

# The Respiratory System

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# Objectives (lecture + practical)

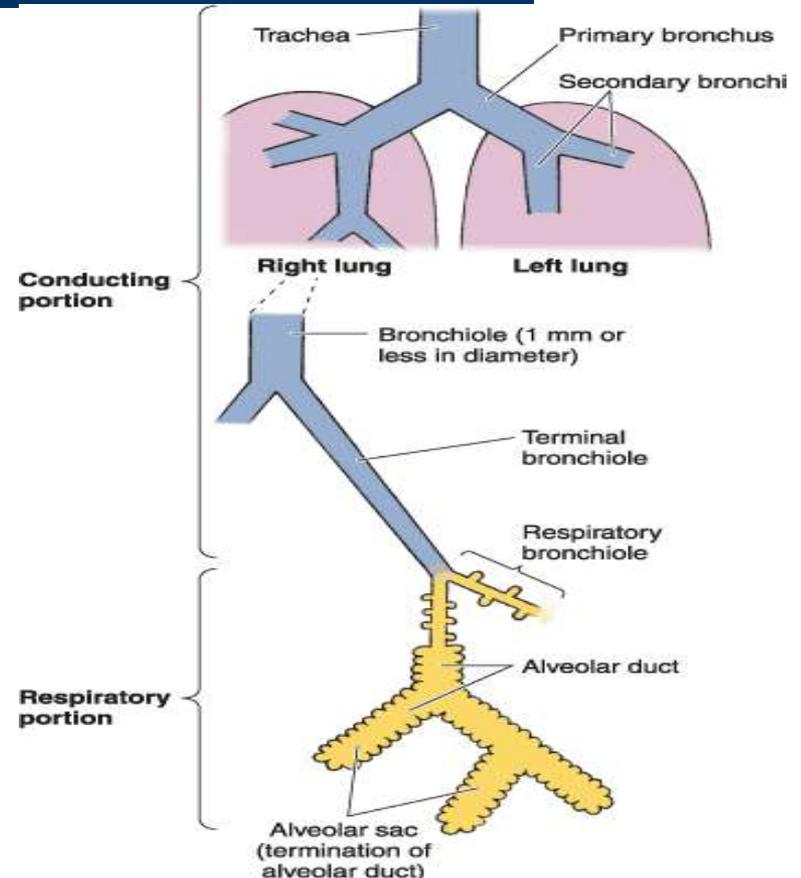
- 1. Identify the conduction part of the respiratory tract and analyze the function of each segment
- 2. Identify the transitional area separating the conduction from the respiratory part
- 3. Comment on the fine structures and function of the pulmonary alveoli and the blood-air barrier

# Objectives (lecture + practical)

- 4. Describe the various units of the lung as seen by the surgeon, the histologist or the physiologist.
- 5. Solve the clinical problems
- E.g: Effect of smoking ?

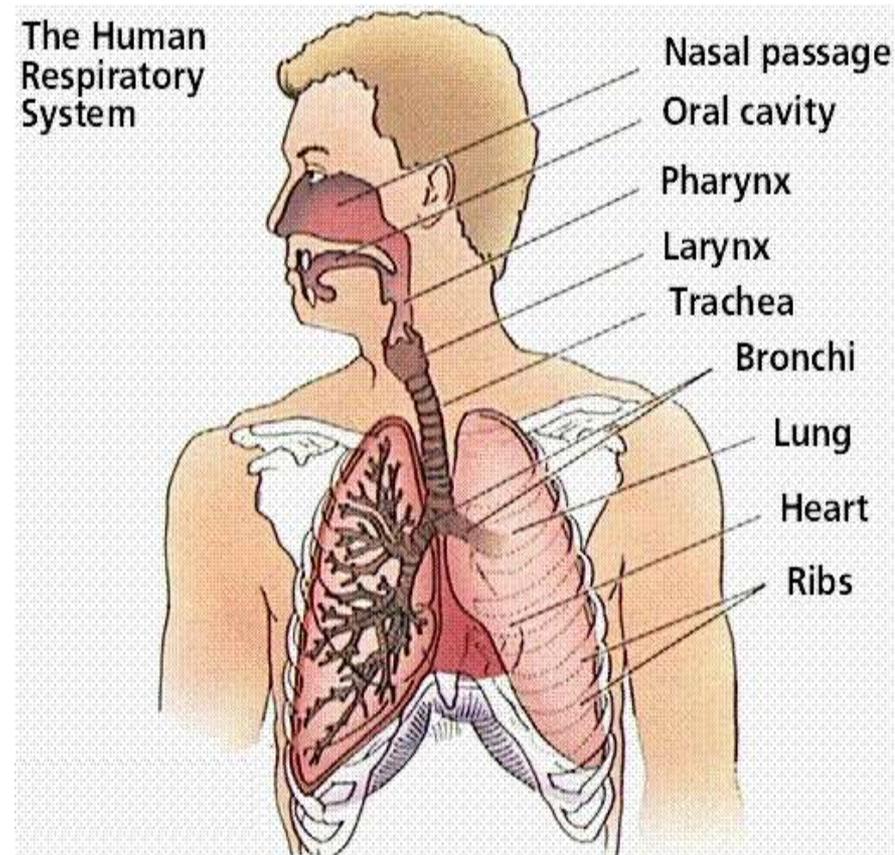
# The Respiratory System

- **Conducting portion:**
  - Provides passage of air
  - No gaseous exchange occur through it
- 
- **Respiratory portion :**
  - Where gas exchange takes place

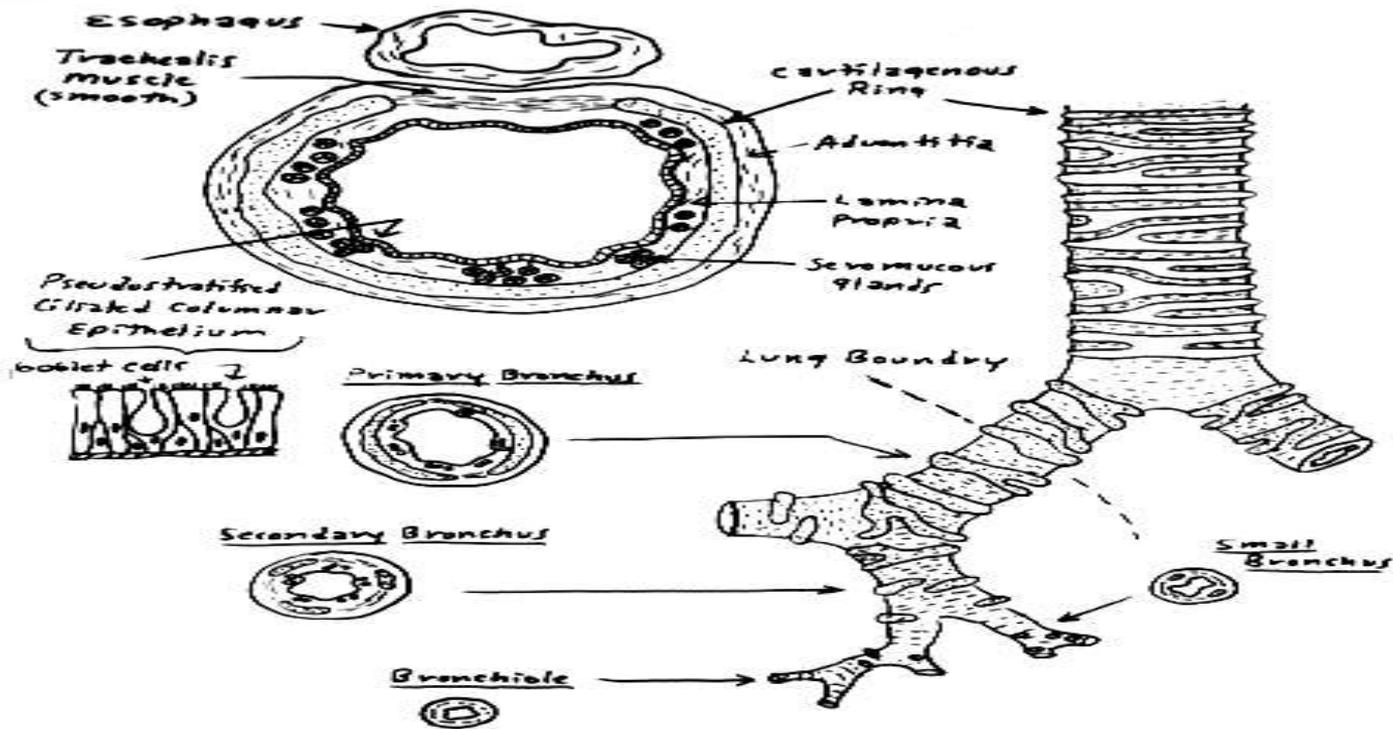


# Conducting portion

- **Nose**
- **Nasopharyngeal cavity**
- **Larynx**
- **Trachea**
- **Bronchi:**  
(1ry,2ndry,3ry)
- **Large Bronchioles**
- **Terminal bronchioles**



# Conducting portion

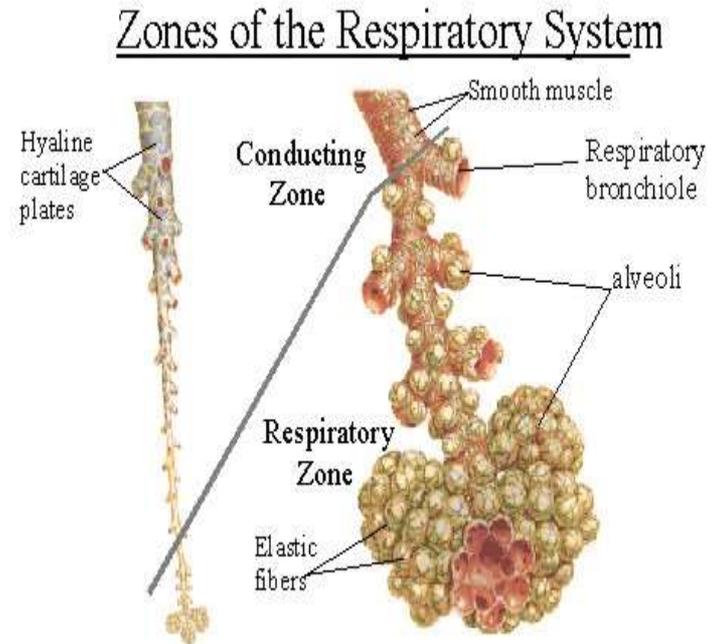


# Conducting portion

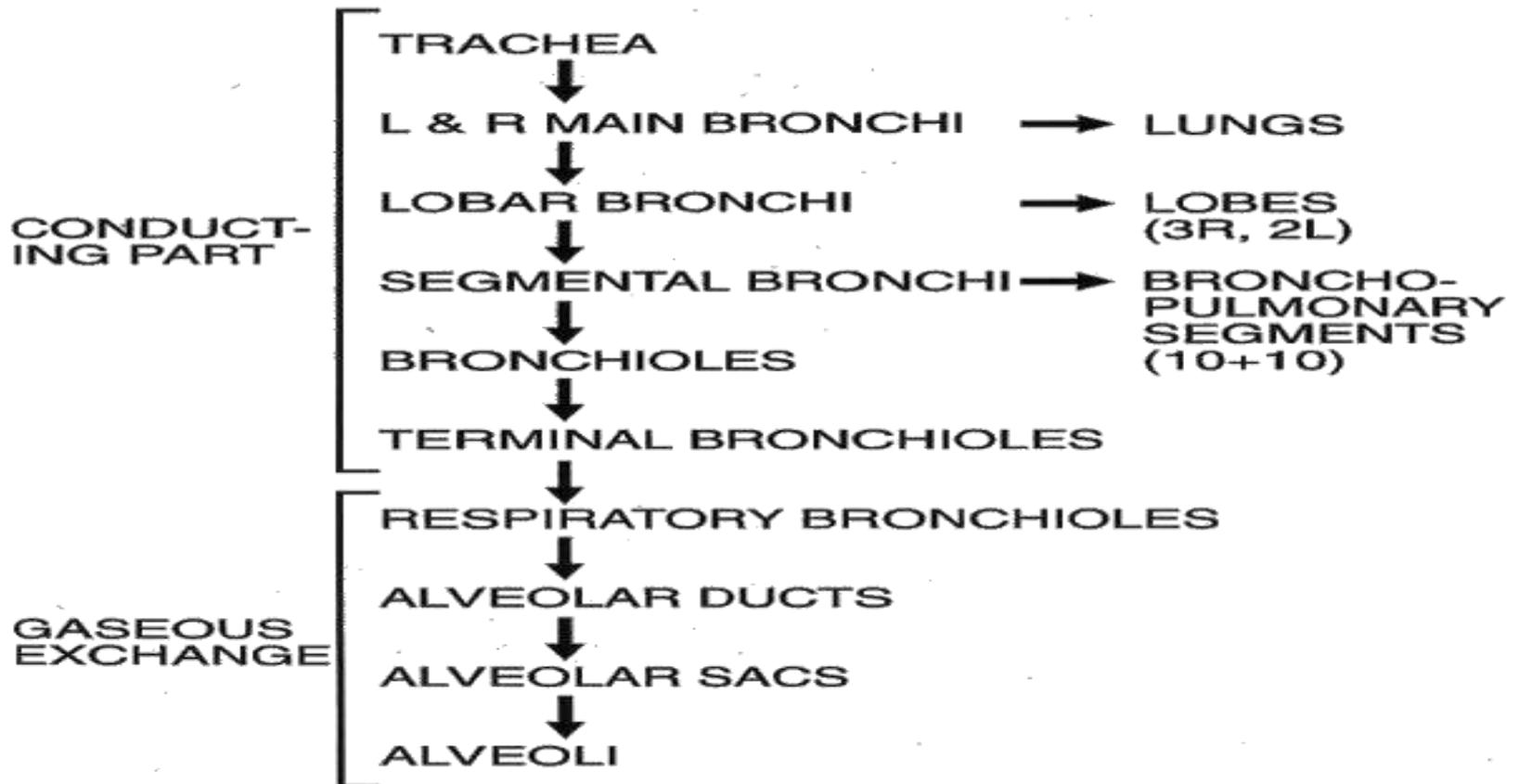
- Major function of the conducting portion is to condition the inspired air
- Before it enters the lungs, inspired air is **cleansed, moistened, and warmed**
- Mucosa of the conducting portion is lined with a specialized **respiratory epithelium**
- Numerous mucous and serous glands as well as a rich superficial vascular network in the lamina propria.

