



# **The Respiratory System**

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Al-Muhtaseb

# Objectives (lecture + practical)

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- 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

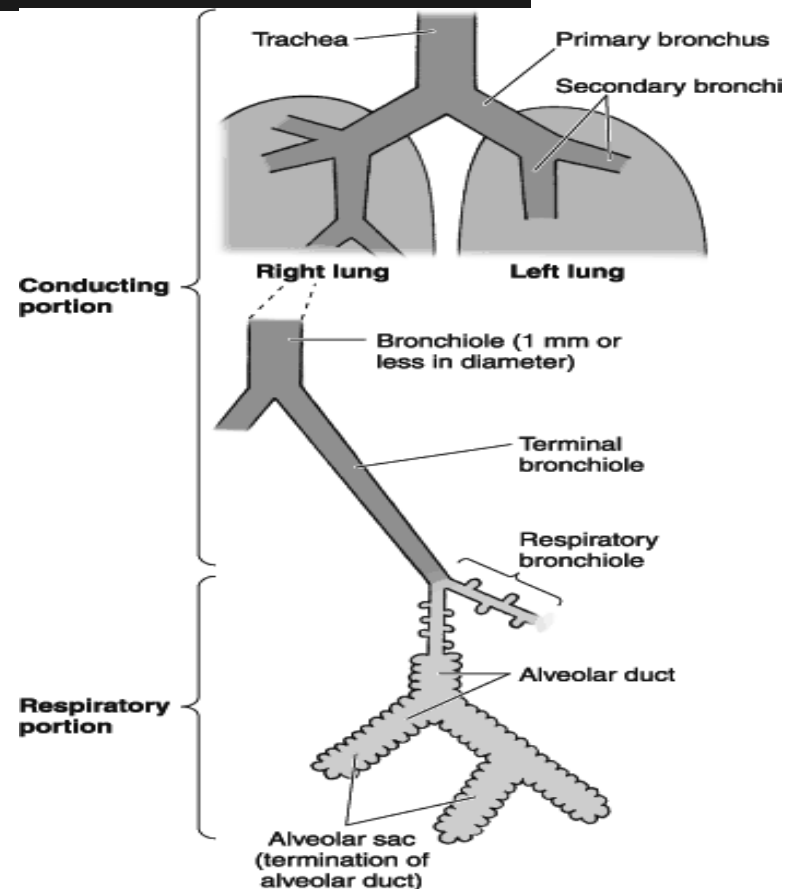
# Objectives (lecture + practical)

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- 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 ?

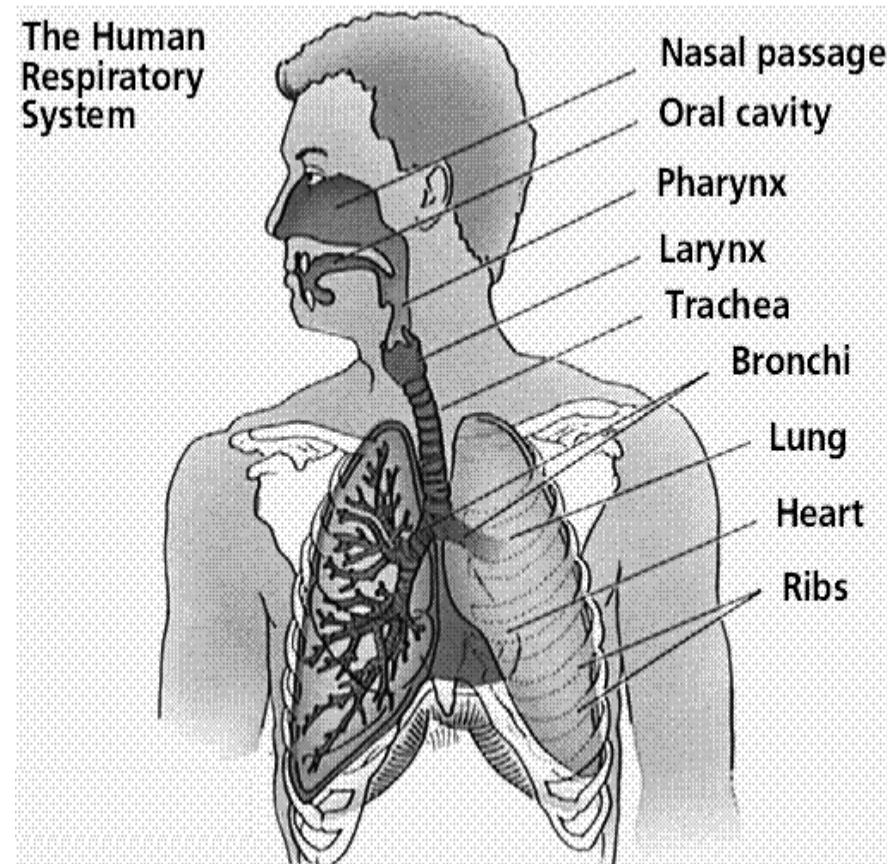
# The Respiratory System

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

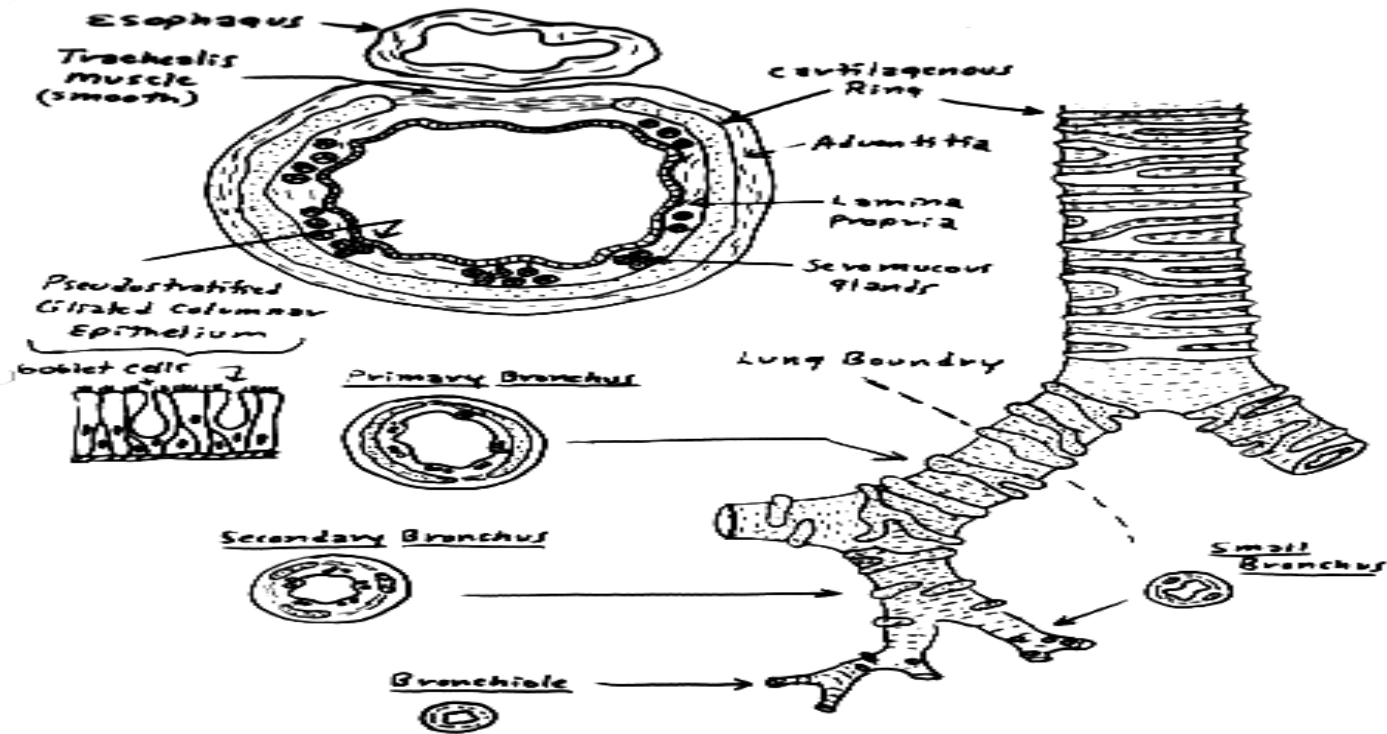


# Conducting portion

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



# Conducting portion

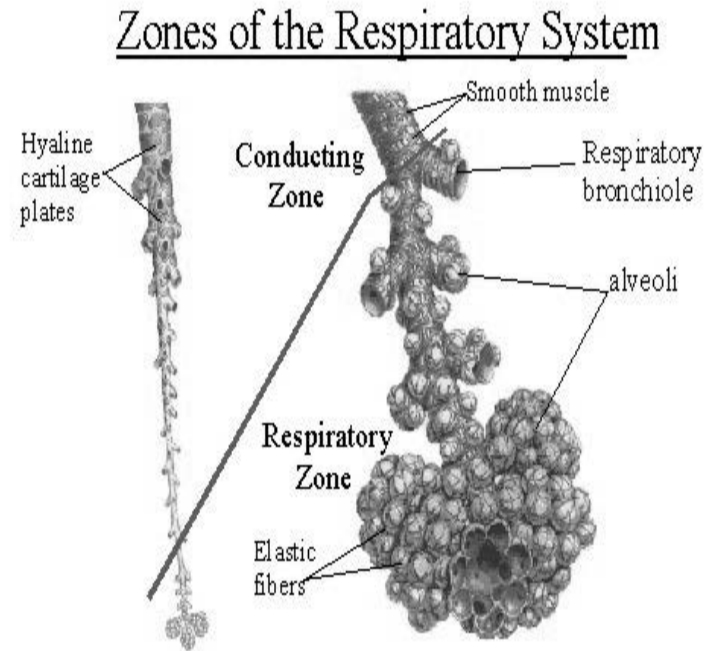


# Conducting portion

- 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.

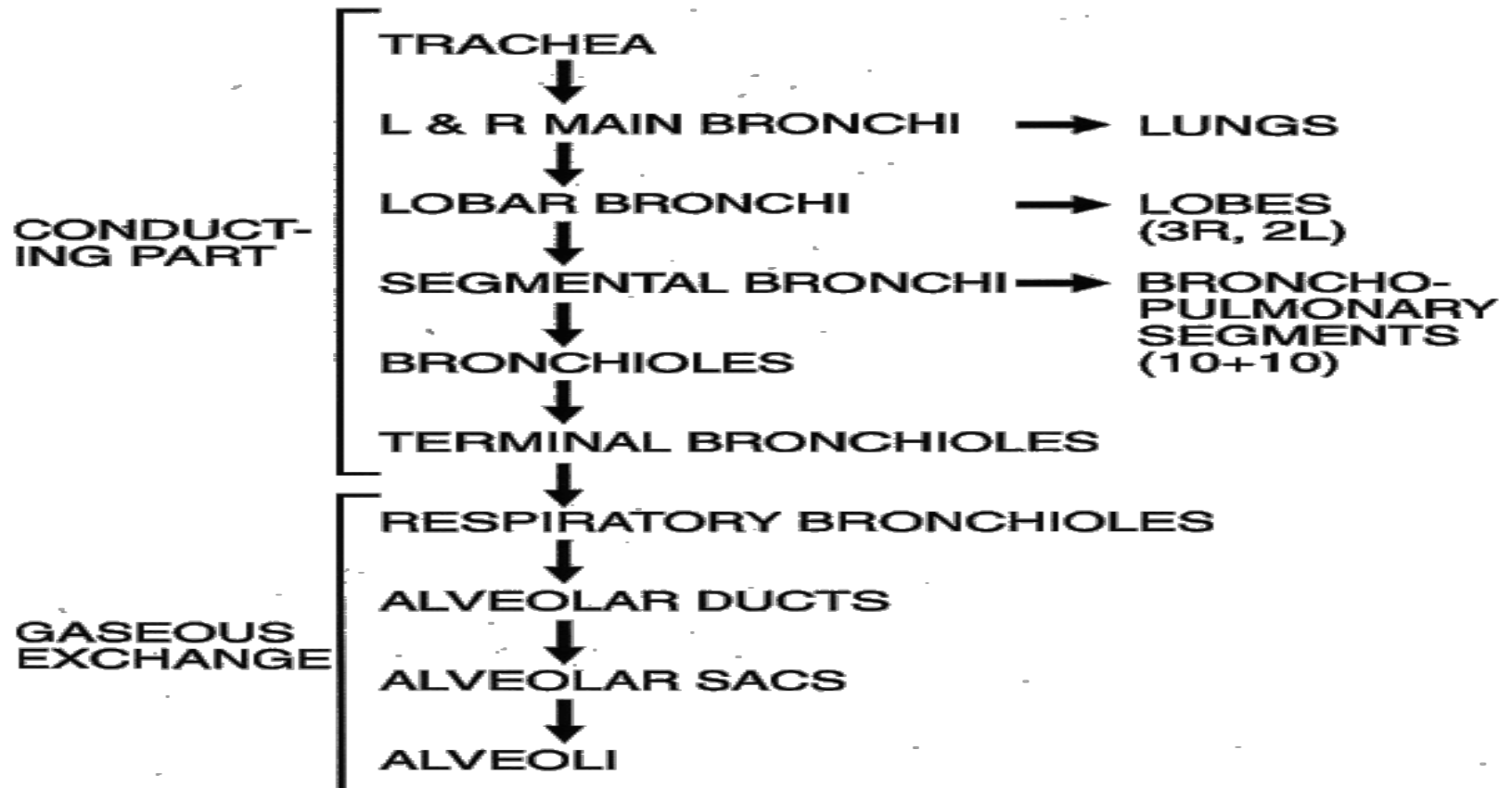
# Respiratory portion

- 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<sub>2</sub> and CO<sub>2</sub> between inspired air and blood.



