

# SH Lecture - Lymphatic Structure and Organs

From Embryology

Contents

## Introduction



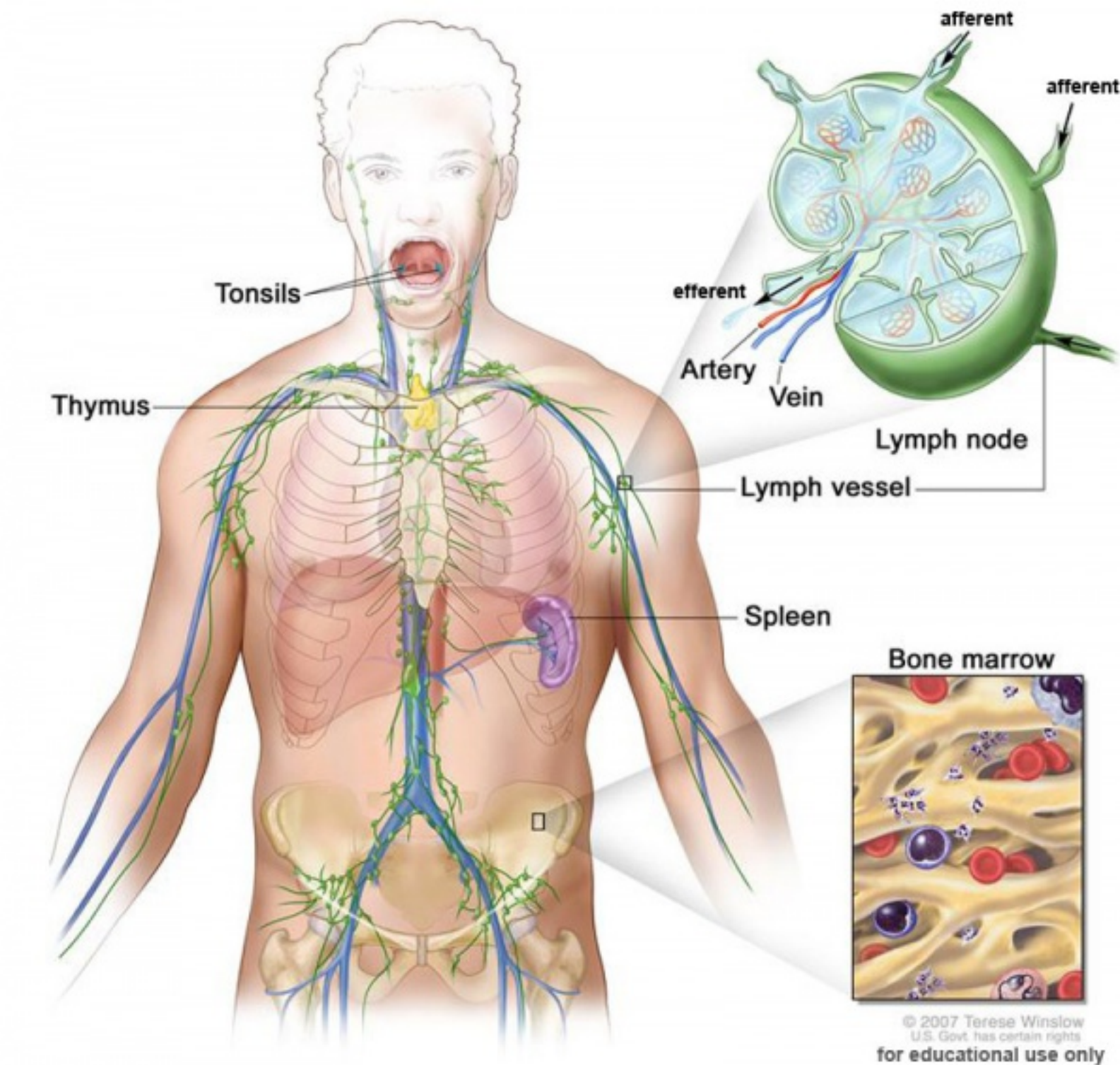
This lecture will provide an overview of the lymphoid structure and histology of key cells, vessels, structures and organs lymphoid organs, including the lymph nodes, spleen and thymus, as well as extranodal lymphoid tissues including mucosal associated lymphoid tissues (MALT).

In this lecture I will go through the structures in sequence from cells through to organs, immunity itself is covered in detail elsewhere in the course.

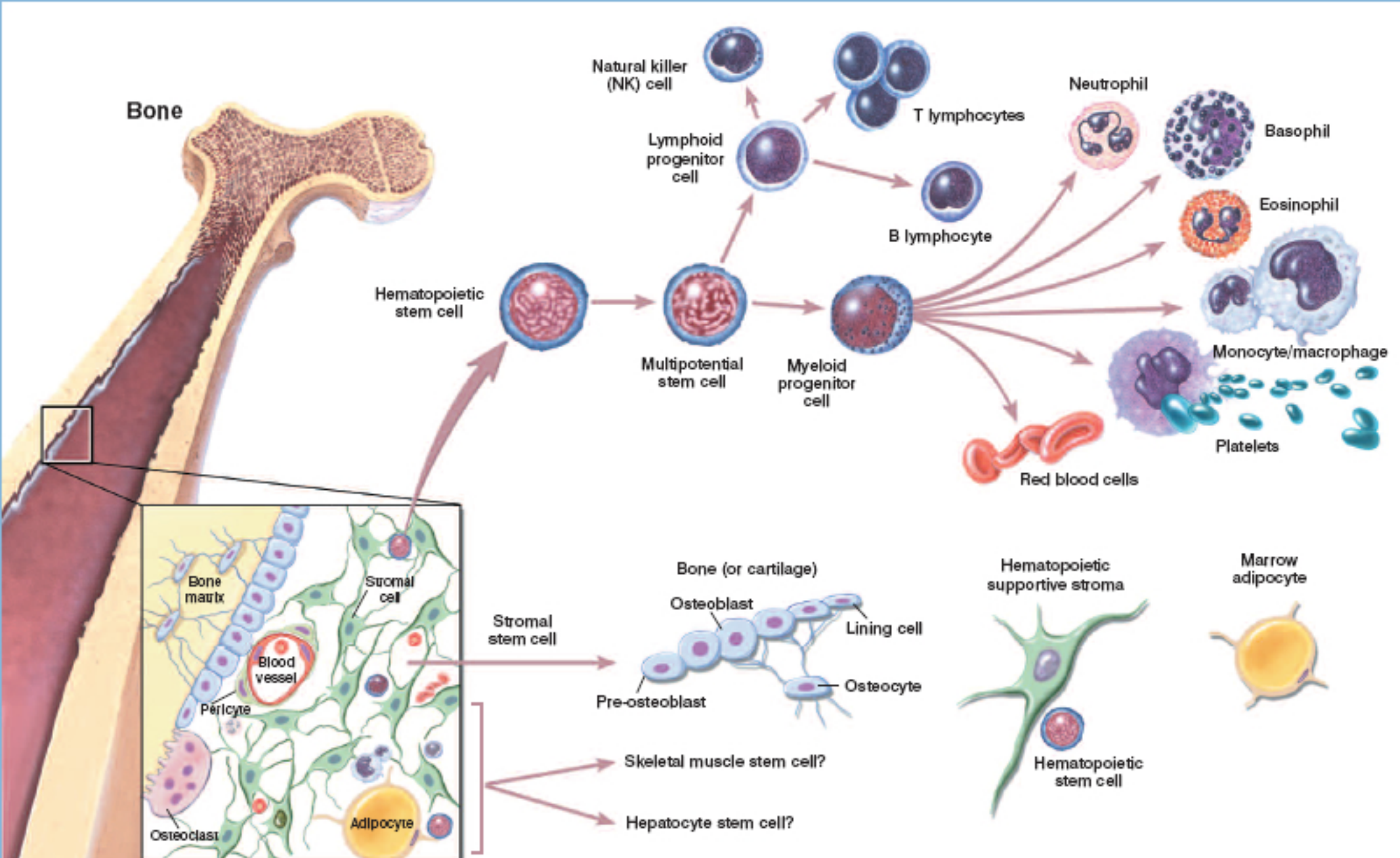
Textbook References [Expand]

Previous Lectures [Expand]

Structure	Function
1. <b>Cells</b> - blood cells (parenchyma), connective tissue (stroma)	1. <b>Immune</b> - “monitor” of body surfaces, internal fluids
2. <b>Vessels</b> - lymphatic vessels	2. <b>Extracellular fluid</b> - returns interstitial fluid to circulation
3. <b>Diffuse</b> - (extra-nodal tissue) nodules, Mucosal Associated Lymphoid Tissues (MALT)	3. <b>Gastrointestinal tract</b> - carries fat and fat-soluble vitamins
4. <b>Nodes</b> - (historic, "glands")	
5. <b>Organs</b> - thymus, spleen	



## Cells



## Two Blood Cell Systems

1. **Mononuclear Phagocytic System** - circulating monocytes of peripheral blood and non-circulating (fixed) tissue macrophages found throughout the body.
2. **Lymphoid System** - lymphocytes, three major types of T, B, and NK.

## Lymphoid Organs

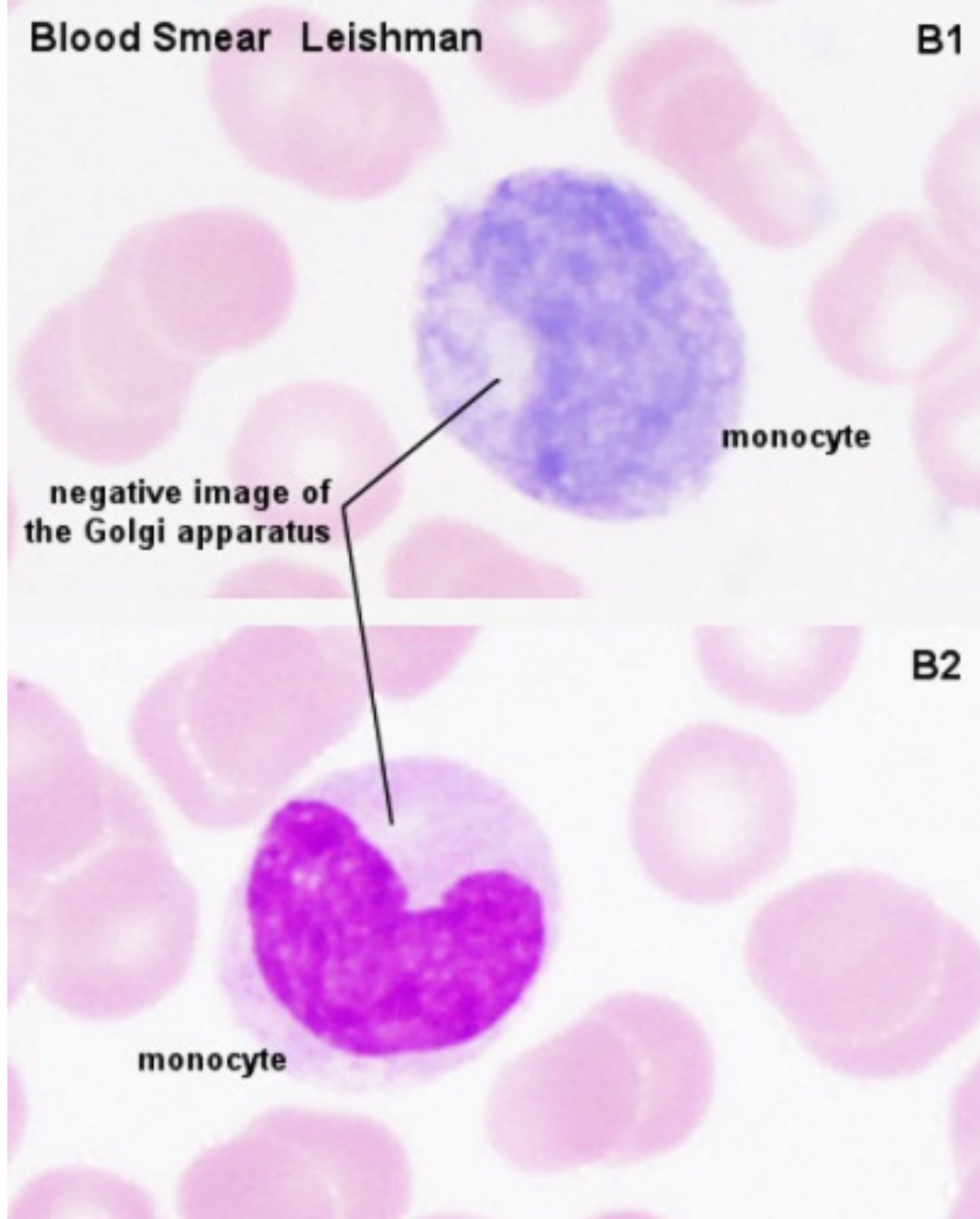
- Central - Lymphocytes develop from precursor cells in bone marrow. (see blood marrow image)
- Peripheral - Lymphocytes respond to antigen lymph nodes or spleen.

## Blood Cells [Expand]

### 1. Mononuclear Phagocytic System

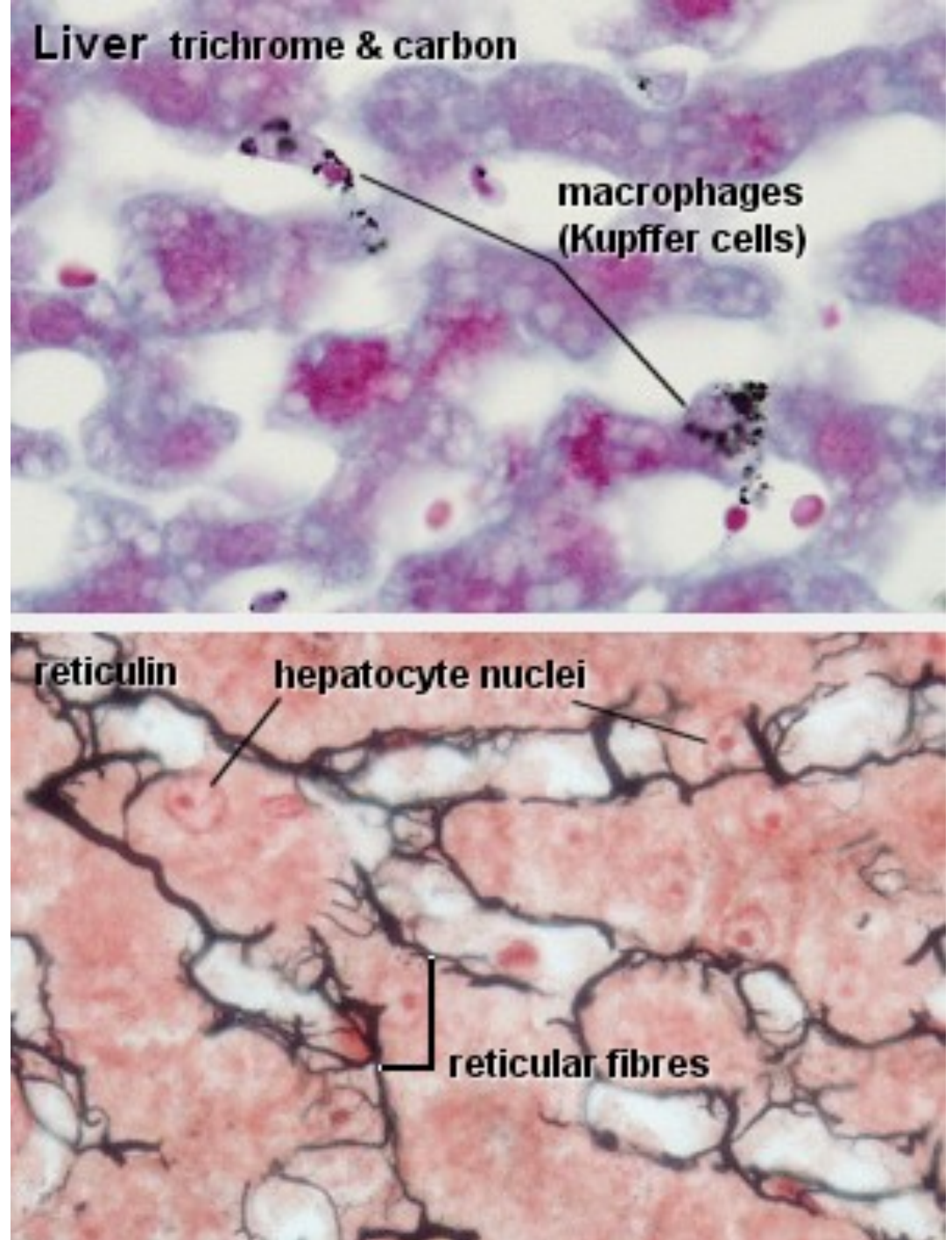
Mononuclear Phagocytic System (MPS, also called Lymphoreticular System or Reticuloendothelial System, RES)





Circulating **monocytes** of peripheral blood.