# Respiratory portion

- Consisting of :
- **Respiratory bronchioles** (region of transition)
- **Alveolar ducts**
- **Alveolar sacs**
- **Alveoli** : main sites for the principal function of the lungs
- the exchange of  $O_2$  and  $CO_2$  between inspired air and blood.

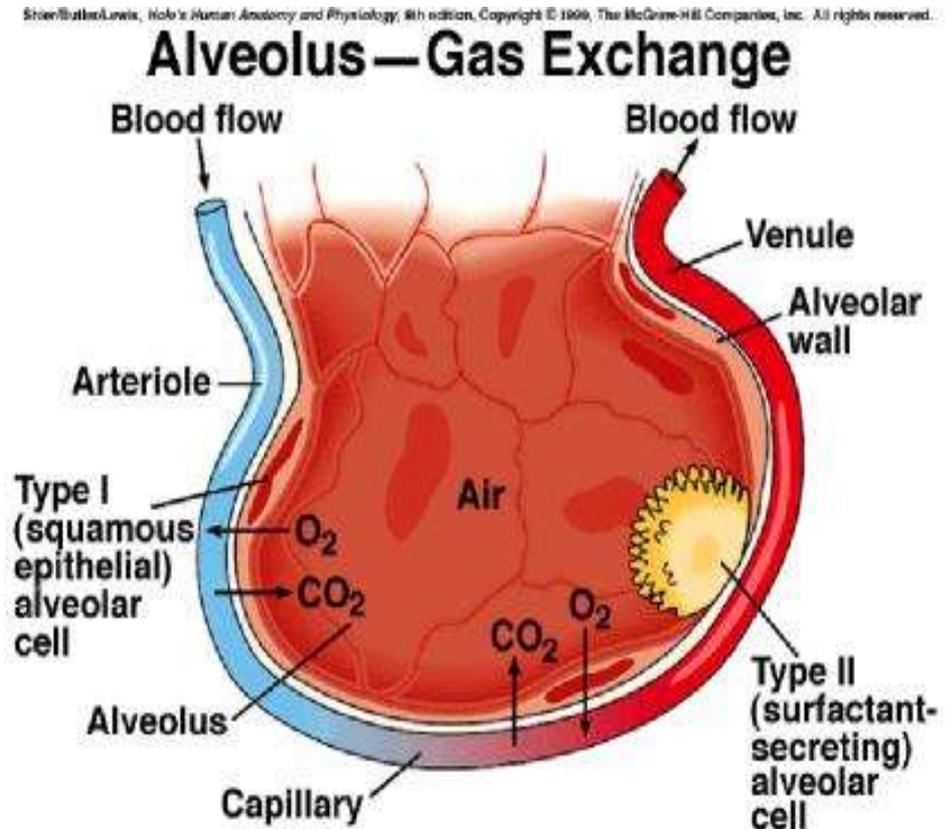


# Respiratory tract



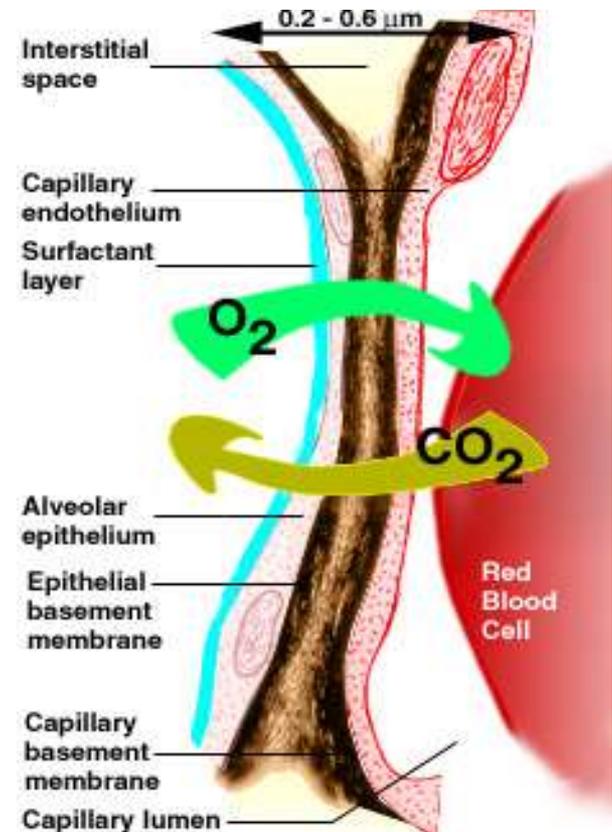
# Gas exchange

- The exchange of gases (O<sub>2</sub> & CO<sub>2</sub>) between the alveoli & the blood occurs by passive diffusion
- When blood first arrives at the pulmonary capillary at its arteriole end, the partial pressures of carbon dioxide and oxygen are:  
PCO<sub>2</sub> = 45 mm Hg  
PO<sub>2</sub> = 40 mm Hg



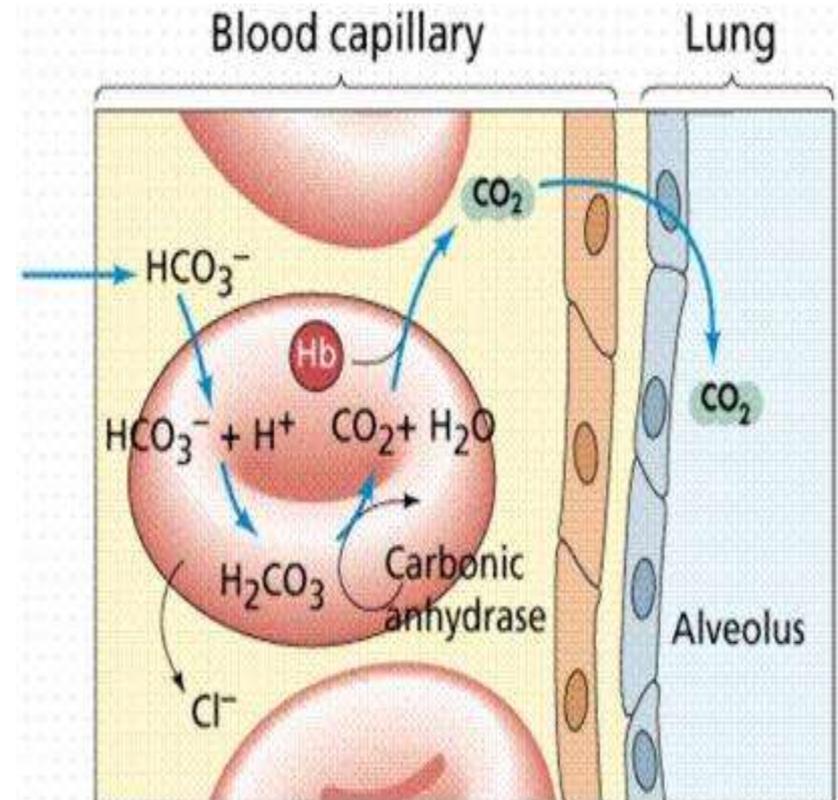
# Gas exchange

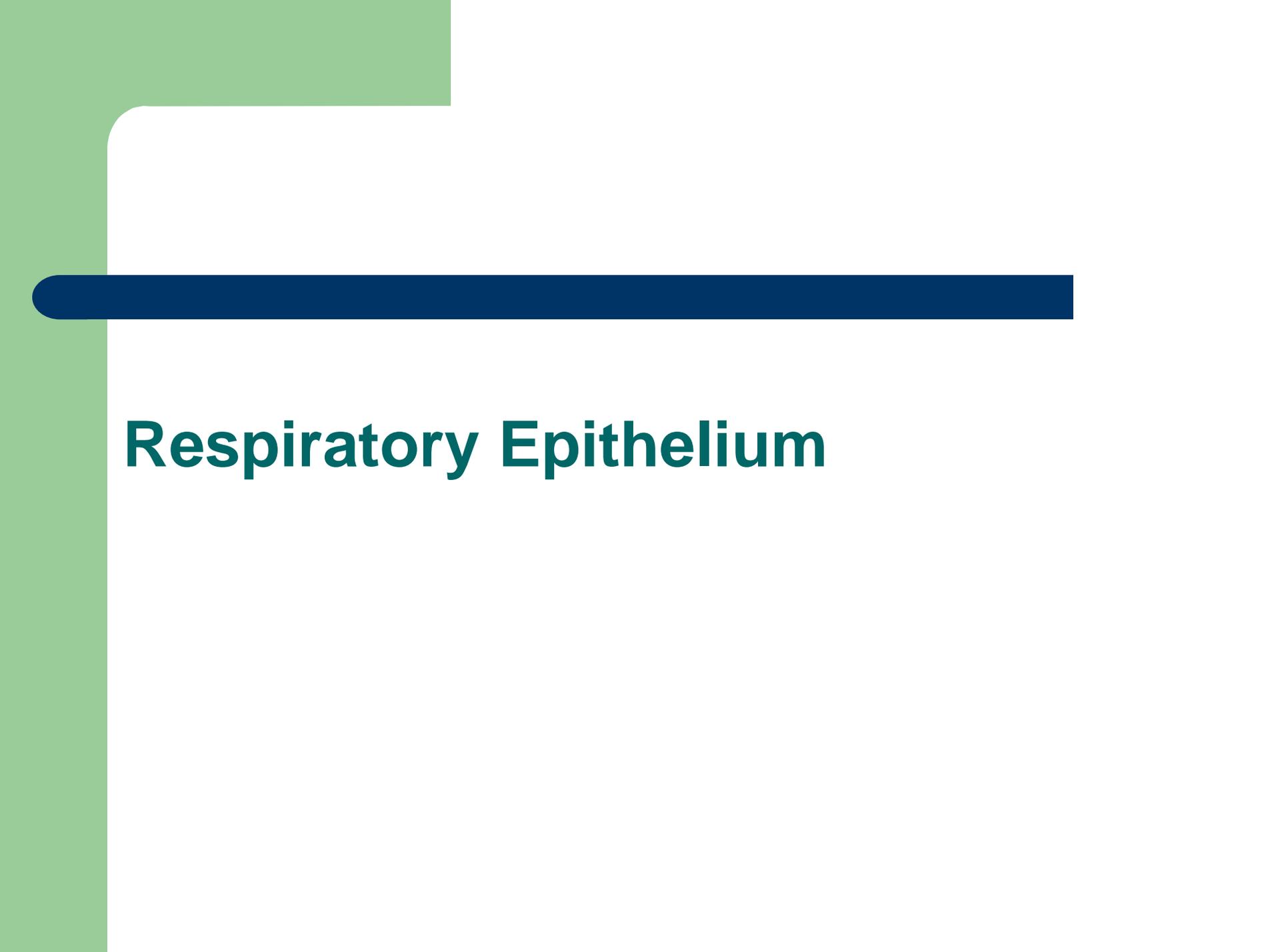
- In the alveoli
- $PO_2 = 105$  mmHg
- $PCO_2 = 45$  mmHg
- $O_2$  is taken up by RBCs and  $CO_2$  is released due to difference in pressure
- After the net diffusion of oxygen  $PO_2$  in the venous end equals **95mmHG**
- Oxygen is then taken by tissue cells for metabolic activity (tissue  $PO_2 = 40$  mmHg)



# Carbon-dioxide in the blood

- 7% dissolved in plasma
- 23% combine with hemoglobin to form **carbaminohemoglobin**
- 70% converted to protons by **carbonic anhydrase** and combines to hemoglobin (reversible reaction)

