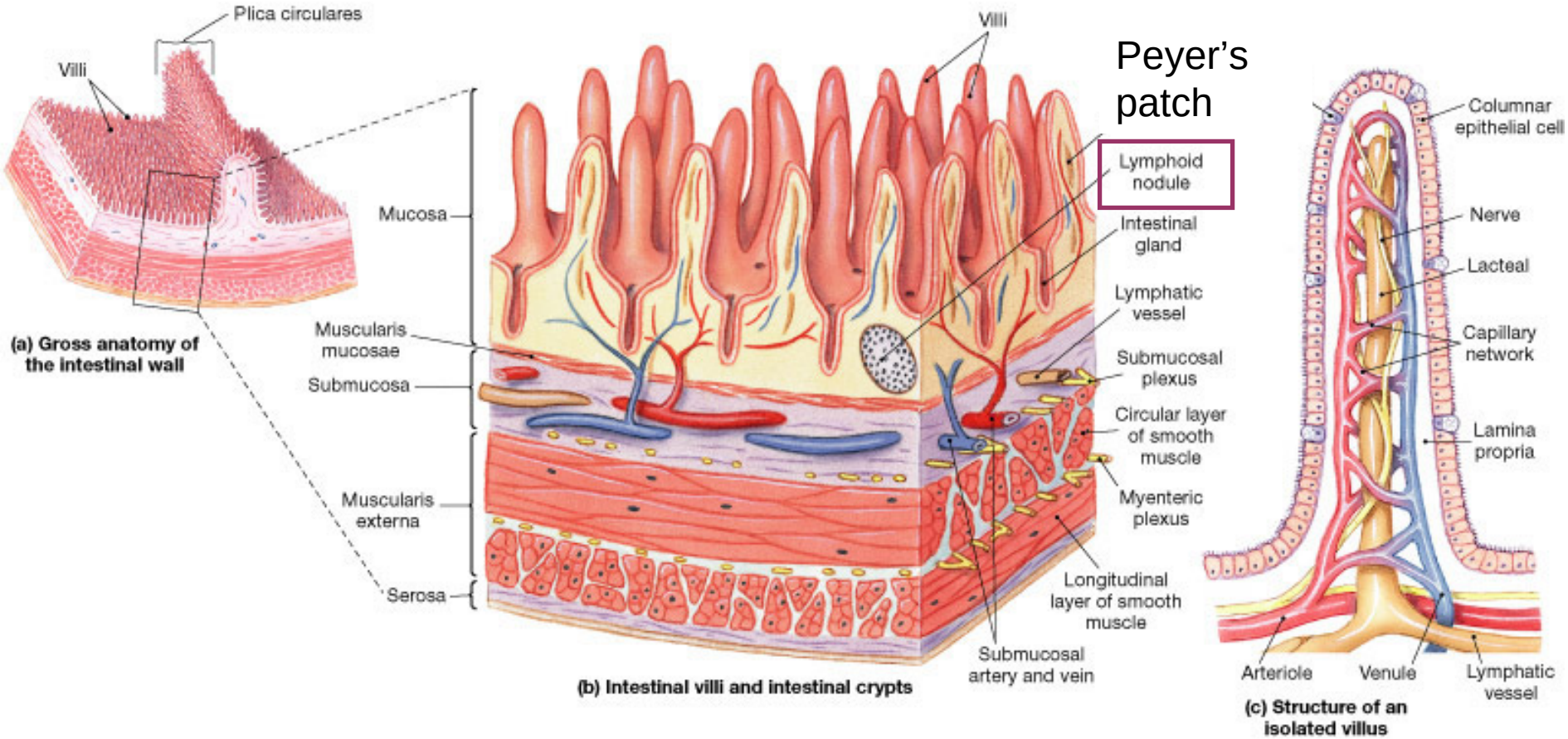
Fig 25.2



(a) Histological organization of the digestive tract

Fig

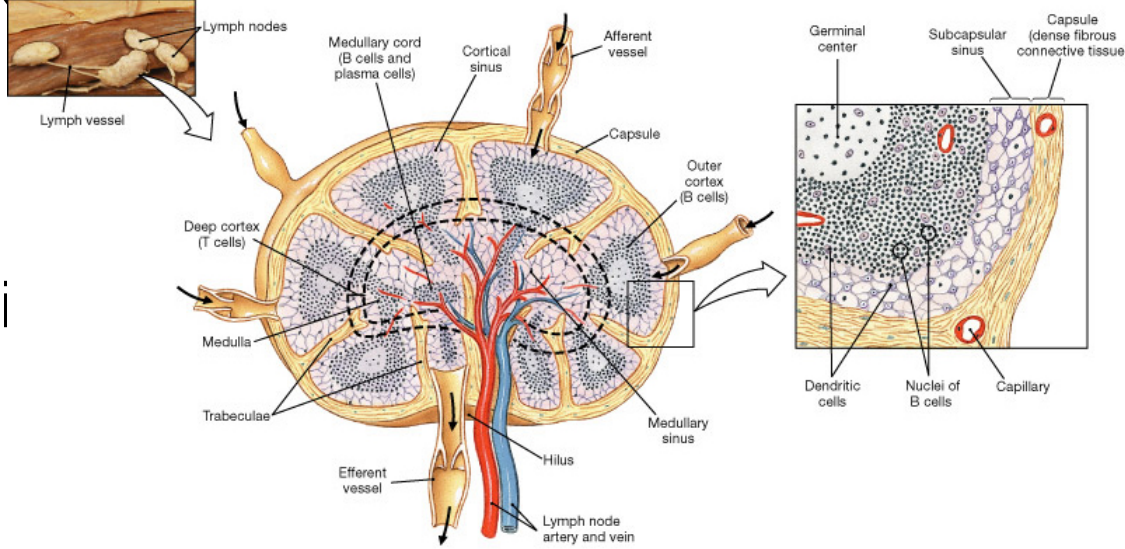
25.15


Plica circulares
Villi
(a) Gross anatomy of the intestinal wall
Mucosa
Muscularis mucosae
Submucosa
Muscularis externa
Serosa
Villi
Peyer's patch
Lymphoid nodule
Intestinal gland
Lymphatic vessel
Submucosal plexus
Circular layer of smooth muscle
Myenteric plexus
Longitudinal layer of smooth muscle
Submucosal artery and vein
(b) Intestinal villi and intestinal crypts
Columnar epithelial cell
Nerve
Lacteal
Capillary network
Lamina propria
Arteriole
Venule
Lymphatic vessel
(c) Structure of an isolated villus

Lymph nodes

