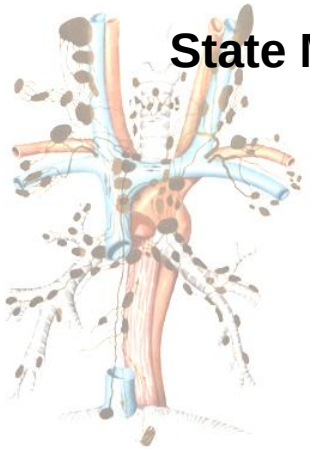
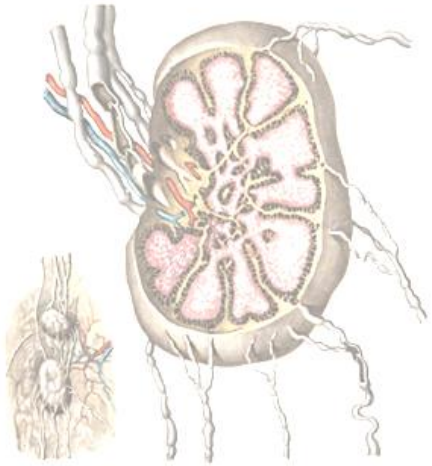
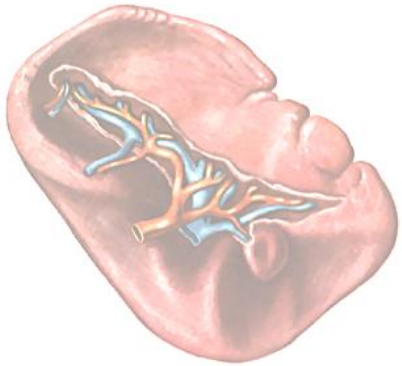
State Medical and Pharmaceutical University “Nicolae Testemiţanu”



Functional Anatomy of the lymphatic and immune systems

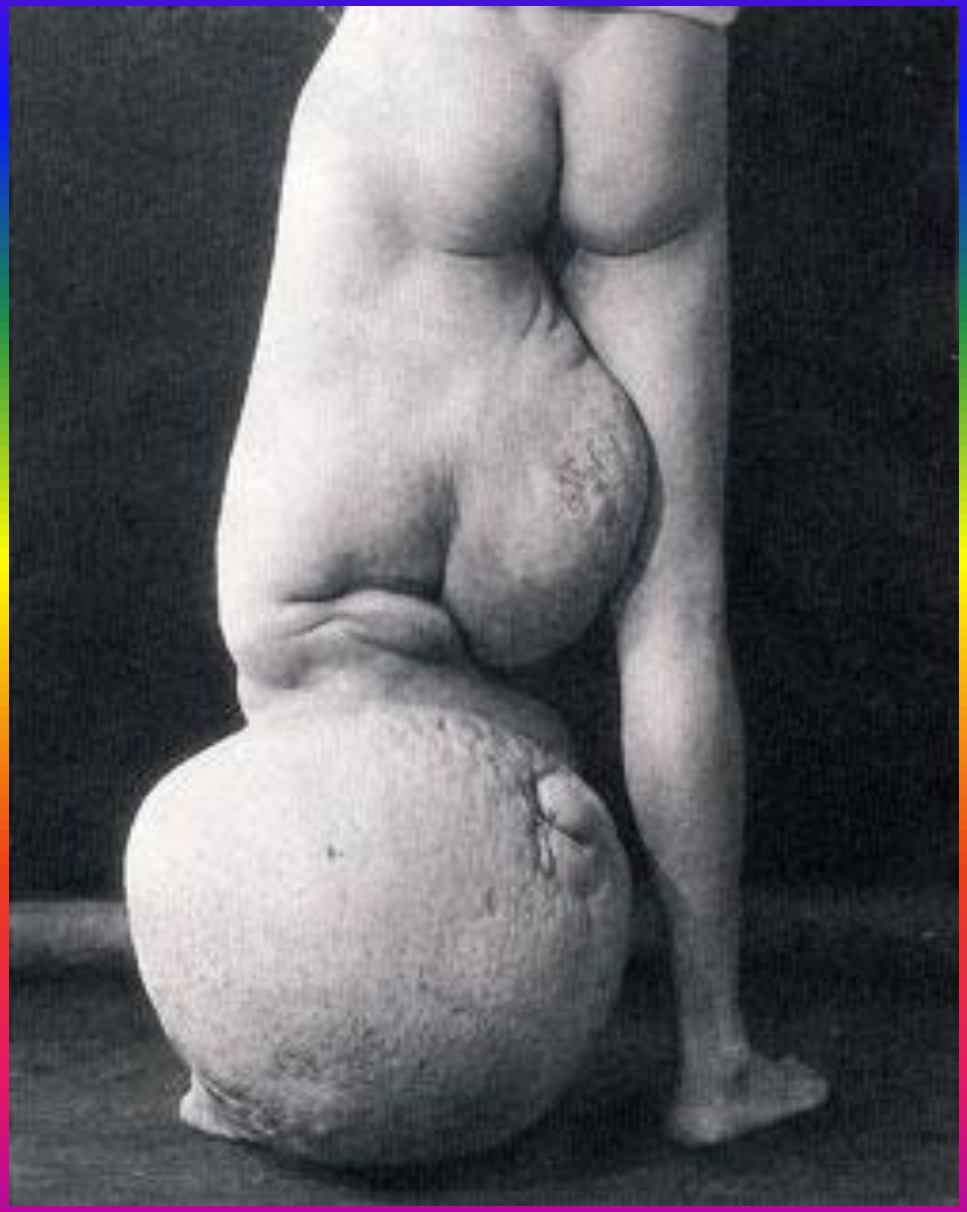




Department of Human Anatomy

Lilian Globa

What does mean this picture?



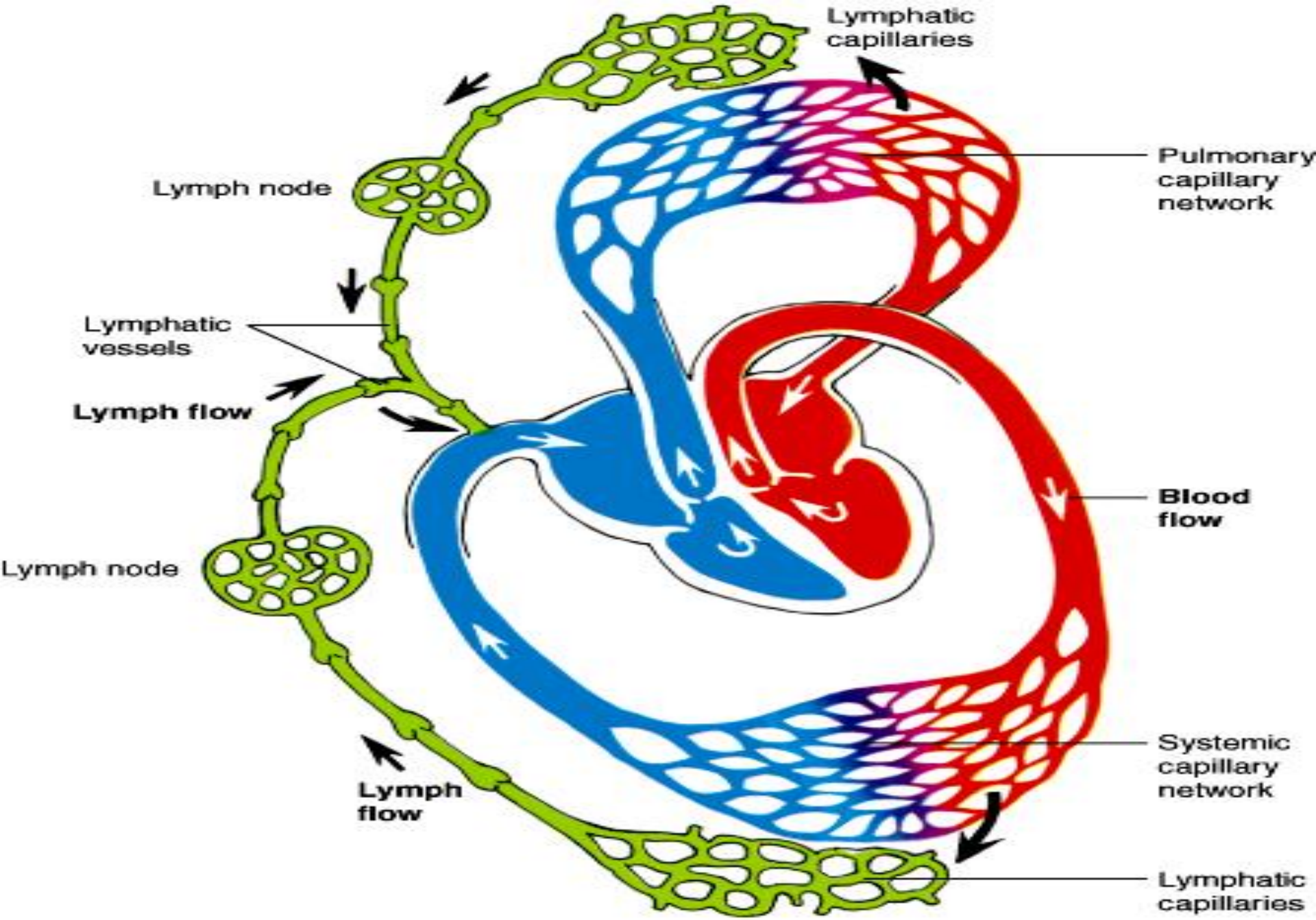
METASTASIS

AIDS

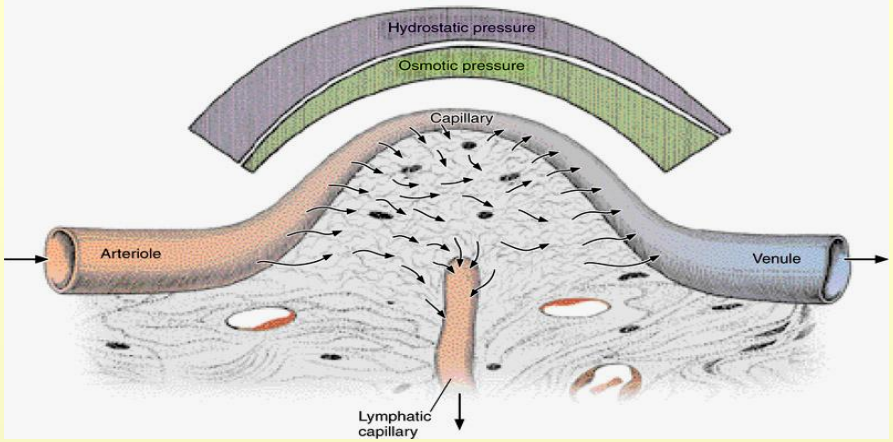
Plan:

1. The Lymphatic System
   - General Structure
   - Morpho-functional Unit of the lymphatic vessels
   - The general characteristic of the lymphatic vessels
   - The general characteristic of the lymphatic nodes
   - The localization and distribution of lymphatic vessels and nodes in the organism
   - The factors that facilitate the lymph circulation
2. The Lymphoid System
   - General data
   - The Classification of the lymphoid organs
3. The development of the Lymphatic System
4. The clinic importance of the lymphoid and lymphatic Systems

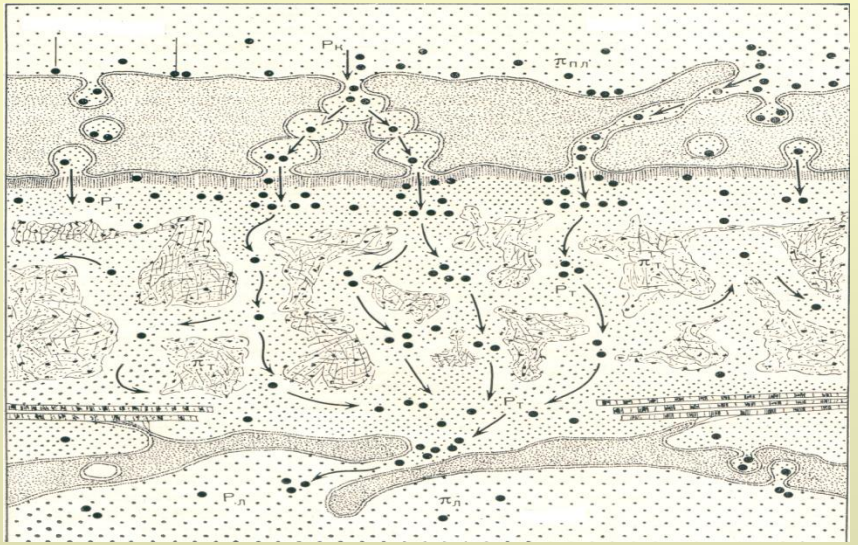
- All metabolic processes in human body follows in fluid medium.
- There are next fluid mediums:
  - Cellular fluid (gel-sol)
  - Interstitial fluid :
    - Gel like fluid
    - Fluid of primary spices (free) – fluid of serous cavities, CSF, endo- & perilimph of the internal ear, fluid of corps vitreous from eye ball, synovial fuid.
  - Blood
  - Lymph
- Circulatory System compose by:
  - Blood circulatory System (heart – central organ, blood vessels)
  - Lymphatic System


Lymphatic capillaries
Pulmonary capillary network
Lymph node
Lymphatic vessels
Lymph flow
Blood flow
Lymph node
Systemic capillary network
Lymph flow
Lymphatic capillaries

Lymphatic System



- Functions:
  - Check and drainage the volume of interstitial fluid – producing lymph
  - Absorb and transport:
    - Lipids and fatsoluble vitamins
    - Proteins
    - Colloids, crystalloids
    - Cells or cellular fragments
  - Barrier
  - Lymphatic nodes also are organs of immune system
  - Is a second path for transport in realizing the function of immune system
  - Deposit for fluid

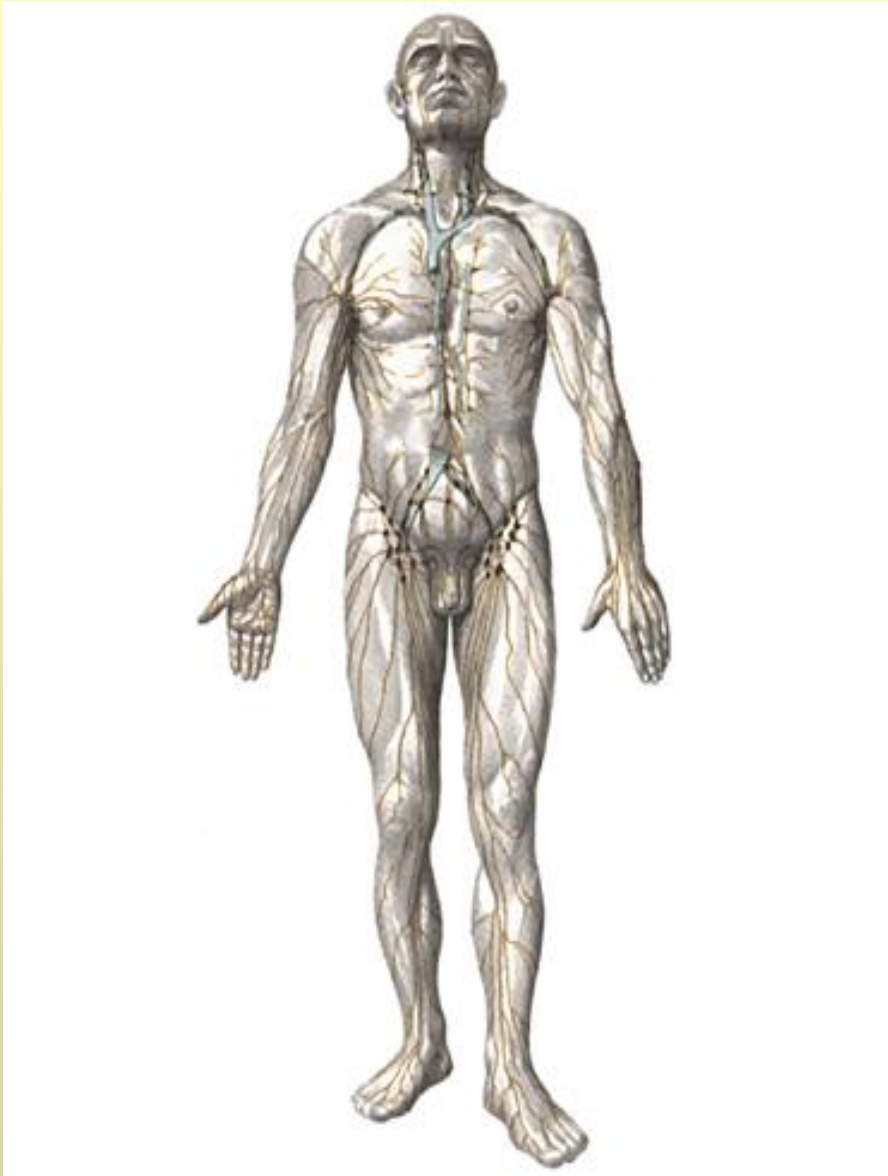


Lymph

- Fluid without color or light pal color
- pH 7,5-7,9
- It is formed by absorption of the interstitial fluid at the level of lymphatic capillaries
- Is composed by water, salts, fats, proteins, hormones, ferments, colloids, crystalloids
- There are lymphocytes and polymorpho-nuclear cells
- There are absents Erythrocytes and thrombocytes
- Lymph will path in its way at least through one lymph node
- Daily is produced around of 2-4 liters of lymph

Lymphatic System

- Is composed by:
  - Lymphatic Vessels :
    - Lymphatic Capillaries
    - Lymphatic Postcapillaries
    - Lymphatic Vessels
    - Lymphatic Trunks
    - Lymphatic Ducts
  - Lymphatic Nodes

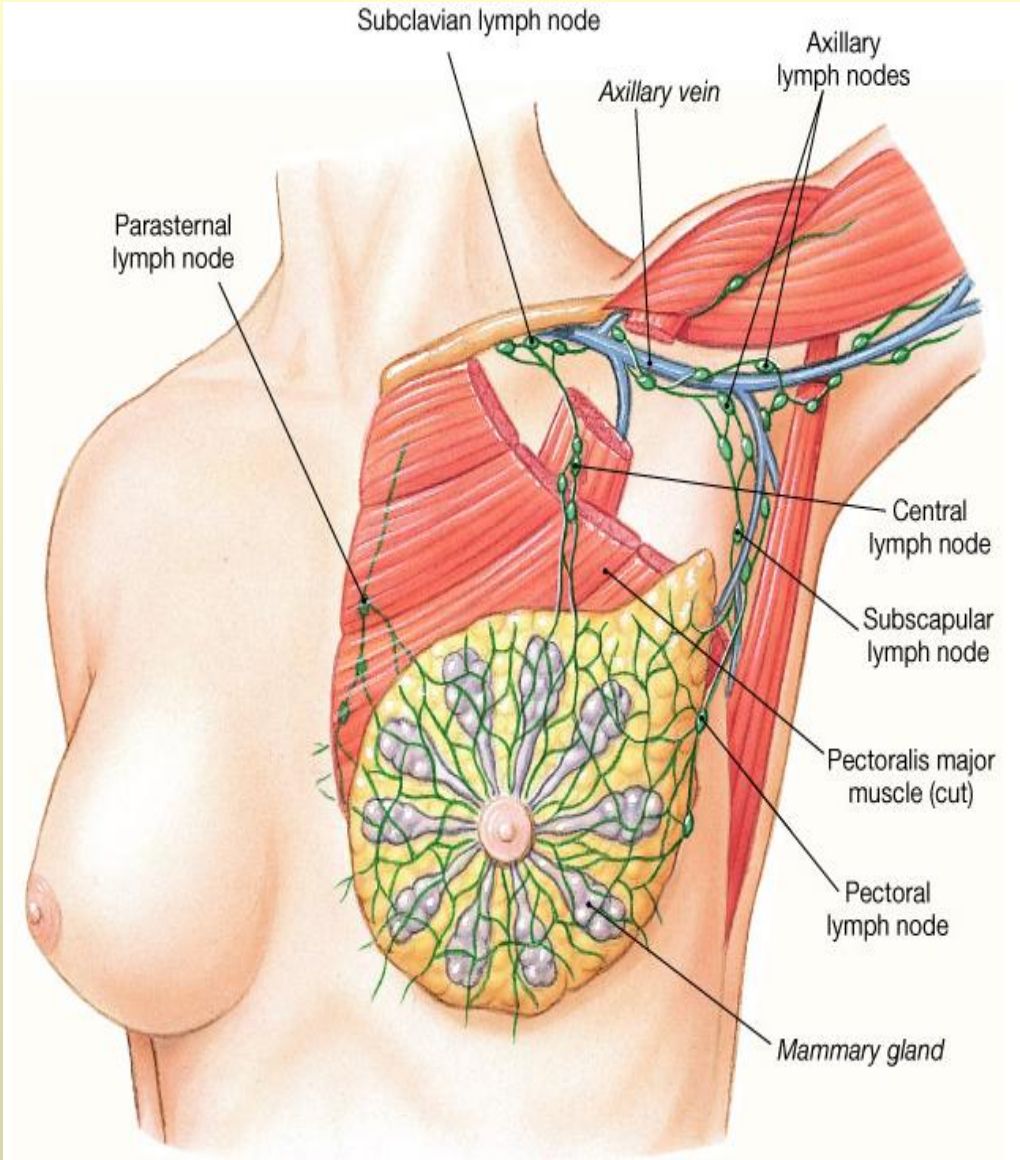


Lymphatic System

Morpho-functional Unit of the lymphatic system:

Regional lymphatic Complex

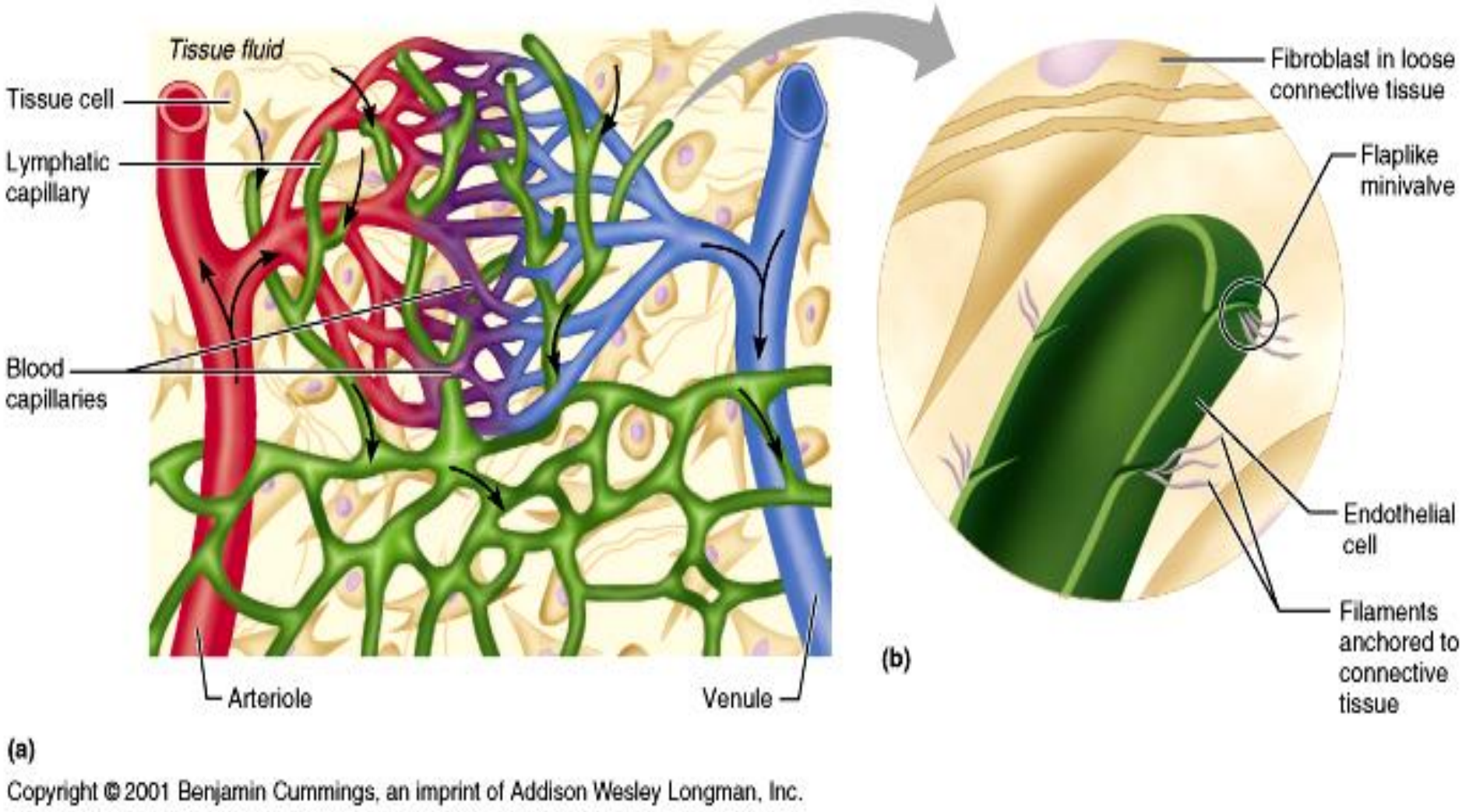
- Lymphatic vessels
- Lymphatic nodes
- Nonvascular pathways of circulation

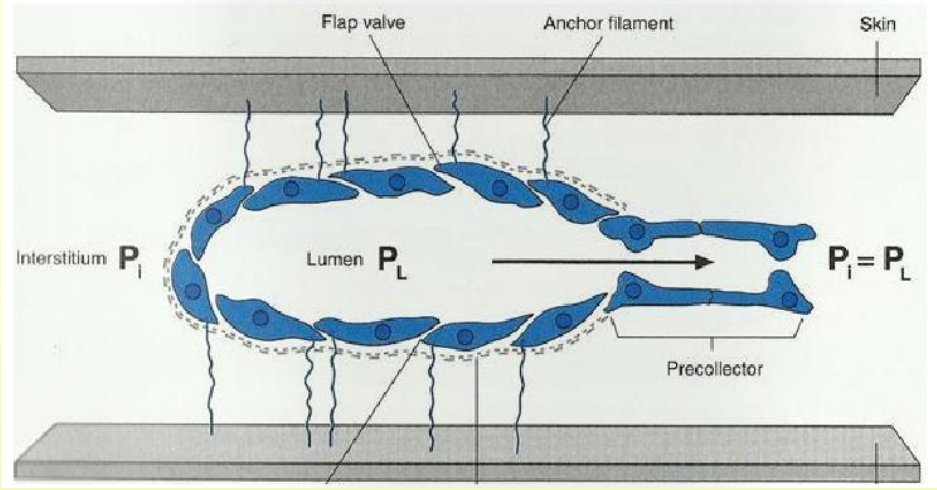


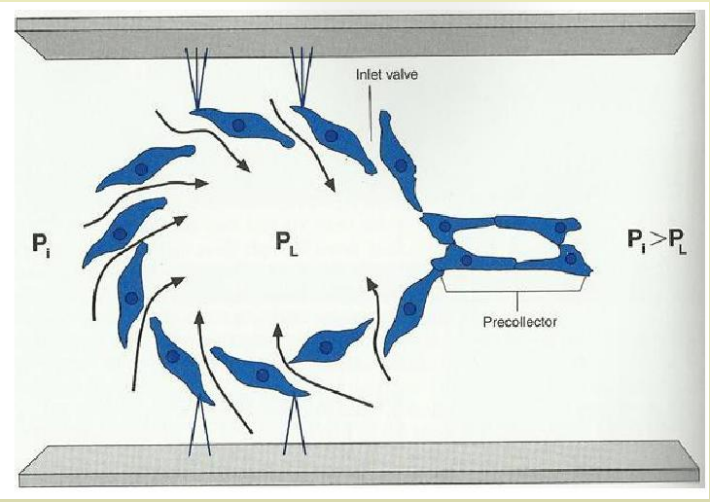
Lymphatic Capillaries

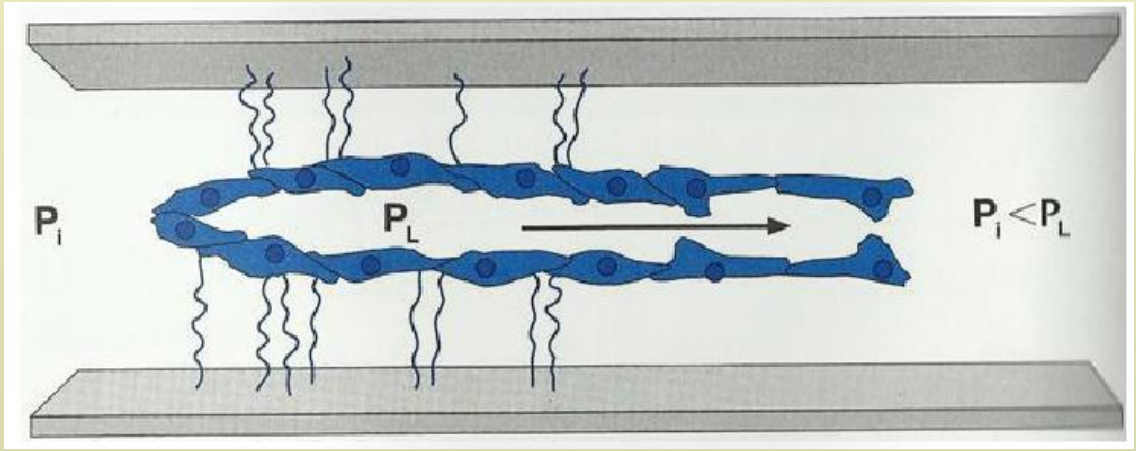
- Starts blind
- There are first segment of the lymphatic vessels
- The wall is built by one layer of endothelium, which made clefts and valves looks inside. Its activity are maintained by anchored filaments that are fixated in connective tissue.
- Has no basal membrane
- There are no pericytes
- More large than blood capillaries (20-200 mkm)
- Are permeable for colloid particles, microorganisms, macromolecules, tumor cells.
- Built superficial and deep plexus.