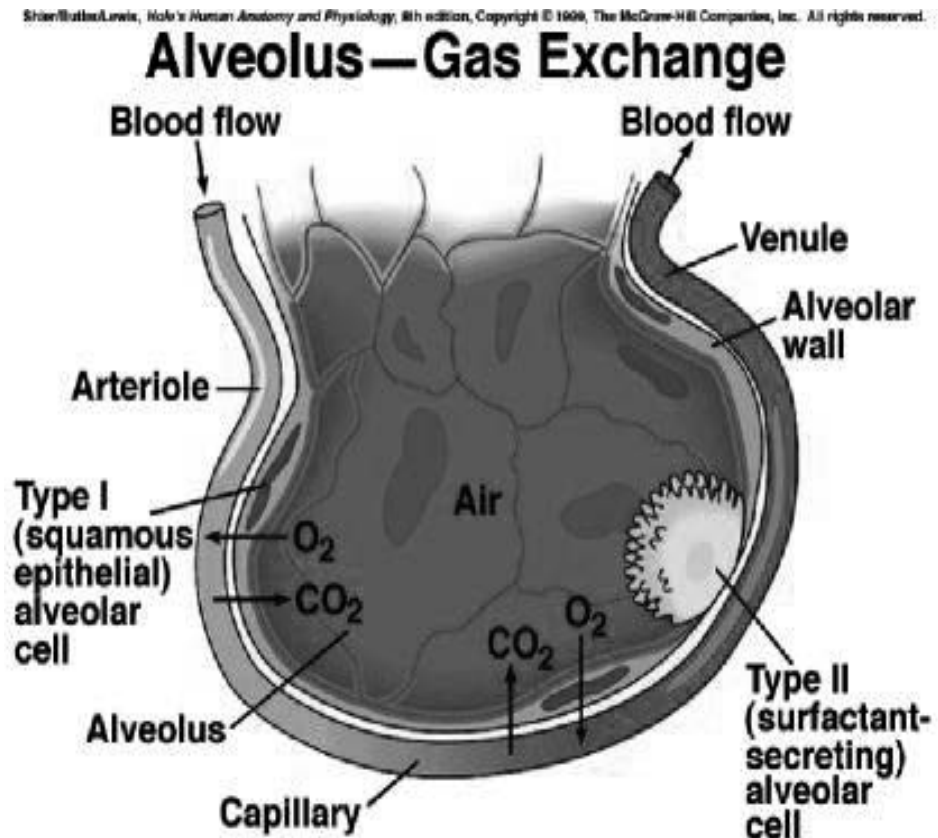


# Respiratory tract



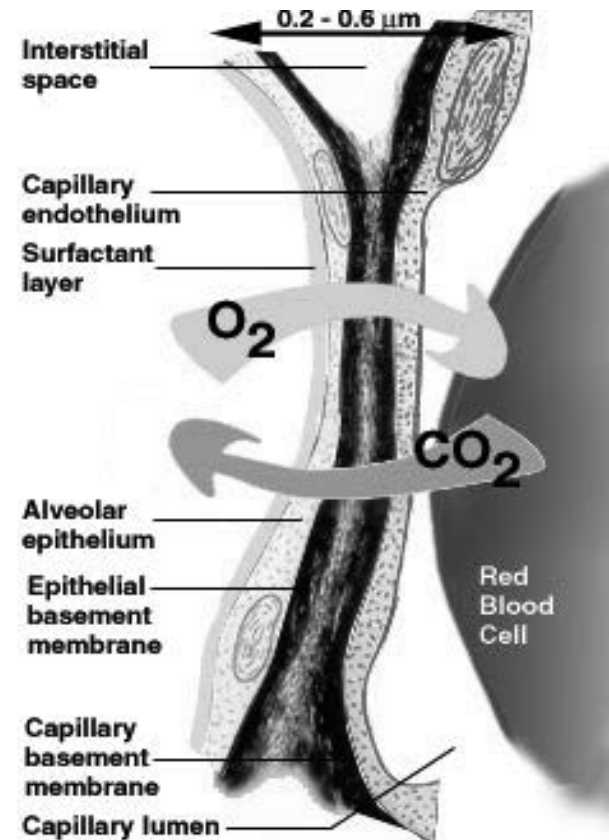
# Gas exchange

- 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



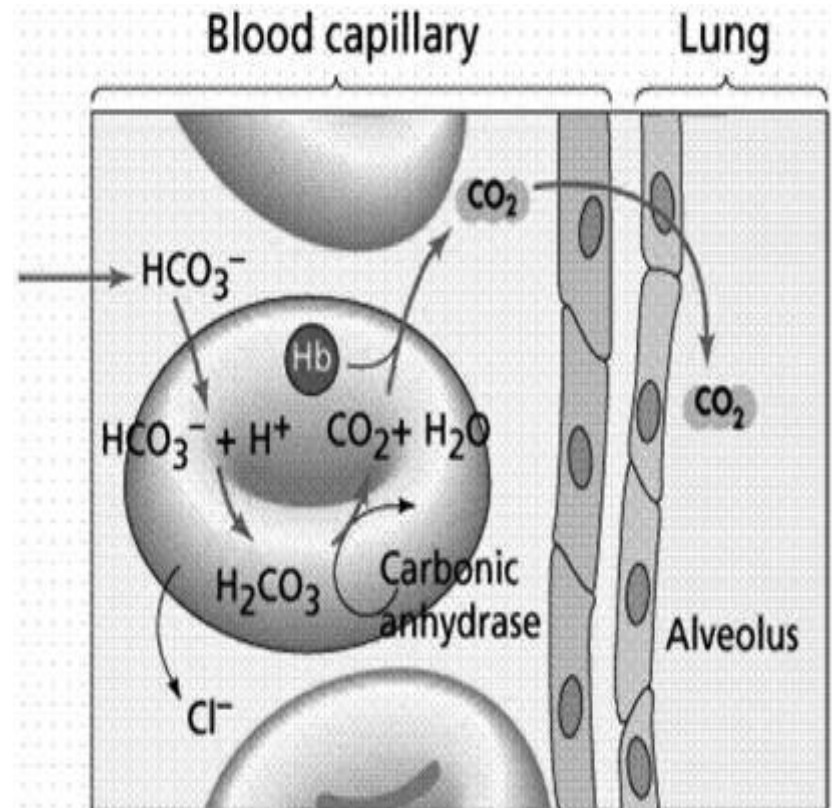
# Gas exchange

- In the alveoli
- $PO_2 = 105 \text{ mmHg}$
- $PCO_2 = 45 \text{ mmHg}$
- $O_2$  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  $PO_2 = 40 \text{ mmHg}$ )



