

# ***CIRCULATORY SYSTEMS***

## Cardiovascular

Derived from mesoderm

Transport System

Has a pump (heart)

Arteries

Veins for return

Veins have valves

Carries RC, WBC, plasma

## Lymphatic

Derived from mesoderm

Transport System

No pump

No equivalent

Lymph vessels for return

Lymph vessels have valves

Carries WBC, plasma

# **The Lymphatic System**

# MAJOR FUNCTIONS OF LYMPHATIC SYSTEM

1. Collection of excess water and proteins from interstitial fluid.
2. Fat transport (tissue near small intestine into bloodstream).
3. Short term immune responses (microorganisms and other substances).
4. Development of long term immunity.

# WHY A LYMPHATIC SYSTEM?

Water, small proteins, white blood cells  
can escape cardiovascular system.

Must have way to return them to  
cardiovascular system, or there will be  
fluid buildup outside in tissues.

# LYMPH ITSELF...

Contains no red blood cells, fluid looks clear.  
Lymph is Latin for "clear water."

In some ways similar to blood, but not identical.  
No red blood cells, and some proteins are too large to escape the cardiovascular system.

Contains millions of white blood cells,  
particularly common are lymphocytes and monocytes.

MONOCYTES (Review): Capable of attacking foreign microorganisms or tissues. They are highly mobile.

When they attack microorganisms individually = "macrophages."

When they attack tissues in a coordinated fashion = "tissue macrophages" or "histocytes."

LYMPHOCYTES: geared toward individual recognition of specific microorganisms or foreign substances.

Two types:

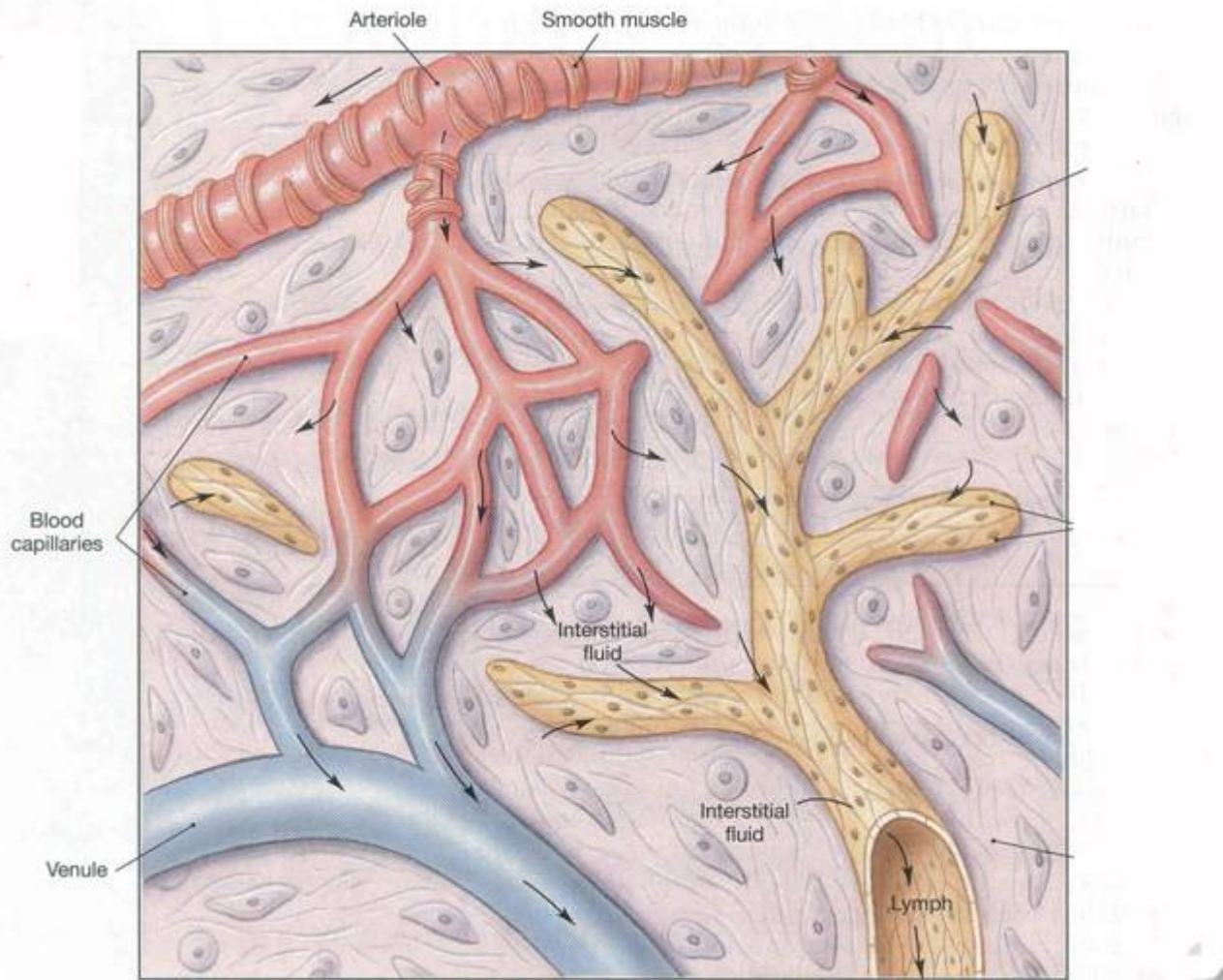
B-lymphocytes – produce specific antibodies.

T-lymphocytes – attack specific

# LYMPH VESSELS

- Smallest are similar to capillaries in construction.
- Do not form a circuit like cardiovascular structures. Lymph capillaries have a "terminal end."
- Densely concentrated near surface of body and other places where body interfaces with external environment.





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# LACTEALS

- Specialized lymph capillaries associated with absorptive surfaces of small intestine.
- One of the ways fat is incorporated in body fluids.
- Absorb fat from small intestine for distribution throughout the body.
- (All the fat droplets make the lymph appear "milky," thus the name lacteal.)

# CIRCULATION OF LYMPH

(How do you do it with no pump?)

Contraction of smooth muscle in larger vessels.

Squeezing action of skeletal muscles.

Dumps into venous system; the connection "pulls" the lymph along.

# STRUCTURAL & MORPHOLOGICAL ORGANIZATION

Generally run parallel to arteries and/or veins.

Over three-fourths of the body dump into the thoracic duct – which runs on the inside or the dorsal body wall (retroperitoneal).

# THORACIC DUCT

Begins as a loosely dilated sac and connections in the abdomen called the CYSTERNA CHYLI.

Drains both legs, and left side of body.

Goes through thorax, receives tributaries from: LEFT SUBCLAVIAN TRUNK (from left arm) and LEFT JUGULAR TRUNK (left side of head and neck).

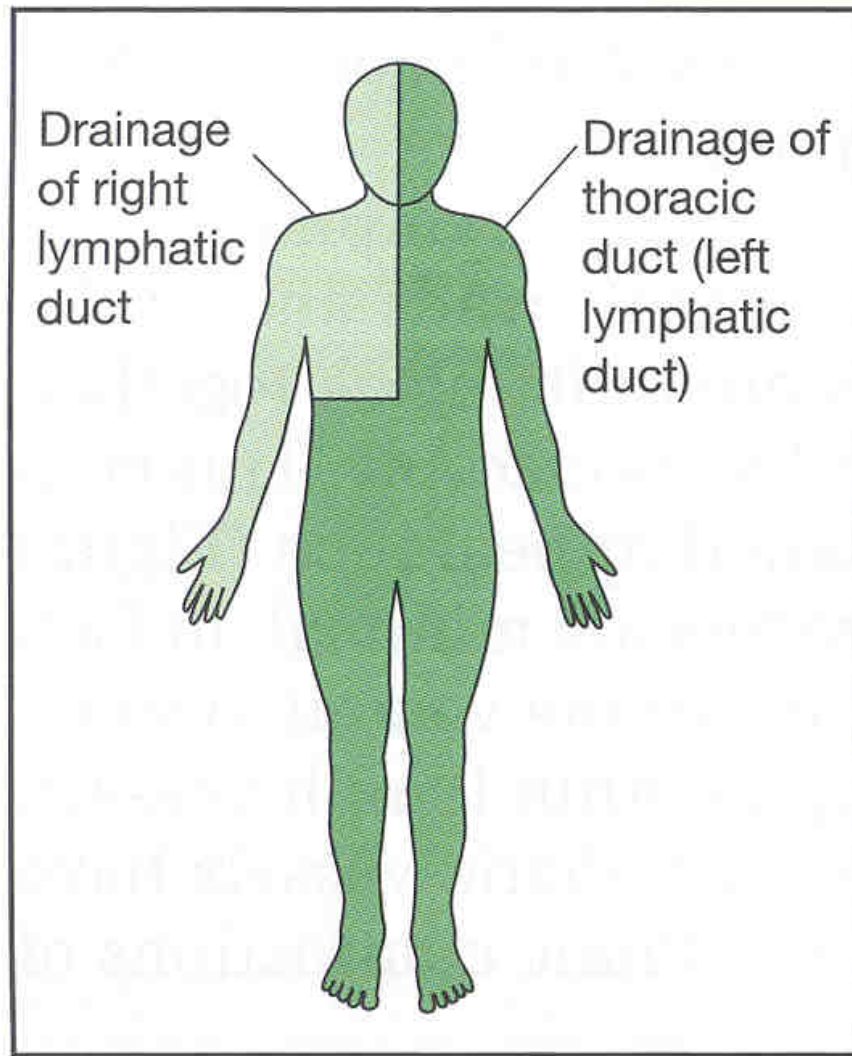
Dumps into venous circulation at junction between left subclavian vein and left jugular vein. (Technically into left brachiocephalic vein.)

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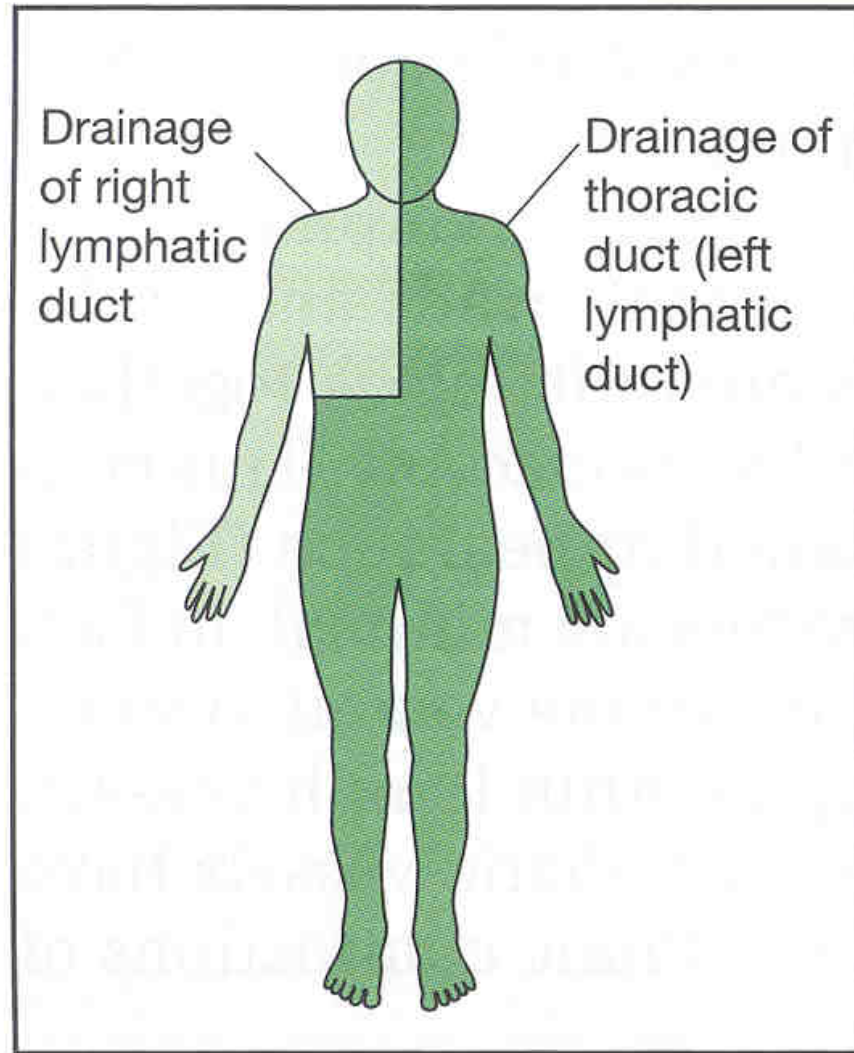


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# RIGHT LYMPHATIC DUCT

Upper right quadrant is drained by right lymphatic duct.

