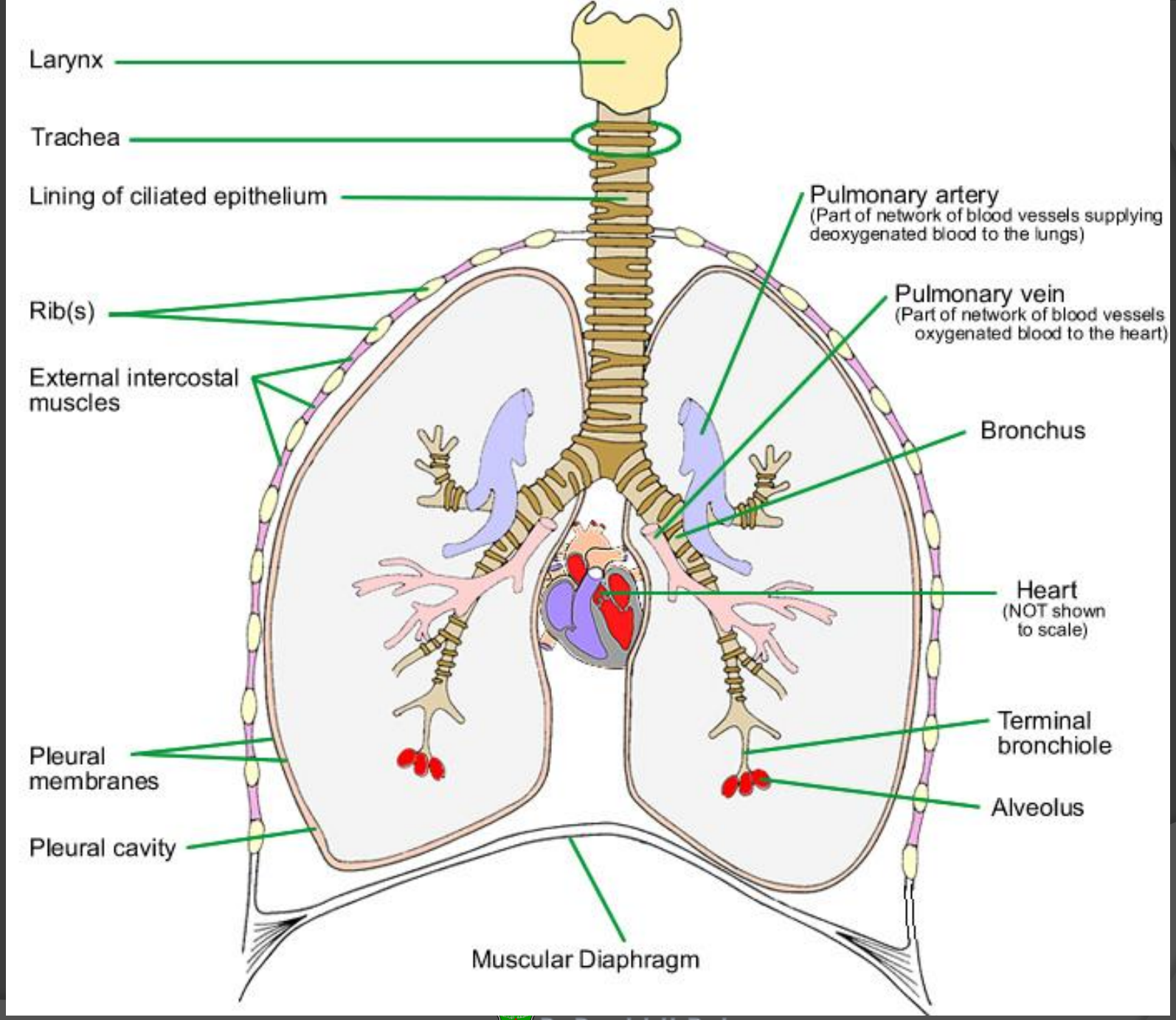
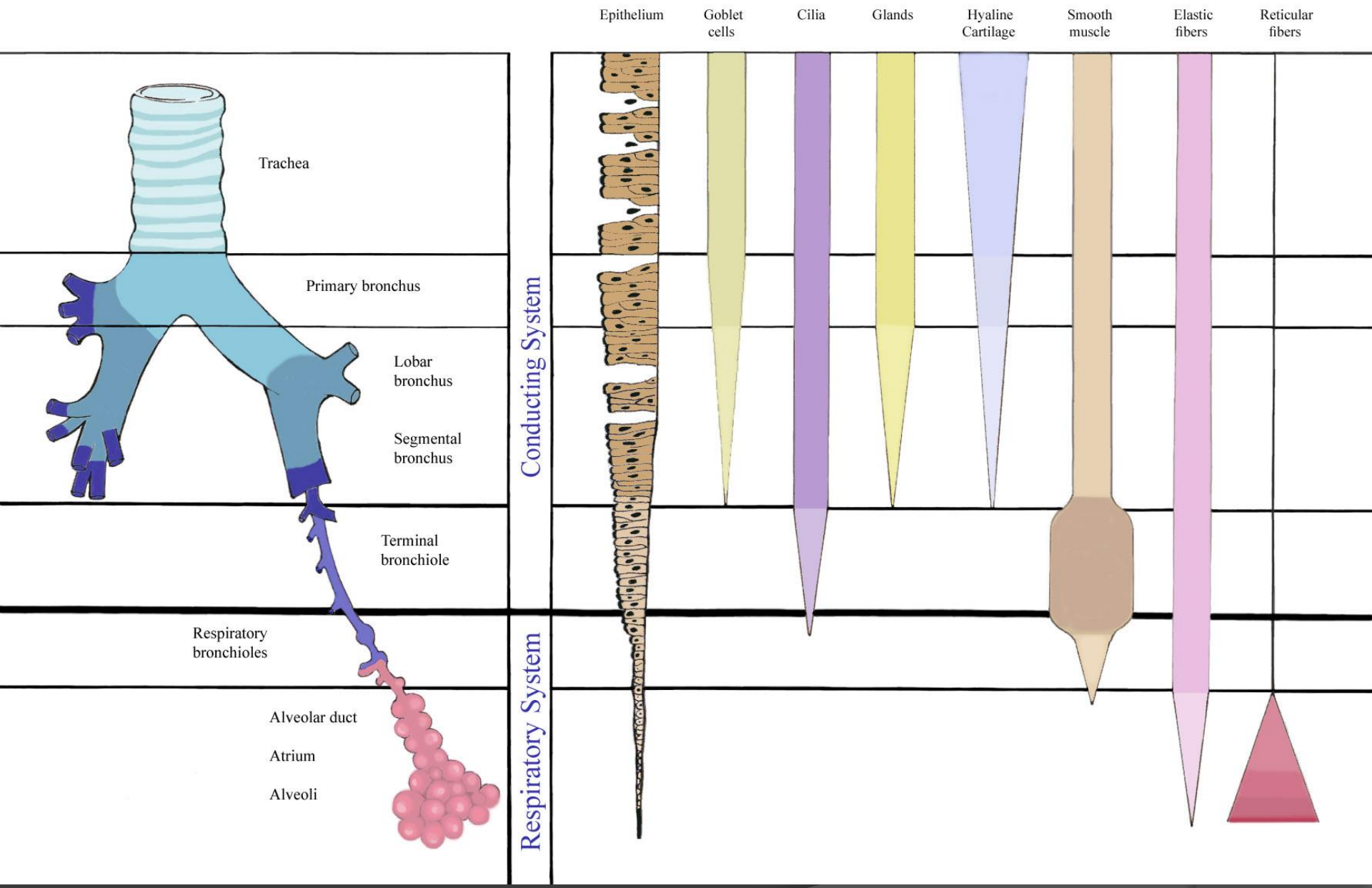
The Pulmonary (Respiratory) System


Larynx
Trachea
Lining of ciliated epithelium
Rib(s)
External intercostal muscles
Pleural membranes
Pleural cavity
Muscular Diaphragm
Pulmonary artery
(Part of network of blood vessels supplying deoxygenated blood to the lungs)
Pulmonary vein
(Part of network of blood vessels oxygenated blood to the heart)
Bronchus
Heart
(NOT shown to scale)
Terminal bronchiole
Alveolus


Epithelium
Goblet cells
Cilia
Glands
Hyaline Cartilage
Smooth muscle
Elastic fibers
Reticular fibers
Trachea
Primary bronchus
Lobar bronchus
Segmental bronchus
Terminal bronchiole
Respiratory bronchioles
Alveolar duct
Atrium
Alveoli
Conducting System
Respiratory System

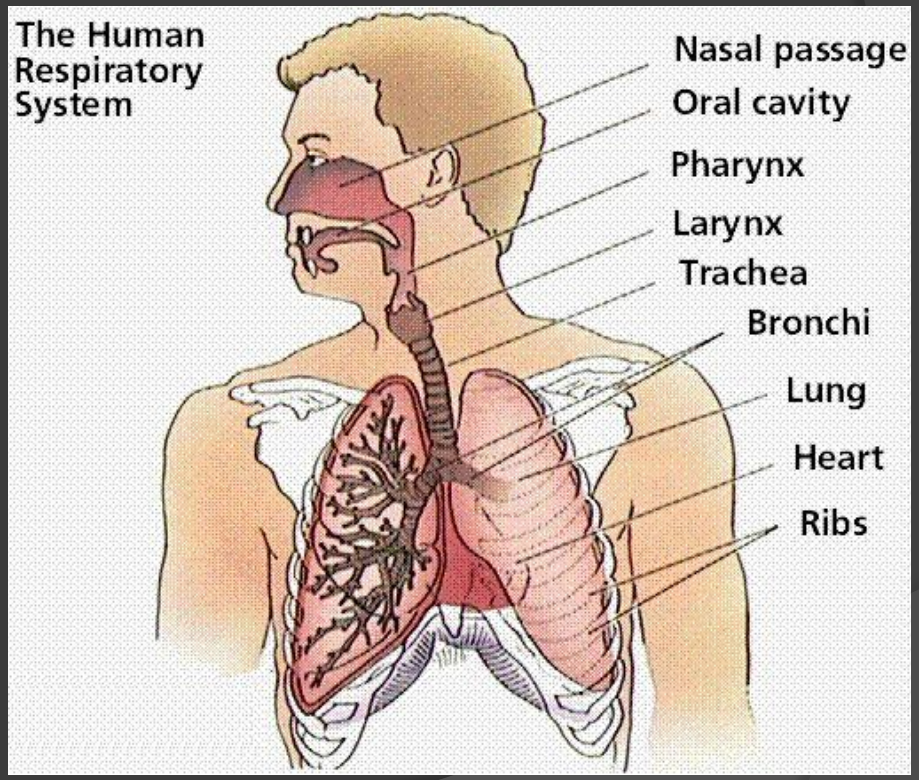
Overview and division of the respiratory system

Conducting system: which conducts air to and from the lungs and consists of:

- Nose and its cavities
- Pharynx (nasal; oral; laryngeal)
- Larynx
- Trachea
- Bronchi
- Bronchioles

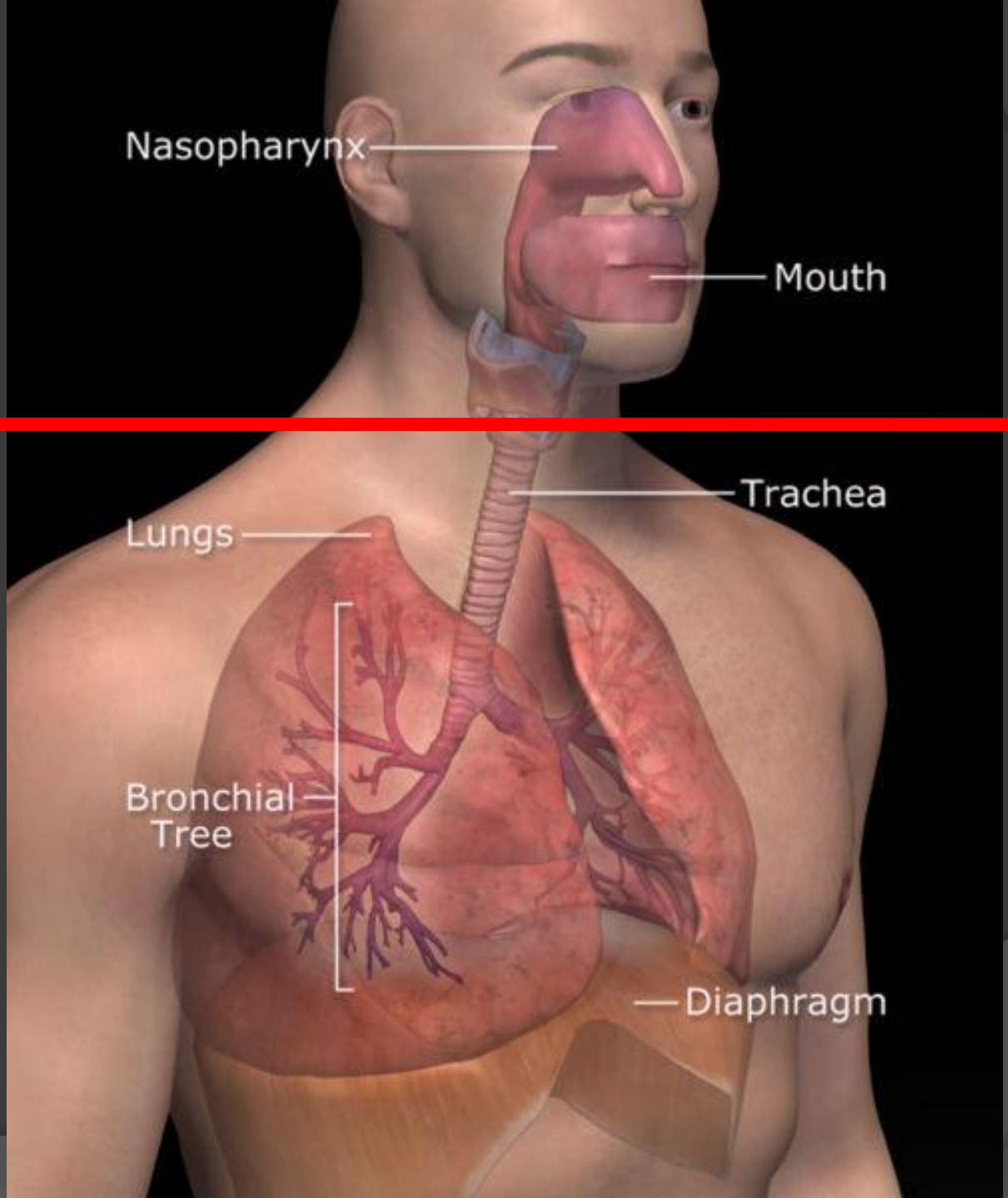
Respiratory system: It provides exchange for CO_2 and O_2 in the blood; it consists of:

