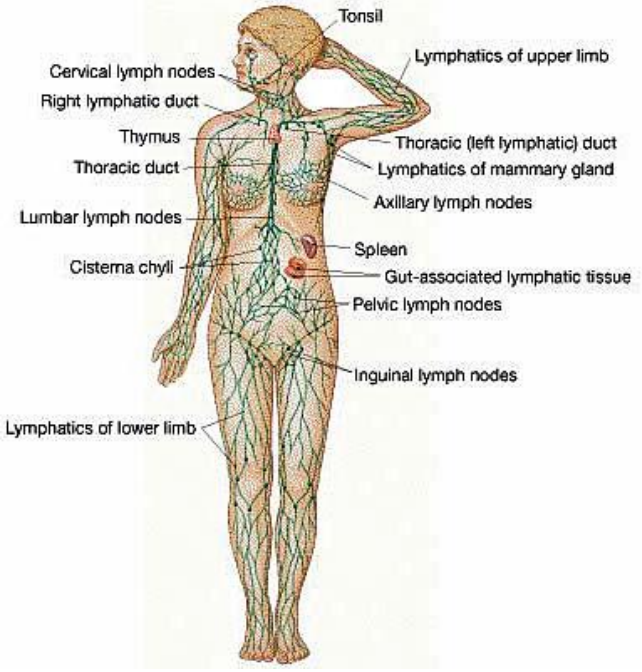
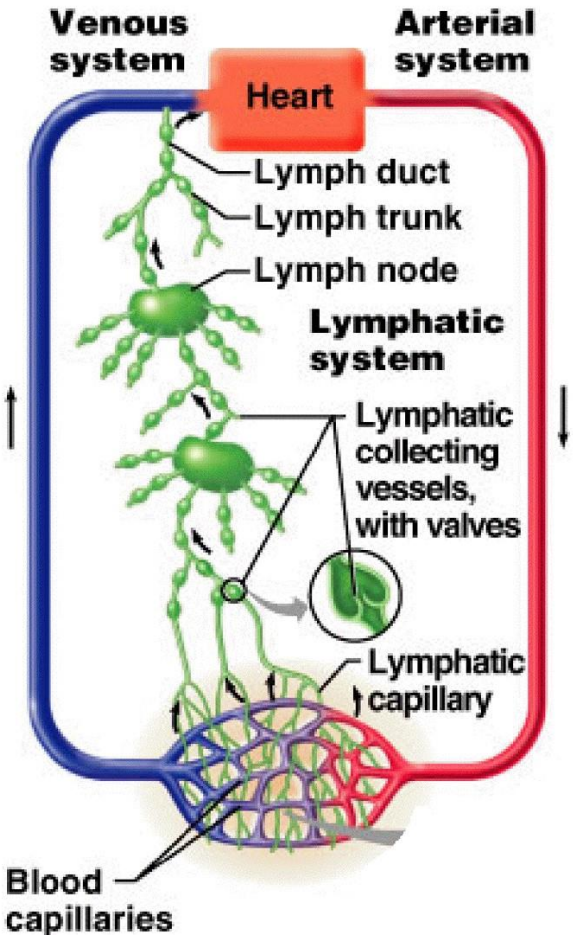
The Lymphatic System

- network of tissues, organs and vessels that help to maintain the bodyôs fluid balance & protect it from pathogens
- lymphatic vessels, lymph nodes, spleen, thymus, tonsils, etc
- without it neither the circulatory system nor the immune system would function
- can be thought of as an accessory to the circulatory system
- it helps the circulatory system to do its job
- the two systems are directly connected together
- it consists of fluid derived from plasma =lymph and white blood cells (esp. lymphocytes and macrophages (monocytes))
- the lymph travels in only one direction - it doesnôt circulate



General Functions of Lymphatic System:

1. ***Returns Fluid from Tissues to Blood*** ~85% of fluids that leak out of blood returns to blood via blood capillaries ~15% returns via lymph capillaries- in 24 hrs lymphatics return fluid equivalent to entire blood volume - if lymphatic system becomes blocked edema
2. ***Returns Large Molecules to Blood*** ~25-50% of blood proteins leak out of capillaries each day
   - they cannot get back into capillaries
   - instead lymphatic capillaries pick them up and return them to the blood
   - if lymphatics are blocked blood protein decreases leading to fluid
   - imbalances in body
3. ***Absorb and Transport Fats*** - Special lymphatic capillaries (=lacteals) in villi of small intestine absorb all lipids and fat soluble vitamins from digested food bypasses liver much goes straight to adipose tissues
4. ***Hemopoiesis*** - some WBCôs (lymphocytes, monocytes) are made in lymphatic tissues (not bone marrow) main supply of lymphocytes
5. ***Body Defense/Immunity*** - lymphoid tissue is an important component of the Immune System (forms a diffuse surveillance defense system in all body tissues and organs
   - the major role of WBCôs is in body defense
   - lymphatic system screens body fluids and removes pathogens and damaged cells