- monocytes entering the connective tissue differentiate into **macrophages**)



Non-circulating (fixed) tissue **macrophages** ( $M\Phi$ )

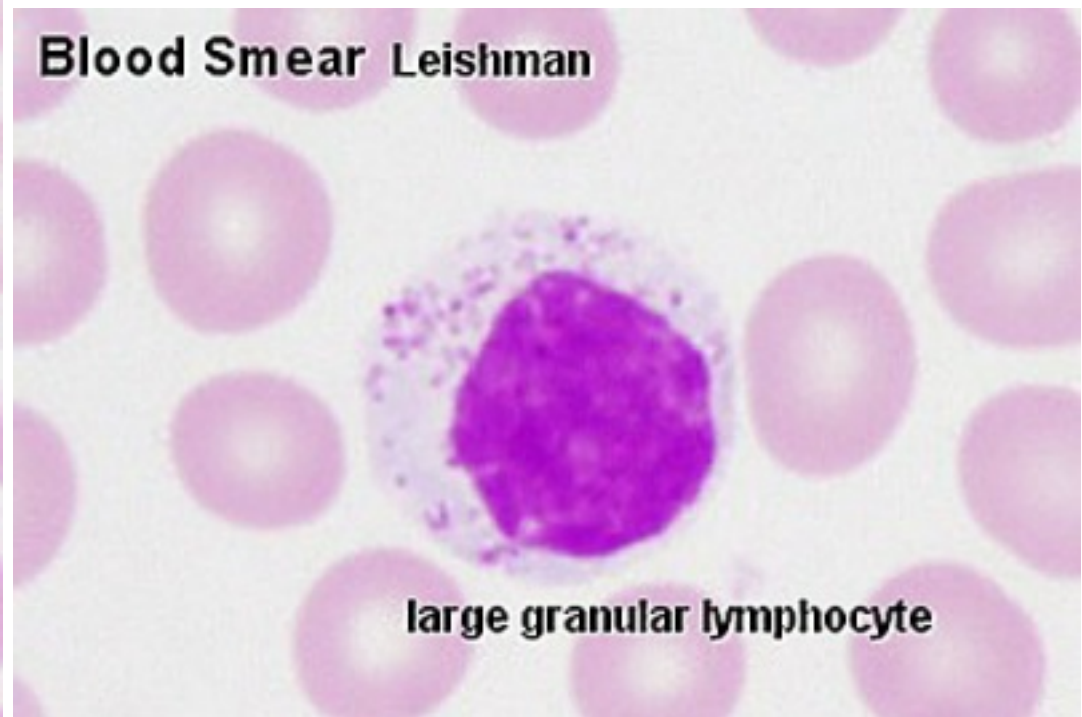
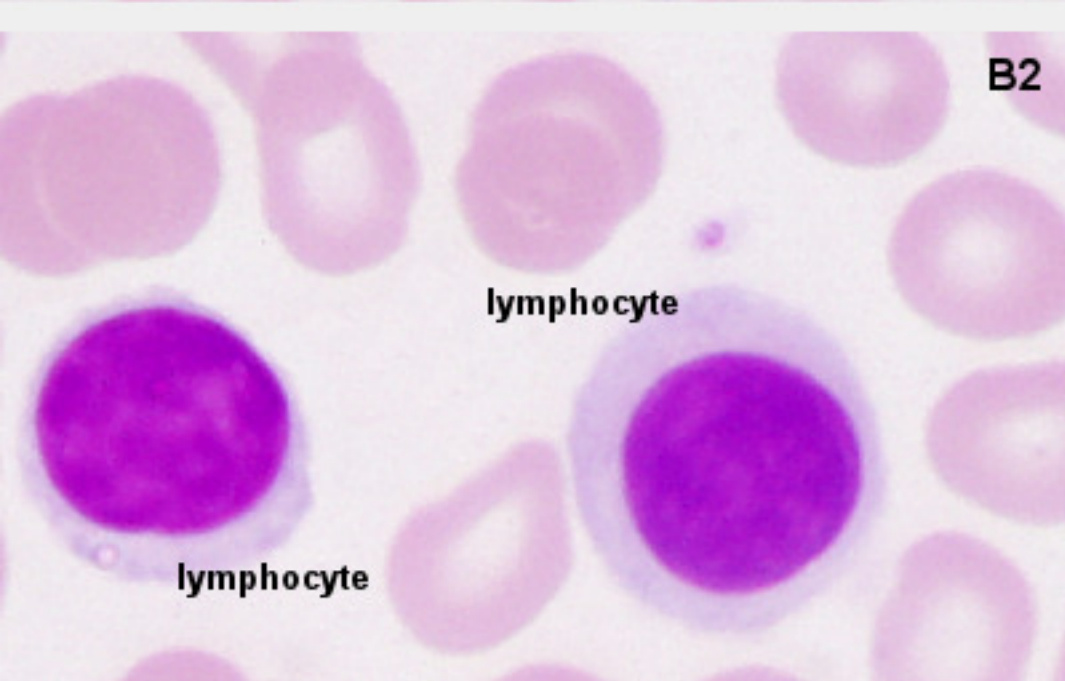
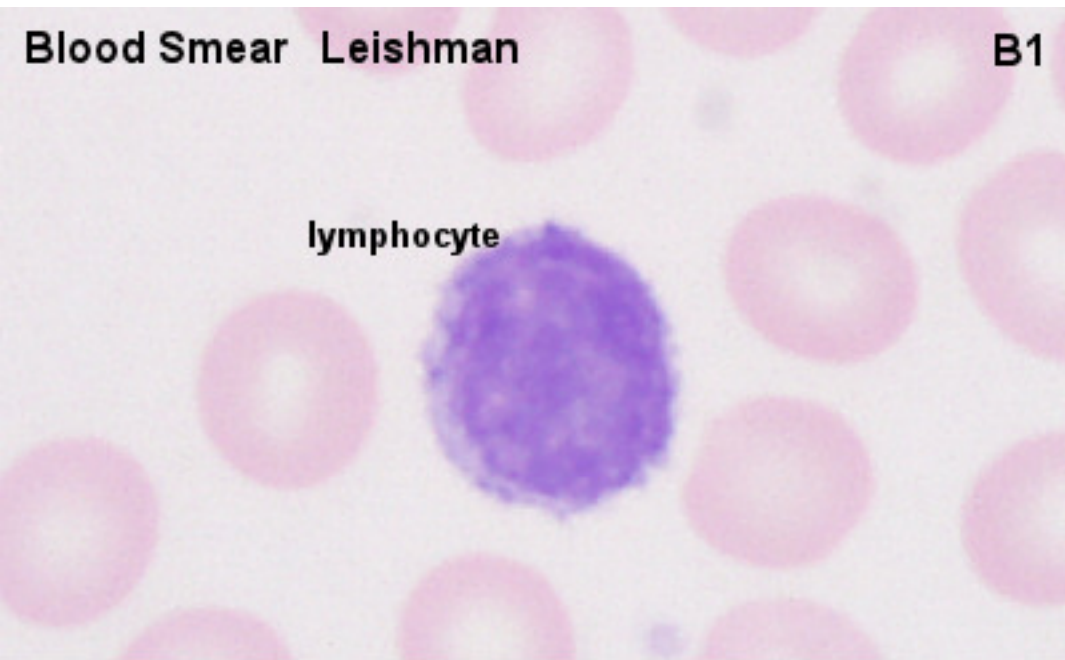
- found throughout the body (Liver, Kuffer cells), spleen, nodes and other tissues.

## 2. Lymphoid System

Adaptive immunity functional cells are the **lymphocytes** (B, T, NK) and **dendritic cells** (process antigen and present it on their surface, monocyte precursor derived).

- Antibody-mediated** - B Lymphocyte secreting antibody = **Plasma Cell**
- Cell-mediated** - T Lymphocytes form **memory cell**, Cytotoxic T cells, T helper cell

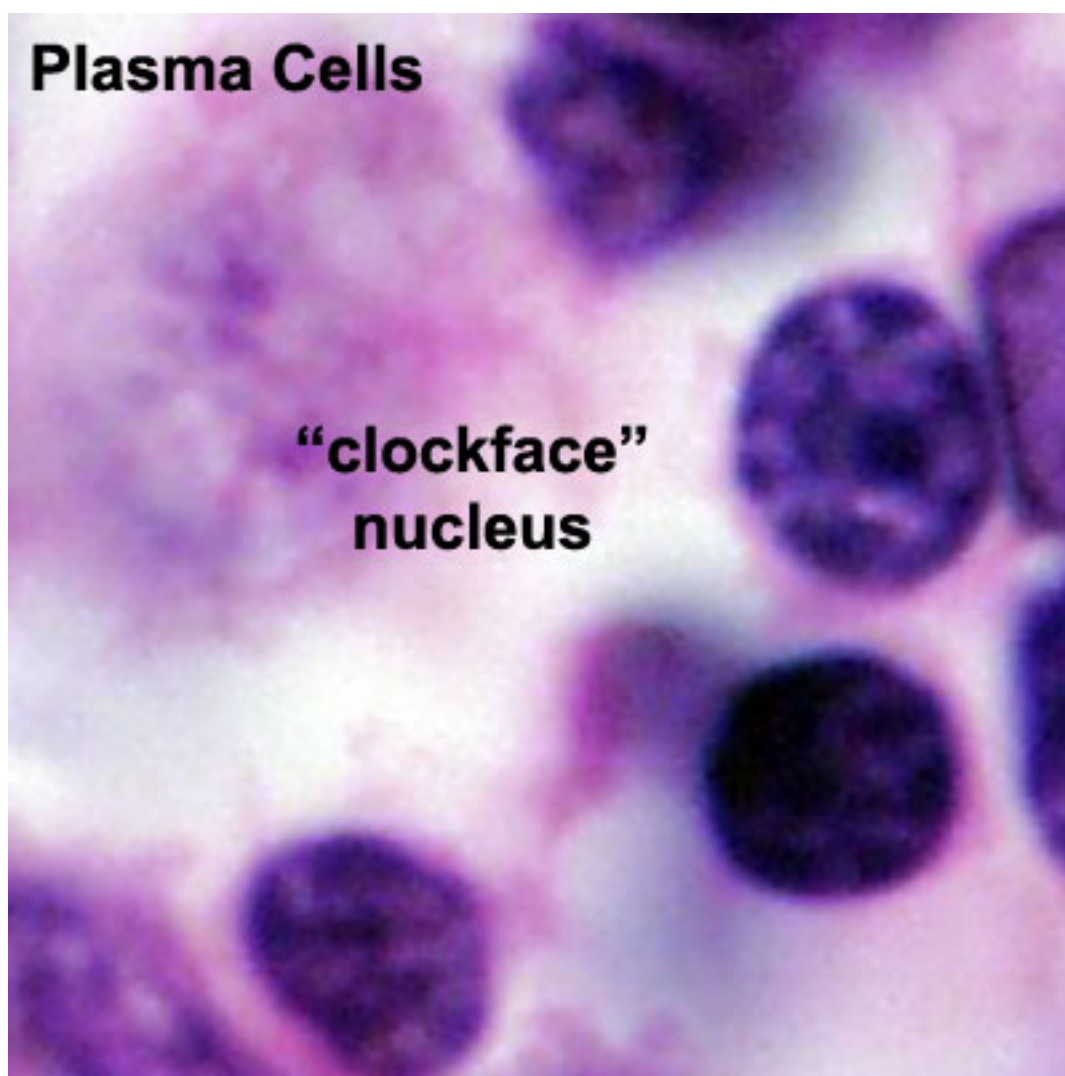




## B Cell Development

## Germinal Centres

- Bone marrow
  - blood
  - Lymph node, nodule
  - Lymphatic vessel
  - Bone marrow
- Bone Marrow
  - Medullary cords contain plasma cells



## Plasma cells

- Activated B cell, plasma B cells, plasmocytes, effector B cells and B cell that is secreting antibody.
- secrete antibody directly into blood for distribution to all body
- in local extrafollicular sites are short lived 2–4 days
- longer-lived plasma cells in bone marrow 3 weeks to 3 months+
- "clockface" nucleus
  - Nucleus has darker (heterochromatin) regions around periphery of nucleus separated by lighter (euchromatin) regions.

## Lymphocyte Electron Micrographs [Expand]

## Lymphocyte Circulation

- Microbial **antigens** are carried into a lymph node by **dendritic cells**, which enter via afferent lymphatic vessels draining an infected tissue.

- **T and B cells** enter the lymph node via an artery and migrate out of the bloodstream through postcapillary venules.
  - Unless they encounter their antigen, the T and B cells leave the lymph node via efferent lymphatic vessels, which eventually join the thoracic duct.
- The thoracic duct empties into a large vein carrying blood to the heart.
- A typical circulation cycle takes about 12–24 hours.

**Links:** MBoC Chapter 24 - The Adaptive Immune System (<http://www.ncbi.nlm.nih.gov/bookshelf/br.fcgi?book=mboc4&part=A4419>) | MBoC Figure 24-14. The path followed by lymphocytes as they continuously circulate between the lymph and blood (<http://www.ncbi.nlm.nih.gov/books/NBK26921/figure/A4442>) | Immunobiology (<http://www.ncbi.nlm.nih.gov/bookshelf/br.fcgi?book=imm>)

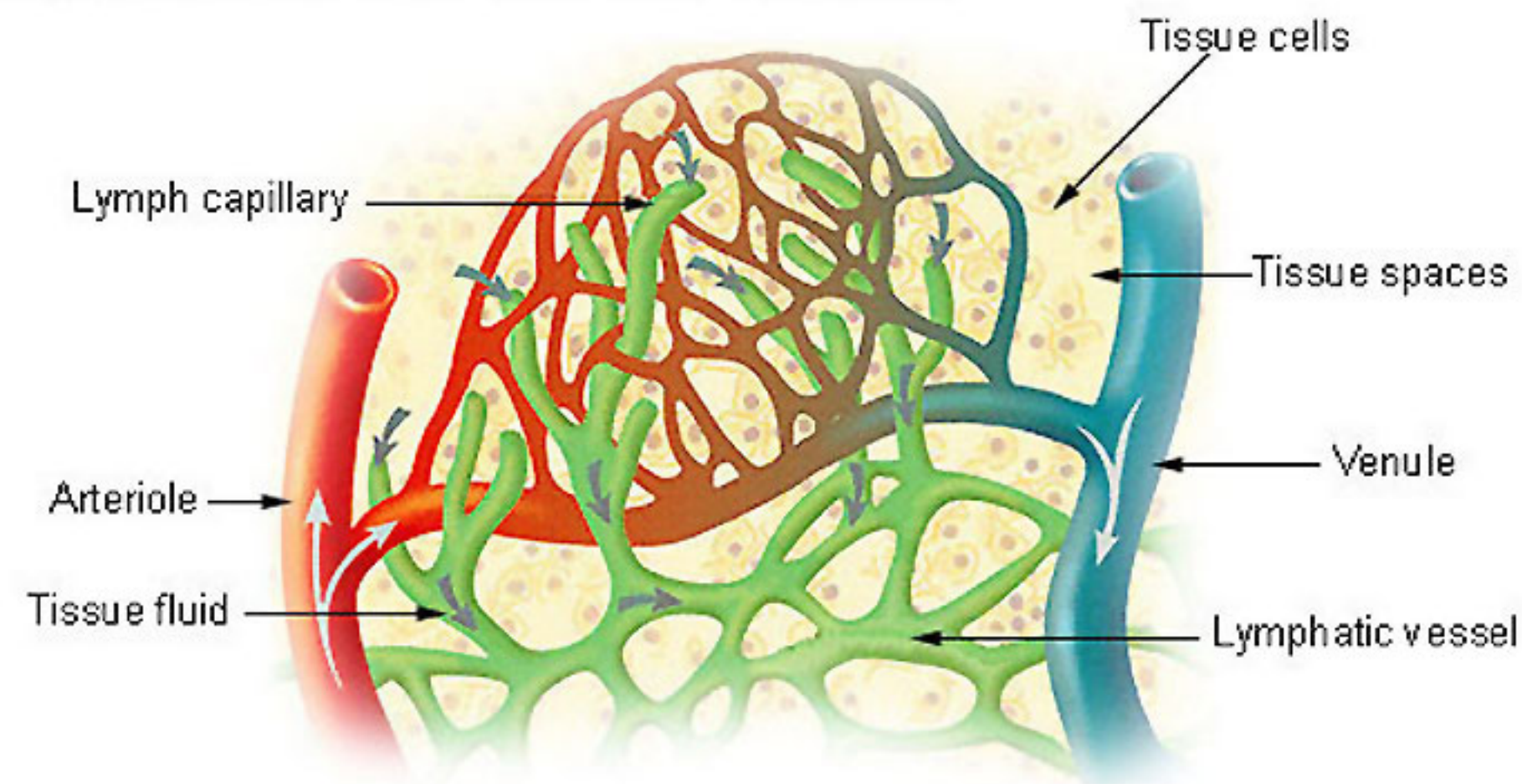
## Lymph Vessels

Three main types (capillaries, collecting vessels, ducts) based on size and morphology.