- Respiratory bronchioles
- Alveolar ducts
- alveoli

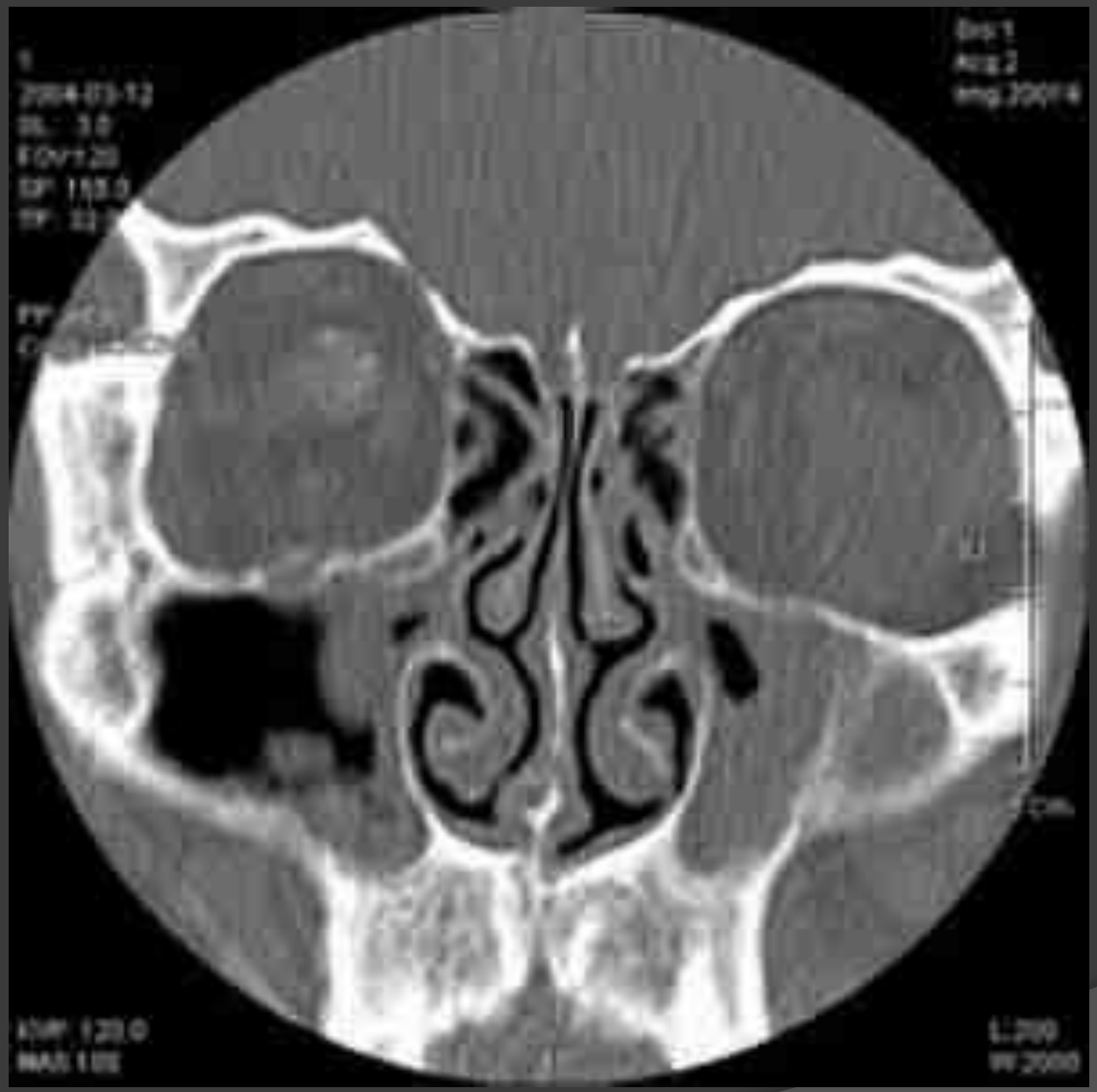


Upper Respiratory Tract

Lower Respiratory Tract



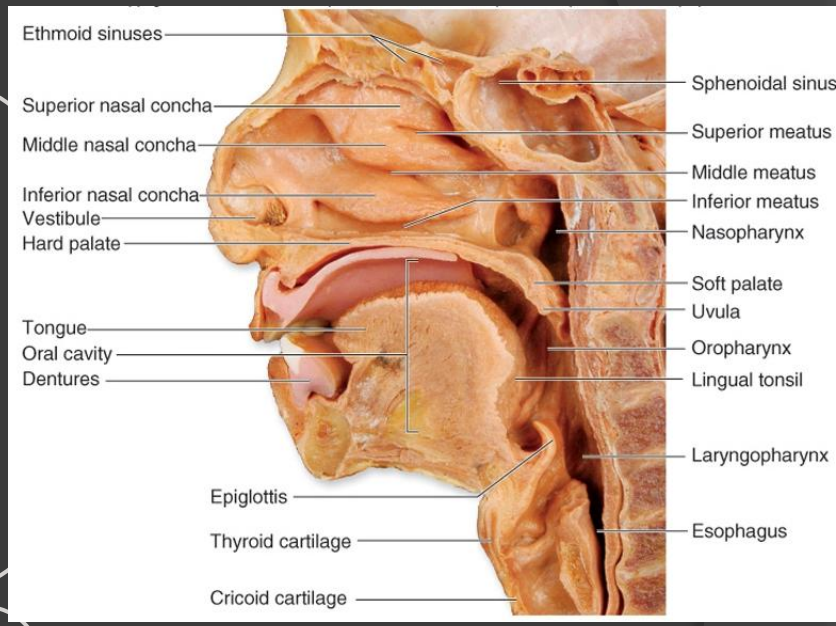
HISTOLOGY OF THE CONDUCTING SYSTEM



Nasal Conchae

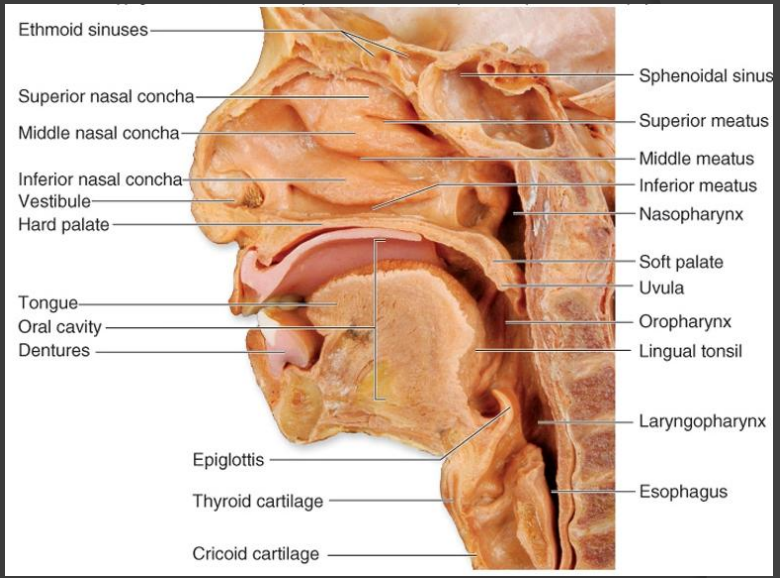
The Nose

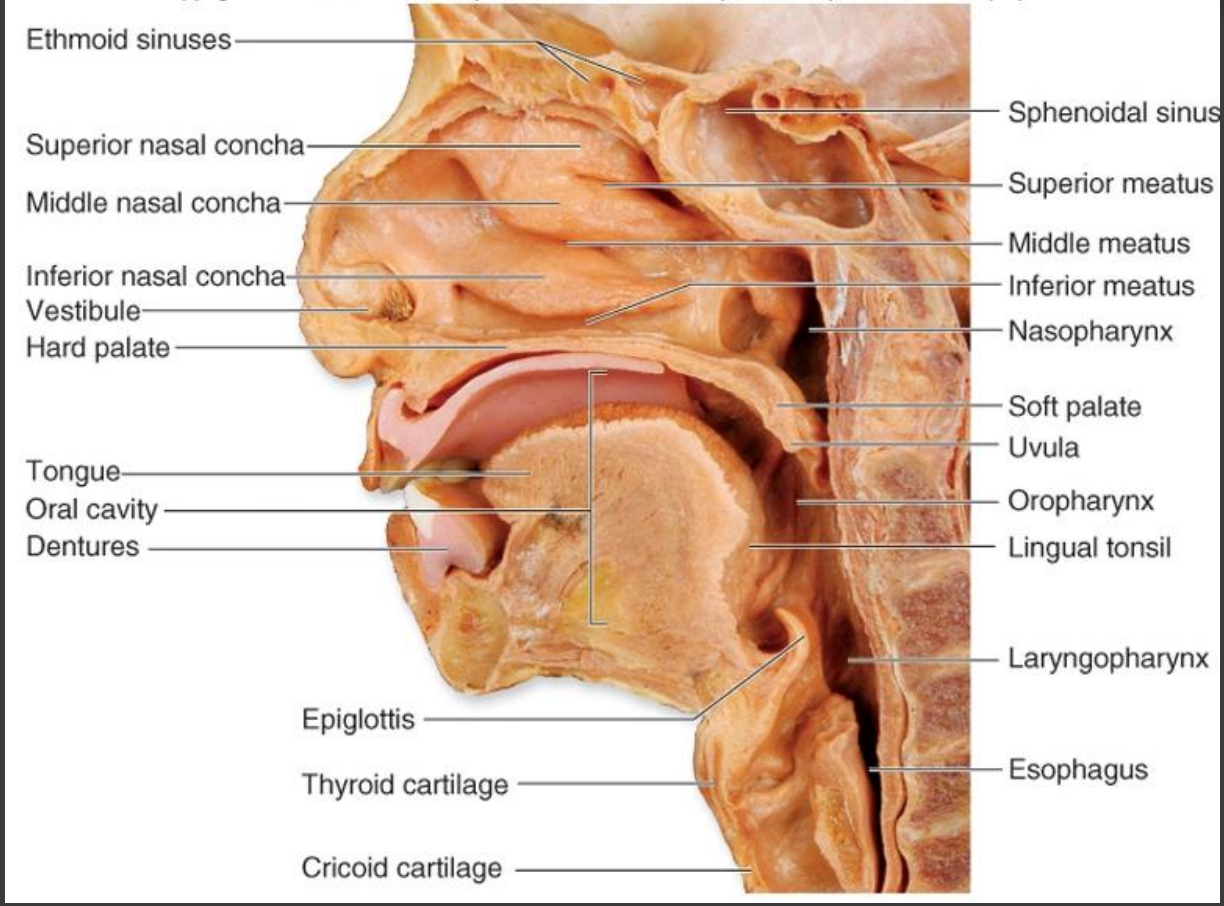
A. **THE NOSE** -- a hollow organ, covered with skin, provided with muscles, supported by cartilage and bone and lined with a mucous membrane (mucoperiosteum).



B. **THE NASAL CAVITIES** -- (separated by the nasal septum):

1. **The vestibule** -- opens to the outside at the **anterior nares**. The skin continues into the vestibule; Changes from epidermis of thin skin to pseudostratified, ciliated, columnar epithelium in the rest of the nasal cavity. The junction between the skin and the mucous membrane is known as the ***white line***; it has relatively low blood supply.