- Distributed throughout the body
- Located along lymphatic vessels
- Contain a dense pack of lymphocytes and macrophages
- Makes the lymphatic vessels look like a stri of beads

Fig 23.9



Thymus

- Site of T cell maturation
- The blood thymus barrier prevents premature stimulations of developing T cells
- Most active in infancy
- With age undergoes involution (shrinkage)

Largest relative to body size at infancy

Absolute largest at puberty

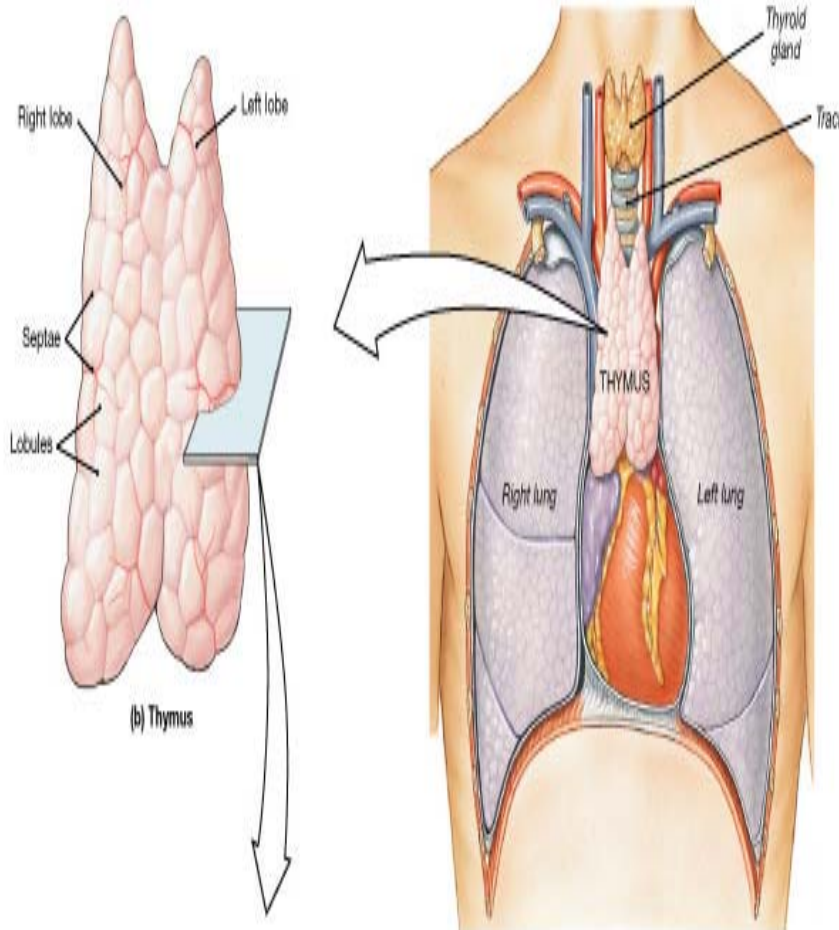


Fig 23.16

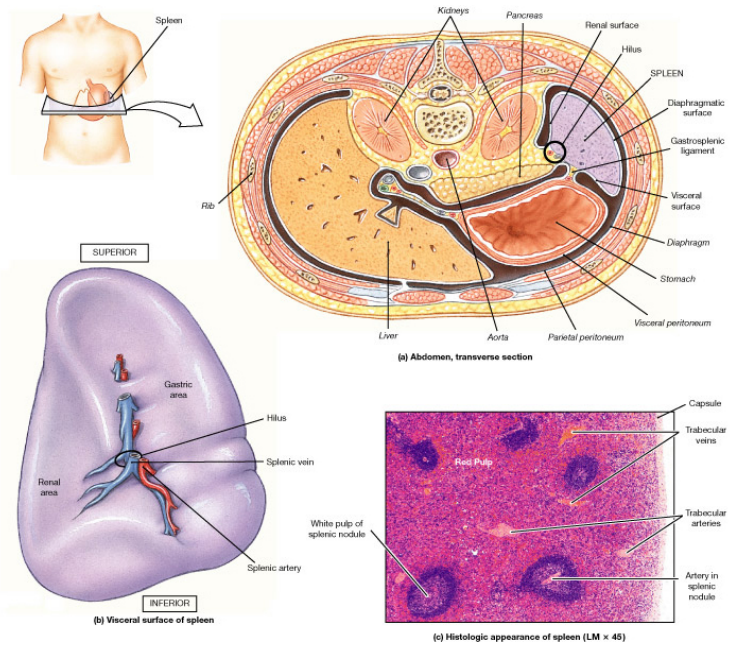
Spleen

- Between 9th-11th ribs on left side
- Destroys ‘abnormal’ blood cells
- Starts immune response of T & B cells to pathogens in the blood