- Remember anatomy acronym - **NAVL** = Nerve, Artery, Vein and Lymph.

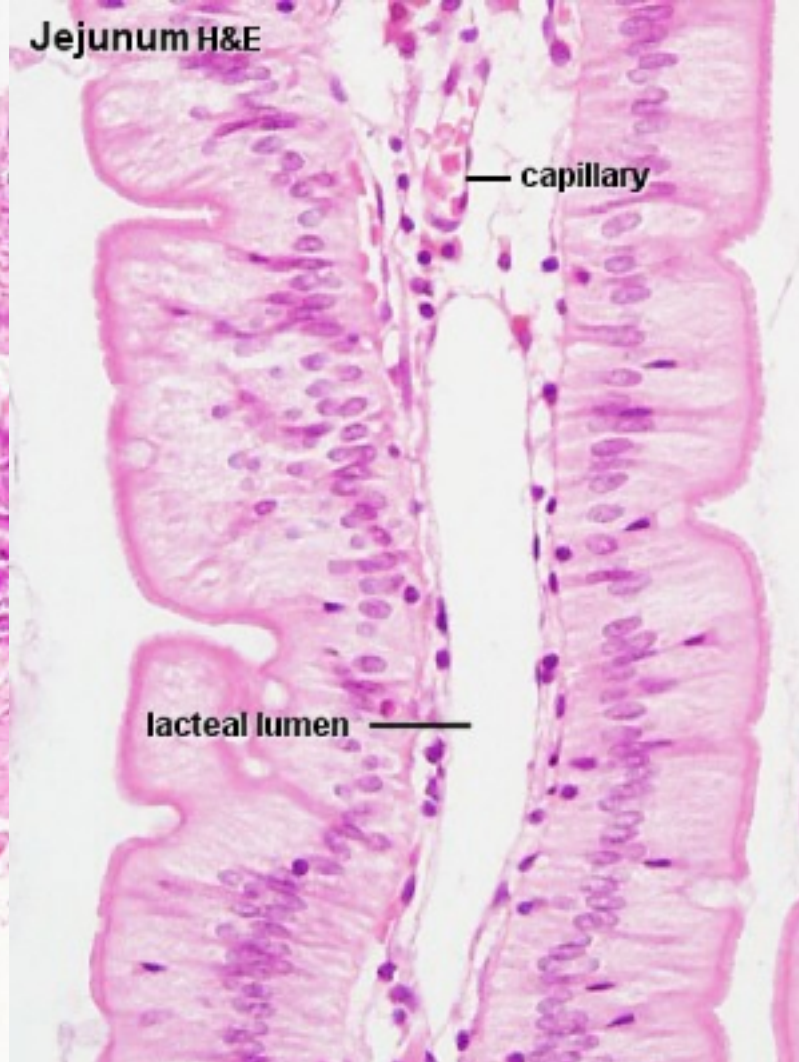
## Lymph Capillaries

### Lymph Capillaries in the Tissue Spaces



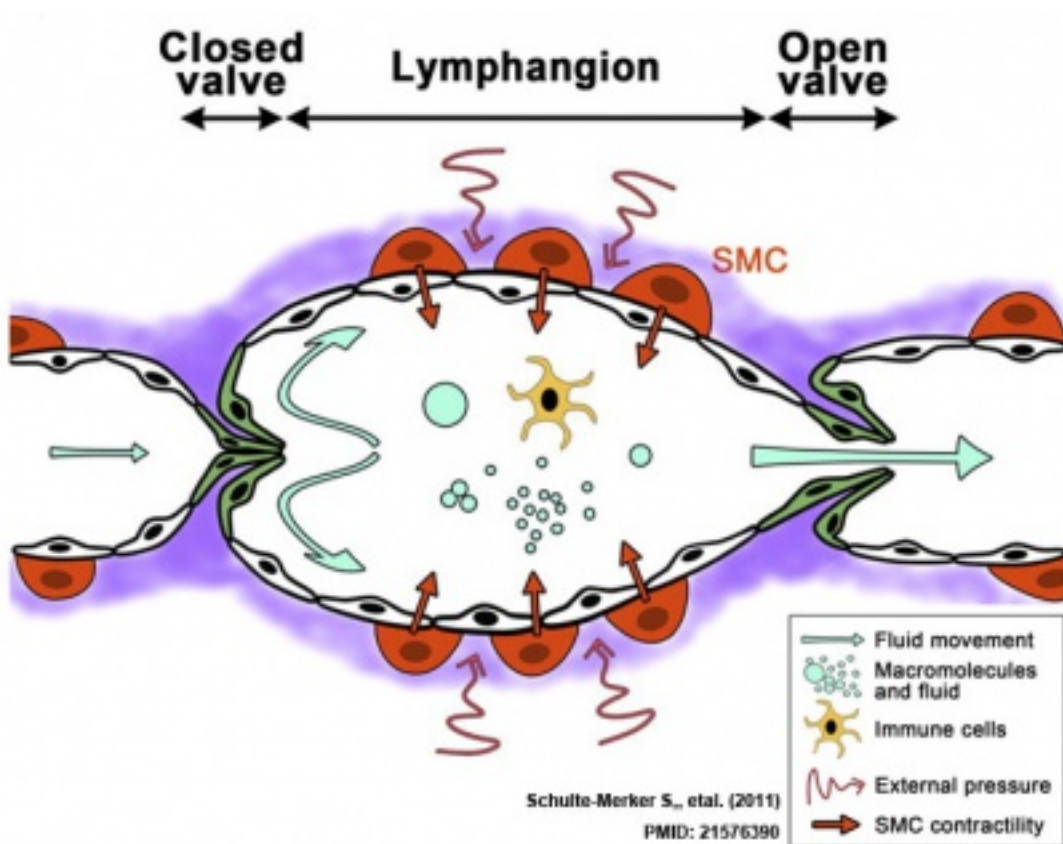
Begin as blind-ending tubes in connective tissue, larger than blood capillaries, very irregularly shaped.





Jejunum lacteal (lymphatic capillary of small intestine villi, absorbs dietary fats)

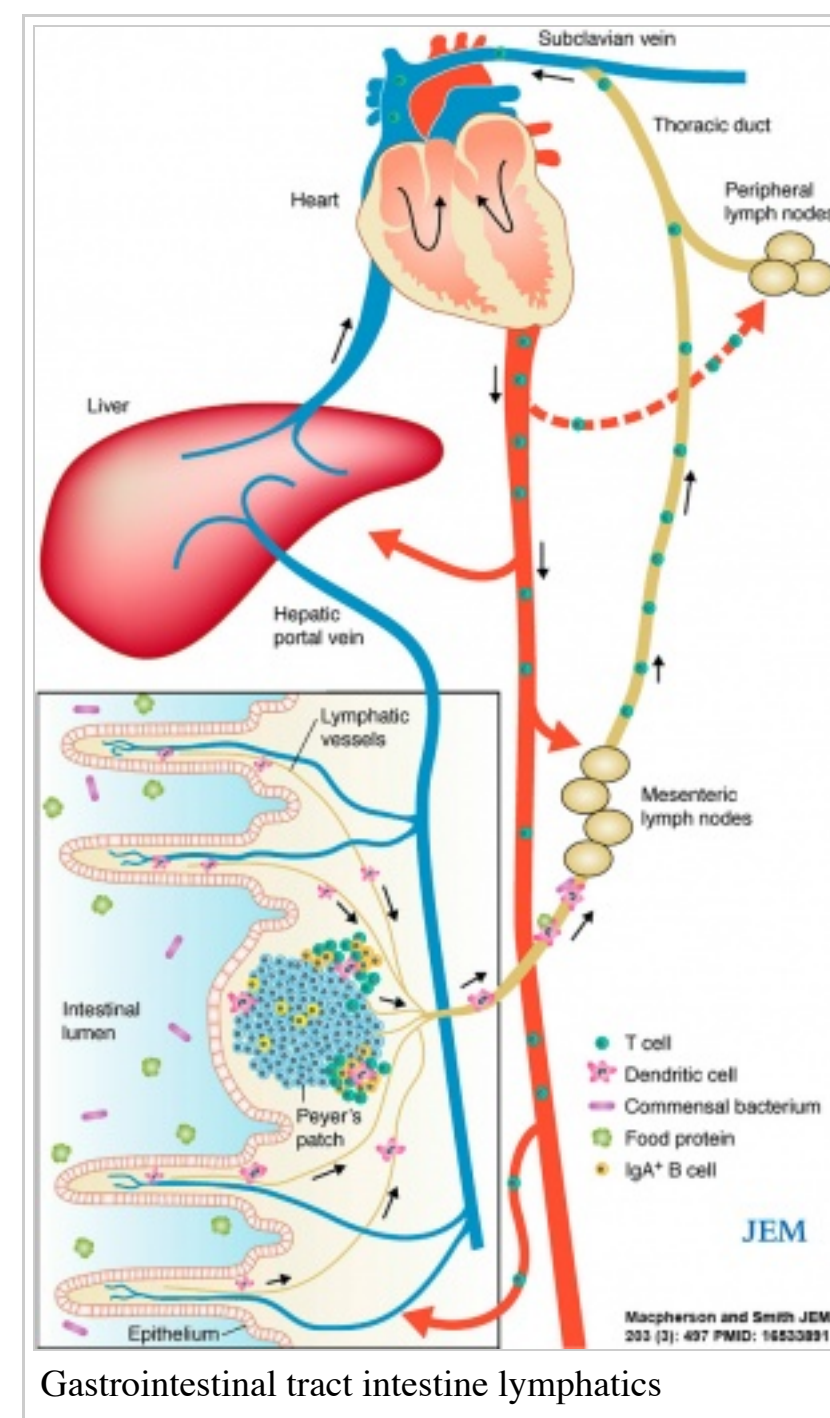
## Lymph Collecting Vessels



Larger and form valves, morphology similar to lymph capillaries. Lymphangion

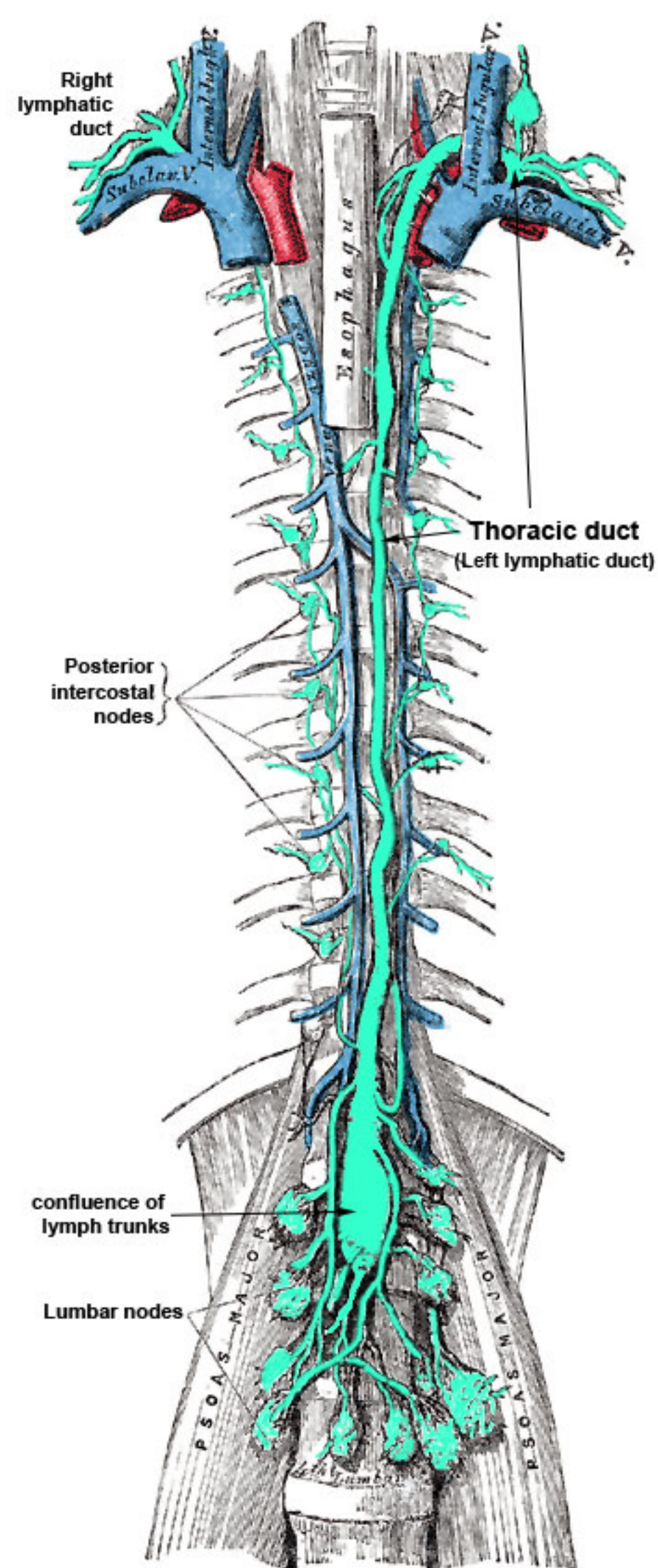
## Lymph Ducts

Smooth muscle cells in wall, 1 or 2 layers.