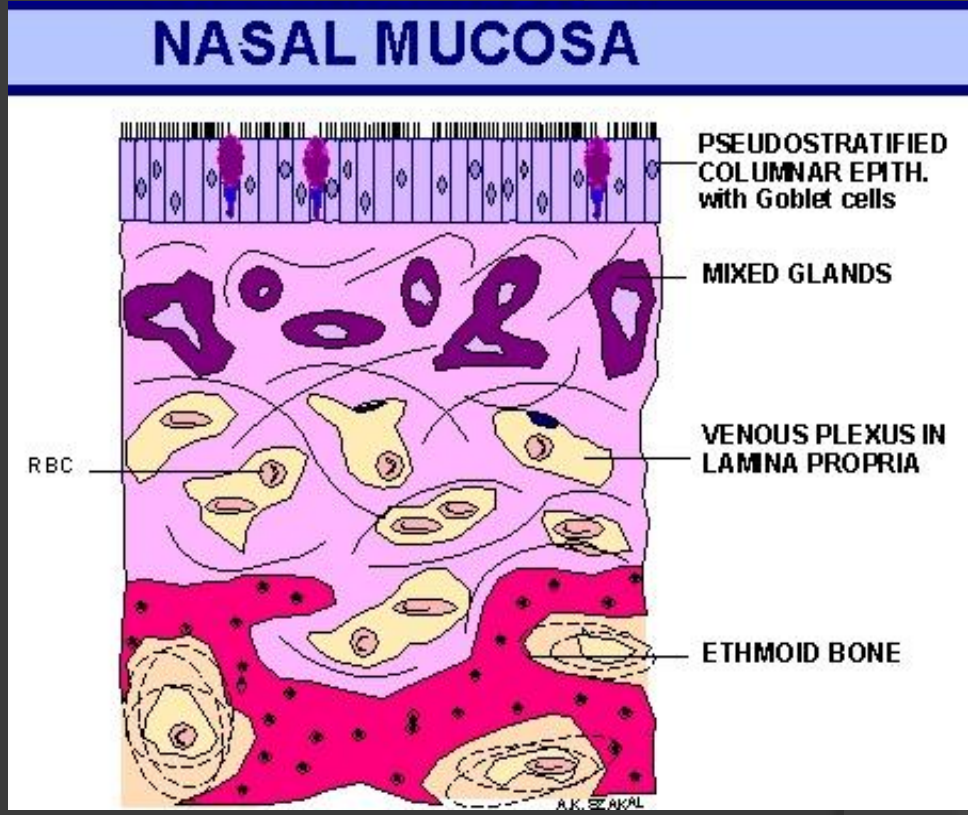


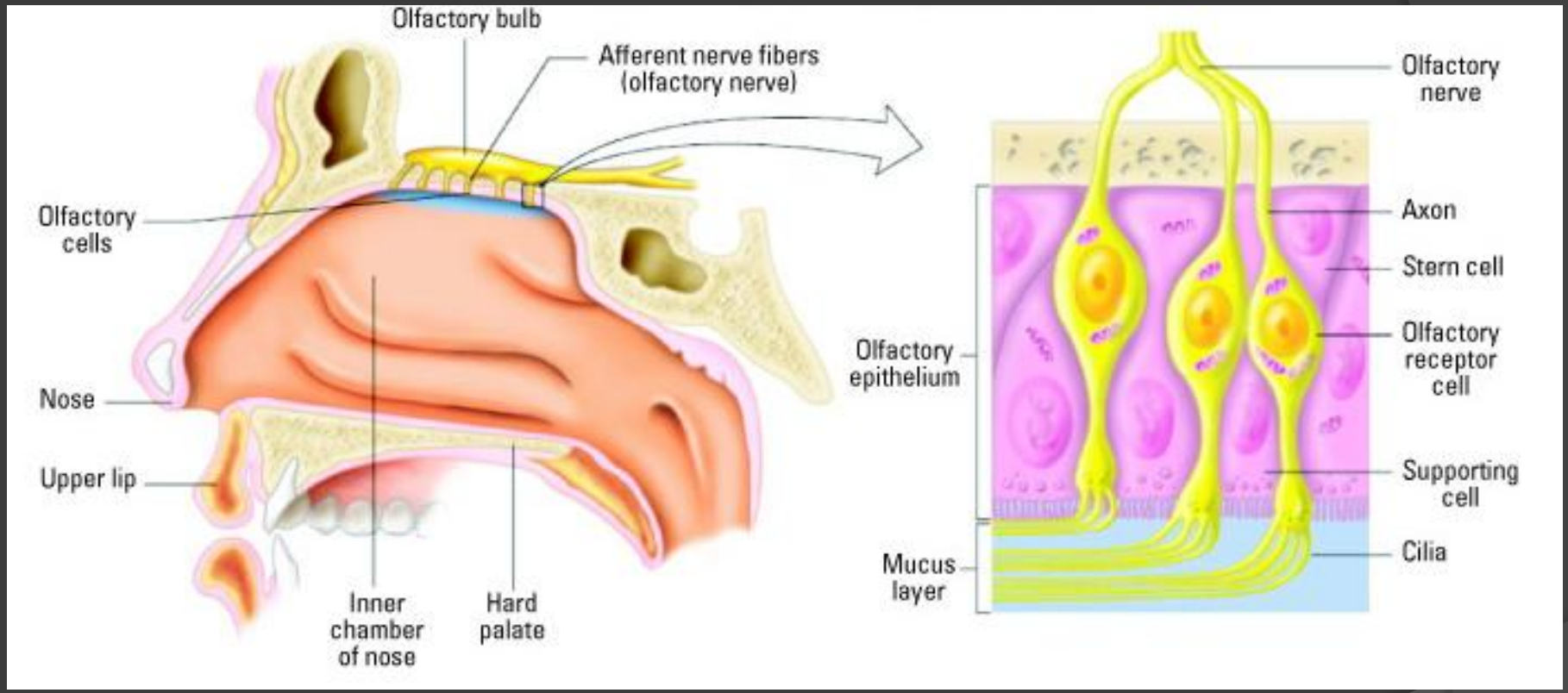
2. **The respiratory region** -- includes nearly all of the septum and lateral walls. The surface area of the lateral walls is increased by shelf-like projections (supported by bone) called **conchae** or **<u>turbinates</u>**.

a. **Epithelium:** pseudostratified, ciliated columnar with goblet cells; Cilia beat backwards, toward the pharynx; Goblet cells sometimes are concentrated in intraepithelial pits; The basement membrane varies from thin to very thick.

b. **Lamina propria:** of loose connective tissue; it contains: mixed sero-mucous glands (comp. tubuloalveolar) and a rich cavernous venous plexus, which serves to warm the passing air; upon irritation the plexus can be distended by blood and reduces air flow; it is described as erectile tissue.

c. **Submucosa:** absent, the deepest layer of the lamina propria fuses with the periosteum below;

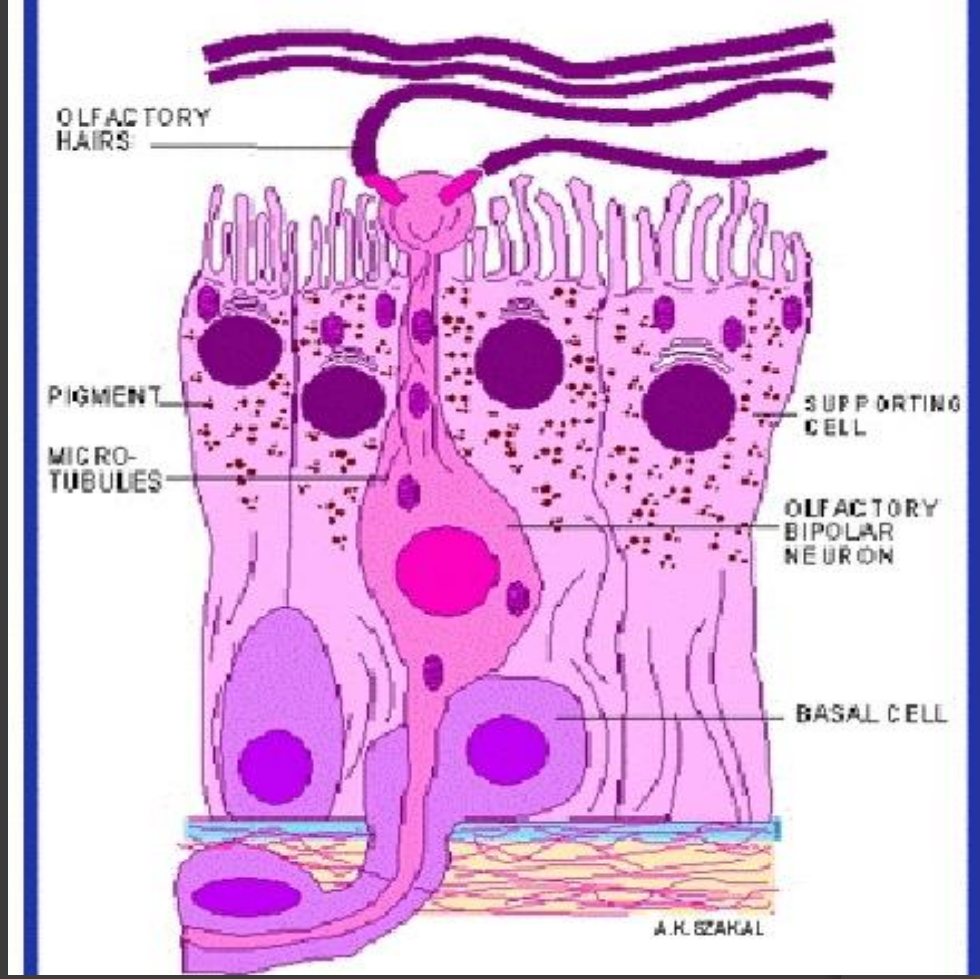




The olfactory region -- located on the superior concha and adjacent septum (dime-size areas).

Olfactory Epithelium

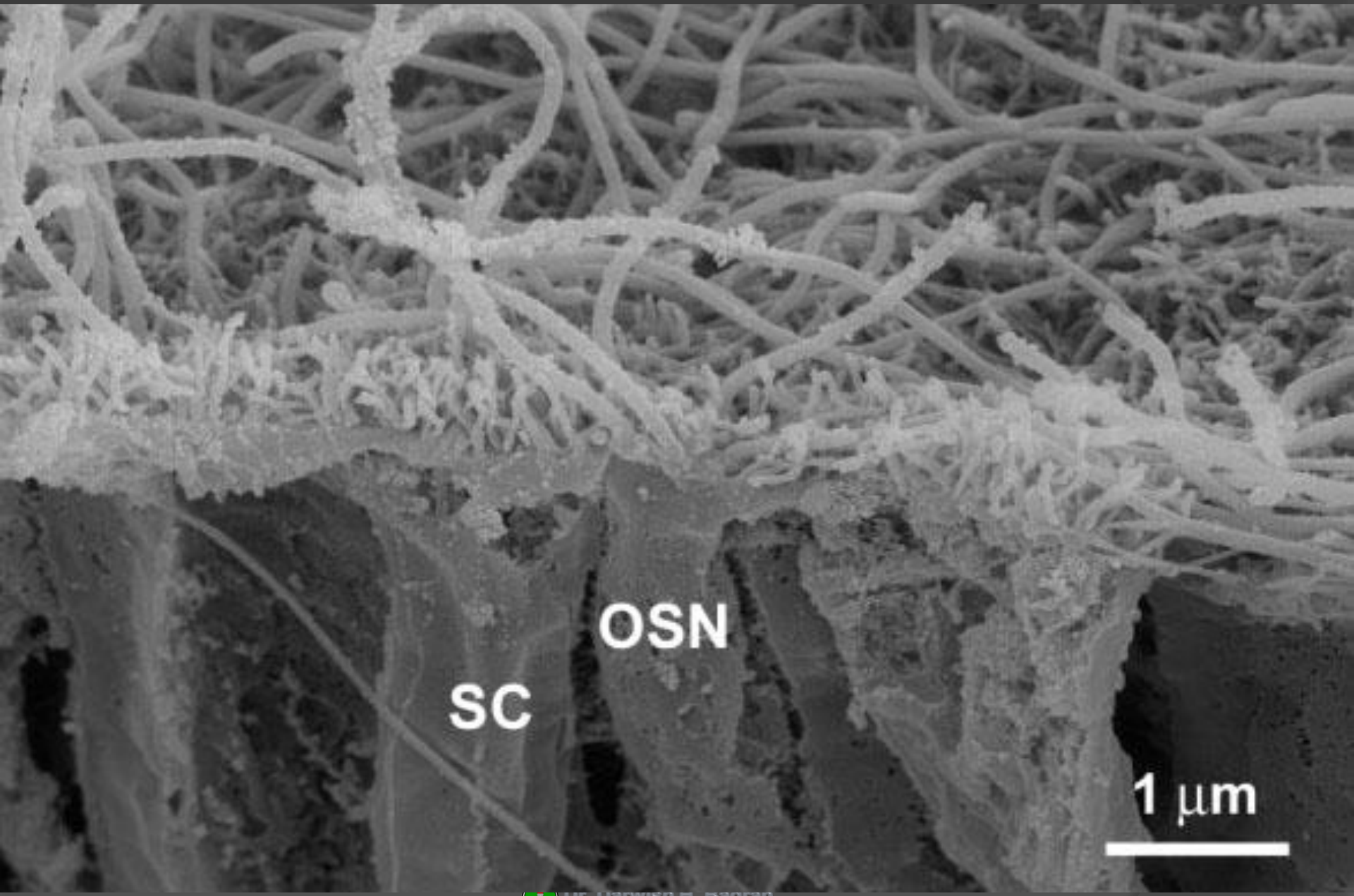
1) Olfactory cells: spindle shaped, with round nuclei; (Nuclei are in the middle and deep zone of the epithelium.) the **apical part** extends to the epithelial surface, ends in a bulbous knob which bears 6-8 olfactory hairs; these hairs or cilia are non-motile, sensory and serve as dendrons; they are embedded in a thick layer of mucus and parallel the surface of the olfactory epithelium. The proximal (basal) part of the cells form a long thin **axonal process**, which constitute the olfactory nerve fibers; these unmyelinated fibers are



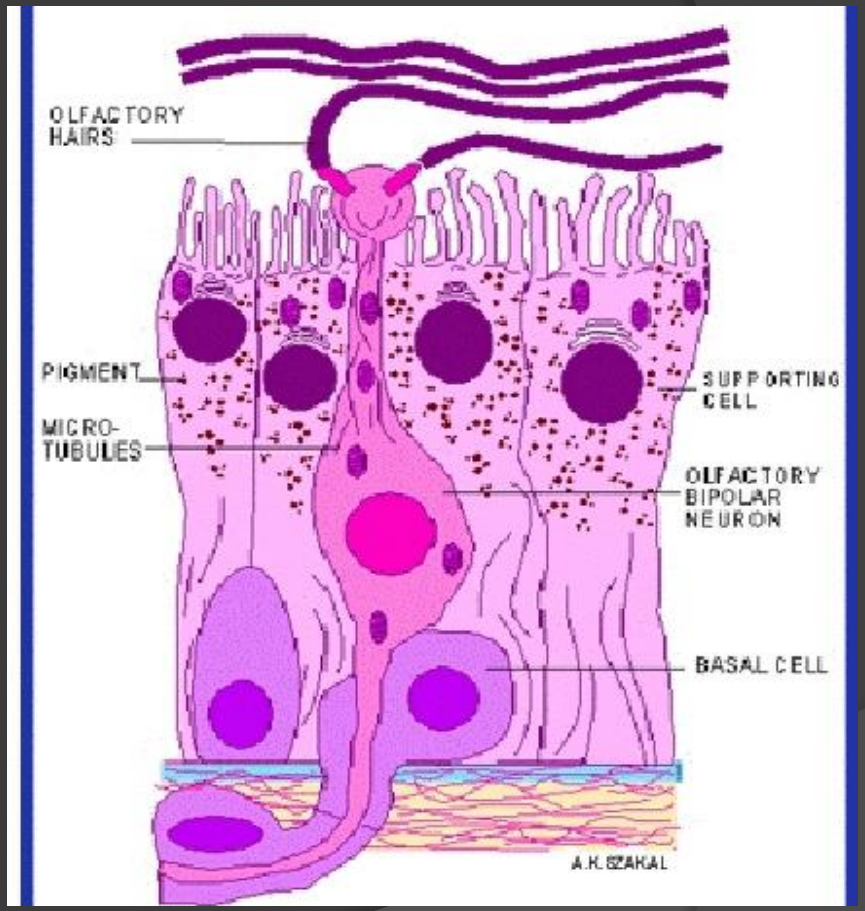
connected to the olfactory center of the brain (in the olfactory bulbs). Olfactory cells are modified bipolar neurons.