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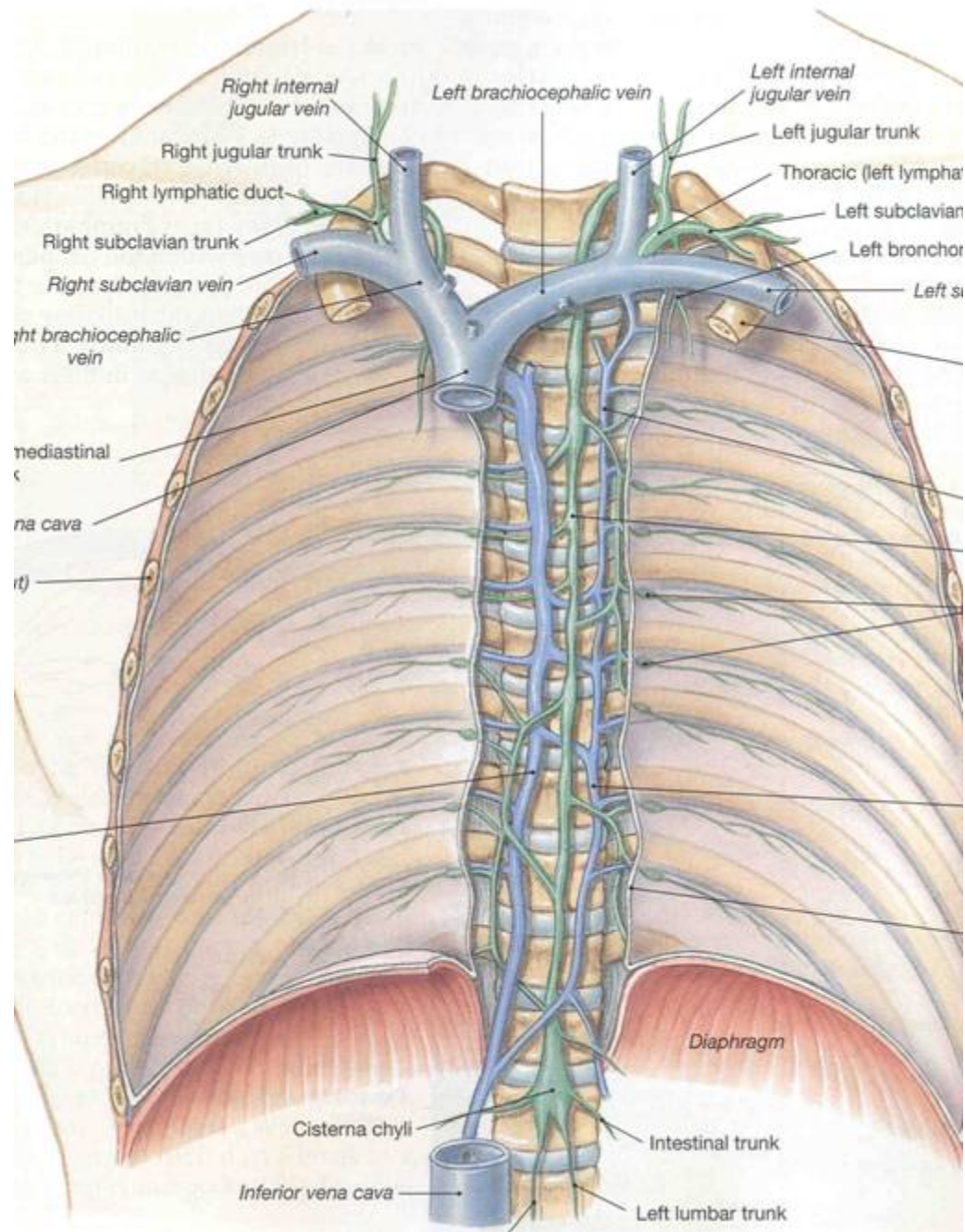


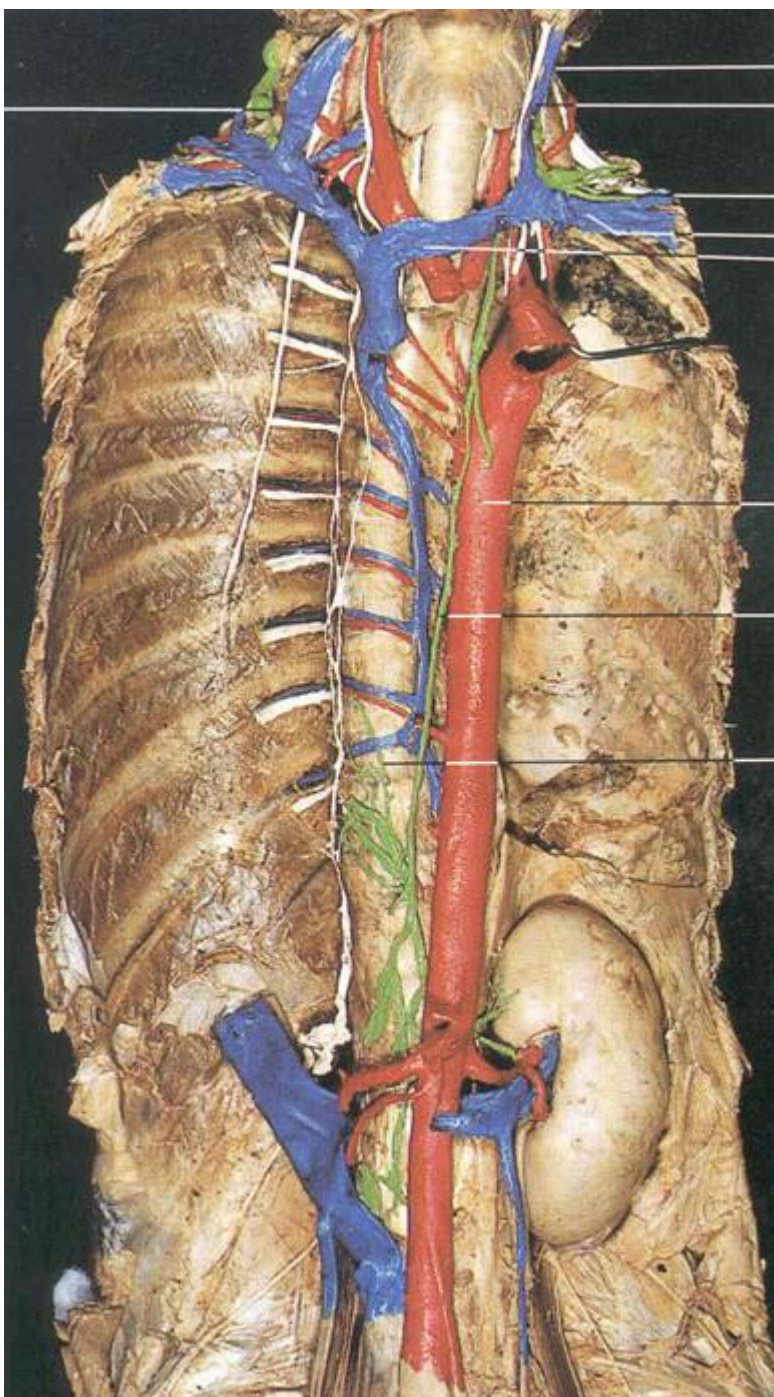
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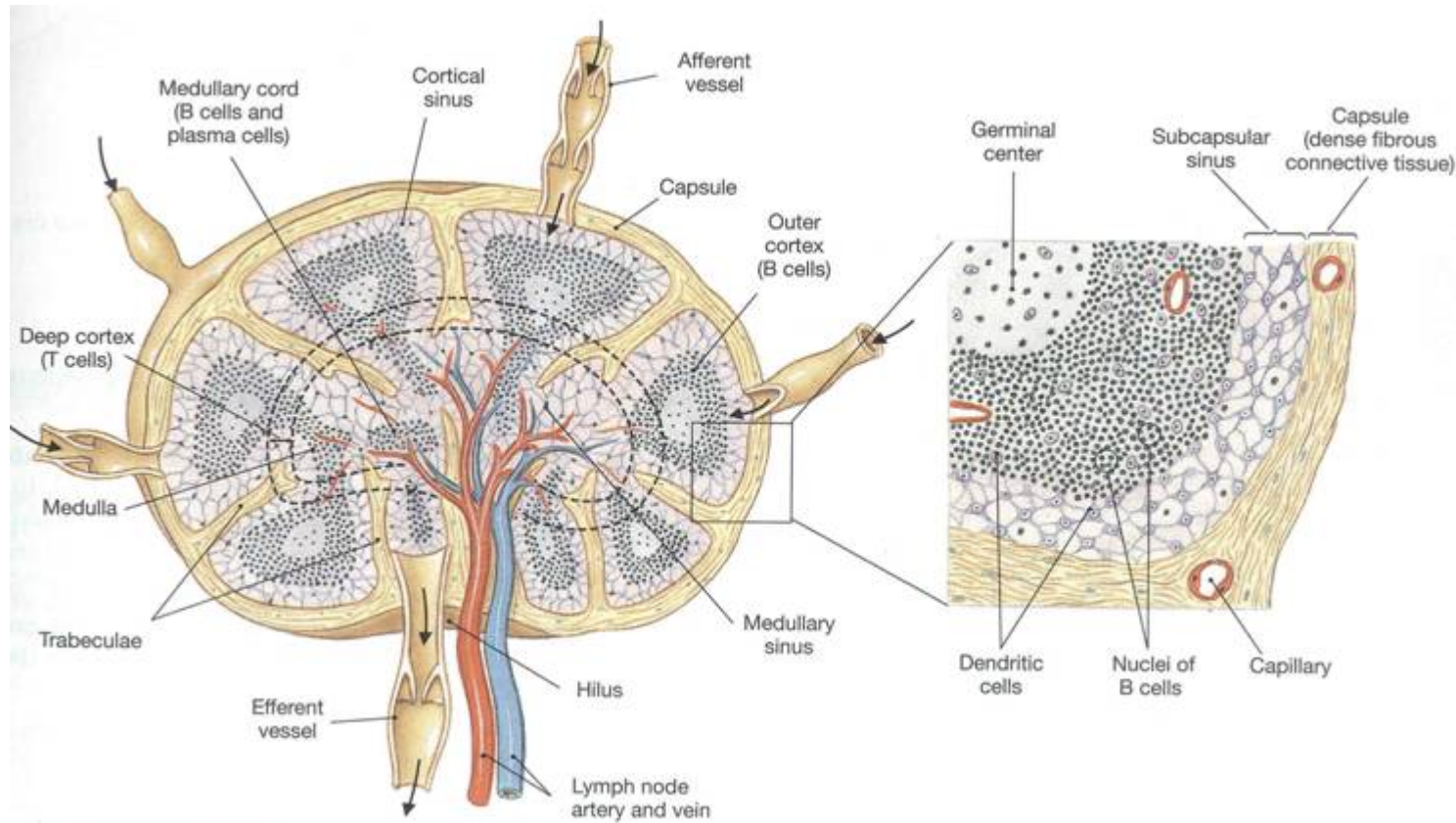
# OTHER LYMPHATIC STRUCTURES

- Lymph Nodes
- Tonsils
- Spleen
- Thymus Gland
- Peyer's Patches

# LYMPH NODES

- Scattered along lymph vessels are concentrated masses of lymph tissue called "lymph nodes."
- Usually 1-25 mm in length, but they can be larger.
- Greatest concentration near groin, axilla, neck, thorax, and along gut tube in abdomen. In women, near mammary glands.
- Macrophages and lymphocytes resident in the outer ("cortex") region of a lymph node. Thus, the nodes can act as filters.
- Afferent (entering) vessels bring lymph in; lymph is filtered through cortex.
- "Medulla" is the inner collecting area.
- Efferent (exiting) vessel leaves at the "hilus."





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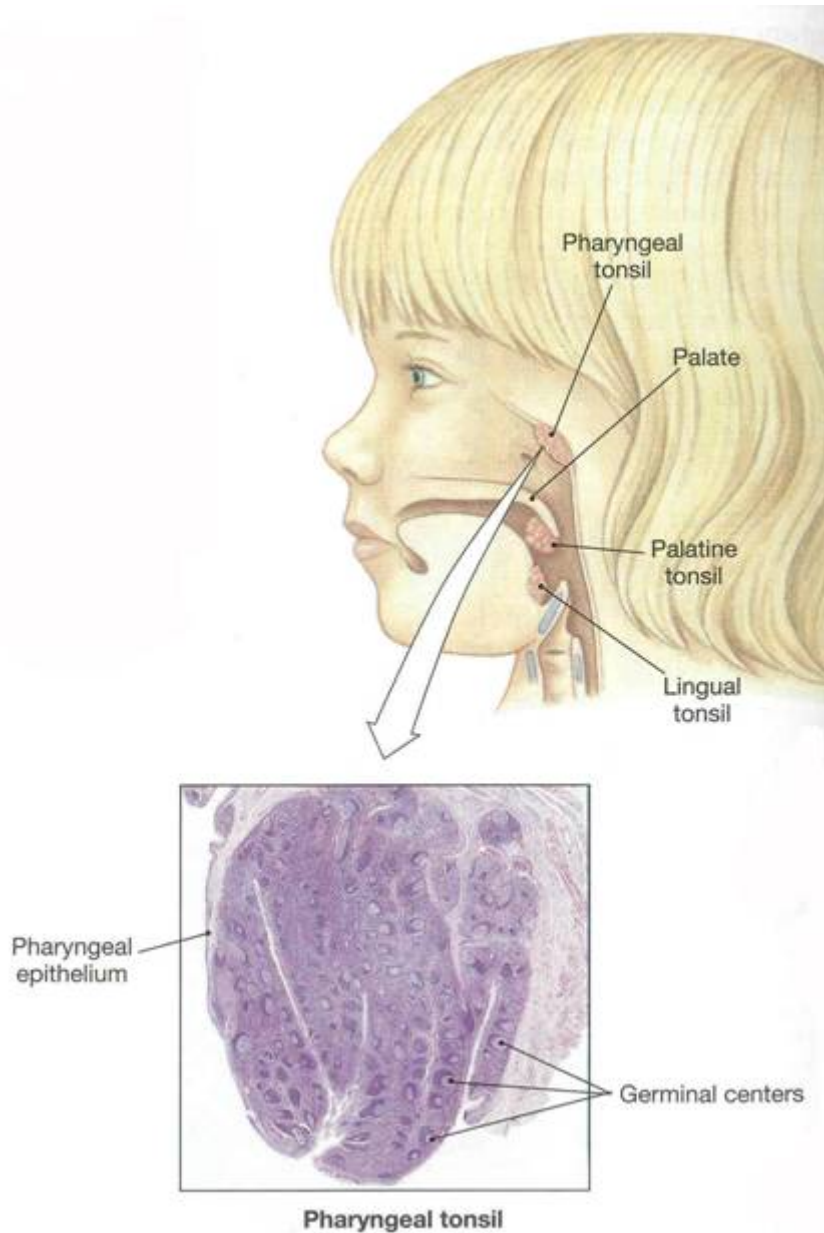
**Efferent (exiting) vessel leaves at the "hilus."**

# TONSILS

- (Sort of like large, glorified lymph nodes, but...)
- They don't act as filters.
- Only produce lymphocytes for export.
- Pharyngeal tonsils, palatine tonsils, and lingual tonsils are defensive structures at the mouth, entrance to digestive and respiratory systems.