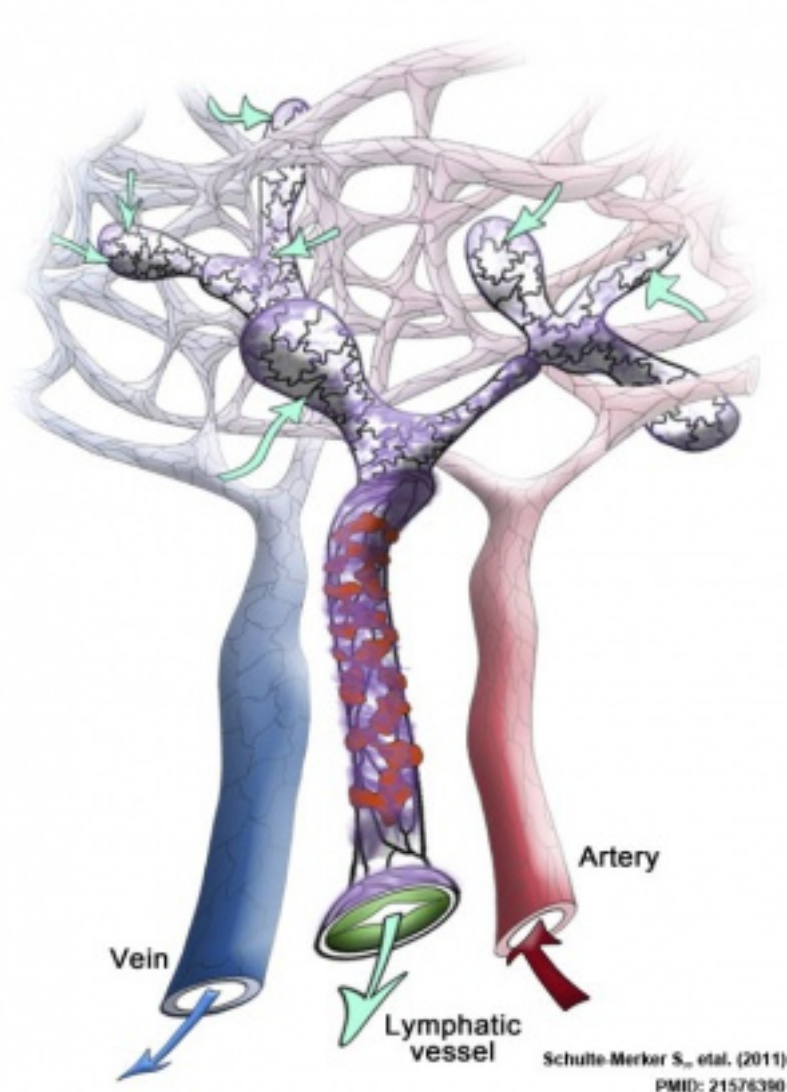


Gastrointestinal tract intestine lymphatics





Thoracic and right lymphatic ducts



## Lymph

- Fluid portion of lymphatic circulation
- blood plasma will leave blood vessels into surrounding tissues
- adds to normal tissue interstitial fluid
- surplus of liquid needs to be returned to circulation
- Lymph vessels provide unidirectional flow of this liquid

## Diffuse Lymphatic Tissue

Alimentary canal, respiratory passage and urogenital tract.

- **BALT** - Bronchus Associated Lymphoid Tissue or **GALT** - Gut Associated Lymphatic Tissue
- **Not enclosed by a connective tissue capsule**
- Located in subepithelial tissue - **lamina propria**
- Diffuse lymphatic tissue + nodules
- Reactive - enlarge when activated (by antigen)

## Lymphocytes

- travel to nodes and back again
- proliferation and differentiation



# Lymph Nodules

- Organized concentrations of lymphocytes
  - No capsule, covered by epithelia
- Nodules are also the unit structure seen in a node
- Oval concentrations in meshwork of reticular cells

## Nodule States

- **Primary Nodule** - Mainly small lymphocytes
- **Secondary Nodule**
  - Central pale region (germinal centre) - Effector cells and macrophages
  - Dark outer ring (small lymphocytes)

## Gastrointestinal Tract

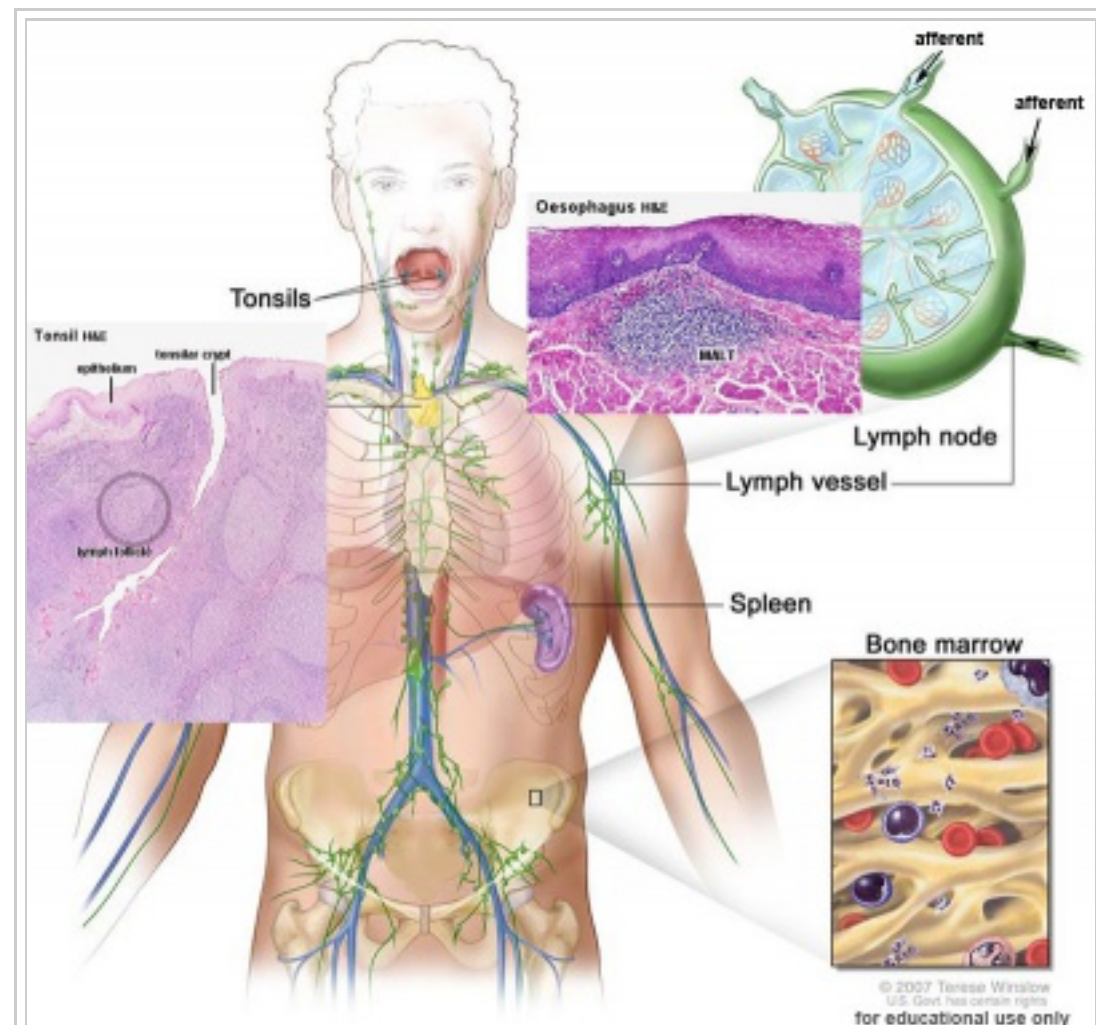
- Oropharynx - Tonsils
- Distal small intestine (ileum) - Peyer's Patches
- Appendix, cecum

## Mucosal Associated Lymphoid Tissues

Anatomical location -  
Palatine (**tonsils**), Lingual  
and Pharyngeal (**adenoids**)

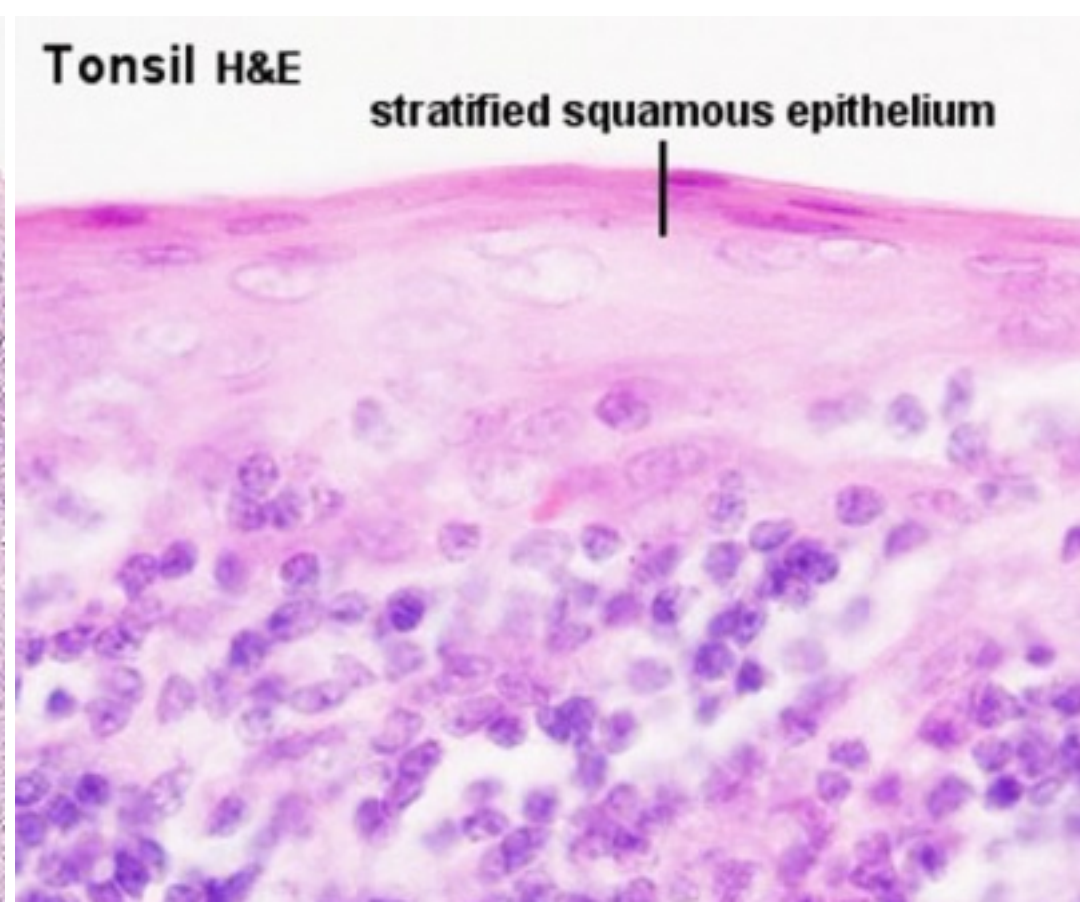
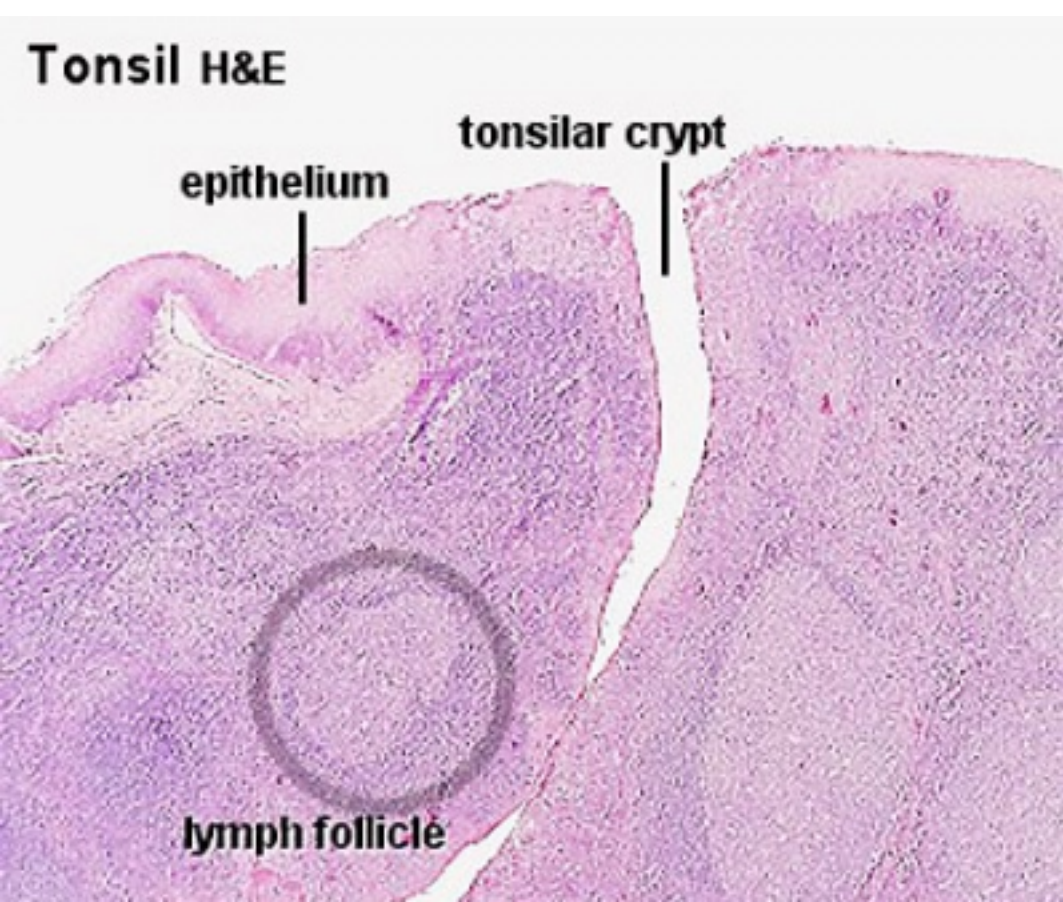
Ring of oral adenoid  
tissue:

- anterior - **lingual tonsil** formed by the submucous adenoid collections.
- lateral - **palatine tonsils** and adenoid collections near the auditory tubes.
- posterior - **pharyngeal tonsil** on the posterior wall of the pharynx.
- between main masses are smaller collections of adenoid tissue.

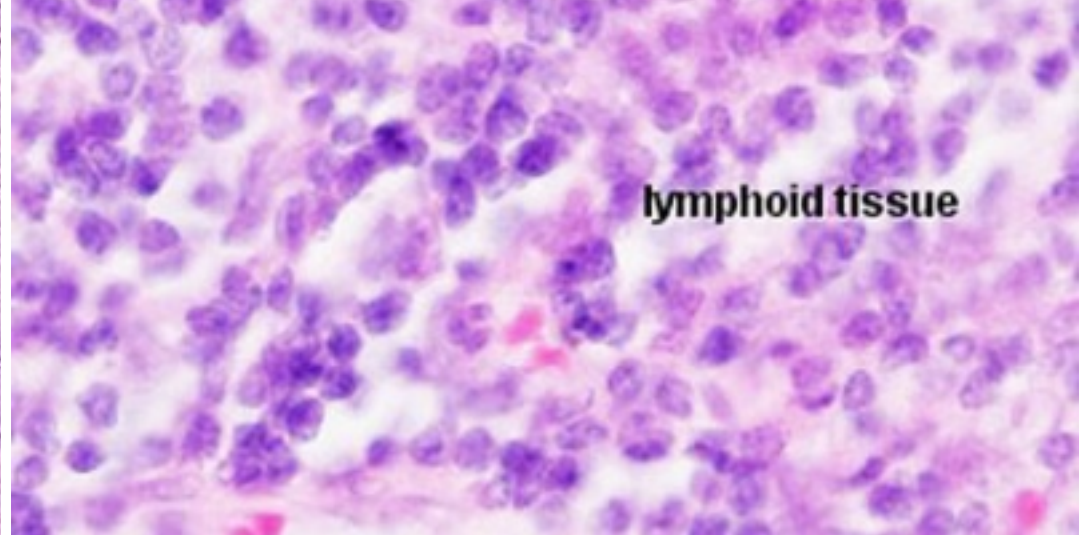
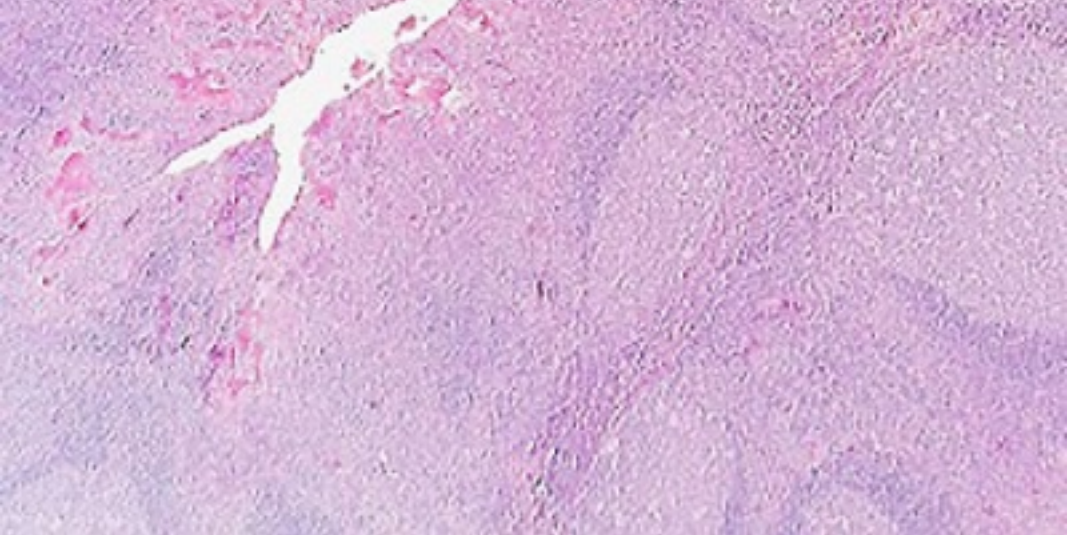