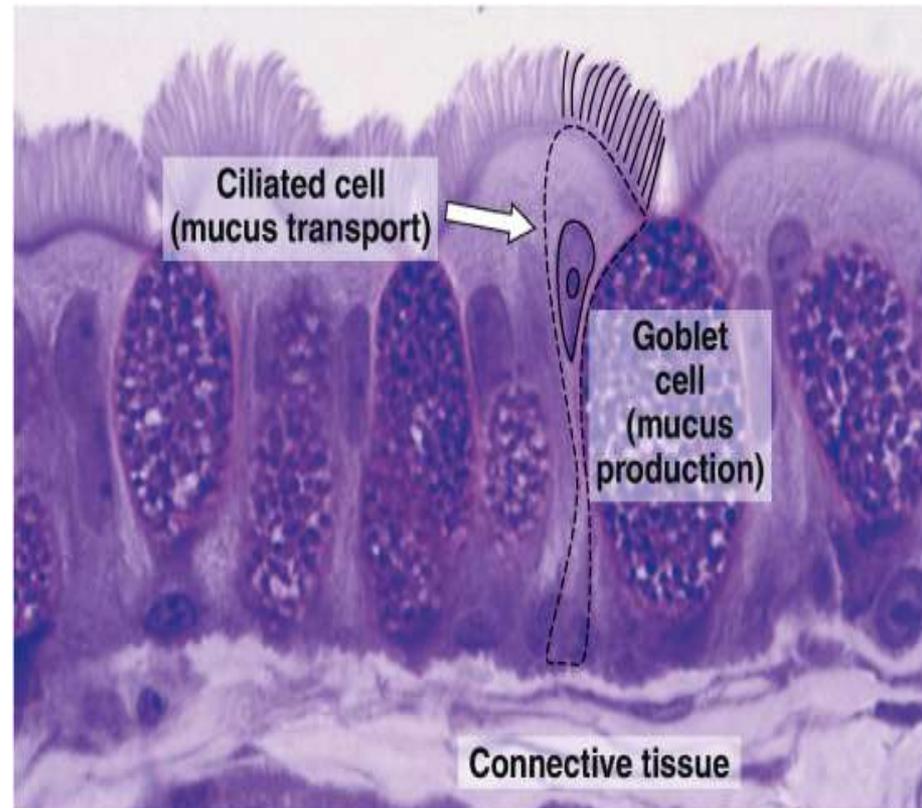




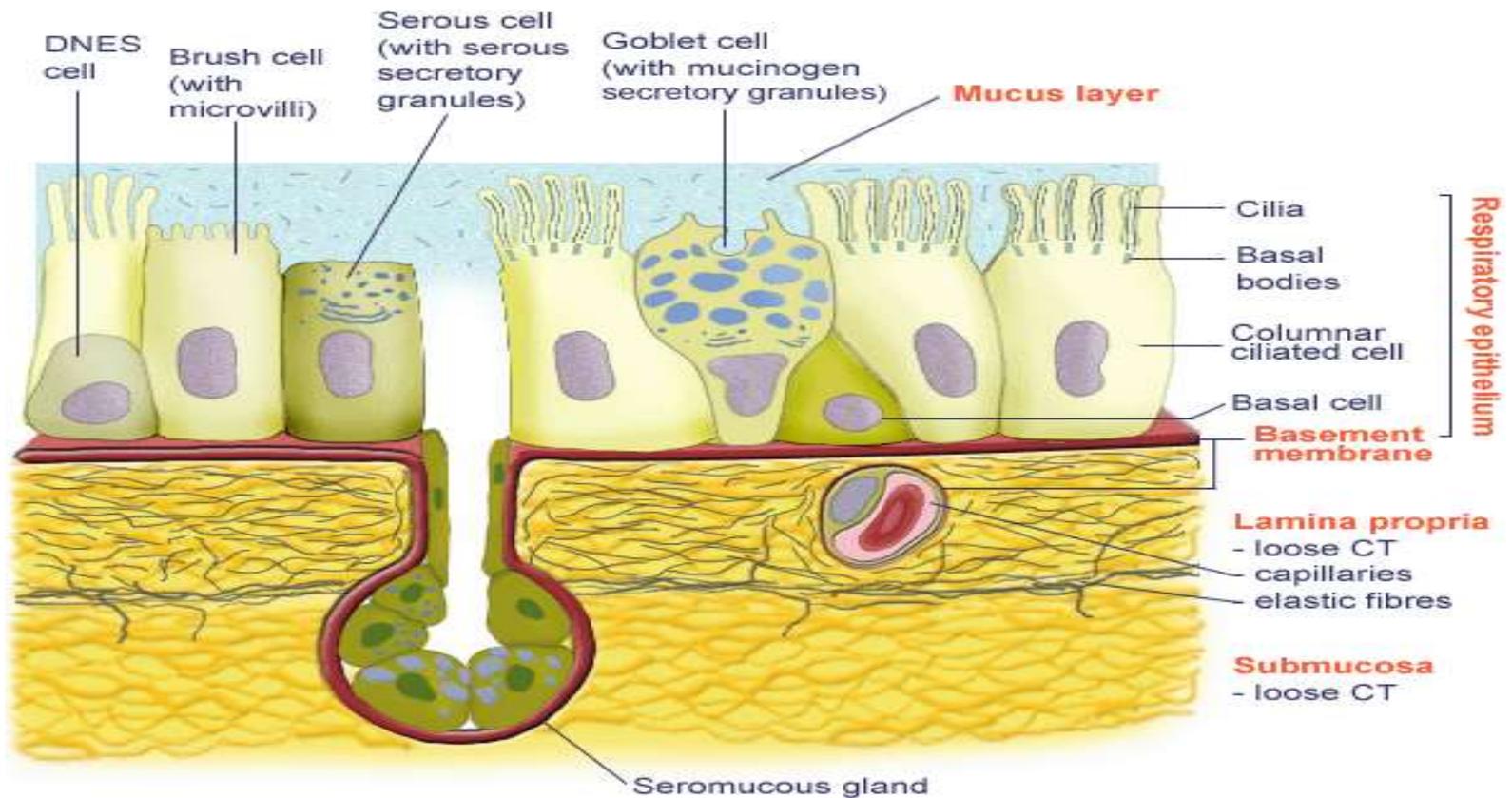
# Respiratory Epithelium

# Respiratory Epithelium

- Lined with ciliated **pseudostratified columnar epithelium**
- Contains 5 types of cells
- All of them resting on basement membrane
- but not all of them reach the surface

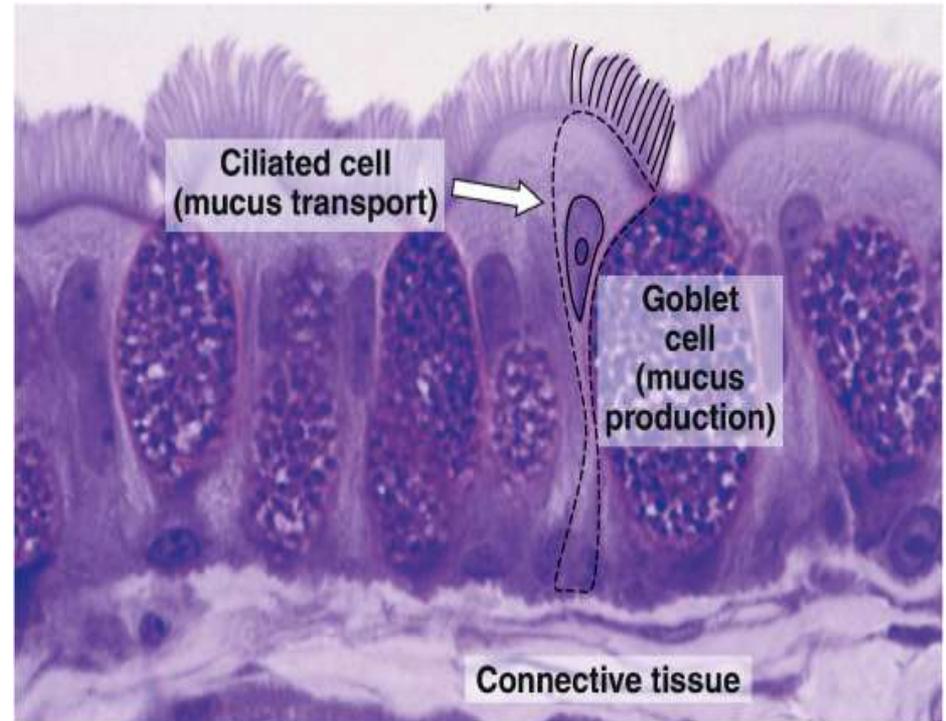


# Respiratory epithelium cells



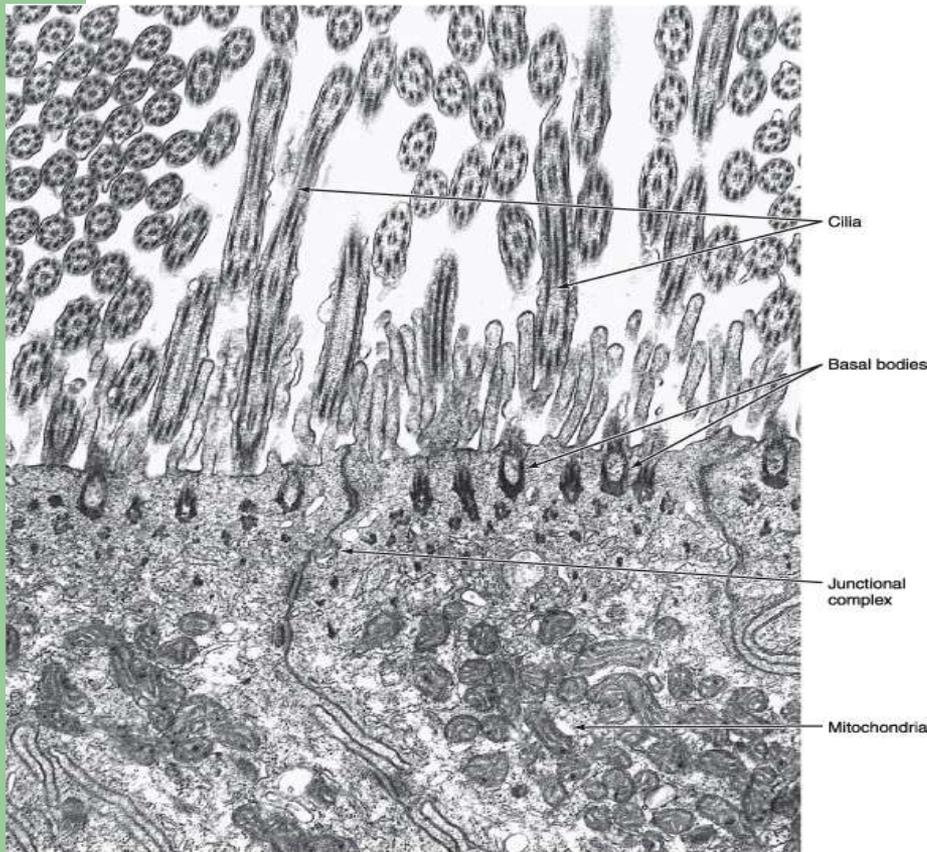
# Ciliated columnar cells

- Most abundant type
- Each cell has about 300 cilia on its apical surface



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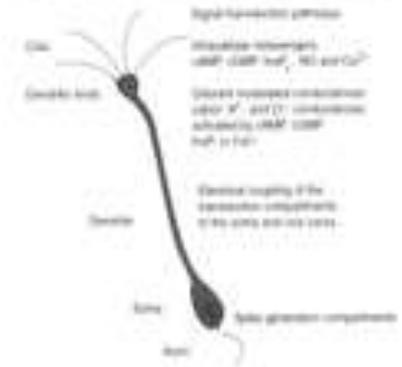
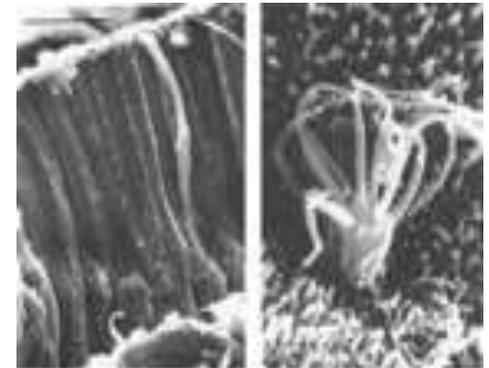
# Ciliated columnar cells



- **Basal bodies:**
- Where cilia is inserted in the apical part of the cell
- **Apical mitochondria**
- supply adenosine triphosphate (ATP) for ciliary beating.

# Ciliary movements

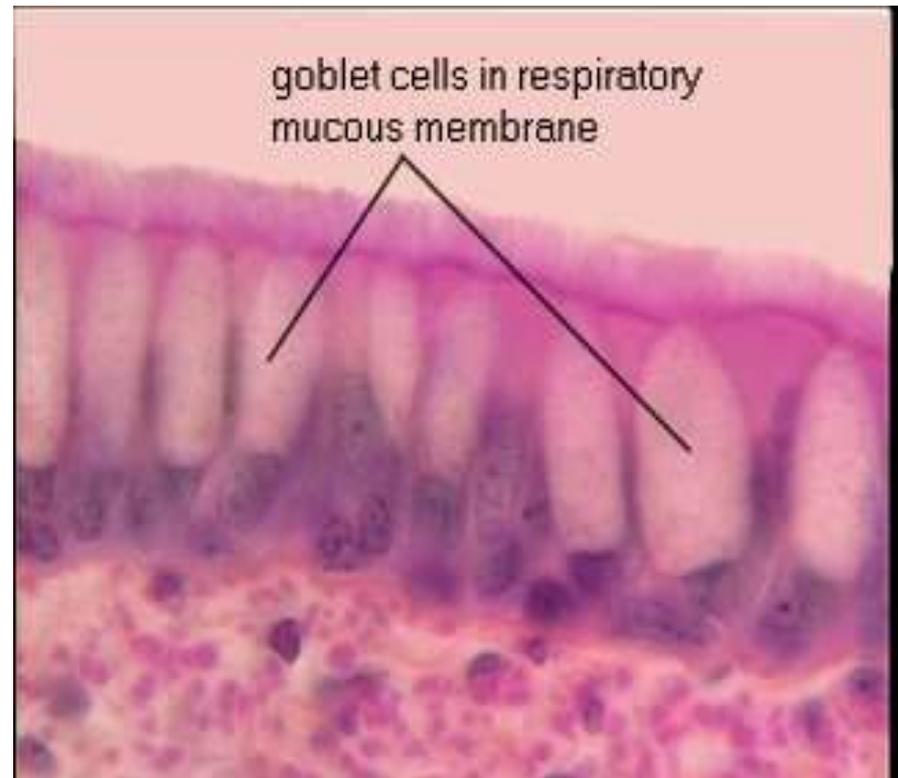
- **Dynein**, a protein normally participates in the ciliary movement
- **Nicotin** prevents formation of dynein, which leads to improper movement of cilia.
- **Immotile cilia syndrome (Kartagener syndrome)**
  - caused by immobility of cilia and flagella
  - induced, in some cases, by deficiency of **dynein**
  - causes infertility in men and chronic respiratory tract infections in both sexes