# 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)

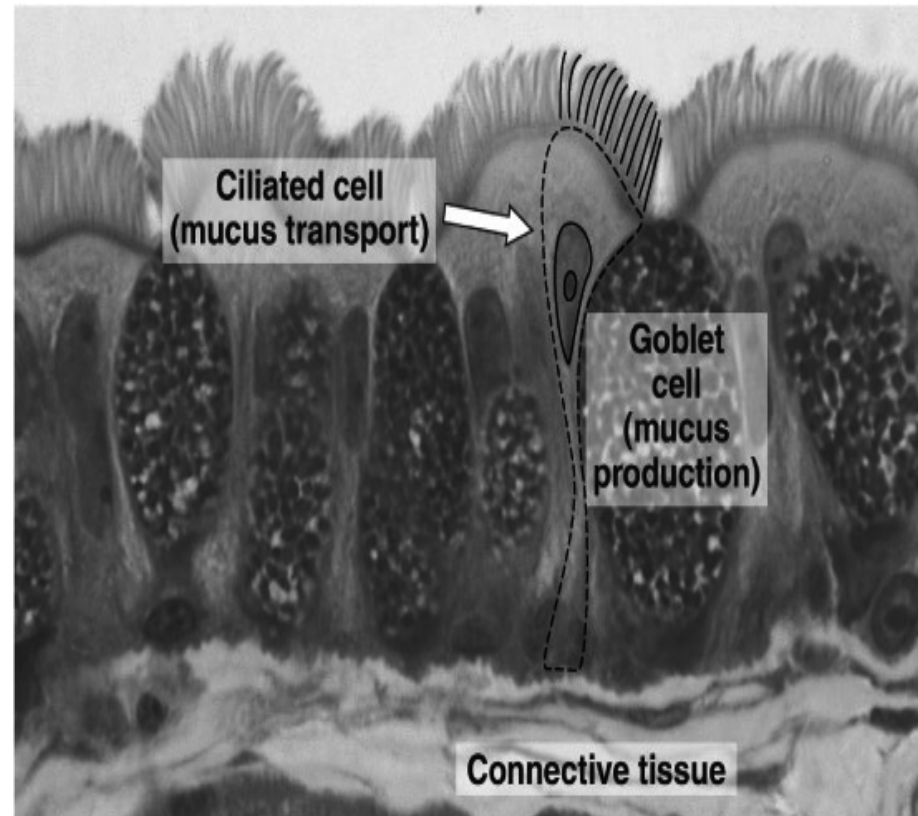




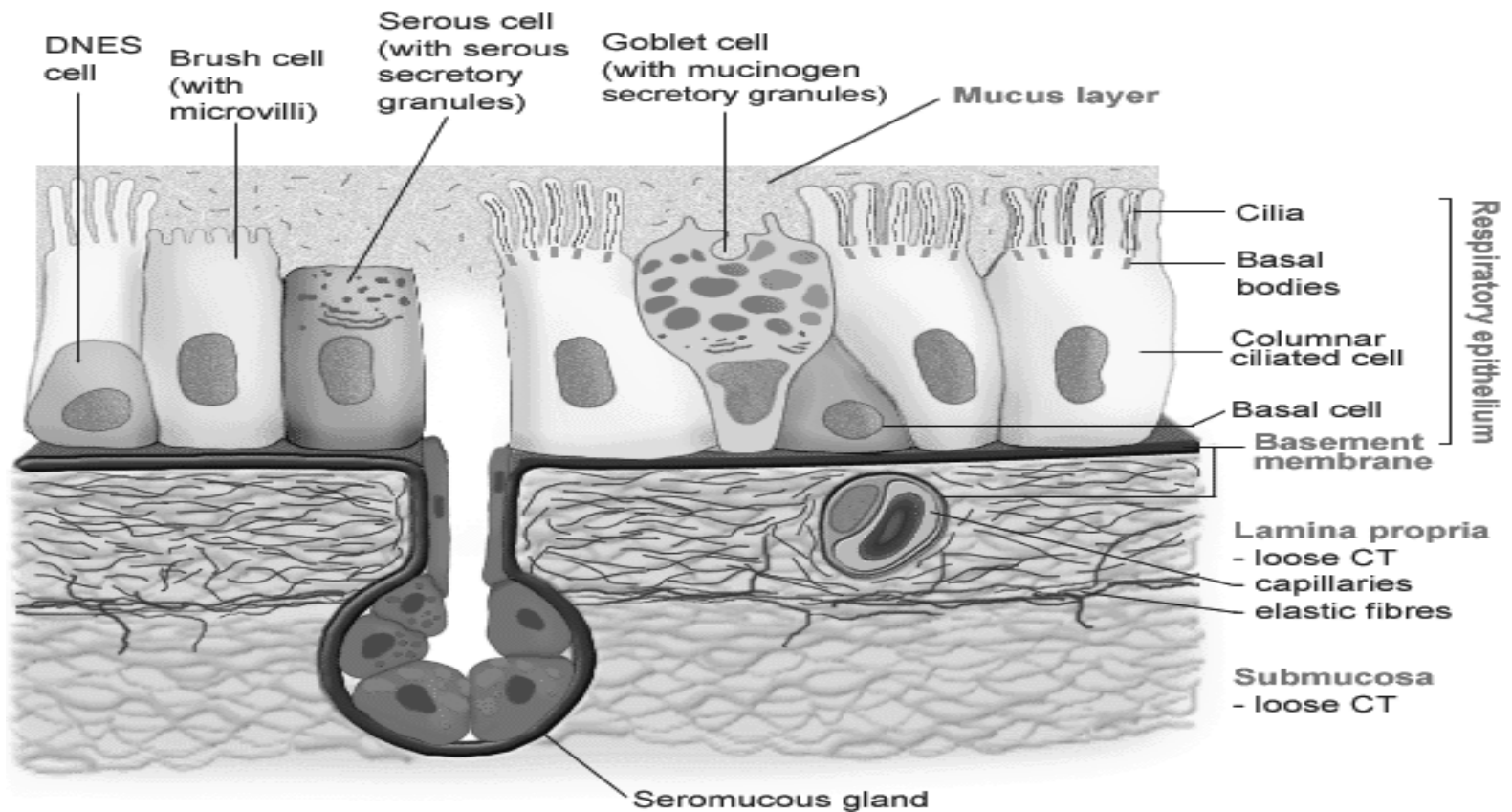
# **Respiratory Epithelium**

# 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

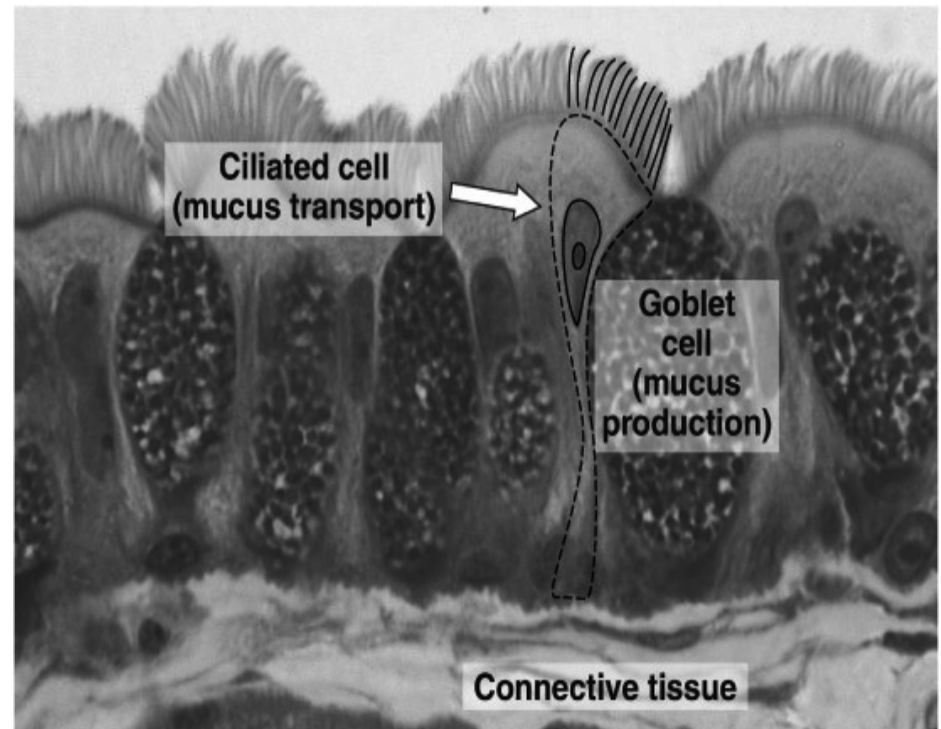


# Respiratory epithelium cells



# Ciliated columnar cells

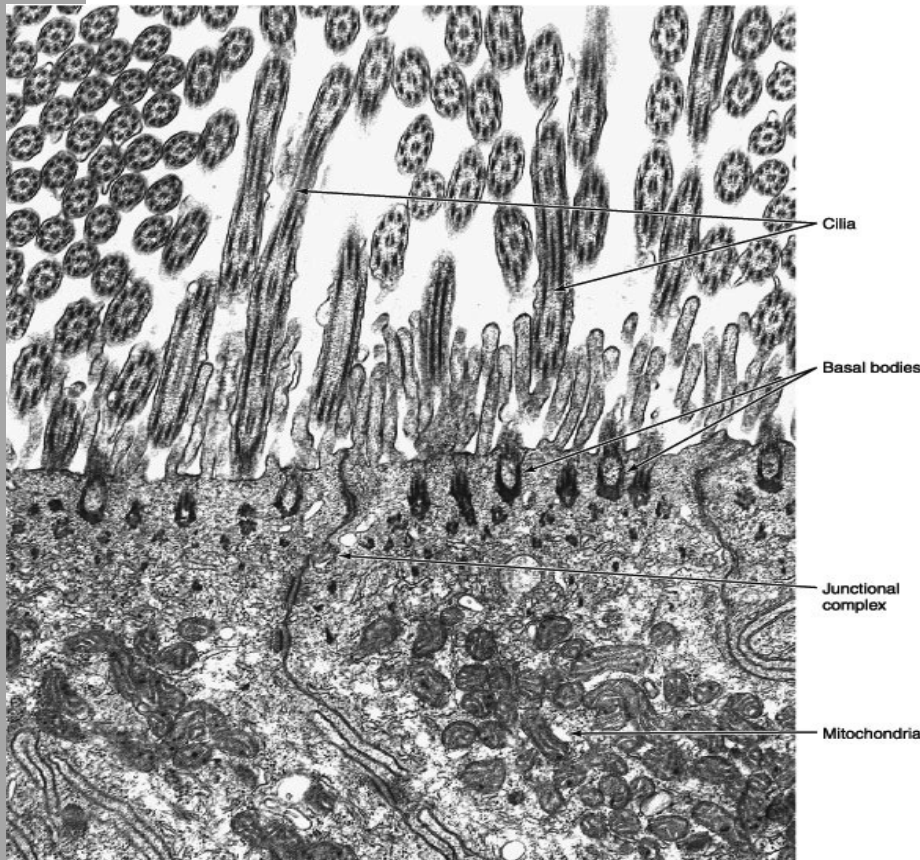
- Most abundant type
- Each cell has about 300 cilia on its apical surface



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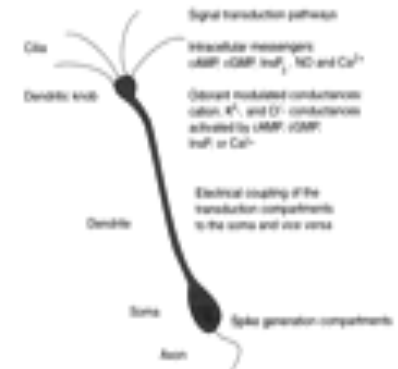
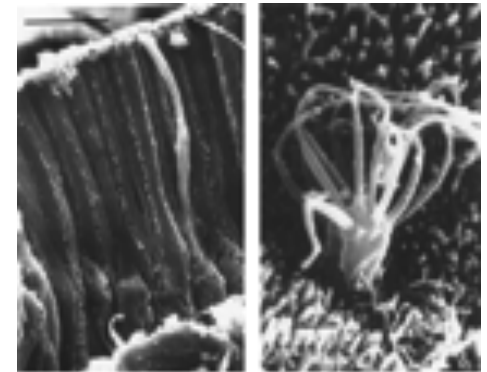
# Ciliated columnar cells



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

# Ciliary movements

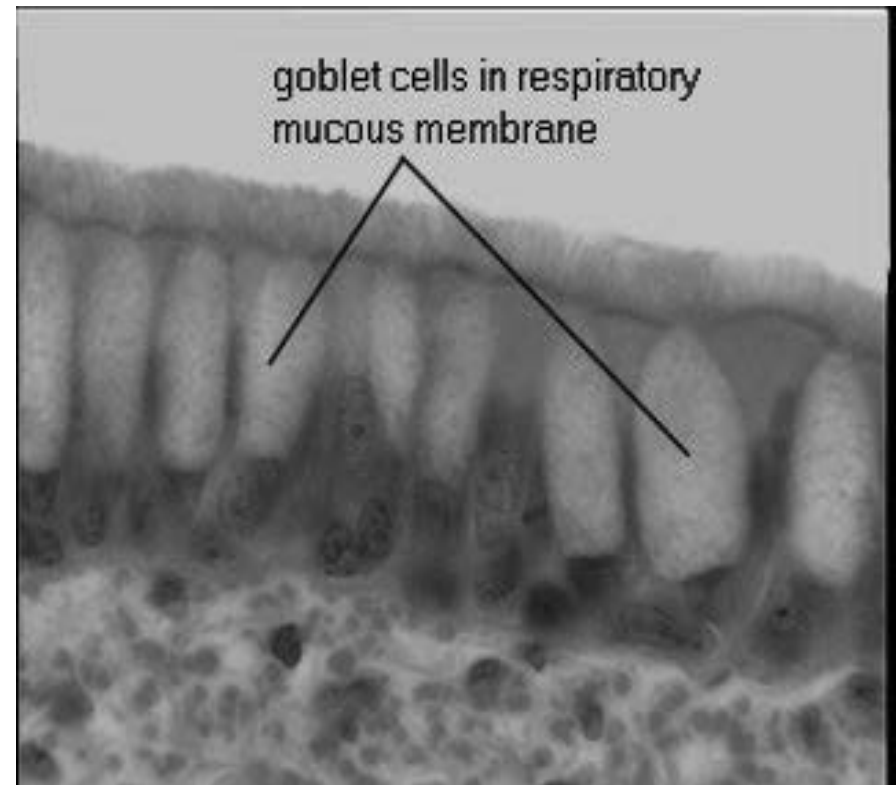
- **Dynein**, a protein normally participates in the ciliary movement
- **Nicotin** prevents formation of dynein, which leads to improper movement of cilia.
- **Immotile cilia syndrome (Kartagener syndrome)**
  - caused by immobility of cilia and flagella
  - induced, in some cases, by deficiency of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