Functions: the olfactory cilia are stimulated by gaseous, odori-ferous substances dissolved in the secretion of serous glands moistening the epithelium.

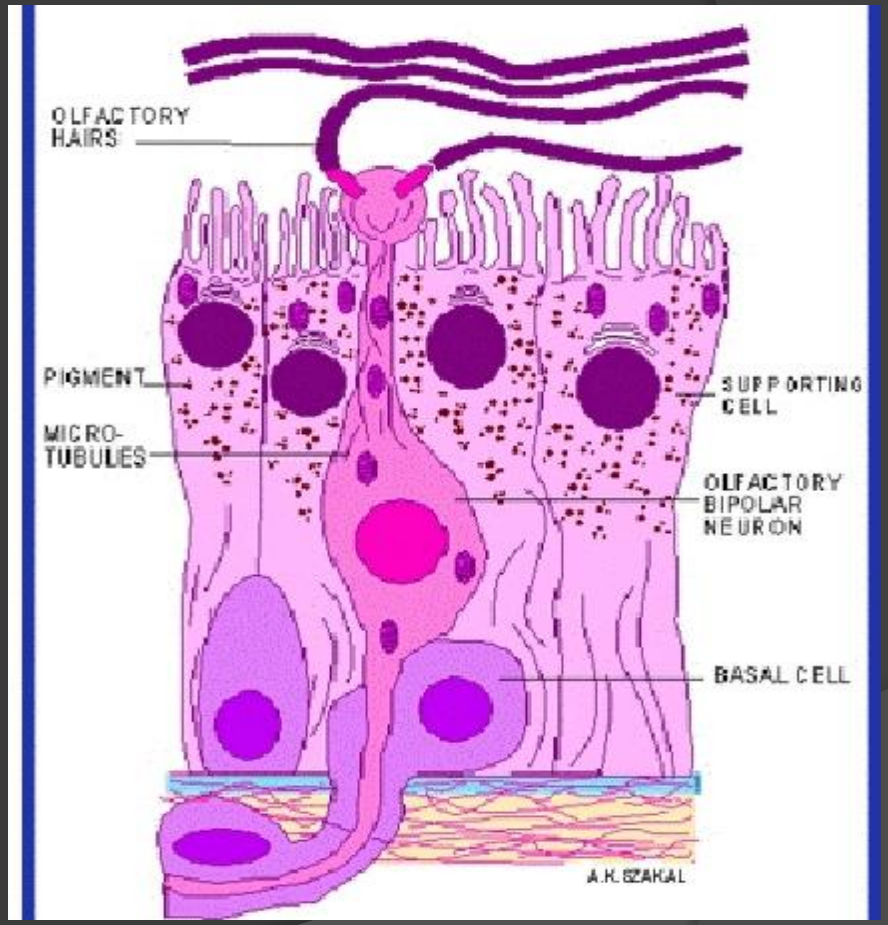
SEM of the surface of the Olfactory Epithelium



2) Supporting cells: tall slender cells make up the upper third of the pseudostratified epithelium (nuclei in top 2-3 rows). They are attached to the sensory (olf.) cells at the surface of the epithelium by **zonula adherens** (junctional complex with terminal web). Have a small Golgi complex in the apical cytoplasm and pigment granules (brown). There are numerous slender villi on their apical surface.

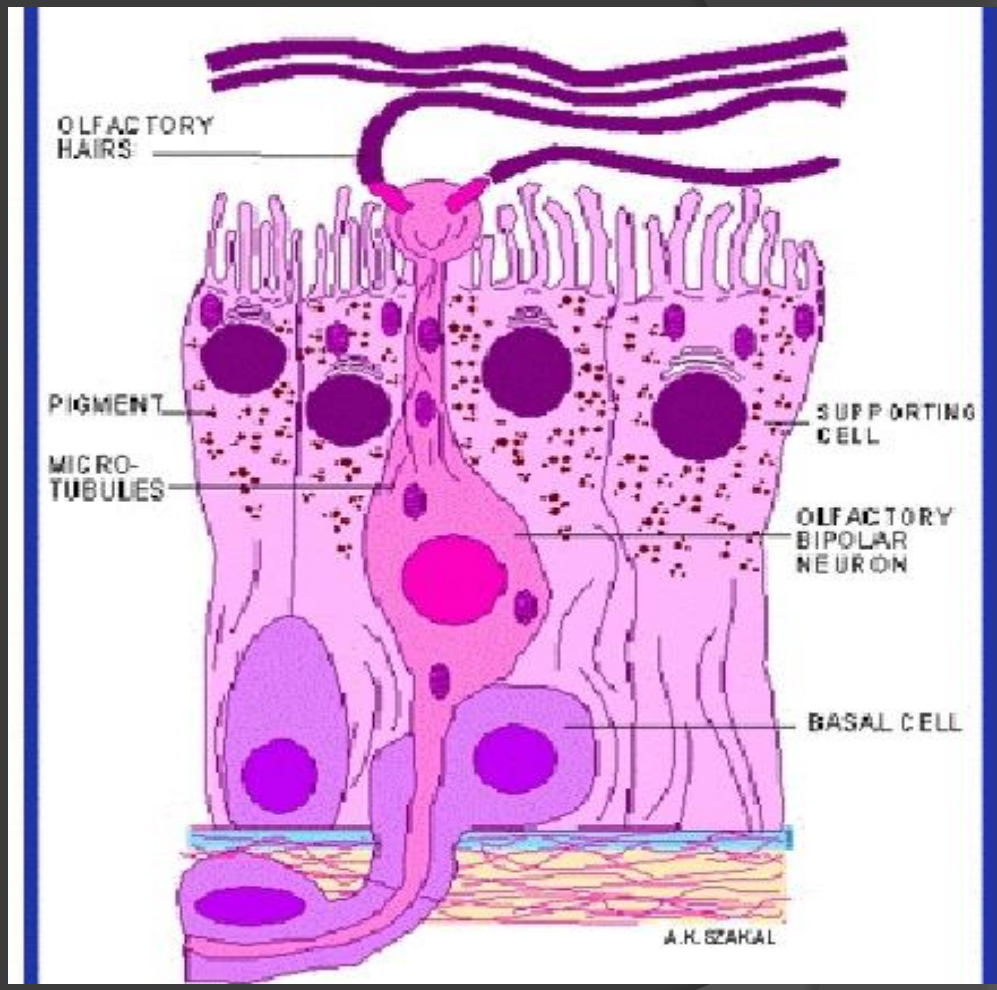


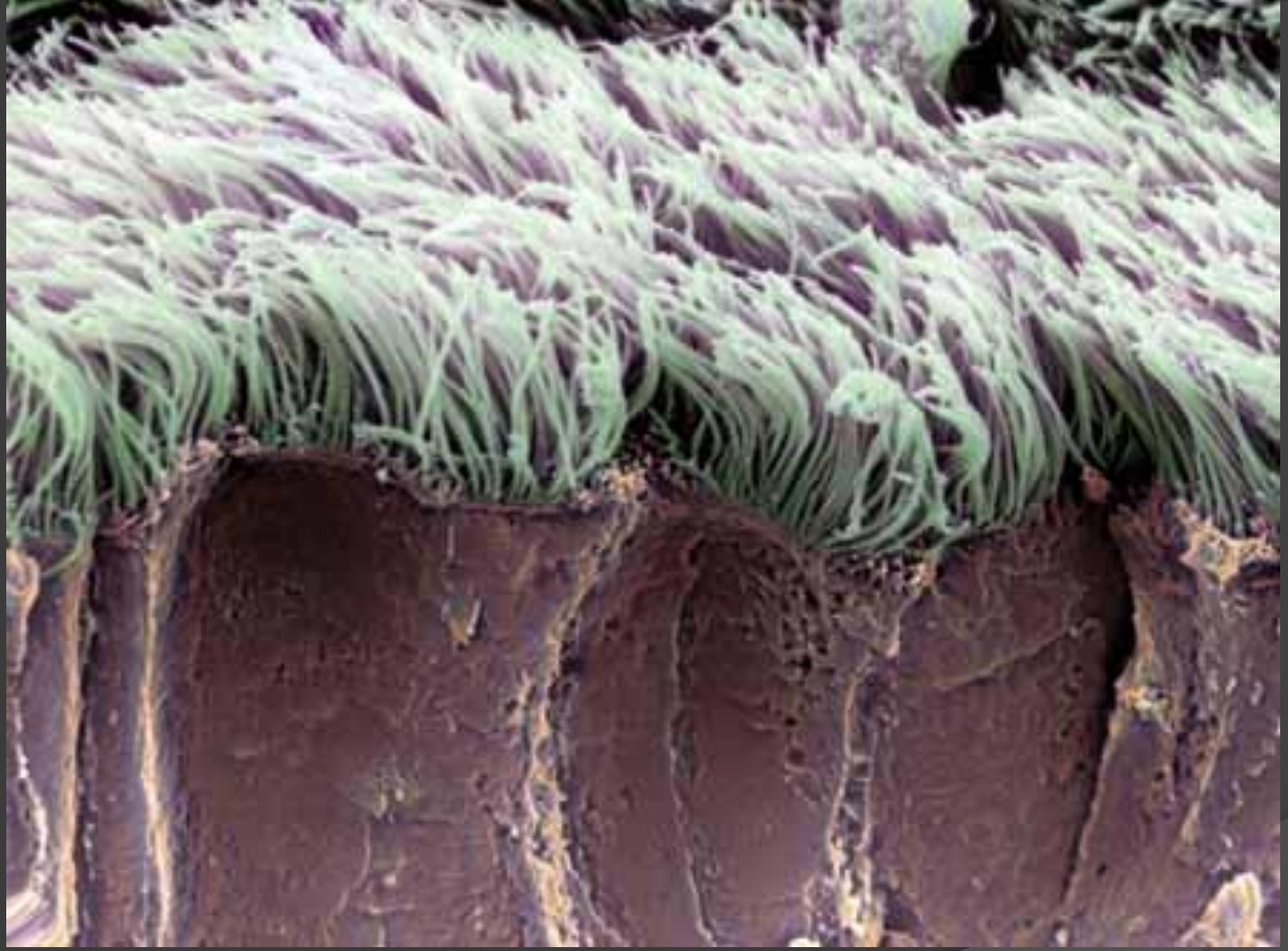
3) Basal cells: constitute a single layer of conical elements a the base of supporting cells (bottom layer of nuclei); have dark nuclei and branching processes.



Lamina propria: continuous with the dense connective tissue of the underlying periosteum in the adult or with the perichondrium in the fetus. The **venous plexus** in the lamina propria is continuous with that of the respiratory regions.

A group of branched, tubuloalveolar (mainly serous) olfactory glands called **Bowman's glands** present in the lamina propria supply the necessary solvents to trap odoriferous substances. The continuous replacement of secretion keeps the receptors ready for new stimuli.