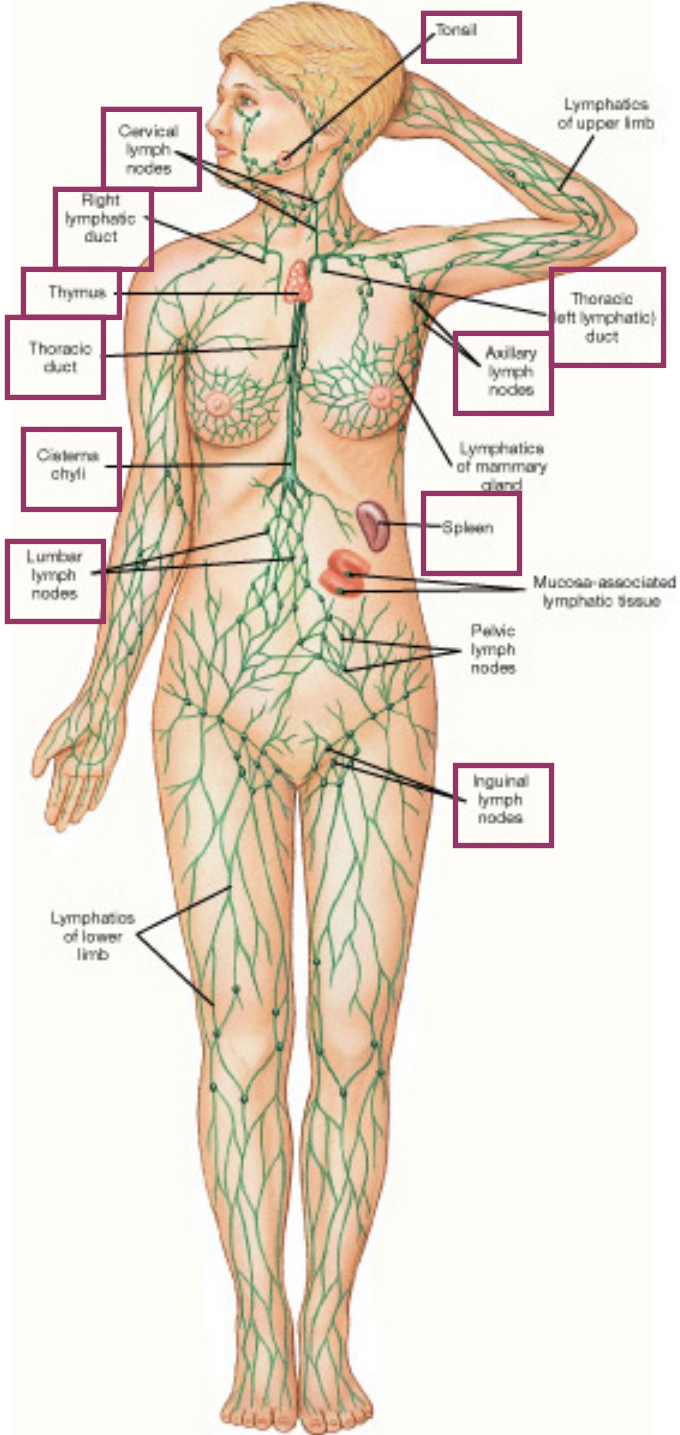
Regions of the spleen

-White pulp-lymphatic nodules

-Red pulp-contains all component of circulating blood



Lab 14


Tonsil
Lymphatics of upper limb
Cervical lymph nodes
Right lymphatic duct
Thymus
Thoracic duct
Thoracic (left lymphatic) duct
Axillary lymph nodes
Cisterna chyli
Lymphatics of mammary gland
Spleen
Lumbar lymph nodes
Mucosa-associated lymphatic tissue
Pelvic lymph nodes
Inguinal lymph nodes
Lymphatics of lower limb