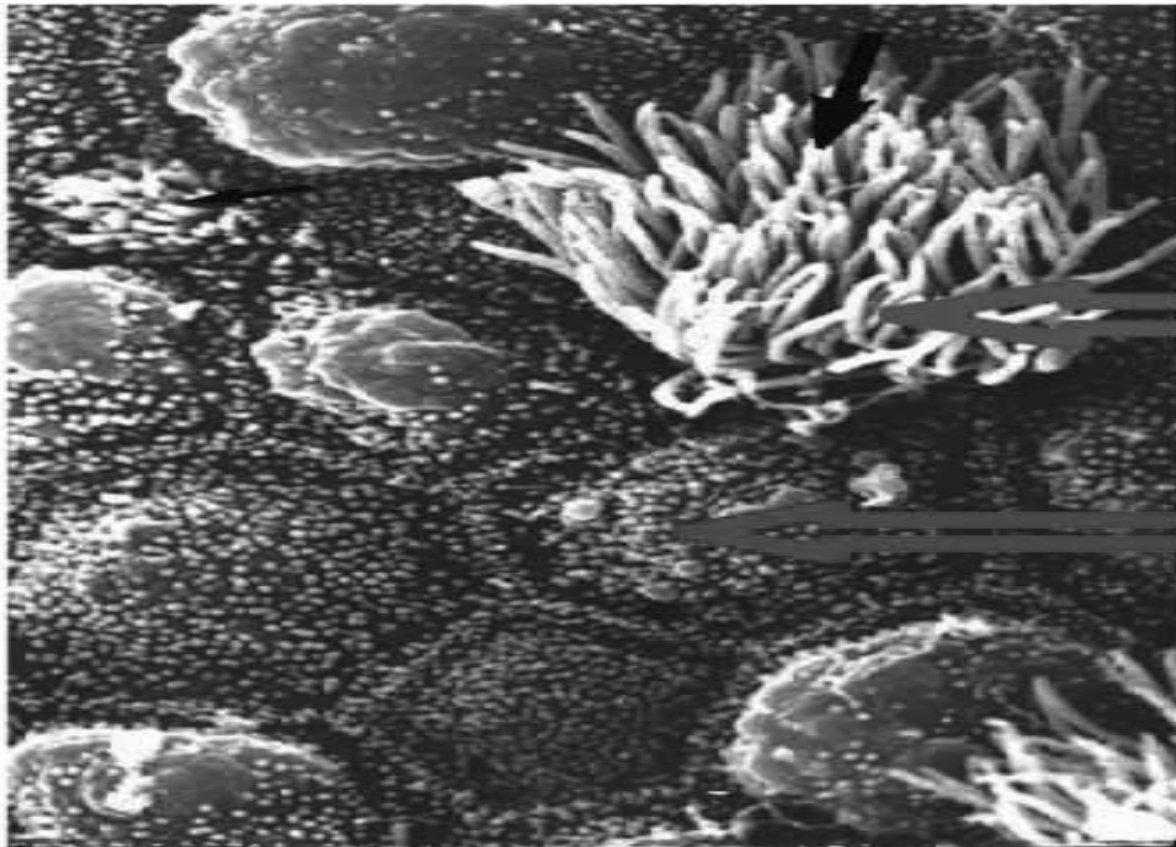
# Mucous goblet cells

Apical mucous droplets

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



# Respiratory epithelium

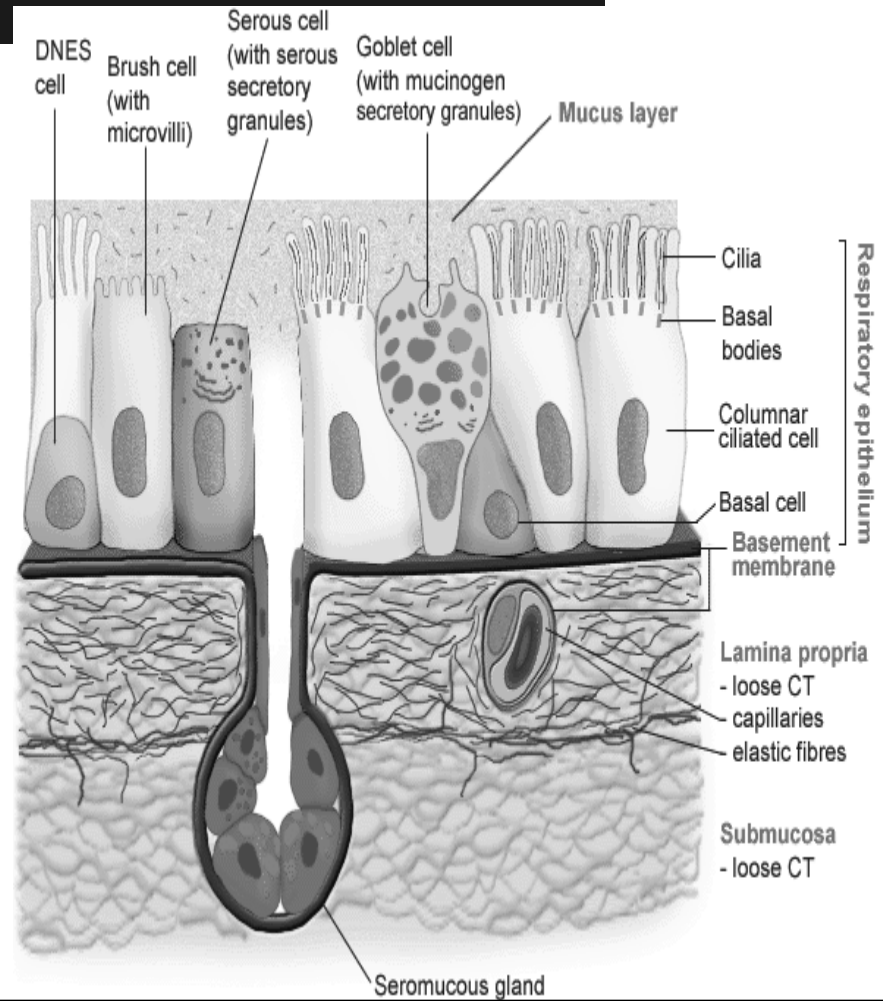


**Cilia,  
seen  
from  
within  
the  
airway**

**Goblet  
cells  
produce  
mucus**

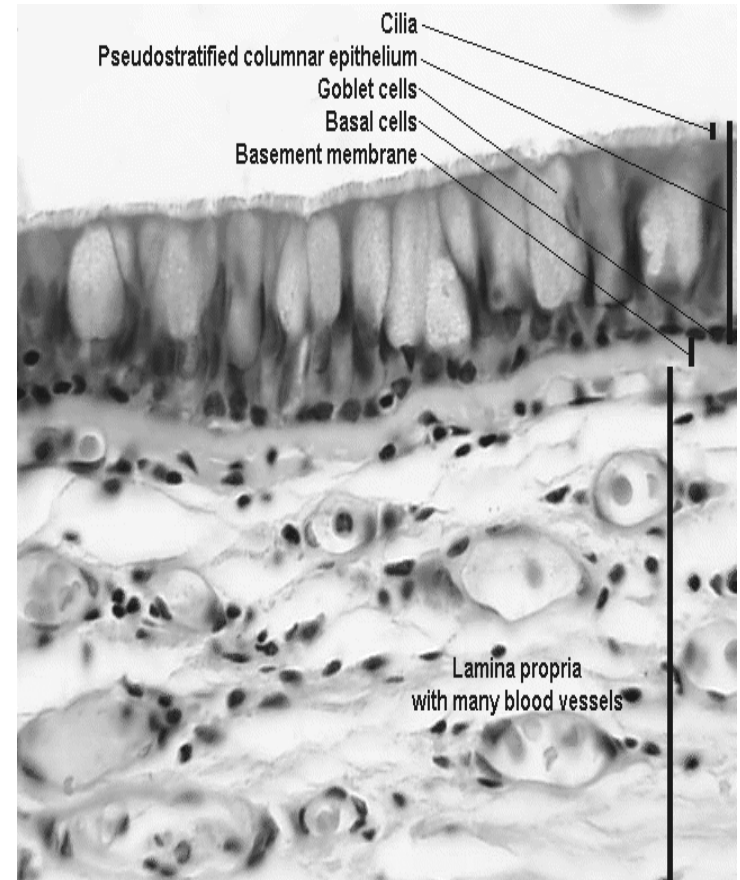
# Brush cells

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



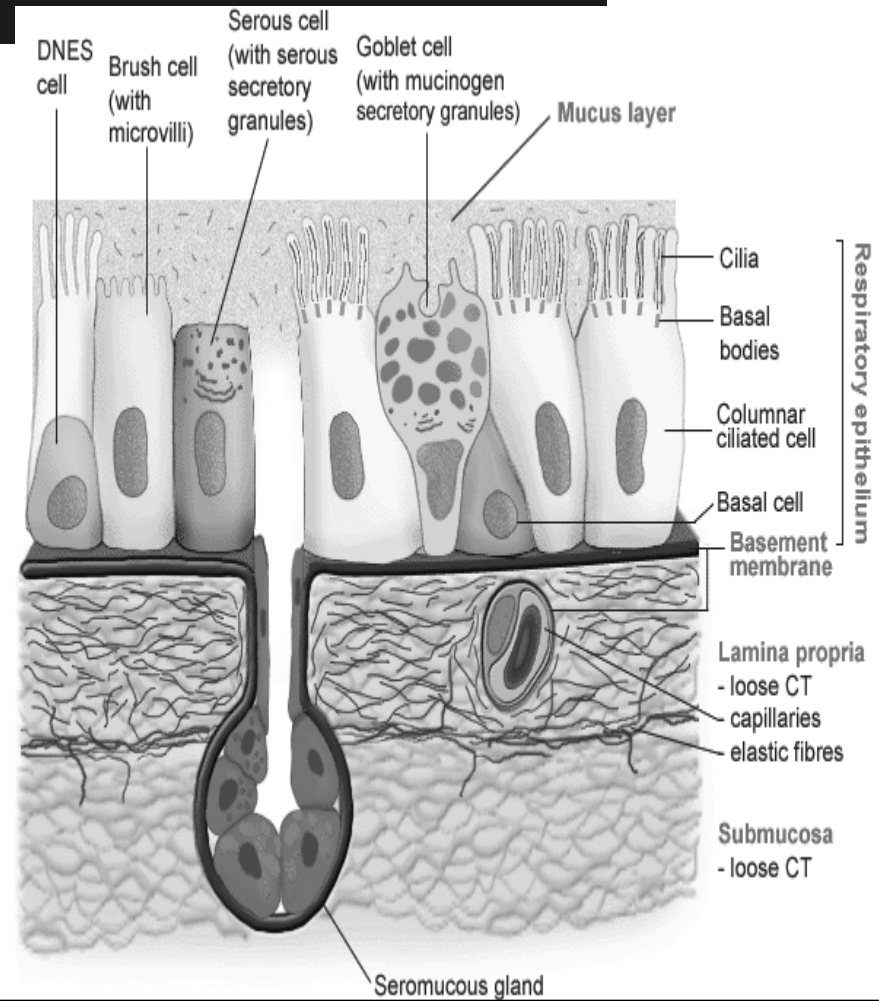
# Basal (short) cells

- 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

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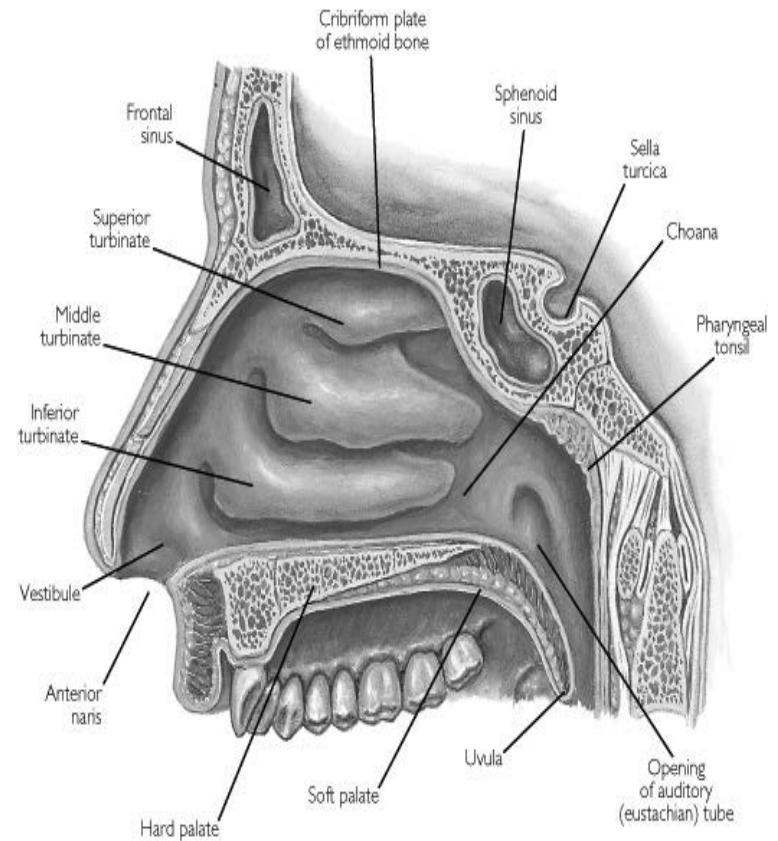
- **3. Supportive layer:**  
*smooth muscle and cartilage*
  
- 4. Adventitia:**  
connective tissue coverings.

