بسم الله الرحمن الرحيم

DOPAMINE SCIENTIFIC TEAM

HISTOLOGY

MID | Lecture 1

Histology of the Upper Respiratory Tract

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Zaid Bushnaq

Reviewed by: Abdulrahman Khw

﴿ وَلَقَدْ نَعْلَمُ أَنَّكَ يَضِيقُ صَدْرُكَ بِمَا يَقُولُونَ ﴿٩٧﴾ فَسَبِّحْ بِحَمْدِ رَبِّكَ وَكُن مِّنَ السَّاجِدِينَ ﴾

سبحان الله وبحمده، سبحان الله العظيم

وَلِلَّهِ الْأَسْمَاءُ الْحُسْنَى فَادْعُوهُ بِهَا

المعنى: الذي أحاط علمه بالأمور الدقيقة، والذي يوصل رحمته وخيره إلى عباده بالطرق الخفية.

٤١

الورود: ورد في القرآن (٧) مرات.

الشاهد: ﴿ وَهُوَ ٱللَّطِيفُ ٱلْخَبِيرُ ﴾ [الأنعام:١٠٣].

اضغط هنا لشرحٍ أكثر تفصيلًا

The Respiratory System

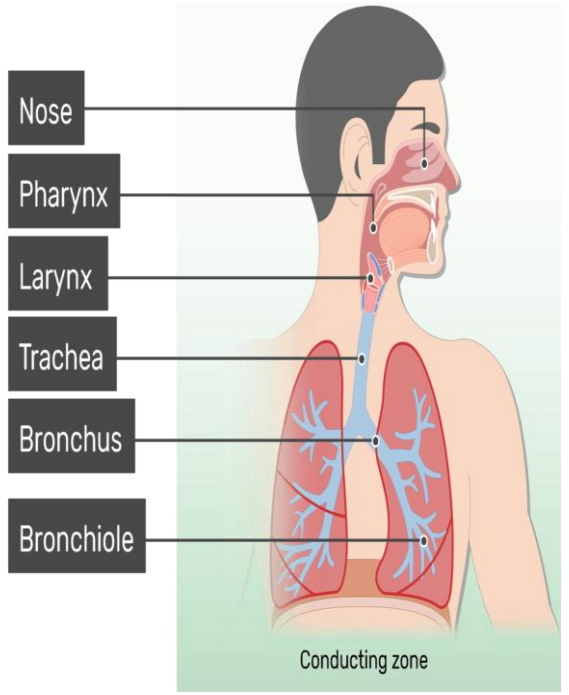
The slides are arranged slightly differently from the doctor’s explanation, but everything is there.

1- Respiratory System Parts

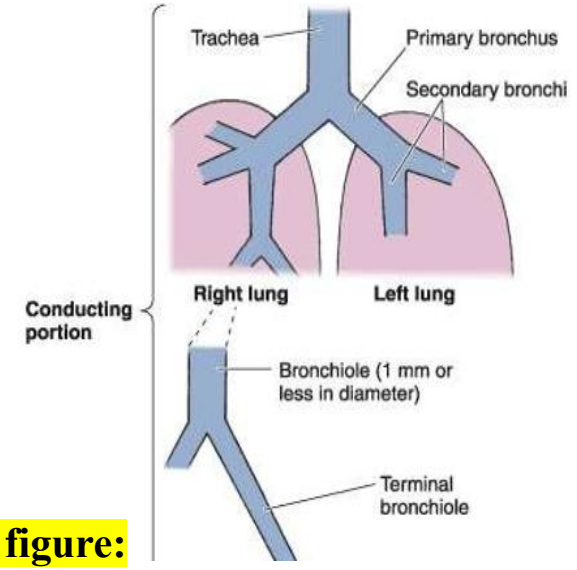
- The respiratory tract is divided into 2 parts:

1. Conduction portion:

- **Parts:**
  - **Nasal cavity** (Nose) → **Pharynx** (Nasopharynx) → **Larynx** → **Trachea** which then divide into right & left main bronchus (**primary bronchi**) → **Secondary bronchi** (lobar bronchi; 3 on the right, 2 on the left) → 10 bronchopulmonary segments (**Tertiary bronchi**) on right and left side → **bronchiole** which is divided into large conduction and terminal bronchiole.
  - **Terminal bronchiole** is just before the respiratory portion. Contain no cartilage, no glands and no goblet cells, the epithelium is simple cuboidal with or **without cilia (Clara cells).**