Lymph

- Lymph is a clear watery fluid that resembles blood plasma but: has fewer proteins its composition varies depending on organs that it drains
- the lymphatic system handles 125 ml/hr (2500-2800 ml of lymph/day) ~1/2 of this from the liver and small intestine alone

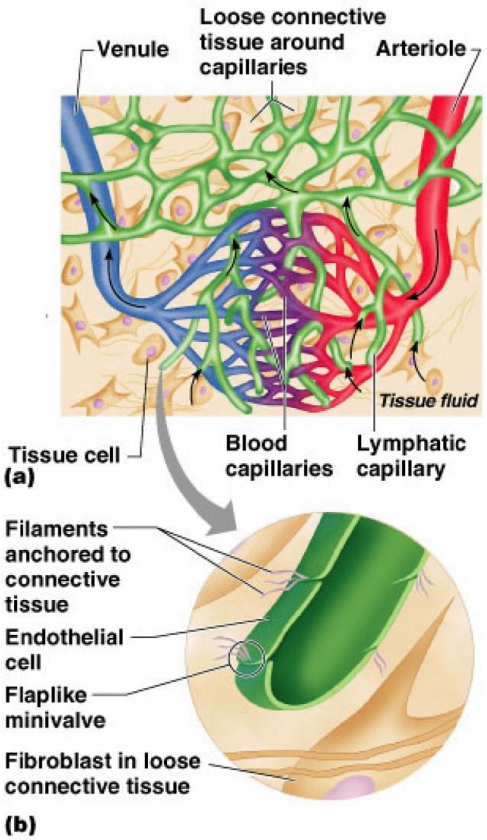
Lymphatic Vessels (lymphatics):

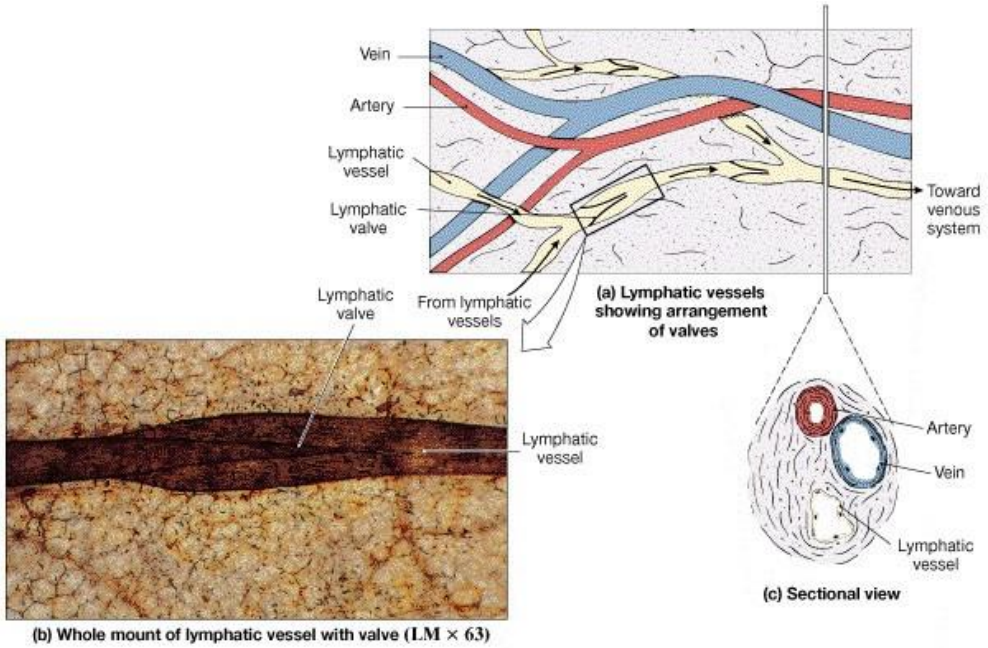
Lymphatic Capillaries originate in tissues as tiny blind ended sacs

- lie side by side with blood capillaries
- single layer of endothelial cells like blood capillaries
- but much more permeable to solvents, and large solutes and whole cells

Lymphatic Vessels - these small lymphatic capillaries merge with others to form larger lymphatic vessels - they resemble veins in structure:

- three layers ï but much thinner
- 1-way valves ï but many more (every few mm or so)
- also has lymph nodes at intervals along its course
- as they converge they become larger and larger



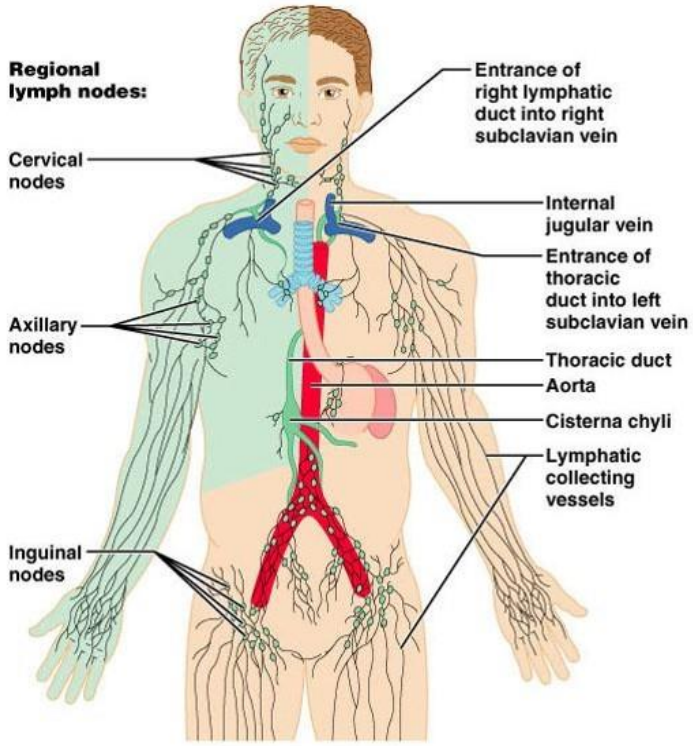


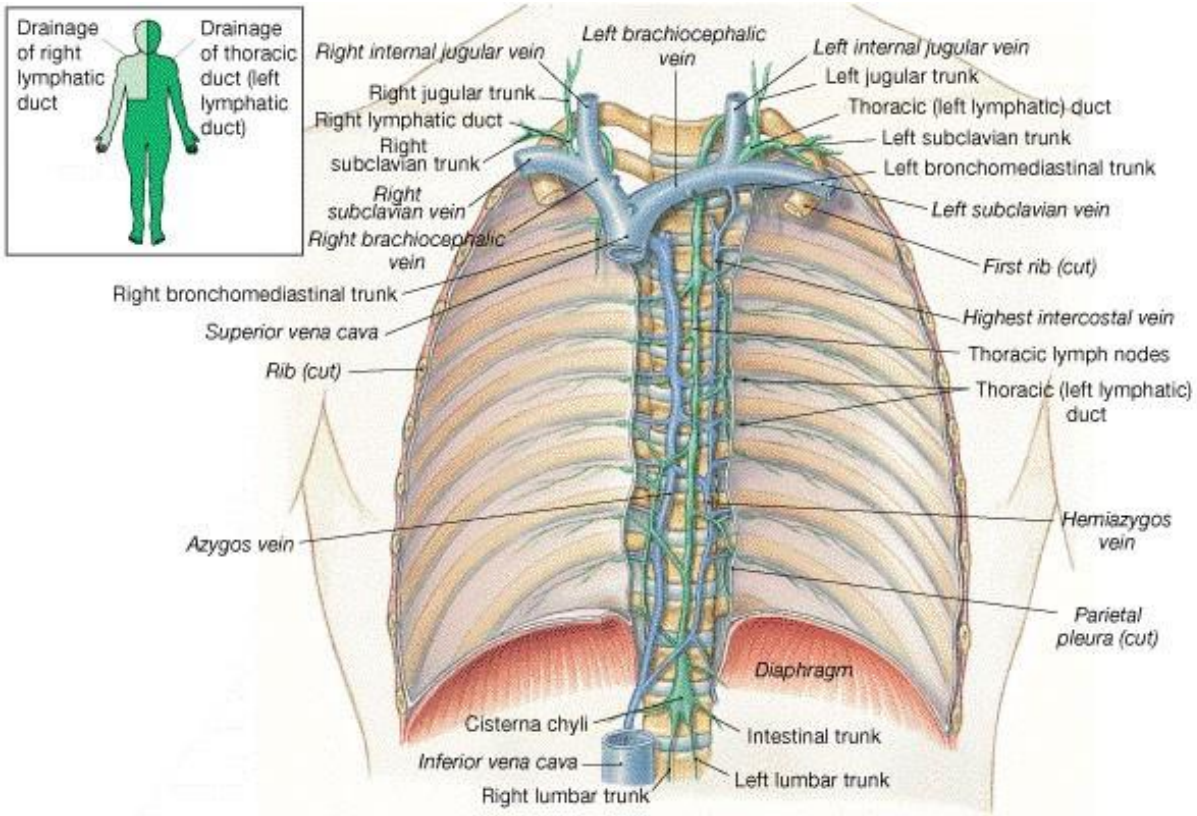
Lymphatic Ducts

- these lymphatic trunks merge together to form two major Lymphatic Ducts
- equivalent to major vessels of circulatory system but more like veins than arteries