# Nasal Cavity



# Nasal Cavity

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



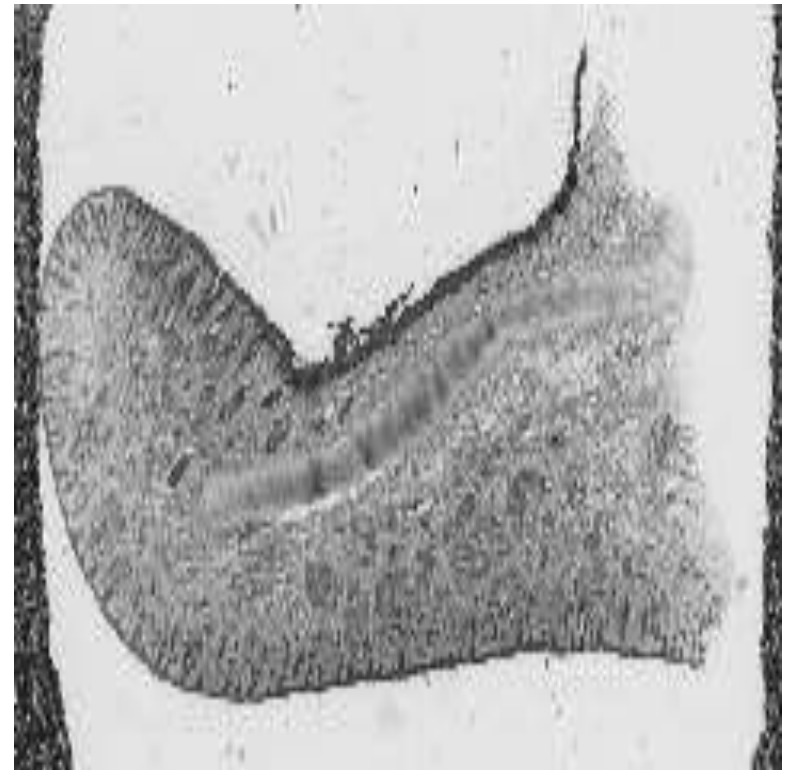
# The vestibule

- 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



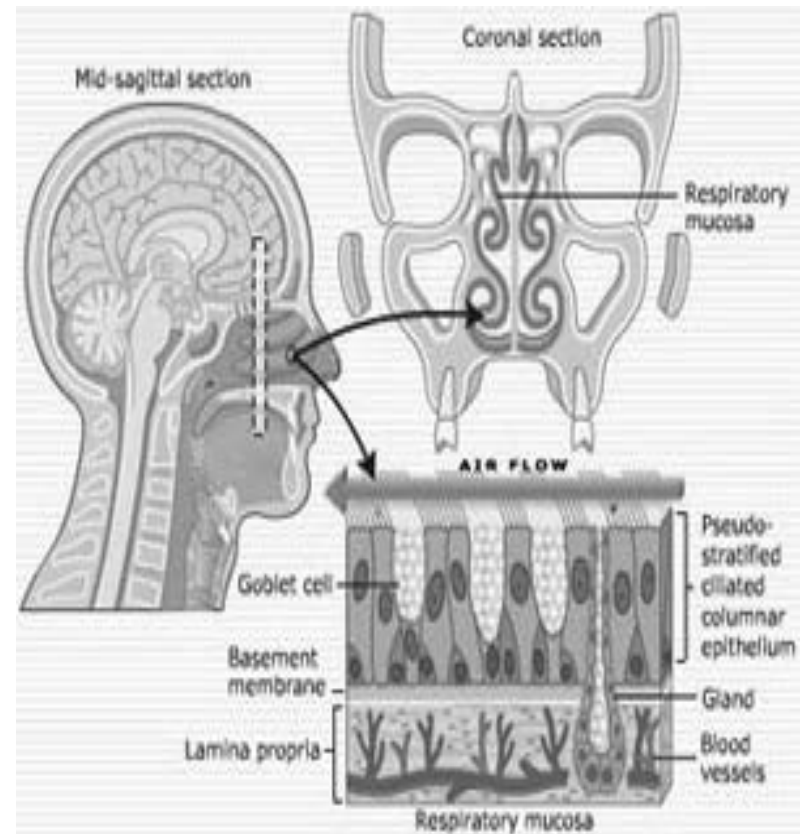
# The vestibule

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



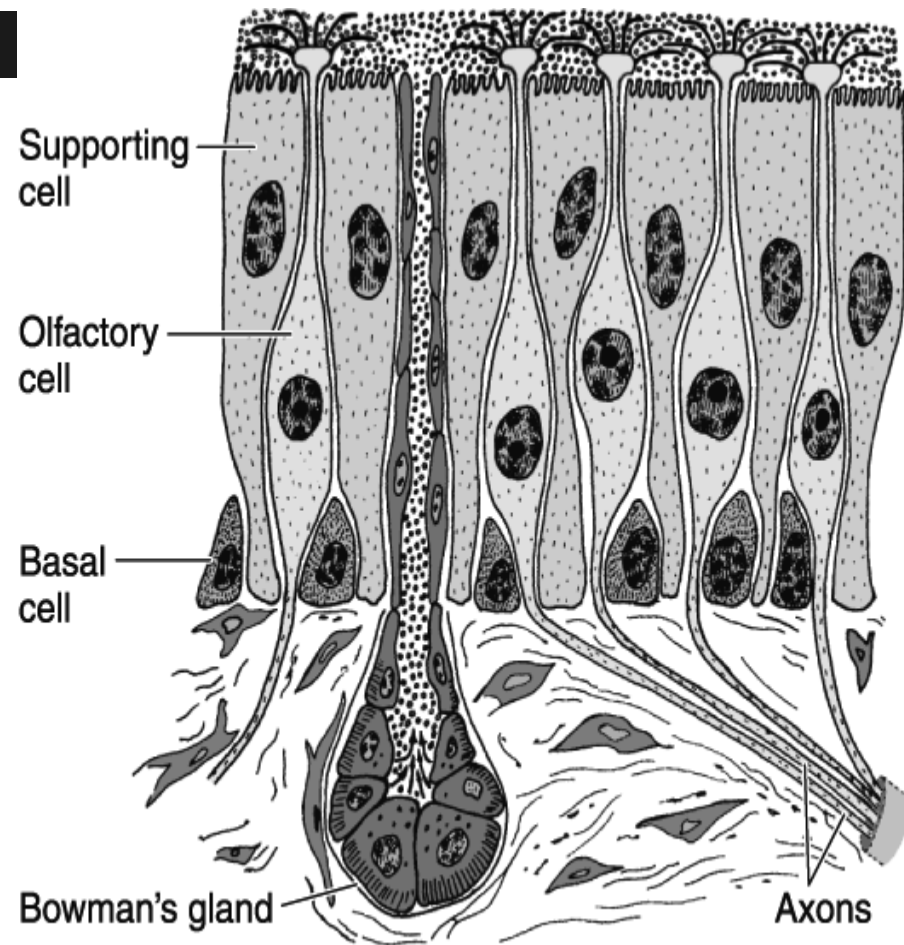
# The respiratory area

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



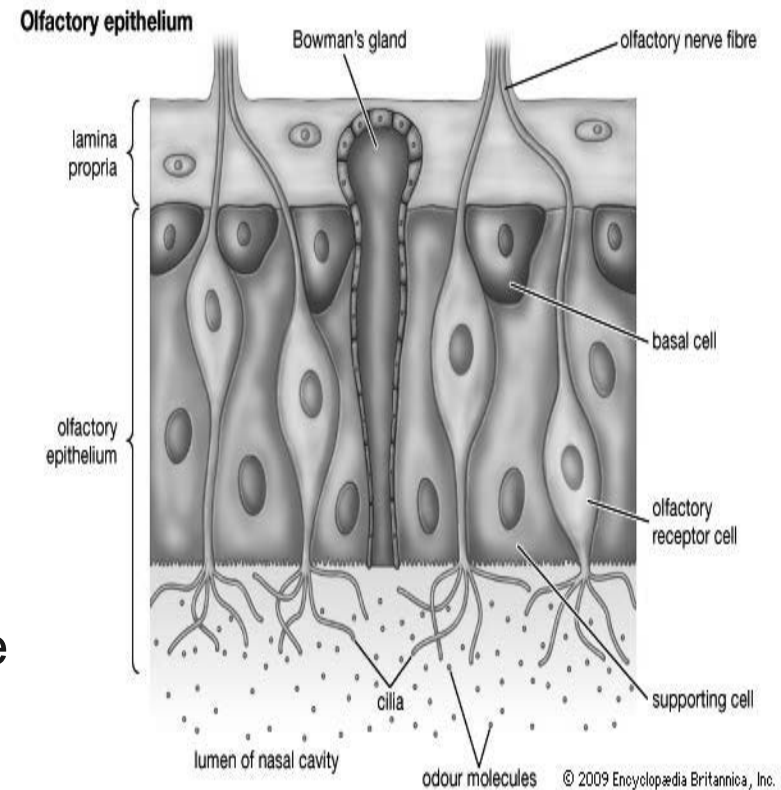
# Olfactory region

- 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



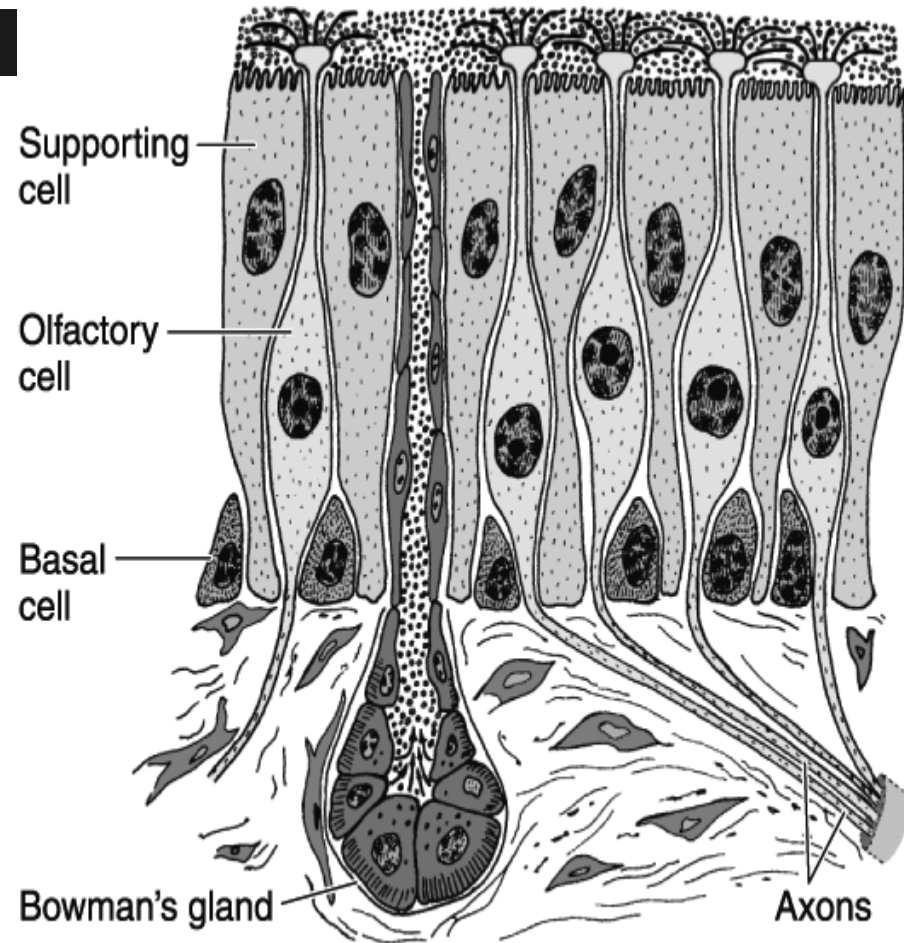


# Olfactory epithelium

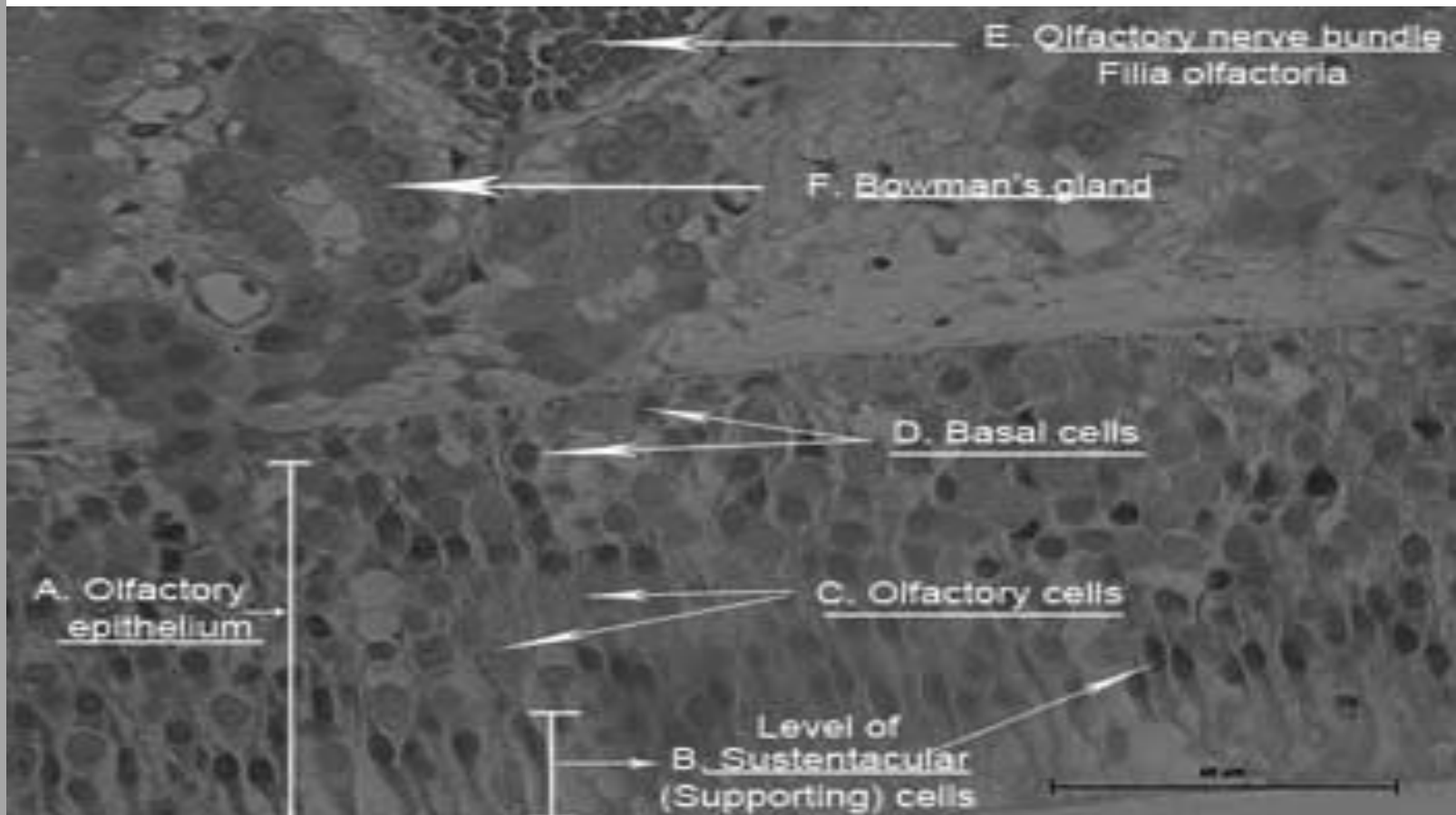
## 3. olfactory cells:

bipolar neurons

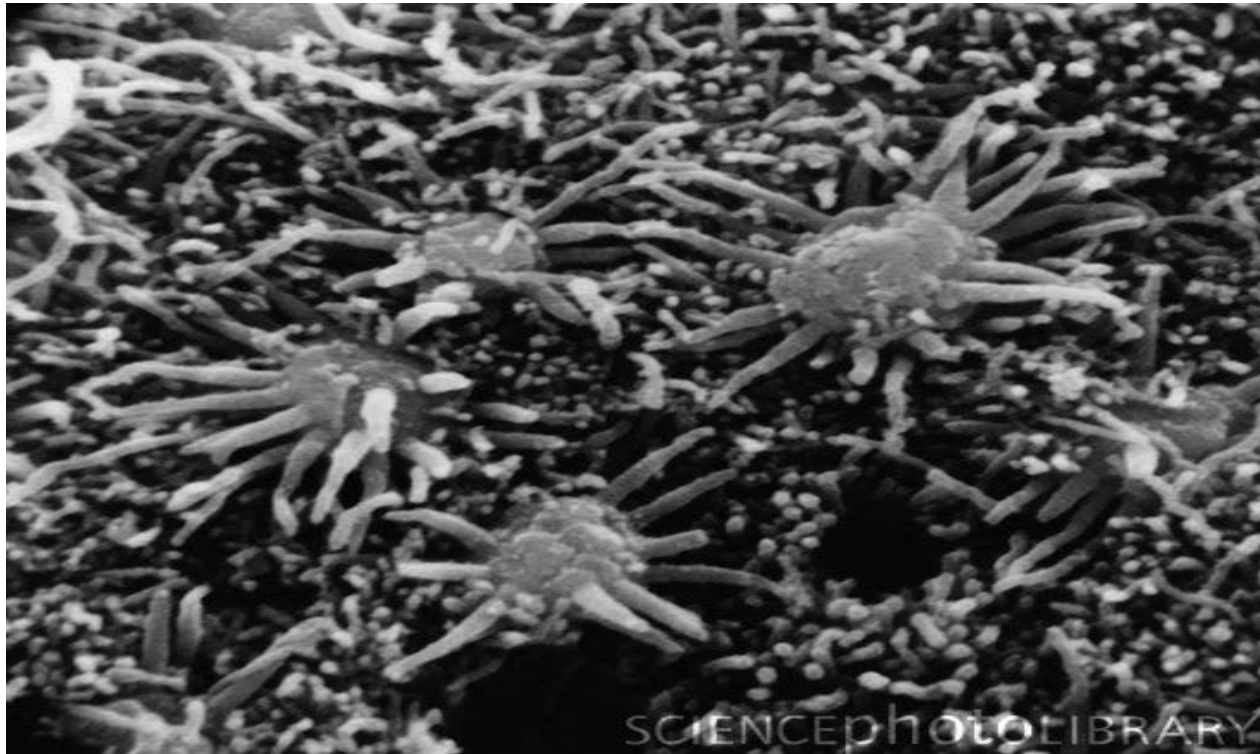
- Their nuclei lie below the nuclei of the supporting cells
- Cilia (nonmotile) rise from their apices (dendrites)
- Respond to odoriferous substances by generating a receptor potential
- Afferent axons of these bipolar neurons unite in small bundles, and synapse with the olfactory lobe.