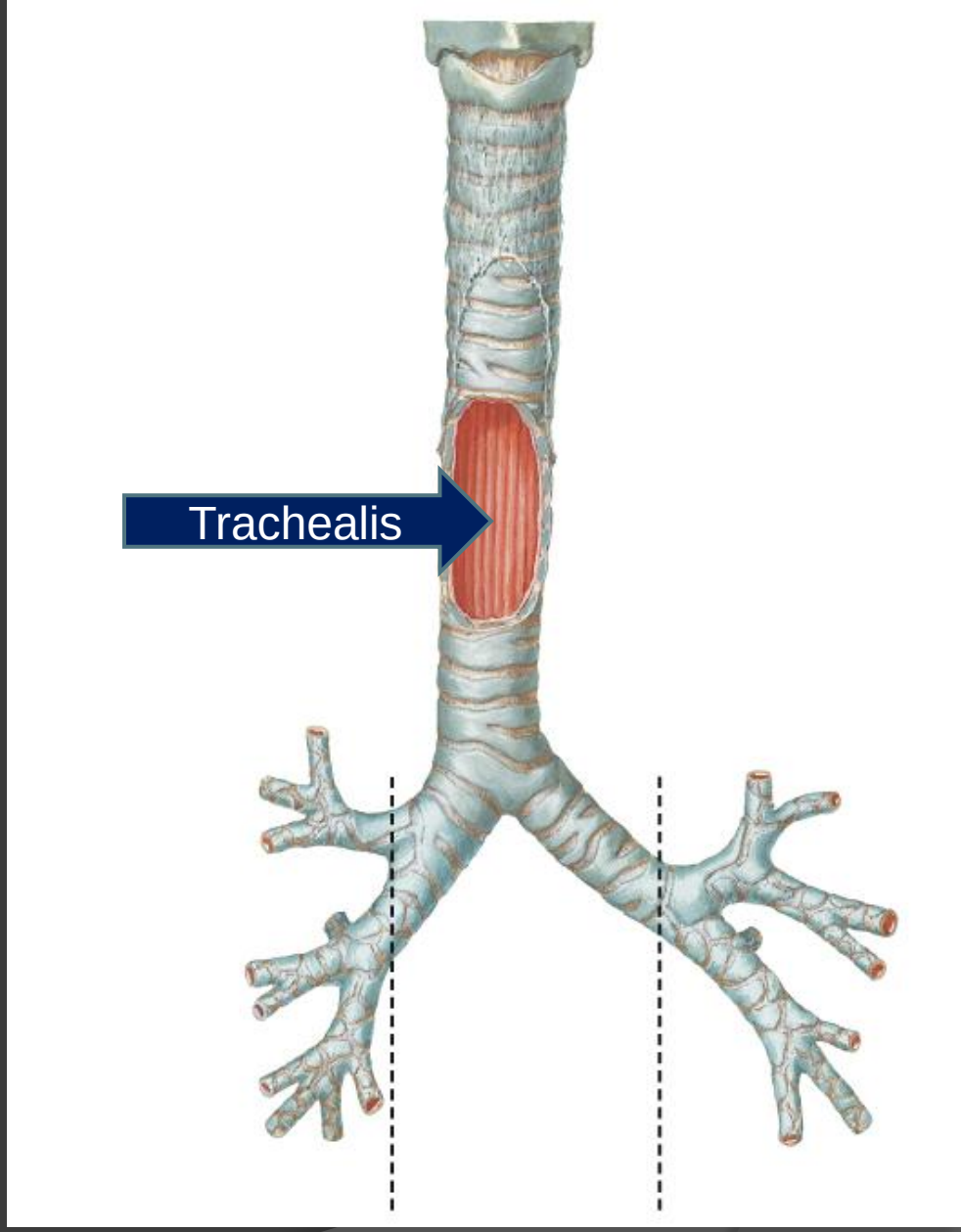


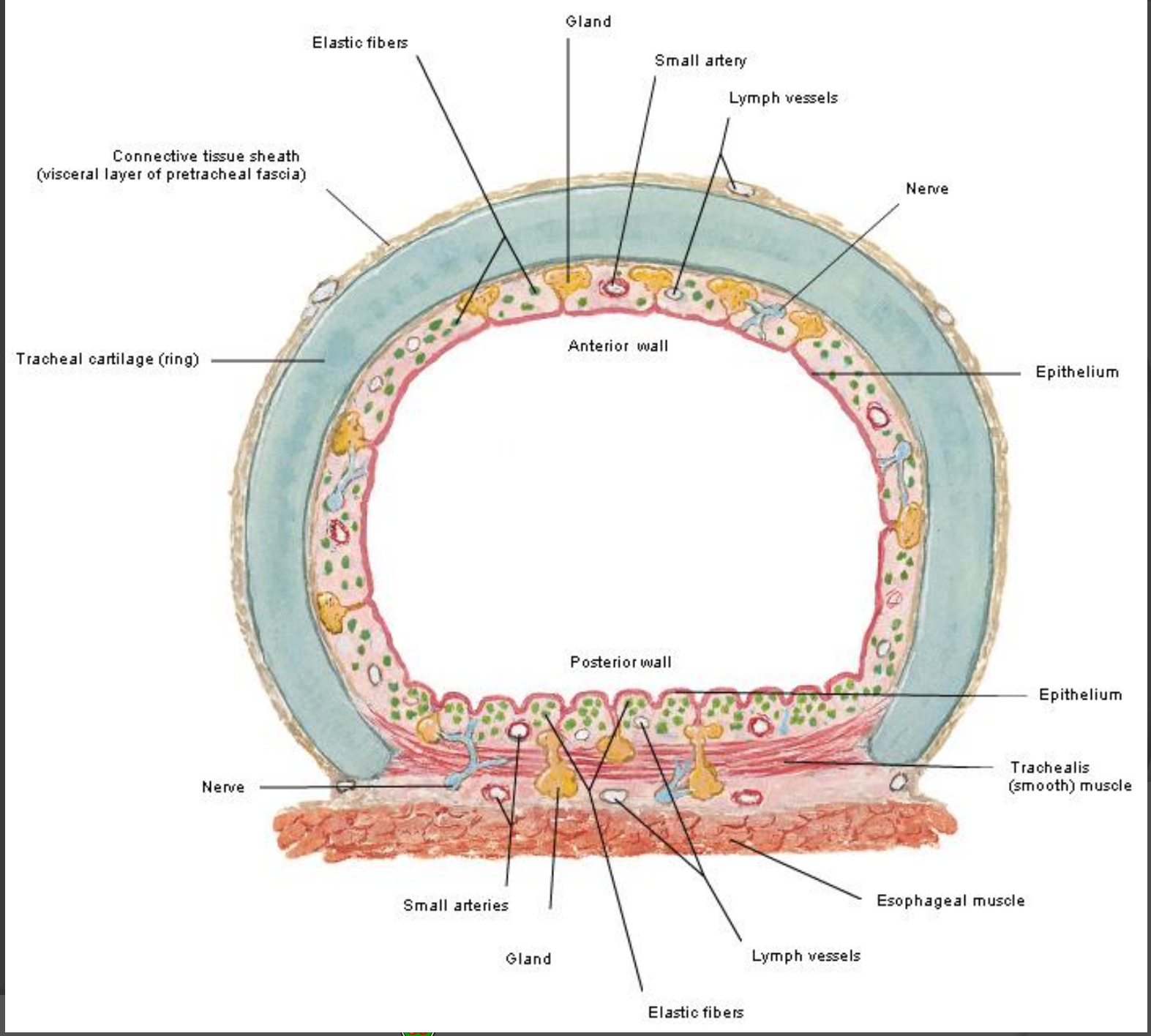


Bronchiolar Epithelium

Trachea

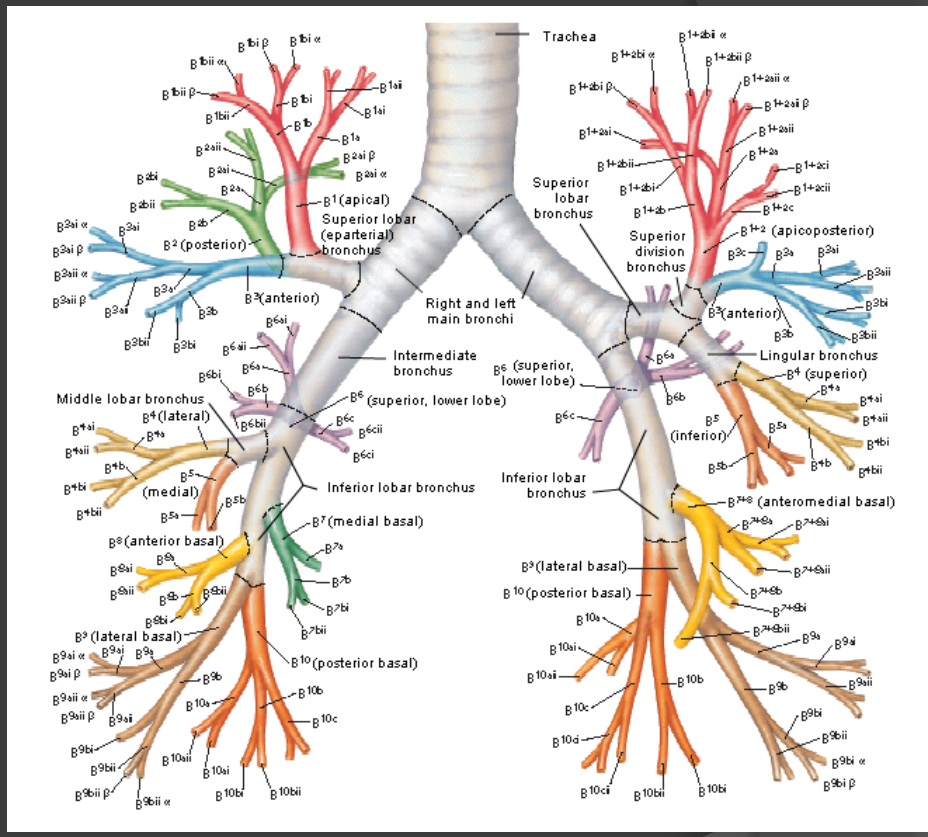
- Thin walled tube 10 cm long
- Bifurcates into 2 primary bronchi
- Respiratory mucosa
- C-shaped hyaline cartilage rings with open ends connected by elastic ligament and smooth muscle (***Trachealis***); contraction occurs in coughing to increase velocity of air




Gland
Elastic fibers
Small artery
Lymph vessels
Connective tissue sheath
(visceral layer of pretracheal fascia)
Nerve
Tracheal cartilage (ring)
Anterior wall
Epithelium
Posterior wall
Epithelium
Trachealis
(smooth) muscle
Nerve
Small arteries
Esophageal muscle
Gland
Lymph vessels
Elastic fibers

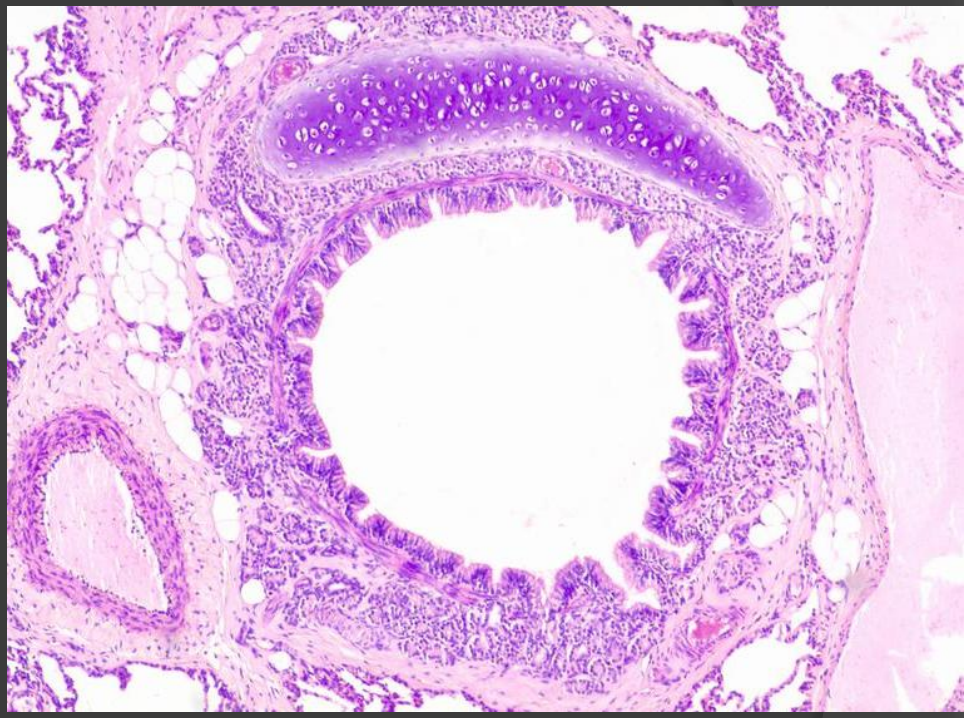
Bronchial Tree

- 2 primary bronchi enter lungs
- 3 intrapulmonary bronchi on right and 2 on the left
- Bronchioles
- Terminal bronchioles

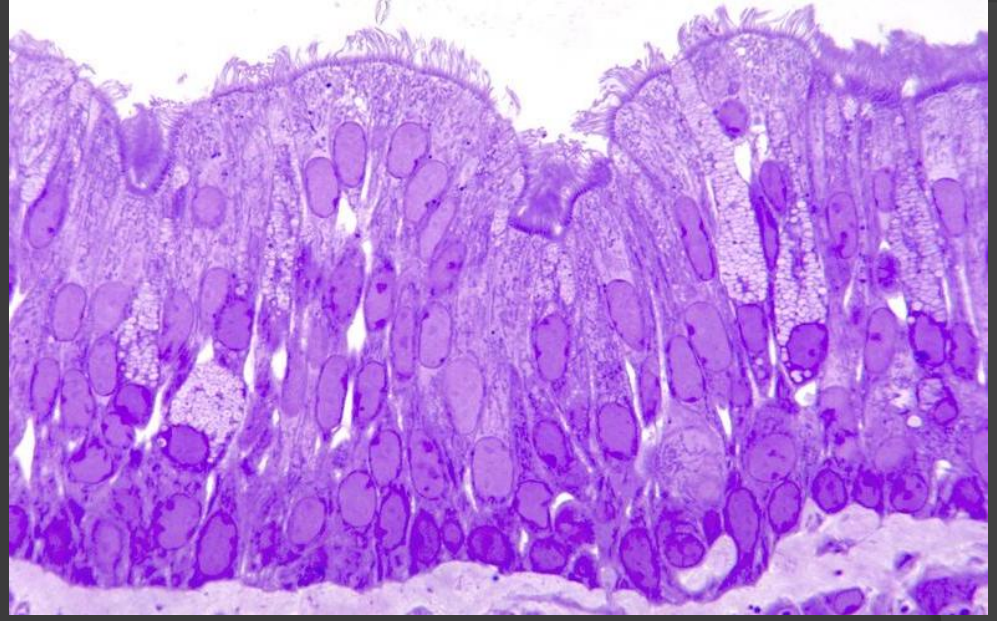


Bronchi

- > 5 mm diameter
- Mucosa and submucosa like trachea
- Smooth muscle, elastic fibers, and serous/mucous glands in lamina propria
- Lymphoid nodules may be present in lamina propria
- Hyaline cartilage present in interrupted plates.



Respiratory Epithelium



Pseudostratified columnar epithelium ciliated with goblet cells.