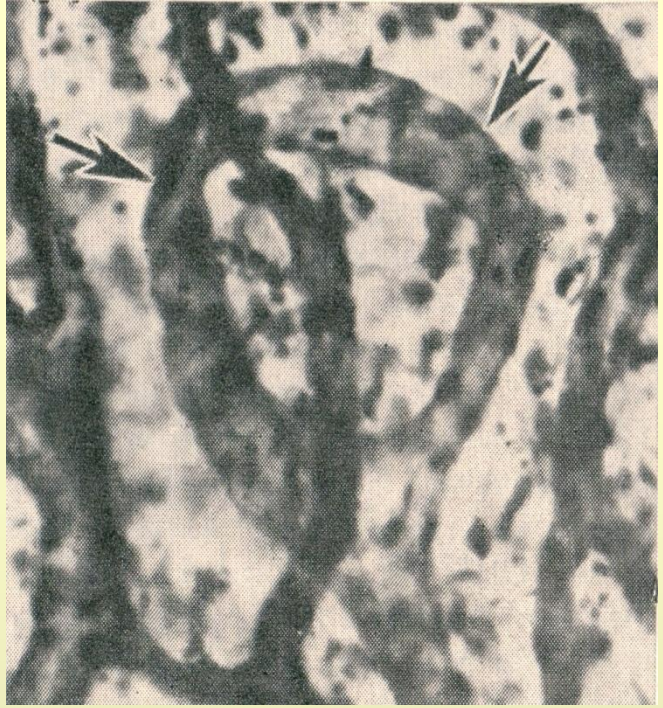
Lymphatic Capillaries

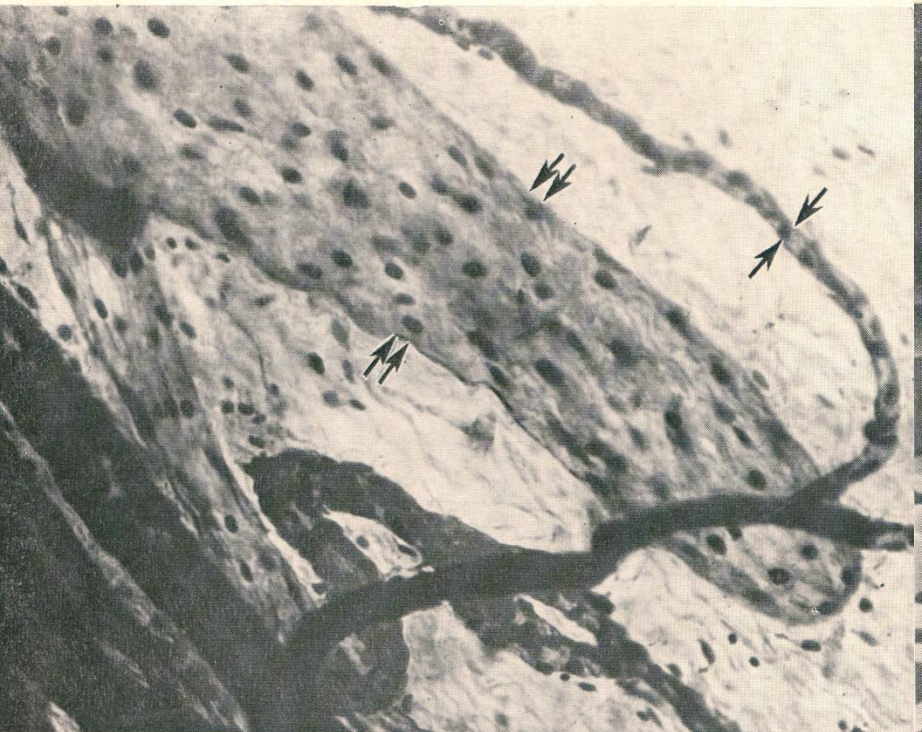


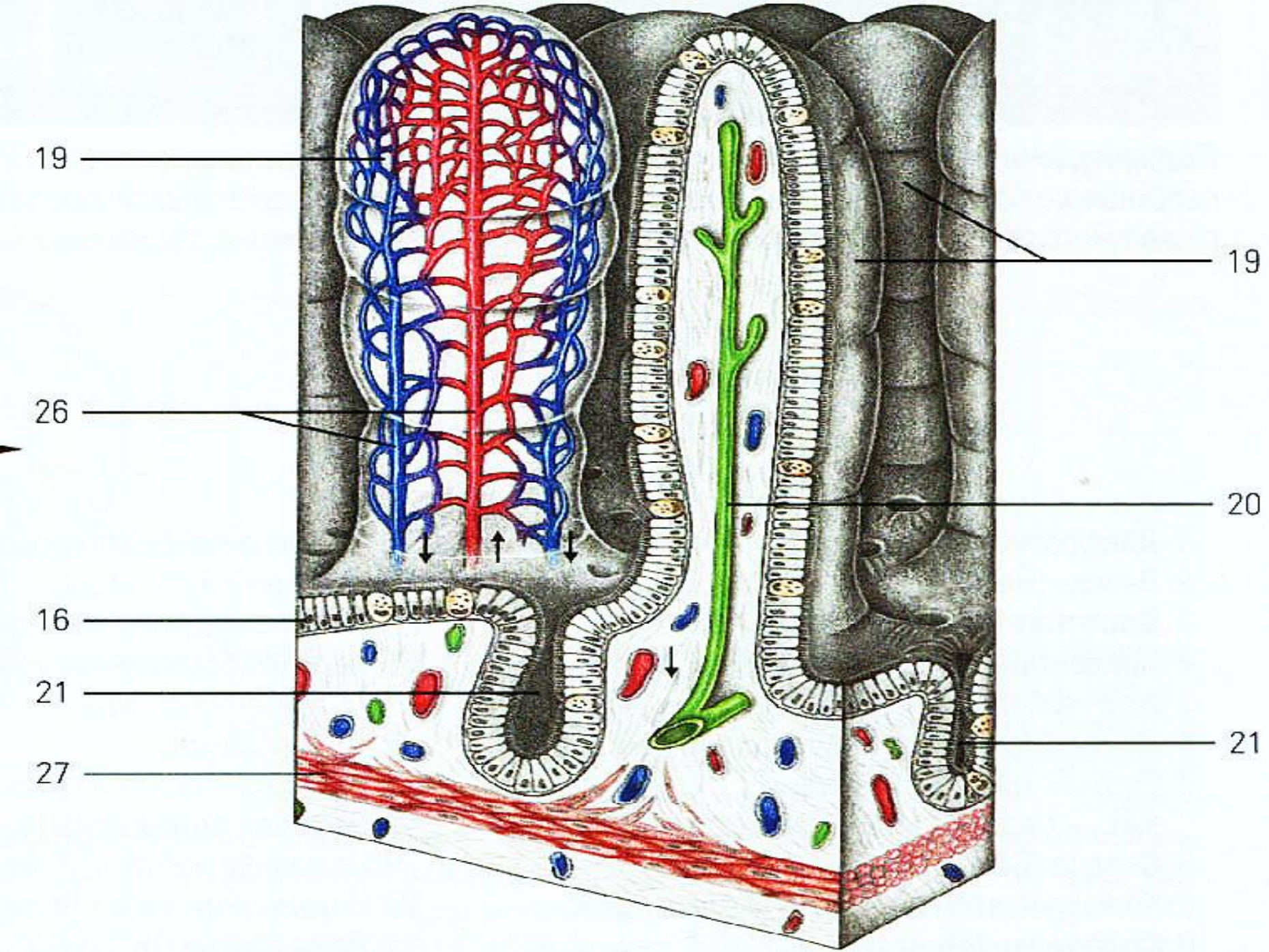

Flap valve
Anchor filament
Skin
Interstitium P_i
Lumen P_L
$P_i = P_L$
Precollector


Inlet valve
P_i
P_L
$P_i > P_L$
Precollector

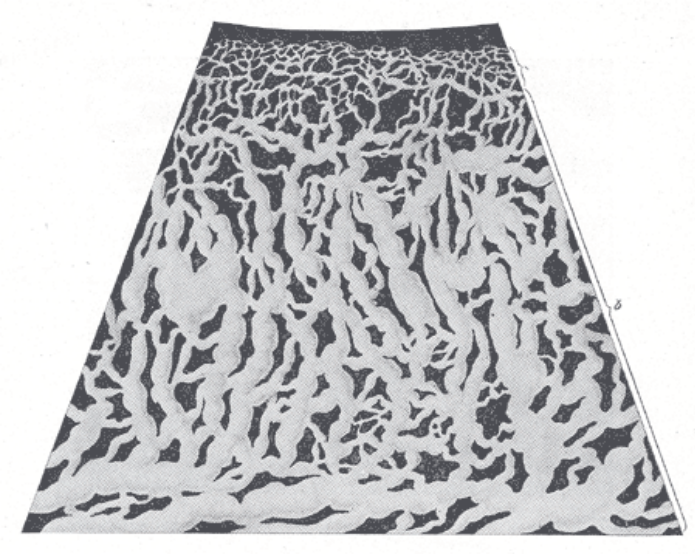

P_i
P_L
$P_i < P_L$

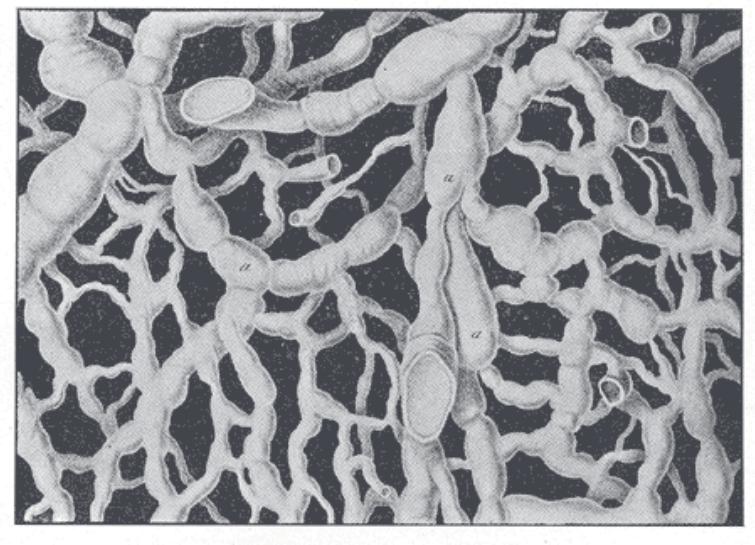


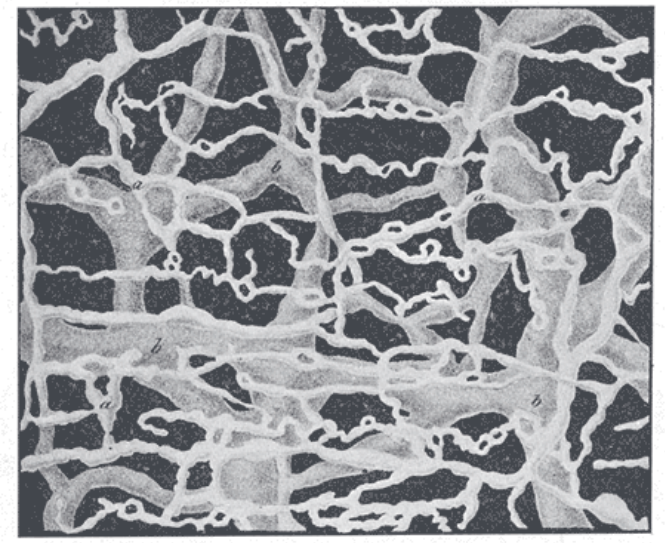


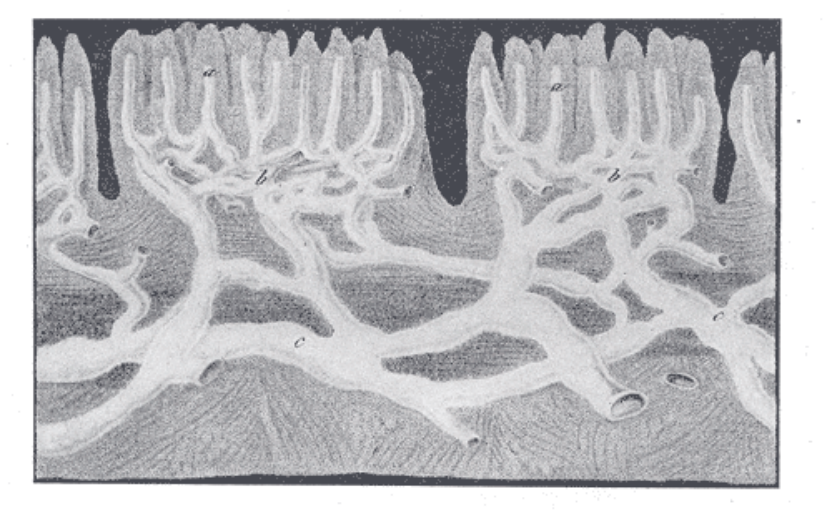

19
26
16
21
27
19
20
21

Lymphatic Capillaries







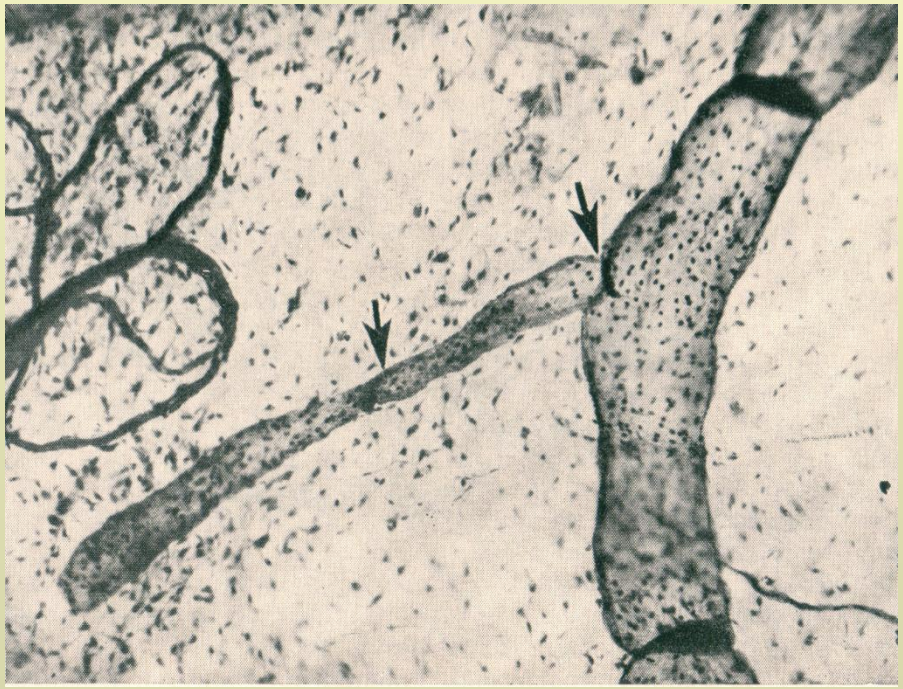


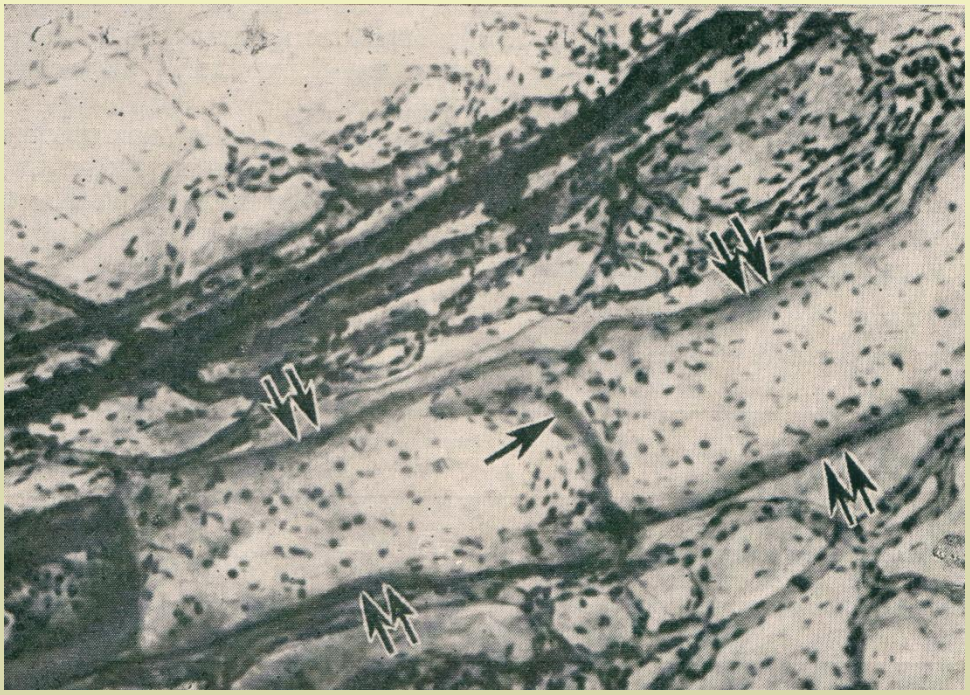
Lymphatic Capillaries

- Are absent in:
  - *Cartilage*
  - *Dentin and dental enamel*
  - *Nail and hear*
  - *Sclera of eye ball, lens*
  - Brain, meninges
  - Spleen
  - Red bone marrow
  - Placenta, umbilical cord
  - Renal glomeruli
  - Epithelial tissue
  - Internal ear

Lymphatic Postcapillaries

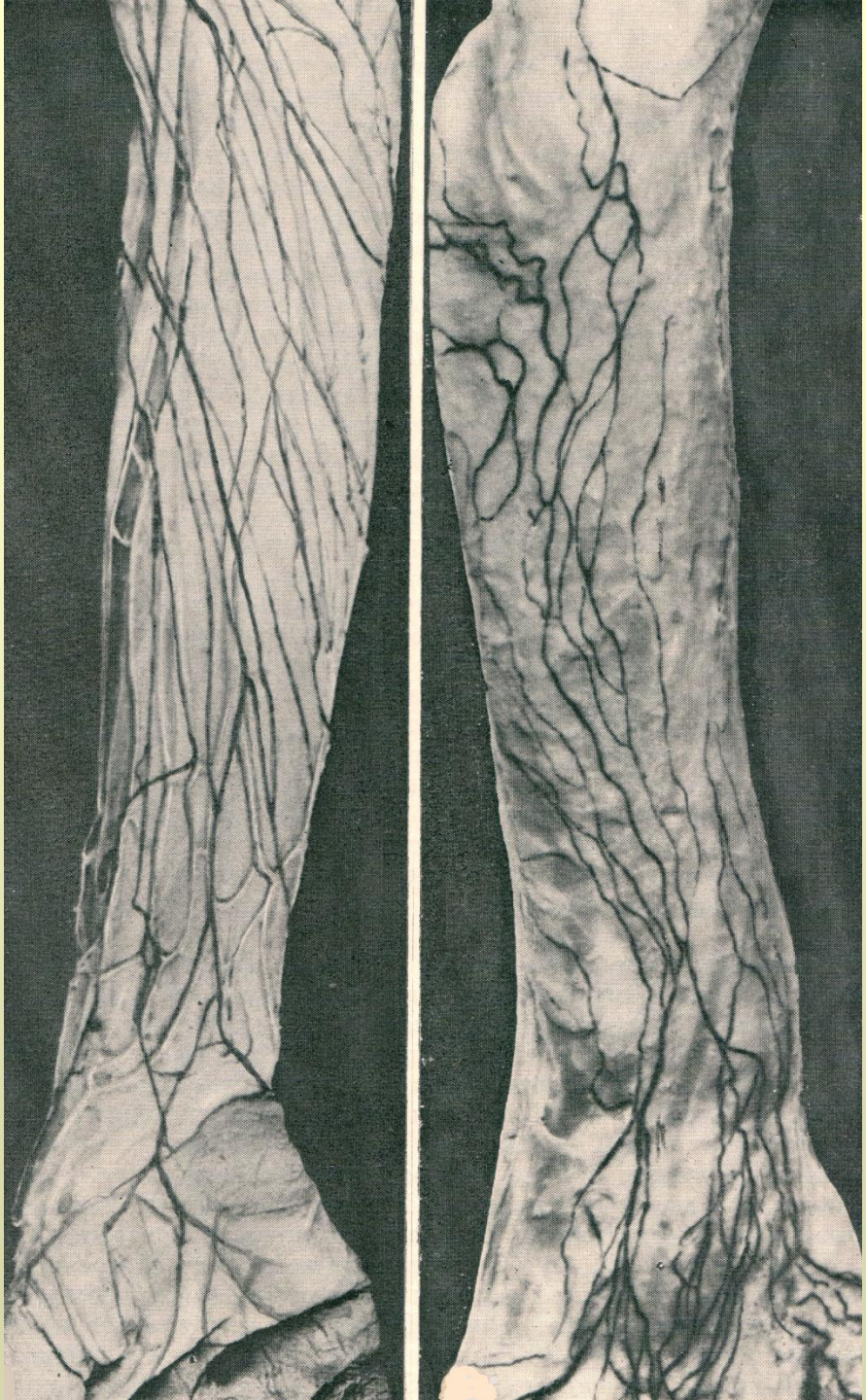
- Are the capillaries, but in the lumen appears **Valve**

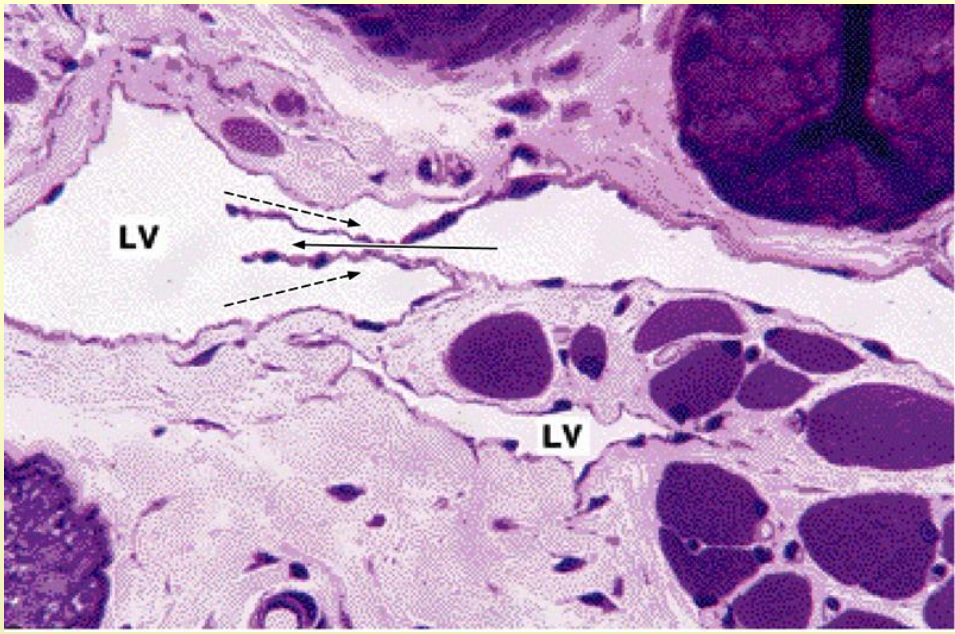


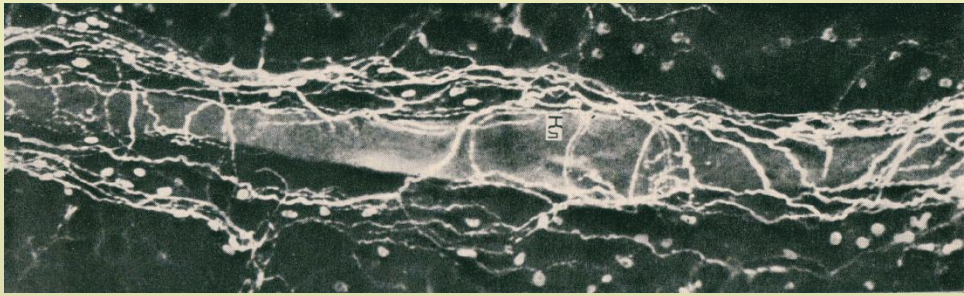


Lymphatic vessels

- In the lumen of pluristratified vessels appear valves (semi lunar type), which permit flow of lymph only to the single direction.
- There are following lymphatic vessels:
    - With transversal strips
    - Reticular type
    - Gofer type
    - Pellucid type
- There are intra- and extra organic vessels
- Building intravisceral and extravisceral; superficial, deep plexuses.




LV
LV

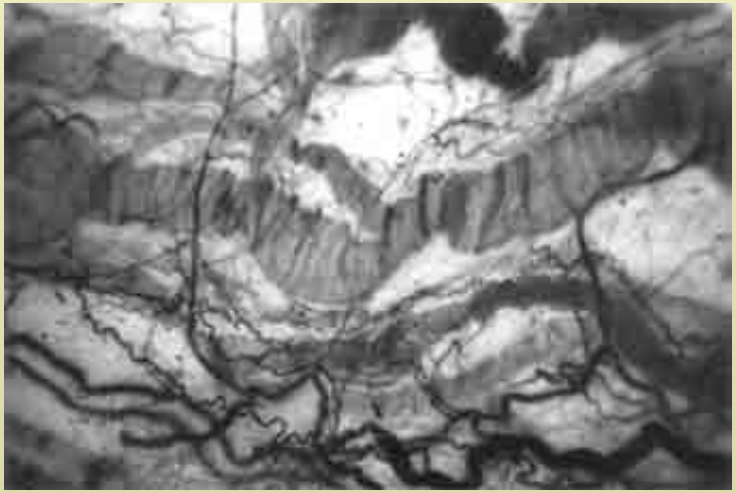


Lymphatic vessels

With transversal strips

Reticular type

.

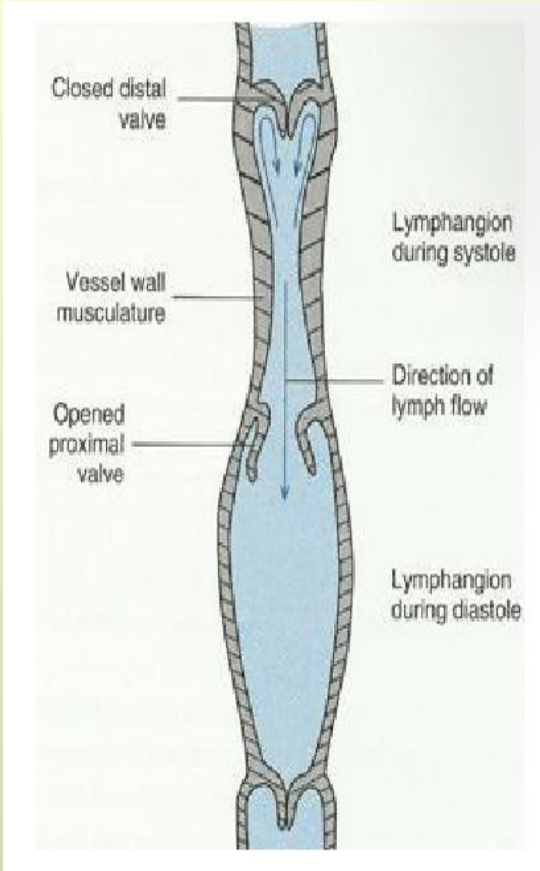


Gofer type

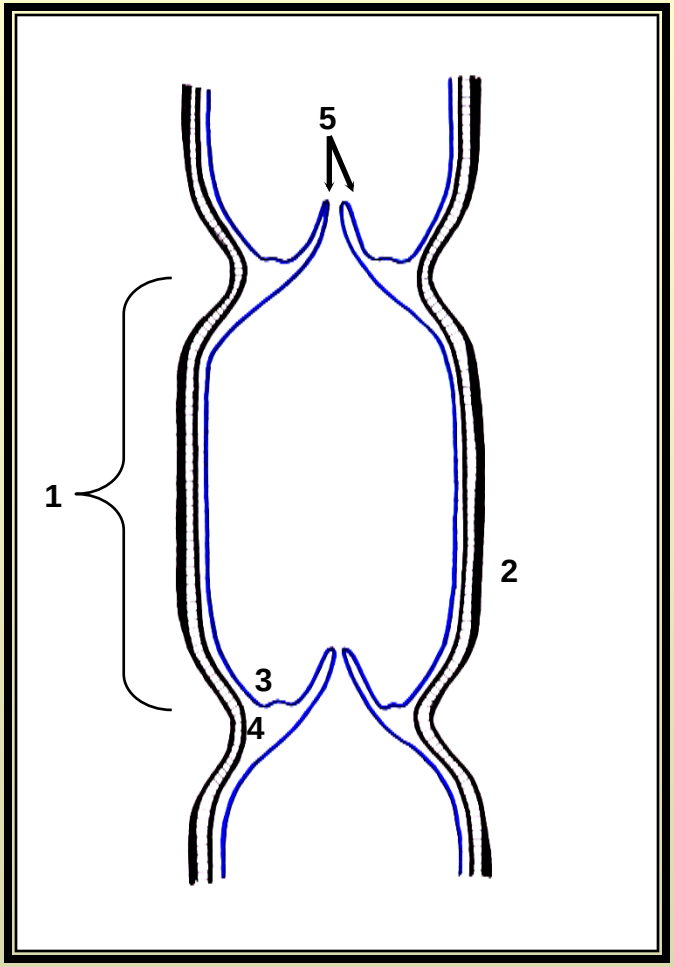
Pellucid type

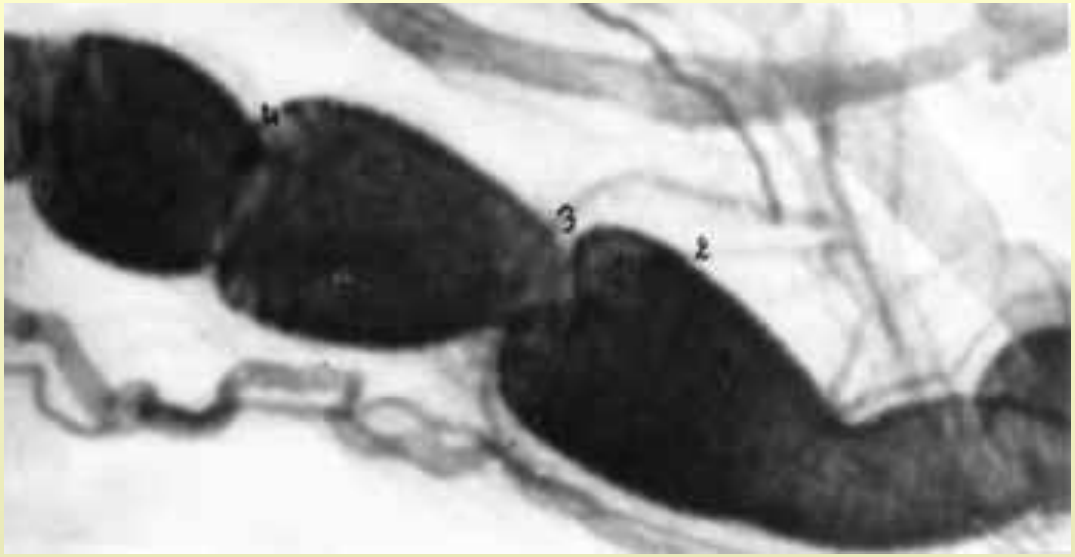
Lymphangion

- Morpho-functional Unit of the lymphatic vessel (micro-segment).
- Represent the part of vessel between 2 pairs of valves (inclusive the caudal).
- Works like a small pump. Myocytes of the wall - middle layer activate automatically as a heart (rhythmically, biphasic with systole and diastole)
- Structure:
  - Muscular sheath
  - Valve sinus
  - Burelet
- Classification by shape: cylindrical, spherical, oval, long, triangular, flat; short etc.