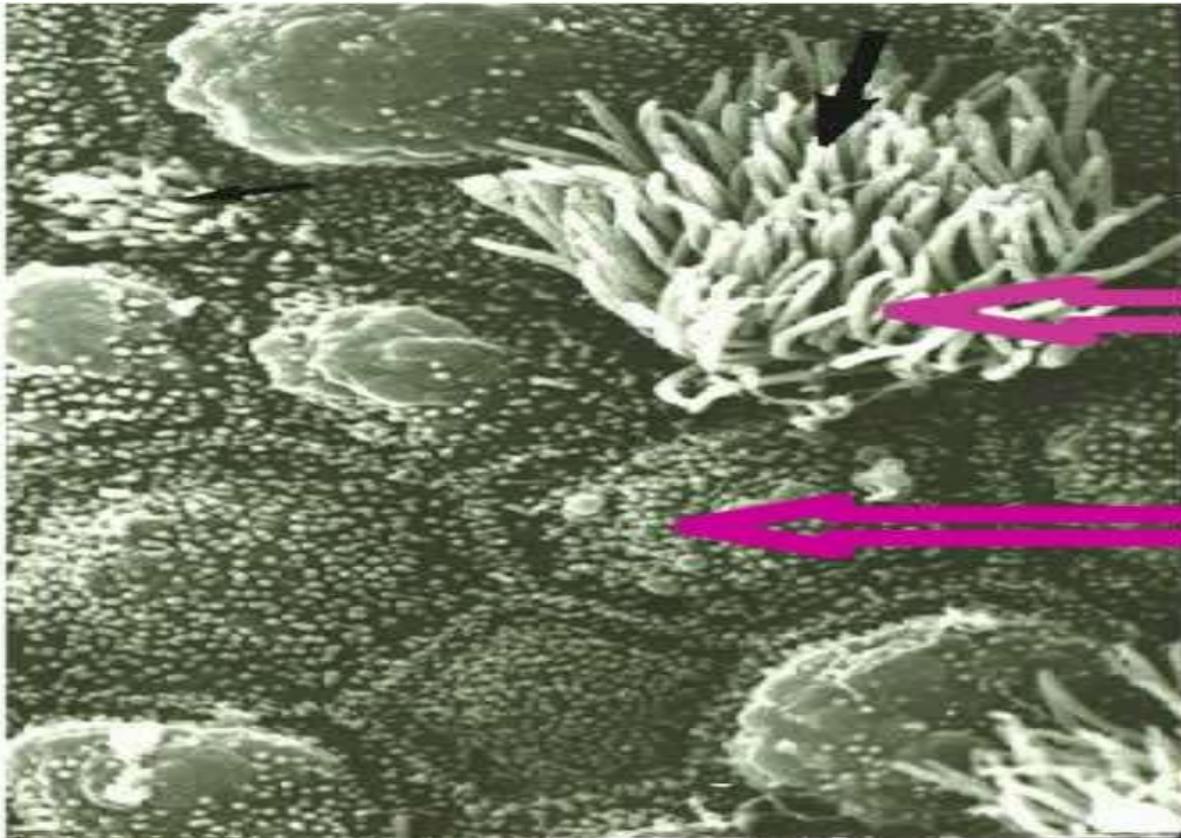
# Mucous goblet cells

Apical mucous droplets

Composed of **glycoproteins** and contains **polysaccharides.**



# Respiratory epithelium

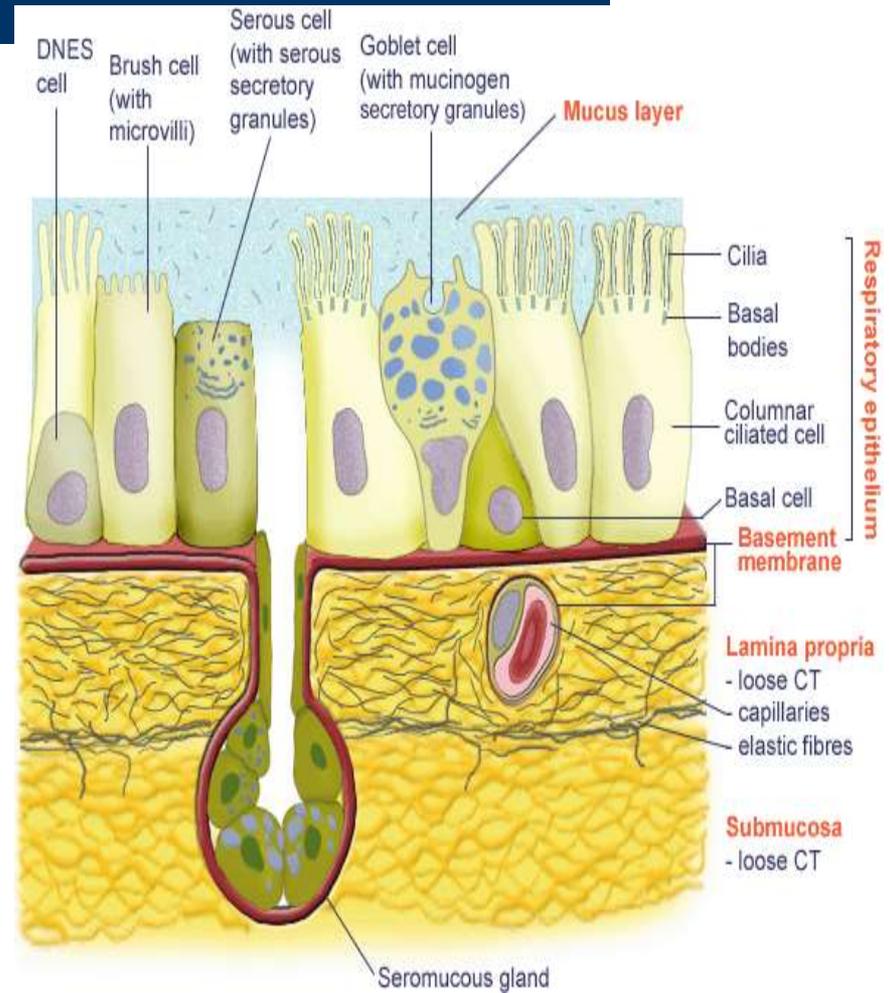


**Cilia,  
seen  
from  
within  
the  
airway**

**Goblet  
cells  
produce  
mucus**

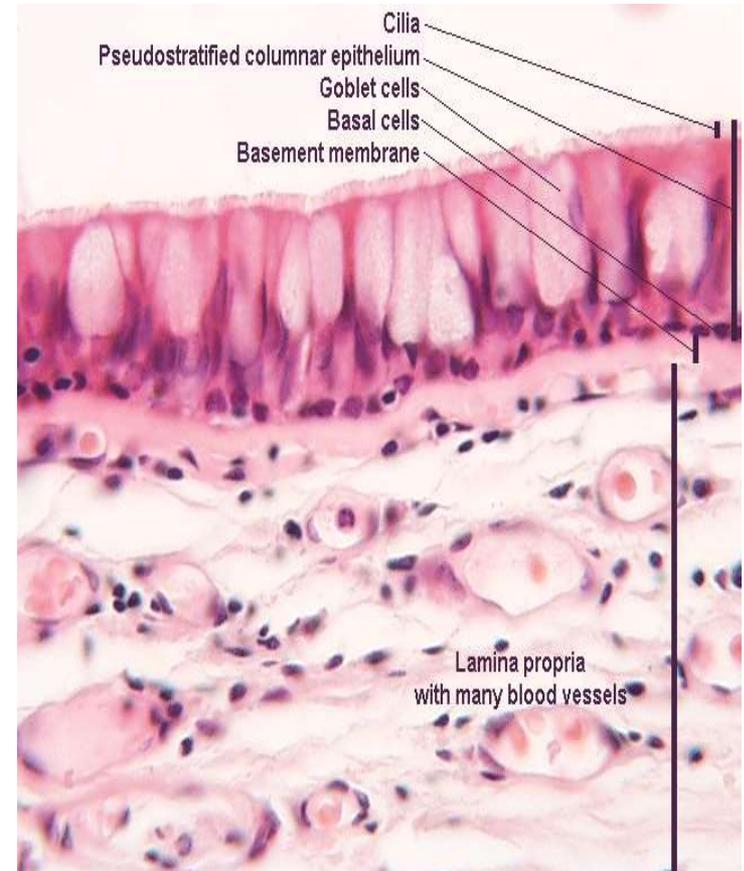
# Brush cells

- Numerous microvilli on their apical surface
- Sensory receptors (afferent nerve endings on their basal surfaces)



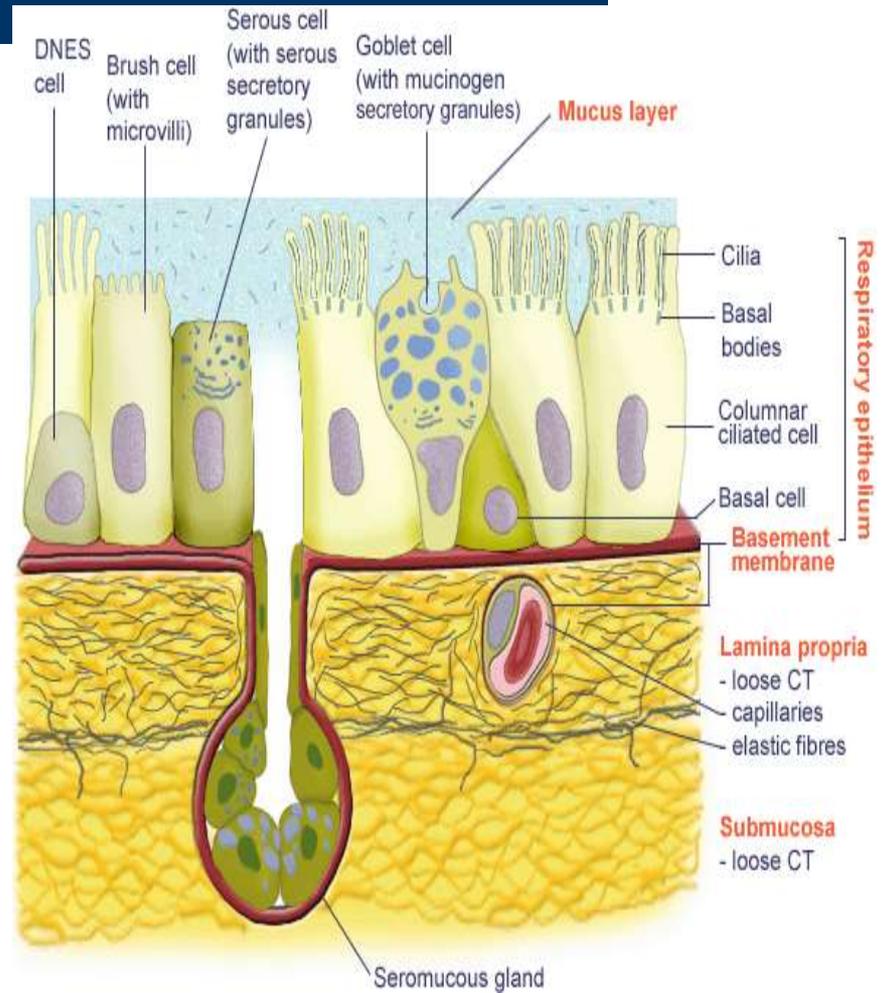
# Basal (short) cells

- Small rounded cells
- Believed to be generative stem cells
- Differentiate into the other cell types (**reserve cells**)



# Small granule cell

- Cells of the **DNES** (diffuse neuroendocrine system)
- Regulates locally the excretions or secretions of mucous and serous glands in the respiratory tract
- Also called **Kulchitsky Cells**



# Layers of the respiratory tube

- 1. **Mucosa** :
  - a. ***epithelium*** resting on a basement membrane and goblet cells
  - b. ***lamina propria***
  - c. ***muscularis mucosa*** (smooth muscle)
- 2. **Submucosa**: that houses mucous and seromucous glands

# Layers of the respiratory tube

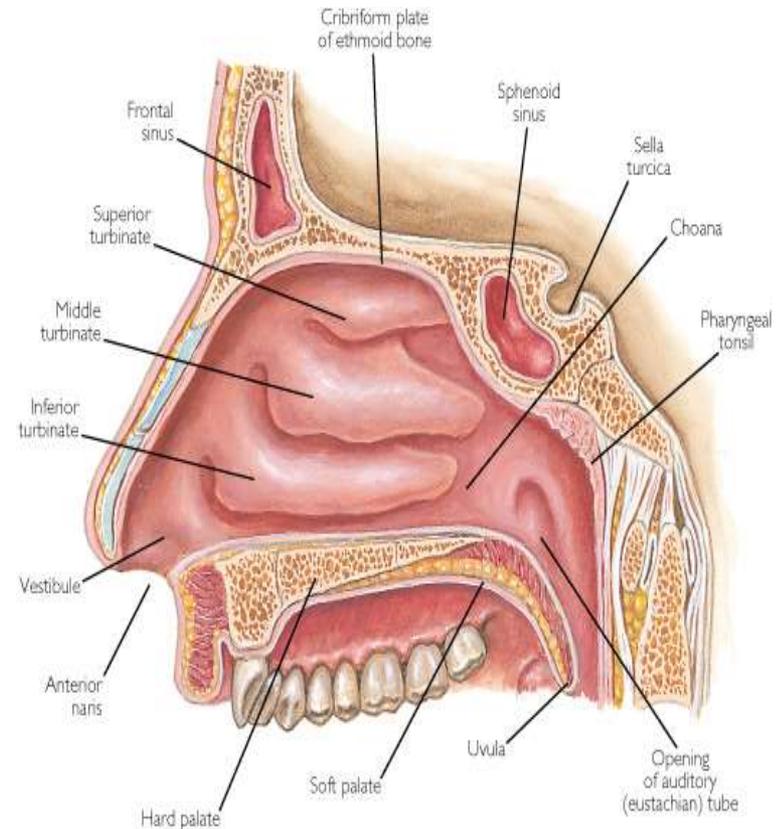
- **3. Supportive layer:**  
*smooth muscle and cartilage*
  
- 4. Adventitia:**  
connective tissue coverings.