Tonsil and MALT

## Palatine Tonsils







- the "tonsils", lateral wall of oropharynx
- covered by **stratified squamous epithelium**
- numerous crypts (10-20) infolds of surface epithelium
- Afferent lymph vessels absent
- Efferent lymph vessels are present

## Lingual Tonsils

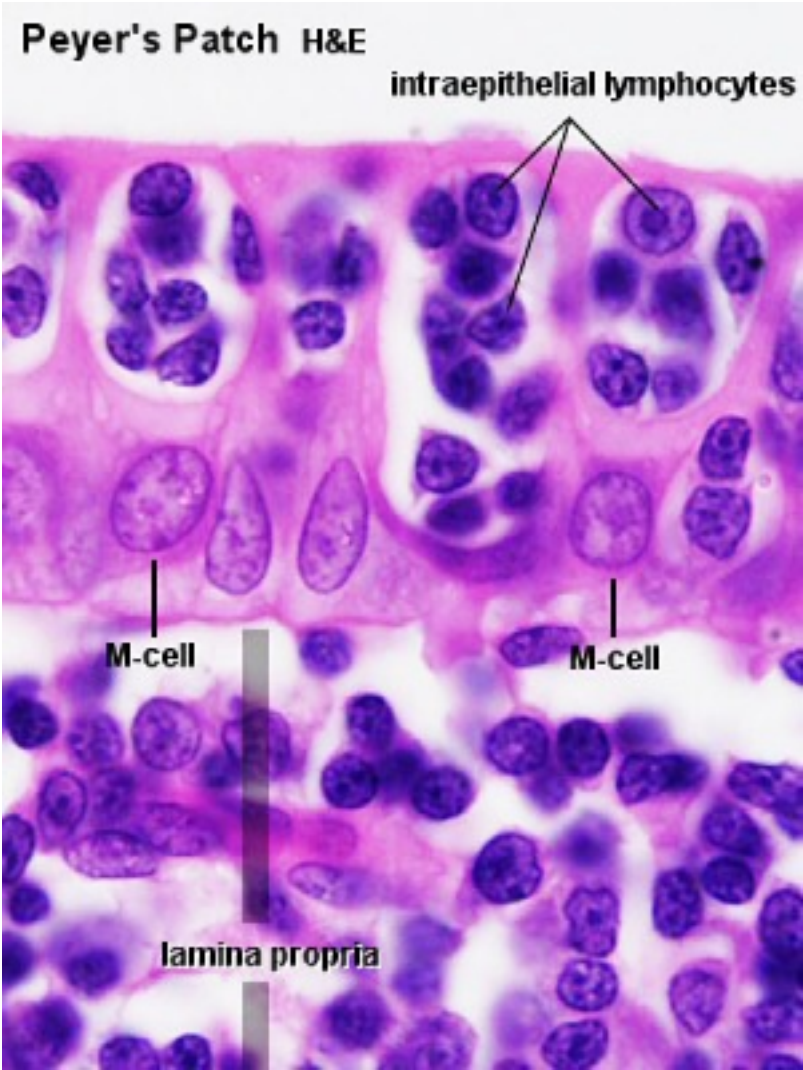
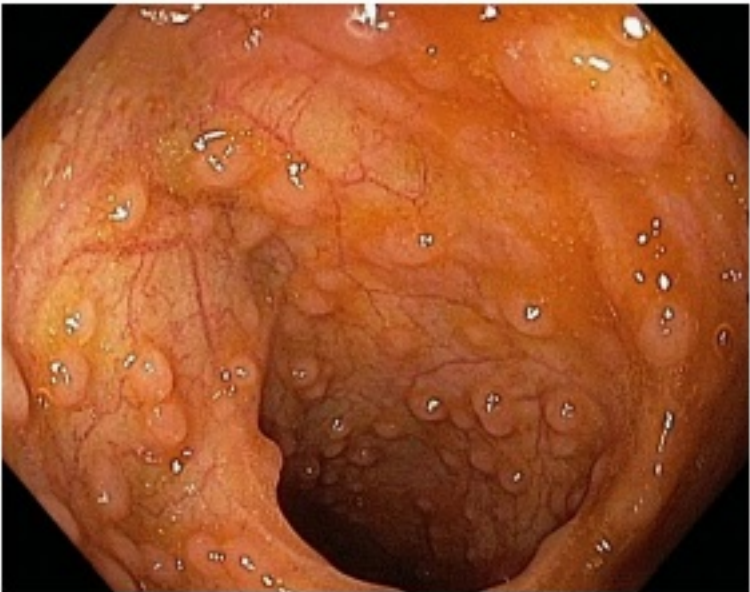
- lamina propria root of tongue
- covered by **stratified squamous epithelium**
- salivary glands and skeletal muscle are directly adjacent

## Pharyngeal Tonsils

- adenoids** or nasopharyngeal tonsils, upper posterior part of throat
- covered by a **pseudostratified ciliated epithelium** with goblet cells

## Peyer's Patch

- located in the ileum



Peyers patches (ileocolonoscopy)

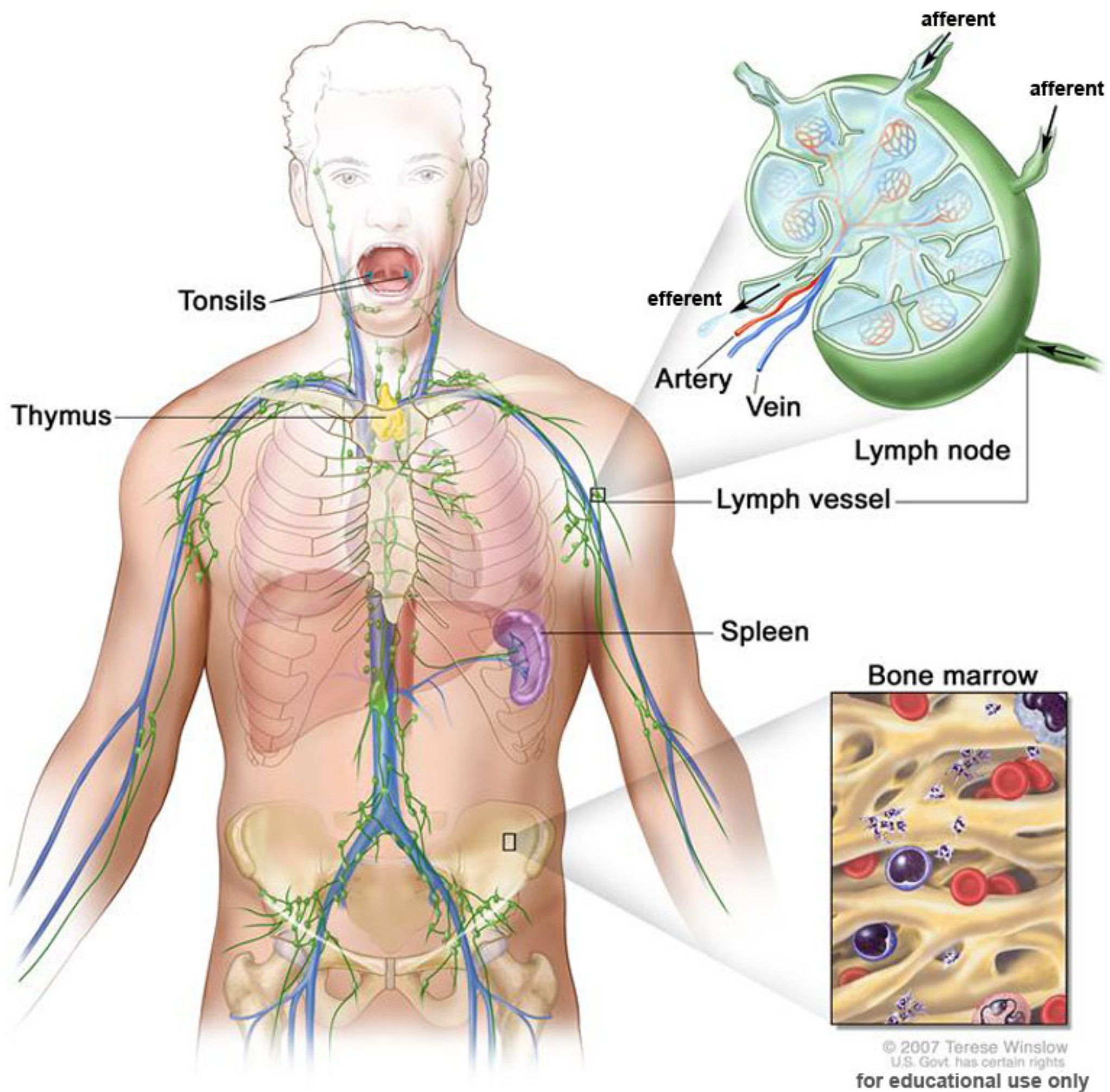
Peyer's Patch (histology)

microfold cells or M-cells  
(transport gut lumen organisms and particles to immune cells across the epithelial barrier).

About Peyer's Patch [Expand]

## Lymph Nodes





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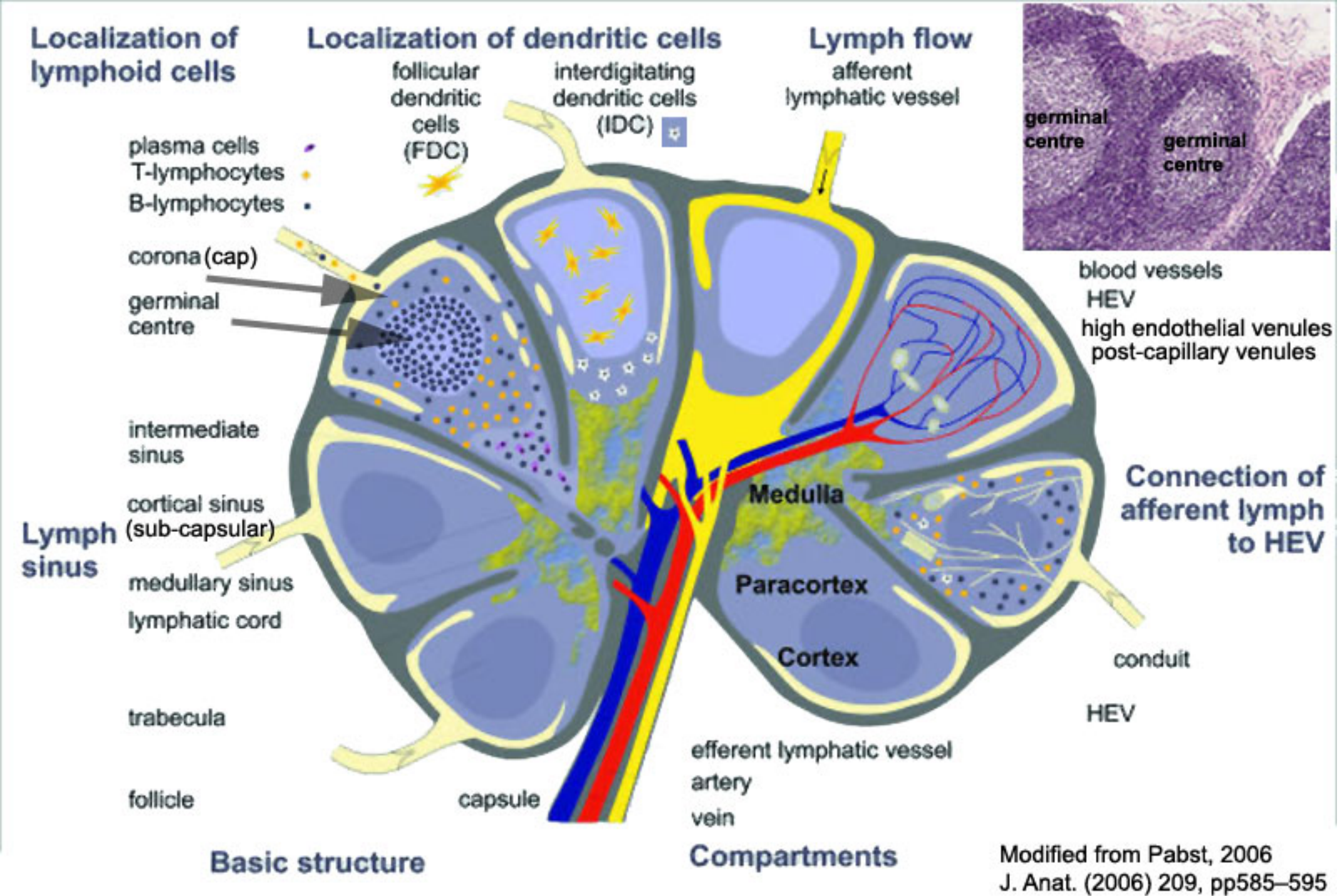
- Location throughout the entire body - Concentrated in axilla, groin, mesenteries
- Encapsulated organ (1 mm - 2 cm)
- Antigen transformed lymphocytes from the blood
- In lymph vessel pathways “filter”
- Afferent- towards node
- Efferent- away from node

#### Lymph flow

- enters the node through **afferent vessels**
- filters through the **sinuses**
- leaves through **efferent vessels**

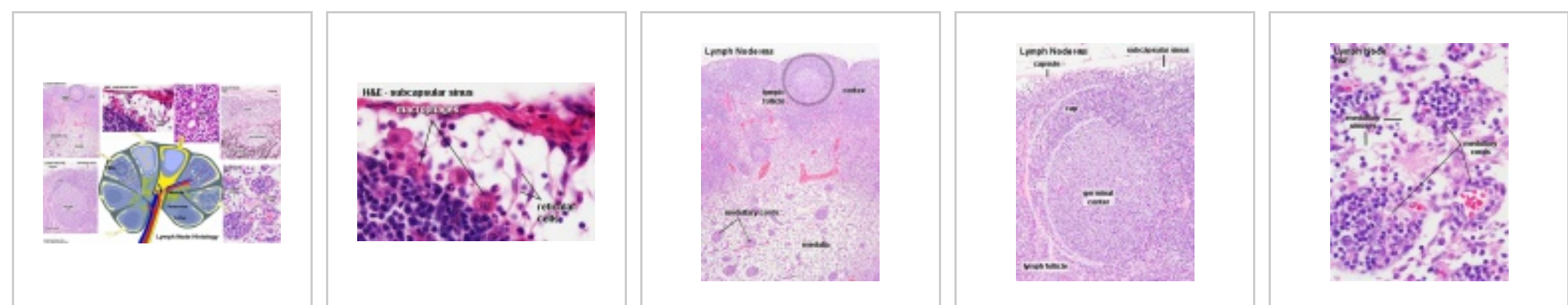
#### Lymph Node Structure





## Connective Tissue

- **Capsule** - dense connective tissue (irregular CT, some adipocytes))
- **Trabeculae** - dense connective tissue
- **Reticular Tissue** - Reticular cells and fibers, supporting meshwork (collagen type III)
  - Reticular cell produces reticular fibers (**collagen type III**) and surrounds the fibers with its cytoplasm
  - reticular fibers can also be produced by fibroblasts



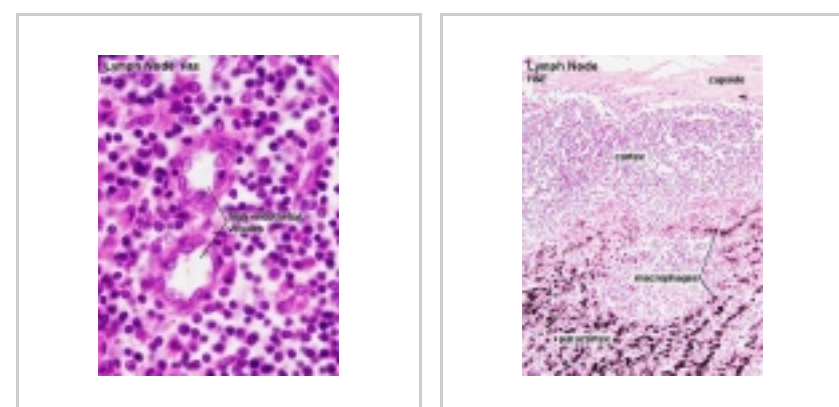
Cartoon with histology features

Subcapsular Sinus (marginal sinus, continuation of trabecular sinus)

Follicle

Germinal Centre

Medullary Cords and Sinuses



High Endothelial Venules

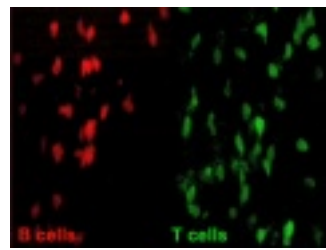
Macrophages



## Lymphocyte (T and B) Traffic

1. Enter from high endothelial venules (HEVs also called post-capillary venules)
2. Spend 8 to 24 h in the lymph node interstitium.
3. Enter a network of medullary sinuses.
4. Drain from sinuses into efferent lymphatic vessels.