Two major Lymphatic Ducts:

- **Right Lymphatic Duct** very short drains upper right quadrant of body drains into right subclavian vein at jct with jugular V
- **Thoracic Duct** much larger and longer drains the rest of body (3/4ths): all of body below diaphragm and left arm and left side of head, neck and thorax begins just below the diaphragm, anterior to vertebral column lumbar trunks and intestinal trunk join to form saclike cysterna chyli drains into left subclavian vein



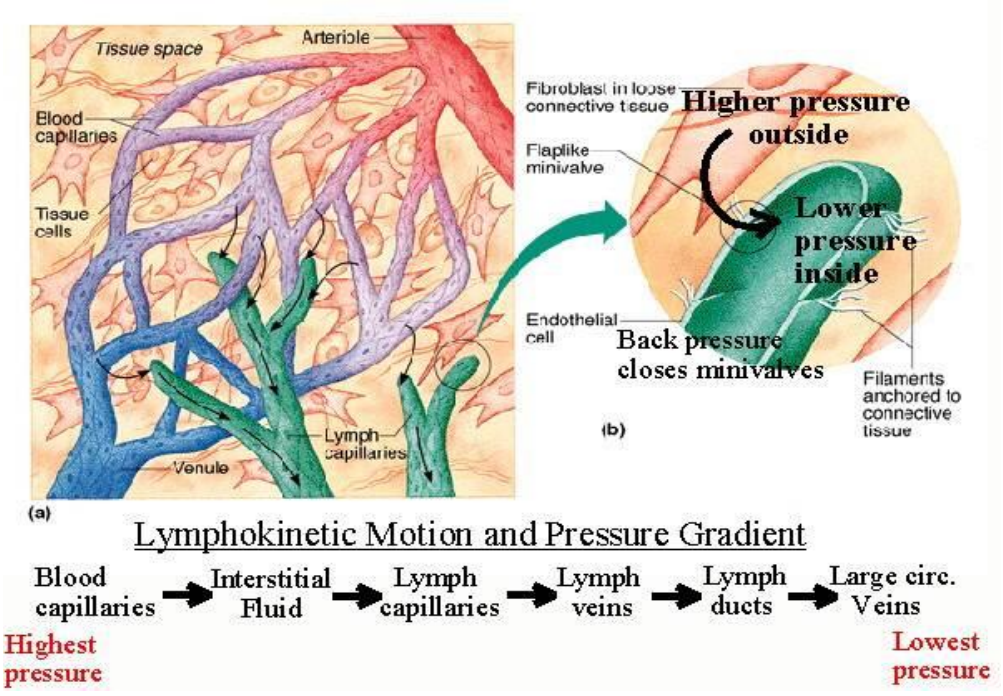


Flow of Lymph:

- fluid pressure in lymphatic system is very low, as in veins
- vessels contract rhythmically direction of flow is maintained by 1-way valves
- also body movements and pulsing of arteries help to move lymph along
- many vessels are wrapped in connective tissue with arteries: the pulsing of the arteries also helps move lymph along

Lymph Circulation

- Lymph vessels are thin walled, valved structures that carry lymph
- Lymph is not under pressure and is propelled in a passive fashion
- Fluid that leaks from the vascular system is returned to general circulation via lymphatic vessels.
- Lymph vessels act as a reservoir for plasma and other substances including cells that leaked from the vascular system
- The lymphatic system provides a one-way route for movement of interstitial fluid to the cardiovascular system.
- Lymph returns the excess fluid filtered from the blood vessel capillaries, as well as the protein that leaks out of the blood vessel capillaries.
- Lymph flow is driven mainly by contraction of smooth muscle in the lymphatic vessels but also by the skeletal-muscle pump and the respiratory pump.