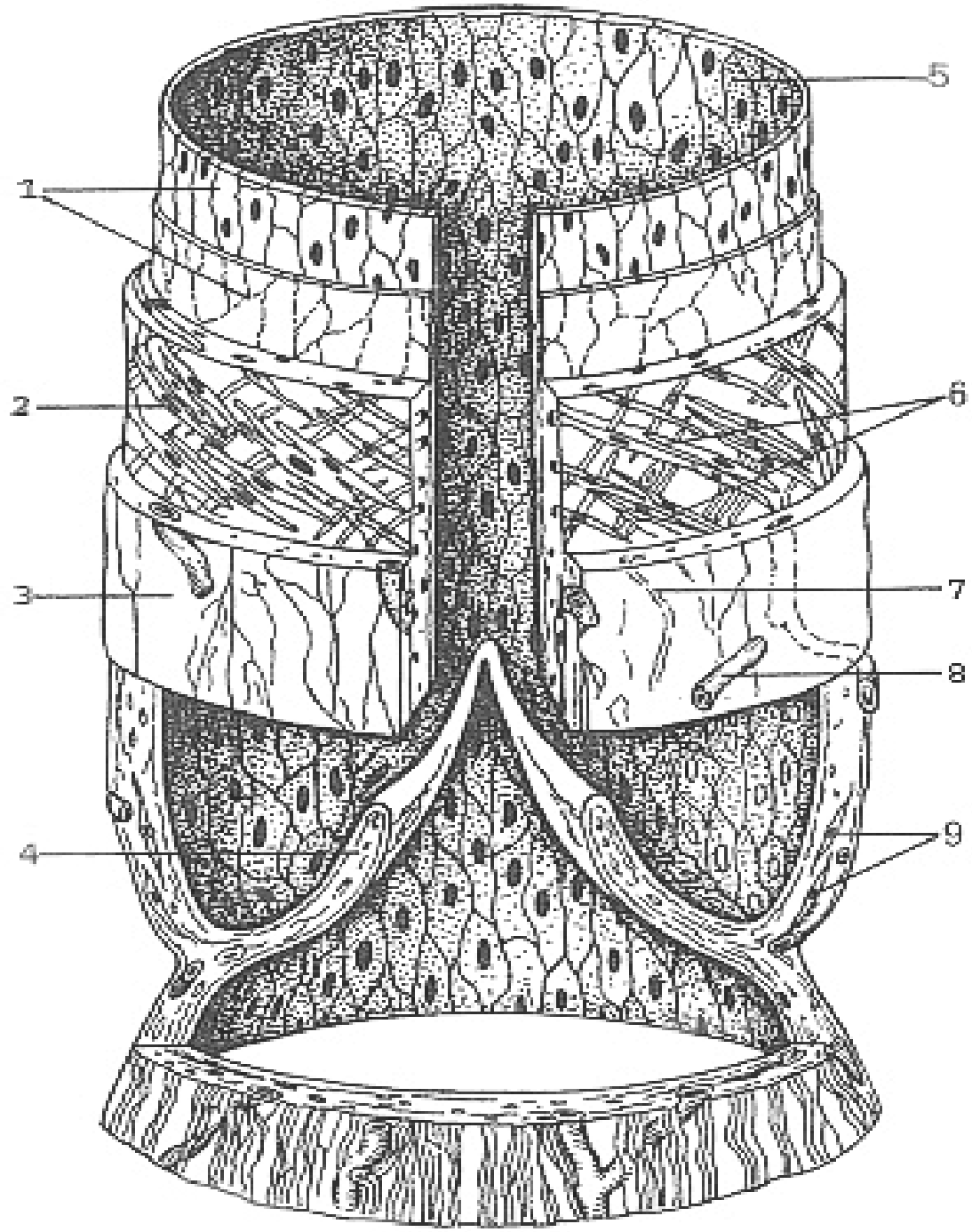


Lymphangion



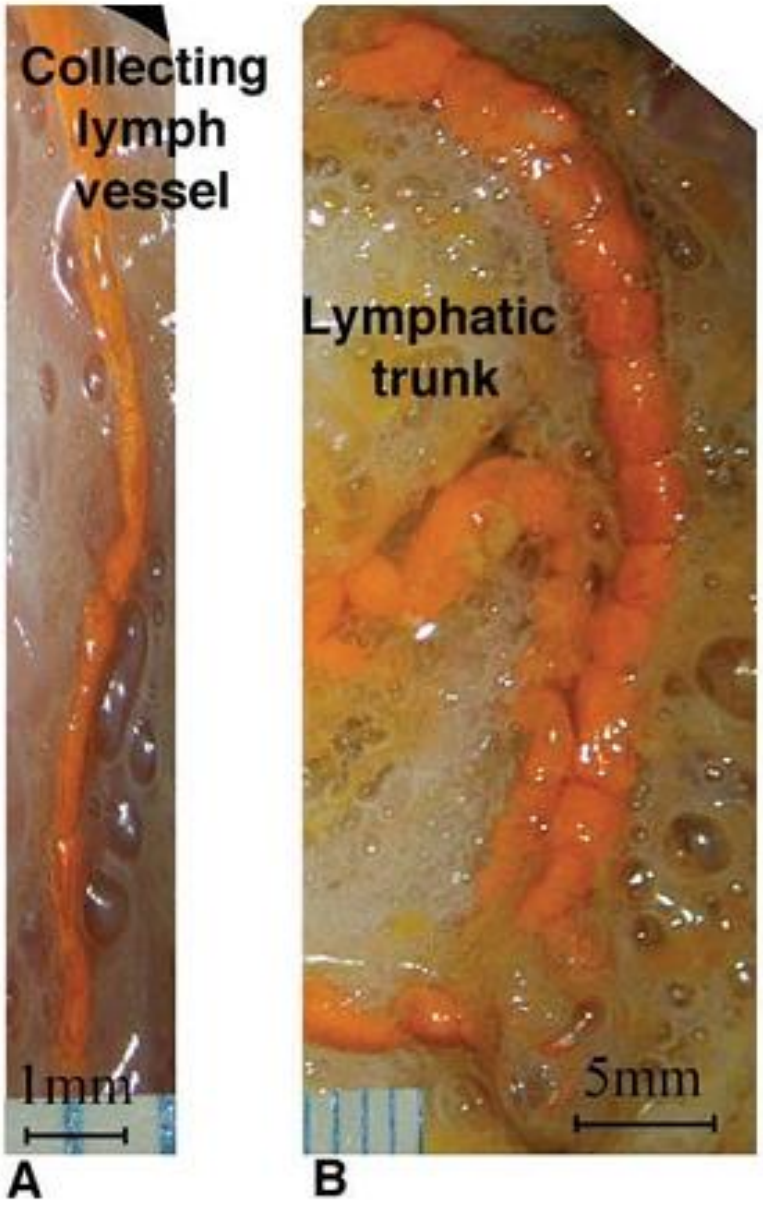


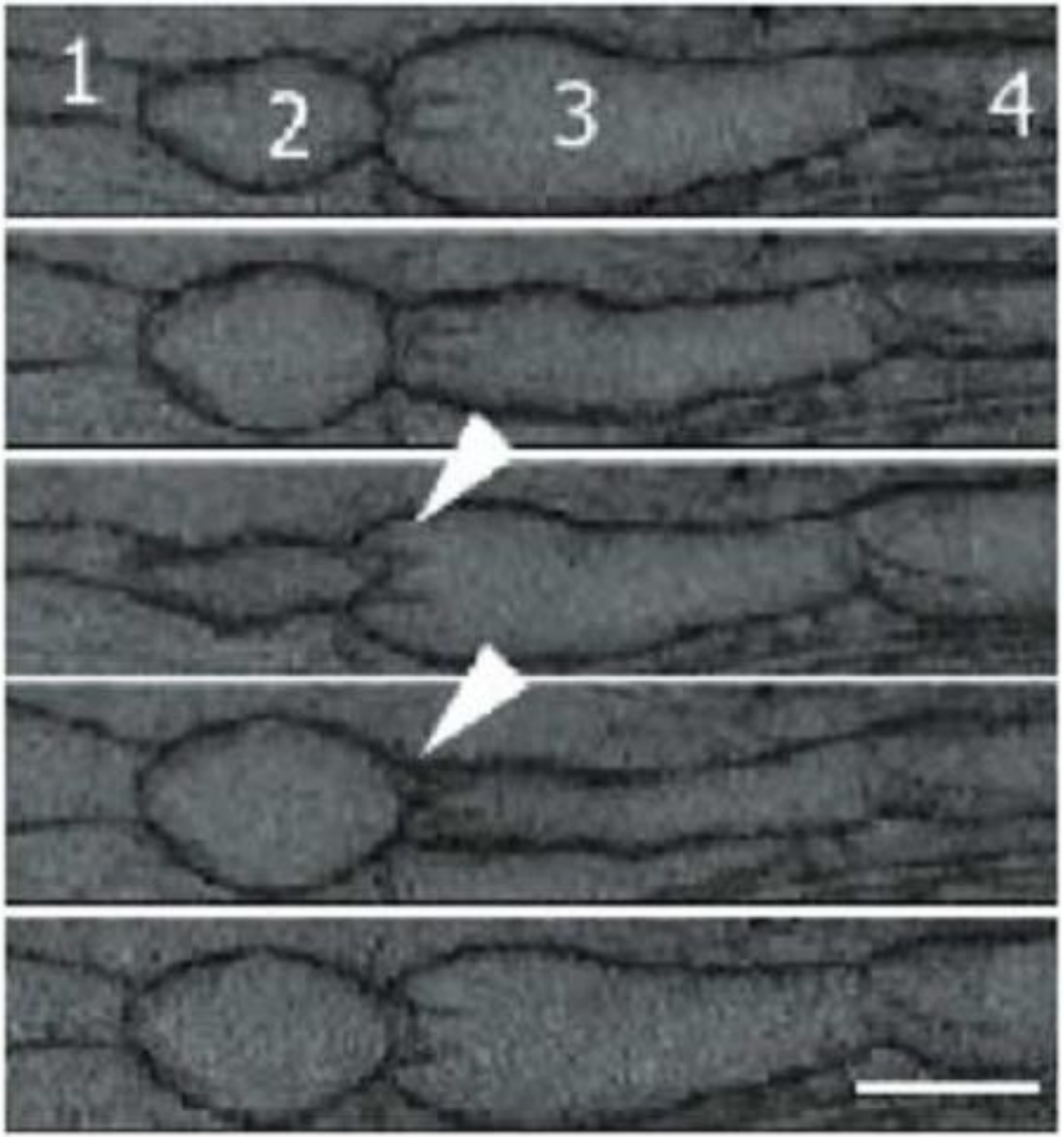
1 lymphangion; 2 muscular sheath;
3 valve sinus; 4 burelete; 5 valves.



Lymphangion

1.Internal layer.
2.Middle layer.
3.External layer.
4.Half of valve.
5.Endoteliocite.
6.Myocytes of midle layer.
7.Collagen fibers.
8.Blood capillaries.
9.Myocytes at the base of valve.

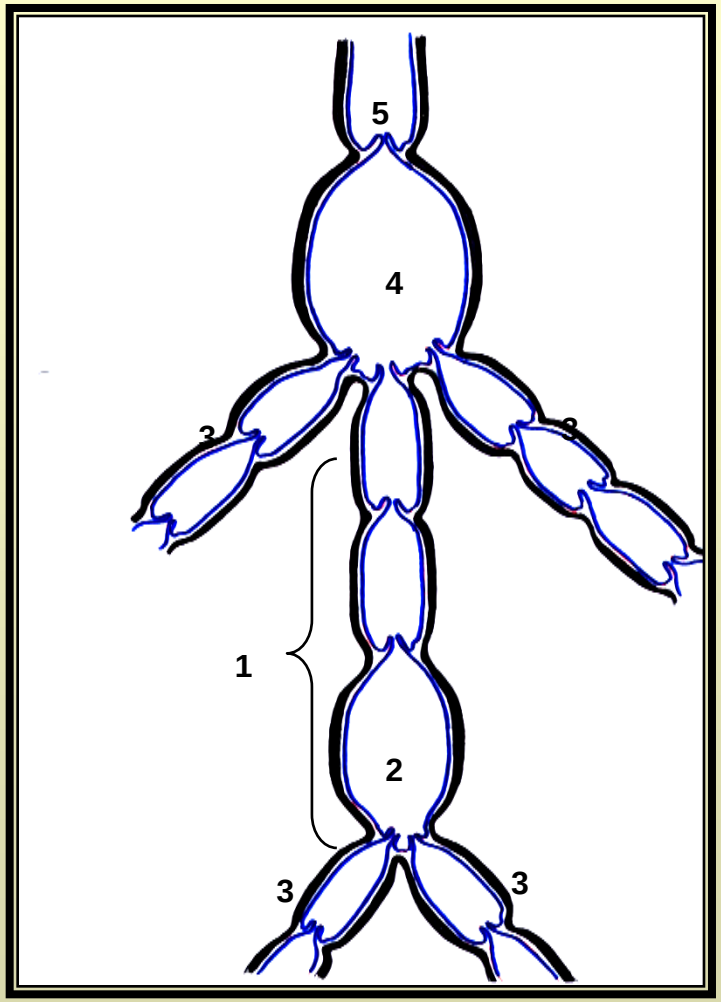

Collecting lymph vessel
1mm
A
Lymphatic trunk
5mm
B
ϕ0.2mm
2mm
(Interval of the valves)
ϕ2mm
Collecting lymph vessel
Lymphatic trunk
C
D

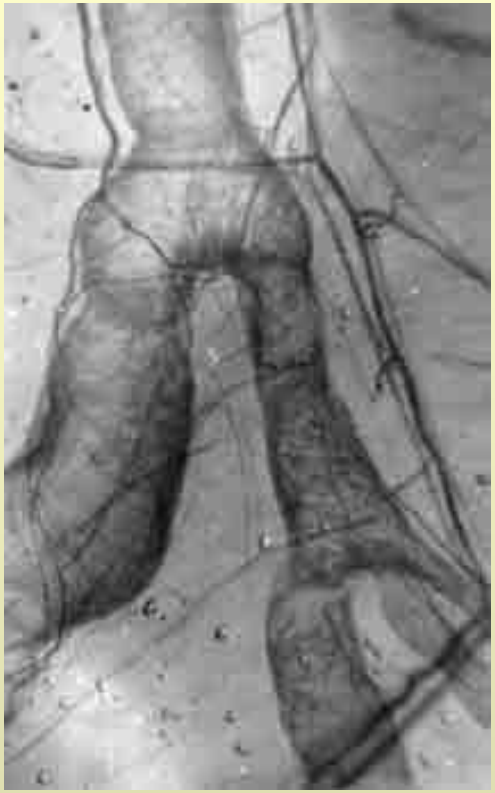

1
2
3
4

Lymphatic vessels

- At the junction of vessels is formed **lymphatic cistern**.
- Vessels that bring lymph toward the cistern are **afferent vessels** (2-5), that vessels which carry lymph from the cistern are **efferent** (1-2).
- **Macro-microsegment** of the lymphatic vessel is segment between 2 pair of **cisterns**, including caudal one.
- Also we distinguish **macro-segment** of the lymphatic vessel, which represents the segment between **2 pair of nodes.**

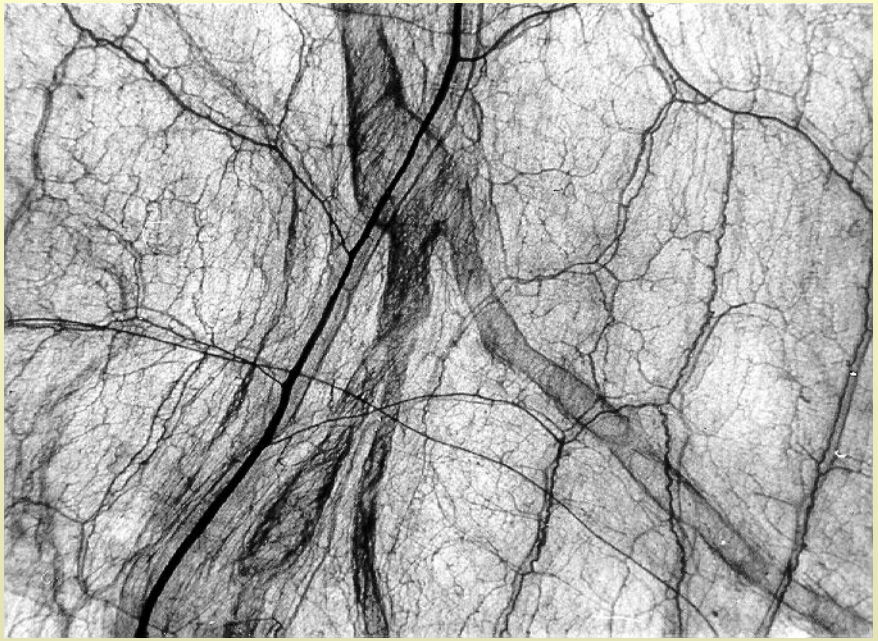
Macromicrosegment of the lymphatic vessels

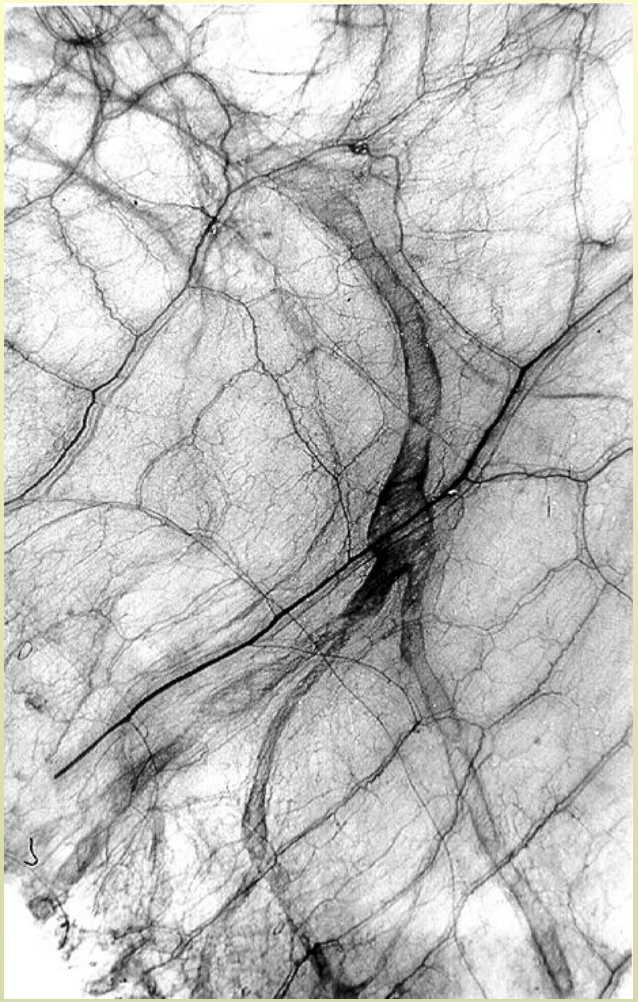




Structure of the macromicrosegment. (after Ştefăneţ M.) 1 macromicrosegment; 2 caudal cistern; 3 afferent vessels; 4 cranial cistern; 5 efferent vessels.

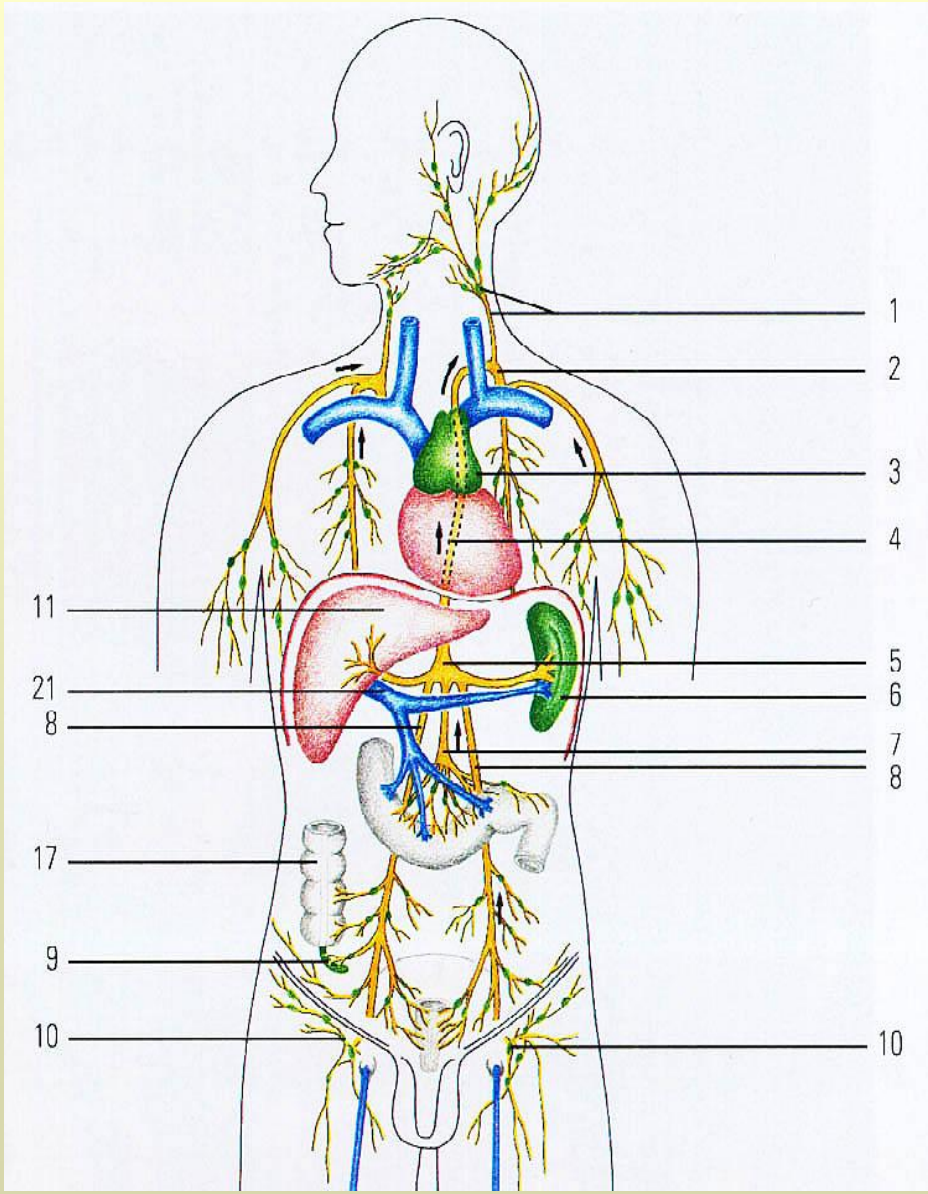
Macromicrosegment of the lymphatic vessels

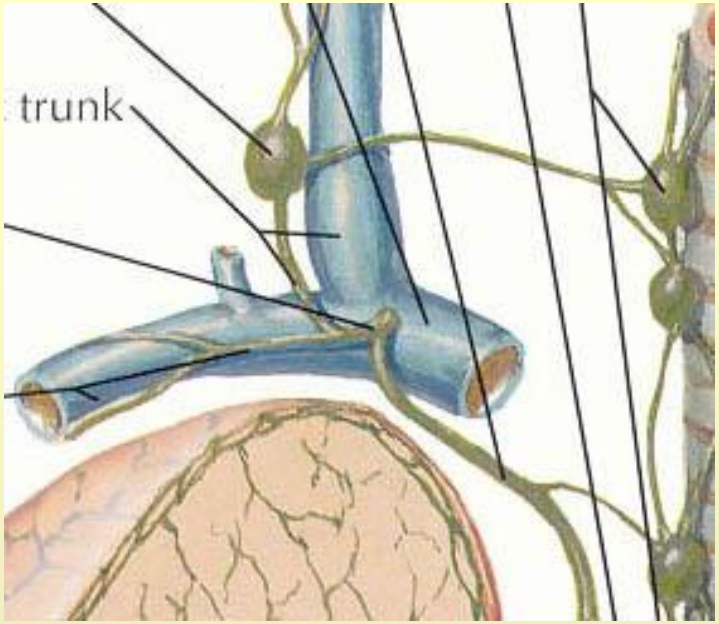


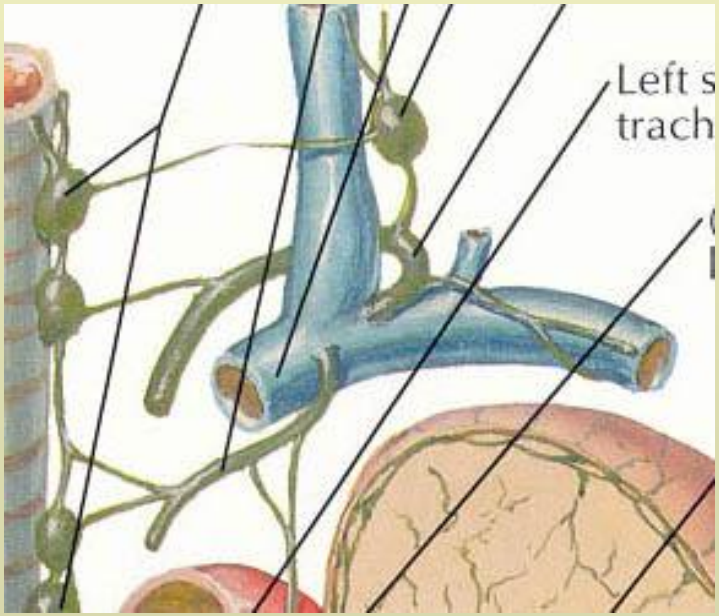


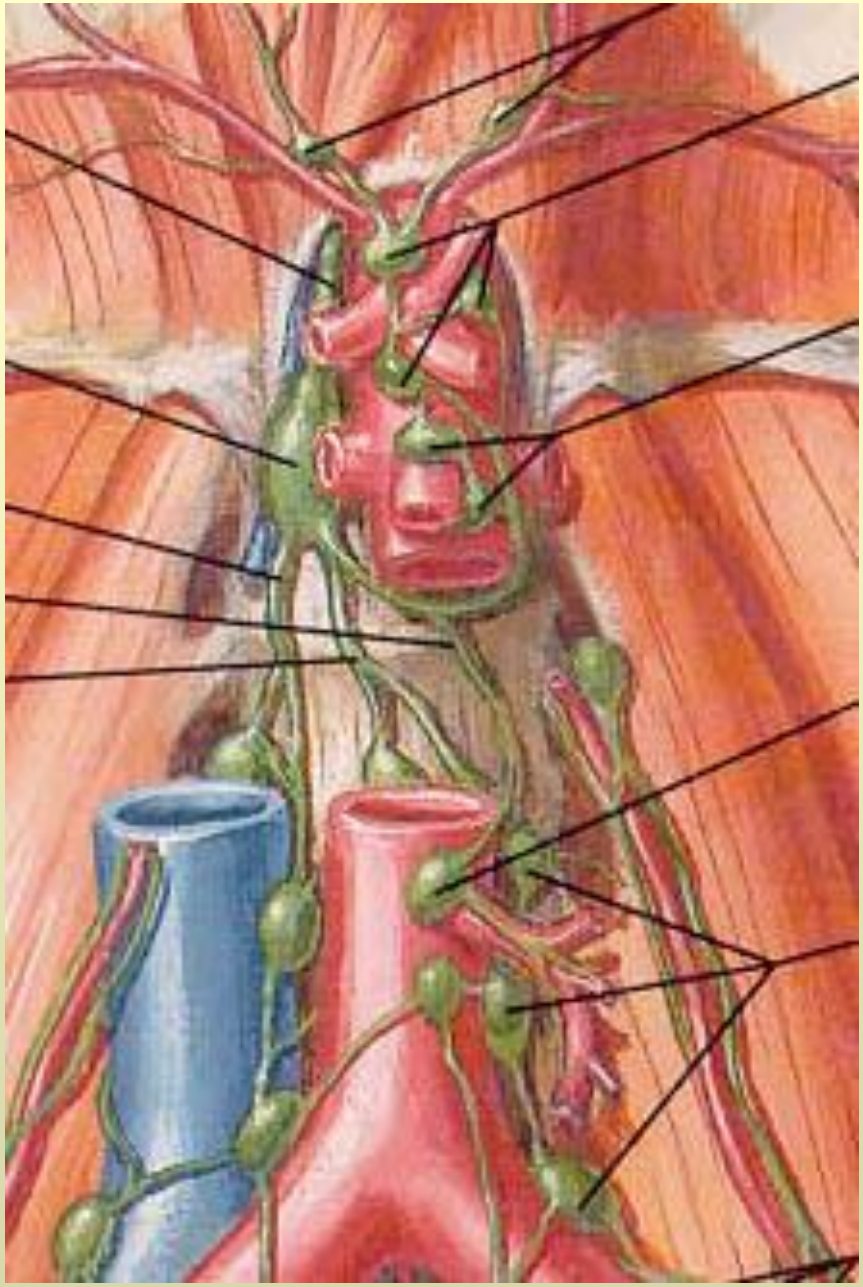
Lymphatic trunks

- There are:
  - Trr. lumbales dexter et sinister
  - Tr. intestinalis
  - Trr. jugulares dexter et sinister
  - Trr. subclavii dexter et sinister
  - Trr. bronchiomediastinales dexter et sinister




trunk


Left s
trach



Lymphatic ducts

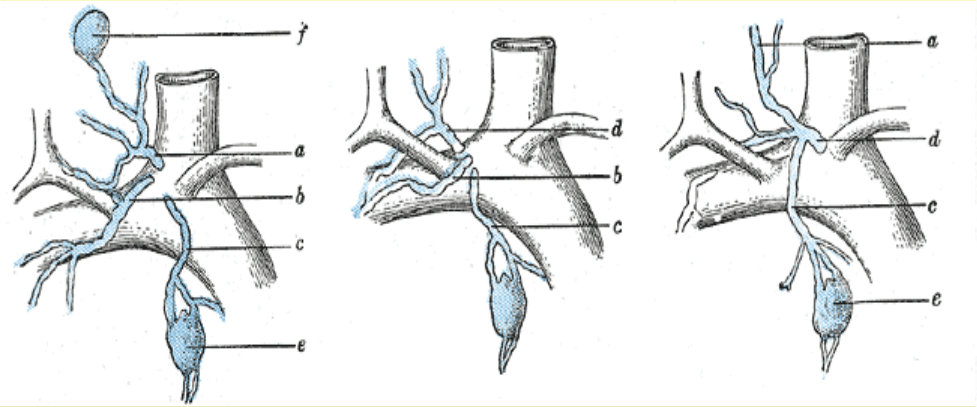
- There are:
  - **Right lymphatic duct –** is formed at the junction of right subclavicular, jugular and bronchomediastinal trunks. Its drainages in the right venous angle.
  - **Thoracic lymphatic duct –** represents the largest lymphatic vessel, that drainages in the left venous angle.