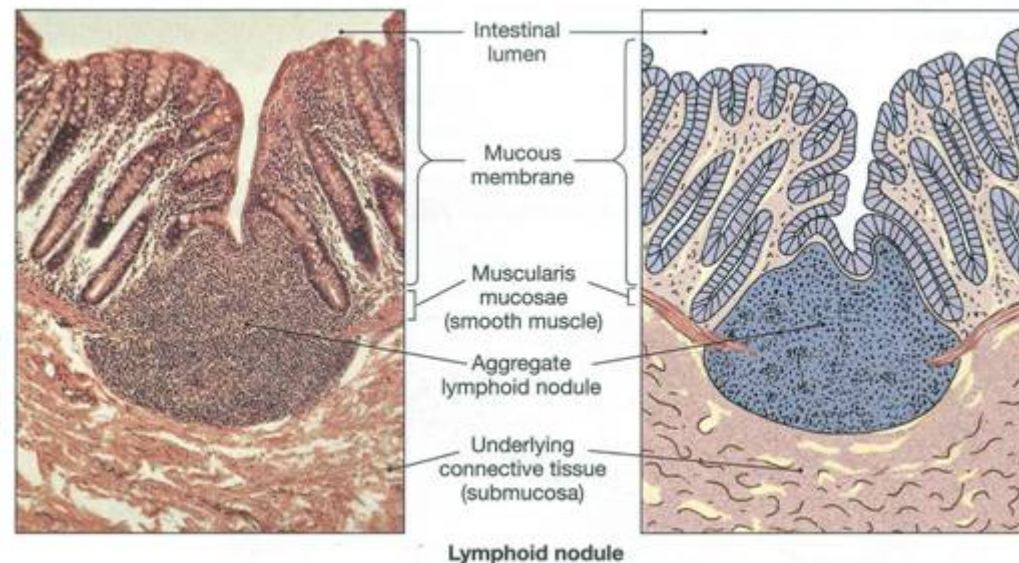
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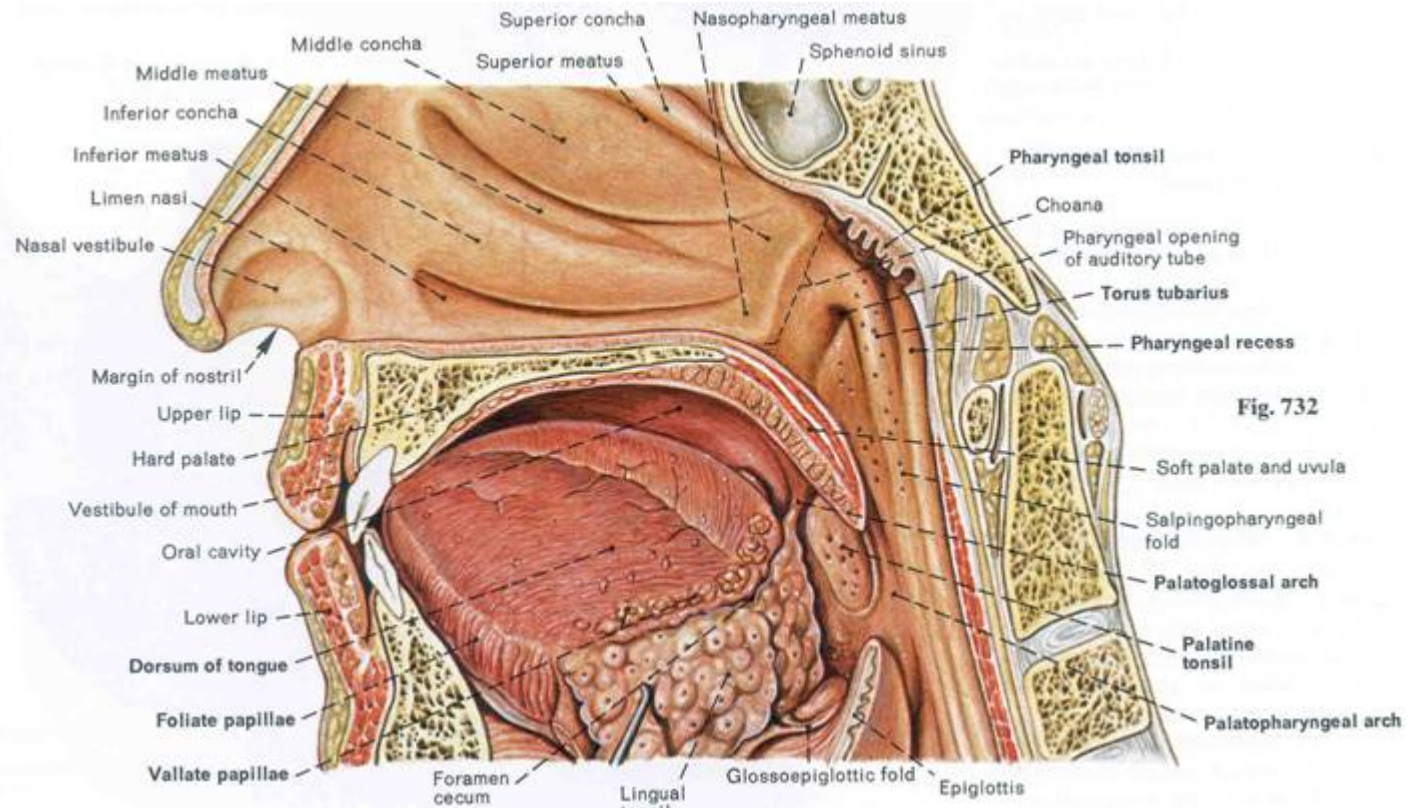
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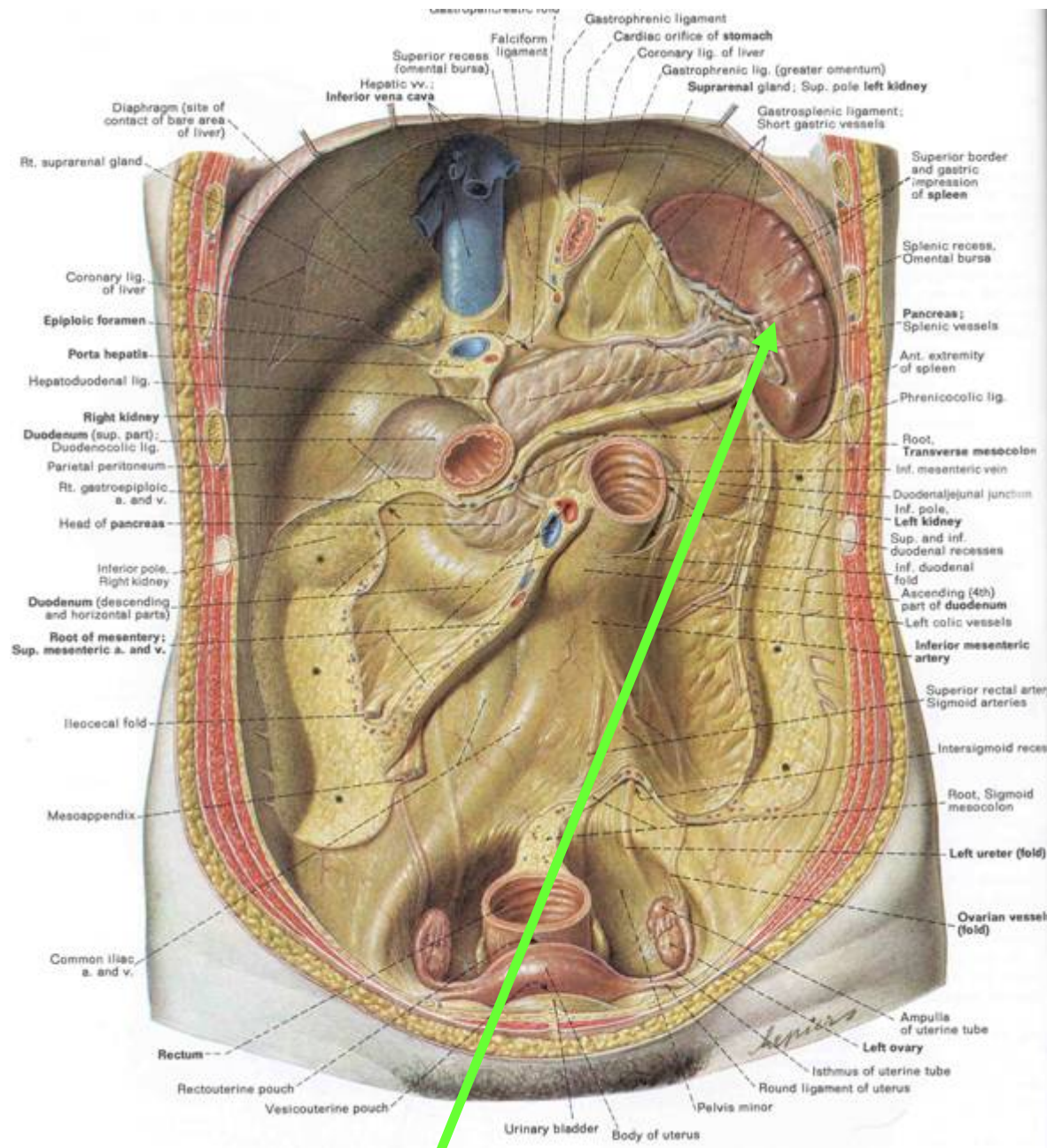
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# SPLEEN

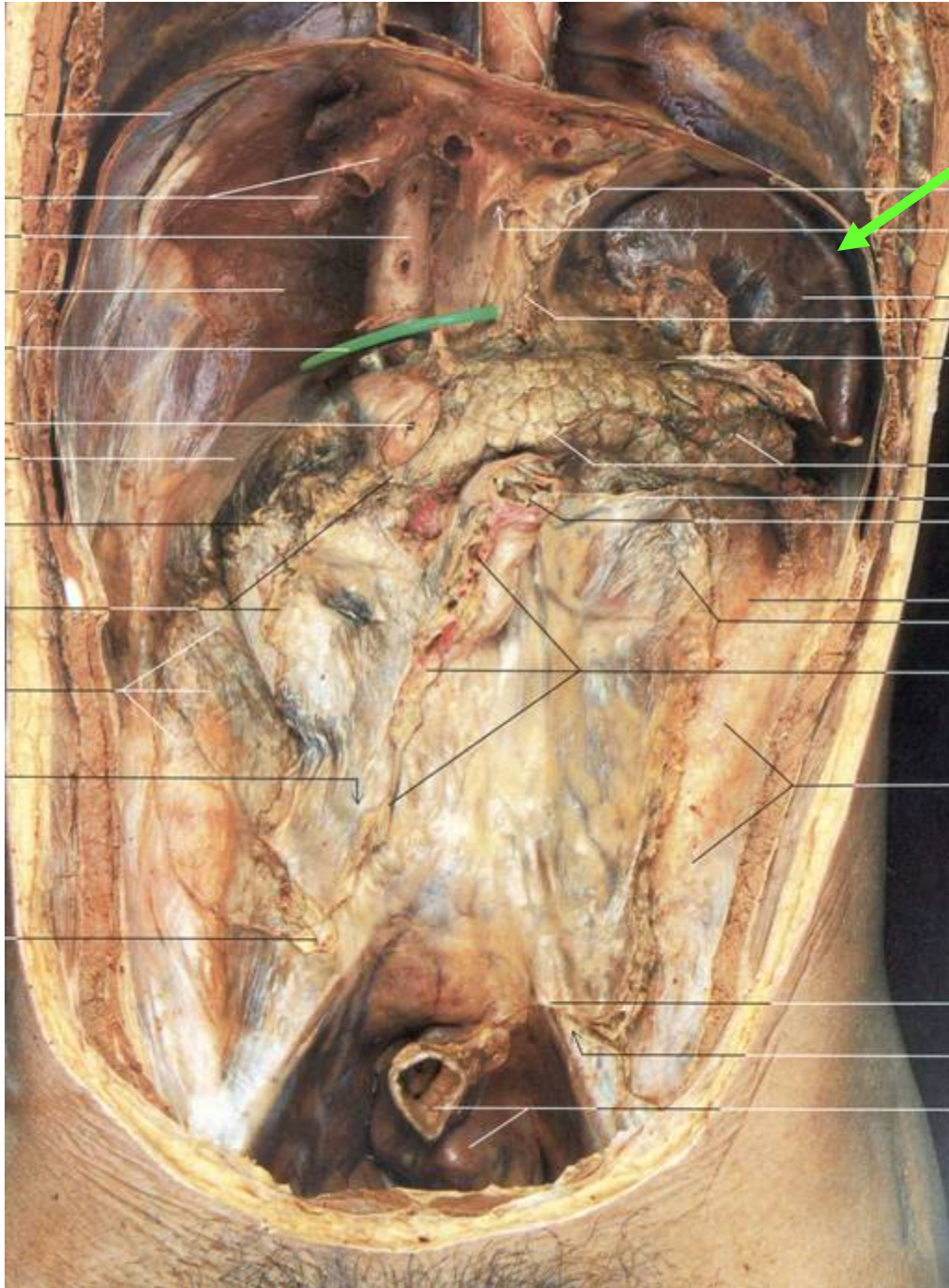
- Not part of the gut (just near it).
- Largest lymphoid organ of body.
- Highly vascularized (perfect for a filter).
- In spleen, BLOOD passes resident macrophages and lymphocytes.
- Not strictly a lymph filter, but its interaction with blood can stimulate production and action of materials normally found in lymph.
- Macrophages abundant: help to scavenge spent red blood cells and recycle hemoglobin.
- Antigens (nasty stuff) in blood activate lymphocytes in spleen for antibody production.
- Produces red blood cells in fetus, can be called back into action in adults under stressful conditions.