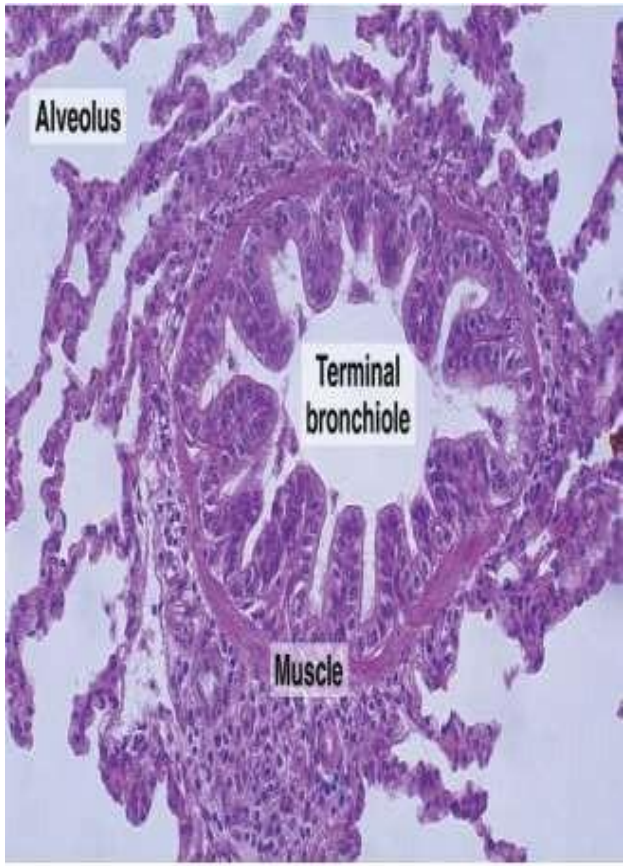
Dr.'s figure:



1- Respiratory System Parts

➢ Bronchiole:

- Compared with other parts of the respiratory tract, bronchioles have a **narrower diameter**.
- The pseudostratified columnar epithelium gradually changes into **simple cuboidal epithelium** with **few goblet cells**.
- **Contain no cartilage**.
- Have **more smooth muscles** than other parts, arranged in spiral and helical patterns around the lumen.
- Because of the absence of cartilage and the presence of abundant spiral/helical smooth muscles, bronchioles are especially affected in **asthma**. Smooth muscle contraction leads to narrowing of the lumen, causing wheezing, particularly during expiration.



Dr.'s figure:

1- Respiratory System Parts

➢ Clinical correlation:

- The presence of 10 bronchopulmonary segments in each lung provides a significant surgical advantage.
- In the past, **lung cancer** was commonly treated by **lobectomy**, which involved removal of an entire lobe. Currently, treatment has shifted toward **segmentectomy**, in which only the affected segments are removed.
- Each bronchopulmonary segment is anatomically independent, being surrounded by connective tissue and supplied by its own bronchi, blood vessels, lymphatics, and nerves.

1- Respiratory System Parts

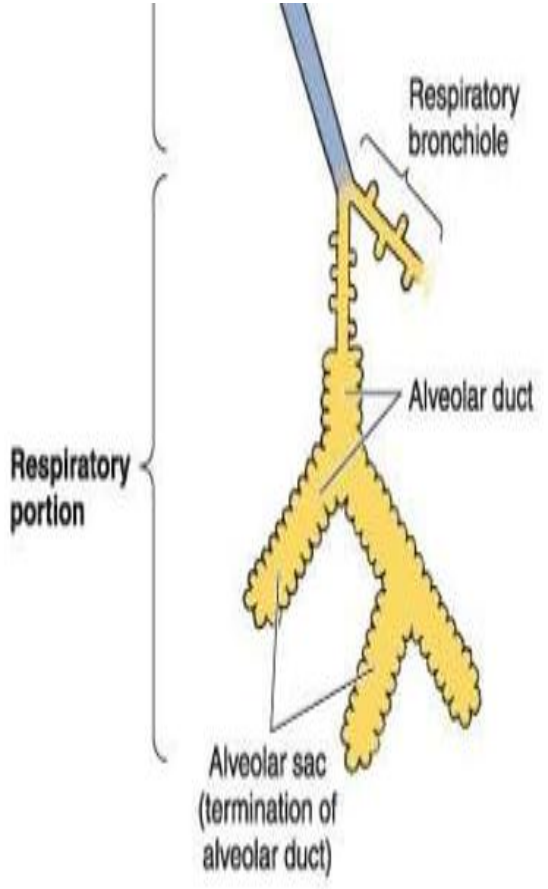
➢ Function of the Conduction portion:

1. Passage (transmission) of air.
2. Cleaning, moistening and warming of air:
   - **Cleaning:** occurs in the nasal vestibule by vibrissae (thick hairs) that filter particles, aided by the outward movement of cilia.
   - **Moistening:** Achieved by seromucous gland secretions, which moisten the air and trap bacteria.
   - **Warming:** Provided by the rich venous plexus in the submucosa, which also protect the brain from cold air.

1- Respiratory System Parts

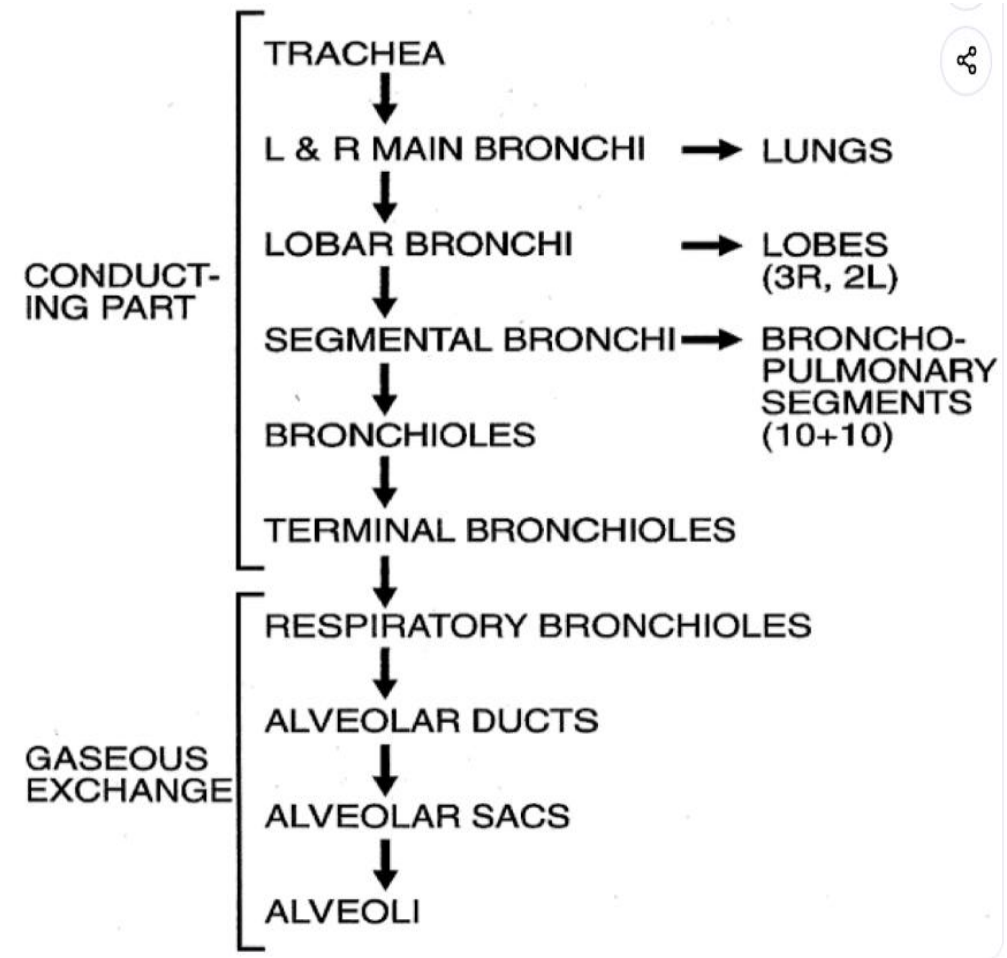
2. Respiratory portion:

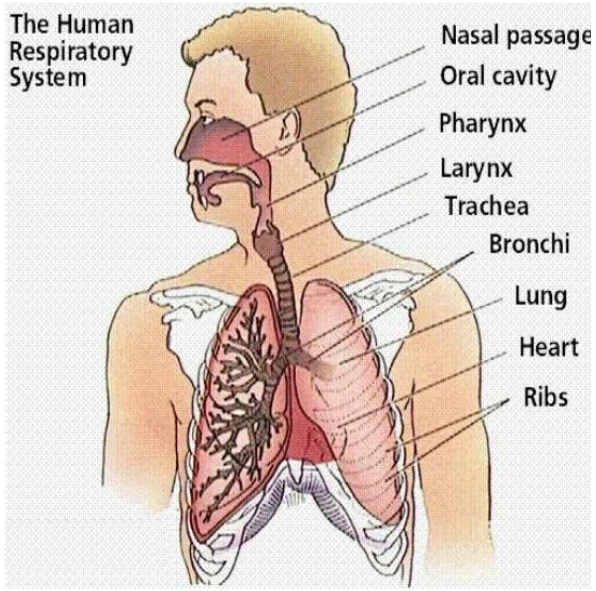
- **Parts**: begin as **Respiratory bronchiole** (Narrower than terminal bronchiole) → open into **alveolar duct** → ends **as alveolar sac.**
- **Alveoli** surround alveolar duct, respiratory bronchiole and alveolar sac.
- **Function:** Gas exchange in the alveoli.
- Lined by **simple squamous epithelium**.
- There are millions of alveoli in each lung, every one is surrounded by a **network of capillaries**; because it is responsible for gas exchange.

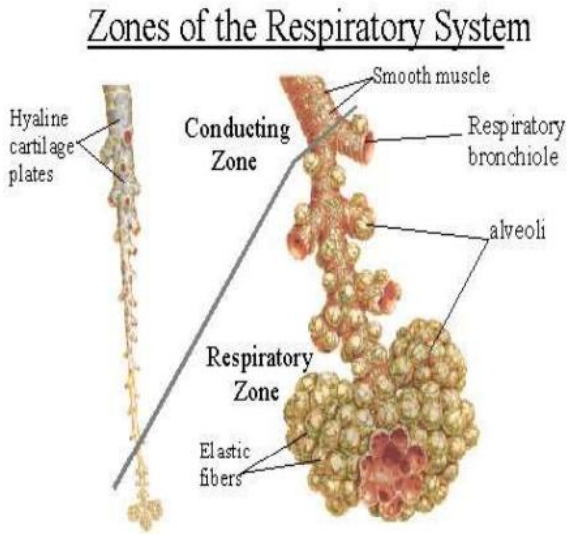


Dr.'s figure:

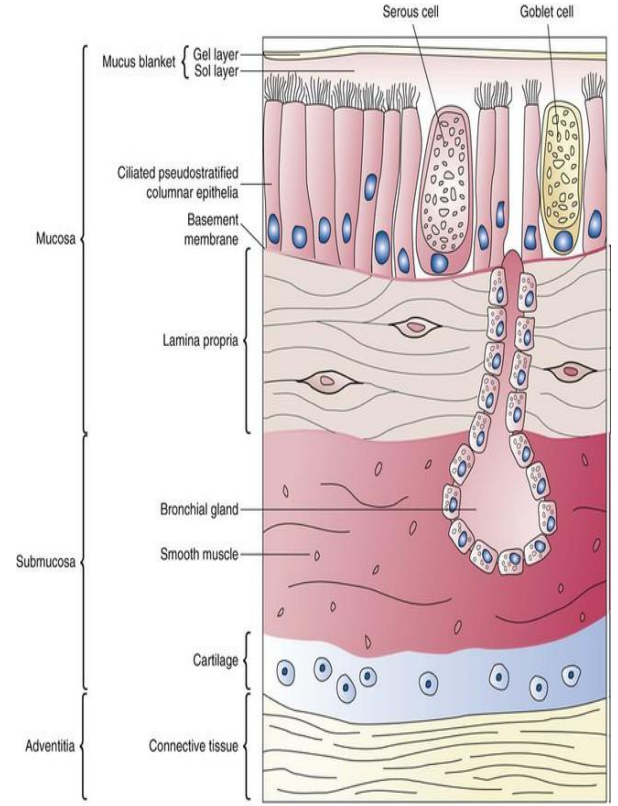
Dr.'s figures:


TRACHEA
L & R MAIN BRONCHI
LUNGS
LOBAR BRONCHI
LOBES (3R, 2L)
SEGMENTAL BRONCHI
BRONCHO-PULMONARY SEGMENTS (10+10)
BRONCHIOLES
TERMINAL BRONCHIOLES
RESPIRATORY BRONCHIOLES
ALVEOLAR DUCTS
ALVEOLAR SACS
ALVEOLI
CONDUCT-ING PART
GASEOUS EXCHANGE