Thoracic duct

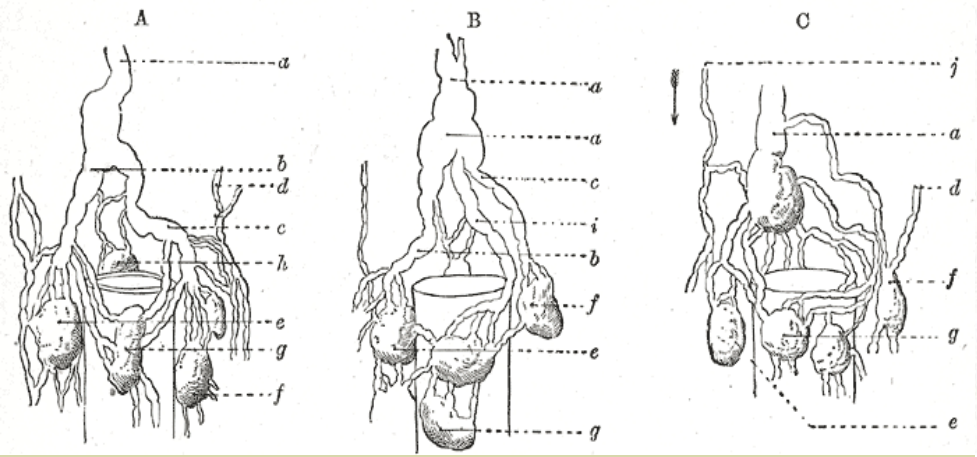
- It is made up by fusion of right and left lumbar trunks with intestinal one. Th 12 - L2
- At this level (abdominal region) is formatted the ***cisterna chyli (75 %)***.
- In the thoracic region is placed between azigos vein and thoracic aorta. Also received the tributaries from left bronhomediastinal trunk and lymphatic intercostal vessels.
- In the cervical region flows in the left venous angle, prior joint left jugular and left sublavicular trunks.
- Before opening the thoracic duct divides in several twigs as “deltă” - 2-4 or more branches.

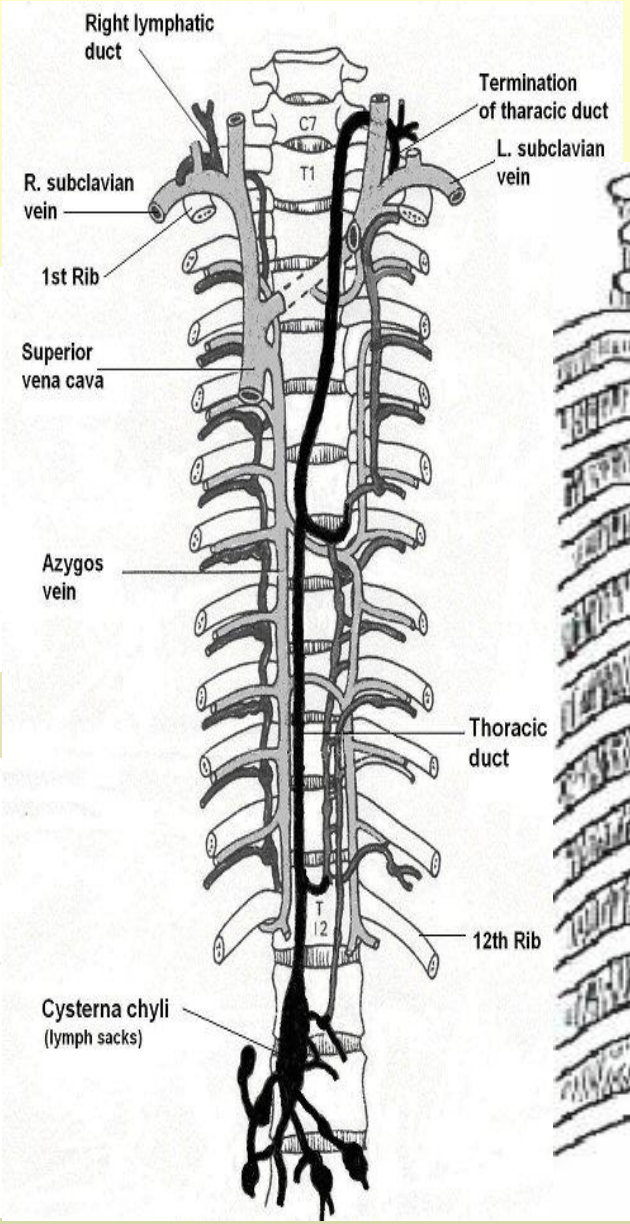
Lymphatic ducts

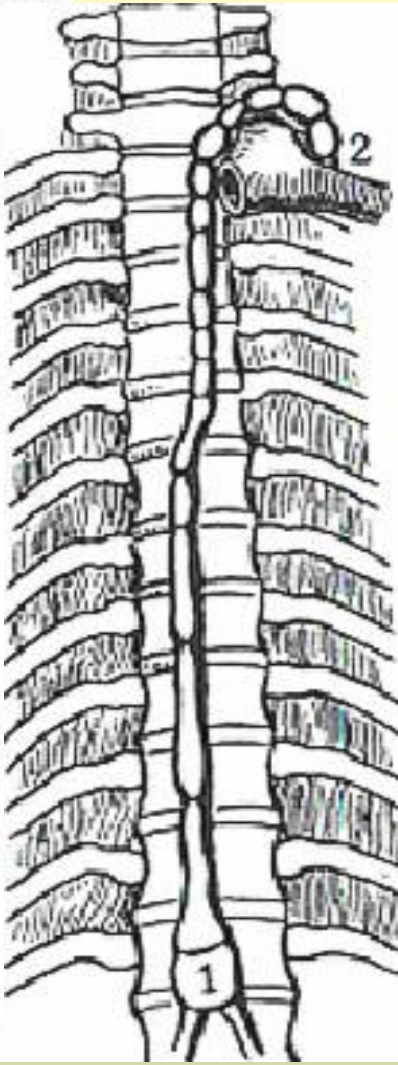
Right lymphatic duct



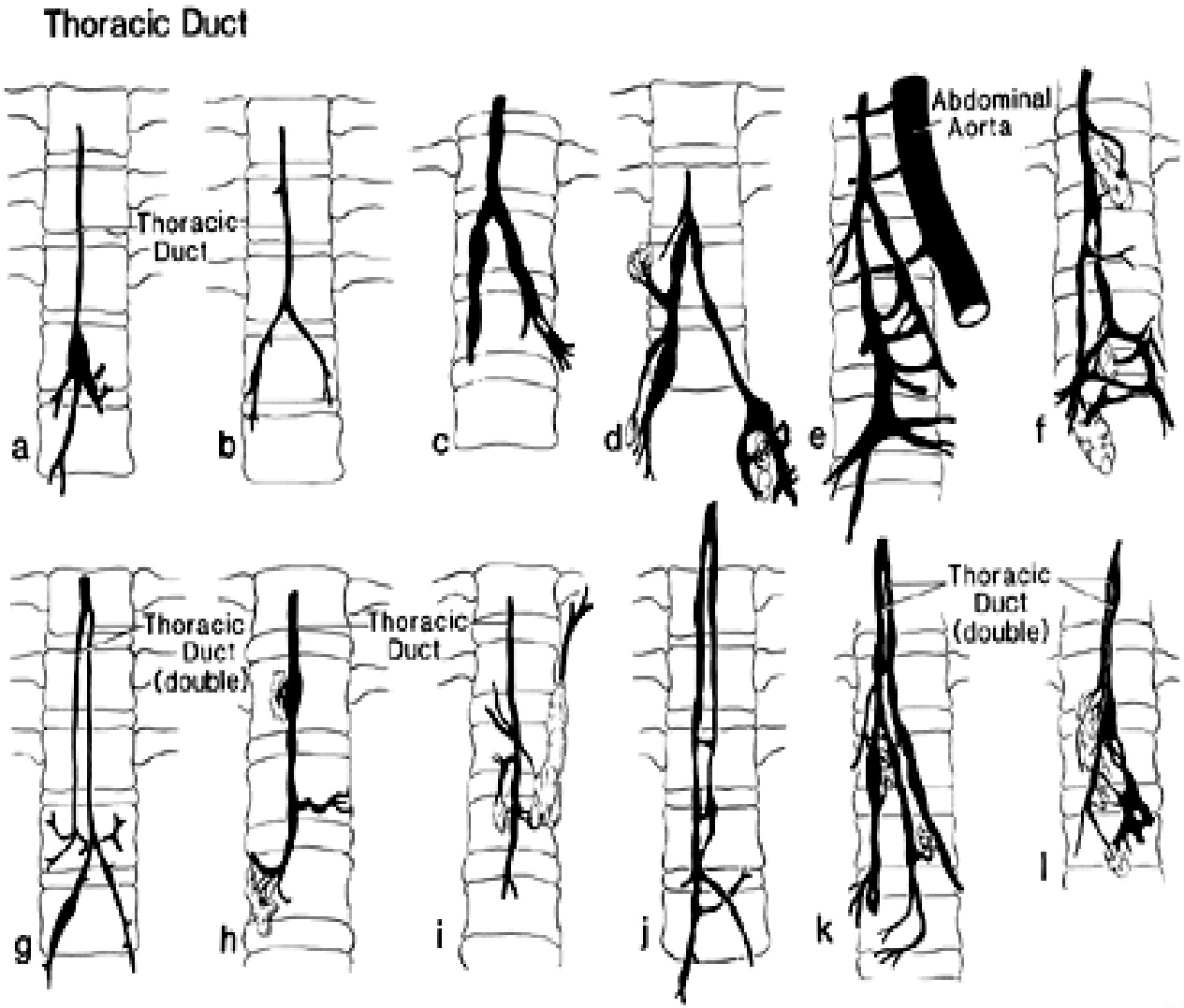
Thoracic duct

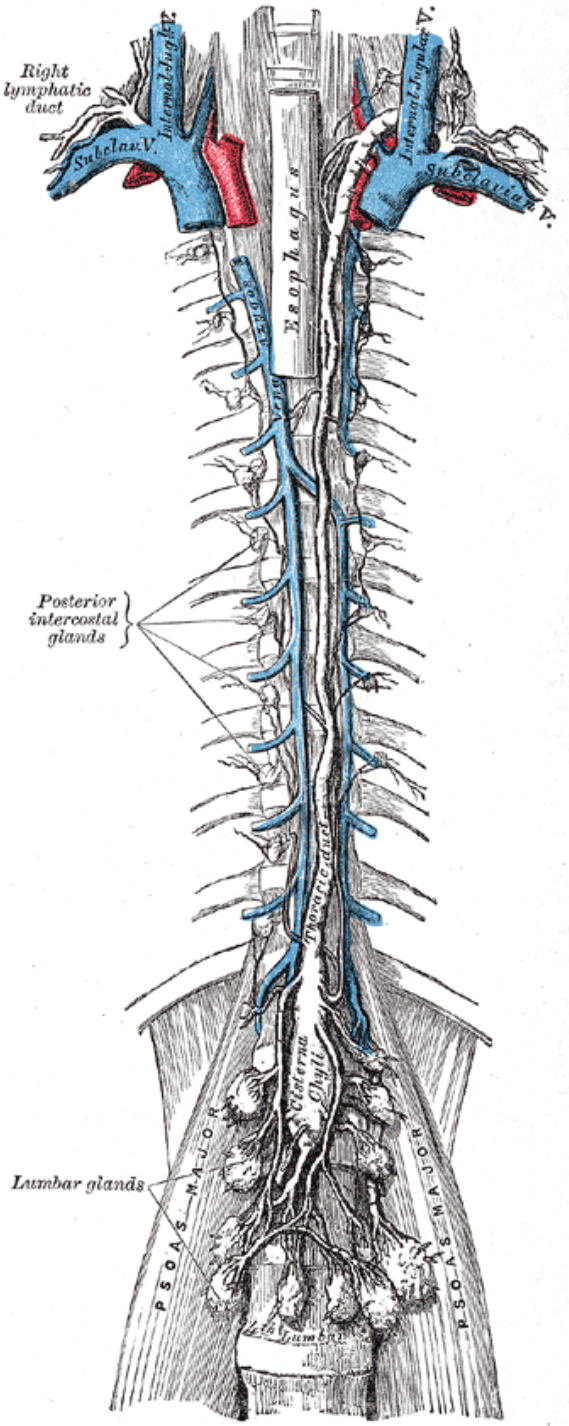




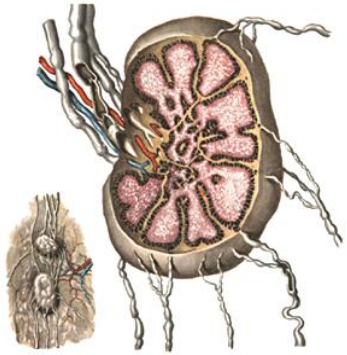


Thoracic duct



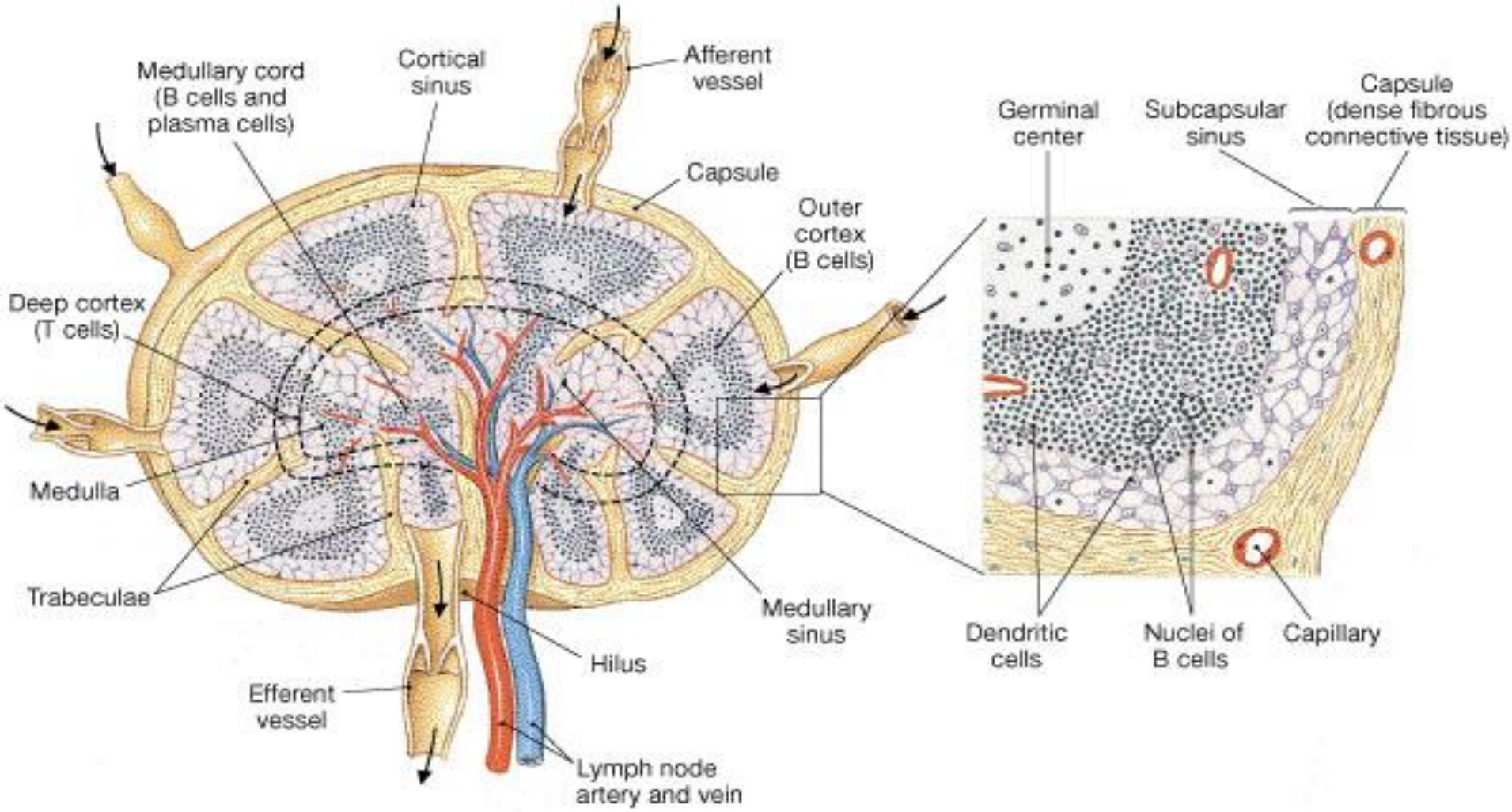


The lymphatic node



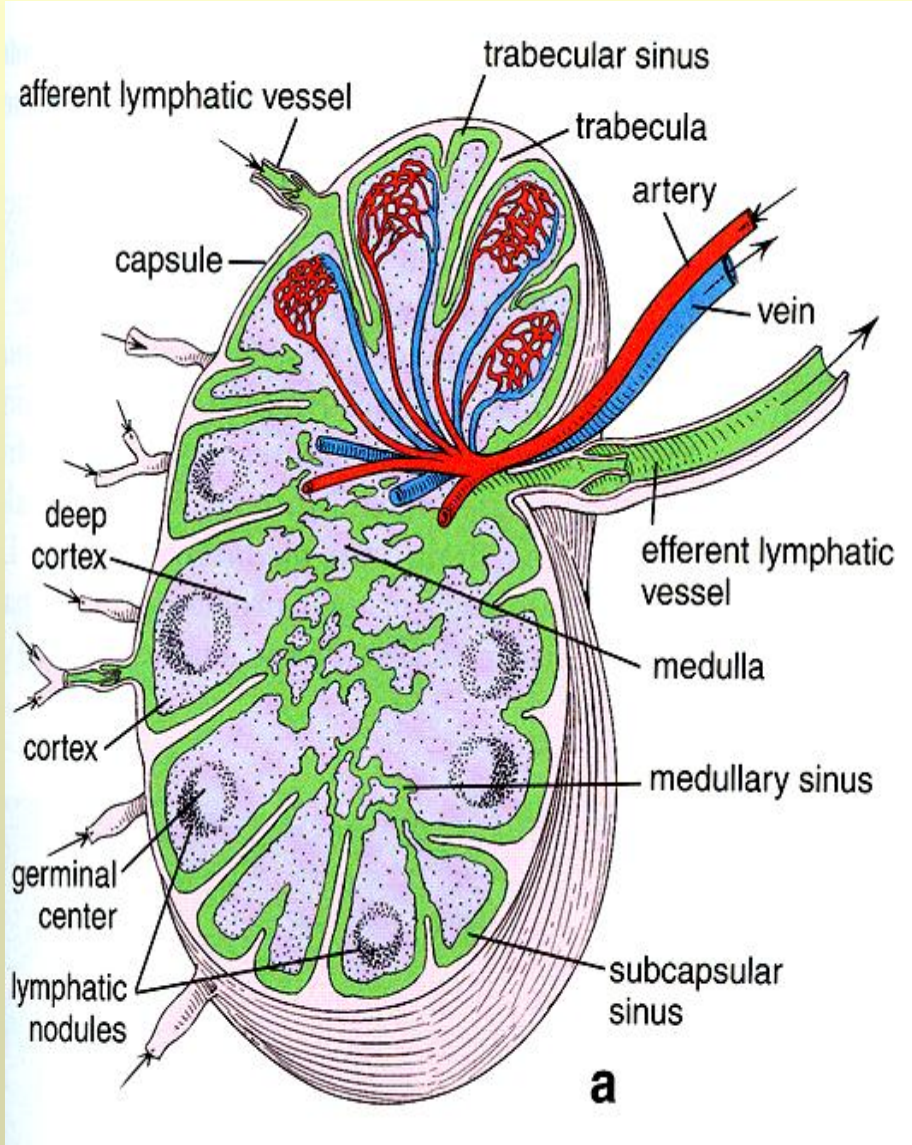
- Localized along the lymphatic vessels
- Shape: elongated, bean, irregular
- Functions: barrier, filtrate the lymph, lymphopoiesis, immunity.
- Structure:
  - Capsule
  - Septa
  - Stroma (reticular tissue)
  - Parenchim (represented by reticular and lymphoid tissue)
    - Cortex (with germinal centres)
    - Paracortical zona
    - Medulla, medullar cords

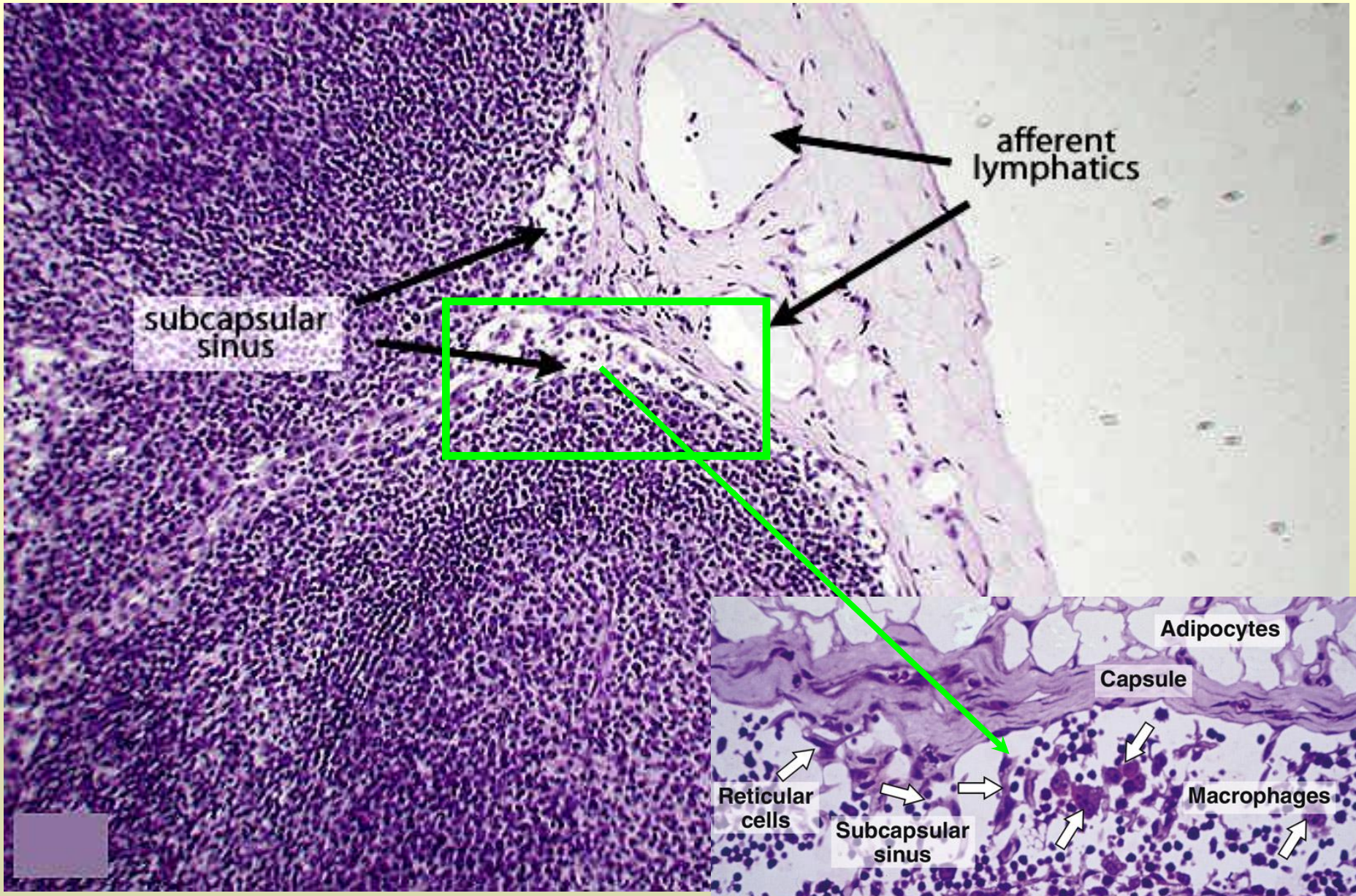
The lymphatic node



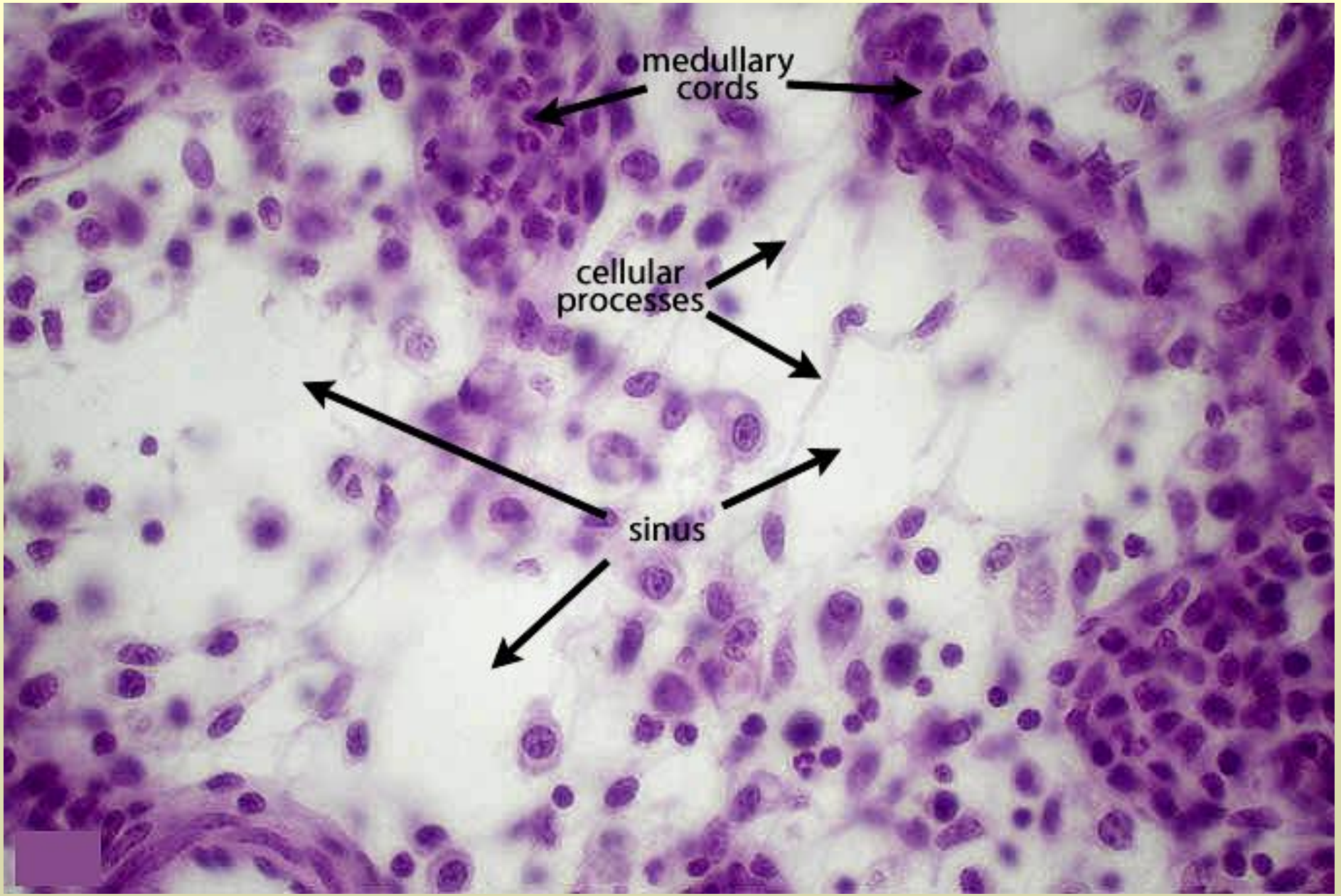
The Circulation of the lymph throw lymphatic node

- The lymph come by **afferent** lymphatic vessels (2-8)
- Pass throw marginal sinus (subcapsular) - cortical sinus – medullar sinuses – hilary sinus (portal)
- Leave by1-2 efferent lymphatic vessels