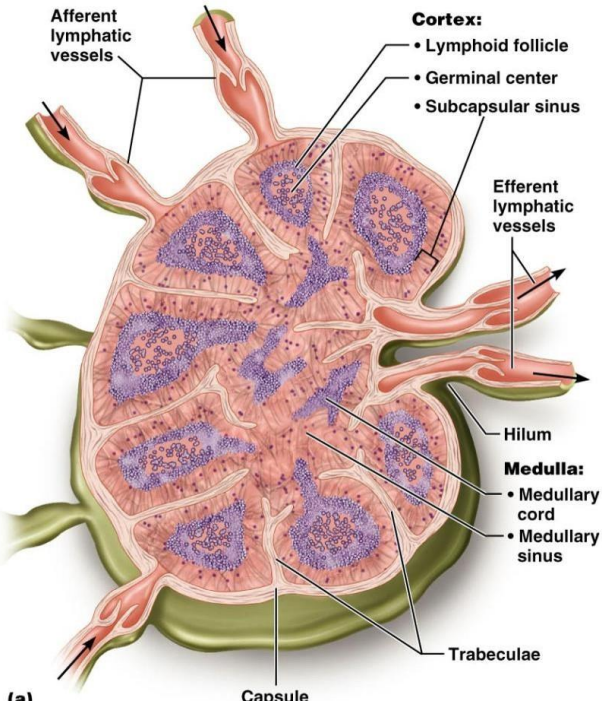


LYMPH CIRCULATION

Interstitial fluid Ÿ *Lymph* Ÿ Lymph capillary Ÿ Afferent lymph vessel Ÿ Lymph node Ÿ Efferent lymph vessel Ÿ Lymph trunk Ÿ Lymph duct {Right lymphatic duct and Thoracic duct (left side)} Ÿ Subclavian vein (right and left) Ÿ *Blood* Ÿ Interstitial fluid

Lymph Nodes

- also called lymph glands
- oval, vary in size from pinhead to lima bean
- most numerous of the lymphatic organs (100ôs)



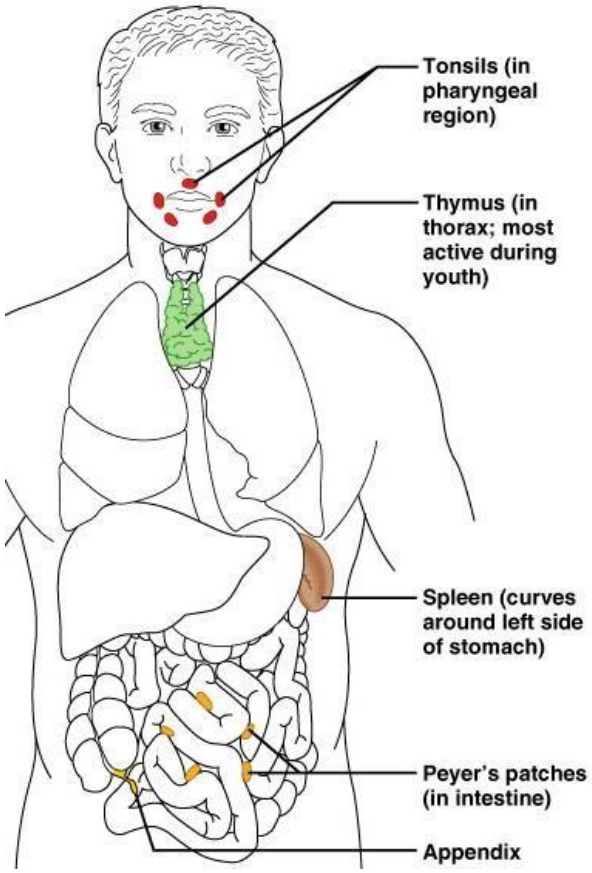
Functions of lymph nodes:

1. ***cleanse lymph*** - as lymph flows through sinuses of node it slows down and microorganisms and foreign matter are removed
2. ***alert immune system*** to pathogens
3. ***important in hemopoiesis*** - lymphocytes and monocytes are made here

- lymph moves into nodes by way of several afferent lymphatic vessels
- moves through sinus channels lined with phagocytic white blood cells
- exits via 1-3 efferent lymph vessels
- the WBCôs in each node remove ~99% of impurities as lymph passes from node to node virtually all impurities are normally removed
- lymph nodes are widespread in body but most occur in groups or clusters:
  - eg. submental & submaxillary lymph nodes floor of mouth; drain nose, lips teeth
  - eg. cervical lymph nodes neck drain neck and head
  - eg. axillary lymph nodes armpit (axilla) and upper chest drains arm and upper thorax including breasts
- breasts contains 2 sets of lymphatics: (NOT mammary glands) those that drain the skin over breast excluding the areola and nipple those that originate in and drain deeper portions of breast and skin of areola and nipple
- numerous connections join the lymphatic systems of the breast with: the other breast axillary nodes (85% of lymph from breast enters them)
- abdominal nodes
- eg. inguinal lymph nodes in groin area drain legs and genitals