Fig

23.1

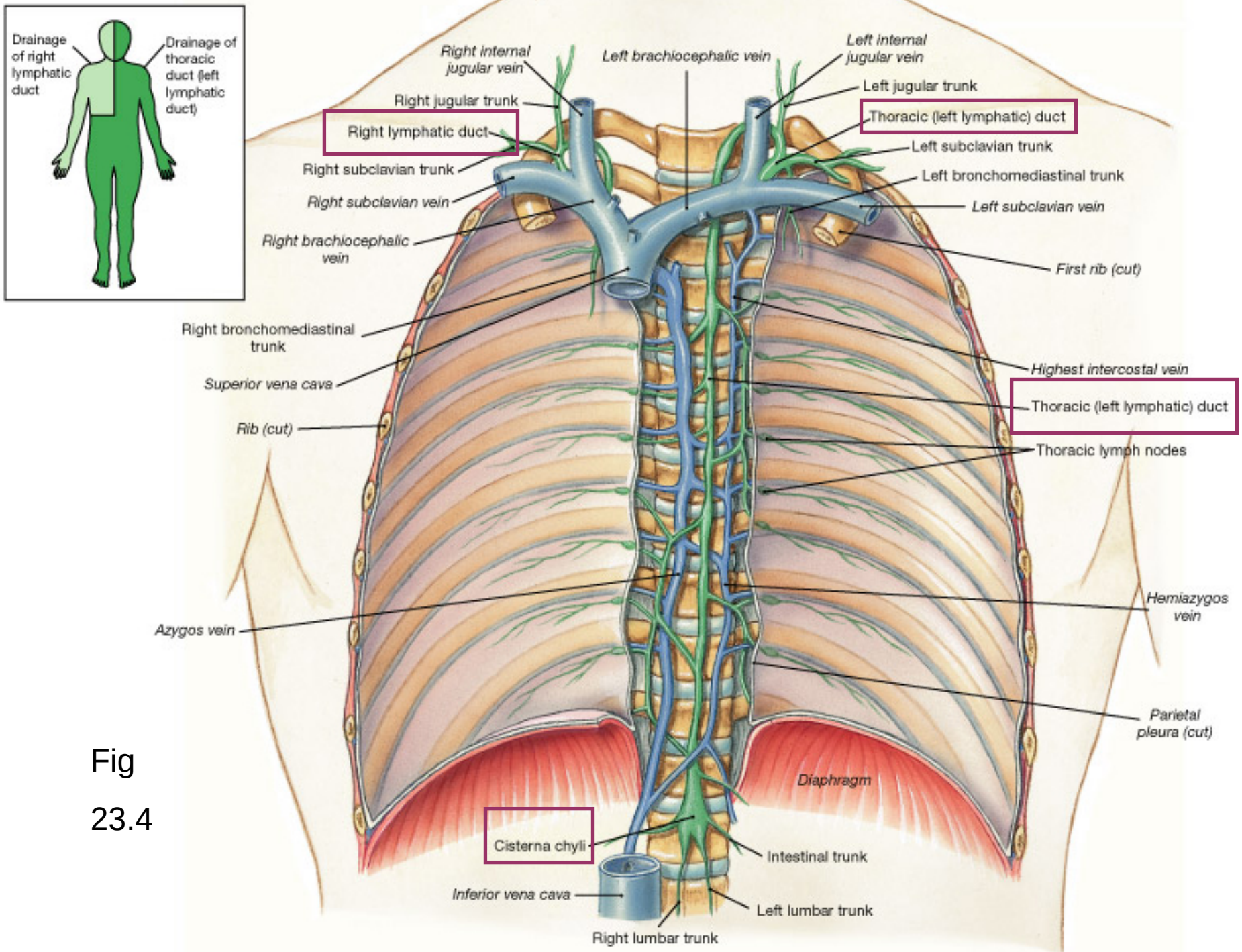
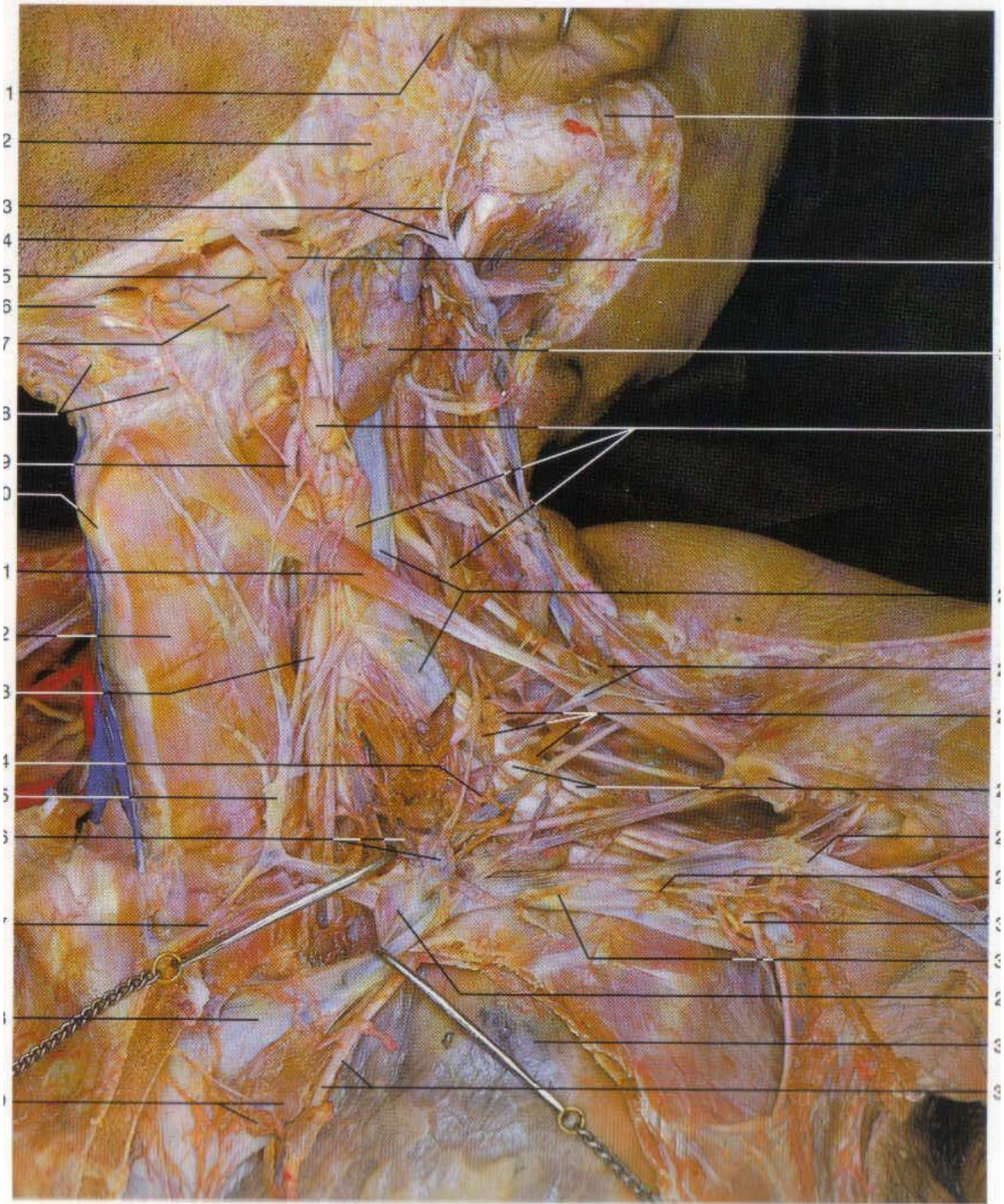