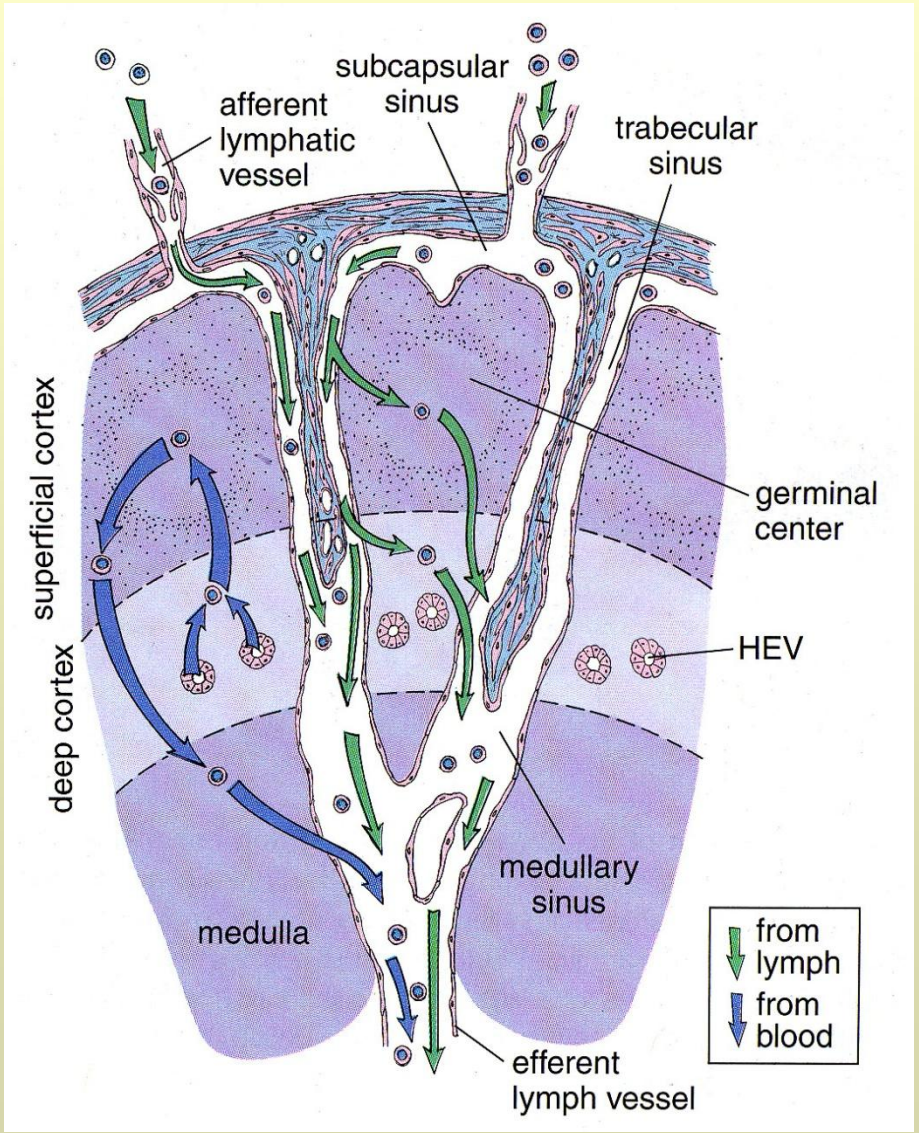
Subcapsular Sinus



Medullar Sinus

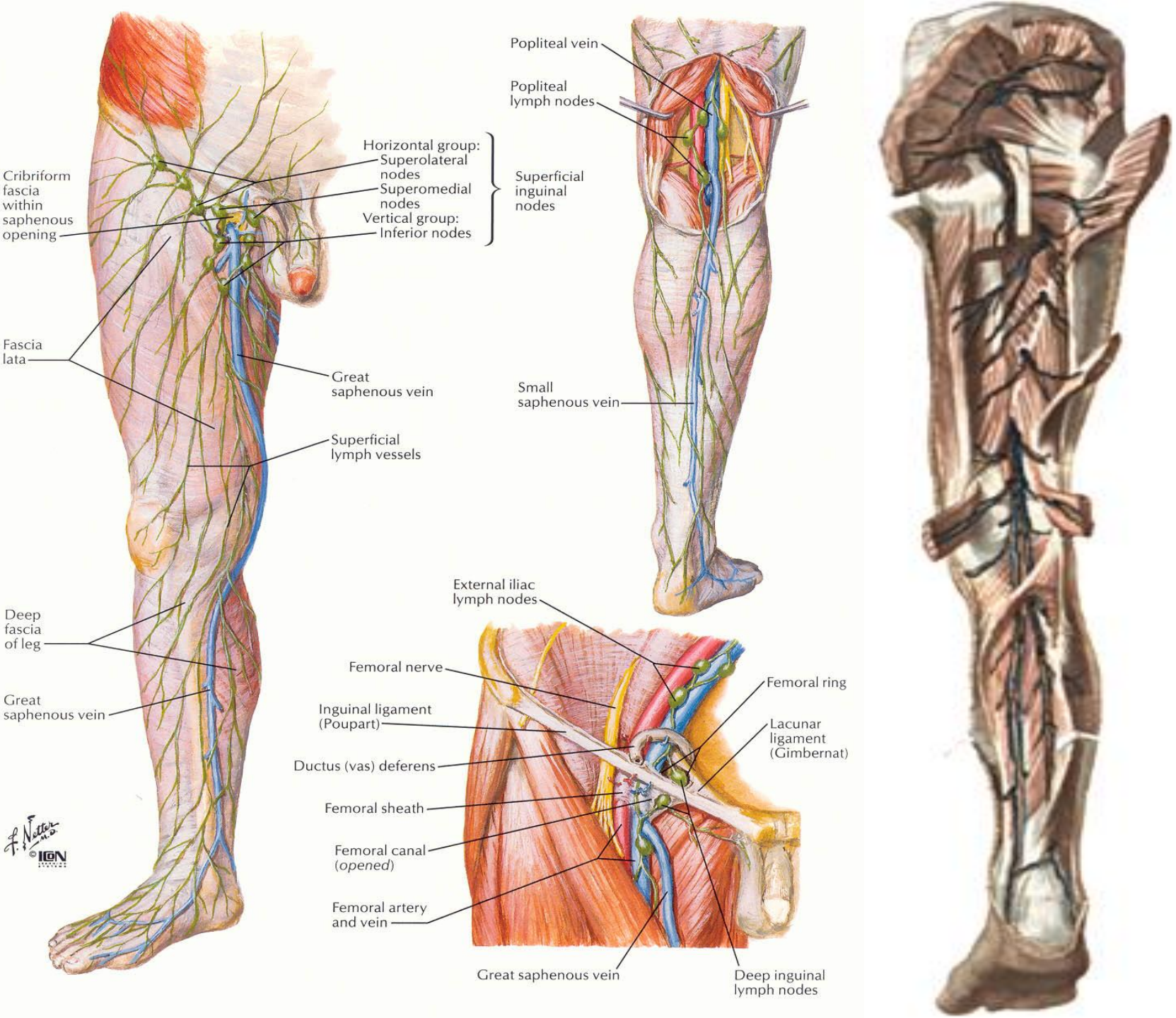
The Circulation of the lymph throw lymphatic node

- There 2 ways of lymph circulation
  - **Indirect**, favorable for metabolic processes and immunities.
  - **Direct**, shorter- in marginal sinus after in
    - hilar sinus



Regional lymphatic vessels and the nodes

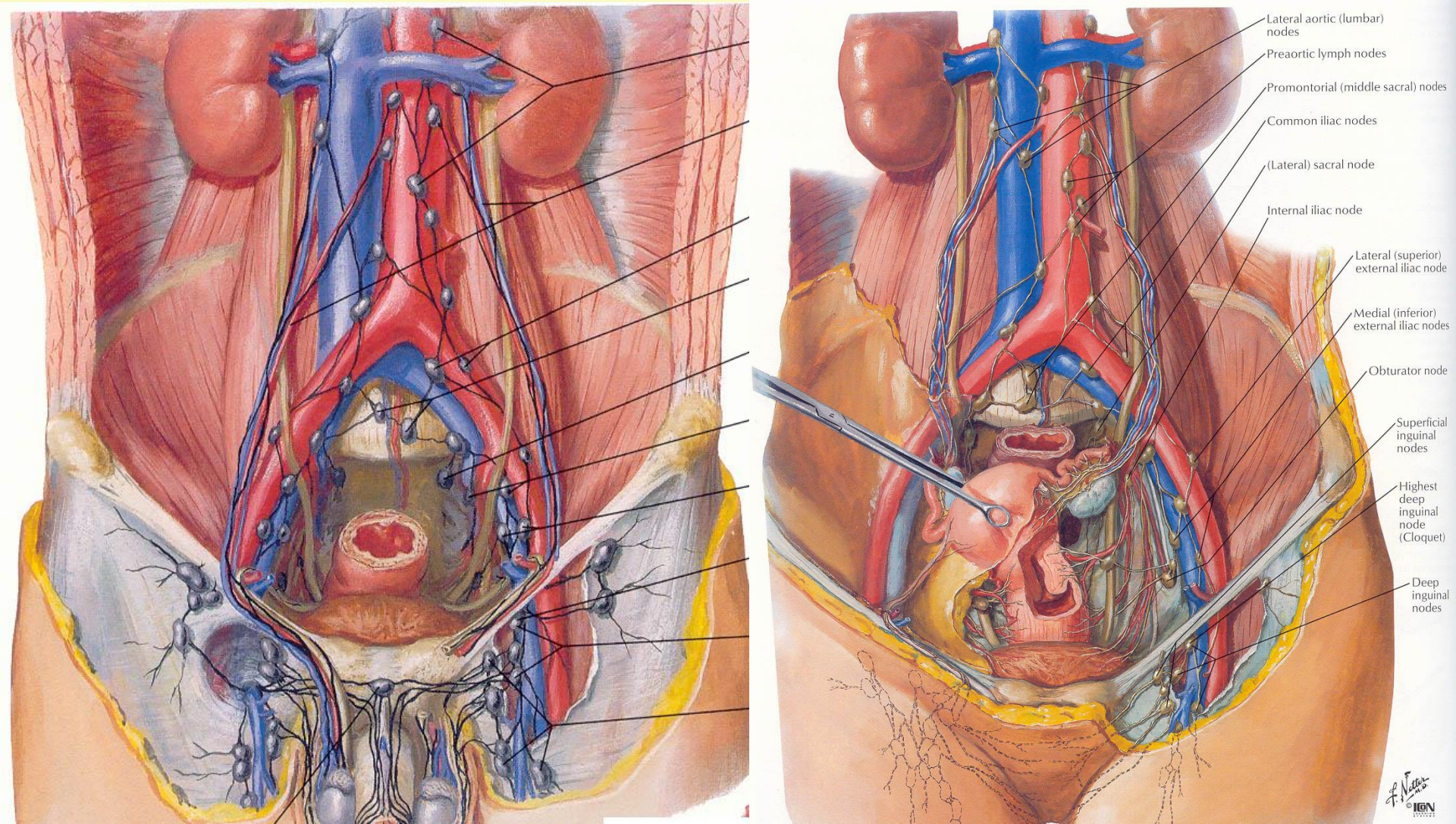
- At the level of lower limb
- Lymphatic vessels:
  - Superficial
  - Deep
- Ganglioni lymphatici poplitei (1-3)
- Ganglioni lymphatici inguinales:
  - Gll. lymphatici inguinales superficiales (4-20)
  - Gll. lymphatici inguinales profundi (1-7)


Cribriform fascia within saphenous opening
Horizontal group:
Superolateral nodes
Superomedial nodes
Vertical group:
Inferior nodes
Fascia lata
Great saphenous vein
Superficial lymph vessels
Deep fascia of leg
Great saphenous vein
Popliteal vein
Popliteal lymph nodes
Superficial inguinal nodes
Small saphenous vein
External iliac lymph nodes
Femoral nerve
Inguinal ligament (Poupart)
Ductus (vas) deferens
Femoral sheath
Femoral canal (opened)
Femoral artery and vein
Great saphenous vein
Femoral ring
Lacunar ligament (Gimbernat)
Deep inguinal lymph nodes

Lymphatic vessels and nodes of the pelvis

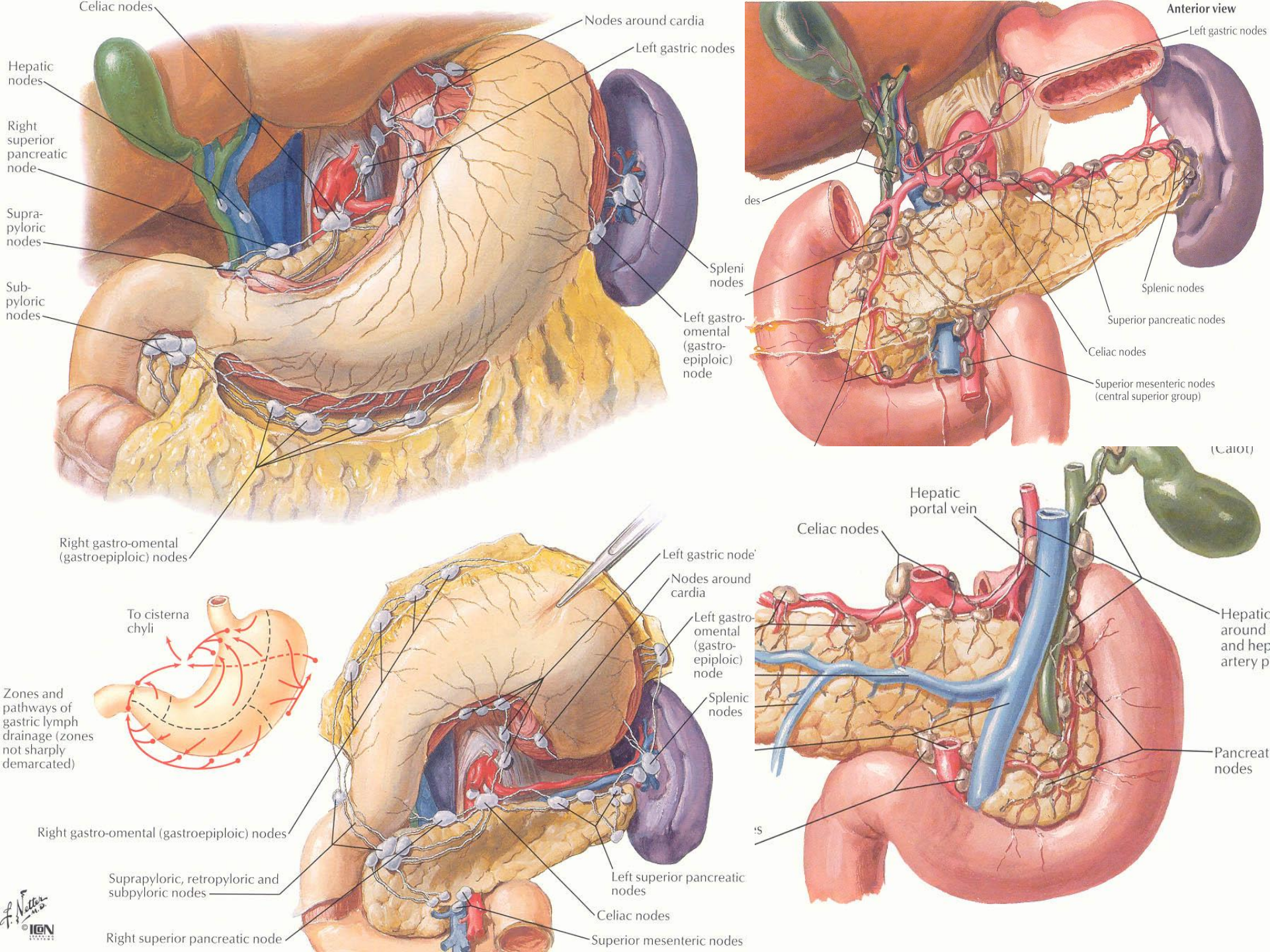
- Nodi **viscerales**:
  - Nodi lymphatici paravezicales
  - Nodi lymphatici parauterines
  - Nodi lymphatici paravaginales
  - Nodi lymphatici pararectales
- Nodi **parietales**:
  - Nodi lymphatici subaortales
  - Nodi lymphatici iliaci communes
  - Nodi lymphatici iliaci interni
  - Nodi lymphatici iliaci externae
  - Nodi lymphatici gluiteales
  - Nodi lymphatici obturatorii
  - Nodi lymphatici sacrales

Lymphatic vessels and nodes of the pelvis

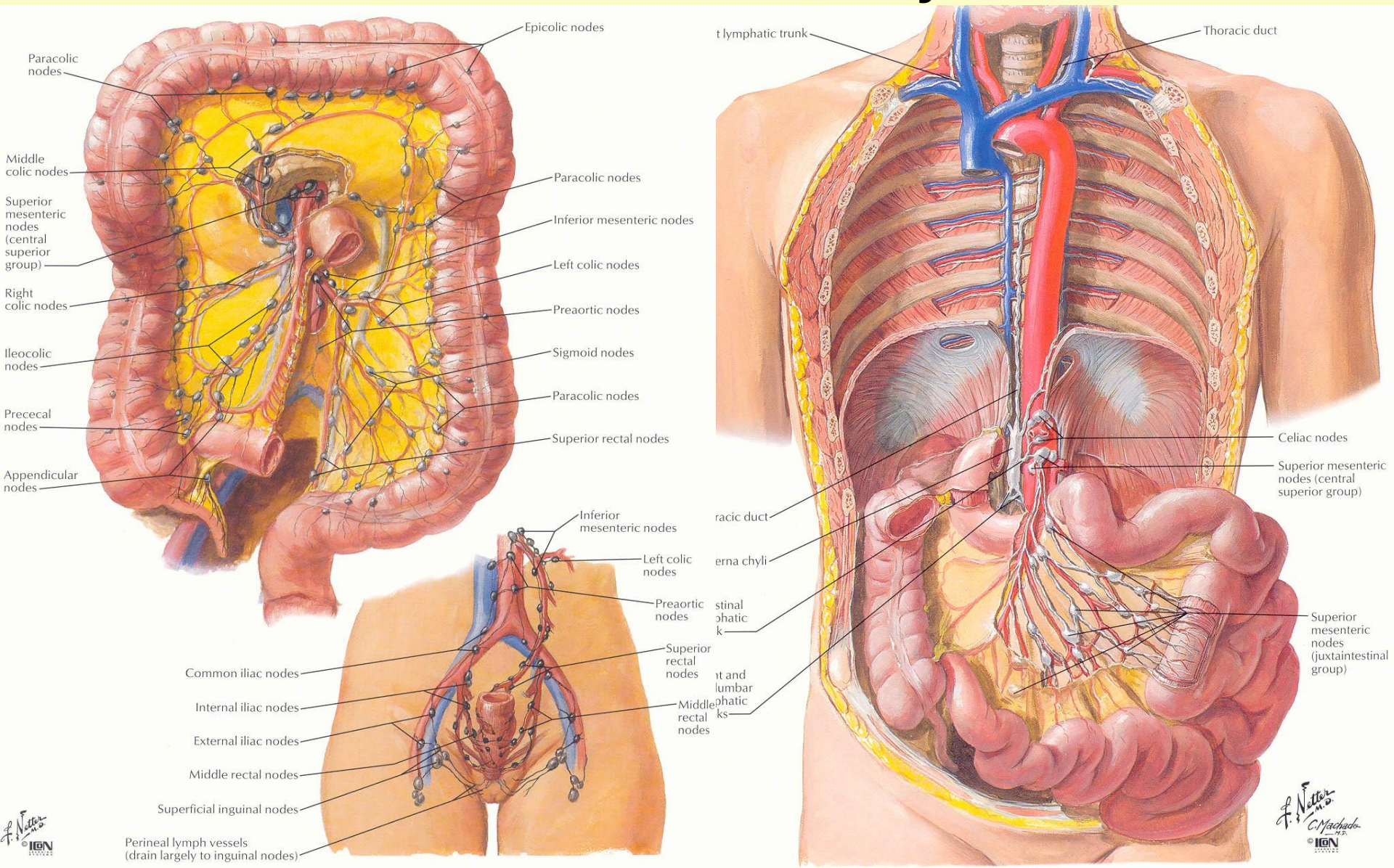


Lymphatic vessels and nodes of the abdominal cavity

- Nodi **viscerales** :
  - Nodi lymphatici coeliaci
  - Nodi lymphatici gastrici
    - Nn. lymphatici gastrici sinistri
    - Nn. lymphatici gastrici dextri
    - Nn. lymphatici pilorici
    - Anulus lymphaticus cardiacus
    - Nn. lymphatici Gastroepiploici dextri
    - Nn. lymphatici Gastroepiploici sinistri
  - Nodi lymphatici pancreatici
  - Nodi lymphatici lienales
  - Nodi lymphatici pancreaticoduodenales
  - Nodi lymphatici hepatici
  - Nodi lymphatici cystici
  - Nodi lymphatici mezenterici
    - Peripheral group (paraintestinales)
    - Middle group
    - Central group


Celiac nodes
Nodes around cardia
Left gastric nodes
Hepatic nodes
Right superior pancreatic node
Supra-pyloric nodes
Sub-pyloric nodes
Splenic nodes
Left gastro-omental (gastro-epiploic) node
Right gastro-omental (gastroepiploic) nodes
Anterior view
Left gastric nodes
Splenic nodes
Superior pancreatic nodes
Celiac nodes
Superior mesenteric nodes (central superior group)
To cisterna chyli
Zones and pathways of gastric lymph drainage (zones not sharply demarcated)
Left gastric node
Nodes around cardia
Left gastro-omental (gastro-epiploic) node
Splenic nodes
Right gastro-omental (gastroepiploic) nodes
Suprapyloric, retropyloric and subpyloric nodes
Right superior pancreatic node
Left superior pancreatic nodes
Celiac nodes
Superior mesenteric nodes
Hepatic portal vein
Celiac nodes
Pancreat nodes

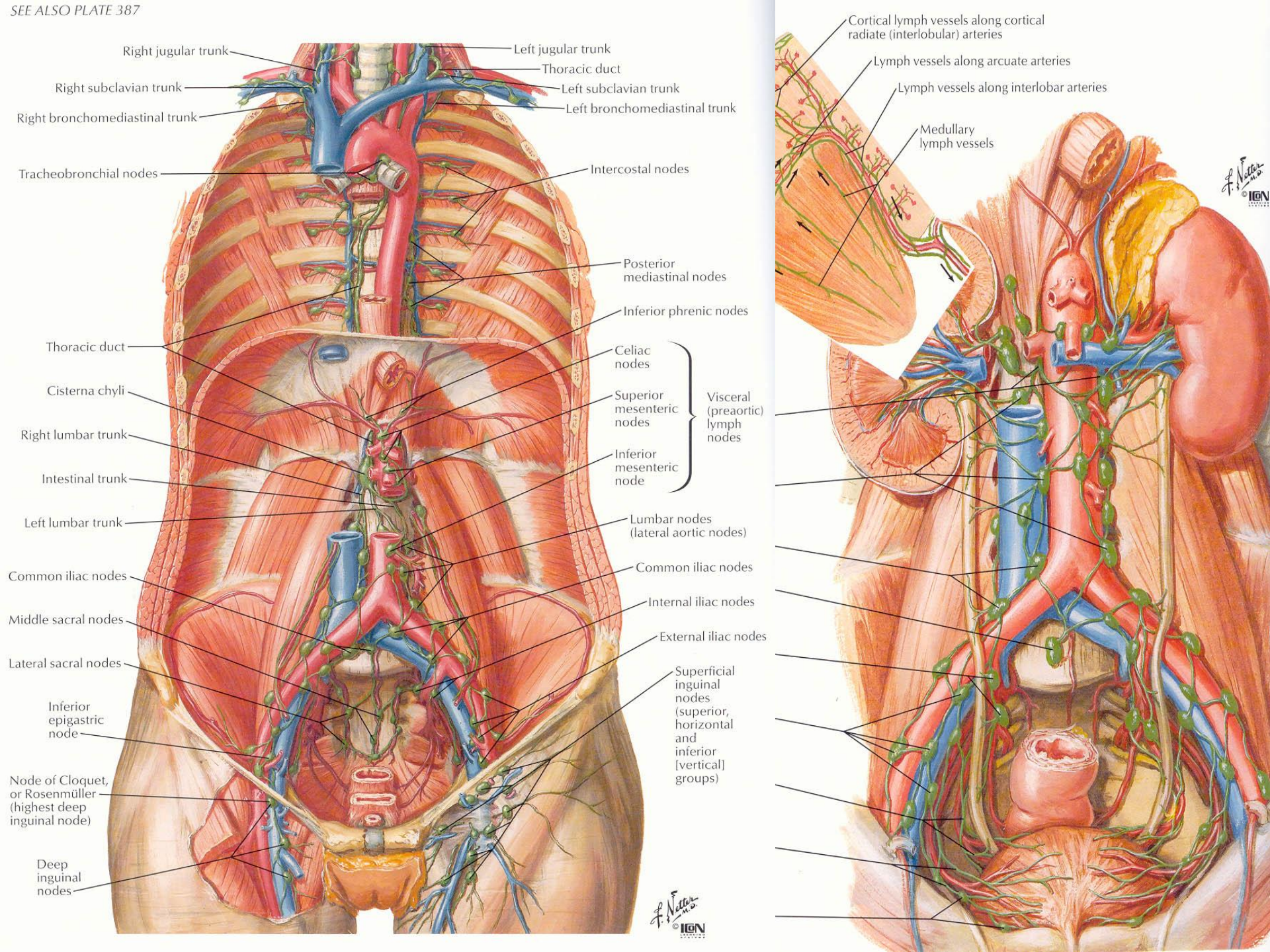
Lymphatic vessels and nodes of the abdominal cavity



Lymphatic vessels and nodes of abdiminal cavity

- Nodi **parietales**:
  - Nodi lymphatici epigastrici inferiores
  - Nodi lymphatici lumbles:
    - sinistri:
      - Nn. lymphatici preaortales
      - Nn. lymphatici postaortales
      - Nn. lymphatici aortales laterales
    - dextri:
      - Nn. lymphatici precavales
      - Nn. lymphatici postcavales
      - Nn. lymphatici cavales laterales
    - intermedii (interaortocavales)
  - Nodi lymphatici phrenici inferiores

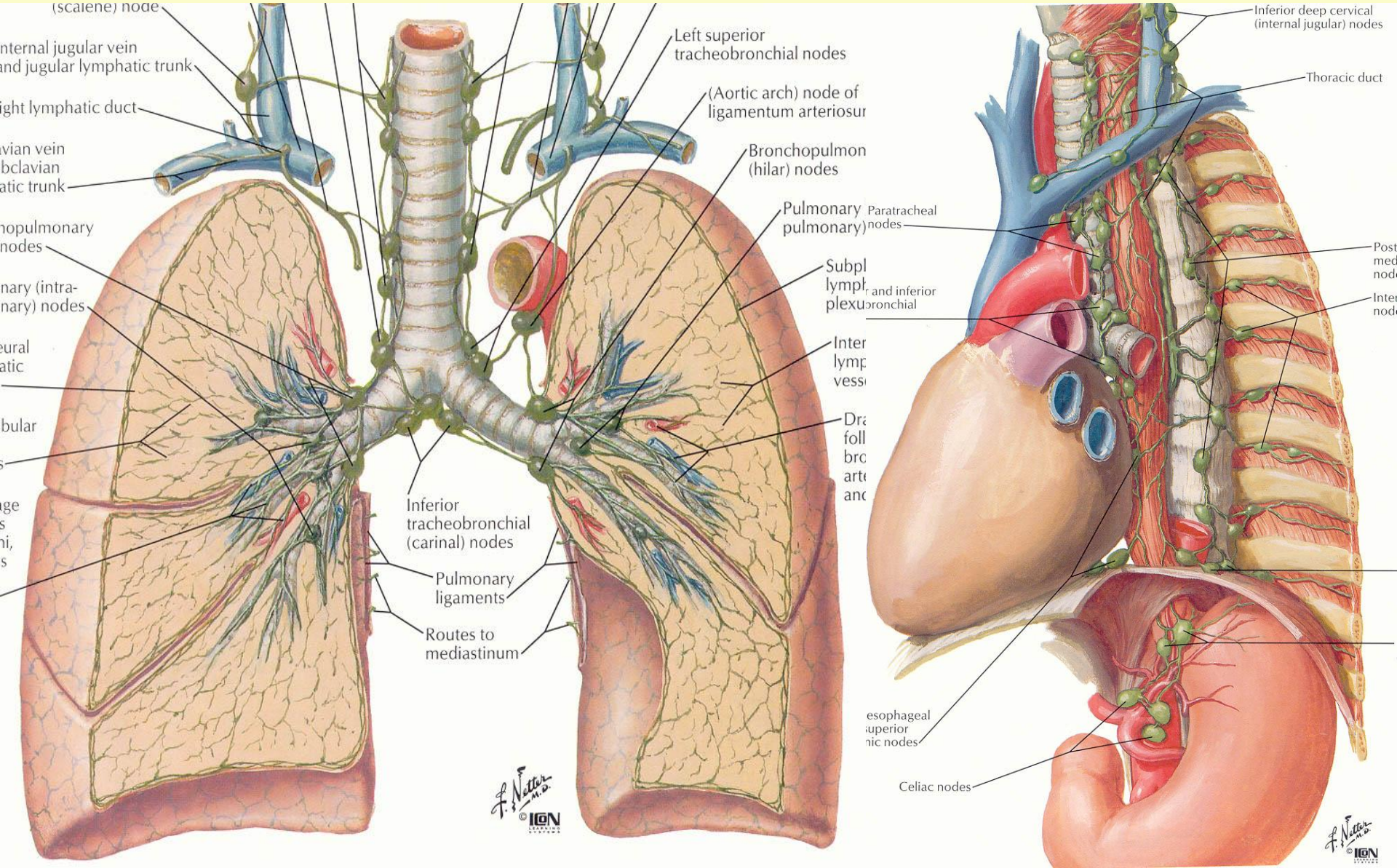
SEE ALSO PLATE 387



Lymphatic vessels and nodes of the thoracic cavity

- Nodi **viscerales**:
  - Nodi lymphatici mediastinales:
    - anteriores:
      - Nn. lymphatici precavales
      - Nn. lymphatici preaorto-carotici
    - posteriores:
      - Nn. lymphatici paraesofagiei
      - Nn. lymphatici interaorto-esofagiei
  - Nodi lymphatici bronchopulmonles dexri et sinistri
    - intraorganici - segmentares, lobares
    - extraorganici - hilares
  - Nodi lymphatici tracheobronhiales:
    - inferiores
    - superiores dexri et sinistri

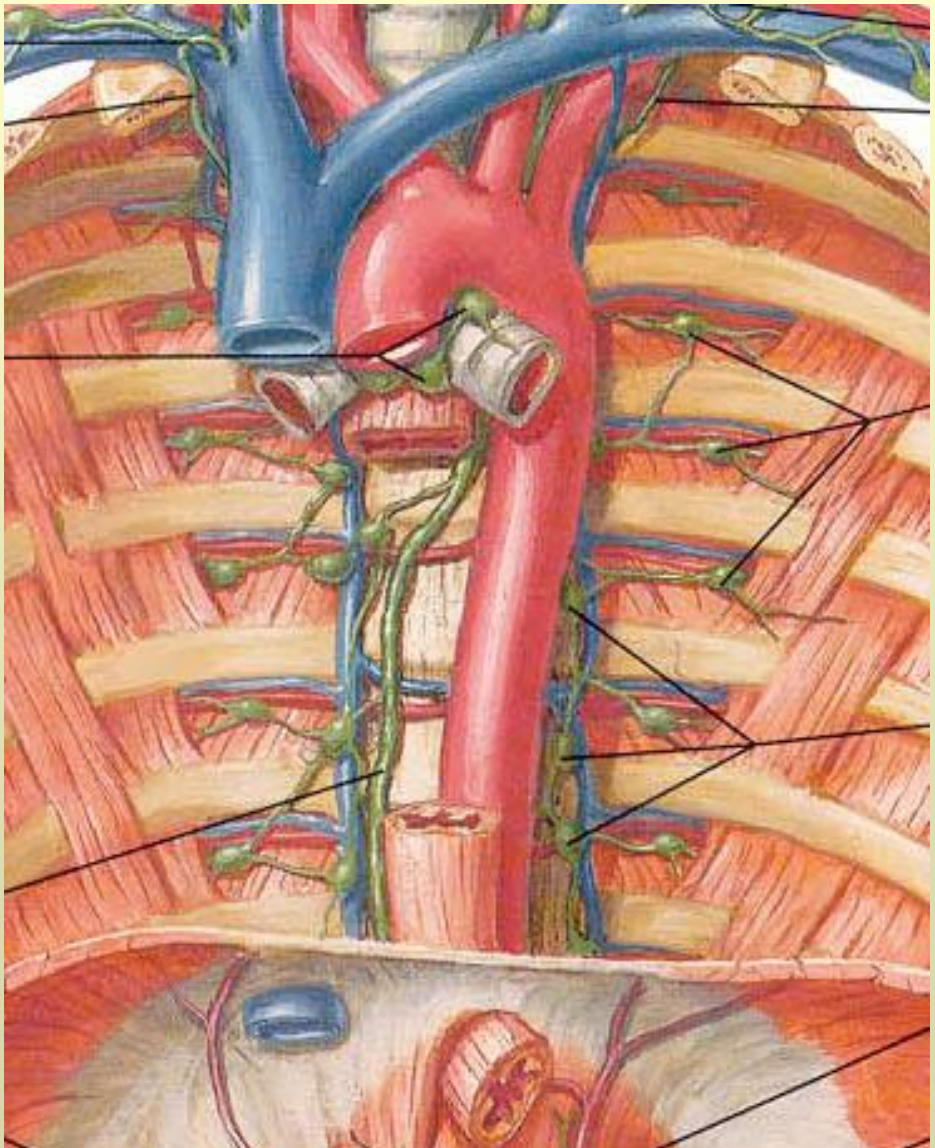
Lymphatic vessels and nodes of the thoracic cavity