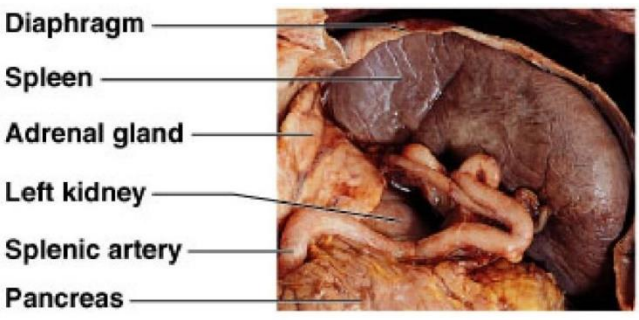
Major Accessory Lymphatic Organs

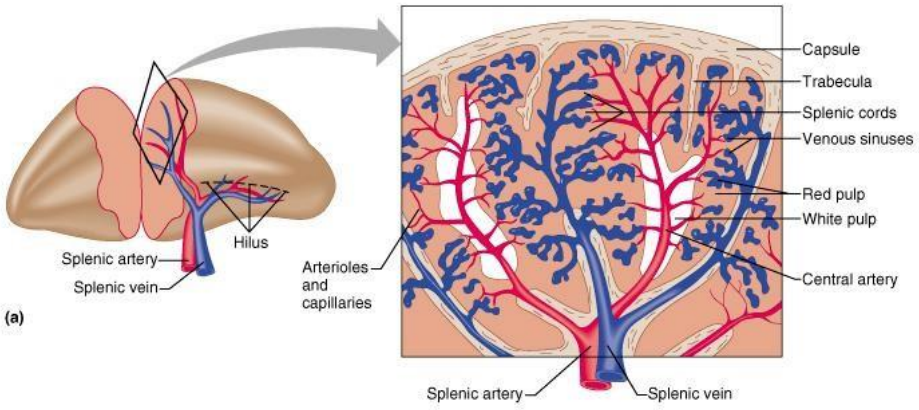
- **Spleen – largest**
- **Thymus**
- **Tonsils**
- **Peyers's patches**
- **Appendix**



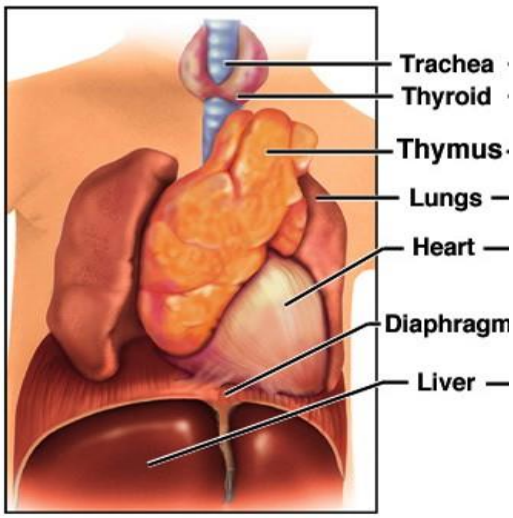
Spleen

- largest of the lymphatic organs
- located below diaphragm in left hypochondriac region
- ovoid in shape
- inside is a network of interlacing fibers: red pulp packed with RBCôs white pulp crowded with lymphocytes, monocytes, and neutrophils
- performs several functions:
  1. defense helps screen blood and removes pathogens and bacteria
  2. hemopoiesis monocytes and lymphocytes are made here (before birth, RBCôs also made here)
  3. erythrocyte and platelet destruction
- spleen is ñerythrocyte graveyardò iron is salvaged from RBCôs 4. blood reservoir able to store blood (~350ml) can constrict and pump blood into circulatory system if hemorrhaging = self transfusion (can squirt 200 ml into blood in <1minute) also, helps stabilize blood volume by transferring excess plasma from blood to lymphatic system