# Olfactory epithelium

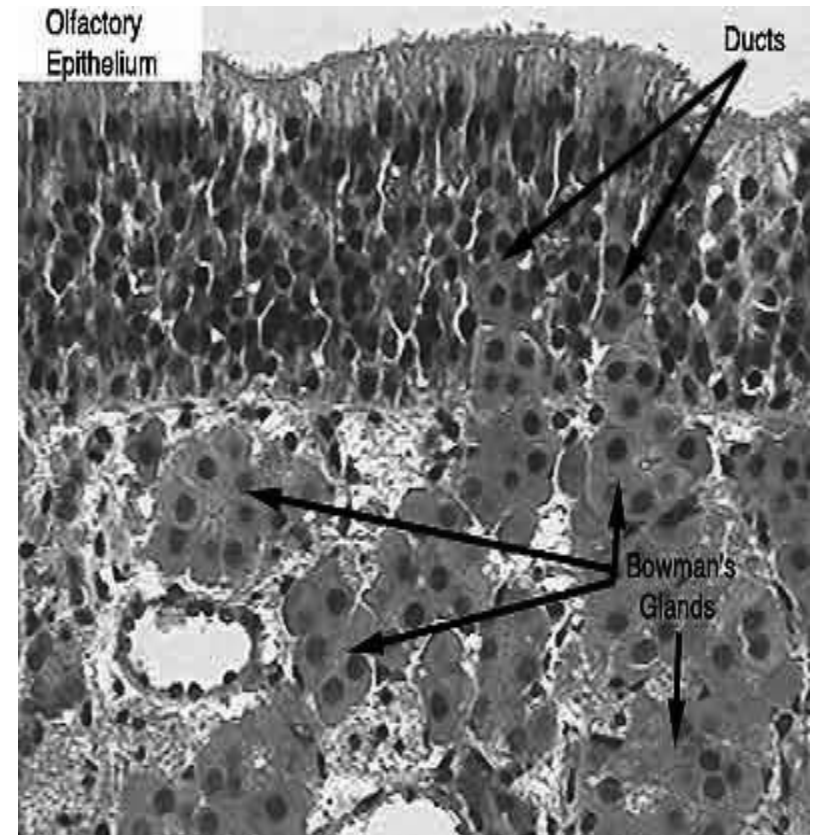


# Olfactory cells

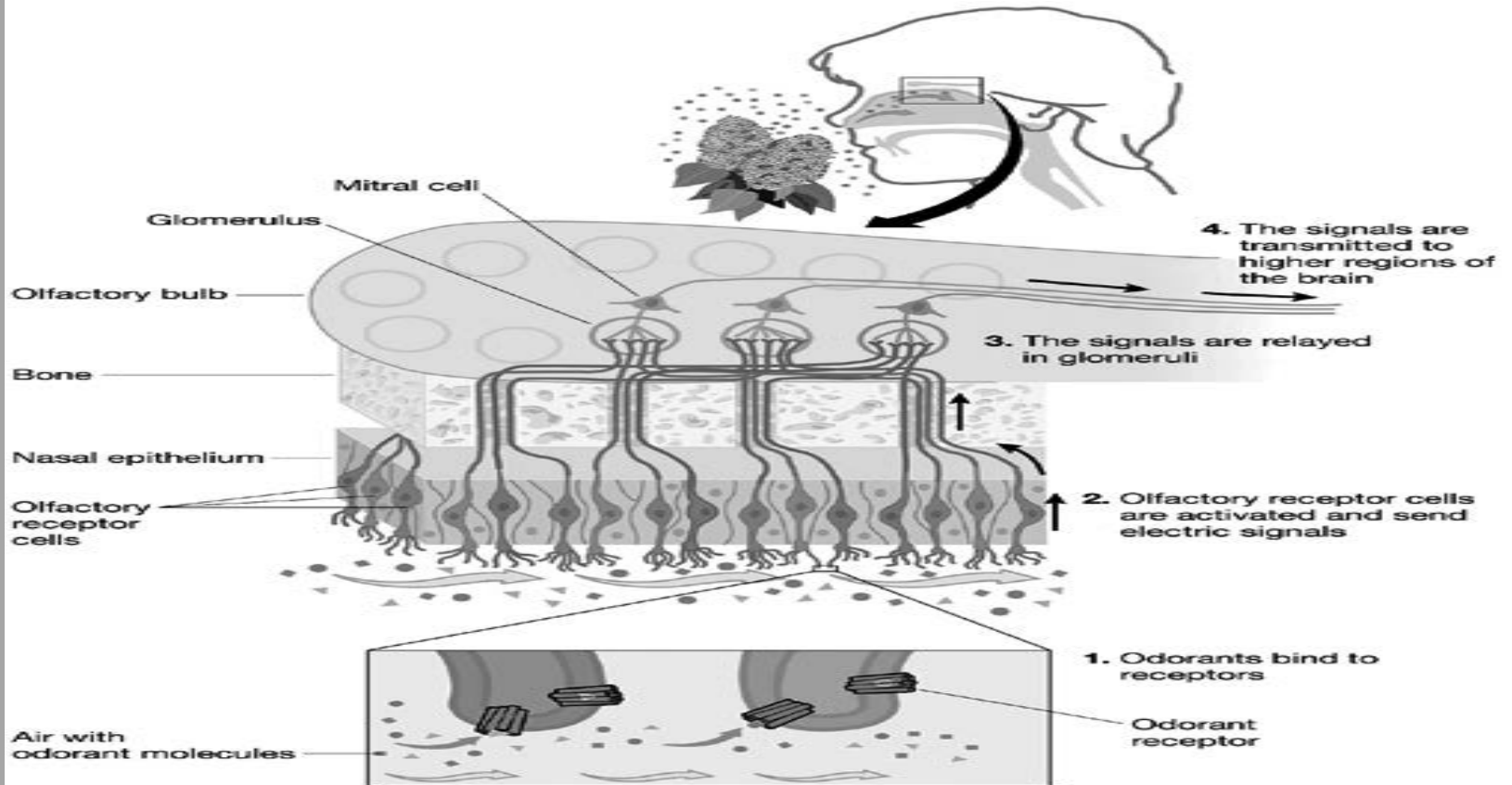


# lamina propria

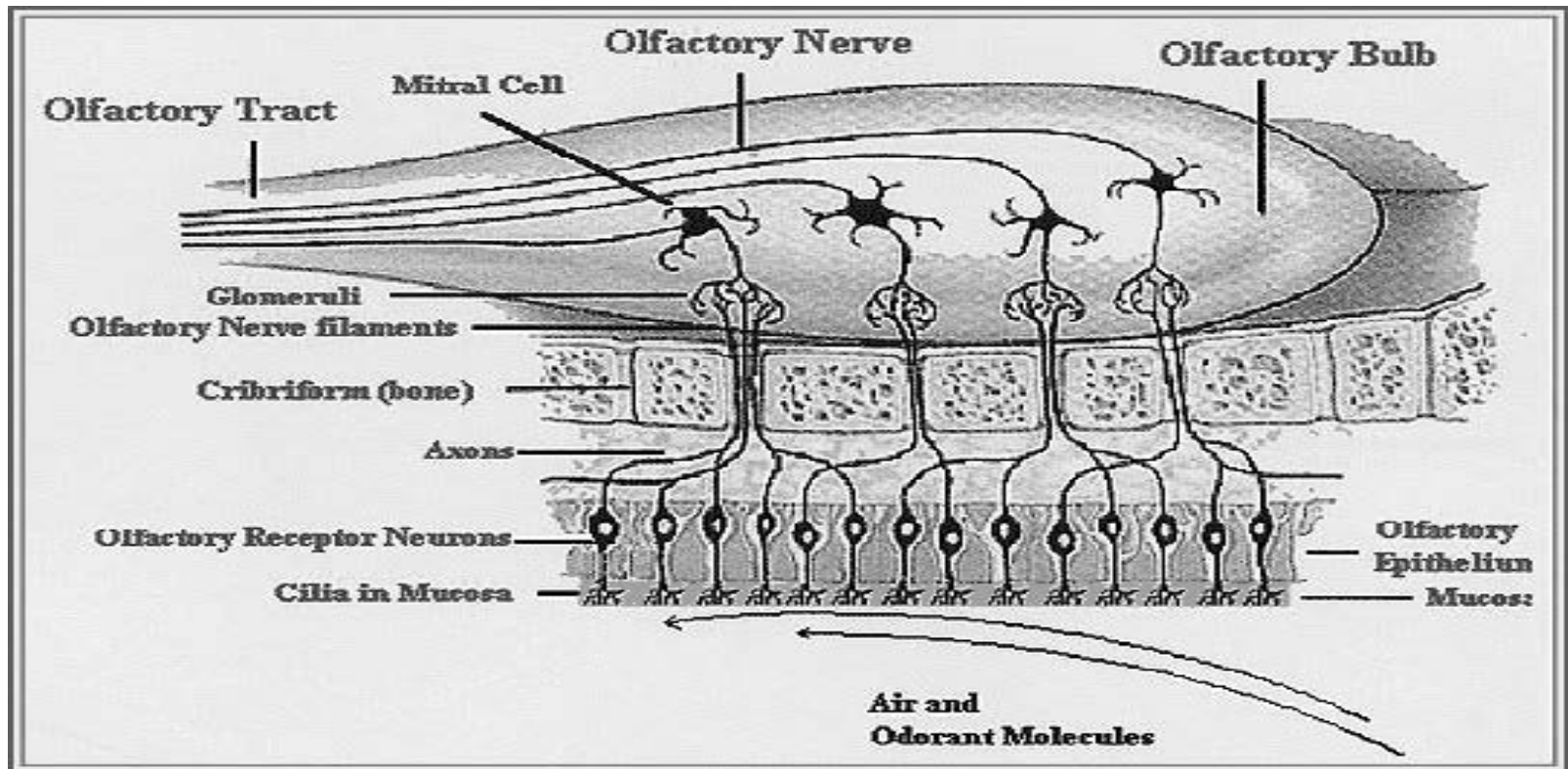
- **Corium** (lamina propria) is rich in blood vessels.
- Contains **Bowman's gland** that secretes watery mucous
- Facilitating the access of new odoriferous substances.