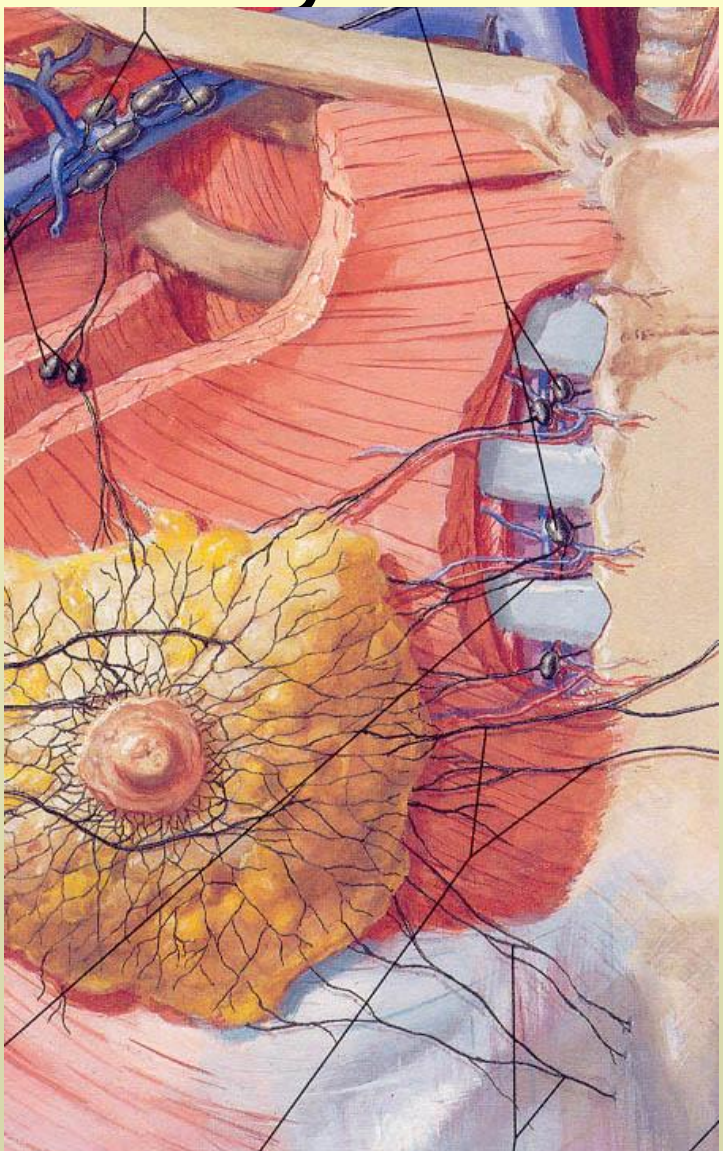


Lymphatic vessels and nodes of thoracic cavity

- Nodi parietales:
  - Nodi lymphatici phrenici superiores
  - Nodi lymphatici parasternales
  - Nodi lymphatici intercostales
  - Nodi lymphatici pericardiaci
  - Nodi lymphatici prepericardiaci

Lymphatic vessels and nodes of the thoracic cavity





Lymphatic vessels and nodes of the **Head** and Neck

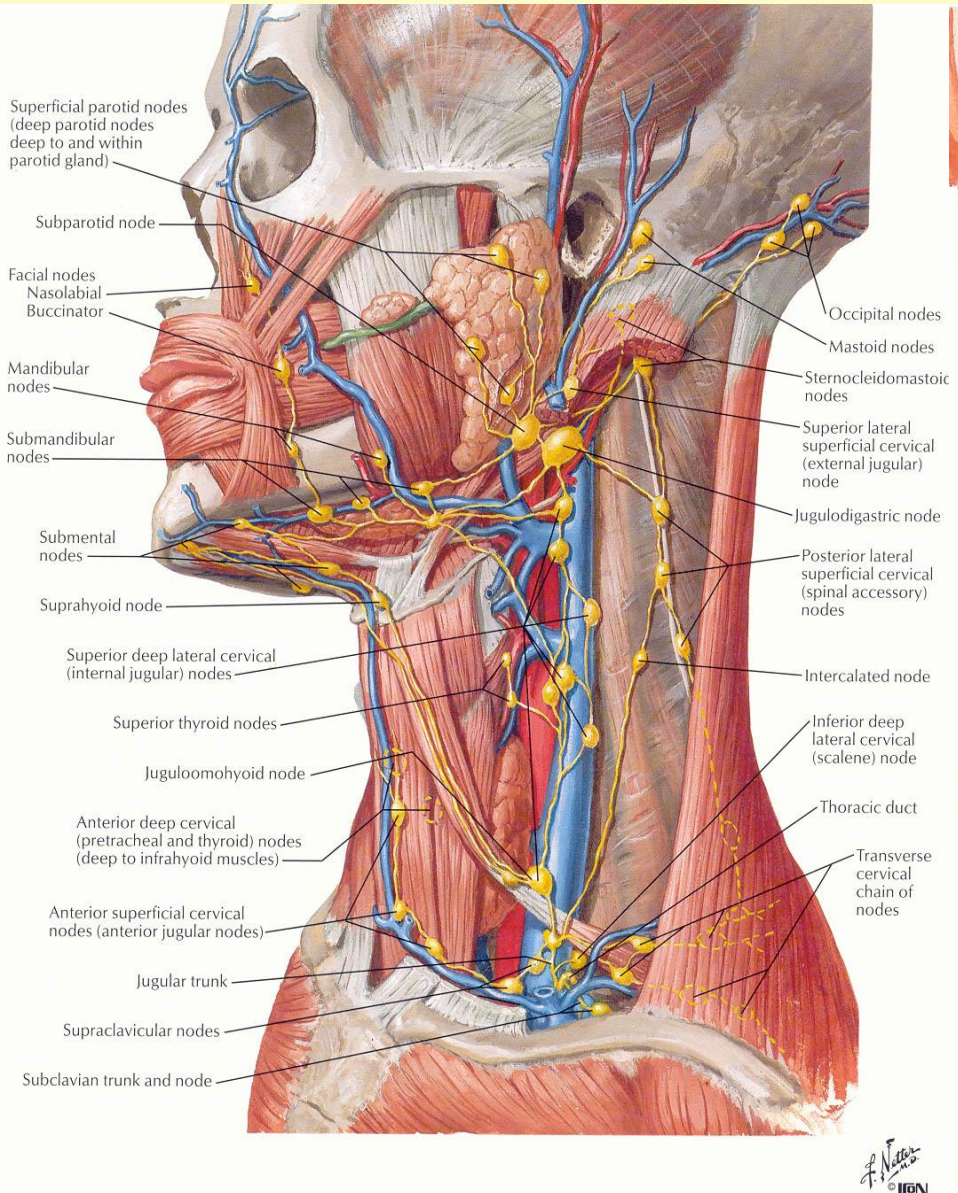
- Nodi **lymphatici occipitales**
- Nodi **lymphatici mastoidei**
- Nodi **lymphatici parotidei (superficiales et profundi)**
- Nodi **lymphatici retrofaringei**
- Nodi **lymphatici mandibulares**
- Nodi **lymphatici faciales**
- Nodi **lymphatici submandibulares**
- Nodi **lymphatici submentales**

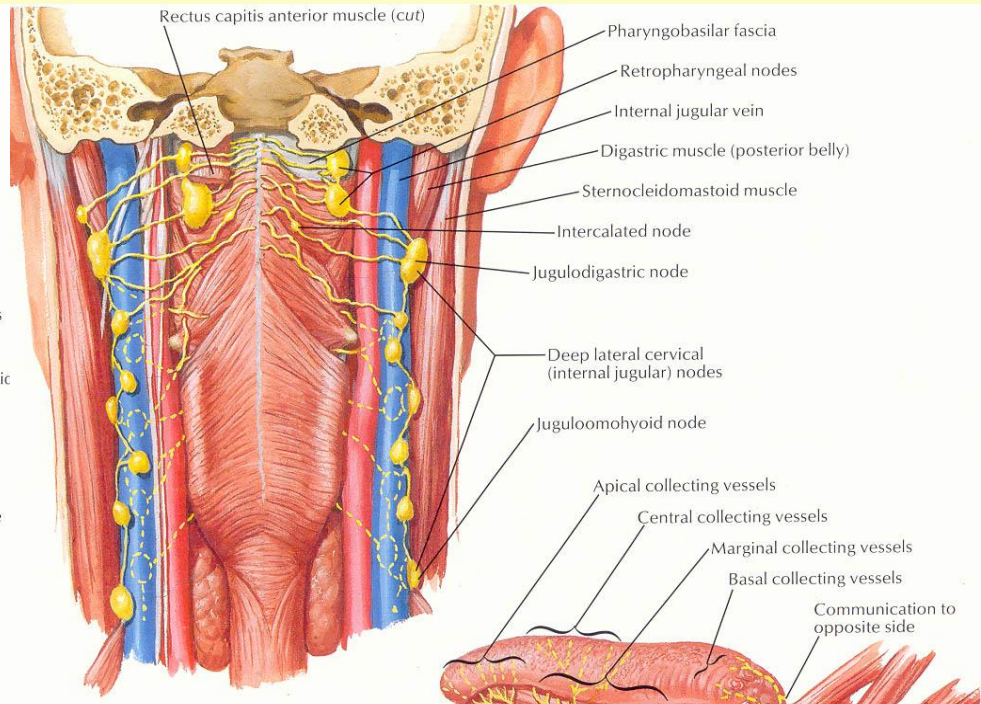
- Nodi *lymphatici cervicales superficiales*
  - *Nn. lymphatici jugulares externi*
  - *Nn. lymphatici jugulares anteriores*
- Nodi *lymphatici cervicales profundi*

  Anteriores
  - *Nn. lymphatici prelaringei*
  - *Nn. lymphatici pretraheales*
  - *Nn. lymphatici paratraheales*

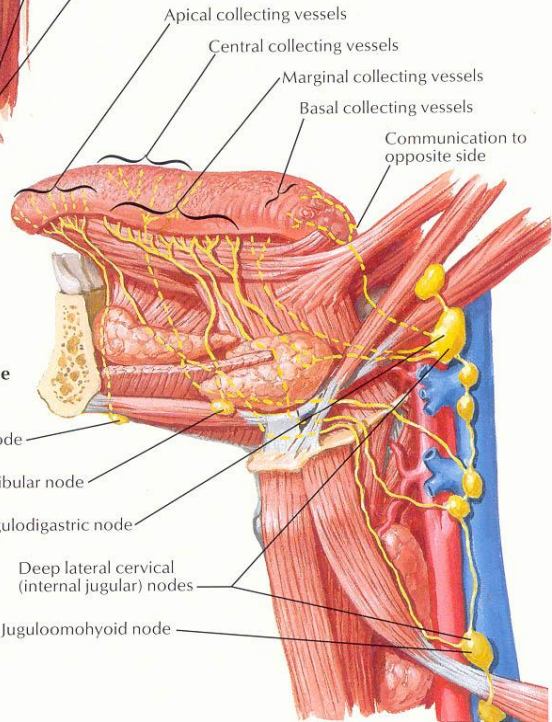
  Laterales
  - *Nn. lymphatici Cervicales laterales profundi (jugulares interni) – superiores et inferiores*
  - *Nn. jugulodigastricus*

Lymphatic vessels and nodes of **Head** and Neck





Lymphatic drainage of pharynx: posterior view

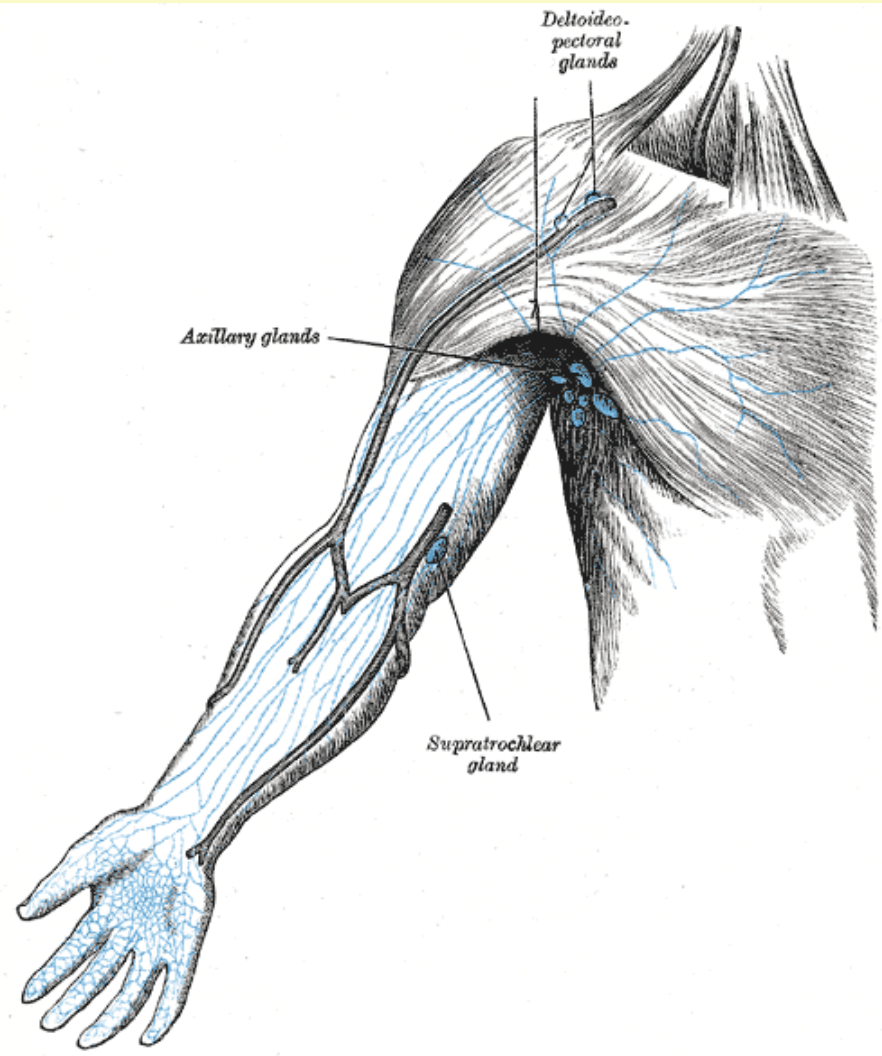


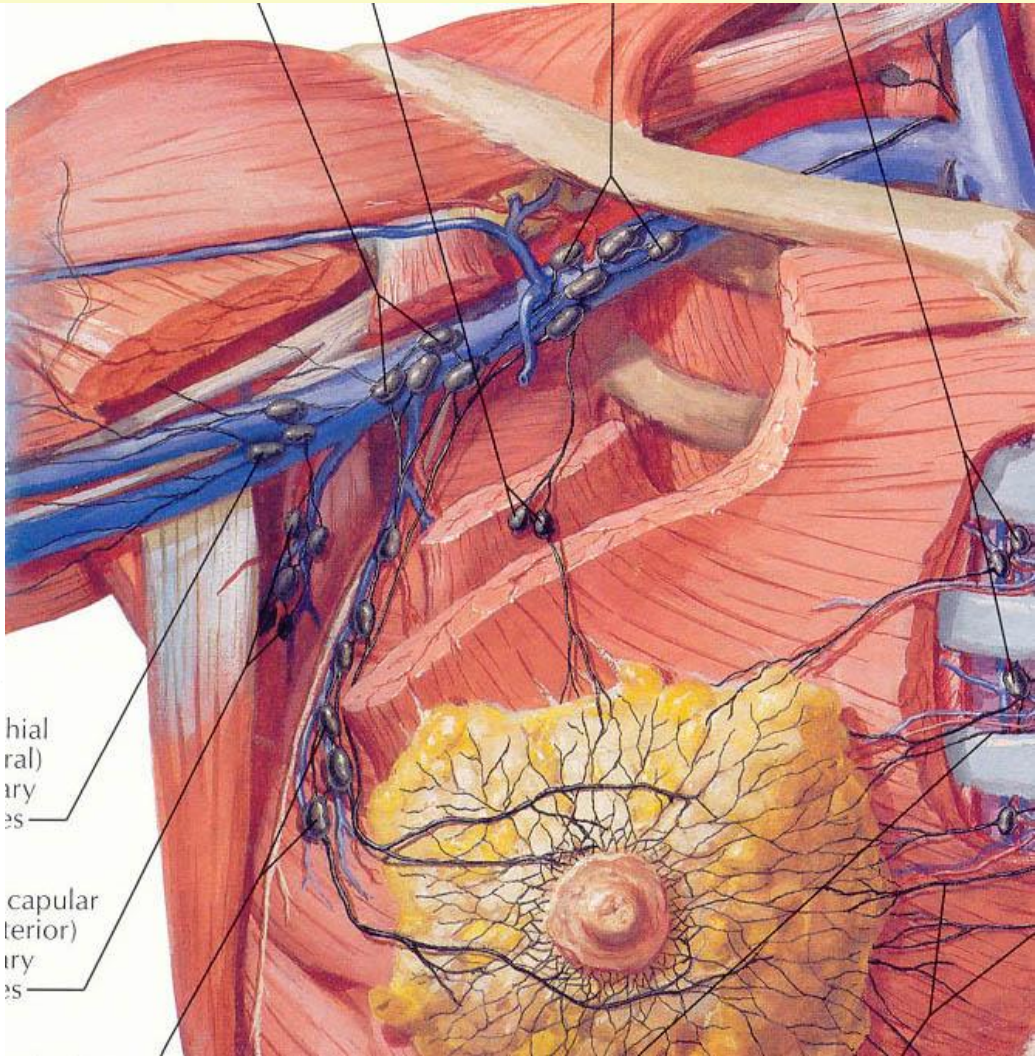
Lymphatic drainage of tongue

Lymphatic vessels and nodes of the upper limb

- Lymphatic vessels and nodes:
  - Superficial
  - Deep
- Nodi lymphatici cubitales (1-3)
- Nodi lymphatici axillares (6 groups):
  1. Nn. lymphatici laterales
  2. Nn. lymphatici mediales (toracici)
  3. Nn. lymphatici subscapulares (posteriores)
  4. Nn. lymphatici inferiores
  5. Nn. lymphatici centrales
  6. Nn. lymphatici apicales

Lymphatic vessels and nodes of upper limb





The Factors, that facilitate the lymphatic circulation

- The somatic and visceral muscular activities (ex. Intestinal peristalsis)
- Aspiration of the pleural cavity during inspiration
- Major pressure of the lymphatic capillaries
- Rhythmic muscular contraction, phases (systolic and diastolic) of the lymphatic vessels
- Motor activity of lymphatic nodes
- Pulsation of the blood vessels

Immune System

For growing up, development, and accommodation to all changes of internal and external environment, the body is always fight with microorganisms and their products.

The maintaining this equilibrium is a duty of the Immune System

Immune System

- Immunity – protection of our organism against genetic foreign structures.

- Immune System – is the sum of all organs and tissues, that maintain the genetic homeostasis of our body, protecting macro-organism against microorganisms, tumor cells, non self cells.

- Functional control is realized by neuro-humoral, paracrine and autocrine mechanisms .

Immunity

- There are 2 major mechanisms of immunity:

  - Nonspecific –standardized answer at foreign invasion

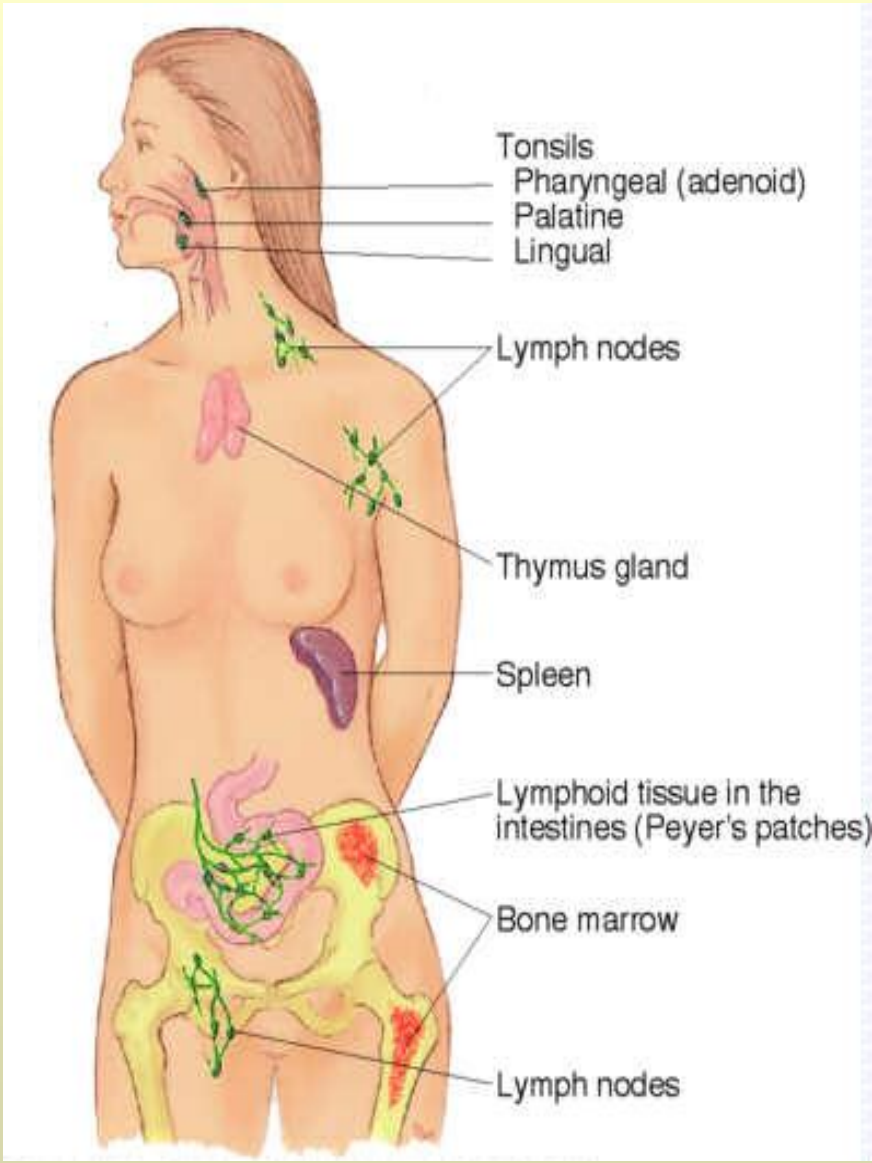
  - Specific – answer in which defense is orientated against exactly to special pathogenic agent.

Immunity

- The activity of Immune System is executed by **cells** and their **secretes**.
  - In Nonspecific Immunity :
    - Neutrophyles
    - Monocytes
    - Macrophages
    - Natural killer cells (NK)
  - In Specific Immunity :
    - Lymphocytes T
    - Lymphocytes B

Immune System

- Central Organs
  - Bone marrow (red and yellow)
  - Thymus
- Peripheral Organs
  - Lymphatic nodes
  - Spleen
  - Lymphoid tissue (associated to mucous of tubular organs) MALT from:
    - Digestive System
      - » pharinx (ring Waldayer)
      - » Small and large intestine (foliculii limfatici solitari, agregaţi, apendicele vermiform)
    - Respirator System
    - Urogenital Apparatus

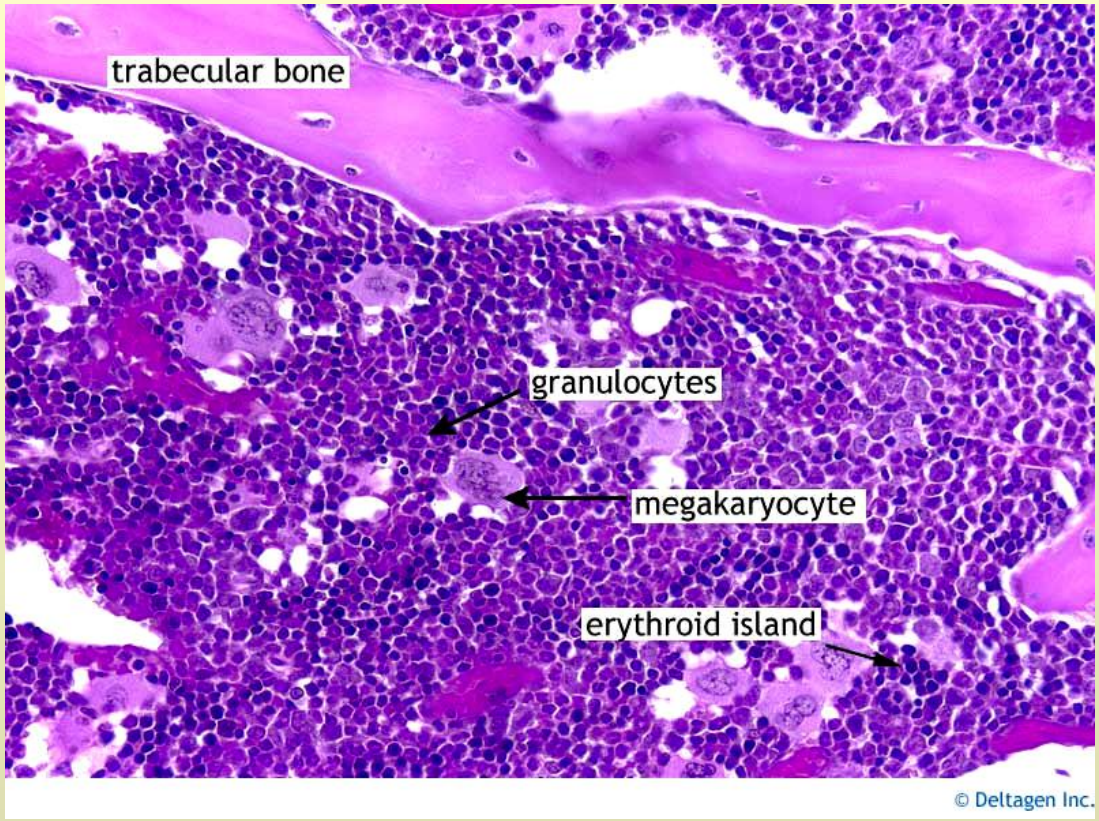


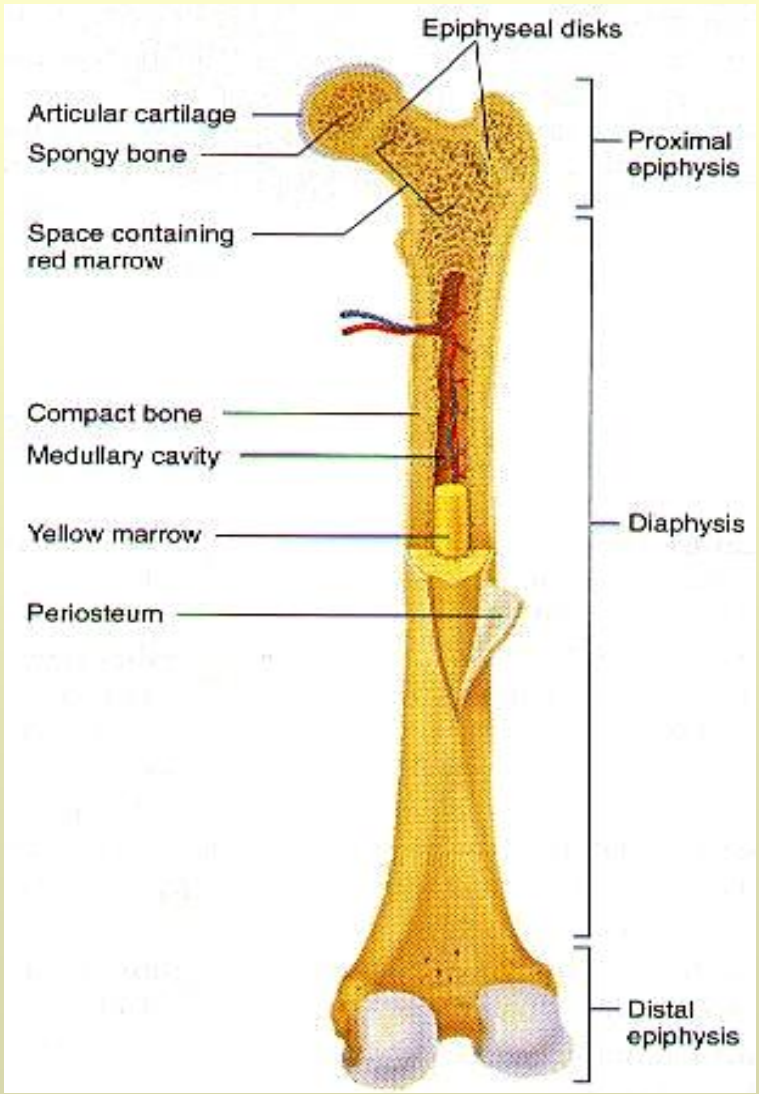
Red bone marrow

- There are:
  - Red bone marrow
  - Yellow bone marrow

- Red bone marrow contain:
  - Cells of myeloid line (erythrocyte, granulocyte (polimorphonuclear), thrombocyte)
  - Cells of lymphoid line (lymphocyte)