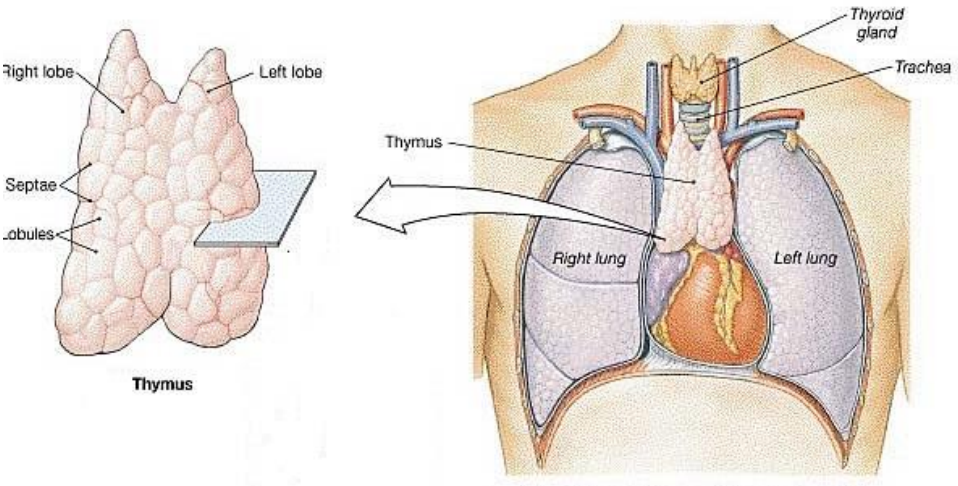




Thymus



- is single unpaired organ in mediastinum and neck region
- plays vital role in initial set up of bodyôs immune system source of lymphocytes before birth which circulate to spleen, nodes and vessels soon after birth it secretes a hormone that causes lymphocytes to develop into plasma cells
- primary function is in early life
- once this job is done it degenerates seems to complete its essential job by end of childhood
- largest when young, esp. puberty
- then gets smaller and is replaced with fat
- Secretes thymosin and thymopoietin which causes T lymphocytes to become immunocompetent
- Lacks B cells (no follicles)
- Atrophies with age: prominent in newborns, stops growth by adolescence, degenerates by old age



MALT (mucosa associated lymphatic tissue) includes:

- Tonsils
- Peyerôs Patches in intestines
- Appendix
- Small bronchiolar follicles

MALT are positioned to:

- Destroy bacteria that breach the mucosal membrane from outside
- Develop ñmemoryò lymphocytes for long term immunity

Tonsils - masses of lymphoidal tissue embedded in mucous membranes of pharynx

- covered by epithelium, with deep pits(=crypts)
- crypts often contain food debris, bacteria, dead wbcôs etc
- three main sets of tonsils:
- **pharyngeal tonsils** (=adenoids) on wall of pharynx behind nasal cavity
- **palatine tonsils** at post margin of oral cavity largest and most often infected = tonsilitis usually Streptococcus today usually treated with antibiotics
- **lingual tonsils** on each side of root of tongue
- Not encapsulated
- blind pouches ï crypts
  - bacteria can enter
  - induced immune response
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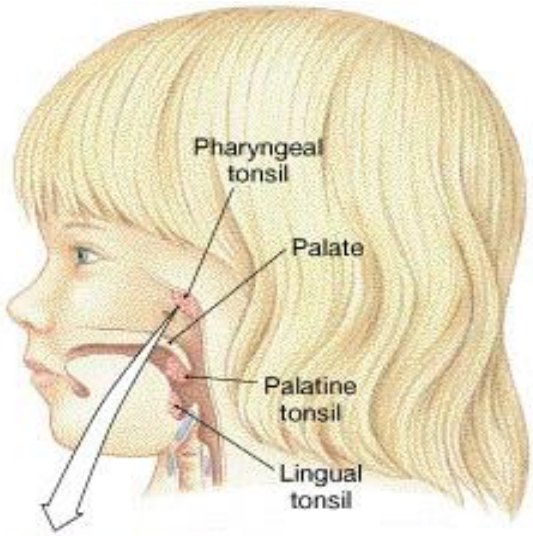
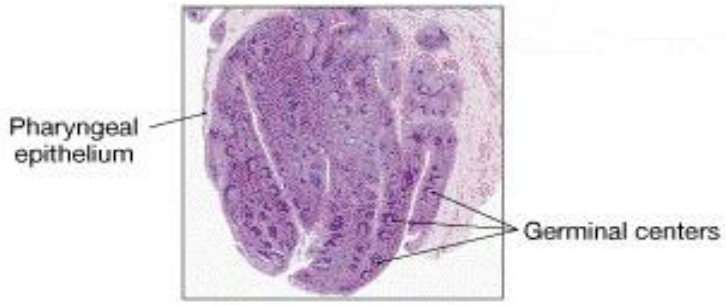
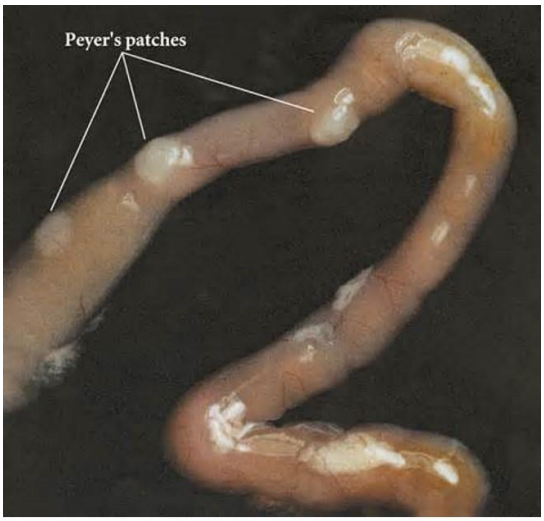
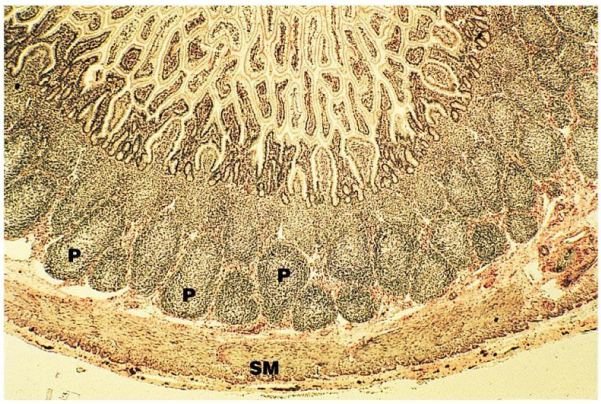