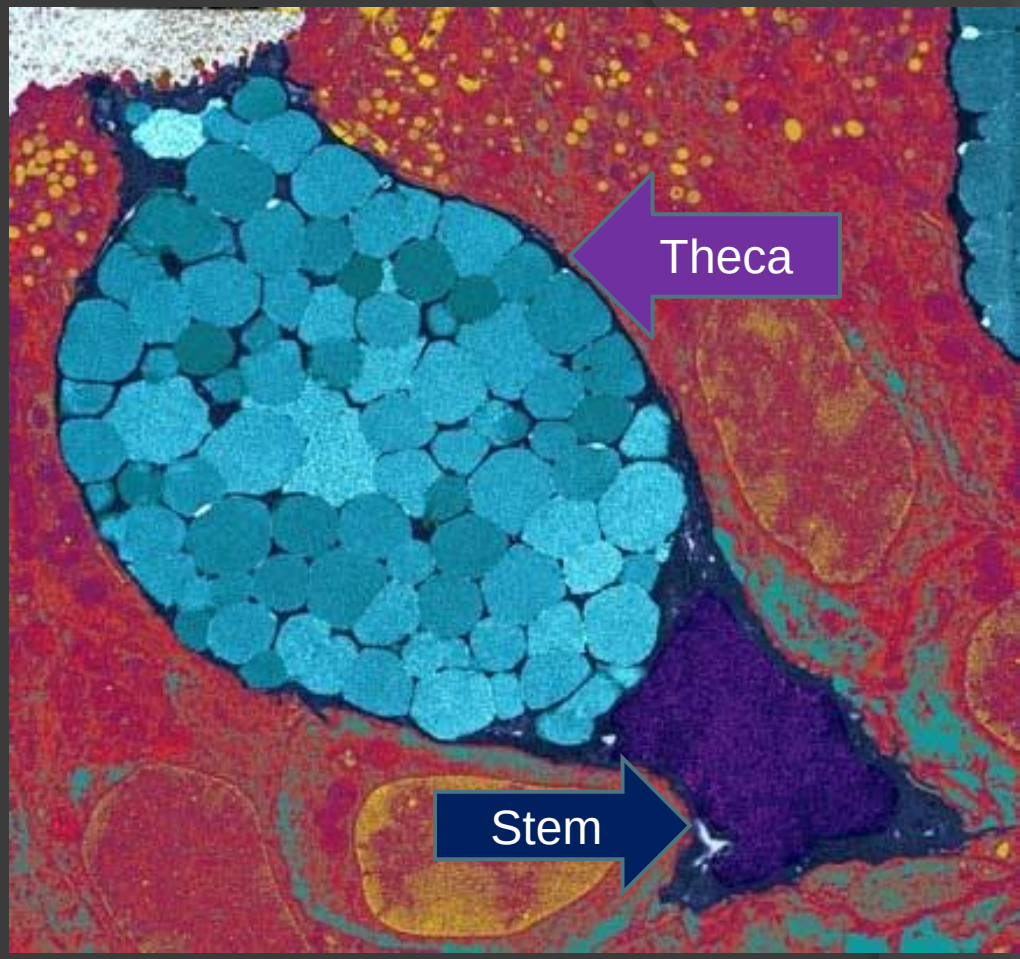
Lies on relatively thick basement membrane.

Contains 5-6 types of cells:

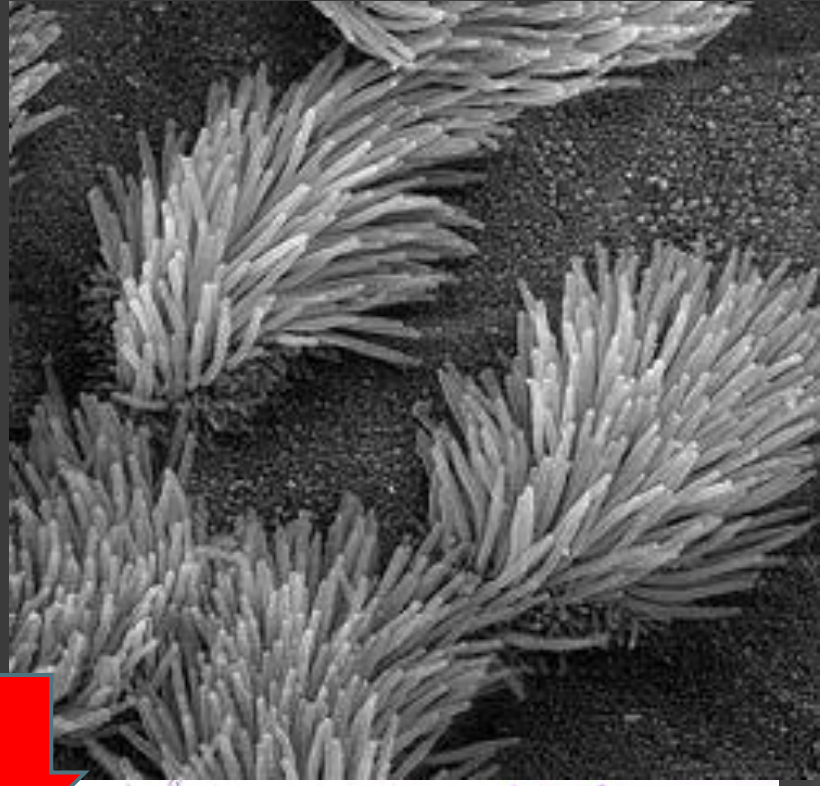
1) Goblet 2) Ciliated columnar 3) Basal
4) Brush 5) Serous?? 6) DNES

1) Goblet cells

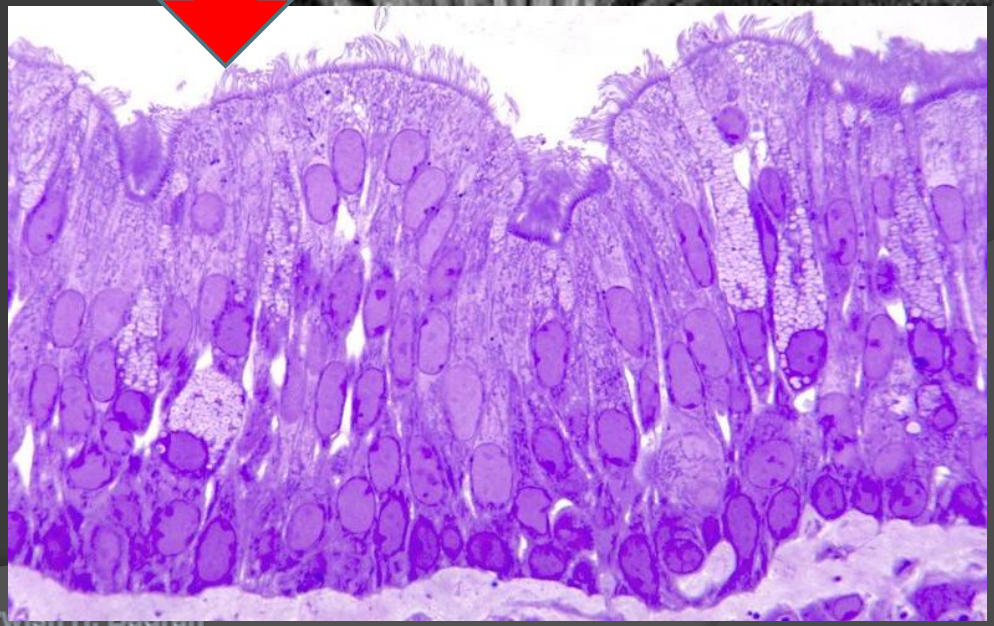
- Form 30% of total cells.
- Secrete mucinogen which becomes mucin on hydration. They can absorb water in < 20ms.
- The part containing secretory granules is known as the theca.
- The basal part is called the stem.
- Cytoplasm contains: rER, Golgi, ribosomes, mitochondria.
- Apical plasmalemma shows microvilli.



2) Ciliated columnar cells



- Form ~35% of total cells.
- Have basally located nucleus.
- Posses cilia and microvilli.
- Apical cytoplasm is rich in mitochondria and Golgi apparatus.
- Basal cytoplasm is rich in rER.
- They move the mucus upwards



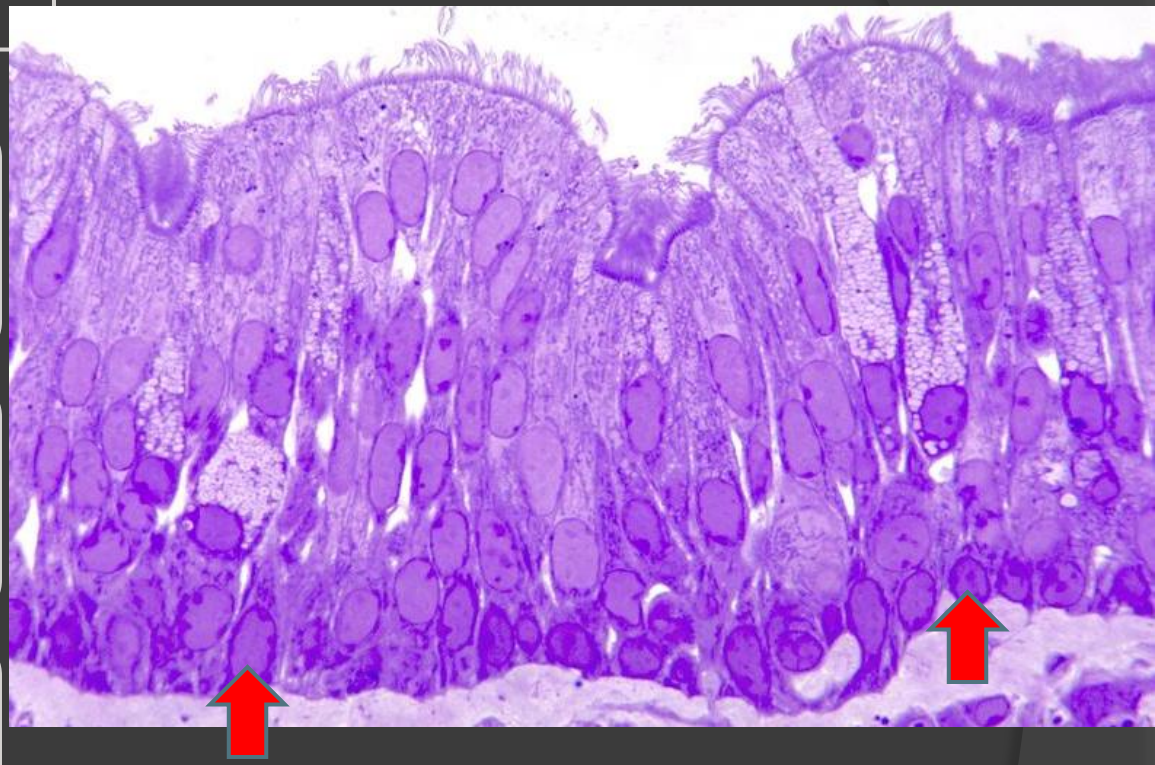
3) Basal (Stem) cells

Form 30% of total cells.

Considered as stem cells.

Relatively short, with large round-oval nucleus

Might replace goblet, columnar and brush cells.



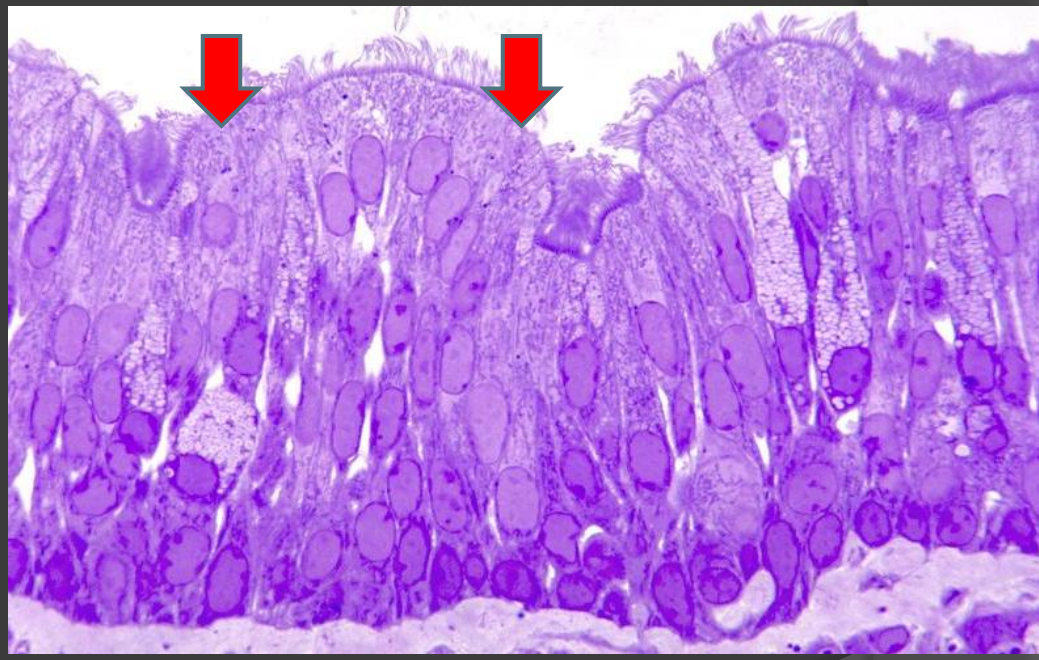
4) Brush cells

Form 3% of total cells.

Columnar cells with microvilli.

Unknown function.

Cytoplasm contains small mucus granules.