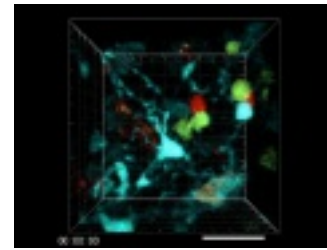
See also Image - Cell Trafficking into and out of Lymph Nodes.



Lymph Node 7

Page | Play

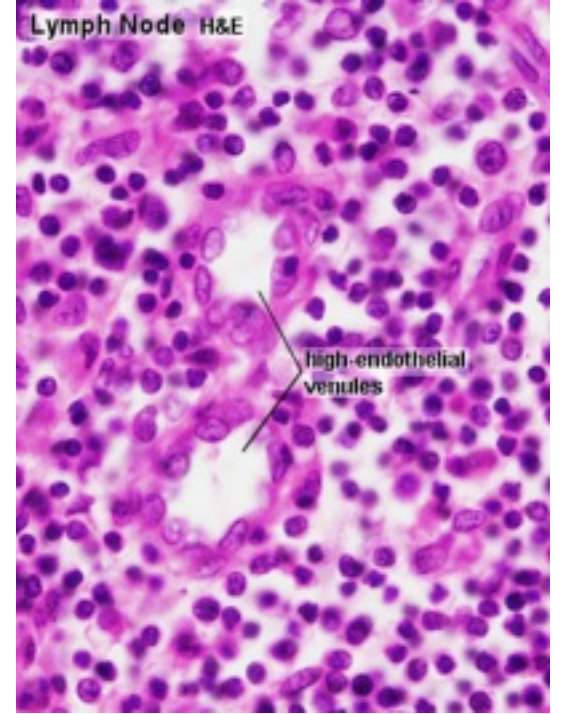
T and B motility



Lymph Node 8

Page | Play

T and B interaction

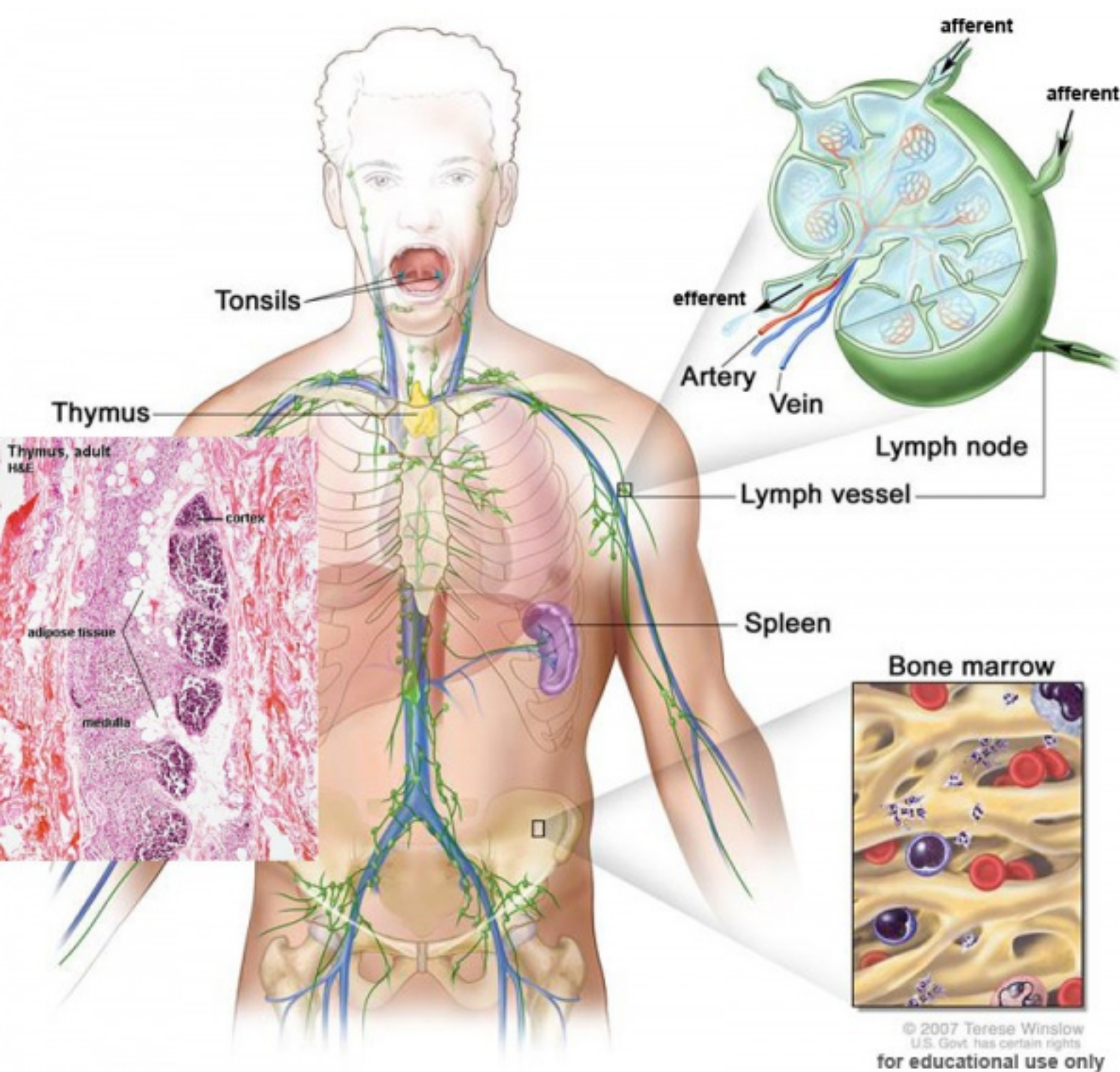


High Endothelial Venules

See also Lymphocyte Migration at High Endothelial Venule Model

**Links:** Immunobiology - Figure 1.8. Organization of a lymph node (<http://www.ncbi.nlm.nih.gov/books/NBK27092/figure/A47>)

## Thymus



## Gross Anatomy

- Superior mediastinum, anterior to heart
- Bilobed lymphoepithelial organ

## Histology

- Contains reticular cells but no fibers
- Stem lymphocytes
  - proliferate and differentiate



- forms long-lived T- lymphocytes
- removes auto-reactive T-lymphocytes (negative selection)

## Thymus Cells

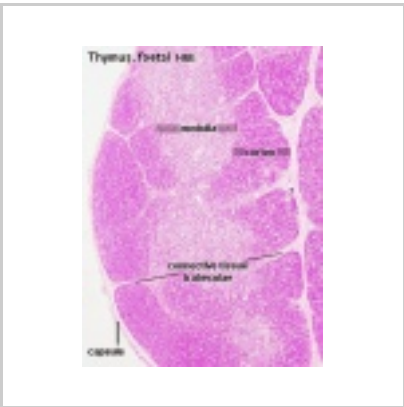
Reticular cells	Macrophages	Lymphocytes
<ul style="list-style-type: none"> <li>■ Abundant, eosinophilic, large, ovoid and light nucleus 1-2 nucleoli</li> <li>■ sheathe cortical capillaries</li> <li>■ form an epitheloid layer</li> <li>■ maintain microenvironment for development of T-lymphocytes in cortex (thymic epitheliocytes)</li> </ul>	<ul style="list-style-type: none"> <li>■ cortex and medulla</li> <li>■ difficult to distinguish from reticular cells in (Stain - Haematoxylin Eosin)</li> <li>■ remove auto-reactive T-lymphocytes</li> </ul>	<ul style="list-style-type: none"> <li>■ located in cortex and medulla</li> <li>■ more numerous (denser) in cortex</li> <li>■ majority are developing T-lymphocytes (= thymic lymphocytes or thymocytes)</li> </ul>

## Development Changes

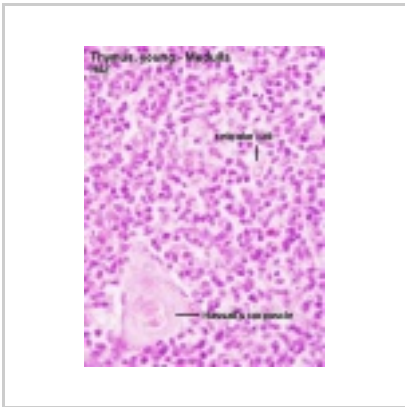
{Changes with age Overall Size

- birth 10-15 g
- puberty 30-40 g
- after puberty - decreases in size (involution)
- middle-aged 10 g, replaced by adipose tissue

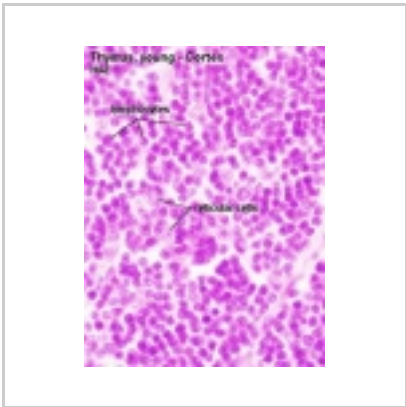
### Histology



Fetal thymus



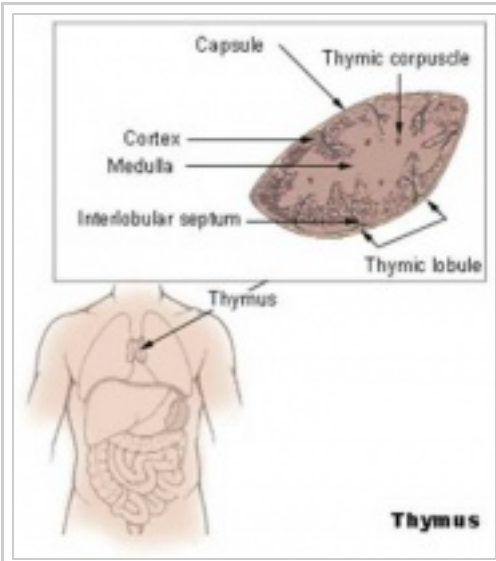
Young medulla



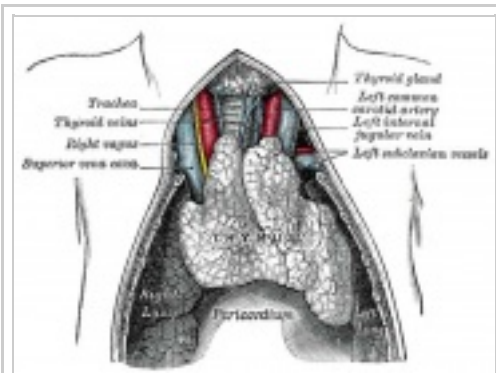
Young cortex

## Adult Thymus

- Cortical lymphoid tissue is replaced by adipose tissue (involution)
- Increase in size of thymic corpuscles
- **Thymic corpuscle** - (Hassall’s corpuscle) mass of concentric epithelioreticular cells.

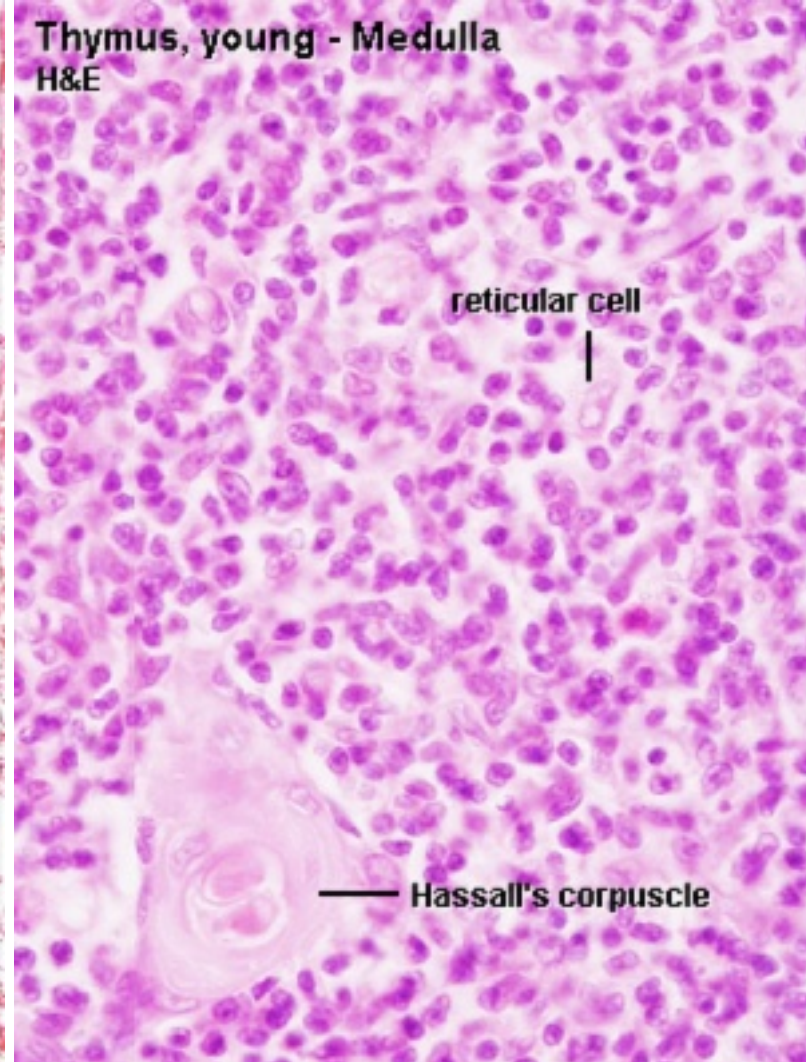
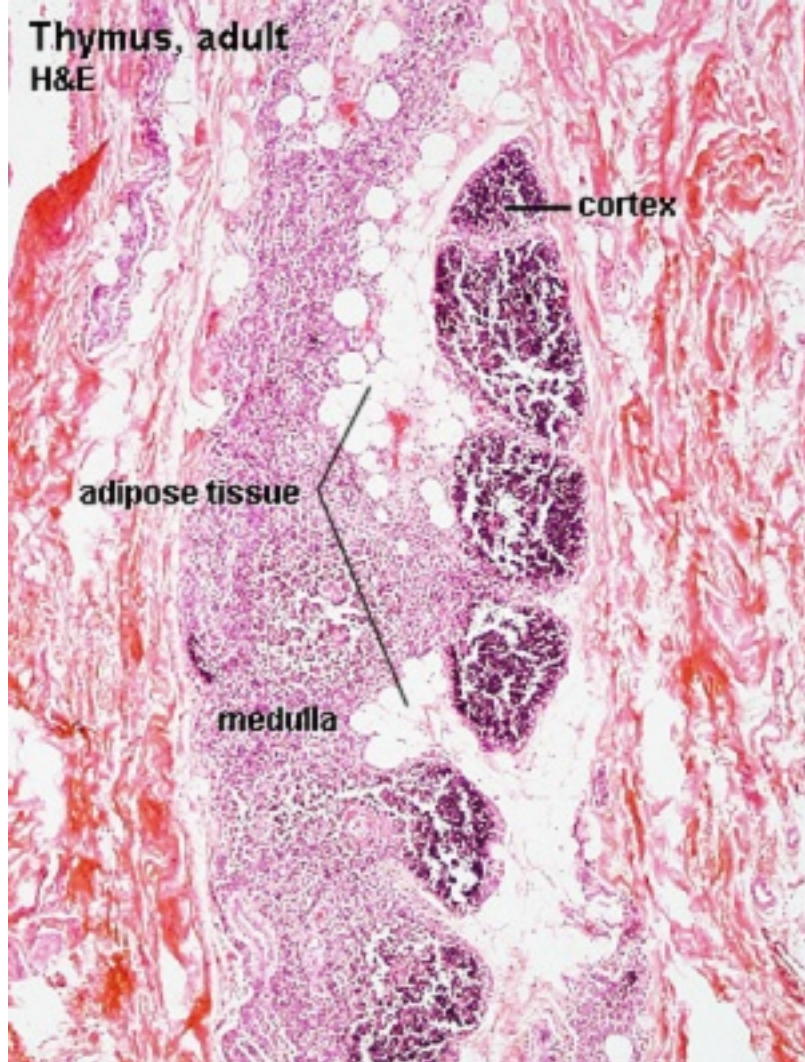