Peyer's Patches

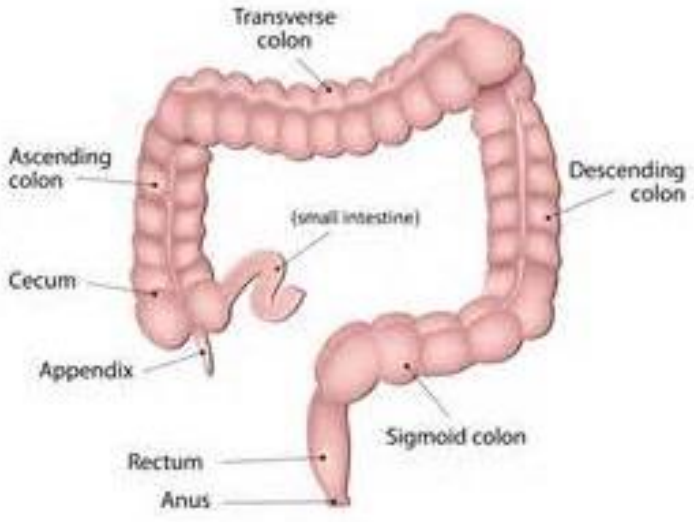
- Small masses of lymphatic tissue found throughout ileum region of small intestine
- roughly egg-shaped lymphatic tissue nodules that are similar to lymph nodes in structure
- analyze and respond to pathogenic microbes in the ileum





Appendix

- The location of the appendix is close to the junction of the large intestine and the small intestine
- Most researchers agree that it has a minor role in immune function ï store good bacteria
- Blockage of the appendix can lead to **appendicitis**, a type of inflammation that is painful and potentially deadly- if it bursts it releases dangerous bacteria into the abdominal cavity
- Treated by surgical removal of the appendix



Disorders of the Lymphatic System

Edema - any disruption of lymphatic flow can lead to edema - excessive accumulation of interstitial fluid- results from injury, inflammation, surgery, or parasitic infections as Elephantitis

Metastatic Cancers - metastasis is when cancer cells break free of original tumor and travel to other sites in the body-

- lymph nodes are common sites of metastatic cancer
- since lymphatic capillaries are so permeable, cancer cells can easily enter and travel in the lymph
- tend to lodge in 1st node they enter and enlarge and destroy the node = lymphoma
- once lymphoma is established cells travel from their to other nodes

Hodgkin Disease - lymph node malignancy early symptoms: enlarged, painful nodes, esp. in neck;-fever, anorexia, weight loss, night sweats, severe itching often progresses to neighboring lymph nodes

Non-Hodgkin Lymphoma - lymphoma similar to above but more common more widespread distribution in body with higher mortality rate

Ruptured Spleen one of most common consequences of blows to left thoracic or abdominal wall it bleeds profusely if damaged, may cause fatal hemorrhaging removal of spleen usually not serious since functions are shared with liver and bone marrow

Elephantitis

- A tropical disease caused by lymphatic obstruction.
- Victim is bitten by a mosquito infected with a roundworm known as a filarial worm.
- The resulting edema leads to fibrosis and elephant-like thickening of the skin.