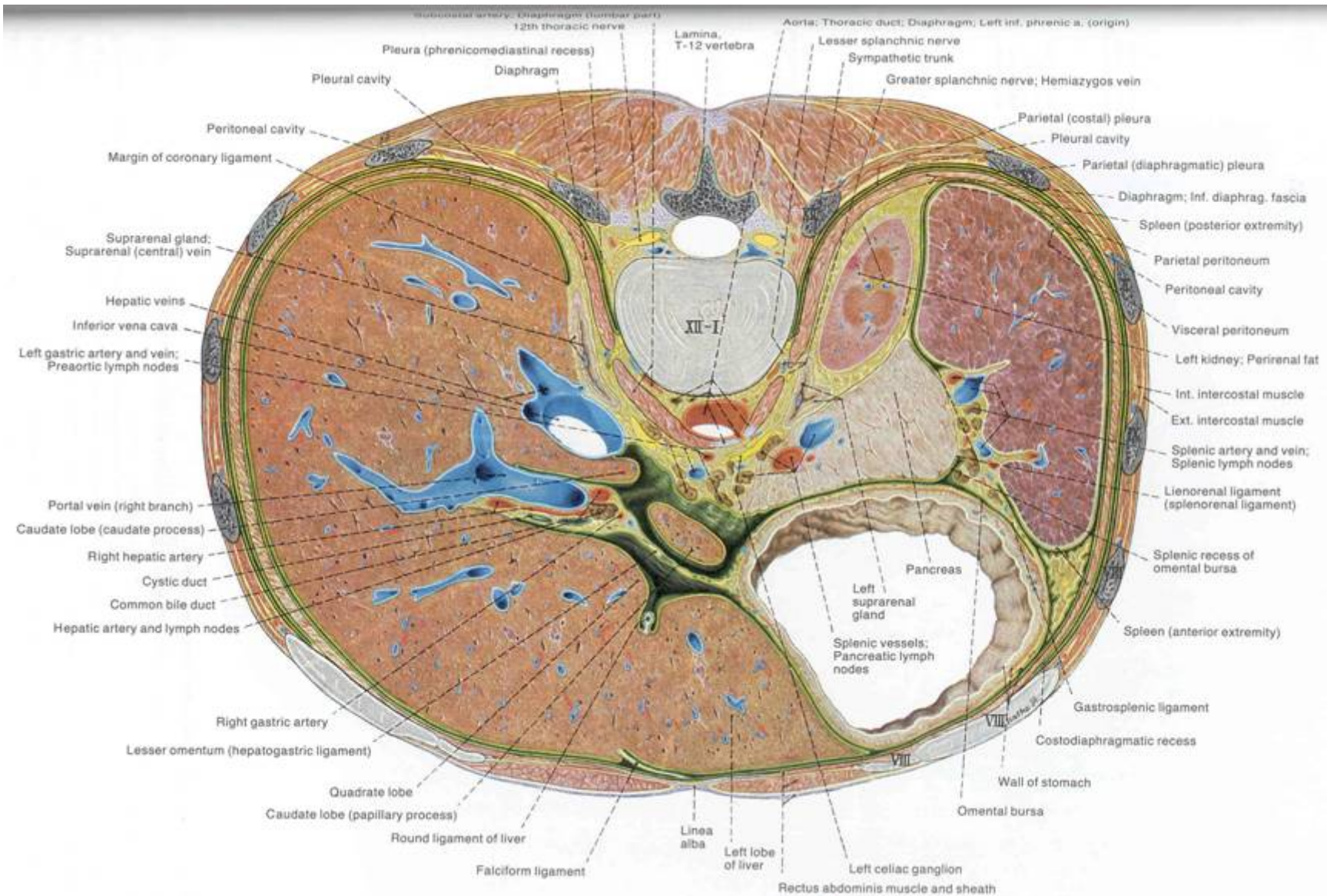
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**SPLEEN**

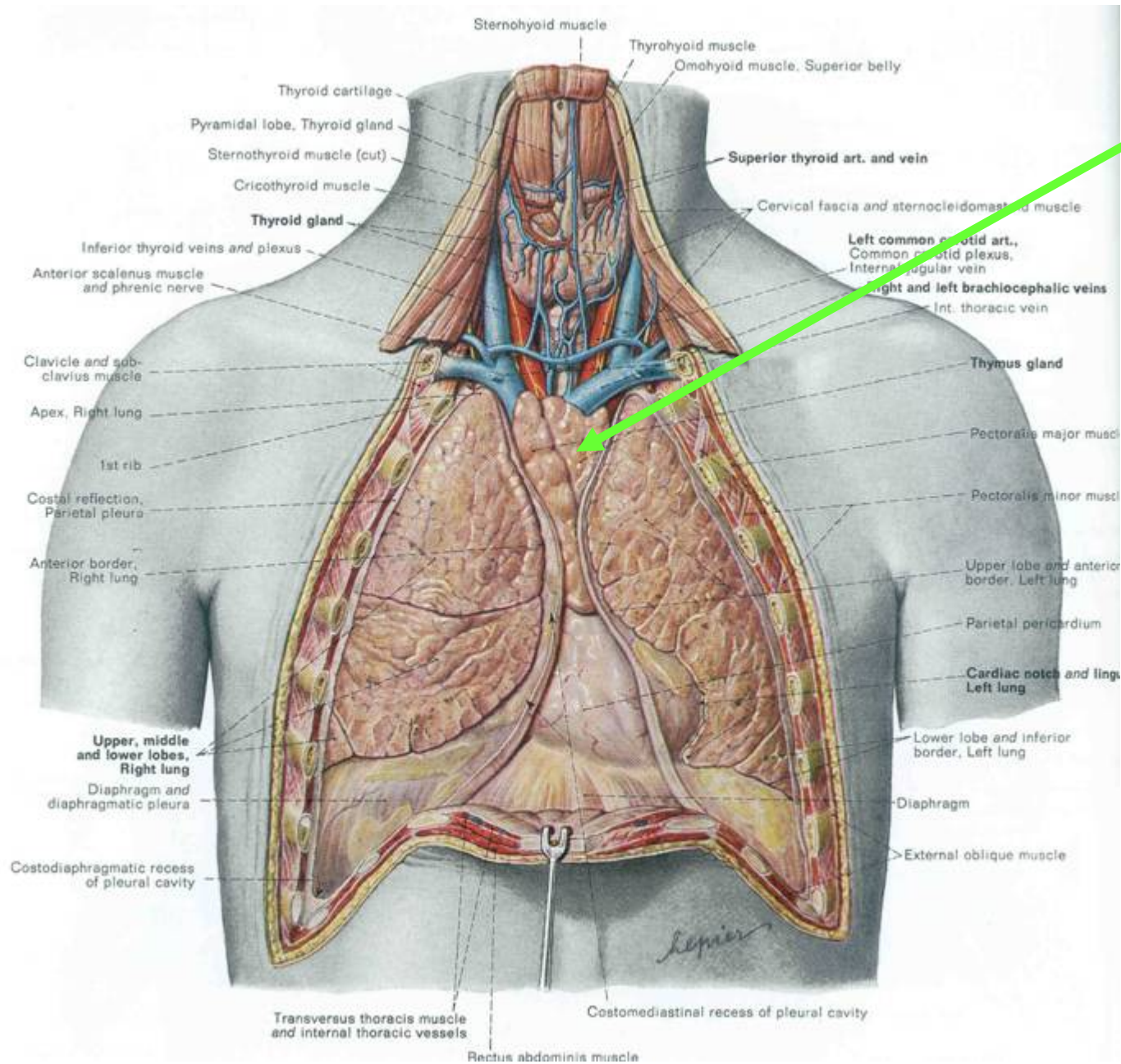


# THYMUS GLAND

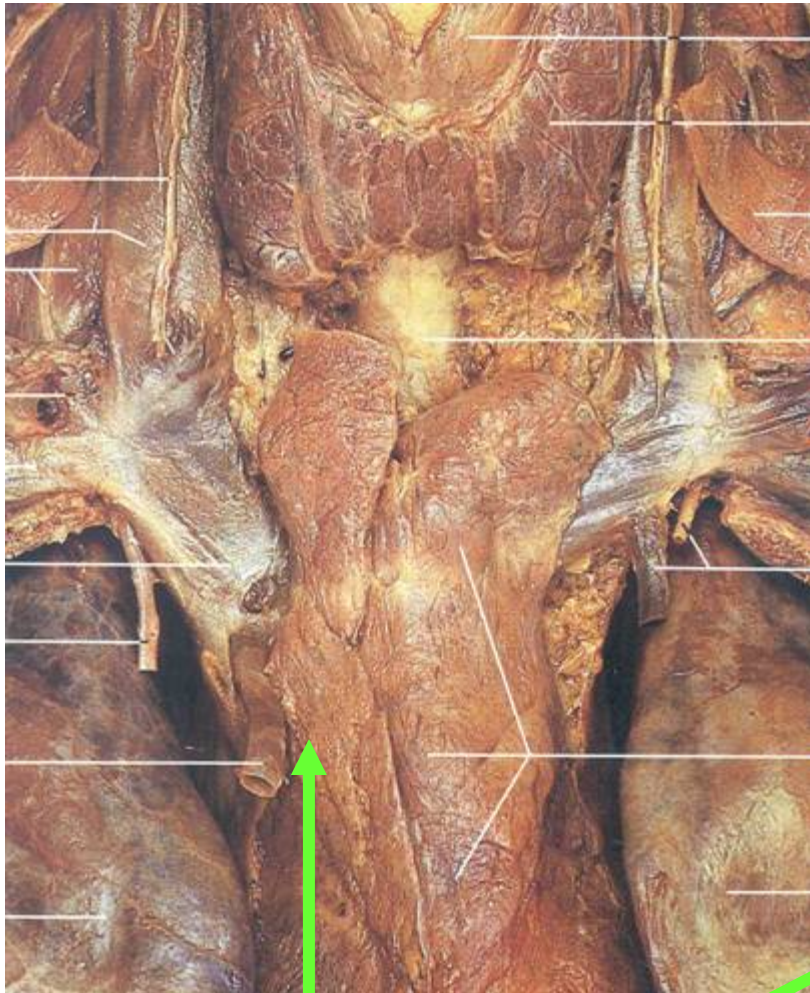
- Ventral to heart and laryngeal structures.
- Has outer cortex (containing many lymphocytes) and inner medulla.
- Fetal thymus: transforms undifferentiated lymphocytes from bone marrow into T-lymphocytes.
- (More later...)