Drainage of right lymphatic duct
Drainage of thoracic duct (left lymphatic duct)
Right internal jugular vein
Left brachiocephalic vein
Left internal jugular vein
Right jugular trunk
Left jugular trunk
Right lymphatic duct
Thoracic (left lymphatic) duct
Right subclavian trunk
Left subclavian trunk
Left bronchomediastinal trunk
Right subclavian vein
Left subclavian vein
Right brachiocephalic vein
First rib (cut)
Right bronchomediastinal trunk
Highest intercostal vein
Superior vena cava
Thoracic (left lymphatic) duct
Rib (cut)
Thoracic lymph nodes
Azygos vein
Hemiazygos vein
Parietal pleura (cut)
Diaphragm
Cisterna chyli
Intestinal trunk
Inferior vena cava
Left lumbar trunk
Right lumbar trunk

Fig 23.4



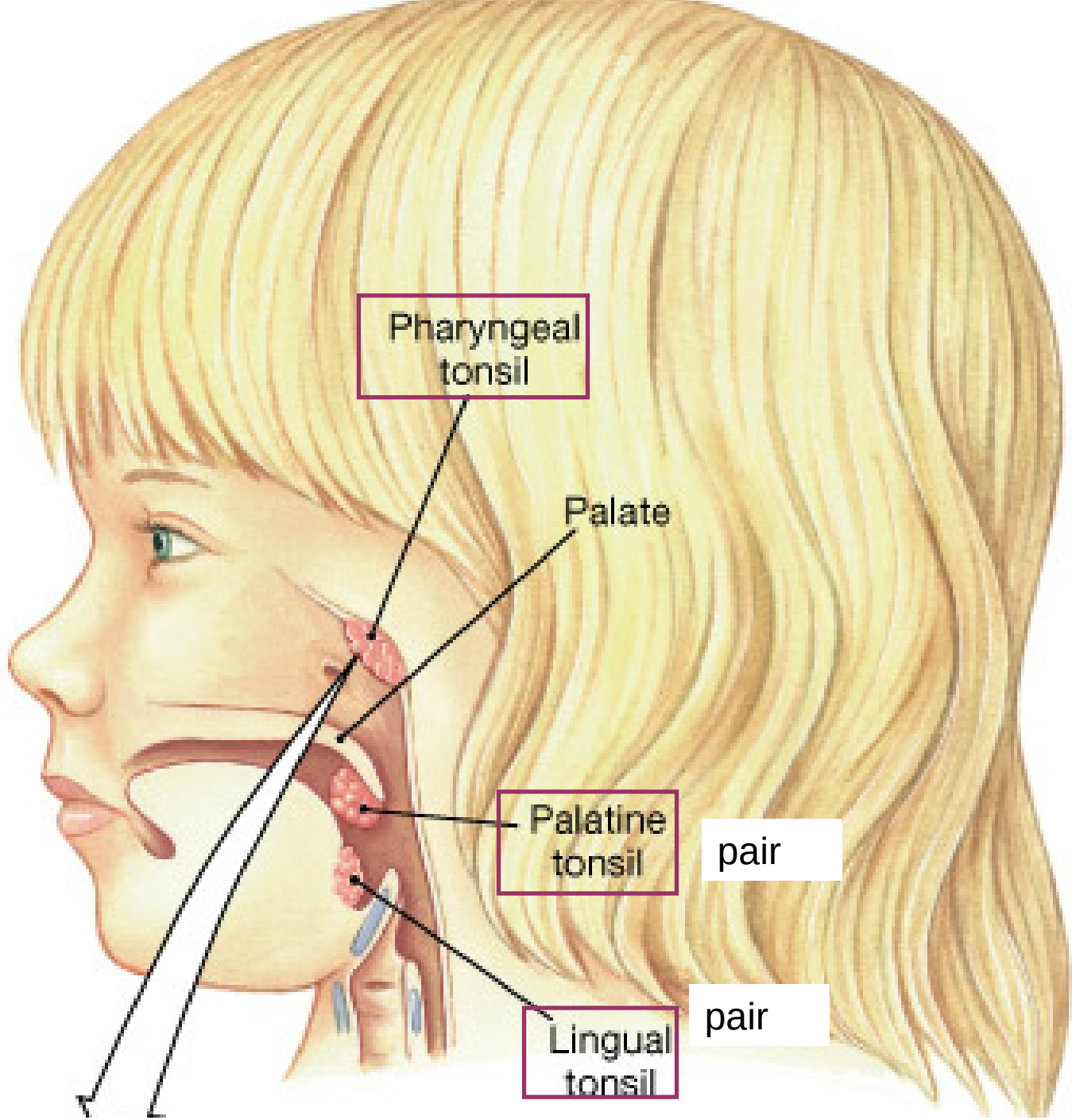
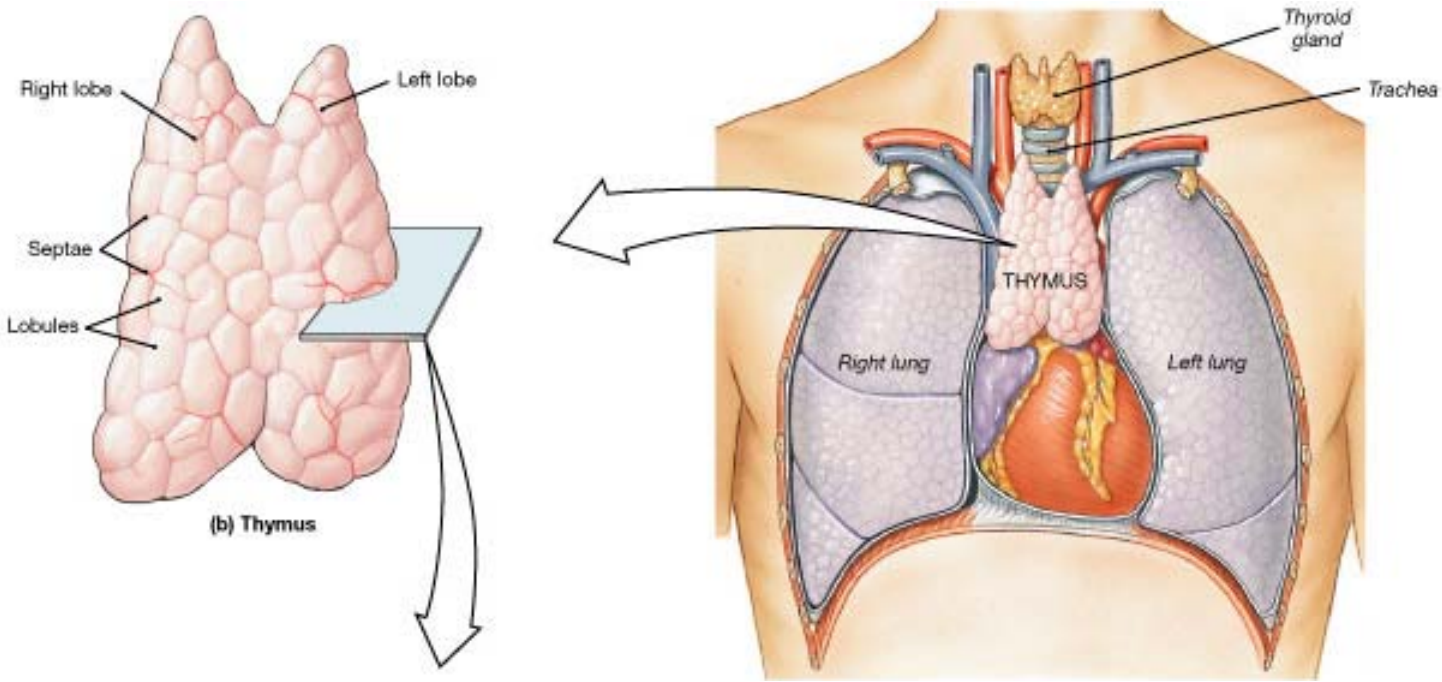