# Nasal Cavity



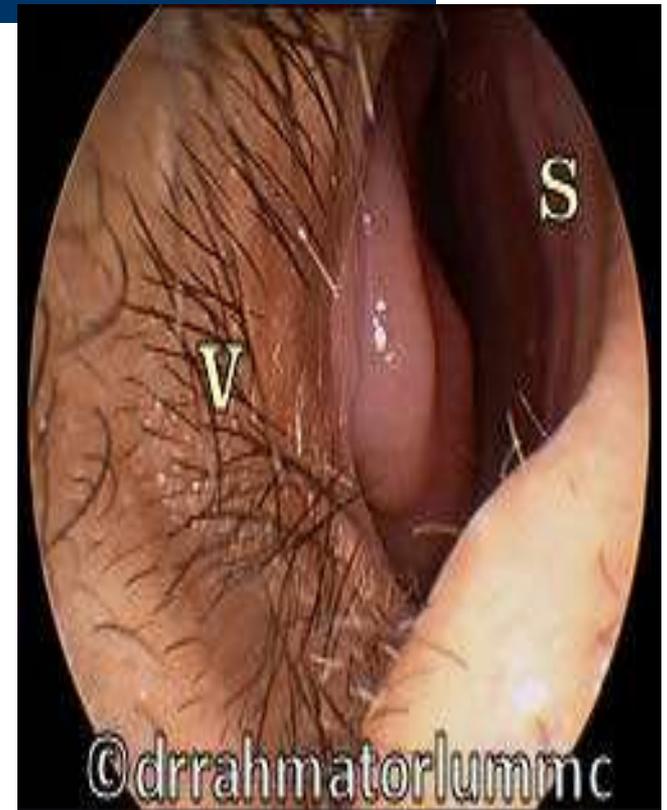
# Nasal Cavity

- Subdivided into
- The **vestibule**
- The **respiratory area**
- **Olfactory region**



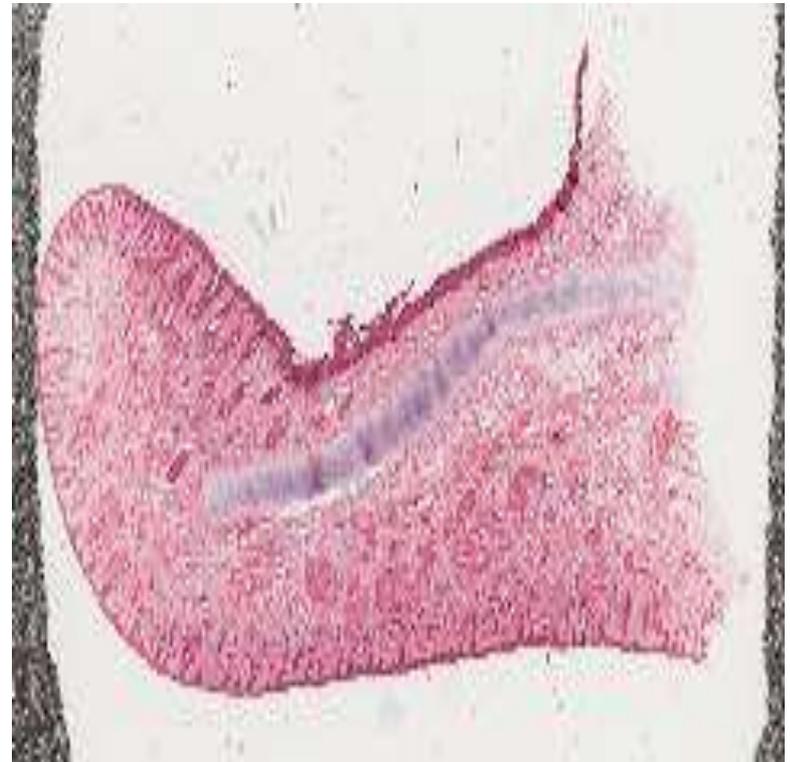
# The vestibule

- Most anterior and dilated portion of the nasal cavity
- Lined by skin
- Contains sebaceous and sweat gland
- Thick short hairs, or **vibrissae**
- Trap and filters out large particles from the inspired air



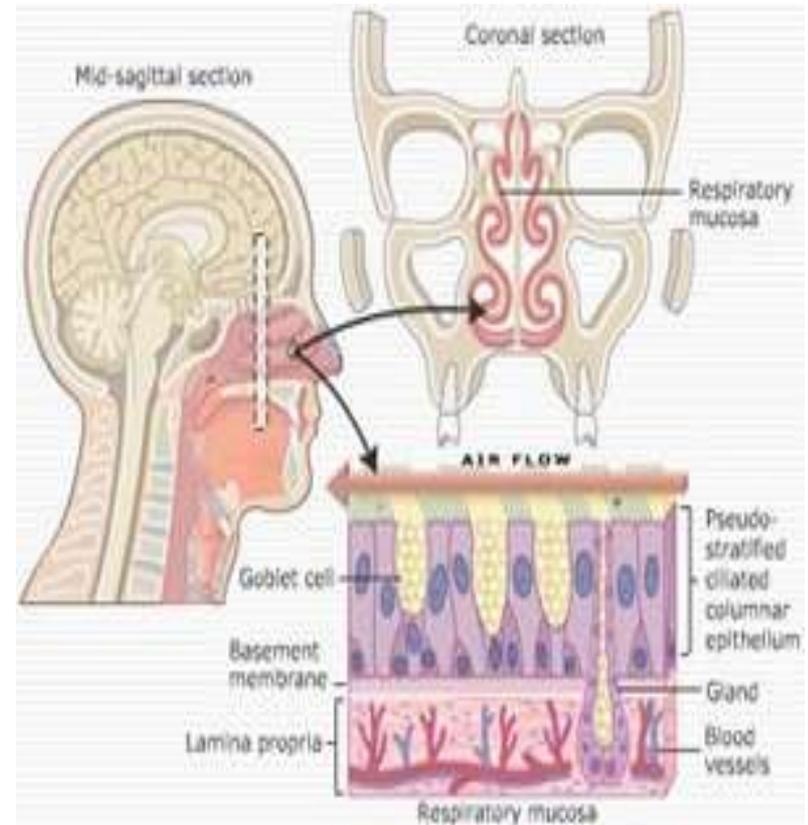
# The vestibule

- Epithelium loses its keratinized nature and undergoes a **transition** into typical respiratory epithelium **before** entering the nasal fossae



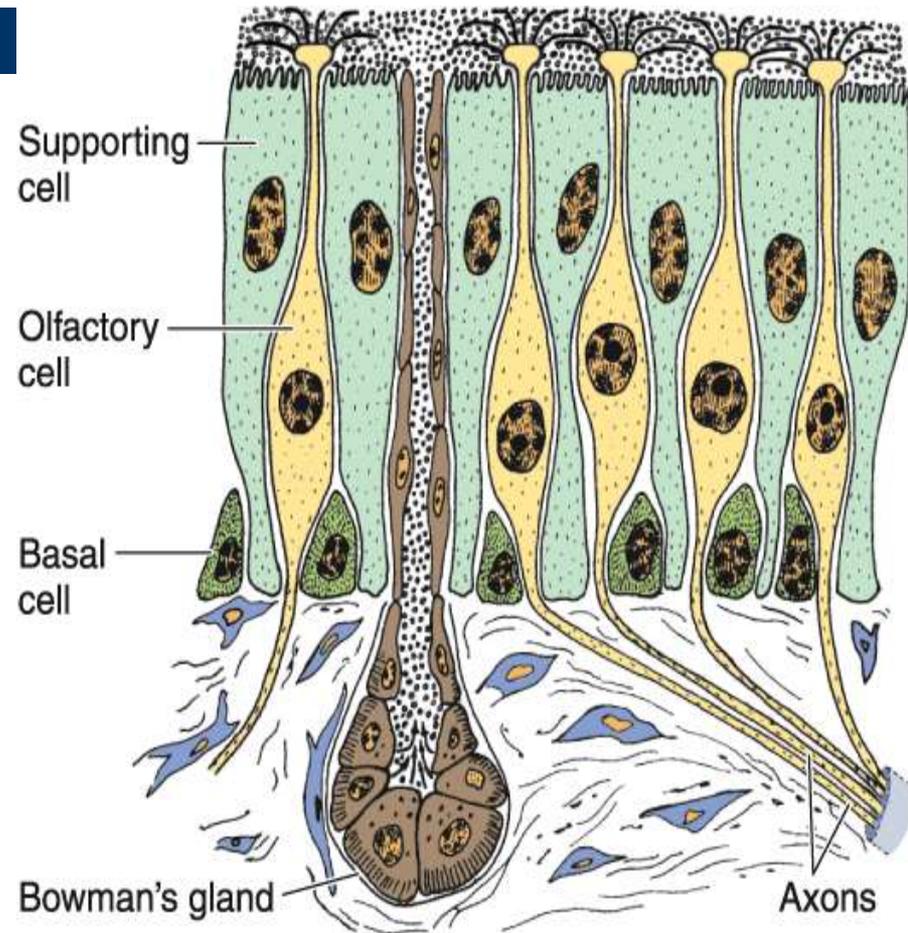
# The respiratory area

- Covered with pseudo-stratified columnar and goblet cells
- The sub. Epithelial connective tissue is rich with blood vessels and seromucous glands.



# Olfactory region

- Present in the roof and upper parts of the nasal cavity
- Covered by **olfactory mucosa**
- Which contains:
- **Olfactory epithelium**
- **Corium (lamina propria)**
- **Bowmans gland**



# Olfactory epithelium

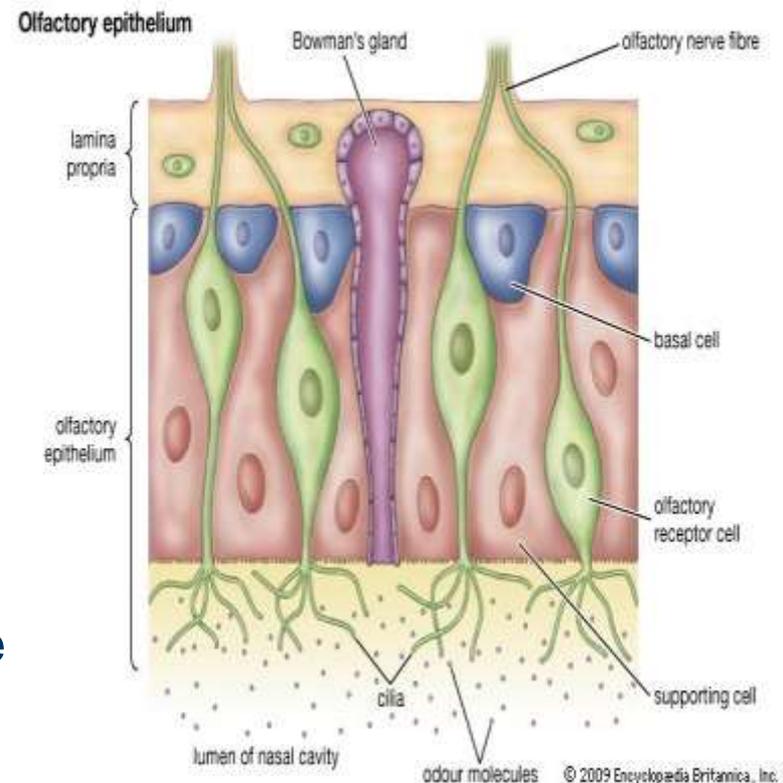
- It is a pseudostratified columnar epithelium composed of three types of cells:

## 1. supporting (sustinacular) columnar cells

- broad, cylindrical apexes and narrower bases
- microvilli submerged in a fluid layer
- contain a light yellow pigment

## 2. basal cells : single layer at the base of the epithelium

- spherical or cone shaped

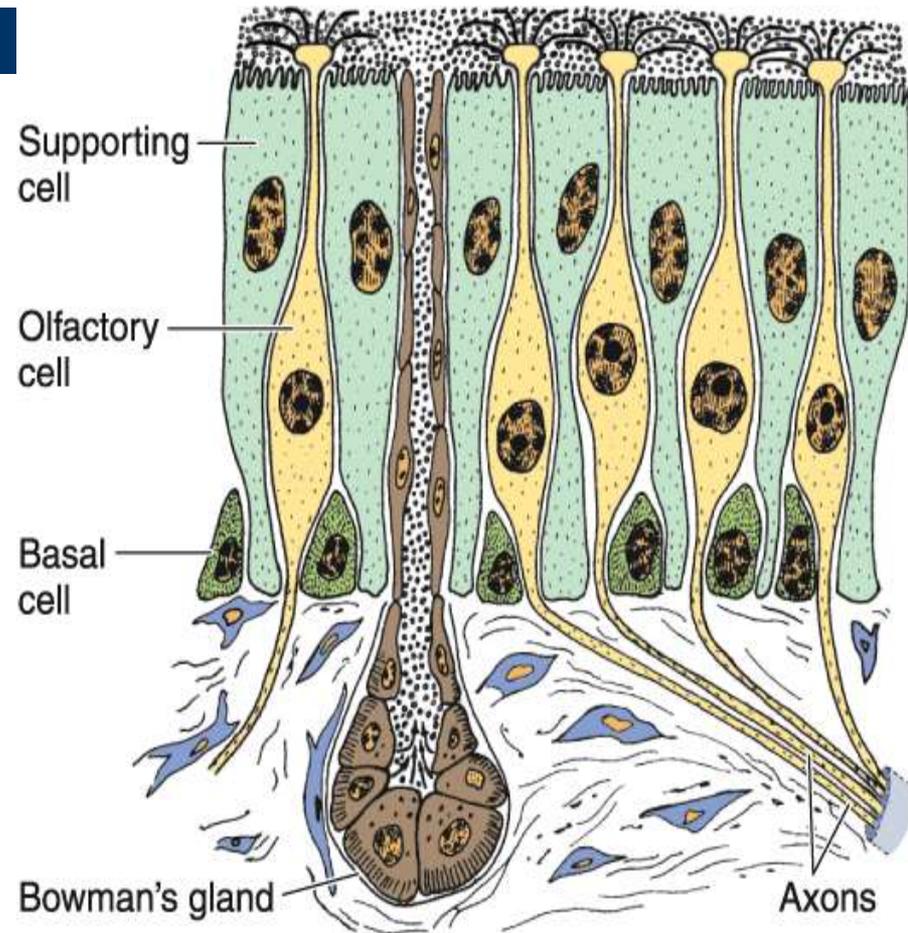


# Olfactory epithelium

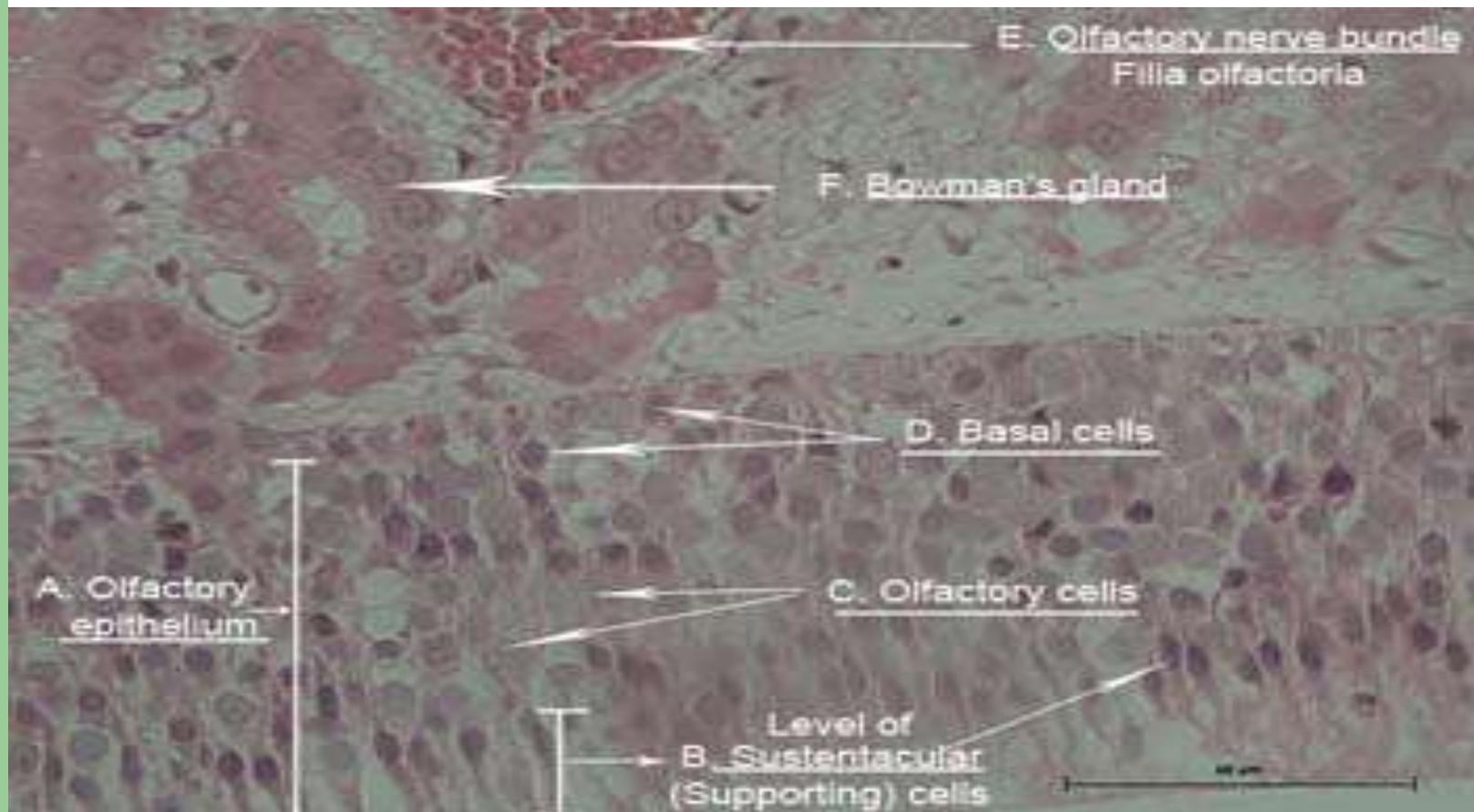
## 3. olfactory cells:

bipolar neurons

- Their nuclei lie below the nuclei of the supporting cells
- Cilia (nonmotile) rise from their apices (dendrites)
- Respond to odoriferous substances by generating a receptor potential
- Afferent axons of these bipolar neurons unite in small bundles, and synapse with the olfactory lobe.



# Olfactory epithelium



# Olfactory cells

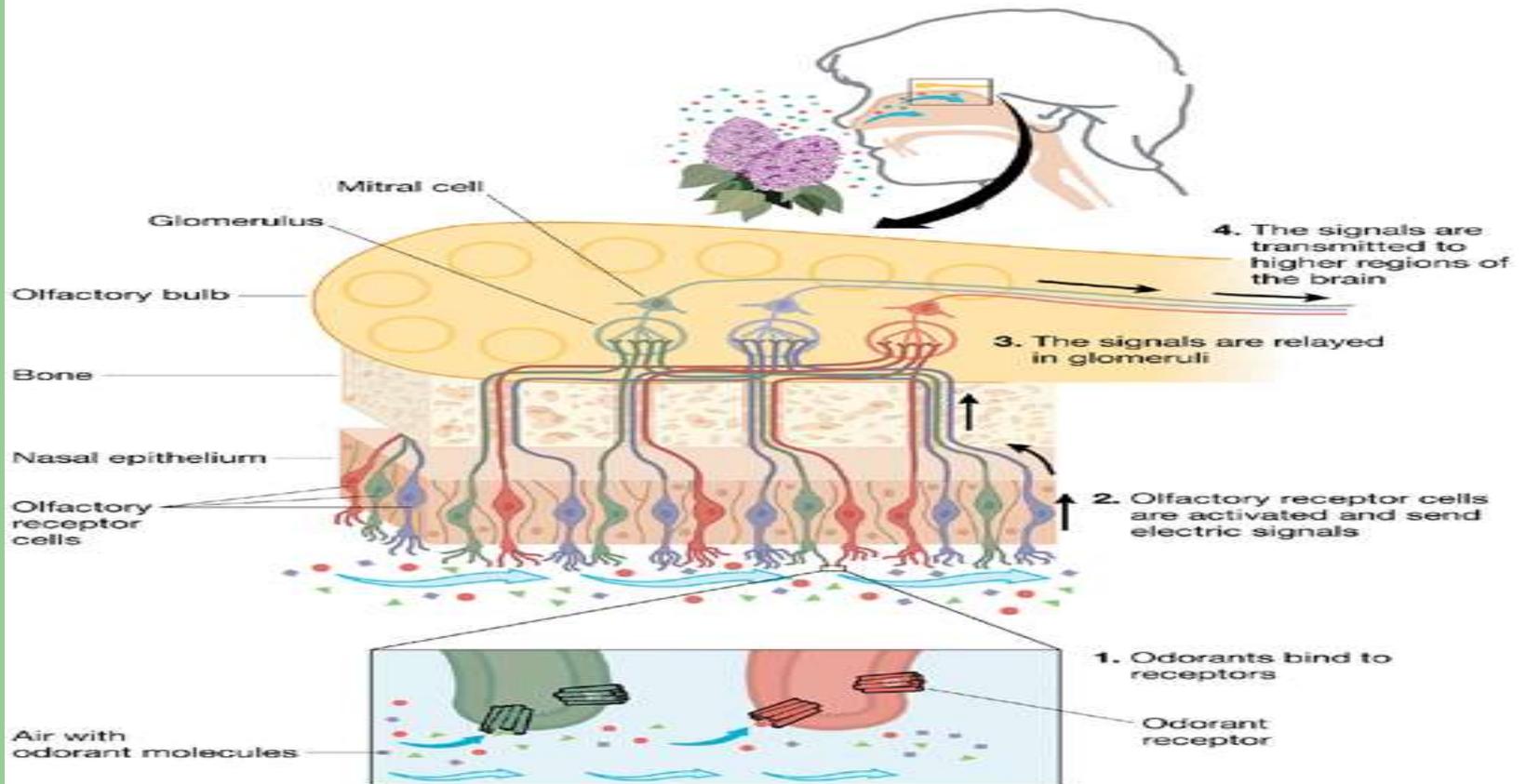


# lamina propria

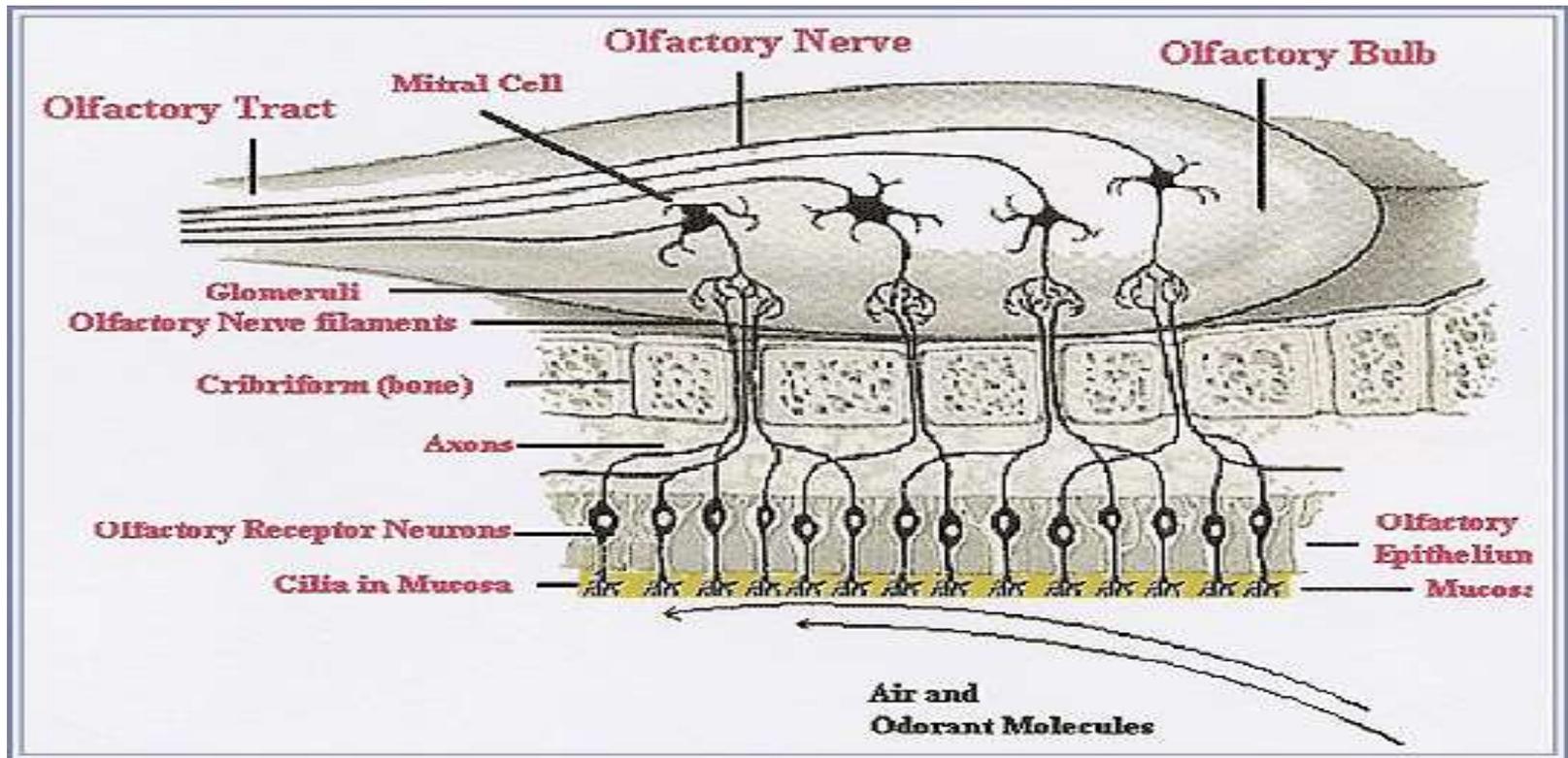
- **Corium** (lamina propria) is rich in blood vessels.
- Contains **Bowman's gland** that secretes watery mucous
- Facilitating the access of new odoriferous substances.



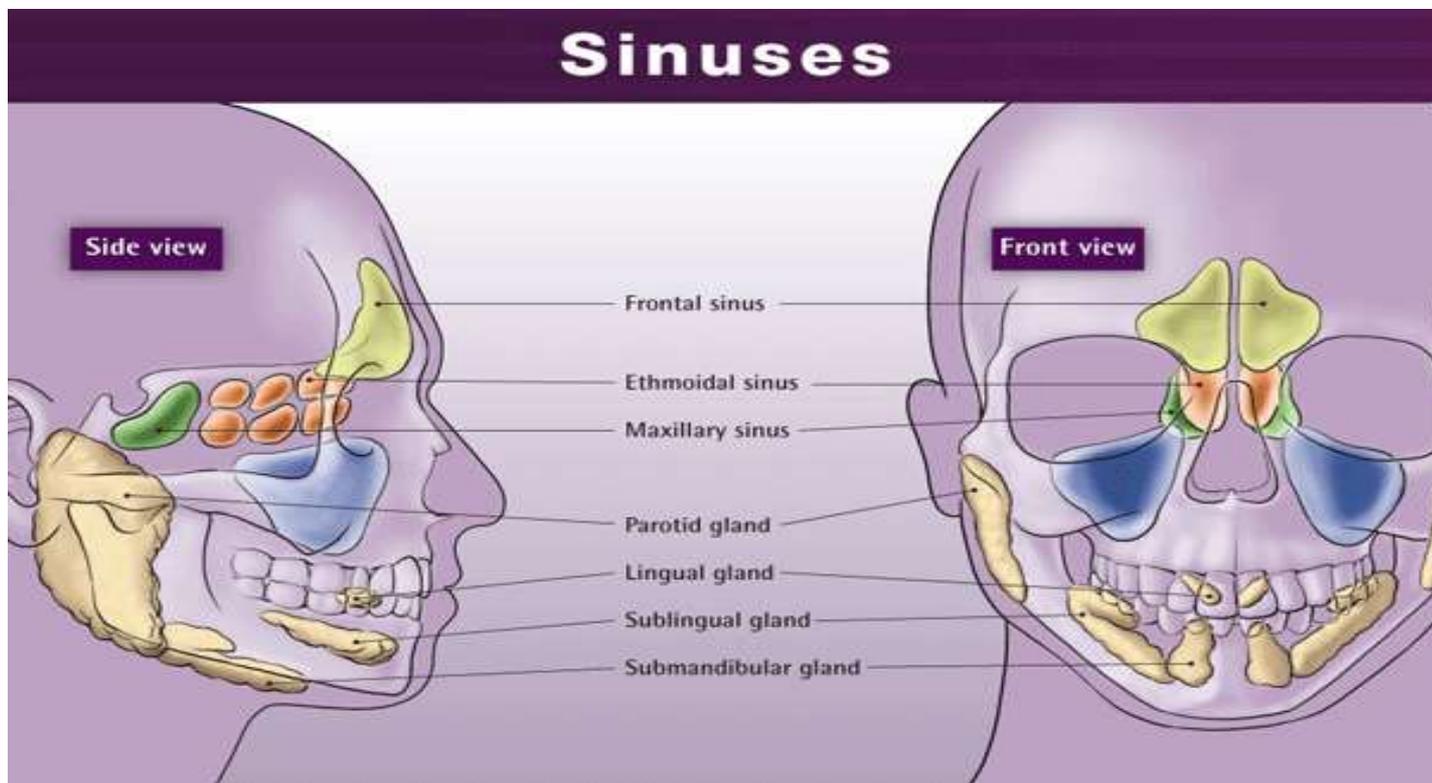
# Olfaction



# Olfaction

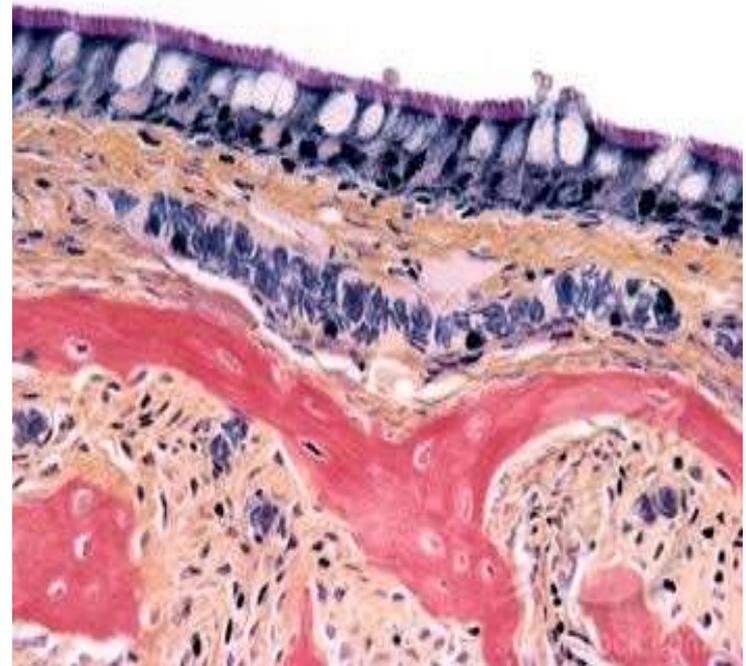


# Nasal Sinuses



# Nasal Sinuses

- lined with a thinner respiratory epithelium
- Contains few goblet cells
- The lamina propria contains only a few small glands
- Continuous with the underlying periosteum