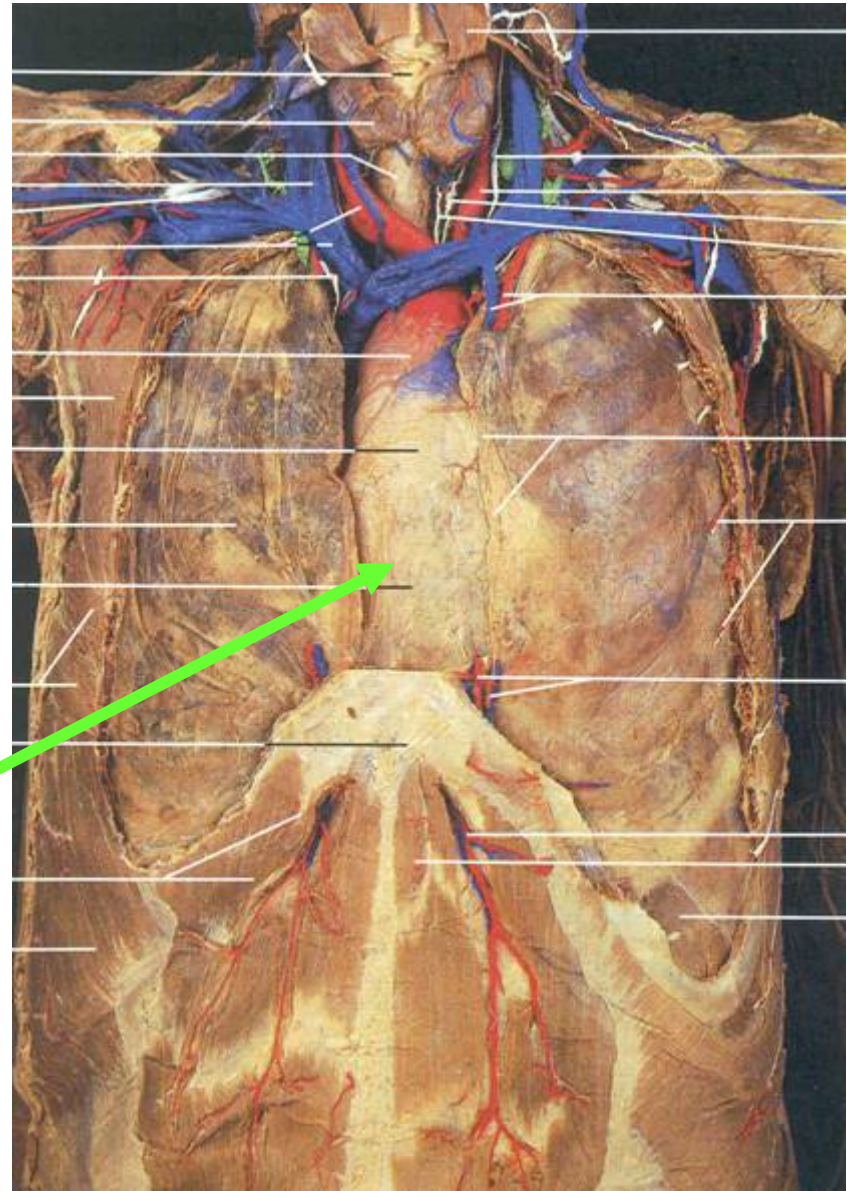
# Adult THYMUS





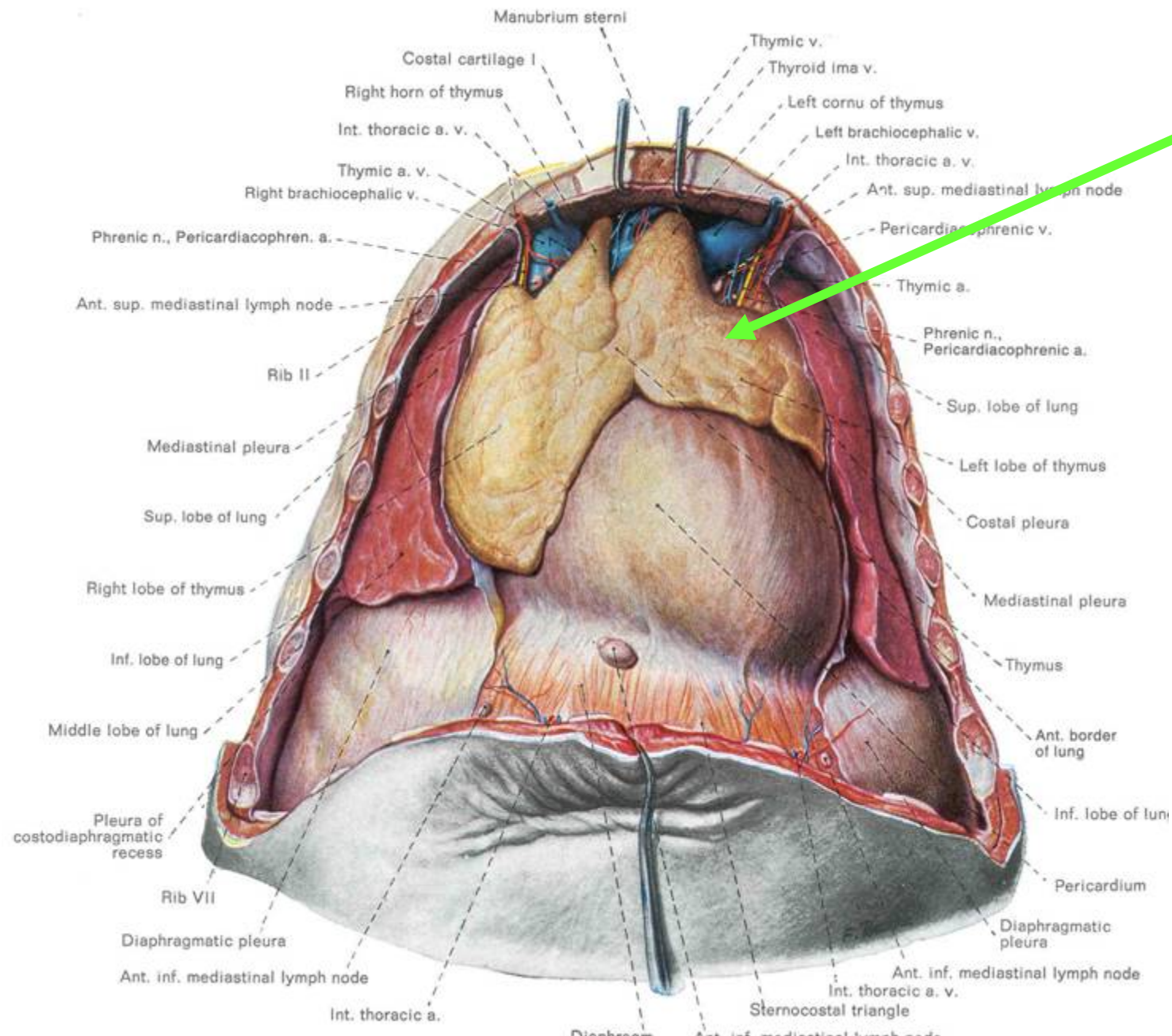


**Adult  
THYMUS**





# One-year old THYMUS



# **PYER'S PATCHES**

(Also known as aggregated lymph nodes.)

Clusters of lymphoid tissue without a fibrous capsule.

Common in tonsils, small intestine, and appendix.

Secrete antibodies in response to antigens in gut tube, particularly ingested viruses and bacteria.

# **DEFENSIVE SYSTEMS**

# **INTEGUMENT**

## **(Skin)**

Protection

Insulation

Sensory

# DEFENSIVE FEATURES OF INTEGUMENT

- Generally impermeable.
- Openings through it have sphincters or barriers in place.
- Slightly acidic: Inhibits bacterial growth.
- Sweat/perspiration helps wash invaders out of pores.
- Openings (mouth and anus) have sphincters and associated mucous membranes (sticky secretions inhibit entrance of foreign matter).

# **SPECIFIC COMPONENTS OF IMMUNE SYSTEM: LYMPHOCYTES**

- B-Lymphocytes (“B cells”)
- T- Lymphocytes (“T cells”)
- Natural Killer Cells (NK cells)
- Memory Cells
- Suppressor Cells

They have different functions in specific

# **B-LYMPHOCYTES**

- Mature in bone marrow, then carried to lymphoid tissue via blood stream and lymphatic circulation.
- This process of maturation and migration takes place throughout life.
- Other lymphocytes can be generated via mitosis of B lymphocytes resident in lymphoid tissues.

# T-LYMPHOCYTES

- Immature lymphocytes leave bone marrow during fetal and early neonatal life.
- Go to thymus gland.
- Mature there before they go on to other lymphoid tissues.
- These are T-lymphocytes.
- Also, and lymphocyte that is derived from one of these original T-lymphocytes via mitosis is also a T-lymphocyte.



# SPECIFIC IMMUNITY

The body must be able to recognize the difference between “self” and “nonself.”

(Any lymphocytes with antibodies that recognize one's own body tissue as an antigen are killed during fetal life.)

# ANTIGENS

A foreign substance or organism.

Any substance against which an antibody is produced.

More specifically, antigens are proteins or polysaccharides on the cell surface of an invading organism.

# ANTIBODIES

- Proteins produced by lymphocytes in response to an antigen.
- They bind to specific sites on antigen surfaces.
- Antibodies don't kill organisms. However, they:
  - can inactivate an invader, and
  - initiate the process of activating phagocytic cells and other natural killers.
- Can combine with bacterial toxins or viruses to prevent attachment to target cells (“inactivation”).
- There is a SPECIFIC antibody for any one given type of individual invader.

# **STAGES OF SPECIFIC IMMUNE RESPONSE**

- (1) Antigen encounter and recognition by lymphocytes.
- (2) Lymphocyte activation.
- (3) Attack.

# **(1) Antigen encounter and recognition by lymphocytes**

Specific lymphocytes are programmed to recognize a specific antigen.

This usually happens in a lymphoid organ, bloodstream, or lymph vessel.

(This could take quite some time...)

## **(2) LYMPHOCYTE ACTIVATION**

Once a lymphocyte has recognized an antigen, it undergoes numerous cycles of mitotic divisions, making more of the same.

Some of the newly produced cells carry out the attack; others influence the activation and function of the attack cells.

### **(3) ATTACK**

B-lymphocytes have specific receptors on their cell membrane –  
**ANTIBODIES** – that bind with  
invading materials/organisms.

# **ANTIBODY STRUCTURE**

**(Remember, they belong to group of plasma proteins called “globulins.”)**

Made up of four polypeptides (amino acid chains).

Two longer and larger, two shorter and smaller.

Have the shape of a letter “Y”.

Intersection of arms and base of “Y shape” is flexible, allowing deformation of antibody when it attaches to an antigen.



# VARIABLE REGION OF ANTIBODIES

- At the tip of the arms of the Y-shape.
- Variable region has the potential to bind with particular classes of antigens.
- Once a raw antibody is stimulated to fit to a specific antigen, it can then react with ONLY that antigen. This is known as SINGLE SPECIFICITY.
- Can fit as precisely as a lock-and-key to an antigen.

# **TYPES OF ANTIBODIES**

Because they are involved in immune response, they are called immunoglobulins, abbreviated Ig...

# SUMMARY OF IMMUNOGLOBULINS

Type	Location (if restricted)	Function/Notes
<b>IgA</b>	Mucous membranes of pharynx—saliva, tears, gut secretions, mother's milk.	Protection at opening of gut tube and nearby. A way for mother to pass on immunity to infant.
<b>IgD</b>		No well understood; may be important in lymphocyte differentiation.
<b>IgE</b>	Widespread	Immediate allergic responses. Bind to mast cells to release histamines and other inflammatory substances
<b>IgG</b>	Most common; can pass out of blood vessels (can pass through placenta)	Produced in great quantity subsequent to initial exposure to a particular antigen.
<b>IgM</b>	Largest,	Secreted at initial exposure to antigen; activate complement.
<b>Complement</b>	~ 20 different types of proteins and other molecules.	Supportive role in immune responses; enhance (complement) defensive systems.

# **UNDERSTANDING HIV and AIDS**

## **PRIMARY IMMUNE RESPONSE**

- B-lymphocyte – antigen contact induces mitosis (plasma cells) for more antibody carrying cells. Antibodies released to circulatory systems.

## **SECONDARY IMMUNE RESPONSE**

- Some “activated B-lymphocytes” become plasma cells.
- Some remain smaller, but retain antigen-recognition ability. (B memory cells)
- Next time similar antigen is encountered, response is MUCH FASTER due to resident and waiting memory cells.

# T-LYMPHOCYTES

- Do not produce antibodies.
- Function in “cell-mediated immunity.”
- “NATURAL KILLER” cells destroy viruses.
  - Secrete “lymphokines” which attract phagocytic cells.
  - Secrete “perforin” which eats holes in the cells membrane or viral coat of invaders.
- “Helper T cells”:
  - Induce macrophages to destroy other antigens
  - STIMULATE B-LYMPHOCYTES TO PRODUCE ANTIBODIES. (Can help hundreds of B-lymphocytes mature by releasing “B-cell growth factor.”)
- “Suppressor T Cells” prevent overreaction of the system. (Inhibit B-lymphocyte production.)

# HUMAN IMMUNODEFICIENCY VIRUS (HIV)

- A retrovirus (RNA-based).
- Once integrated into host, can remain dormant for years.
- Preferentially enters and **DISABLES HELPER T-LYMPHOCYTES**.
- Without these, B-lymphocytes can't mature to make antibodies, and natural killer cells can't function fully.

Thus, an infected person can't produce antibodies against even the simplest of invaders.

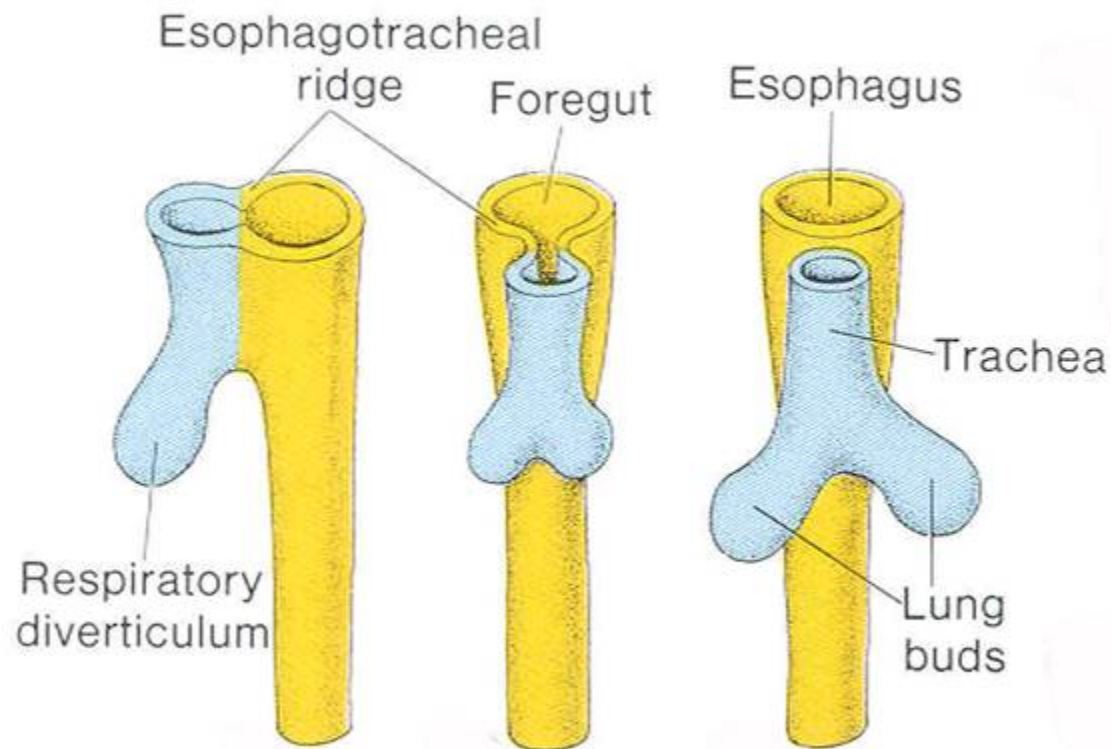
# Development of Respiratory System





# EARLY DEVELOPMENT

- Trachea is a tubular outgrowth of the embryonic gut.
- Begins as a bud in pharynx floor.
- Each fork is called a primary bronchus.



Trachea is a tubular outgrowth of the embryonic gut.