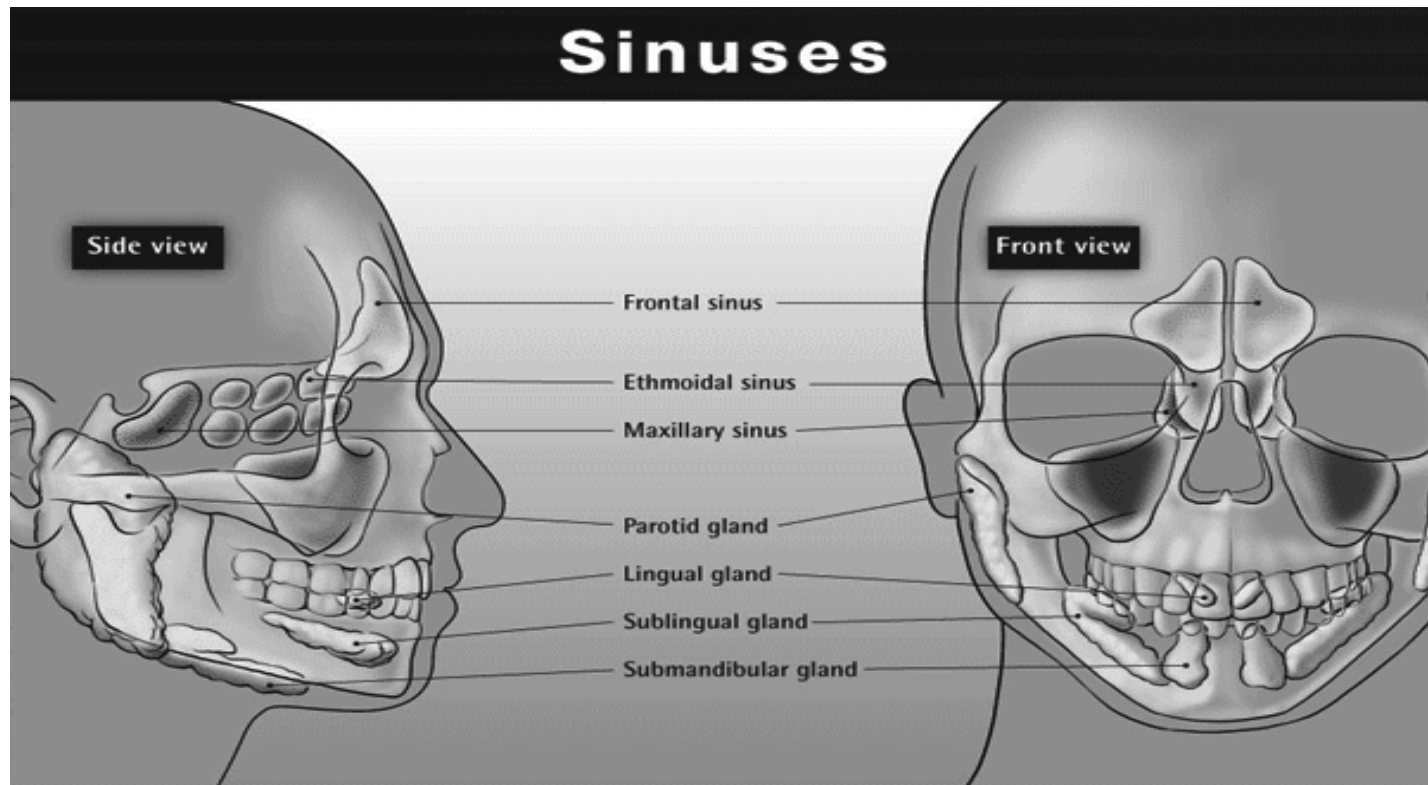
# Olfaction



# Olfaction

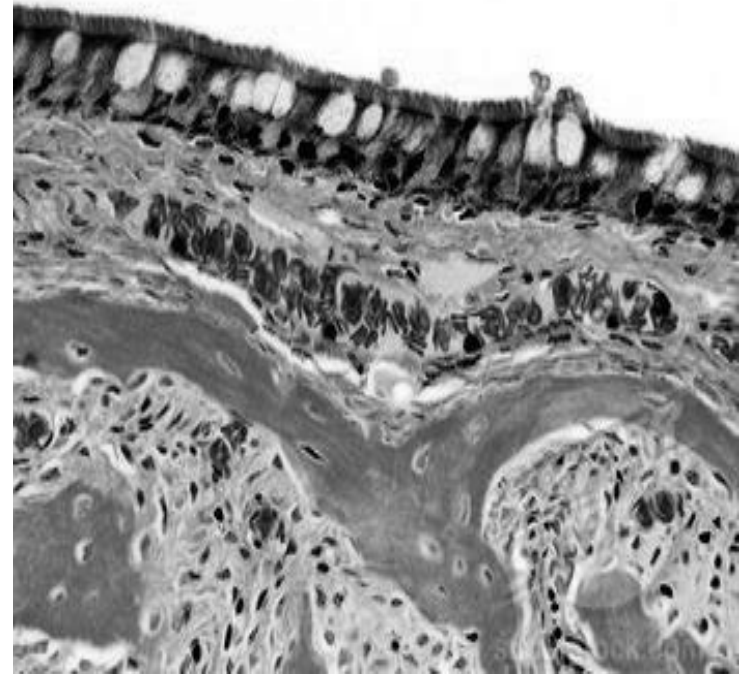


# Nasal Sinuses



# 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



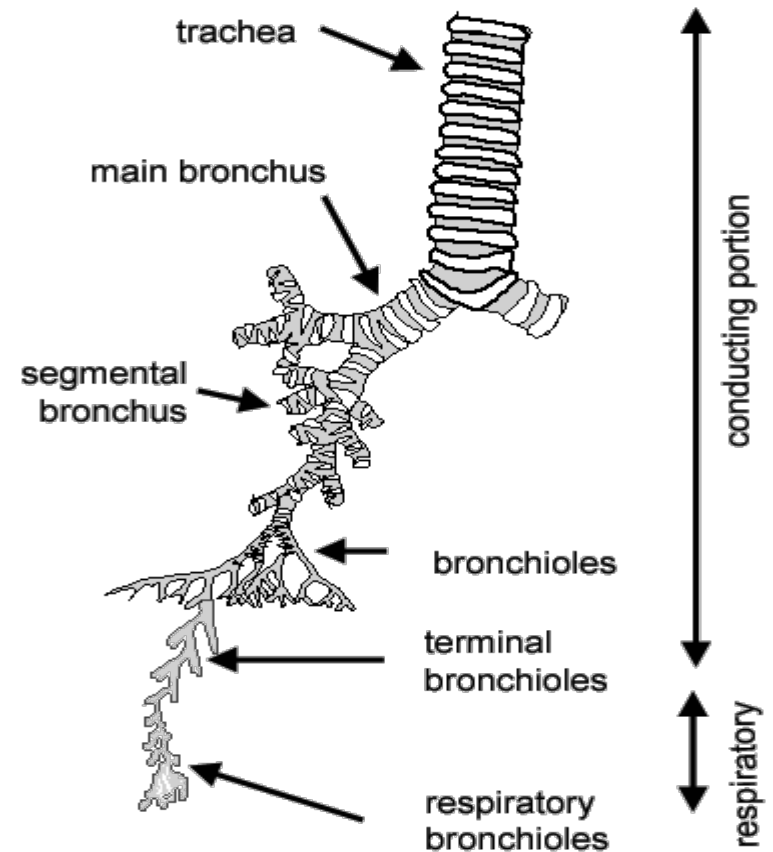


# The Bronchial Tree



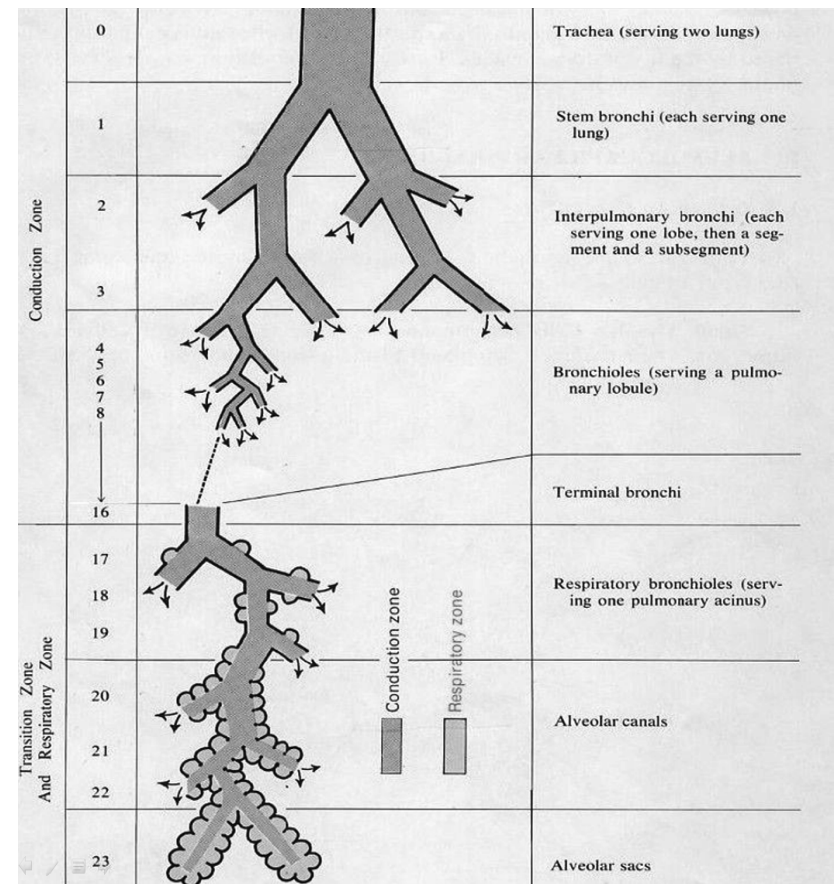
# Structural changes in the bronchial tree

- 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



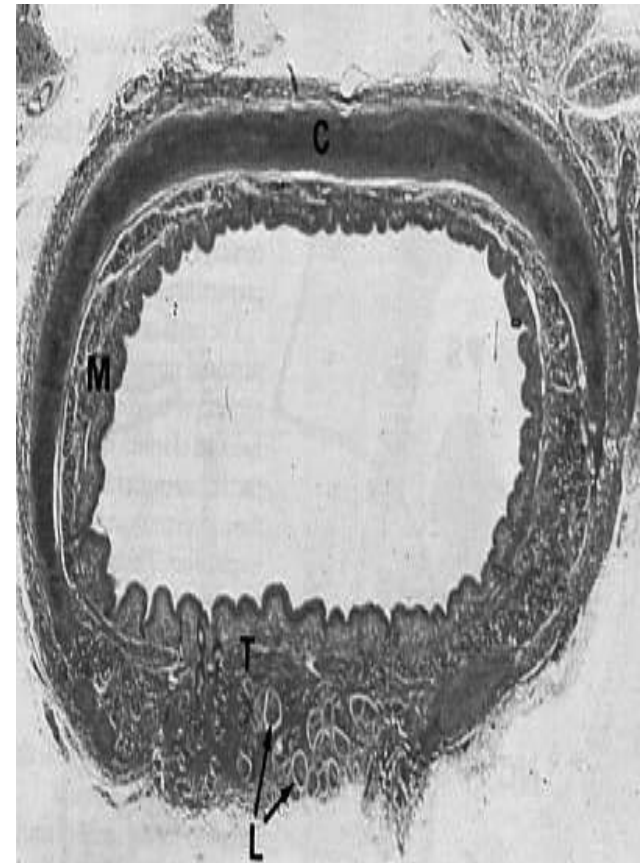
# Structural changes in the bronchial tree

- 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)