Pharyngeal tonsil
Palate
Palatine tonsil
pair
Lingual tonsil
pair

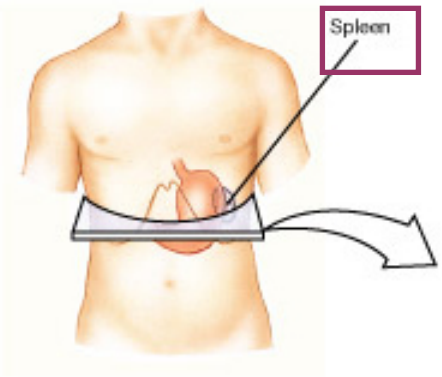
Fig 23.8

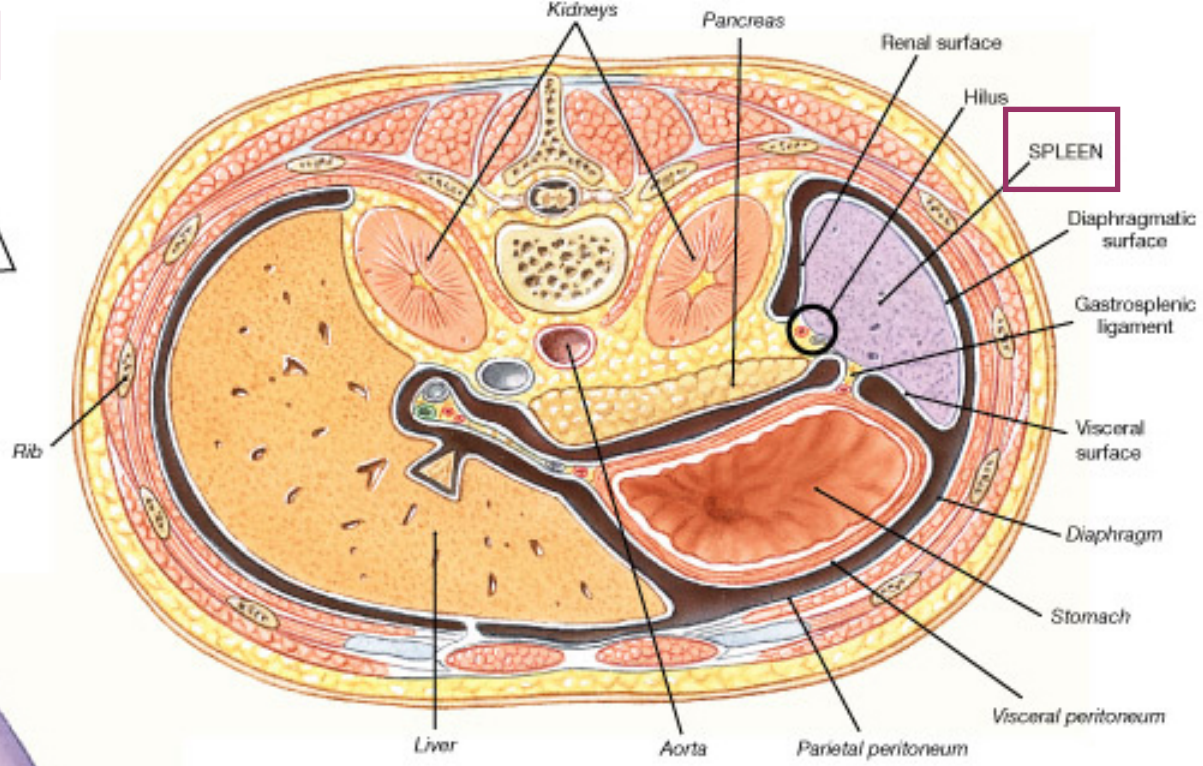

Right lobe
Left lobe
Septae
Lobules
(b) Thymus
Thyroid gland
Trachea
THYMUS
Right lung
Left lung