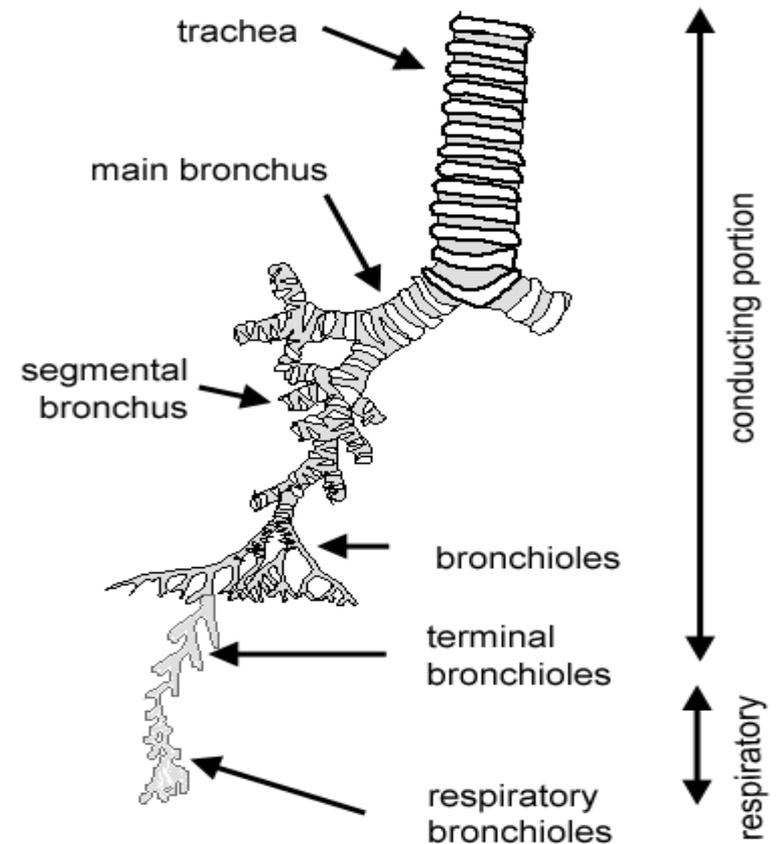


# The Bronchial Tree



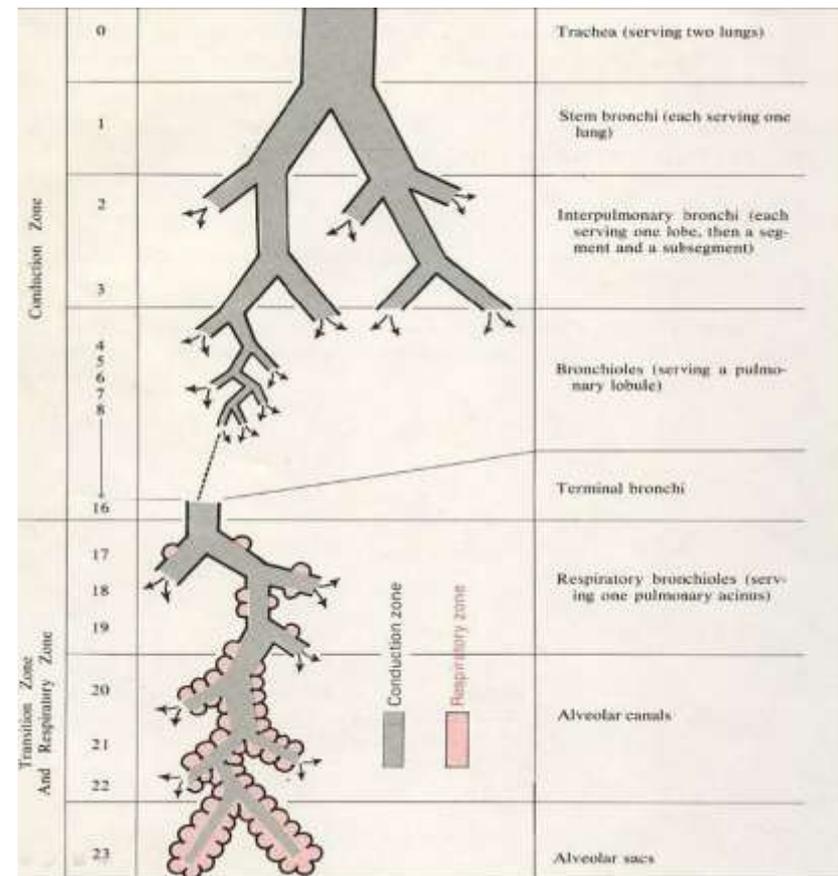
# Structural changes in the bronchial tree

- The trachea extends from the level of C6 to T4 (bifurcation point)
- Only The trachea and the 1ry (main) bronchus are extra-pulmonary
- We have **three** lobar(2ndry) bronchus in the right and **two** in the left lung



# Structural changes in the bronchial tree

- Segmental (tertiary) bronchus is almost 5mm or less in diameter
- Each bronchiole enters a pulmonary lobule
- Each large bronchiole (1 mm) gives 5-7 terminal ones
- Terminal bronchioles (0.5 mm) contain **clara cells** (no cilia) and **neuroepithelial bodies** (chemoreceptor)



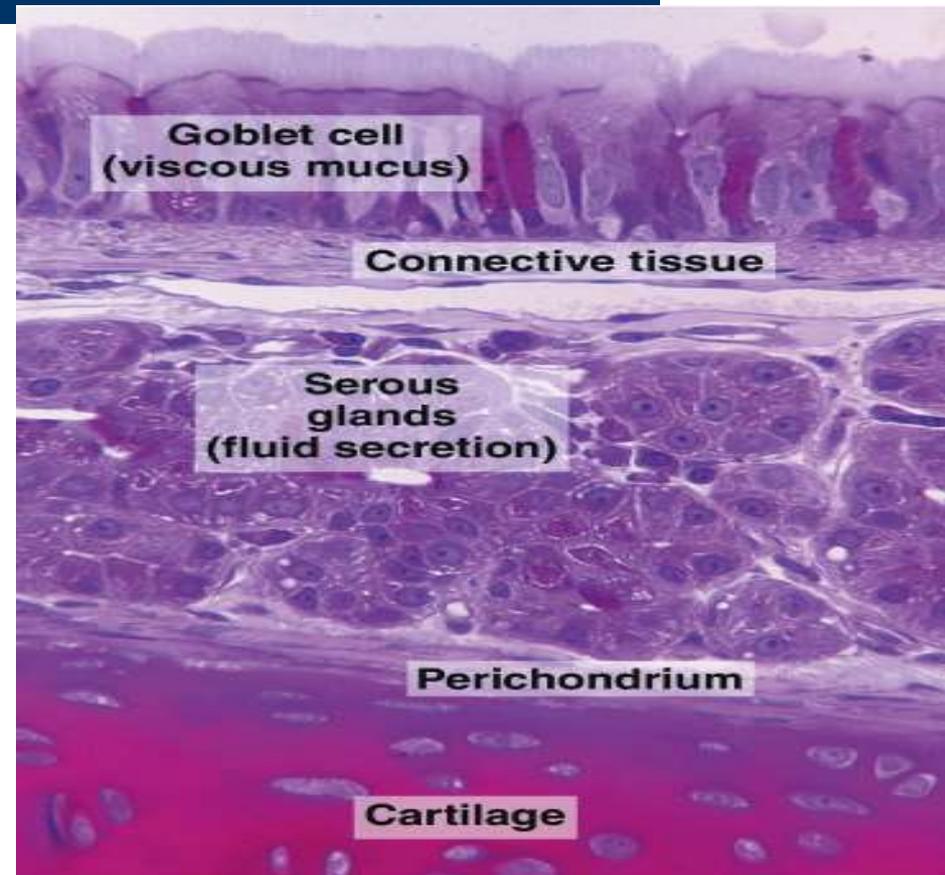
# Trachea

- lined with a typical respiratory mucosa
- **C-shaped** rings of hyaline cartilage that keep the tracheal lumen open (in the lamina propria)
- Fibroelastic ligament and bundle of smooth muscle (**Trachealis**) bind to the perichondrium and close the rings **posteriorly**
- Some longitudinal muscles may be found behind the trachealis



# Trachea

- Numerous seromucous glands that produce a more fluid mucus
- Contain the same 5 types of cells in the mucosa



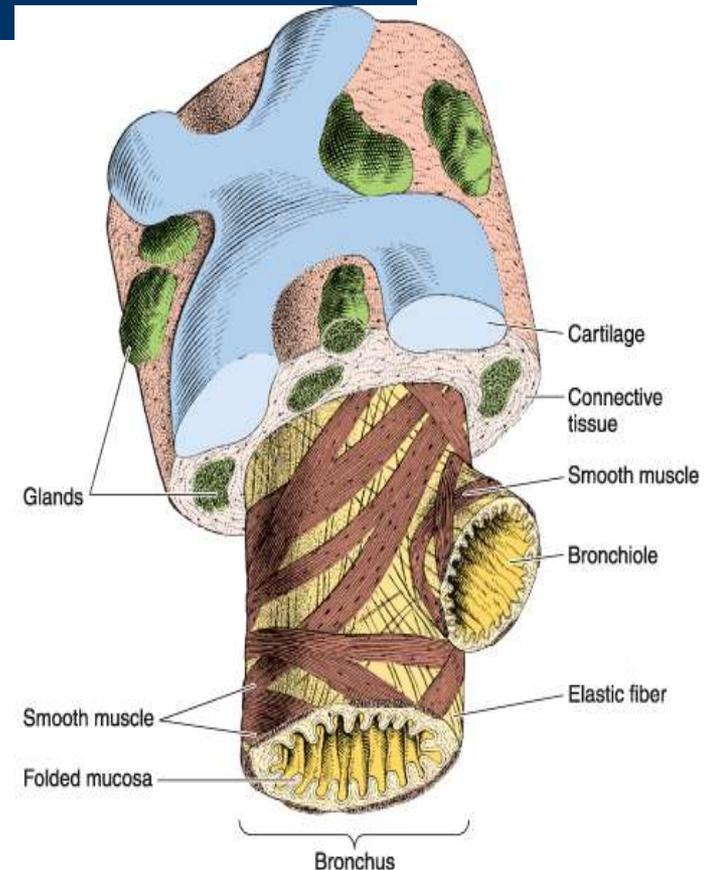
# Trachea

- The ligament prevents overdistention of the lumen
- The muscle allows regulation of the lumen
- Contraction of the Trachealis muscle and the resultant narrowing of the tracheal lumen are involved in the **cough reflex**



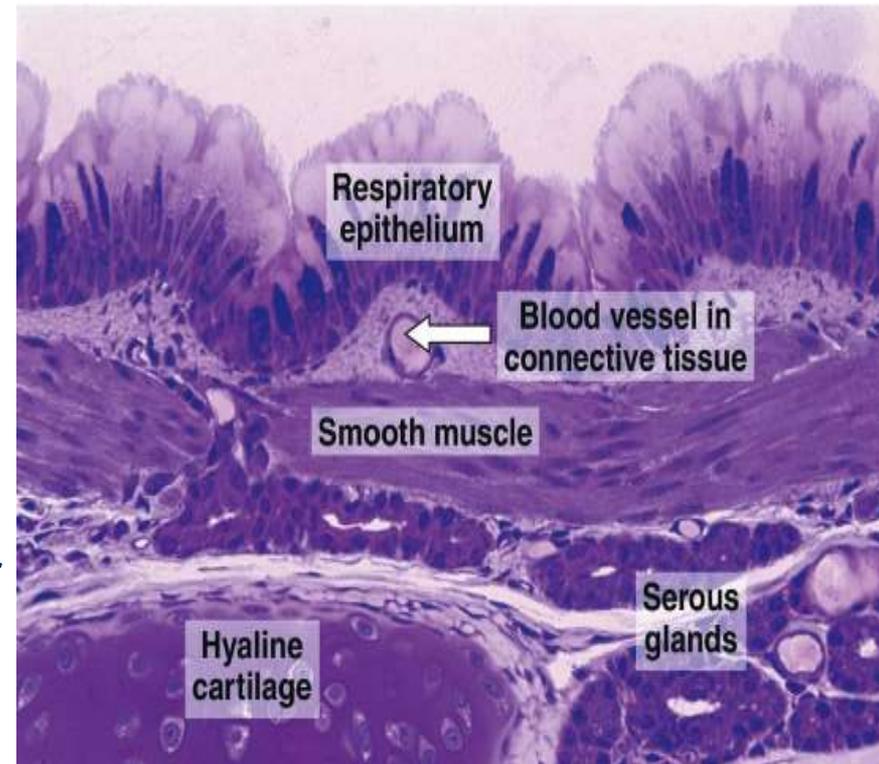
# Bronchi

- Divided into:
- **Extrapulmonary (primary bronchus) :**
- Resembles trachea in structure
- **Intrapulmonary (2ndry and tertiary) :**
- They have complete muscular layer
- Cartilaginous plates instead of rings