Red bone marrow



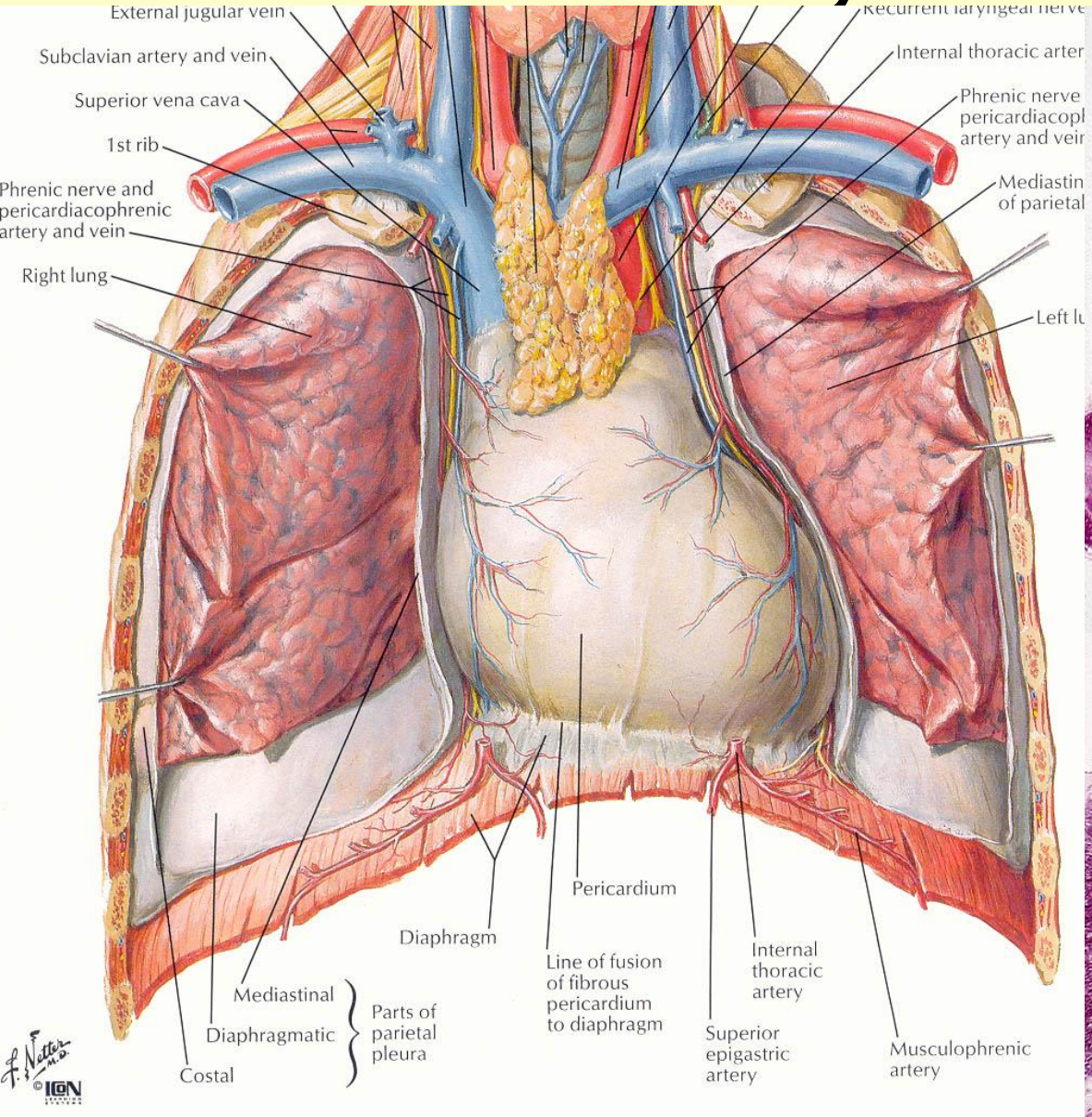


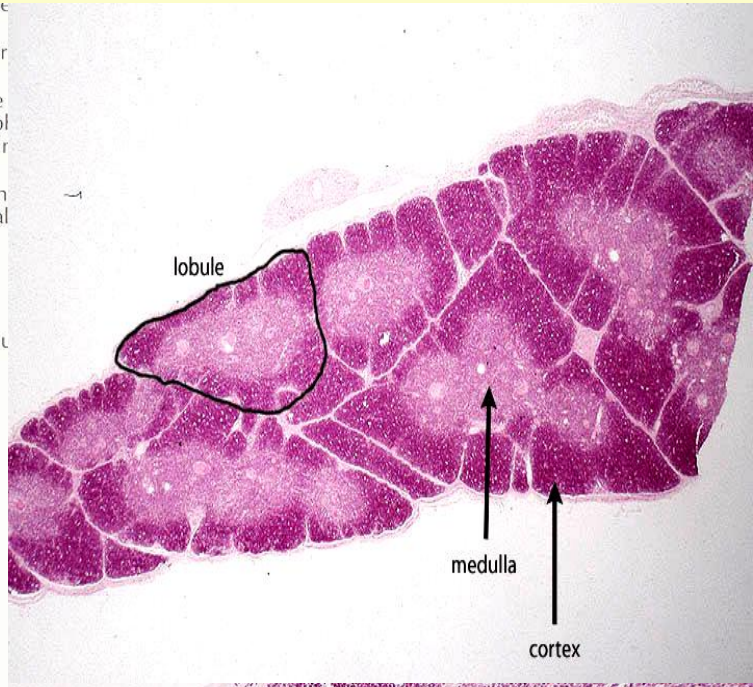
Red bone marrow
Yellow bone marrow

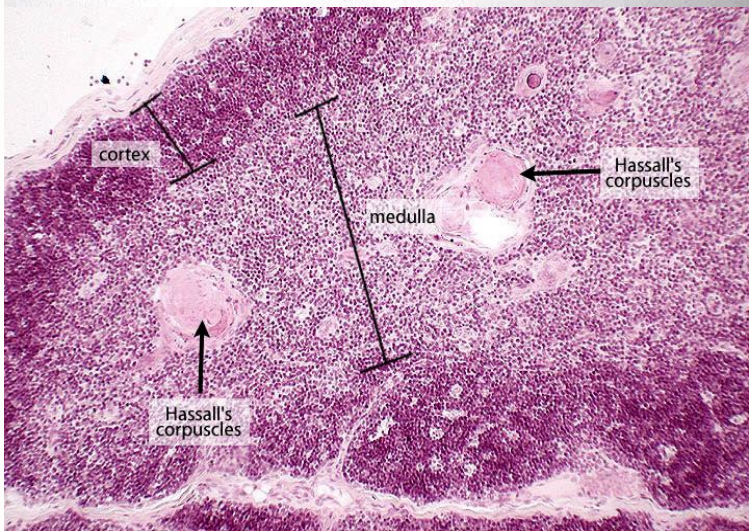
Thymus

- **The central** immune organ (place of antigen independent differentiation of lymphocytes T).
- Hematopoietic Organ (embryonic in period, begining with week.7-8; granulocyte- and lymphocytopoesis)
- Formed by right lobe and left lobe
- Localized in superior mediastinum
- Structure:
  - Conjunctiva Capsule
  - Septa
  - Lobule –morpho-functional unit
  - Parenchyma
    - Cortical Substance (barrier hemato-thymic)
    - Medullar Substance (Hassall corpuscle)
  - Stroma (reticulo-epithelial tissue)

Thymus


External jugular vein
Subclavian artery and vein
Superior vena cava
1st rib
Phrenic nerve and pericardiacophrenic artery and vein
Right lung
Recurrent laryngeal nerve
Internal thoracic arter
Phrenic nerve pericardiacopl artery and veir
Mediastin of parietal
Left lu
Pericardium
Diaphragm
Line of fusion of fibrous pericardium to diaphragm
Internal thoracic artery
Superior epigastric artery
Musculophrenic artery
Mediastinal
Diaphragmatic
Costal
Parts of parietal pleura

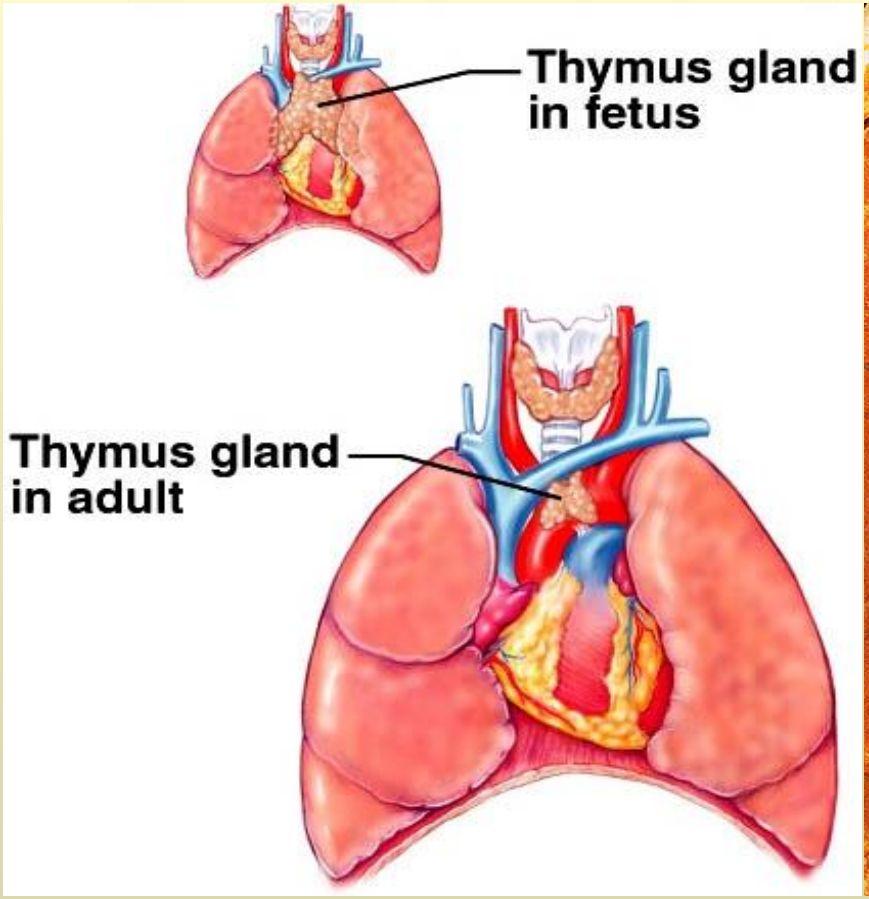

lobule
medulla
cortex

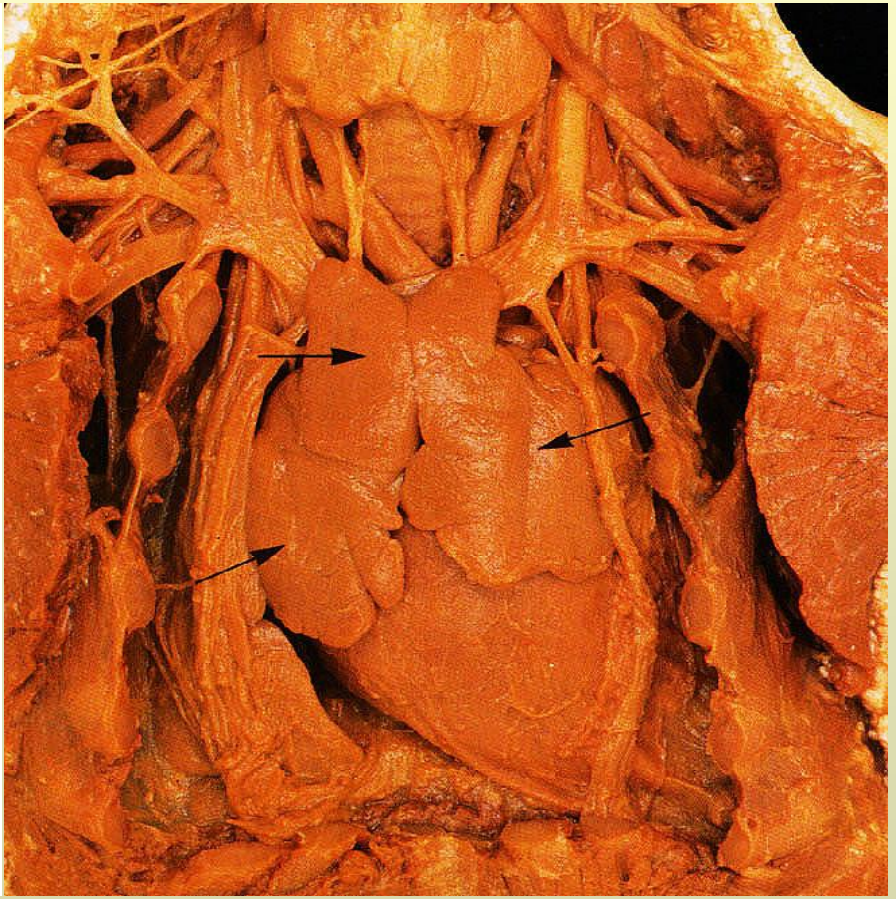

cortex
Hassall's corpuscles
medulla
Hassall's corpuscles

Thymus

- It is developed from bronchial pouches III-IV (4-5 week- 24 week)
- In newborn present 13 gr. weight; at 3-20 years the mass is 30 gr.; after 20 years– 15 gr.
- Until 10 years predominate the cortical substance, after dominance move to medulla.
- In the process of involution the thymus parenchyma **does not** despaired at all, but persist as island surrounded by fat tissue.

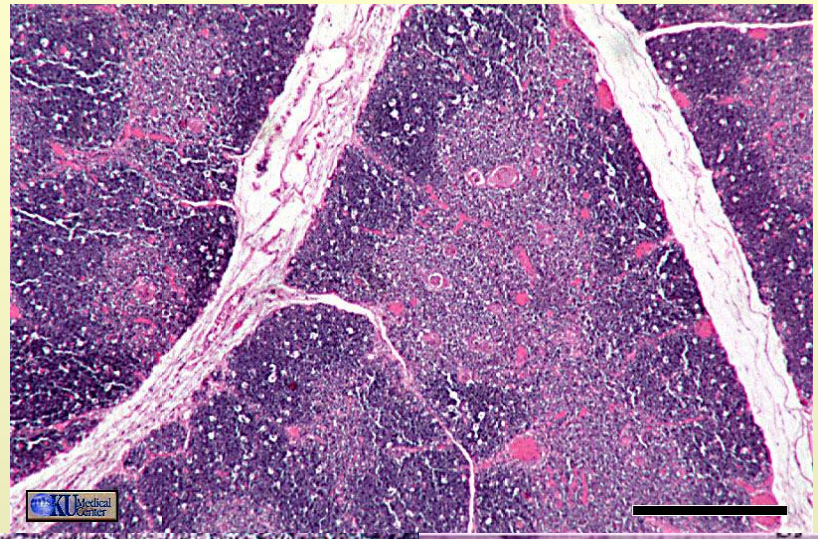
Thymus



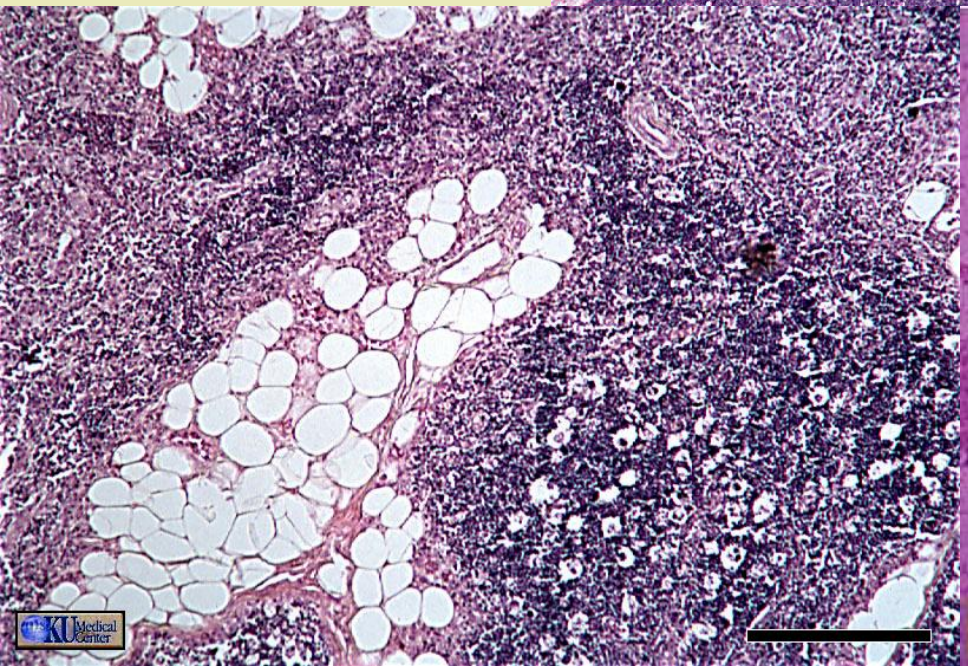


Thymusul

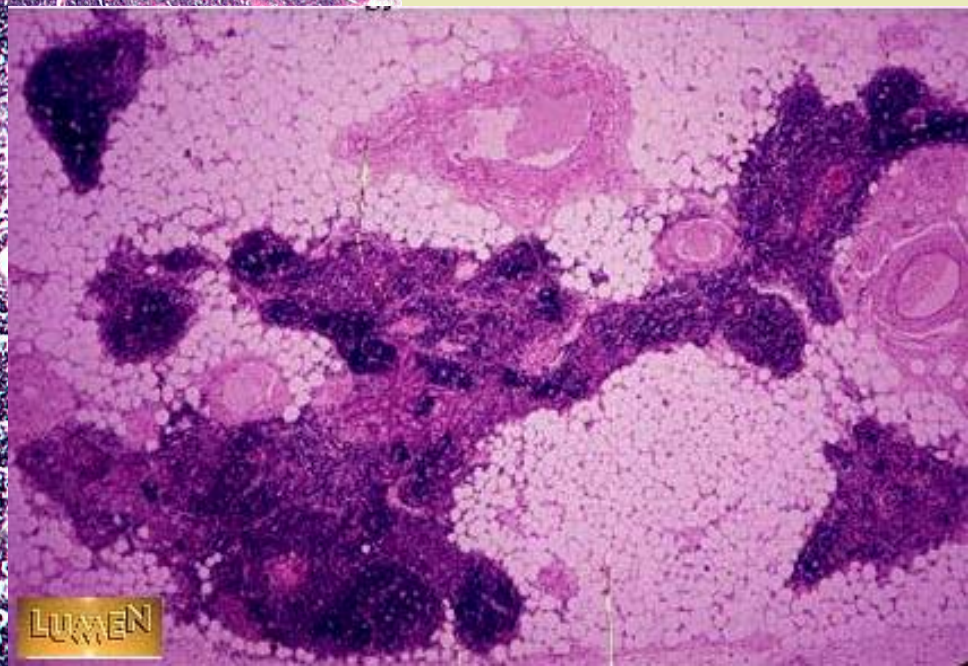
child



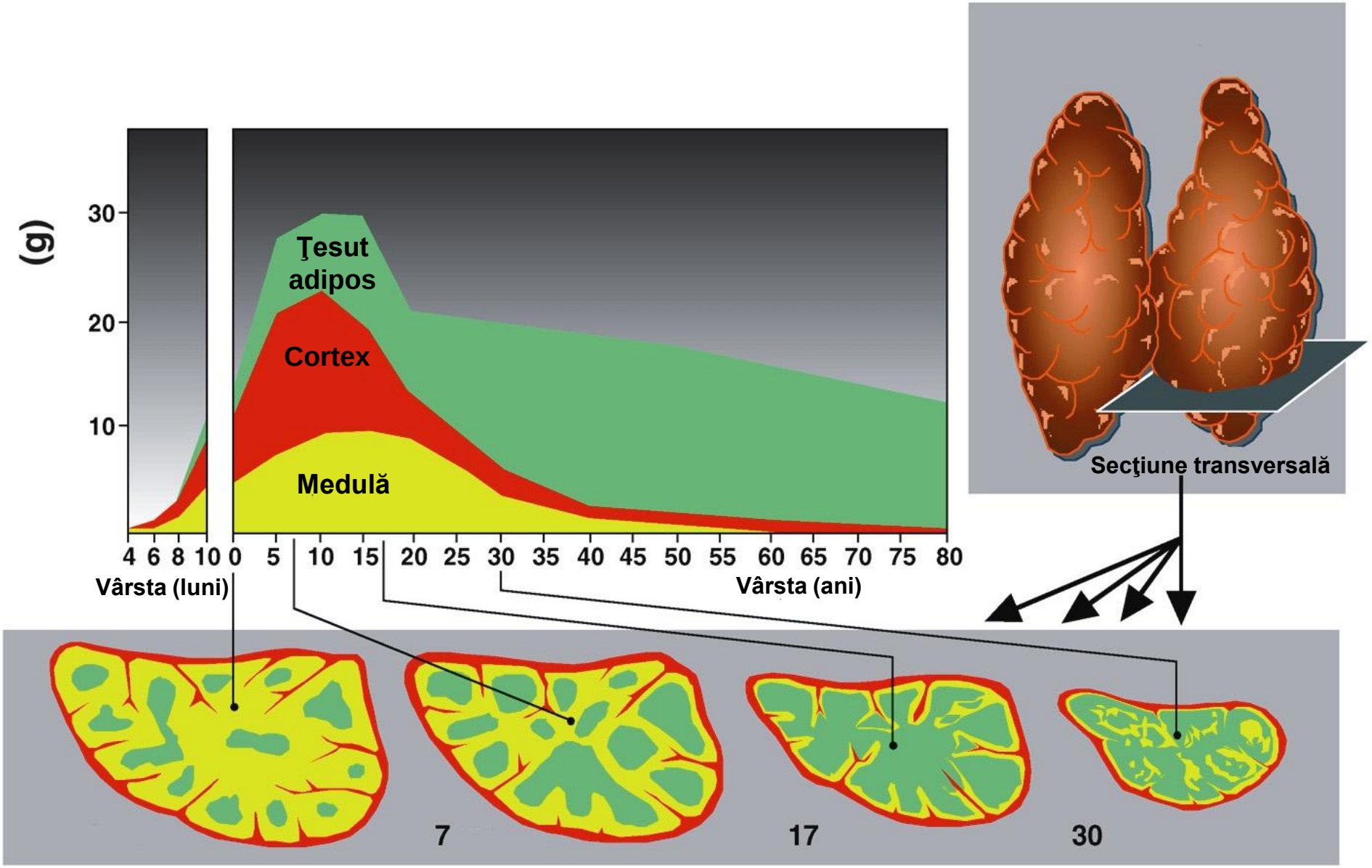
20 years



50 years

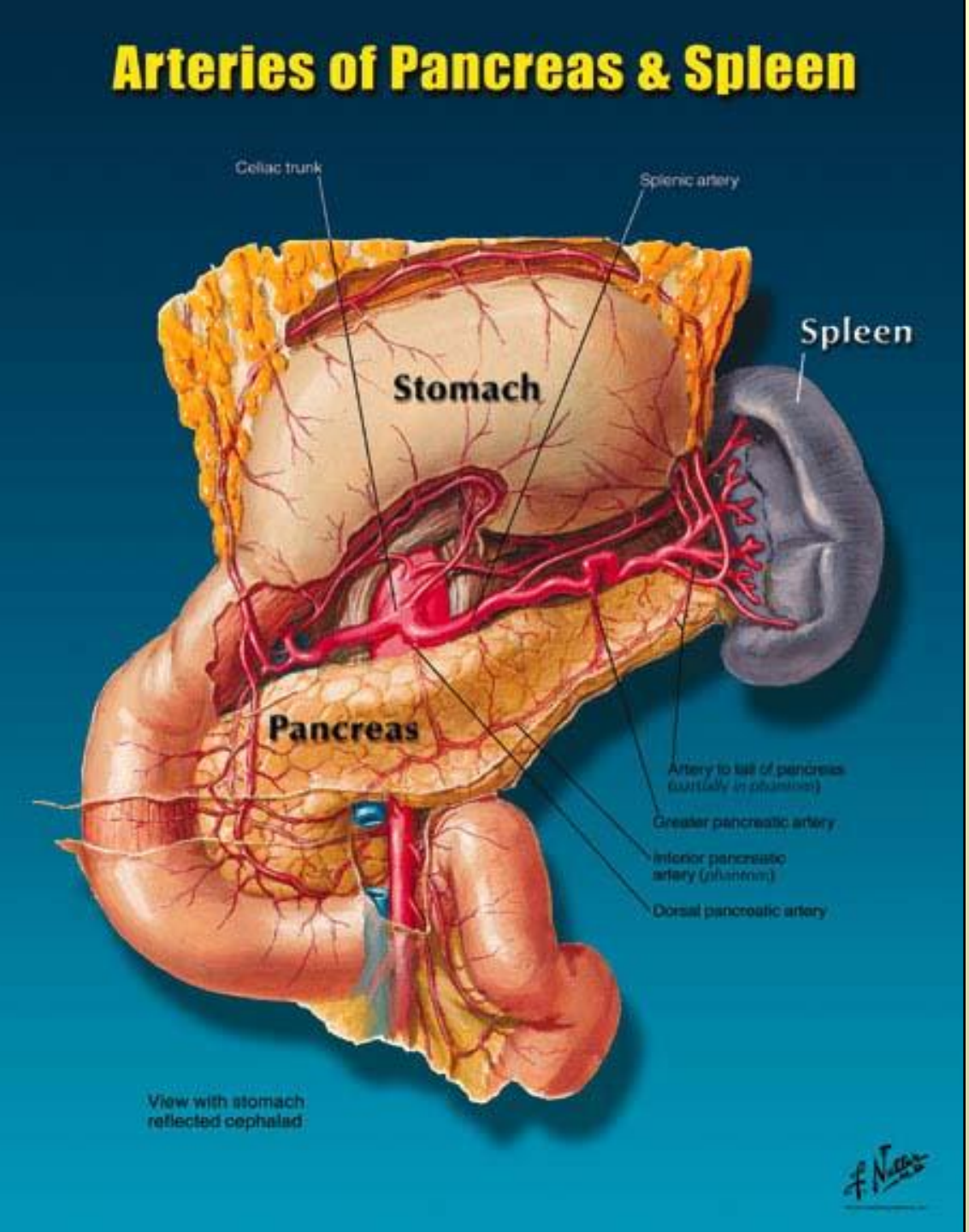


Thymus Involution

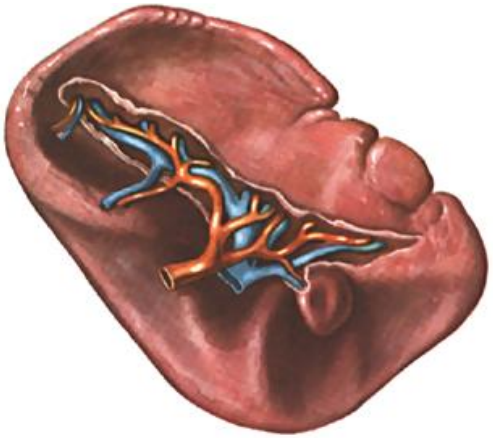


Spleen

- Peripheral immune Organ (place of antigen dependent differentiation of lymphocytes
- Function:
  - Filtrate
  - The large secondary organ al immune system
  - Hemathopoiesis (intrauterine – universal, after birth - lymphopoetic)
  - Reservoir for blood
  - Place for break down of erythrocytes and thrombocytes
  - Participate in metabolism of Hemoglobin (transferine, bilirubine, Bile ac)
  - Is considered for blood system, as lymphatic ganglion for lymphatic system
- Distinguish:
  - Diaphragmatic Surface
  - Visceral Surface
  - Lienal hilum
  - Superior Margin (anterior)
  - Inferior Margin (posterior)
  - Superior Pole
  - Inferior Pole
- Localized in abdominal cavity (intraperitoneal)
- Reports to stomach, pancreas, kidney, left suprarenal gl., colon (flexura colica sinistra), ribs IX-XI.