Adult Thymus



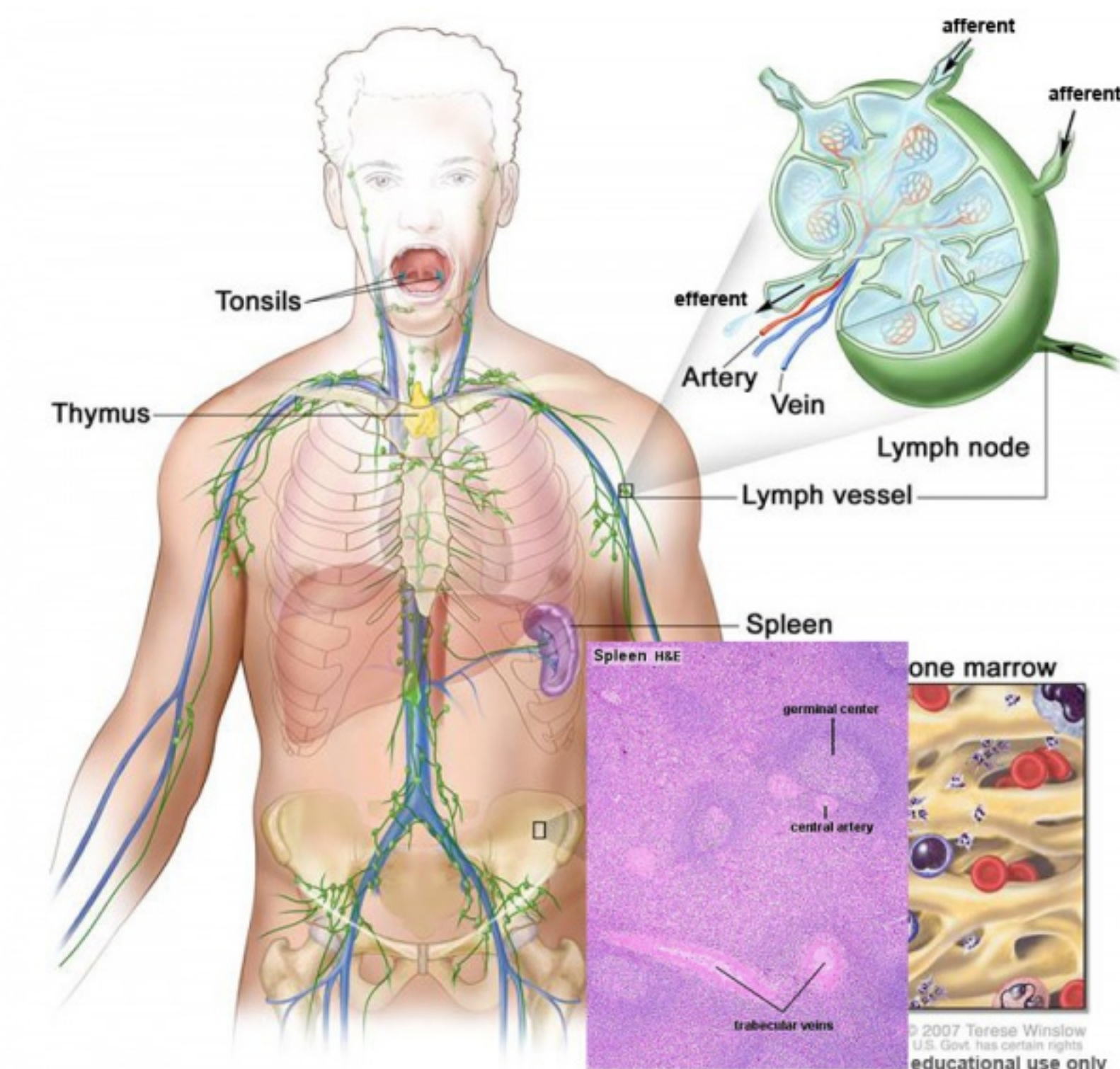
Fetal thymus anatomy





**Thymus Histology:** Fetal Thymus overview | Fetal Thymus Medulla | Fetal Thymus Cortex | Adult Thymus | unlabeled fetal overview | unlabeled fetal medulla unlabeled fetal thymic corpuscle unlabeled fetal cortex | unlabeled adult overview | Category:Thymus | Immune System Development

## Spleen



## Spleen Function

1. **Immune** - filters blood in much the way that the lymph nodes filter lymph.



1. **Lymphocytes** in the spleen react to pathogens in the blood and attempt to destroy them.

2. **Macrophages** then engulf the resulting debris, the damaged cells, and the other large particles.

2. **Red Blood Cell Removal** - spleen (and liver) removes old and damaged erythrocytes from the circulating blood.

3. **Blood Reservoir** - The sinuses in the spleen also act as a reservoir for blood.

- In emergencies, such as hemorrhage, smooth muscle in the vessel walls and in the capsule of the spleen contracts.

This squeezes the blood out of the spleen into the general circulation.

Structure

- Capsule, trabeculae (dense connective tissue)

Splenic pulp white pulp, red pulp - based on appearance and cell content.

White Pulp

- lymphocytes surround central arteries

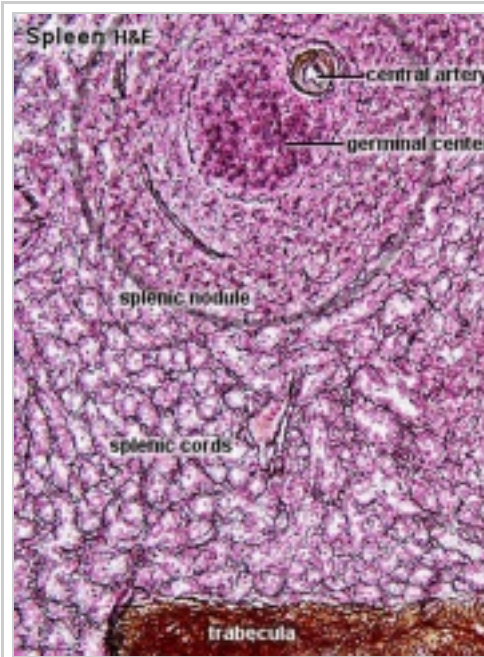
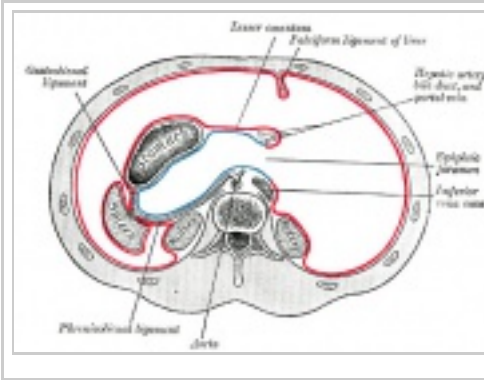
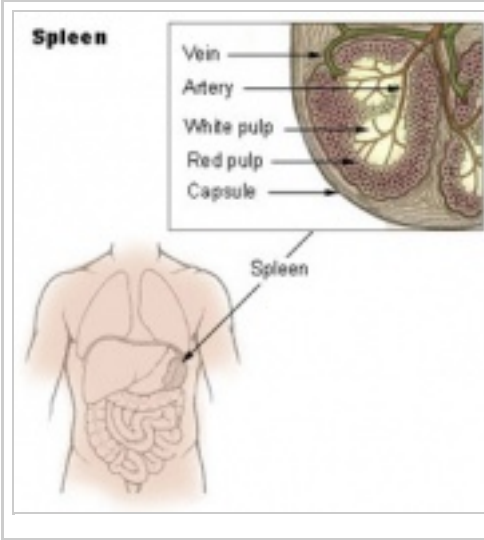
as periarterial lymphoid sheath (PALS)

Red Pulp

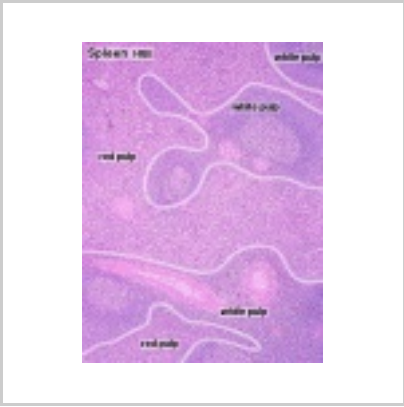
- Red blood cells

Splenic cords and sinuses

Reticular Fibers (type III collagen) act as supporting meshwork.



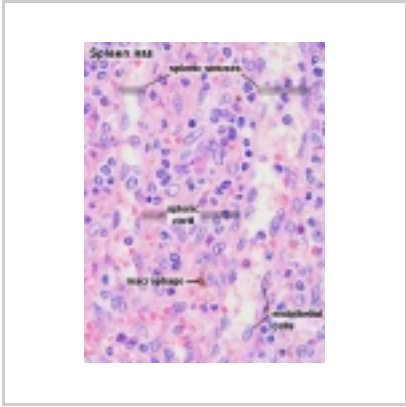
White pulp -periarterial lymphoid sheath (PALS)



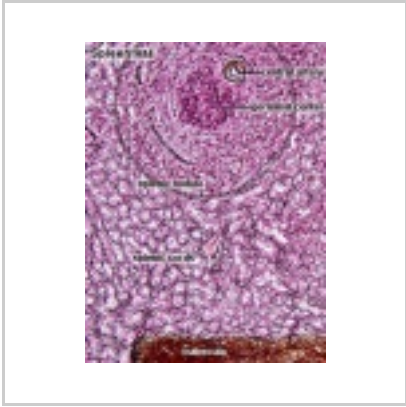
Overview Red and White Pulp



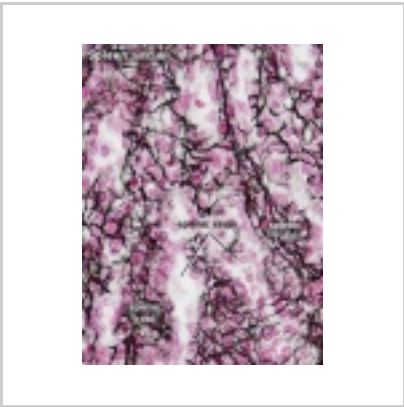
Overview Red and White Pulp



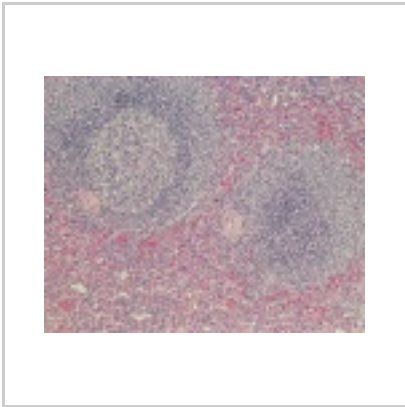
Cords and Sinuses



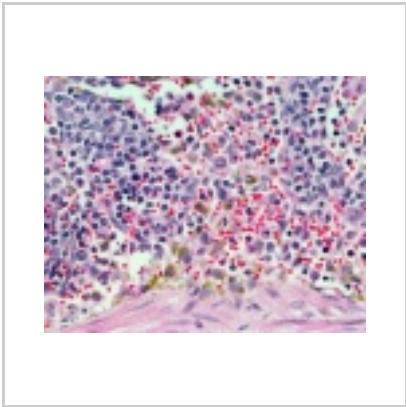
Reticular Fibre overview



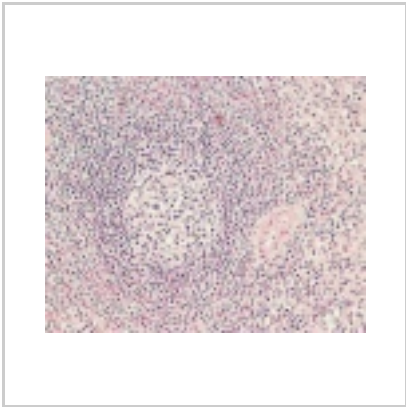
Reticular Fibre detail



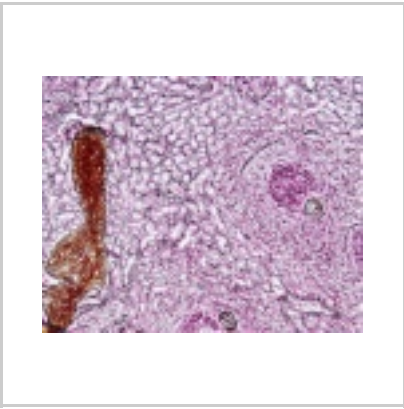
unlabeled red and white pulp



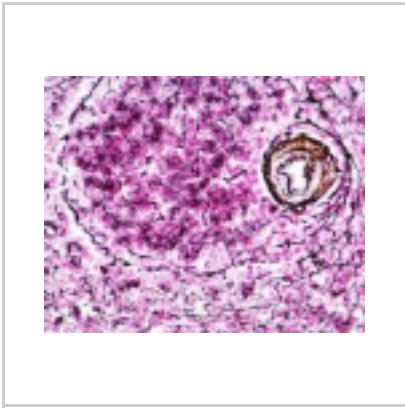
unlabeled red pulp and macrophages



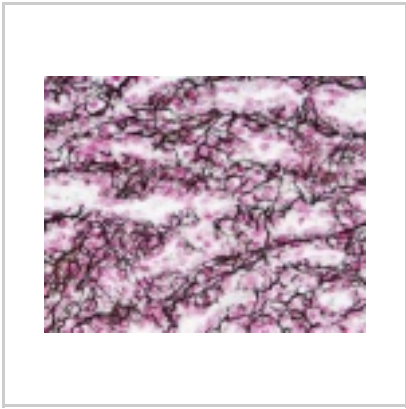
unlabeled white pulp germinal centre



unlabeled reticular fibre



unlabeled white pulp reticular



unlabeled red pulp reticular

**Spleen Development:** Adult Histology | Overview Red and White Pulp | Overview Red and White Pulp | Cords and Sinuses | Reticular Fibre overview | Reticular Fibre detail | unlabeled red and white pulp | unlabeled red pulp and macrophages | unlabeled white pulp germinal centre | unlabeled reticular fibre | unlabeled white pulp reticular | unlabeled red pulp reticular | Structure cartoon | Cartoon and stain | Category:Spleen | Histology Stains | Immune System Development



# Additional Information

*Content shown under this heading is not part of the material covered in this class. It is provided for those students who would like to know about some concepts or current research in topics related to the current class page.*

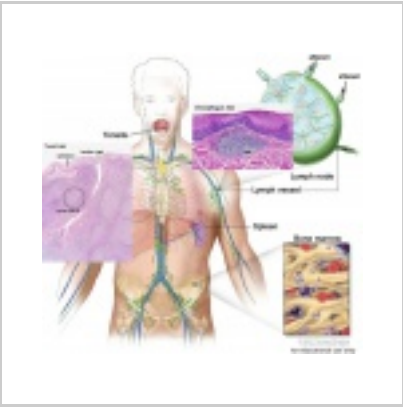
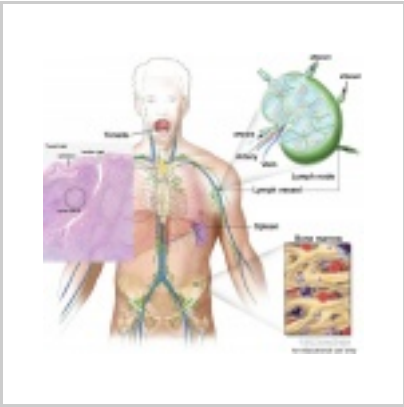
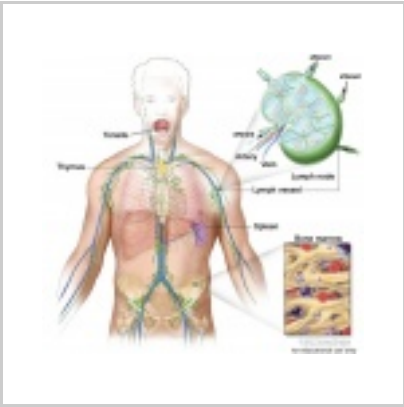
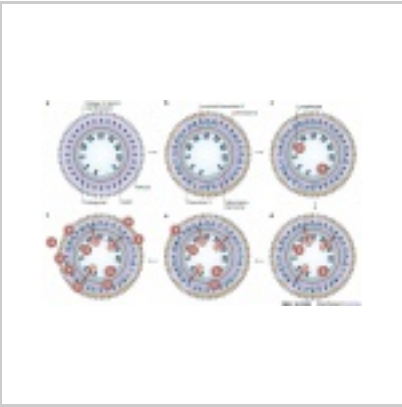
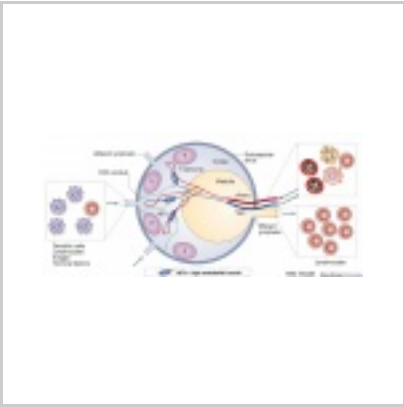
If you have comments or questions specifically related to this lecture, please leave them on the Student lecture feedback page.