# Differences between the trachea and bronchi

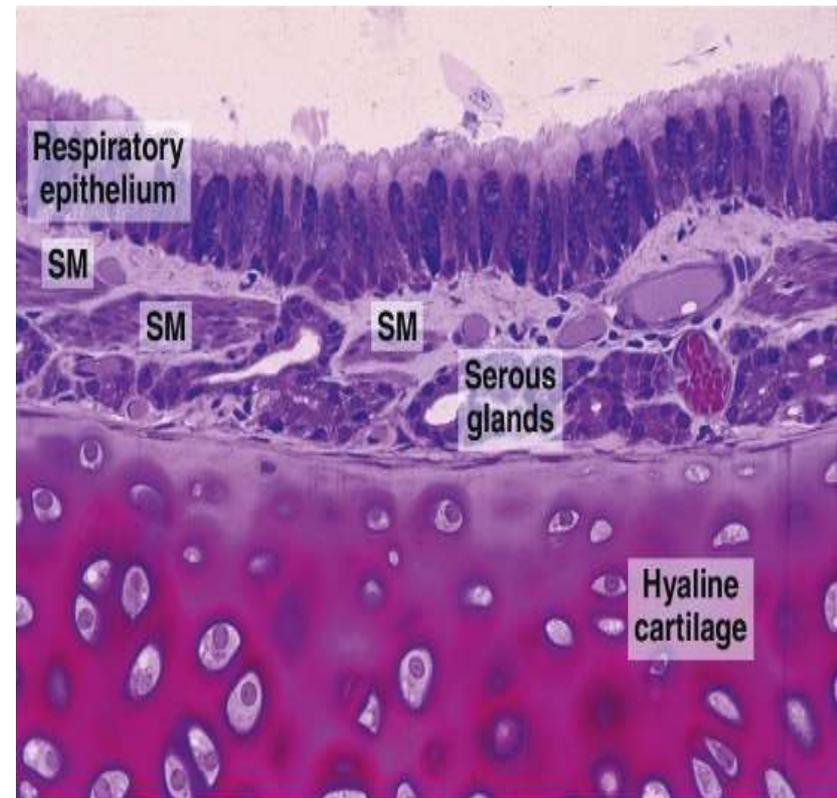
- 1. narrower lumen (small bronchus 5mm or less)
- 2. irregular bronchial cartilage plates
- 3. smooth muscle layer consisting of **spirally arranged bundles** between the lamina p. and submucosa
- Contraction of this muscle layer is responsible for the folded appearance of the bronchial mucosa



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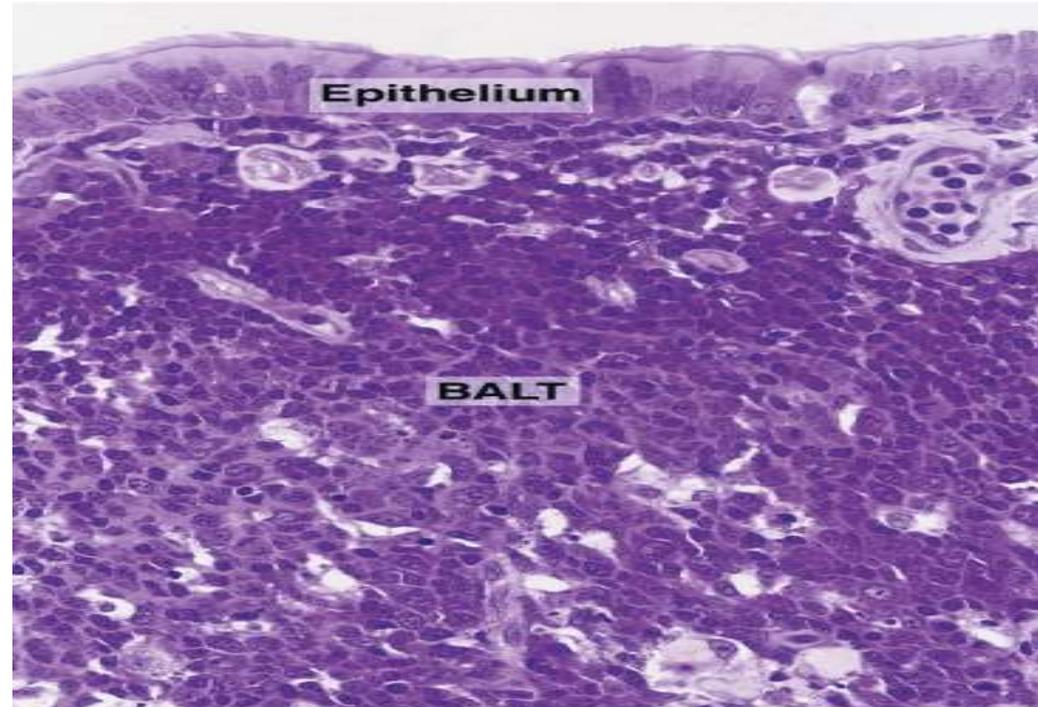
# Differences between the trachea and bronchi

- 4. lamina propria is rich in elastic fibers and contains an abundance of mucous and serous glands
- 5. respiratory epithelium with fewer goblet cells



# Differences between the trachea and bronchi

- 6. Numerous lymphocytes and Lymphatic nodules (BALT) are present (infiltrated by the adventitia)



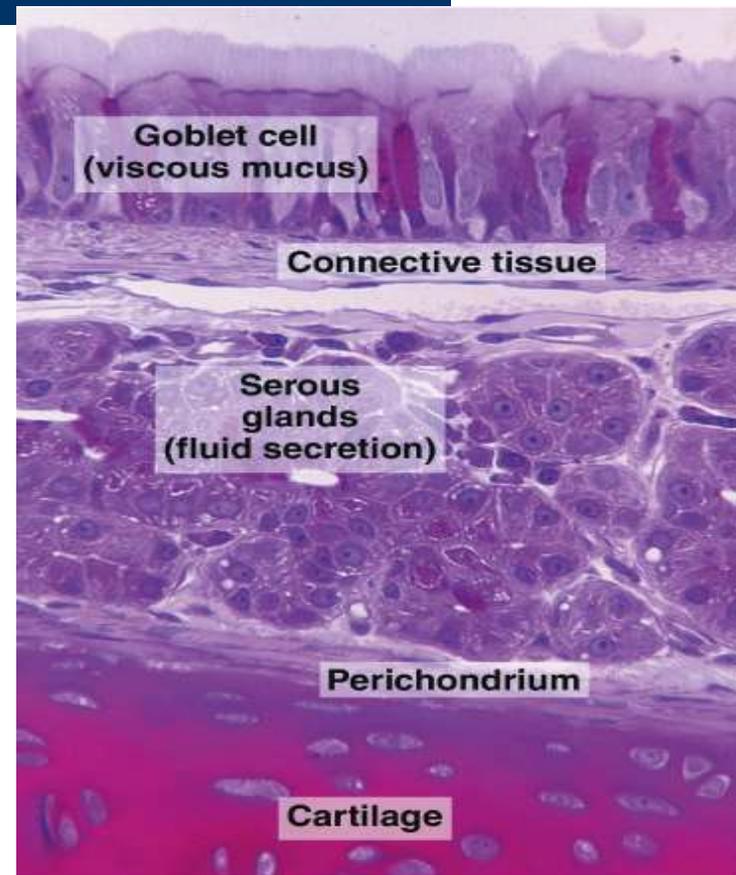
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# **Structural changes in the conducting portion of the respiratory tract**



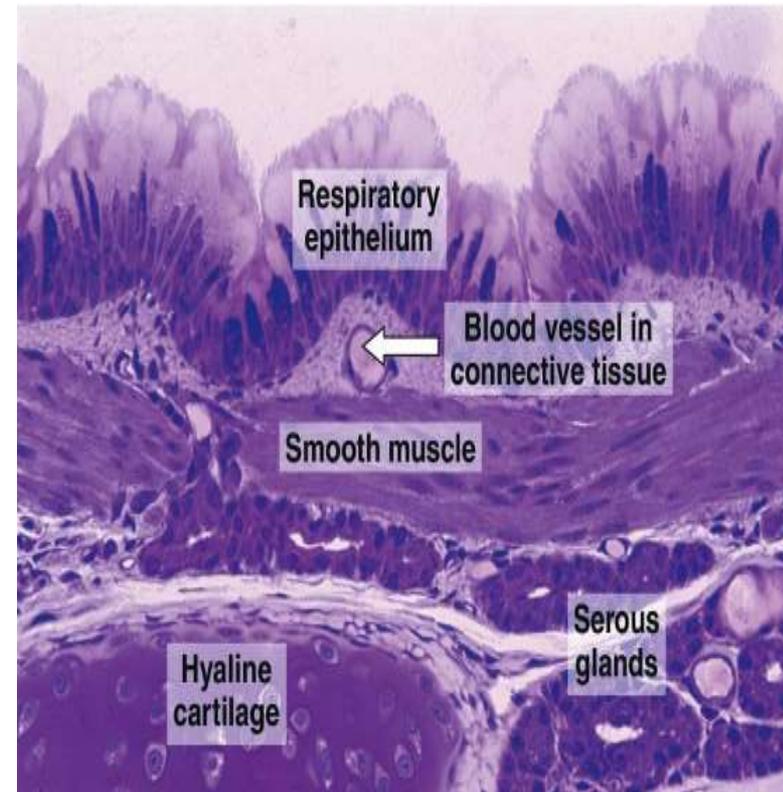
# Extra-pulmonary bronchi

- **Pseudostratified ciliated columnar epithelium with goblet cells.**
- Prominent basement membrane.
- Relatively thin lamina propria (elastic layer at base)
- Submucosa with **seromucous glands**
- "C" shaped hyaline **cartilage rings** w/ smooth muscle between ends of cartilage



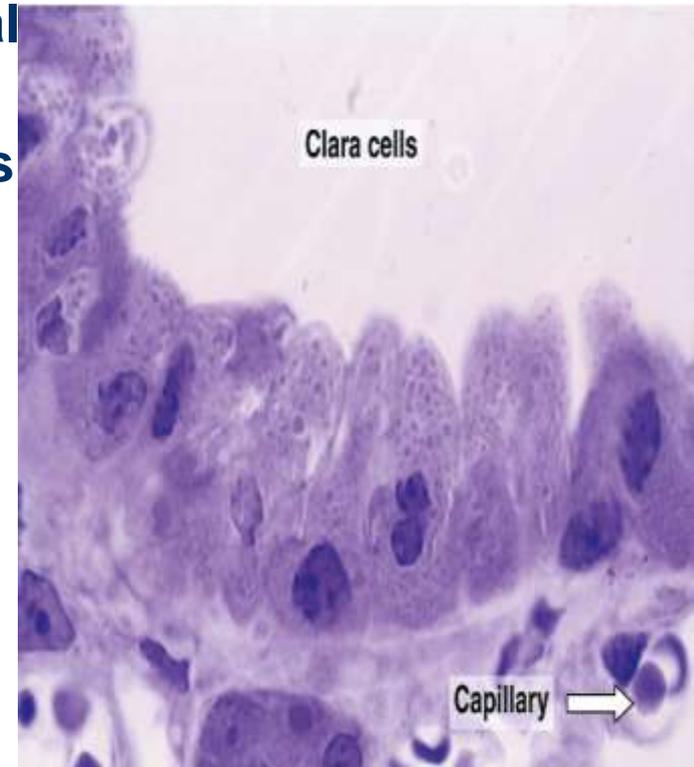
# Intrapulmonary bronchi

- **Pseudostratified ciliated columnar** changing to **ciliated simple columnar** in smaller branches. **Goblet cells** at all levels.
- Below lamina propria are interlacing **spirals** of **smooth muscle**
- Seromucous glands decrease as bronchi get smaller.
- **Plates of cartilage** gradually disappear



# Bronchioles (1 mm or less)

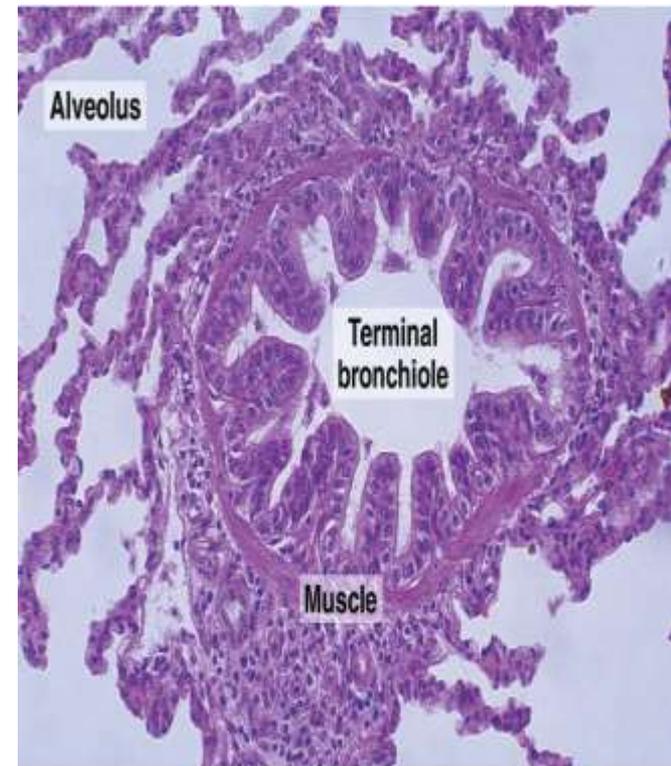
- **Ciliated columnar to ciliated cuboidal**
- **Goblet cells decrease and Clara cells appear**
- Spirals of **smooth muscle** relatively heavier than elsewhere (gradually decrease in amount)
- **No** seromucous glands
- **No** cartilage



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# Respiratory bronchioles

- **Cuboidal epithelium with some cilia.** Clara cells and **no goblet cells.**
- Thin supporting wall of C.T. and an incomplete layer of smooth muscle.
- **Outpocketings of alveoli,** numbers increase at lower levels.



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# Bronchioles

- **Clara cells**
  - devoid of cilia
  - secrete proteins that protect the bronchiolar lining against oxidative pollutants and inflammation.
- **Neuroepithelial bodies**
  - contain secretory granules and receive cholinergic nerve endings
  - **chemoreceptors** that react to changes in gas composition within the airway

# Elastic Fibers

- Longitudinal elastic fibers are present in all the segments of the bronchial system (in the L.propria)
- The smaller the bronchiole the higher proportions of elastic fibers

**Thank You**