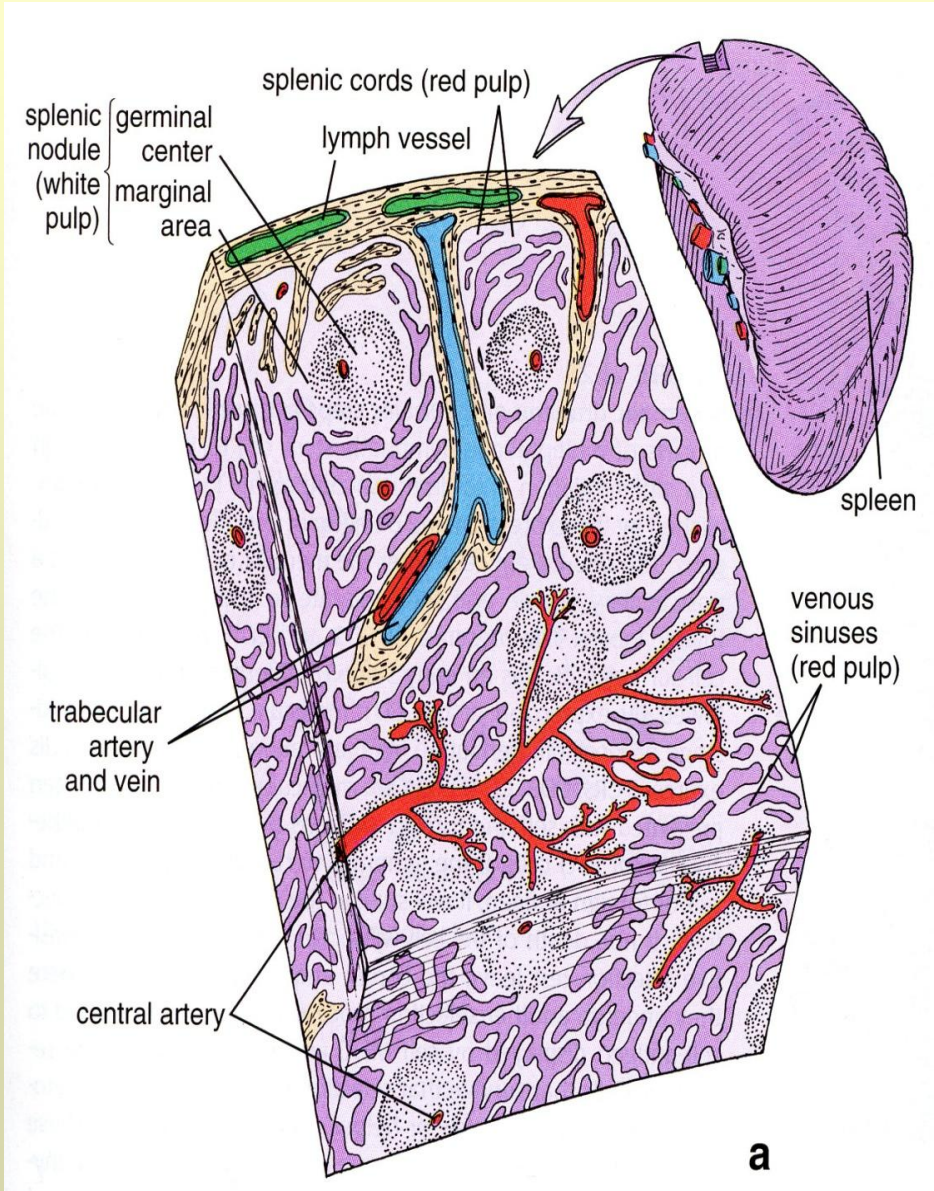

Arteries of Pancreas & Spleen
Celiac trunk
Splenic artery
Spleen
Stomach
Pancreas
Artery to tail of pancreas
Greater pancreatic artery
Inferior pancreatic artery
Dorsal pancreatic artery
View with stomach reflected cephalad

Spleen

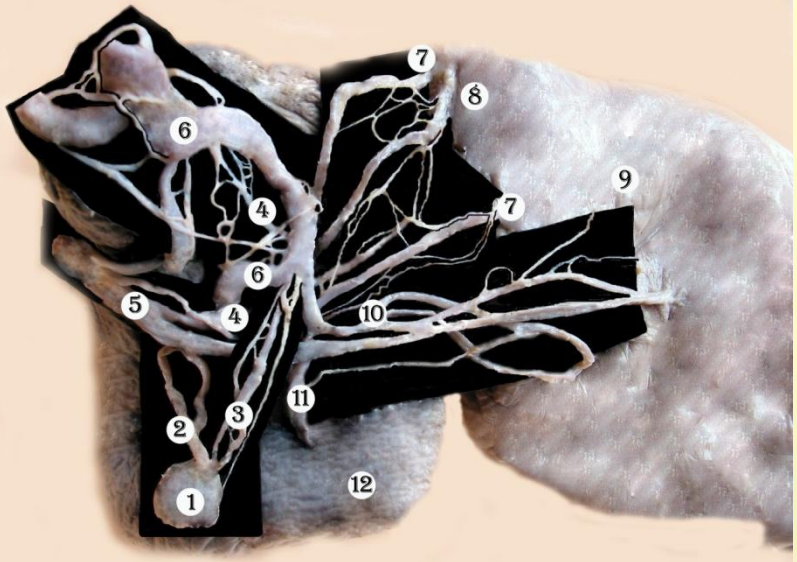


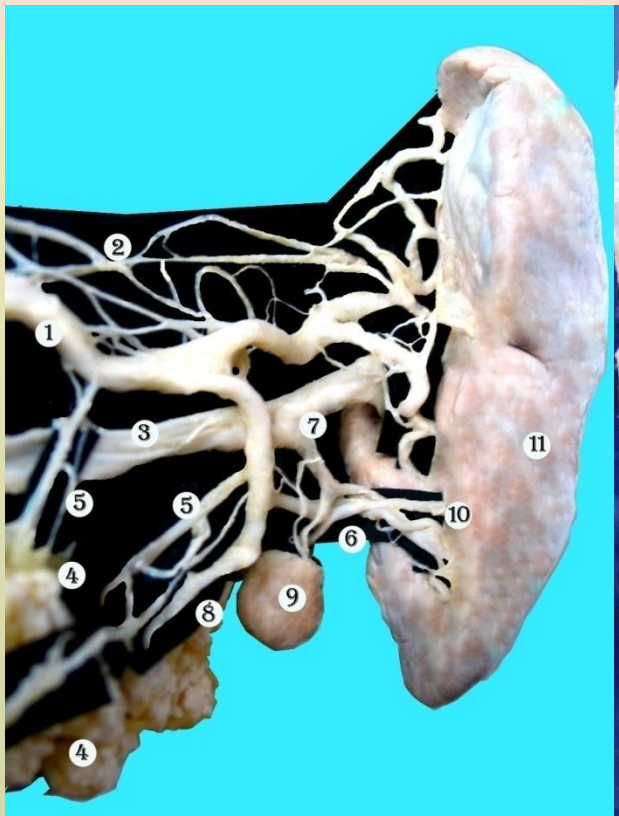
Spleen (Lien)

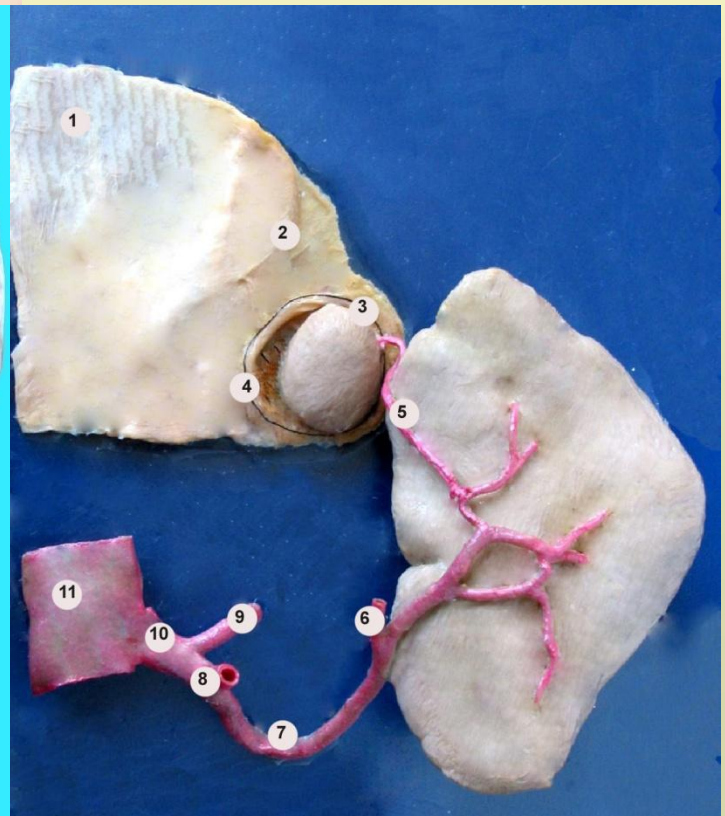
- Structure:
  - Conjunctive capsule and trabecules in association with myocyites
  - Parenchyma
    - White Pulp (all lymphoid nodes)
    - Red Pulp (venous sinusoid)
  - Stroma (reticular tissue)
  - Abundant blood supply (tip opened and closed circulation)
- Congenital Anomalies :
  - Complete Absence
  - Spleen Hypoplazia
  - Accessory Spleens (spleniculi)
- Pathology:
  - Splenomegalia
  - Ruptures of spleen



Spleniculi



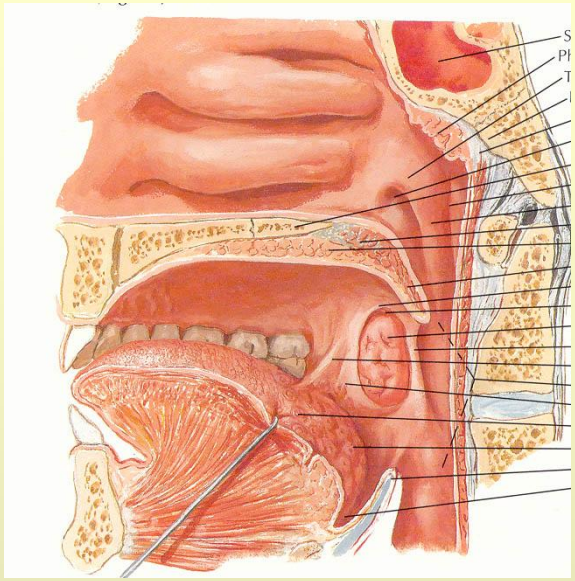




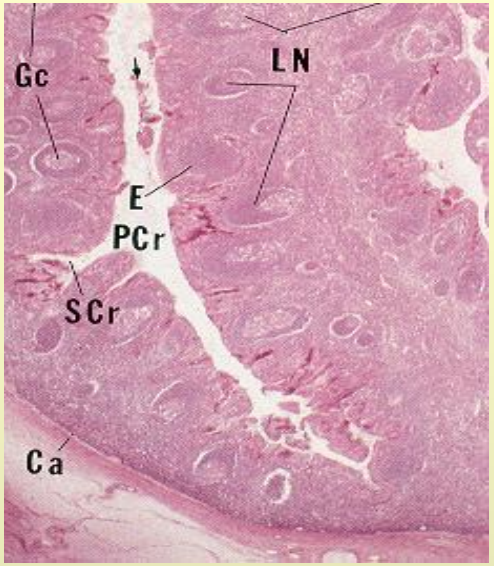
Disseminate Lymphoid tissue (associated to mucous coat)

- Digestive System:
  - Pharyngeal lymphoid ring (lingual, pharyngeal, palatine, tubal tonsils)
  - Solitary Lymphoid Nodules
  - Aggregate Lymphoid Nodules (Peyer patches)
  - Lymphoid Nodules of vermiform appendices
- Respirator System (MALT)
- Urogenital Apparatus

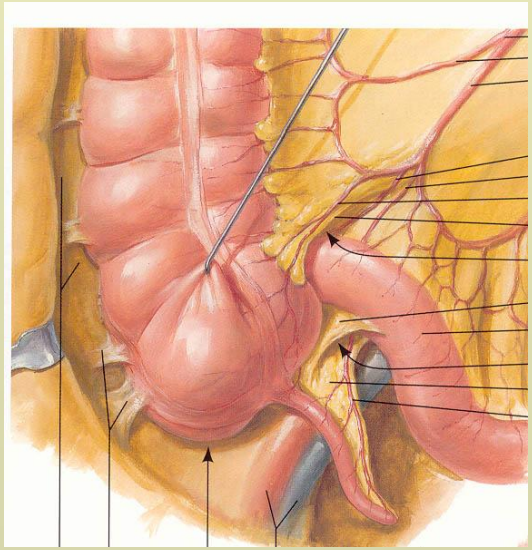
Disseminate Lymphoid tissue



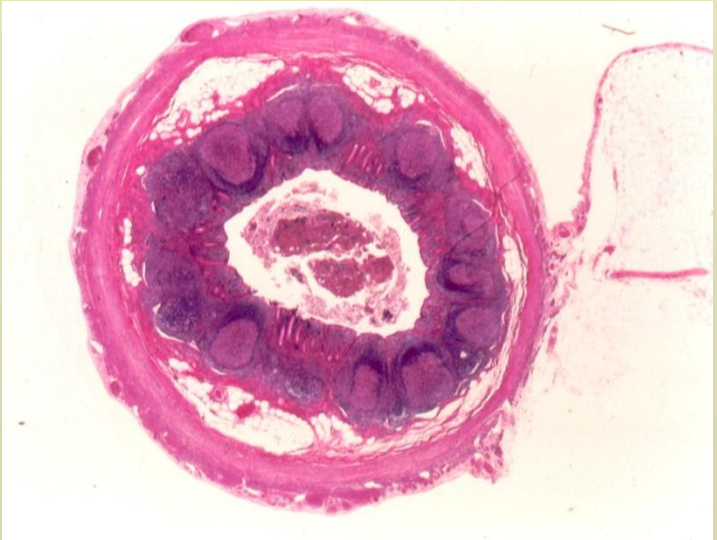
Pharyngeal lymphoid ring

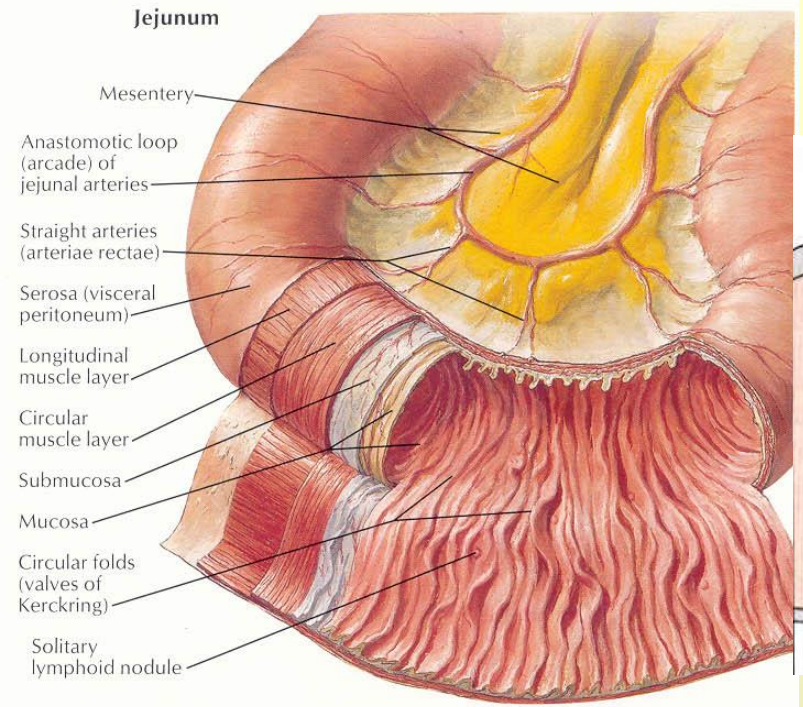


Pharyngeal and palatine tonsils

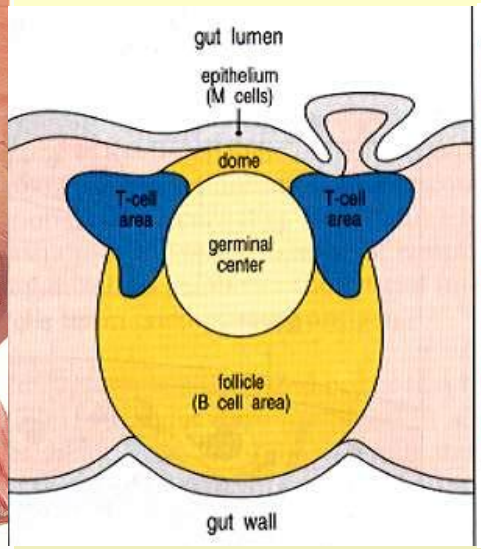


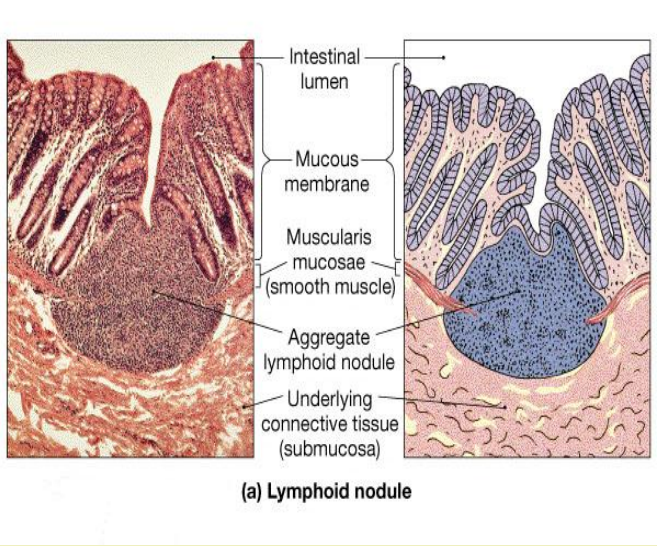
Lymphoid Nodules of vermiform appendices

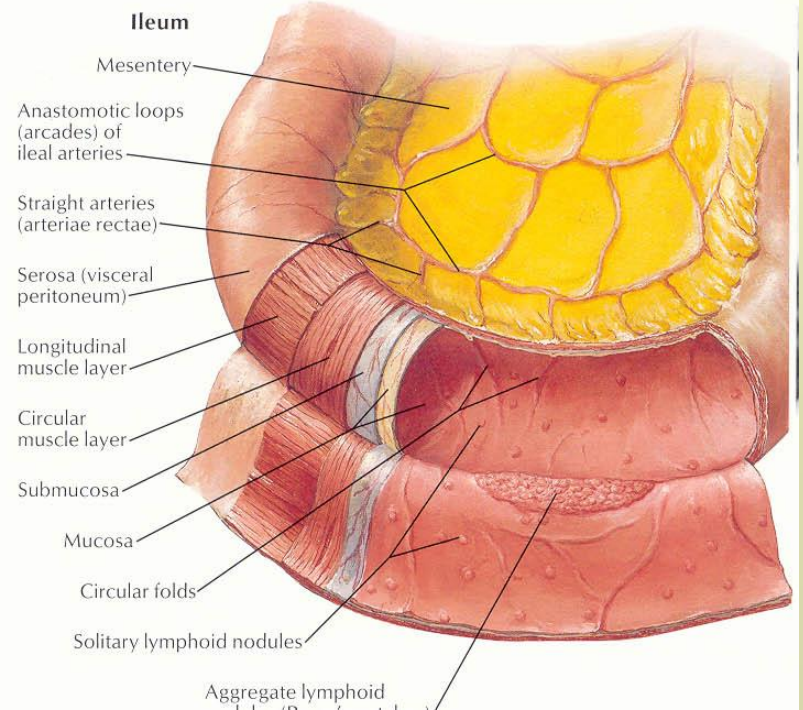




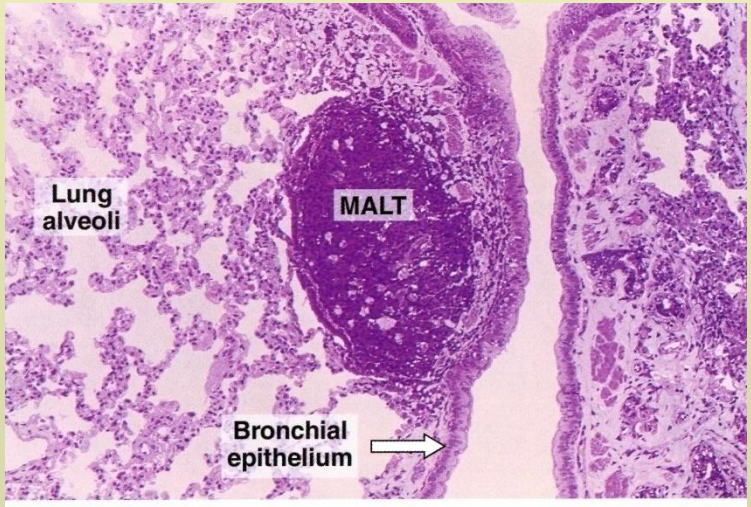
Solitary Lymphoid Nodules



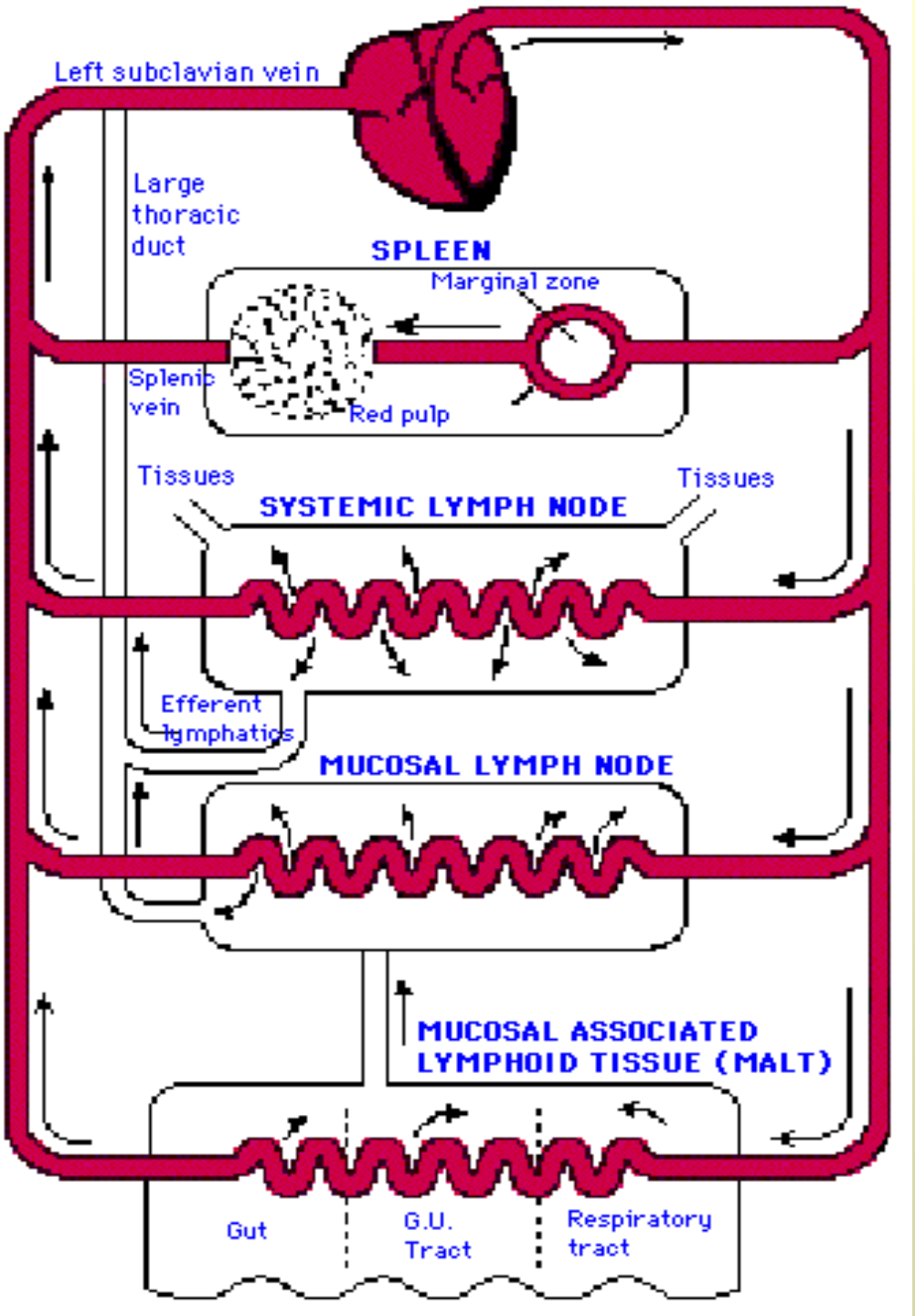




Aggregate Lymphoid Nodules (Peyer patches)



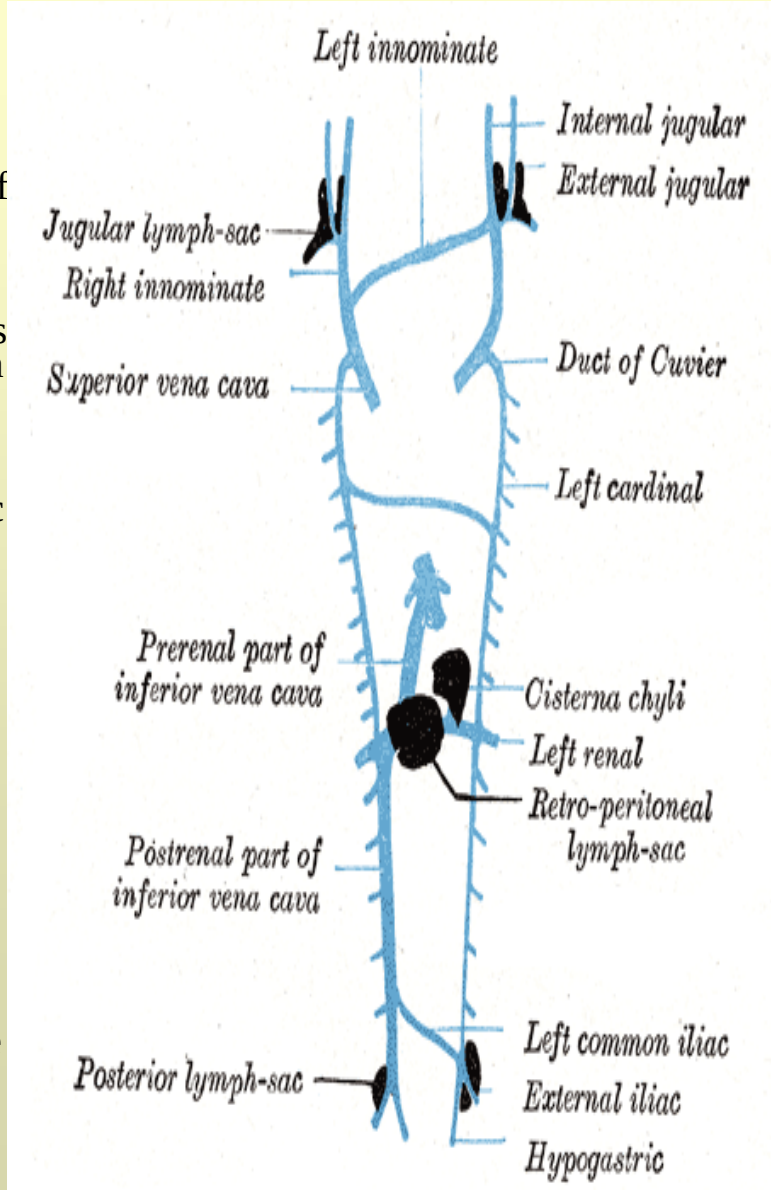
Respirator System (MALT)


Left subclavian vein
Large thoracic duct
SPLEEN
Marginal zone
Splenic vein
Red pulp
Tissues
Tissues
SYSTEMIC LYMPH NODE
Efferent lymphatics
MUCOSAL LYMPH NODE
MUCOSAL ASSOCIATED LYMPHOID TISSUE (MALT)
Gut
G.U. Tract
Respiratory tract

Developmental Aspects of the Lymphatic System

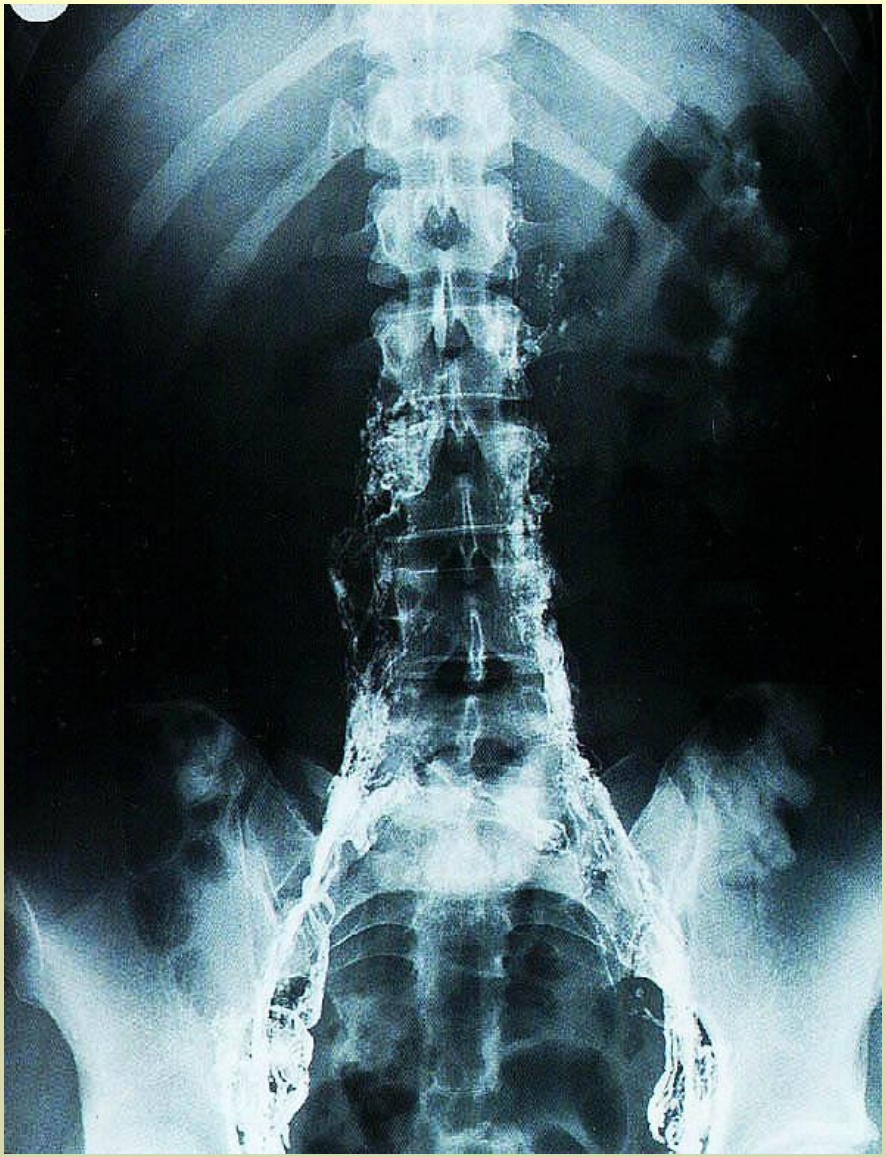
- By **the fifth week** of embryonic development, the beginnings of the lymphatic vessels and the main clusters of lymph nodes are apparent. These arise from the budding of lymph sacs from developing veins.
- The first of these, the **jugular lymph sacs**, arise at the junctions of the internal jugular and subclavian veins and form a branching system of lymphatic vessels throughout the thorax, upper extremities, and head.
- **The two** main connections of the jugular lymph sacs to the venous system are retained and become **the right lymphatic duct** and, on the left, the superior part of the thoracic duct.
- Caudally the elaborate system of abdominal lymphatics buds largely from the primitive inferior vena cava. The lymphatics of the pelvic region and lower extremities form from sacs on the iliac veins.

- Except for the thymus, which is an endodermal derivative, the lymphoid organs develop from mesodermal mesenchymal cells that migrate to particular body sites and develop into reticular tissue.
- The thymus, the first lymphoid organ to appear, forms as an outgrowth of the lining of the primitive pharynx. It then detaches and migrates caudally to the thorax where it becomes infiltrated with immature lymphocytes derived from hematopoietic tissues elsewhere in the embryo's body.
- Except for the spleen and tonsils, the lymphoid organs are poorly developed before birth. Shortly after birth, they become heavily populated by lymphocytes, and their development parallels the maturation of the immune system. There is some evidence that the embryonic thymus produces hormones that control the development of the other lymphoid organs.



Clinical Importance

- Methods of investigation:
  - Palpation lymphatic nodes
  - Lymphography
  - Scintigraphy
- Throw lymphatic system is spread infection and cancer (metastasis)
- The lymph nodes are first barrier for lymph (sentinel lymph node) will stop the metastasatioin (swollen, painful, joint in conglomerate)
- Ecologic Lymphology (cleaning up the internal environment)
- Inflammation of the nodes– lymphadenitis (acute, chronic, specific or nonspecifice)
- Tonsillitis - inflammation of the tonsils, typically due to bacterial infection; they become red, swollen, and sore.



- In the case of the stases of interstitial fluid is development - edema:
  - Edema of lower limbs of pregnant women
  - elephantiasis: Typically a tropical disease in which the lymphatics (particularly those of the lower limbs and scrotum) become clogged with parasitic roundworms, an infectious condition called filariasis; swelling reaches enormous proportions.
- **Pathology of the immune System** :
  - Hyper sensible Reactions (allergy, anaphylactic shock, bronchial asthma)
  - Rejections of the transplants
  - autoimmune Diseases (lupus erythematic, scleroderma, myopathia, vasculitis)
  - Syndromes of the immune deficiency (**AIDS**)
  - Amyloidosis
- **Pathology of the lymphatic** :
  - Inflammatory Reactions
  - Lymphoid Neoplasm
  - Myeloid Neoplasm (leukemia)
- Mechanisms to regulate the drainage function – detoxification of **the lymphatic regional complex**:
  - Lympho stimulation
  - Lympho protection
  - Lympho correction
  - Lympho suppression
- Prosthesis the function of **the lymphatic regional complex**