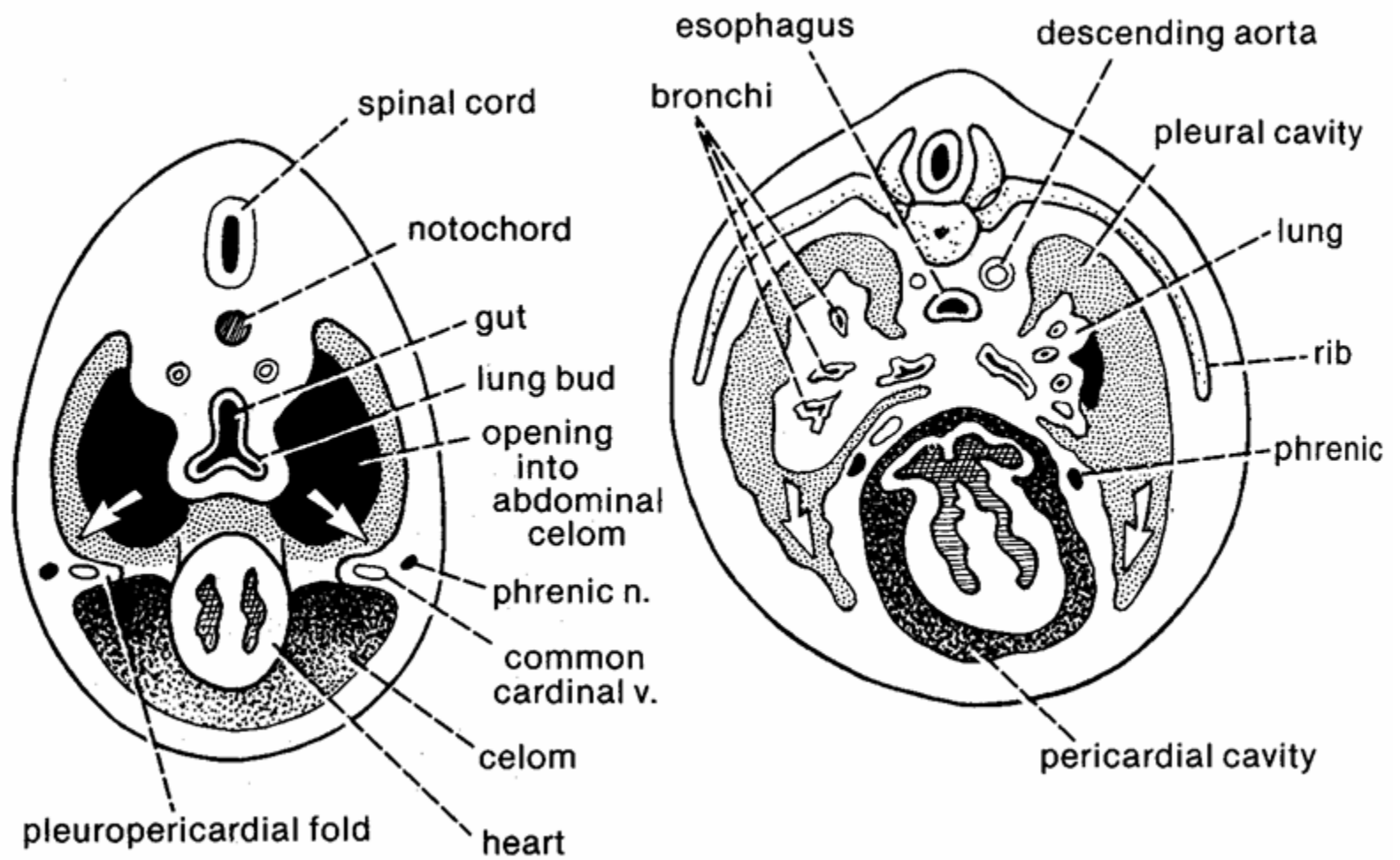
Begins as a bud in pharynx floor.

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# GERM LAYER DERIVATIONS

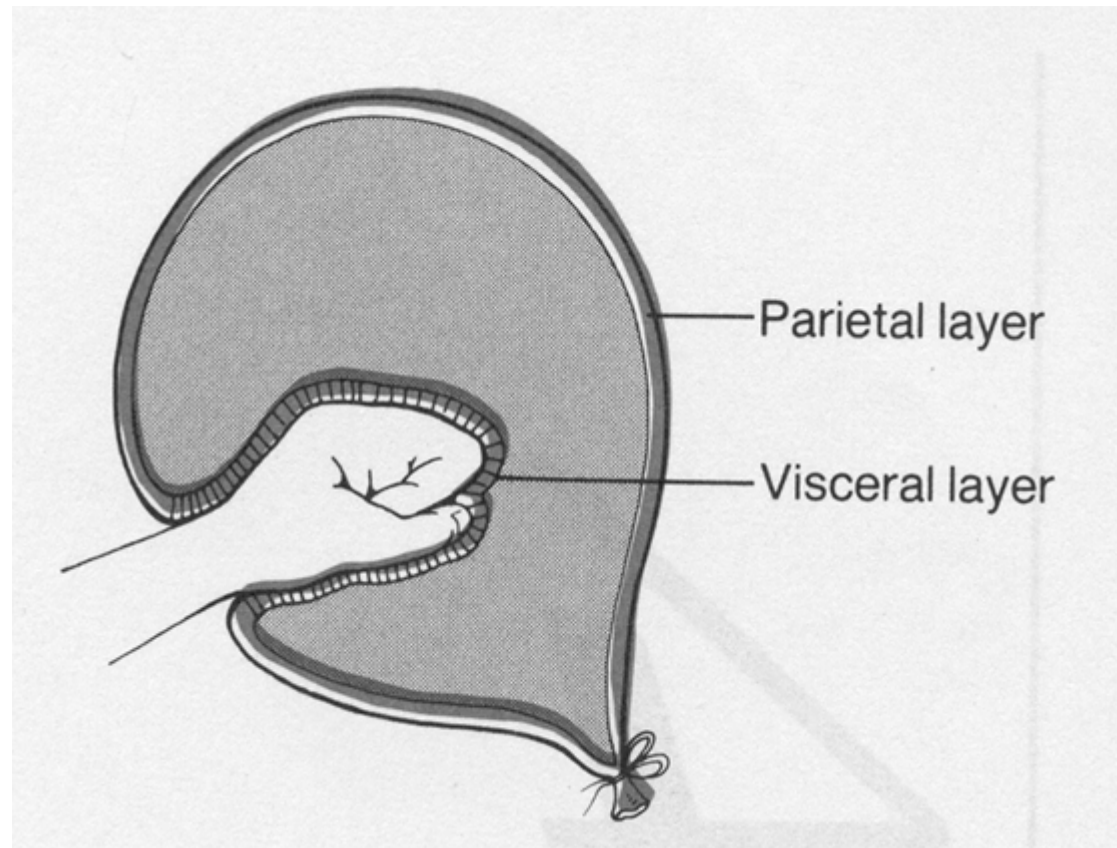
As outgrowths of pharynx, lung lining is derived from endoderm.

Cartilagenous support of bronchi is derived from visceral arch skeleton. Therefore, from NEURAL CREST.

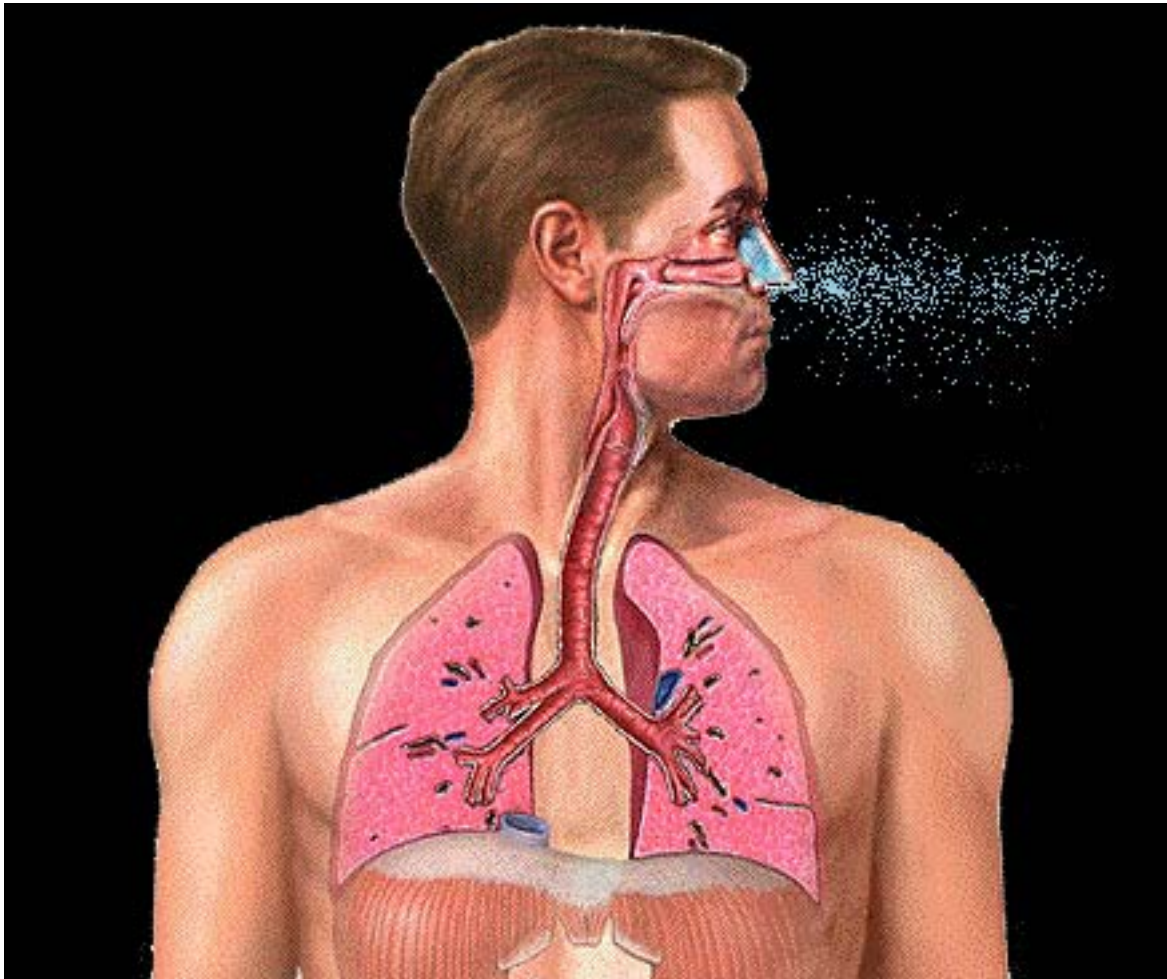


During Development...

Coelom wraps around lungs (as if the lungs were pushing into a mesodermally constructed balloon).