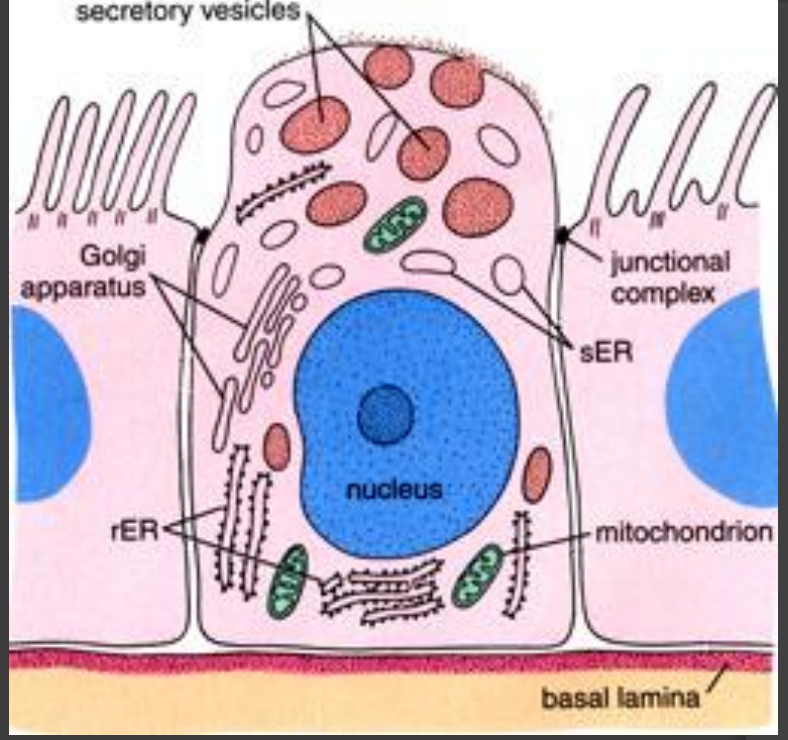


5) DNES

- Form 3-4% of total cells.
- Basal cytoplasm contains several granules.
- Granular content usually released into nearby connective tissue.
- They secrete substances that control the functions of other cells.
- It is believed that their processes into the lumen monitor the O2 & CO2 levels in the lumen.
- Can be seen in immuno-stained sections only

Clara cells

- Dome-shaped cells with microvilli.
- Apical cytoplasm contains granules and many rER.
- Their secretion protects bronchiolar epithelium.
- They detoxify certain toxins in the sER.
- They secrete surfactant like substance.
- They divide to replace degenerated bronchiolar epithelium.



They start to appear from the carina, and increase in number distally.

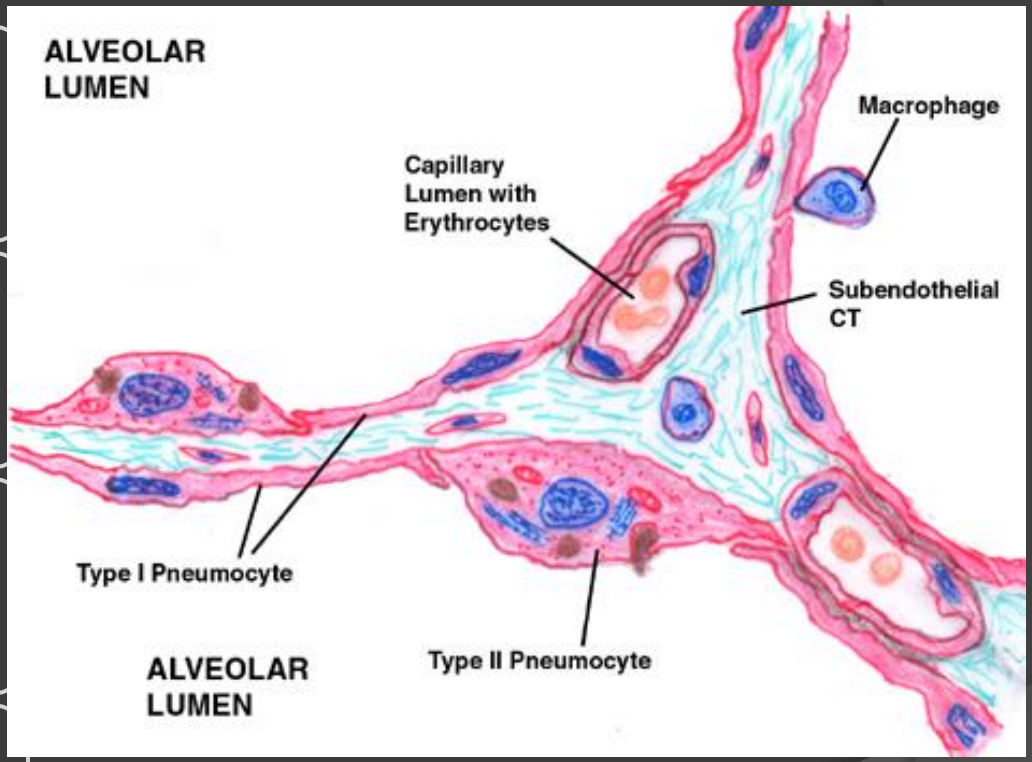
Pneumocytes type I

Simple squamous epithelial cells with tapering ends forming 90% of alveolar surface.

Has a well developed basal lamina.

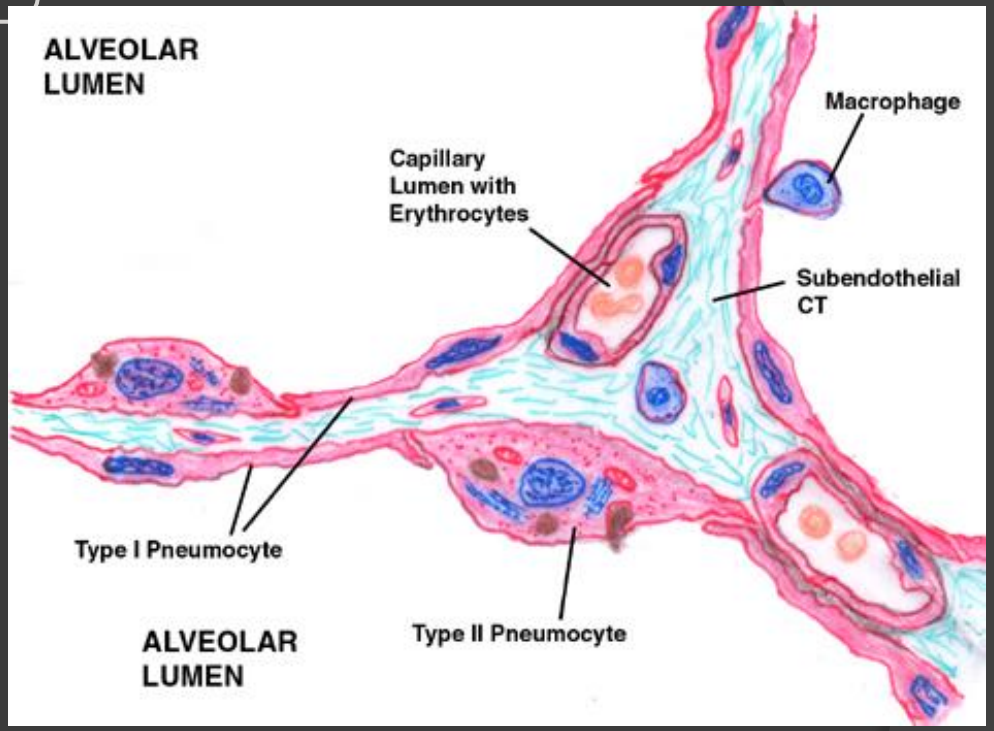
Nucleus seen in the widest arts of the cell surrounded by organelles.

Form occluding junctions with each other and with type II.



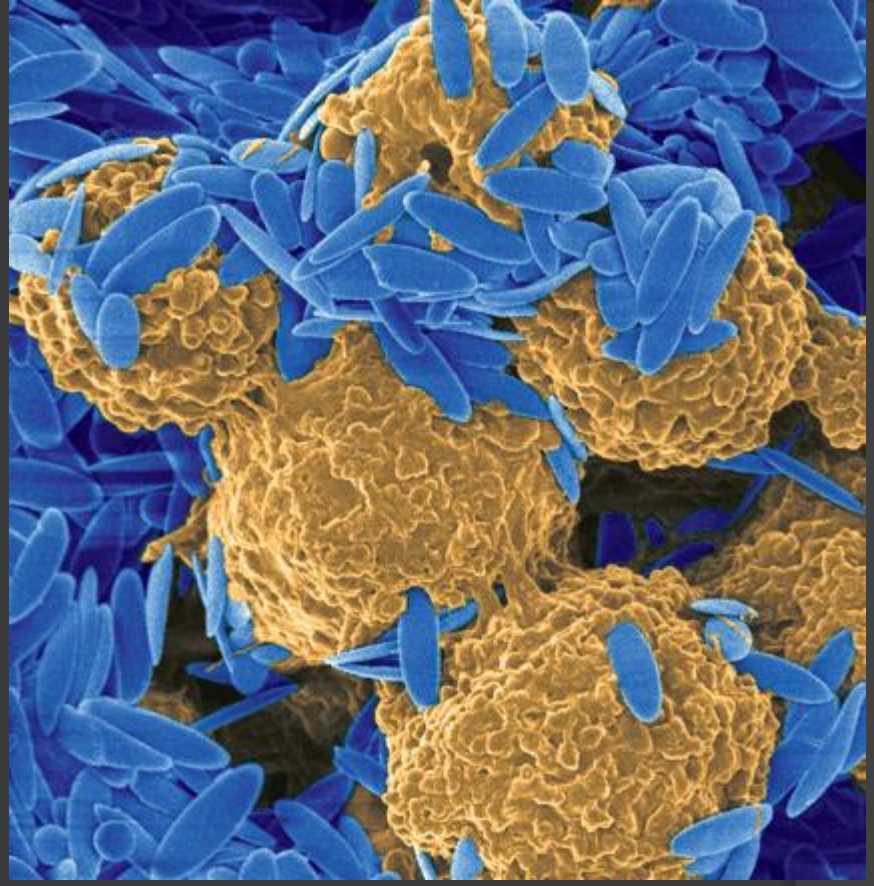
Pneumocytes type II

- More numerous than type I but occupy less surface area.
- They are cuboidal cells located in the interalveolar septum (septal cells).
- Have apical microvilli, central nucleus, rER,Golgi, and mitochondria.
- Lamellar bodies are frequent and secrete the *surfactant*.
- These cells replace degenerated type I cells.



Alveolrar Macrophages

- Originate from blood monocytes.
- Enter the alveolar lumen between alveolar cells.
- They maintain sterile environment by phaocytosing foreign bodies.
- They assist in uptake of surfactant.
- They migrate to bronchi and they either return to alveoli or become swallowed or expectorated.
- They may migrate into lymph vessels.



Terminal Bronchioles

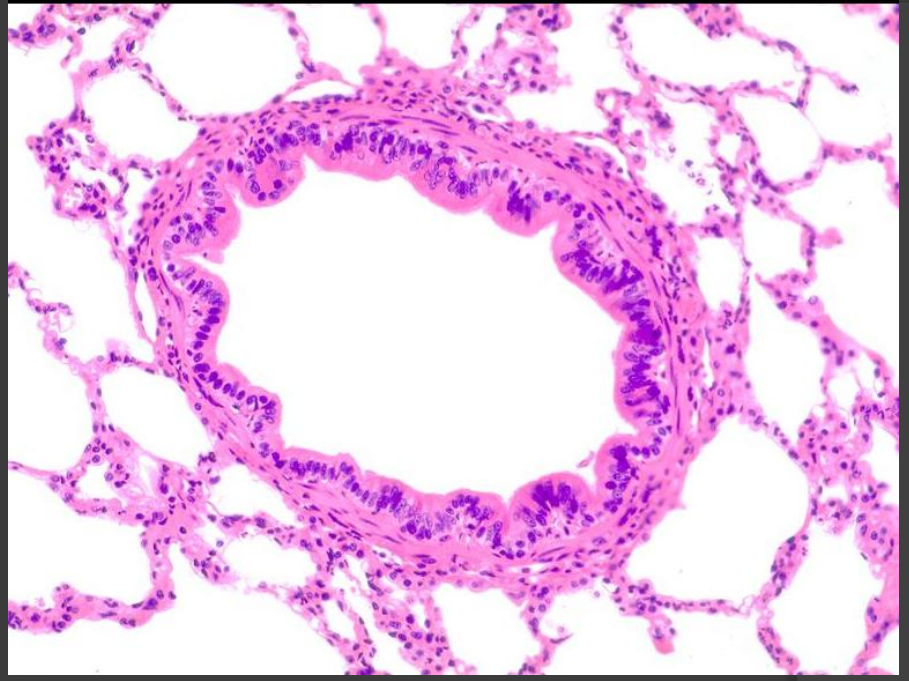
The smallest and the most distal of the conducting system.

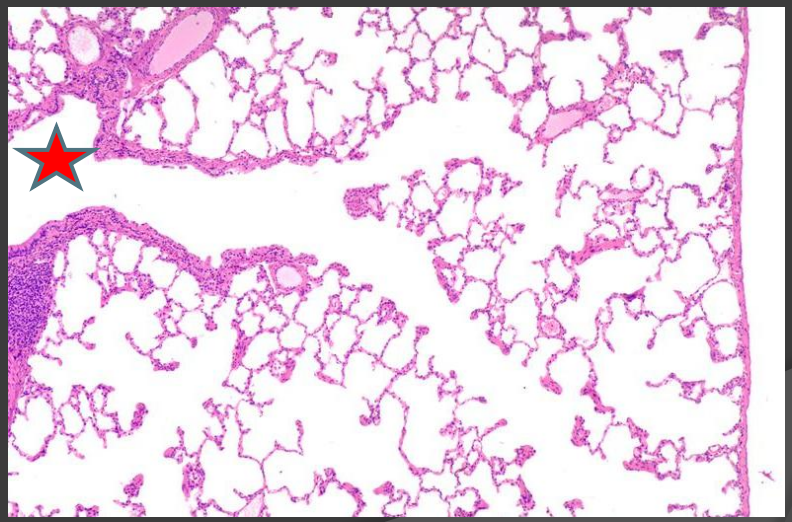
Less than 0.5 mm in diameter.

Epithelium is composed of Clara cells and cuboidal ciliated cells.

Lamina propria is composed is composed of fibroelastic connective tissue surrounded by 1-2 layers of smooth muscles.

NO goblet cells, NO cartilage, No glands in the lamina propria.