Fig

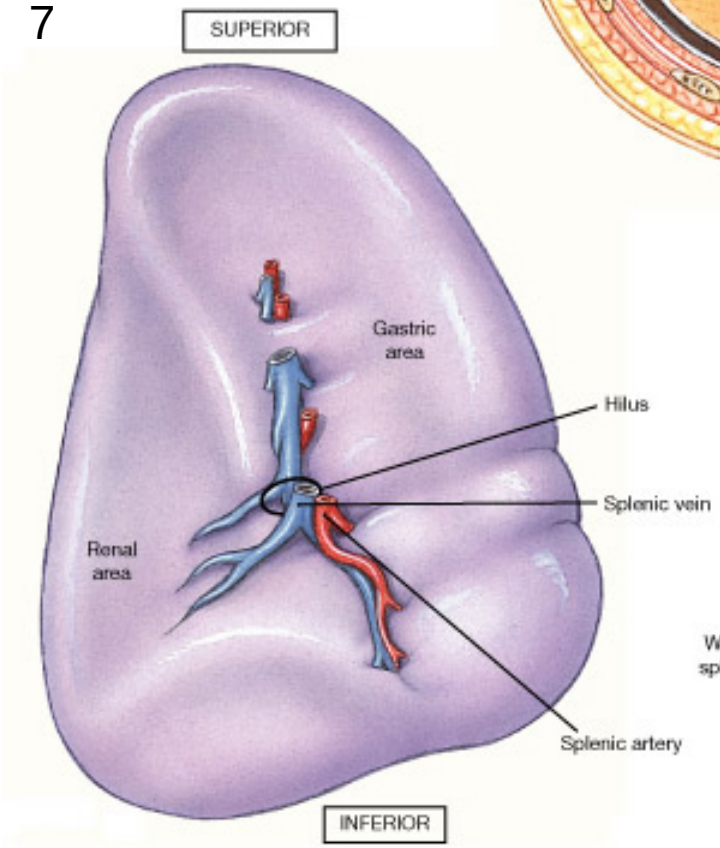
23.16

Fig 23.17

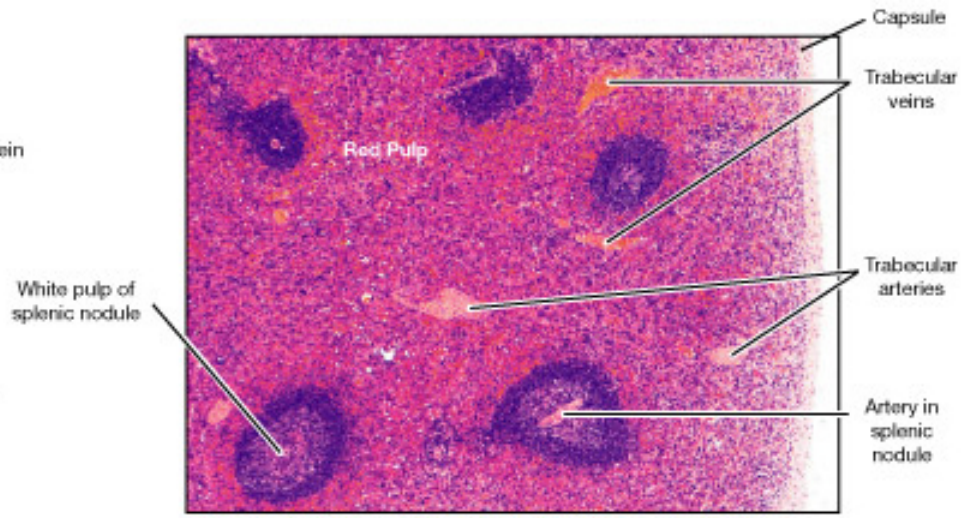




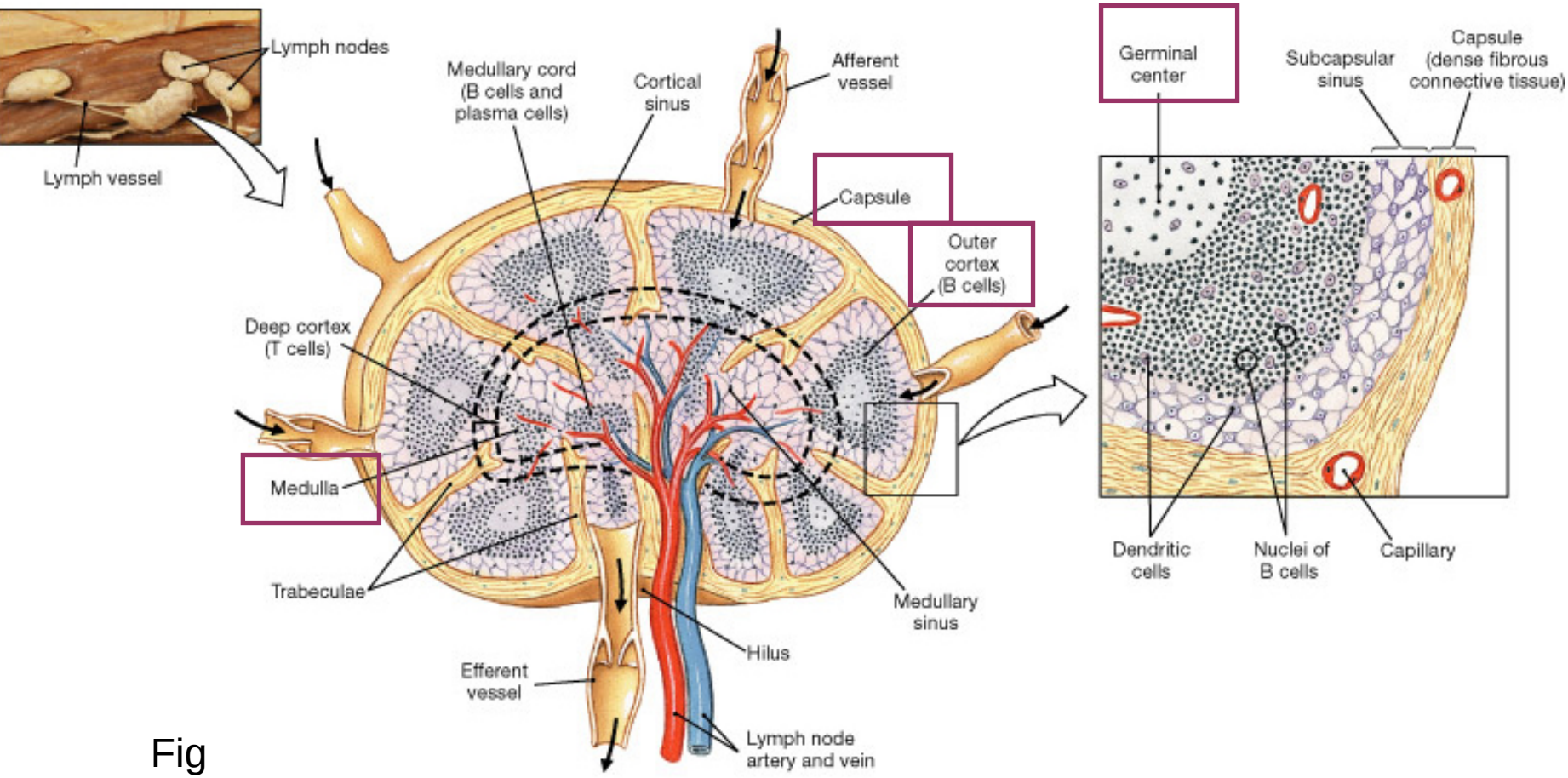
(a) Abdomen, transverse section



(b) Visceral surface of spleen



(c) Histologic appearance of spleen (LM × 45)


Lymph nodes
Lymph vessel
Medullary cord
(B cells and
plasma cells)
Cortical
sinus
Afferent
vessel
Capsule
Outer
cortex
(B cells)
Deep cortex
(T cells)
Medulla
Trabeculae
Medullary
sinus
Hilus
Efferent
vessel
Lymph node
artery and vein
Germinal
center
Subcapsular
sinus
Capsule
(dense fibrous
connective tissue)
Dendritic
cells
Nuclei of
B cells
Capillary

Fig

23.9