# Upper Respiratory System



**Nose**

**Nares**

# Upper Respiratory System



**Nose**

**Frontal**

**Nasal**

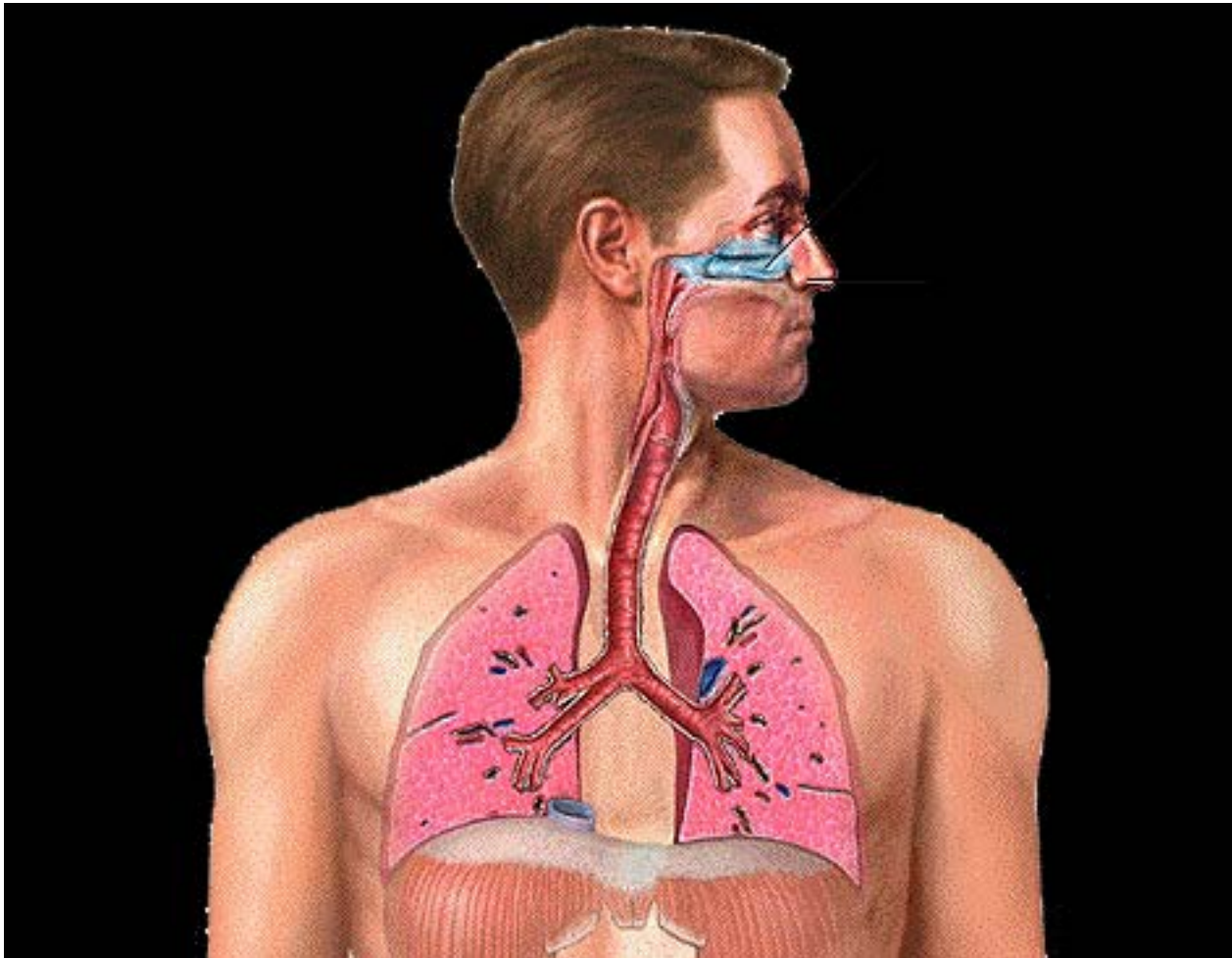
**Vomer**

**Ethmoid**

**Maxilla**



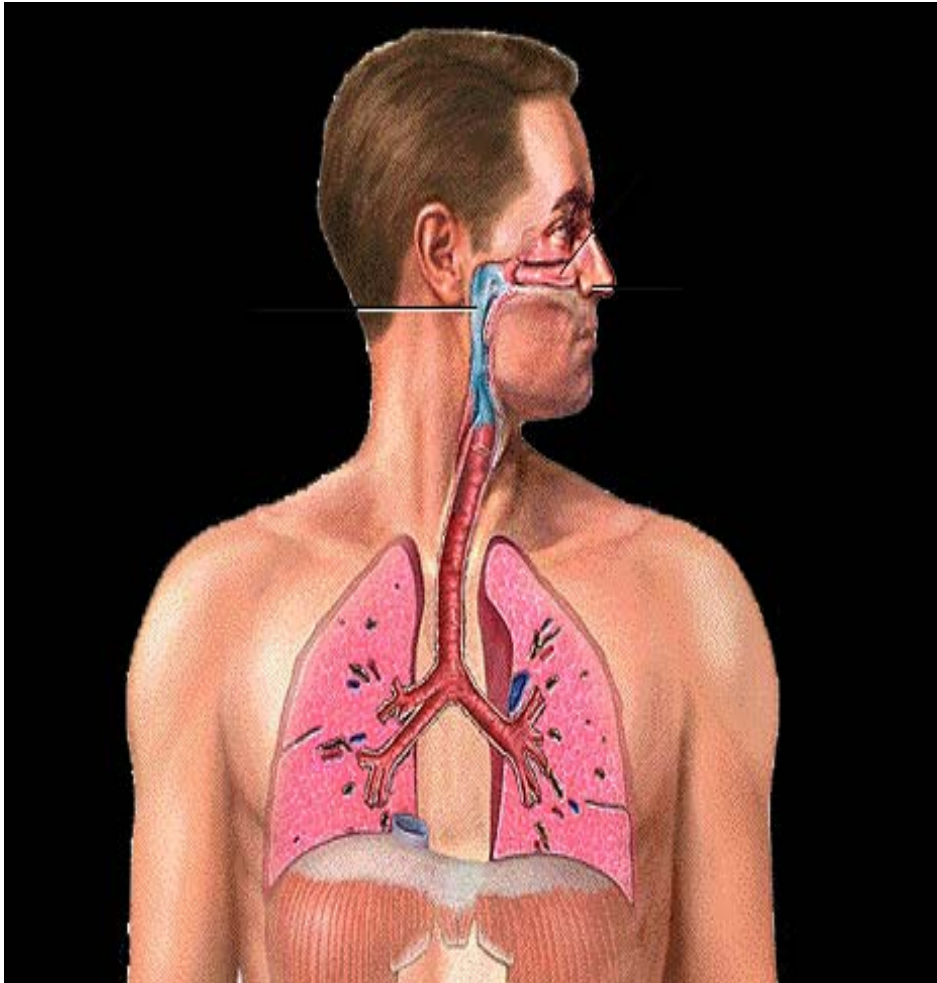
# Upper Respiratory System



**Nose**

**Nasal  
Cavity**

# Upper Respiratory System



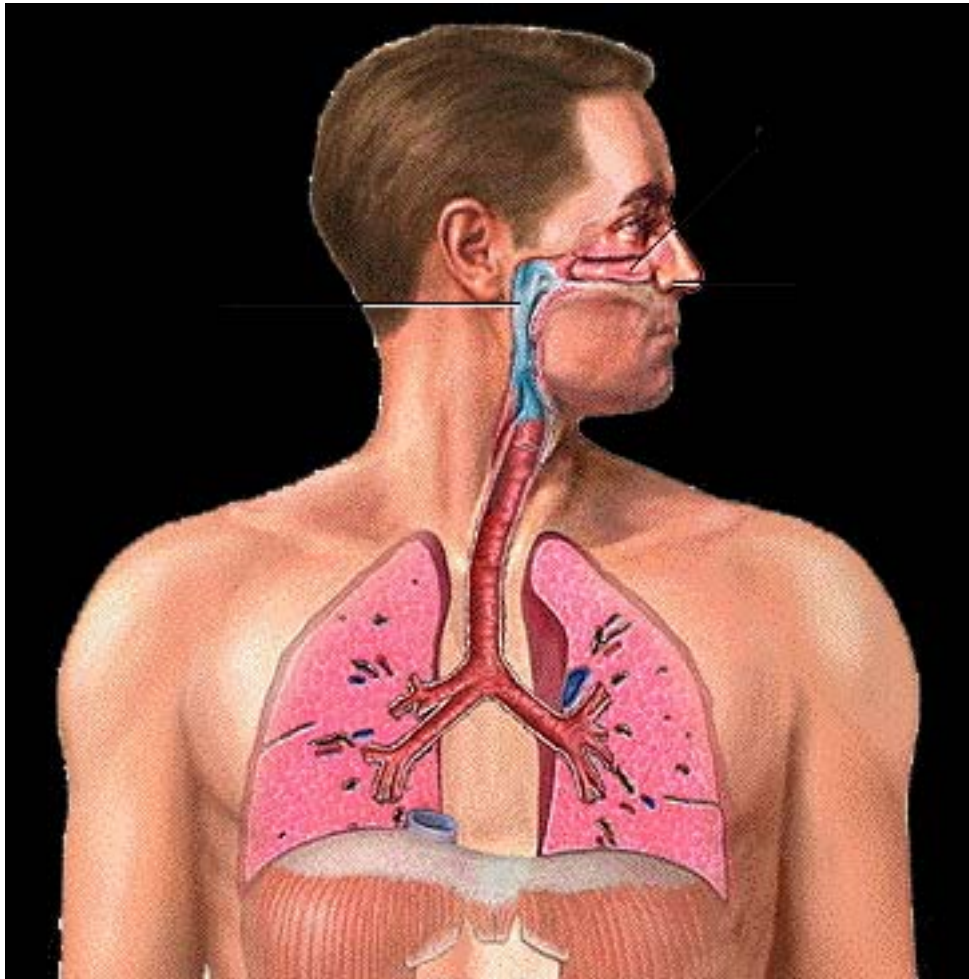
**Pharynx**

**Nasopharynx**

**Oropharynx**

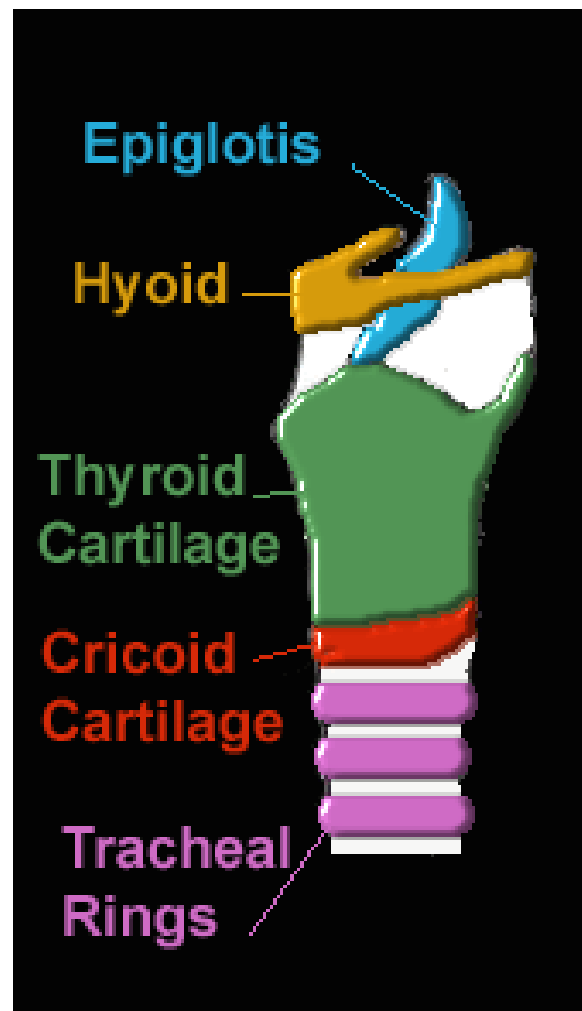
**Laryngopharynx**

# Lower Respiratory System



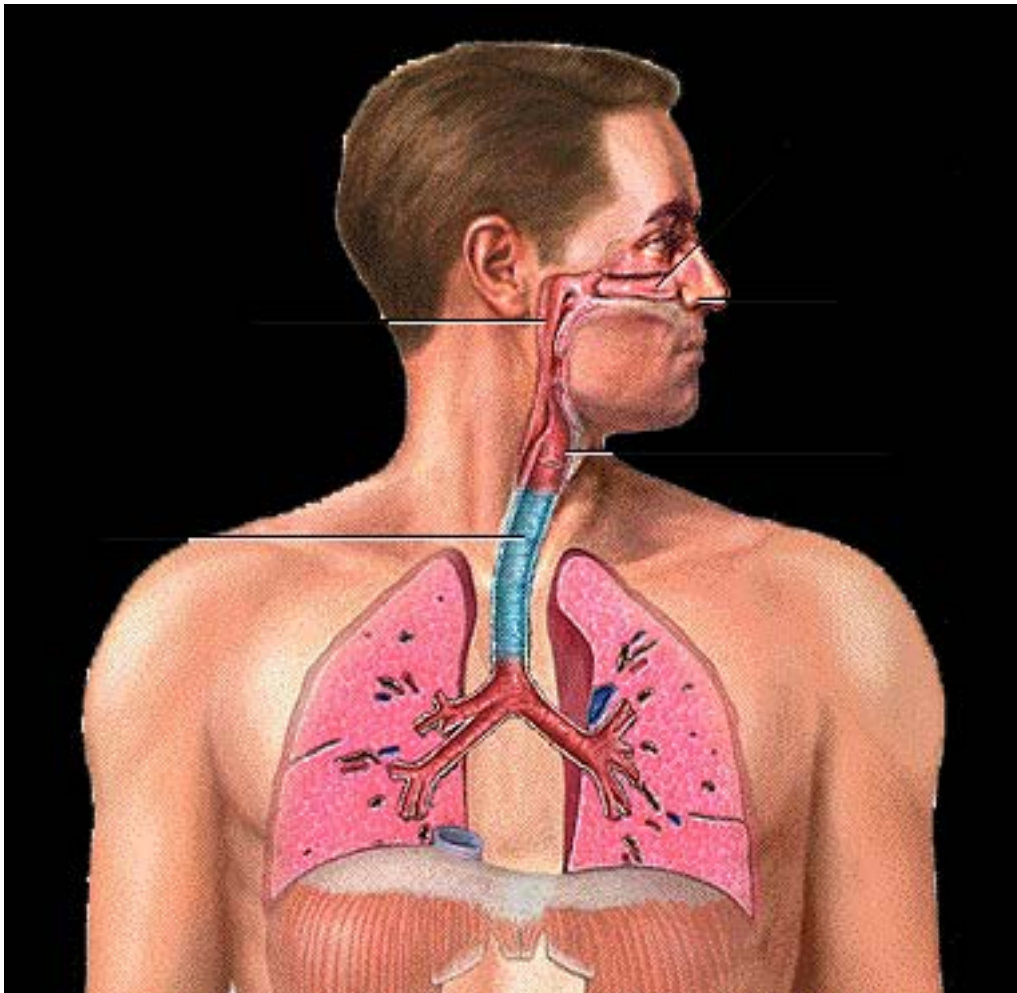
Larynx

# Lower Respiratory System



## Larynx

# Lower Respiratory System



**Trachea**

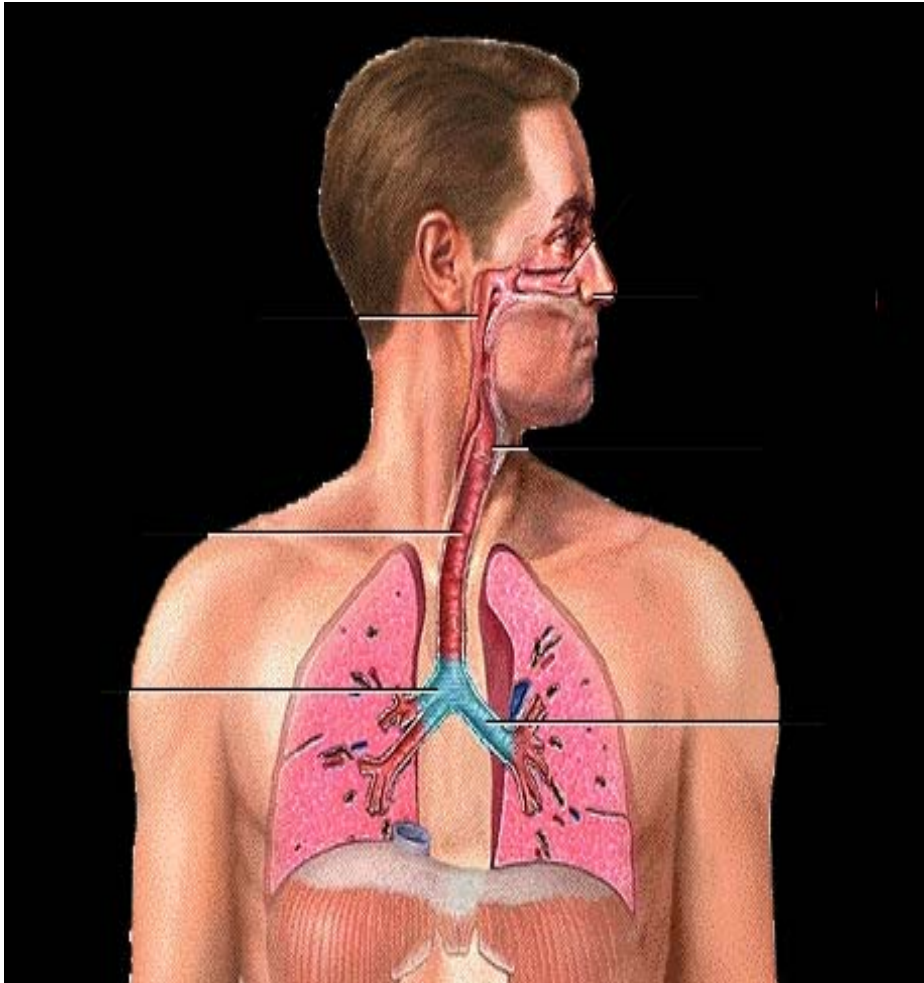