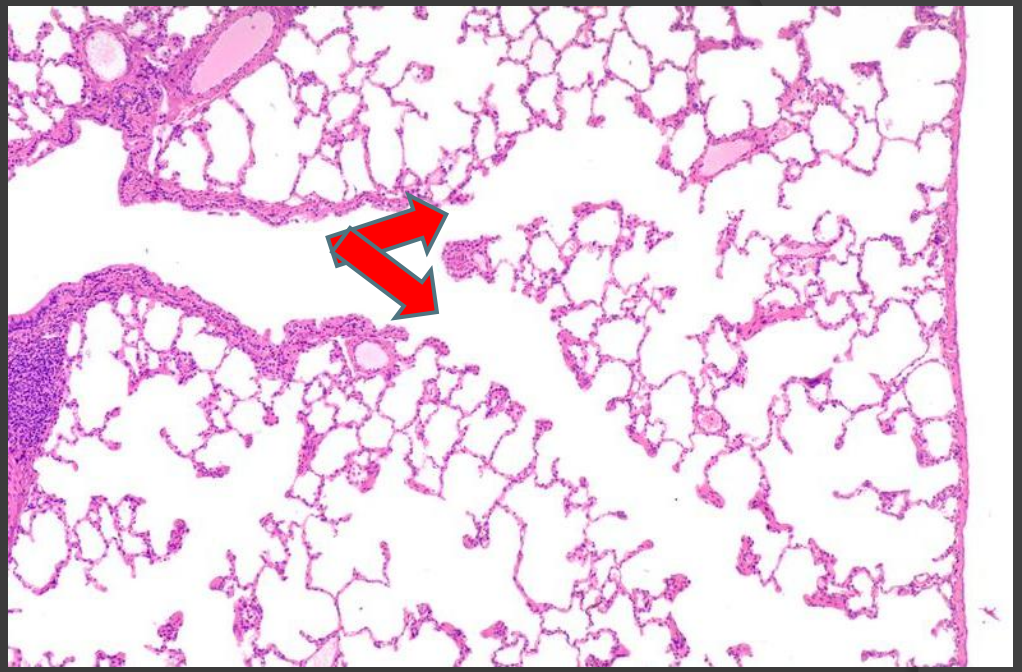
Respiratory Bronchioles

The first region for gaseous exchange.

Their wall is interrupted by alveoli. Transition between conducting and respiratory tissues

Ciliated cuboidal epithelium with Clara cells changes to type 1 alveolar cells

Smooth muscle and elastic fibers underlie epithelium (parasympathetic stimulation: bronchial constriction; sympathetic stimulation: bronchial dilation)

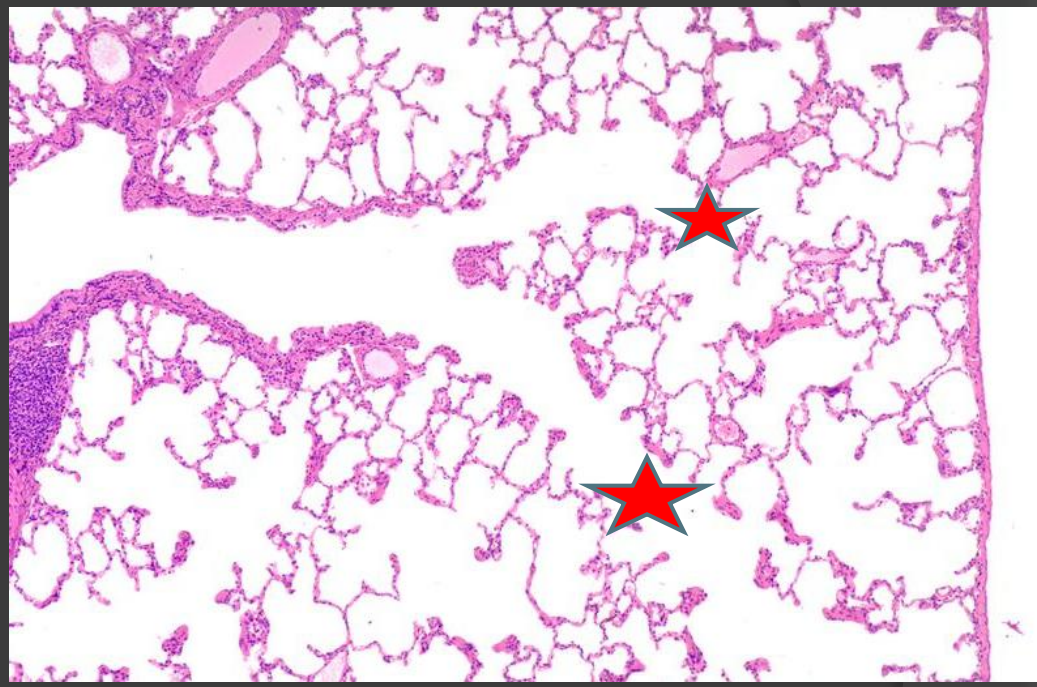


Alveolar Ducts

There is no wall, but alveoli arranged in one line.

Each alveolar duct branches and ends in an alveolar sac.

The beginning of the alveolar sac is known as *atrium*.



Alveoli

The primary histological and functional units of the respiratory system.

Total number of alveoli is ~ 300 million covering ~ 150 m2.

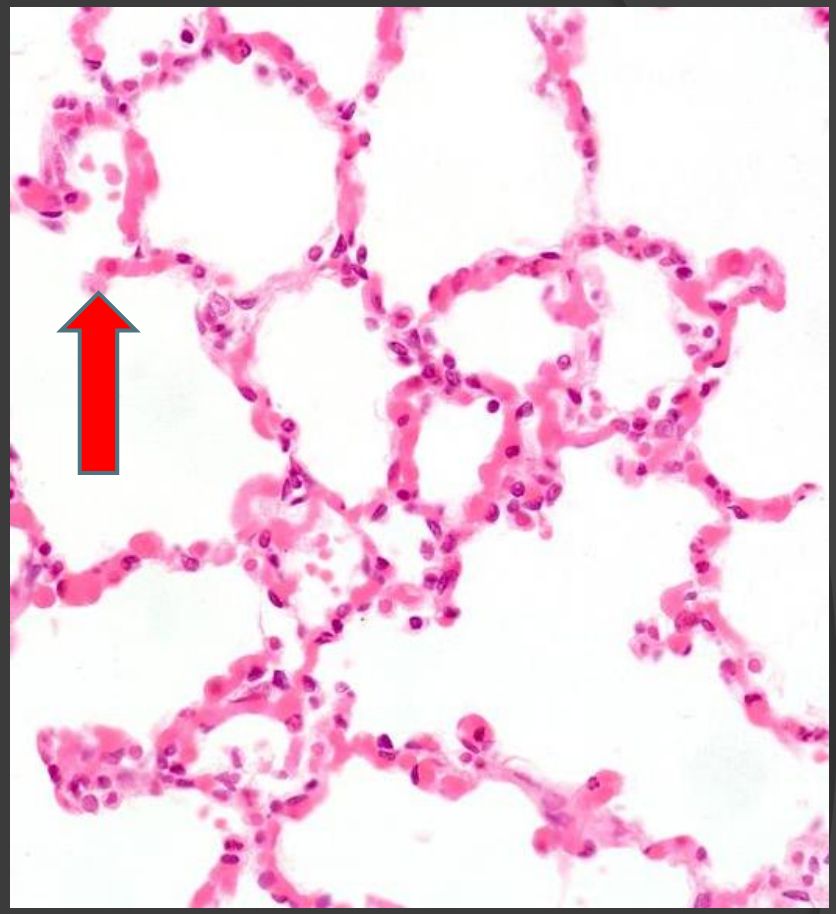
The interalveolar septum

occupies the region between two adjacent alveoli.

Each (face) is lined by alveolar epithelium.

Its thickness is extremely variable.

It contains continuous capillaries, collagen type III, elastic fibres, fibroblasts, mast cells, and lymphocytes.

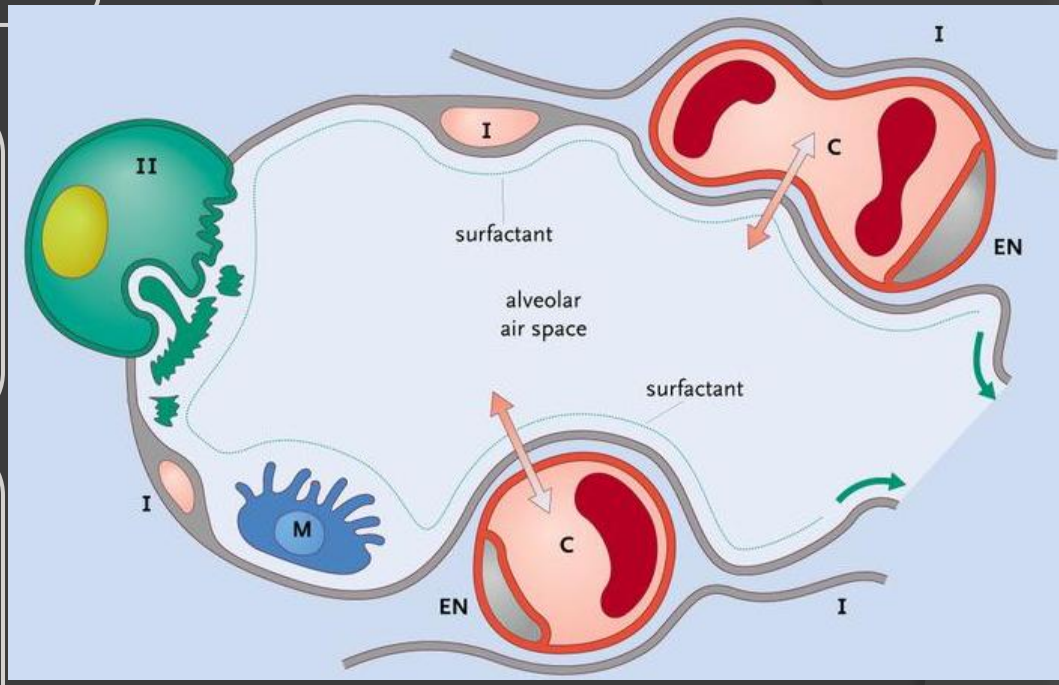


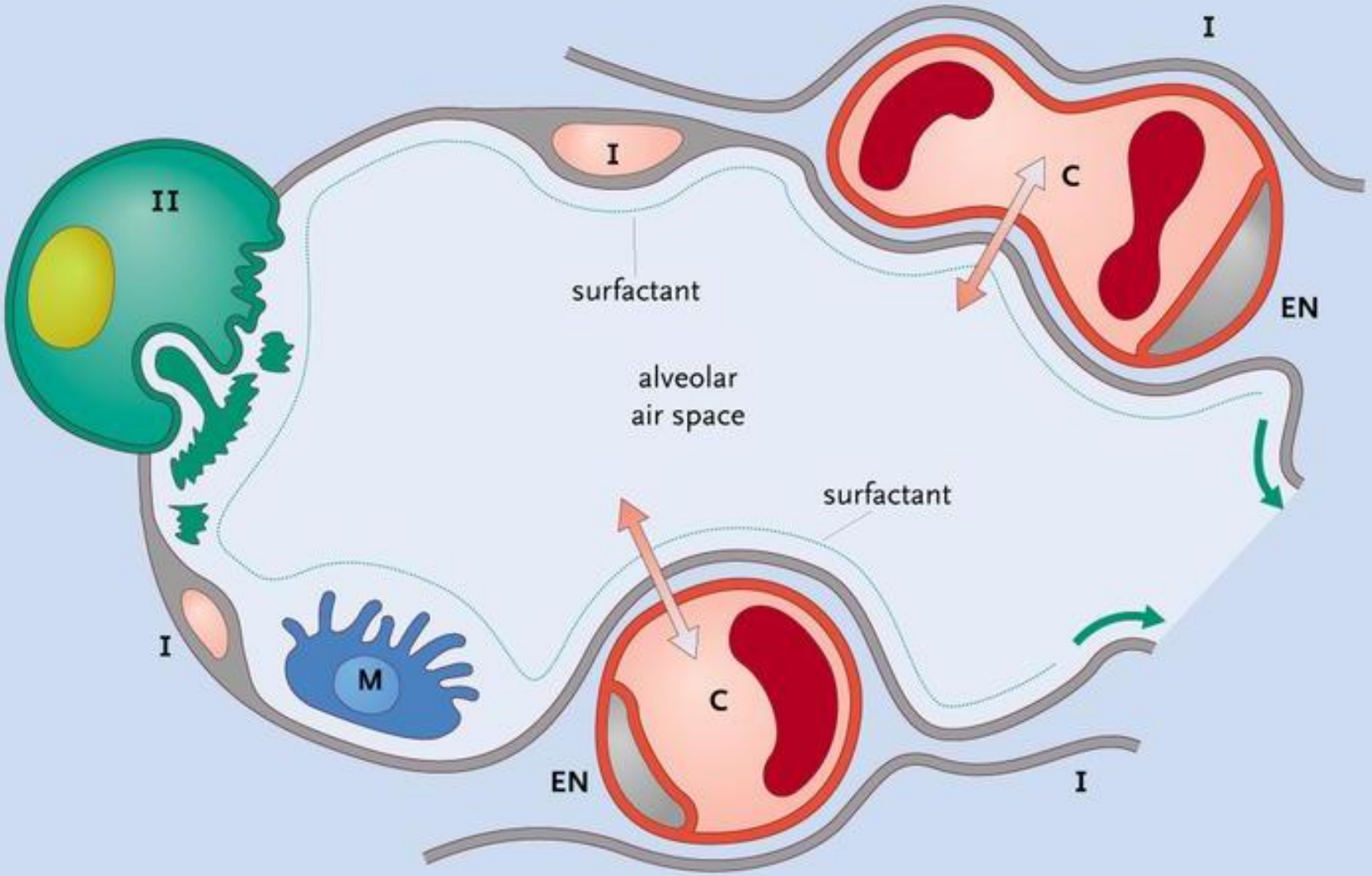
The Blood-Air Barrier (BAB)

It is the region where the interalveolar septum septumis traversed by respiratory gases.

It is composed of:

- Surfactant
- Type I pneumocytes
- Fused basal lamina
- Endothelium.




I
II
I
C
surfactant
EN
alveolar
air space
surfactant
I
M
C
EN
I