*The following is not part of the lecture and is for reference purposes only.*



**SH Practical - Lymphatic Structure and Organs** associated practical support page. Note that virtual slides will be used in the associated practical class and this linked page is provided for student self-directed learning of concepts from the virtual slides.

**Lymphatic cartoon links:** Overview | Tonsil | Tonsil and MALT | Thymus | Spleen | Bone marrow | **Lecture - Lymphatics** | Immune System Development



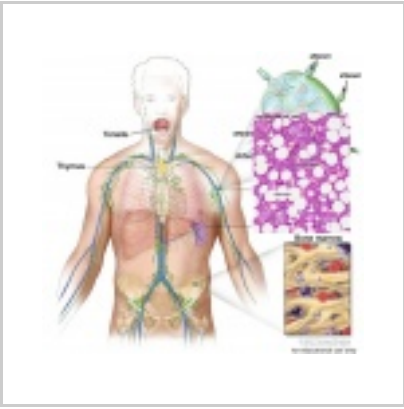
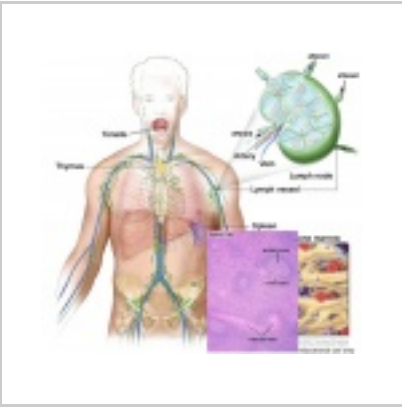
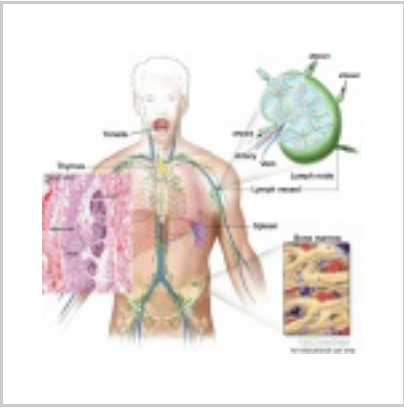
Cell Trafficking into and out of Lymph Nodes

Lymphocyte Migration at High Endothelial Venule Model

Overview

Tonsil

Tonsil and MALT



Thymus

Spleen

Bone marrow

**Lymph Node Cartoons:** Detailed structure | Cartoon with Histology | Lymphocyte traffic | Simple structure | Simple node anatomy | Wiki node image | Internal structure | Mesenteric lymph node | Histology | Gallery | Lymph Node Development

**Mouse Lymphocyte Motility Movies** [Expand]

**Additional Images** [Expand]

**Janeway's Immunobiology** [Expand]

## Nature Immunology - Videos

These are short (5-10 min) animations showing how the immune system monitors the epithelial and environment interface at different anatomical locations.

- Immunology of the skin (<http://www.nature.com/ni/multimedia/skin/index.html>)
- Immunology of the lung (<http://www.nature.com/ni/multimedia/lung/index.html>)
- Immunology in the gut mucosa (<http://www.nature.com/ni/multimedia/mucosal/index.html>)

**Blood Cells** [Expand]

**Anatomy of the Human Body (1918) - Lymphatics** [Expand]

Textbook Links: MBoC Figure 24-6. The development and activation of T and B cells | <http://www.ncbi.nlm.nih.gov/books/NBK26921/figure/A4430/> Figure 24-7. Electron micrographs of nonactivated and activated



lymphocytes (<http://www.ncbi.nlm.nih.gov/books/NBK26921/figure/A4429>) | Immunobiology - Figure 1.9. Organization of the lymphoid tissues of the spleen (<http://www.ncbi.nlm.nih.gov/books/NBK27092/figure/A48>)

**Structure** - Cells, Vessels, Diffuse (extra-nodal tissue), Nodes, Organs.

- Cells
- Vessels
- Diffuse
  - Mucosal Associated Lymphoid Tissues (MALT)
  - Extranodal Lymphoid Tissues
  - Nodules
- Lymph Nodes
  - Position
  - Structure
  - Function
- Organs
  - Position, Structure, Function
  - Thymus
  - Spleen

## Terms

A few key terms associated with the Lymphoid system.

- **adenoid** - (Greek " +*-oeides* = in form of) in the form of a gland, glandular; the pharyngeal tonsil.
- **afferent lymph** - vessel carrying lymph towards a node.
- **Antibody mediated immunity** - the immune function of plasma cells (active B lymphocytes) secreting antibody which binds antigen.
- **antibodies** - mammals have five classes (IgA, IgD, IgE, IgG, and IgM)
- **antigen** - any substance that is recognised by the immune system and stimulates antibody production.
- **appendix** - is a gut-associated lymphoid tissue located at the beginning of the colon. The anatomy is as a finger-like structure that arises from the cecum. The length (2.5-13 cm) is longer in both infants and children and also has more abundant lymphatic tissue in early life. The wall structure is similar to the small intestine (though with no villi), nor plicae circularis. Lymph nodules surround the lumen of the gastrointestinal tract and extend from the mucosa into the submucosa.
- **B lymphocyte (cell)** - historically named after a structure called the **bursa** of Fabricius in birds, a source of antibody-producing lymphocytes. These cells develop in the bone marrow. (More? Electron micrographs of nonactivate and activated lymphocytes)
- **BALT** - Bronchus Associated Lymphoid Tissue
- **band cell** - (band neutrophil or stab cell) seen in bone marrow smear, a cell undergoing granulopoiesis, derived from a metamyelocyte, and leading to a mature granulocyte. Also occasionally seen in circulating blood.
- **cecum** - (caecum, Latin, *caecus* = "blind") within the gastrointestinal tract a pouch that connects the ileum with the ascending colon of the large intestine.
- **cell** - has a specific cell biology definition, but is often used instead of "lymphocyte" when describing B and T cells.
- **Cell-mediated immunity** - the immune function of T lymphocytes.
- **CD** - (cluster of differentiation) identifies immunological surface markers on cells.
- **CD4+** - (T helper cells) refers to T lymphocytes that express CD4 (glycoprotein of the immunoglobulin superfamily) on their surface.
- **CD8+** - (cytotoxic T cells) refers to T lymphocytes that express CD8 (glycoprotein of the immunoglobulin superfamily) on their surface.
- **"clockface"** - a term used to describe the appearance of plasma cell nuclei due to the clumping of the chromatin at the nucleus periphery. More clearly seen in tissue plasma cells than the bone marrow smear, where they are sometimes confused with the basophilic erythroblasts.
- **cords of Billroth** - spleen cellular columns located in red pulp. surrounded by splenic sinusoids. Cords contain reticular cells, macrophages, lymphocytes, plasma cells and erythrocytes.
- **cortex** - outer layer, used in association with medulla (inner layer or core) a general description that can be applied to describing an organ with a layered structure.
- **dendritic cells** - (DCs) immune cells that function to process antigen and present it on their surface to other immune cells.
- **Effector cells** - the immune functioning (active) B and T lymphocytes.
- **Efferent lymph** - vessel carrying lymph away from a node.
- **GALT** - Gut Associated Lymphatic Tissue
- **haemopoiesis** (hemopoiesis) formation of blood cells.
- **Hassall's corpuscle** - thymic corpuscle.
- **HEV** - (high endothelial venule) within the lymph node these specialised post-capillary venules enables blood lymphocytes to enter a lymph node. Their endothelial cells express ligands that bind lymphocytes, aiding their adhesion and subsequent transmigration into the lymph node.
- **IgA** - the main class of antibody in secretions (saliva, tears, milk, and respiratory and intestinal secretions).
- **IgD** - the immunoglobulin B cell starts to produce as a cell-surface molecule after leaving the bone marrow.
- **IgE** - bind Fc receptors (surface of mast cells in tissues and basophils in the blood).
- **IgG** - the major class of immunoglobulin in the blood.
- **IgM** - the first class of antibody made by a developing B cell, which may switch to making other classes of antibody.
- **immunodeficiency** - when one or more components of the immune system is defective. (More? Immunobiology - immunodeficiency (<http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Search&db=books&rid=imm.section.1494>))
- **involution** - in the Thymus refers to the replacement, mainly in the cortex, of cells by adipose tissue. (More? PubMed- thymus)



- involution (<http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?db=PubMed&cmd=Search&term=thymus+involution&doptcmdl=Books>)) | Cancer Medicine - Thymomas and Thymic Tumors (<http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Search&db=books&rid=cmed6.section.23856#23857>))
- **Kupffer cells** - stellate macrophage cells located in the liver sinusoids, named after Karl Wilhelm von Kupffer (1829 - 1902) a German anatomist who originally identified these cells. (More? Liver Development)
  - **lamina propria** - a layer of loose connective tissue found underneath the epithelium of mucosa.
  - **Leukocyte**- (Greek, leuko= clear, white) white blood cell.
  - **lingual**- related to the tongue.
  - **lymph node** - connective tissue encapsulated lymphoid organ (1mm - 2cm in size), positioned in the pathway of lymph vessels.
  - **M cell** - (microfold cell) found in the follicle-associated epithelium of the Peyer's patch. Function to transport gut lumen organisms and particles to immune cells across the epithelial barrier.
  - **macrophage** - a large highly motile white blood cell which engulfs foreign material (bacteria etc) and both degenerating cells and cell fragments. Found in many different tissues and locations. (More? Immunobiology - Defects in phagocytic cells are associated with persistence of bacterial infection (<http://www.ncbi.nlm.nih.gov/books/bv.fcgi?rid=imm.figgrp.1508>))
  - **MALT** - Mucosa Associated Lymphoid Tissue
  - **medulla** - inner layer or core, used in association with cortex (outer layer) a general description that can be applied to describing an organ with a layered structure.
  - **Memory Cell** - effector T cell (lymphocyte)
  - **NALT** - Nasal Associated Lymphoid Tissue.
  - **NK cell** - (Natural killer cell, large granular lymphocytes) are a type of cytotoxic lymphocyte, responding rapidly to virally infected and tumor cells.
  - **normoblast** - seen in bone marrow smear, a developing erythroblast (red blood cell) that still retains a nucleus.
  - **parenchyma** - (Greek = *enkeim* "to pour in") cells forming the functional cells of an organ or tissue. These cells carry out the function of the organ at a cellular level, and are not the structural cells, connective tissue, extracellular matrix (stromal).
  - **periarterial lymphoid sheath** - (PALS) in the spleen the white pulp that surrounds the central arteries. (T-lymphocytes,macrophages and plasma cells)
  - **Plasma Cell** - active B cell (lymphocyte) which is secreting antibody. Located in either bone marrow or peripheral lymphoid tissues, these cells have and increased cytoplasmic volume (due to increase rough endoplasmic reticulum) in comparison to the inactive (non-secreting) lymphocyte.
  - **secondary lymphoid organs** - spleen, regional lymph nodes, Peyer's patches, Isolated Lymphoid Follicles (ILFs), tonsils and Nasal Associated Lymphoid Tissue (NALT).
  - **sentinel lymph node** - the hypothetical first lymph node or group of nodes reached by metastasizing cancer cells from a primary tumour.
  - **splenic sinusoids** - enlarged spleen capillary spaces located in red pulp and surrounding cords of Billroth.
  - **stroma** - (Greek = "a cover, table-cloth, bedding") tissue forming the framework/support of an organ or tissue. That is the structural cells which form connective tissue and secrete extracellular matrix, rather than the functional cells (parenchymal). All organs can therefore be functionally divided into these 2 components, stromal/parenchymal.
  - **Subcapsular sinus** (=marginal sinus) space lying under the connective tissue capsule which receives lymph from afferent lymphatic vessels.
  - **tertiary lymphoid tissue** - develop at sites of persistent infection or chronic inflammation.
  - **Thymic corpuscle** (=Hassall's corpuscle) a mass of concentric epithelioreticular cells found in the thymus. The number present and size tend to increase with thymus age. (see classical description of Hammar, J. A. 1903 Zur Histogenese und Involution der Thymusdriise. Anat. Anz., 27: 1909 Fiinfzig Jahre Thymusforschung. Ergebn. Anat. Entwickl-gesch. 19: 1-274.)
  - **thymic epitheliocytes** - reticular cells located in the thymus cortex that ensheath the cortical capillaries, creating and maintain the microenvironment necessary for the development of T-lymphocytes in the cortex.
  - **T lymphocyte (cell)** - named after thymus, where they develop, the active cell is responsible for cell-mediated immunity. (More? Electron micrographs of nonactivate and activated lymphocytes (<http://www.ncbi.nlm.nih.gov/books/bv.fcgi?rid=mboc4.figgrp.4430>))
  - **thymus** - thymus has a key role in the development of an effective immune system as well as an endocrine function. Immune system T cells are essential for responses against infections and research relates to the postnatal development of T cells within the thymus. Thymus Development
  - **tonsils** - mucosal-associated lymphoid tissues consists of: 2 palatine tonsils (tonsilla palatina), adenoids (tonsilla pharyngealis) and 1 lingual tonsil (tonsilla lingualis)
  - **tonsillar ring** - ring of lymphoid tissue (tonsils) around where the mouth and nasal cavity meet the throat.
  - **vermiform appendix** - see appendix, anatomical region containing gut-associated lymphoid tissue located within the gastrointestinal tract at the beginning of the colon. The anatomy is as a finger-like structure that arises from the cecum. The length (2.5-13 cm) is longer in both infants and children and also has more abundant lymphatic tissue in early life. The wall structure is similar to the small intestine (though with no villi), nor plicae circularis. Lymph nodules surround the lumen of the gastrointestinal tract and extend from the mucosa into the submucosa.

## Glossary Links

A | B | C | D | E | F | G | H | I | J | K | L | M | N | O | P | Q | R | S | T | U | V | W | X | Y | Z | Numbers | Symbols