**Smooth muscle**

**Tracheal rings**

**Cilia**



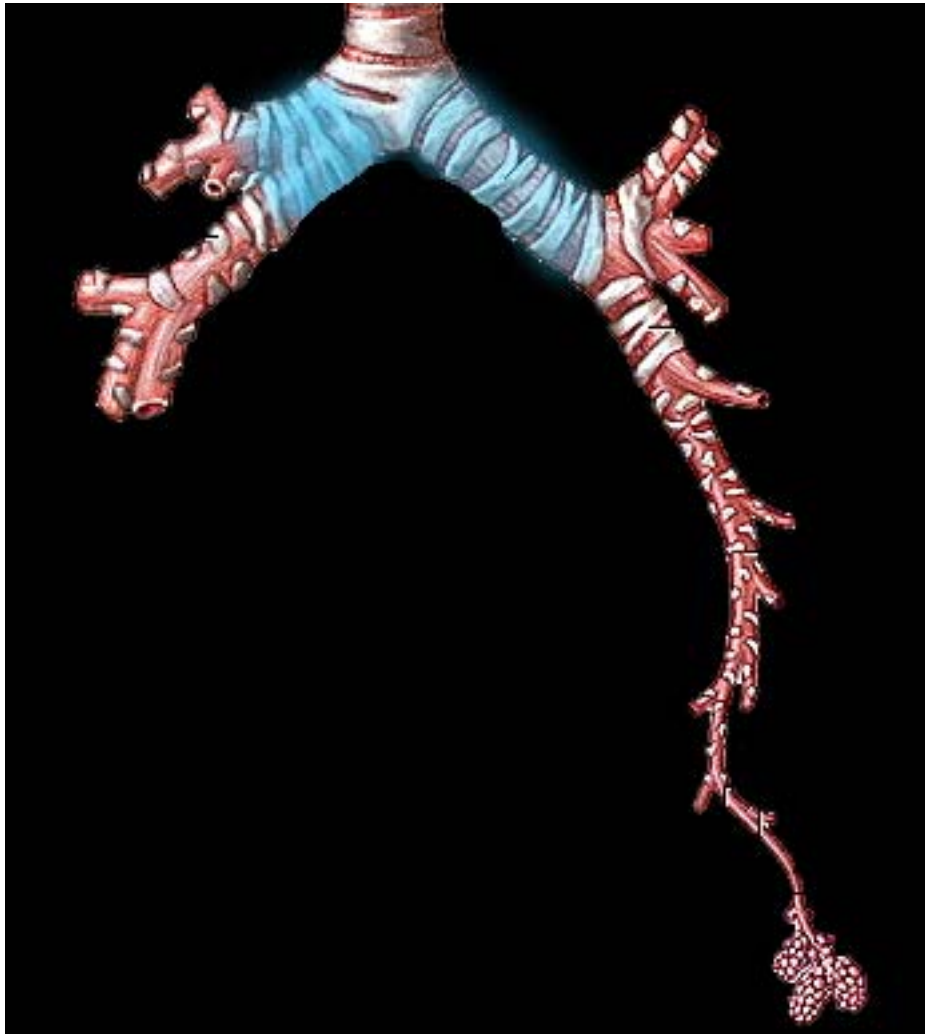
# Lower Respiratory System



## Bronchi

Left and right  
primary  
bronchi

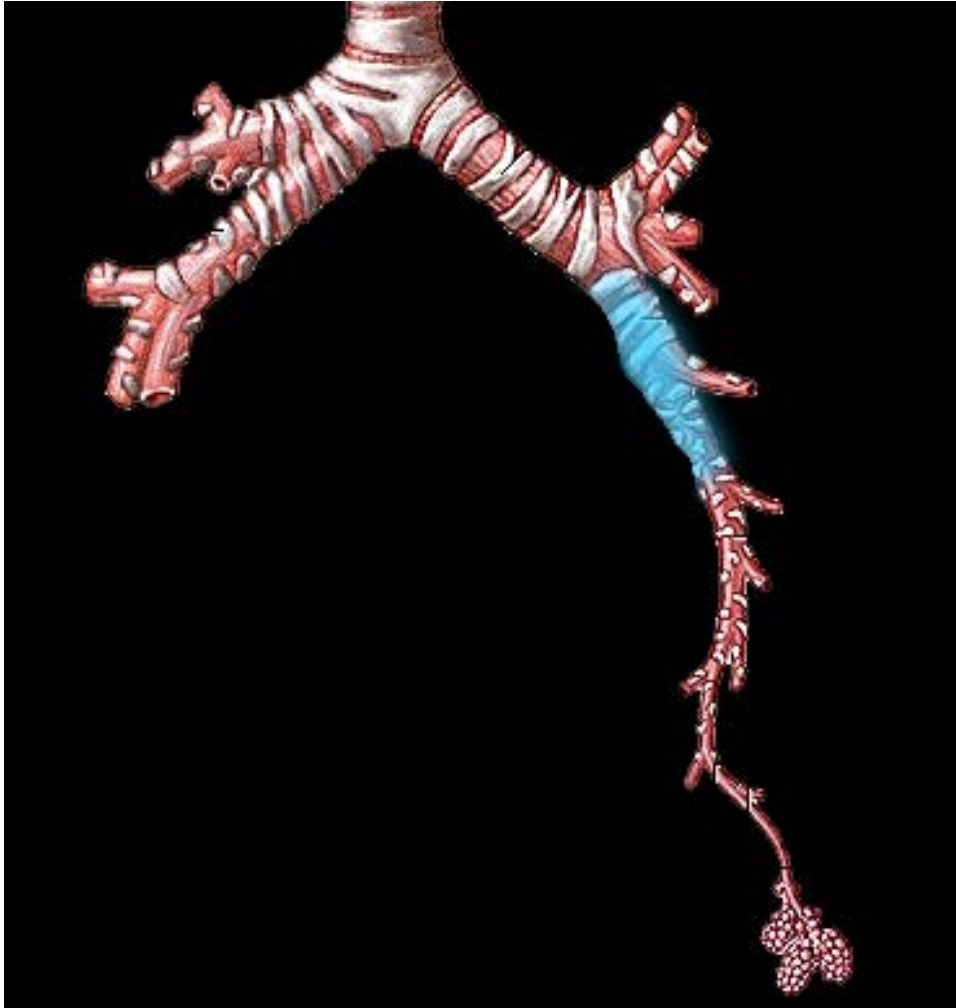
# Lower Respiratory System



## Bronchi

Left and right  
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# Lower Respiratory System

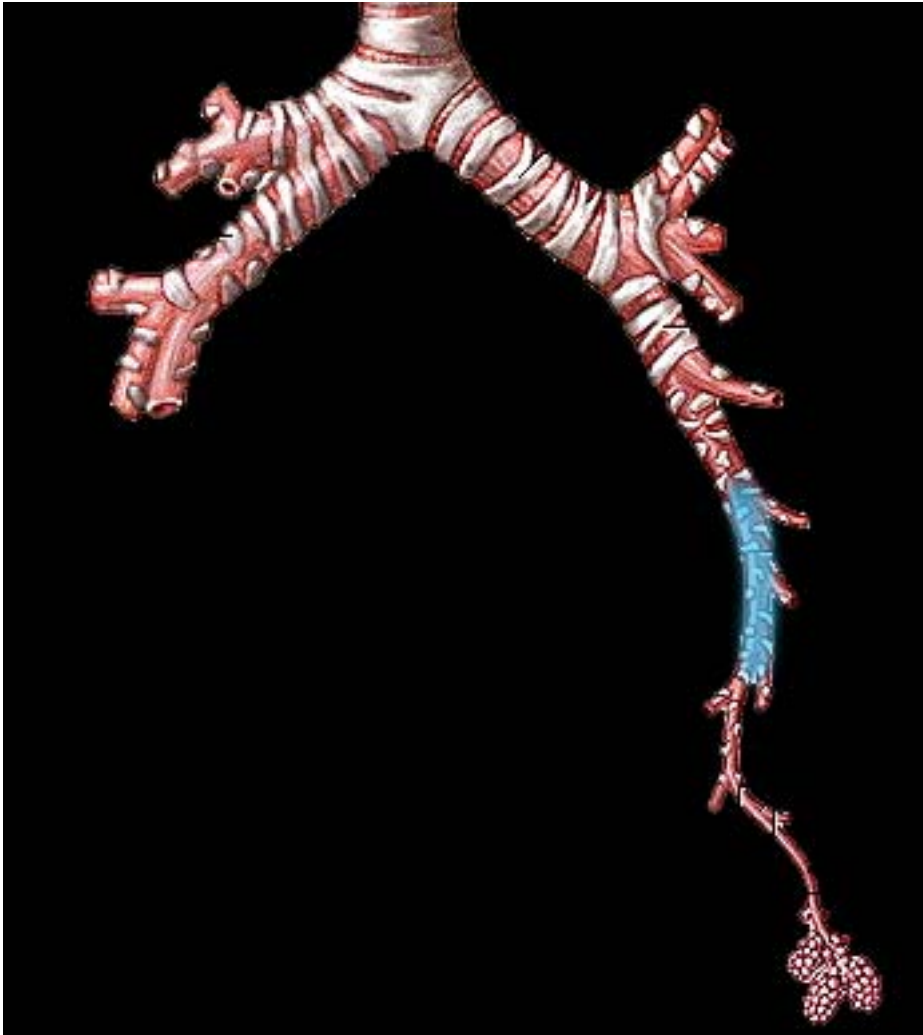


## Bronchi

**Further  
subdivided into  
secondary  
bronchi**



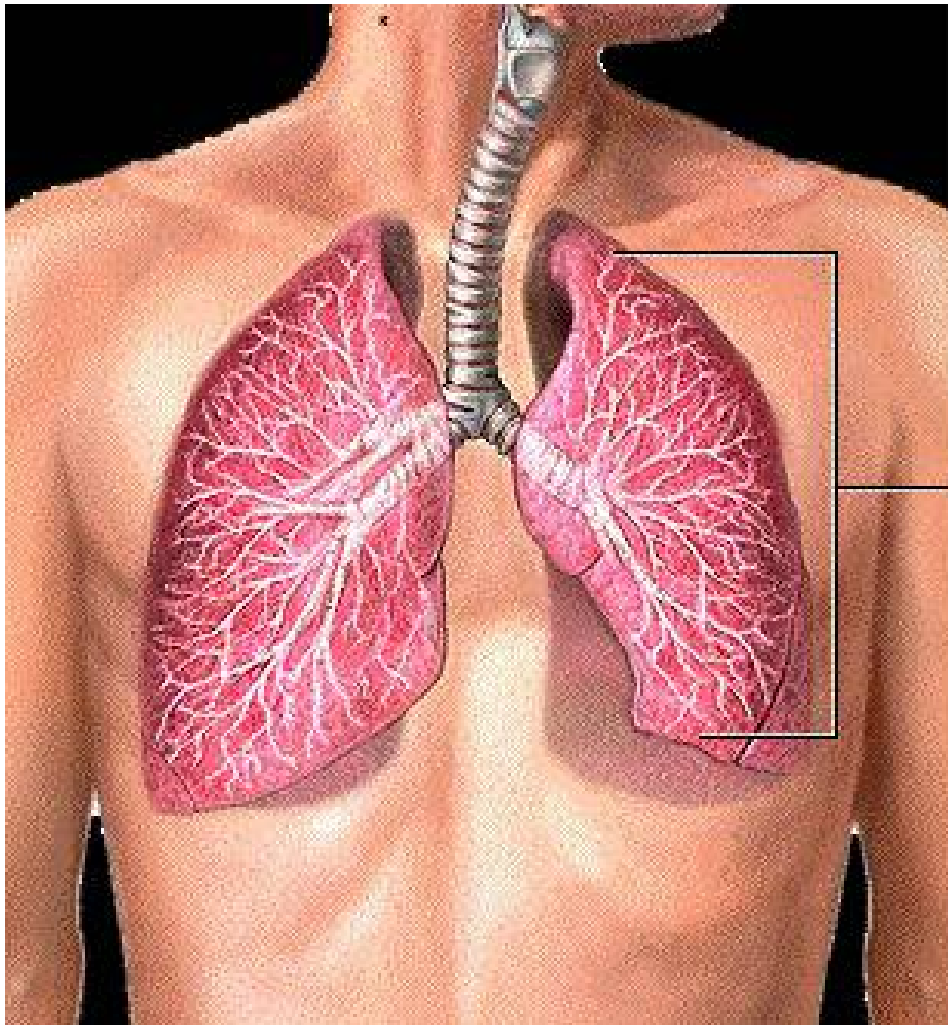
# Lower Respiratory System



## Bronchi

Further  
subdivided into  
tertiary  
bronchi

# Lower Respiratory System



## Bronchi

**Further  
subdivisions  
result in the  
bronchial tree**