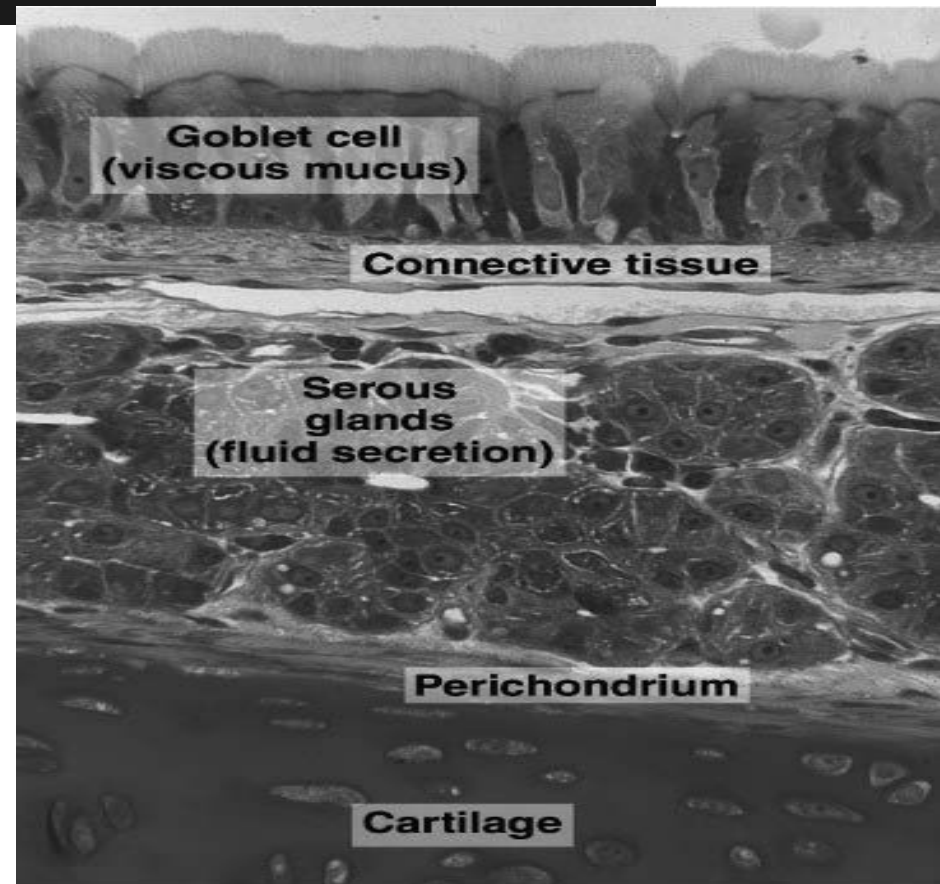
# Trachea

- 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



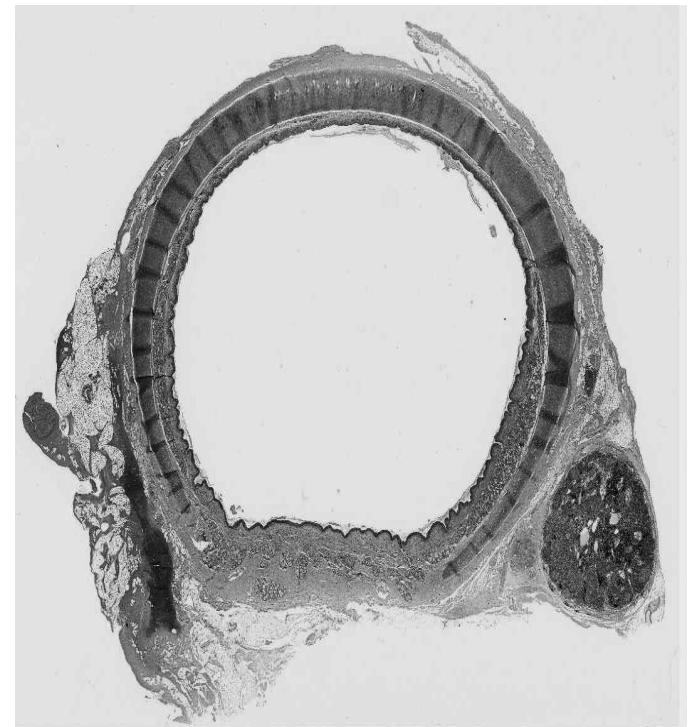
# Trachea

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



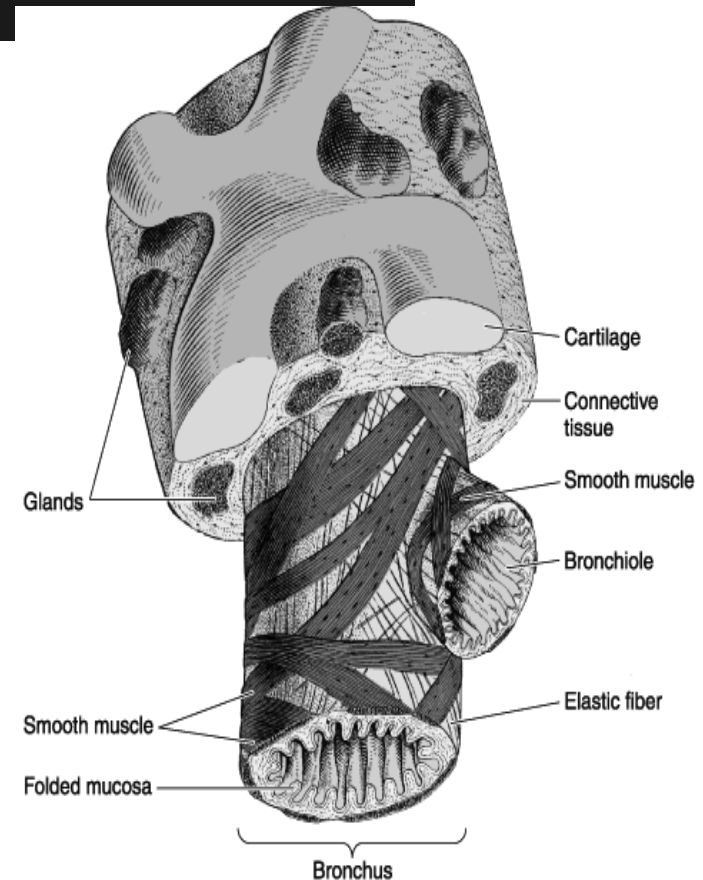
# Trachea

- 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**



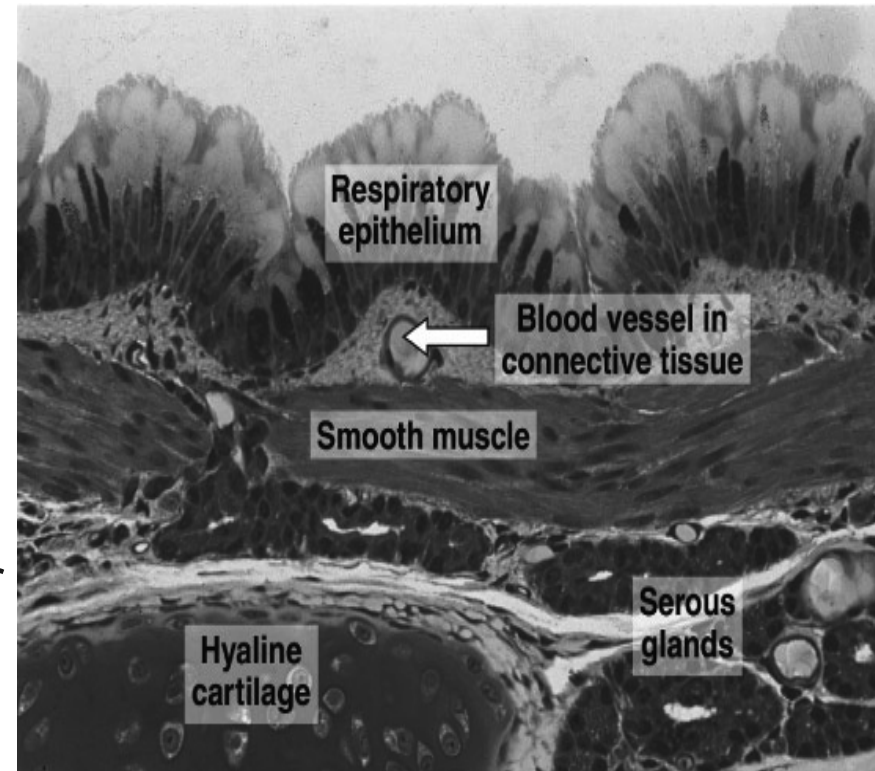
# Bronchi

- 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

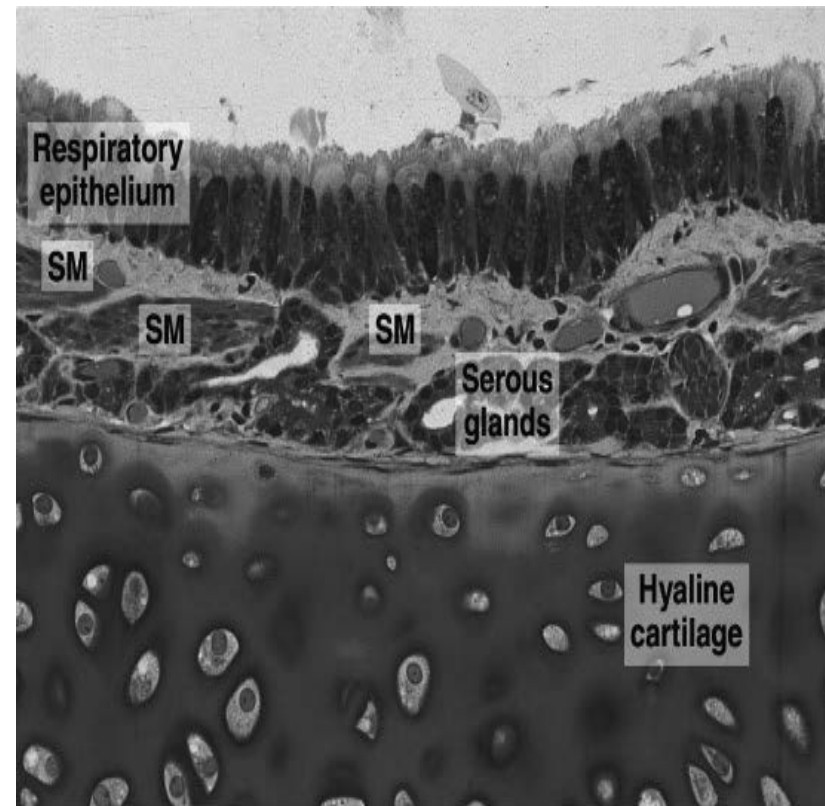
- 1. narrower lumen (small bronchus 5mm or less)
- 2. irregular bronchial cartilage plates
- 3. smooth muscle layer consisting of **spirally arranged bundles** between the lamina p. and submucosa
- Contraction of this muscle layer is responsible for the folded appearance of the bronchial mucosa





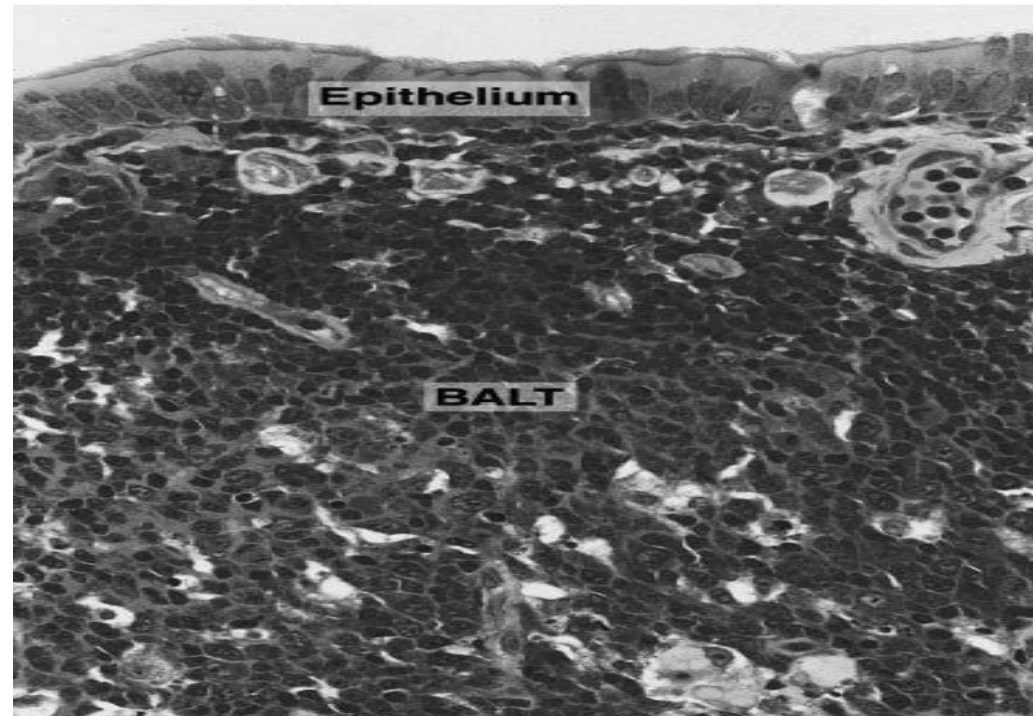
# Differences between the trachea and bronchi

- 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)



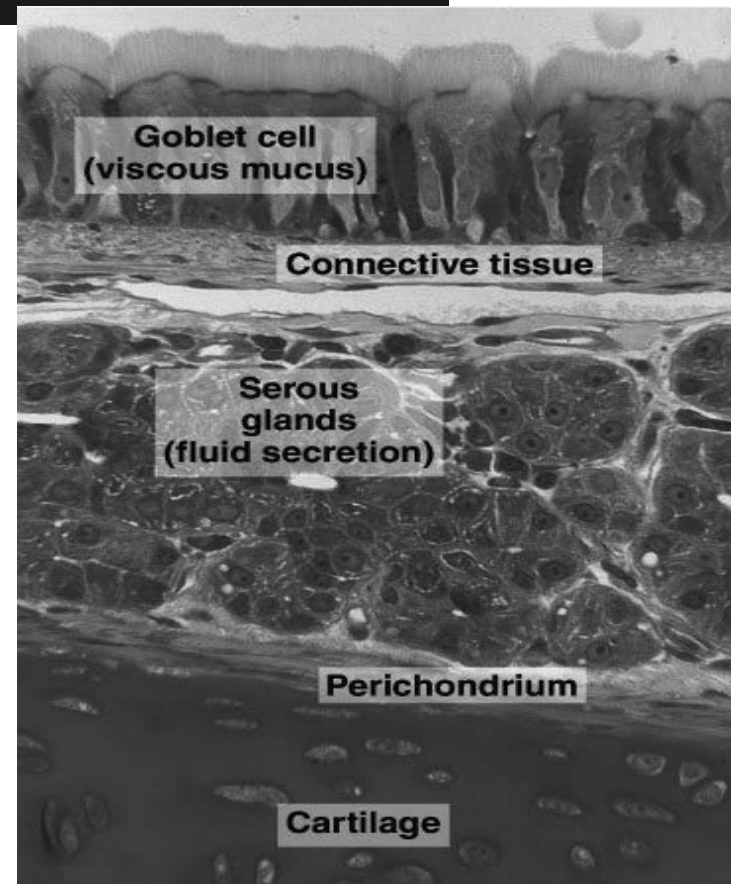
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# **Structural changes in the conducting portion of the respiratory tract**



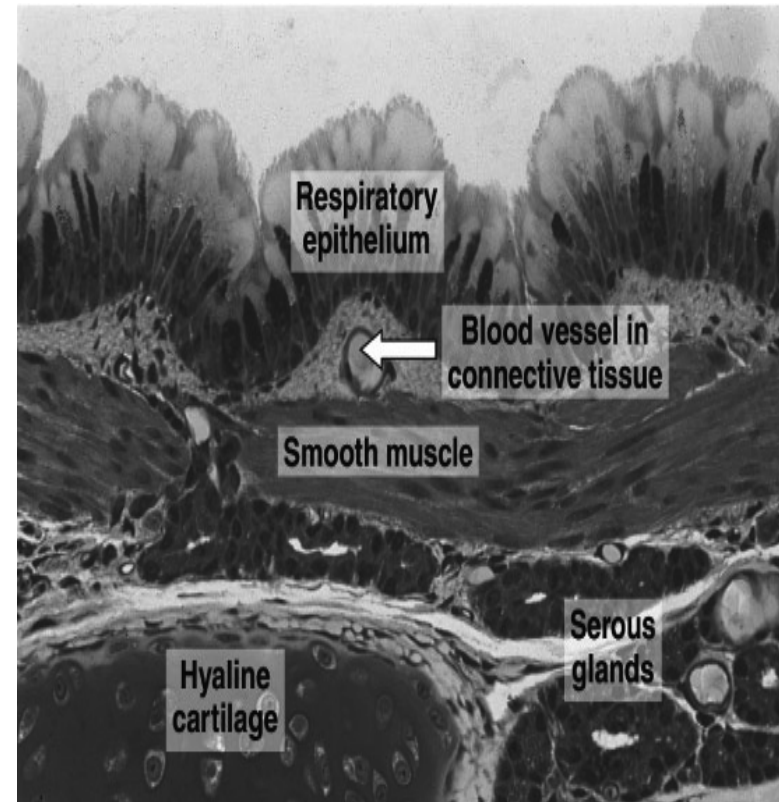
# Extra-pulmonary bronchi

- **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



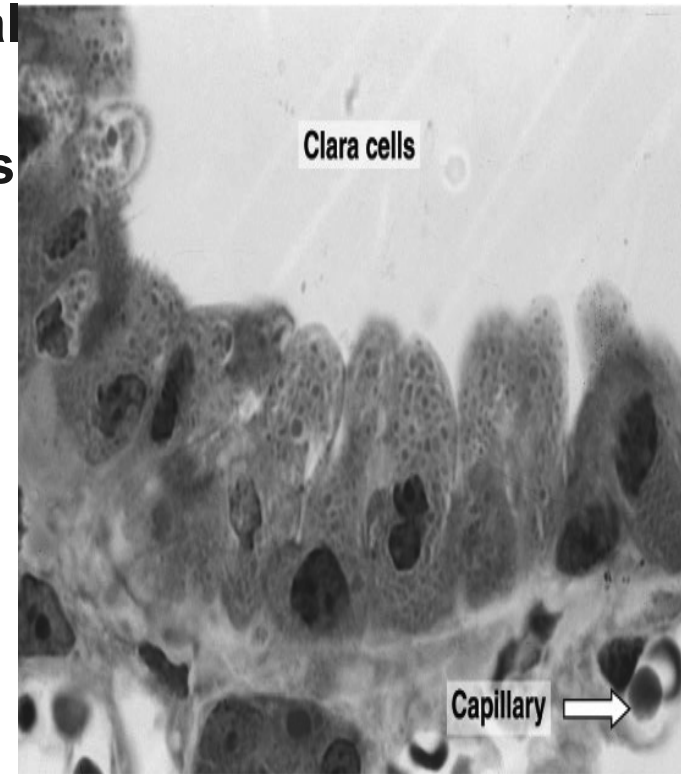
# Intrapulmonary bronchi

- **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)

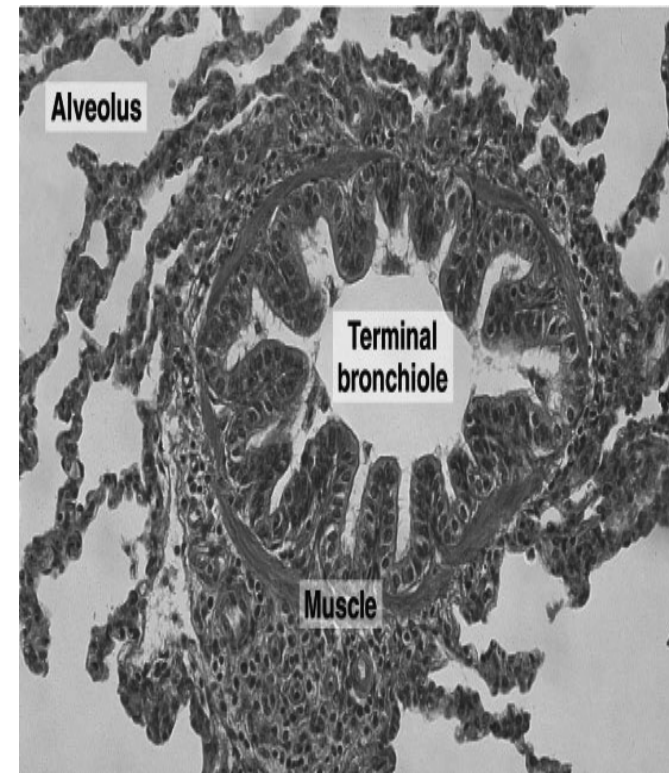
- **Ciliated columnar to ciliated cuboidal**
- **Goblet cells decrease and Clara cells appear**
- Spirals of **smooth muscle** relatively heavier than elsewhere (gradually decrease in amount)
- **No seromucous glands**
- **No cartilage**



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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.**



# 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