The Human Respiratory System
Nasal passage
Oral cavity
Pharynx
Larynx
Trachea
Bronchi
Lung
Heart
Ribs

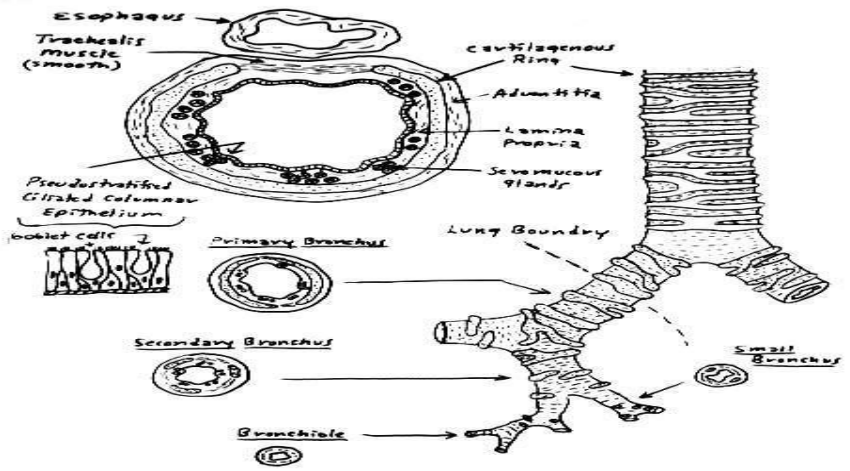

Zones of the Respiratory System
Hyaline cartilage plates
Conducting Zone
Smooth muscle
Respiratory bronchiole
alveoli
Respiratory Zone
Elastic fibers

2- Respiratory System layers



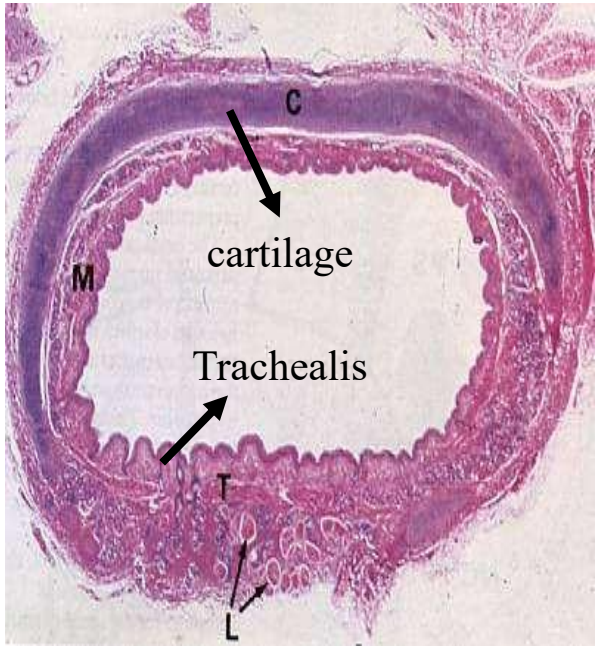
Layers of the respiratory tract:

- **Mucosa:**
  - **Lining epithelium:** pseudostratified ciliated columnar with goblet cells *(except in bronchioles as mentioned before)*.
  - **Lamina propria:** has no or very few glands, In contrast to GI tract which has an abundance
  - **Muscularis mucosa.**
- **Submucosa:**
  - **Seromucous glands**, whose **ducts open into the lumen**.
- **Supportive layer:** *(muscular layer in GI)*
  - **Smooth muscles.**
  - **Hyaline cartilage:** keeps the airway patent for the passage of air.
- **Adventitia.**
  - Connective tissue layer.



Dr.'s figure:

3- Supportive layer



Dr.'s figures:

➢ **Hyaline cartilage distribution:**

- **Trachea:** the cartilage is C-shaped and absent posteriorly. The posterior gap is bridged by the trachealis smooth muscle **(why?); esophagus** is posterior to it which has peristaltic movement and permits descending of the bolus.
- **Primary, secondary and tertiary bronchi**: plates of cartilage (small pieces of hyaline cartilage), these plates become fewer as we go distally (become 2 or plates), Primary (highest).

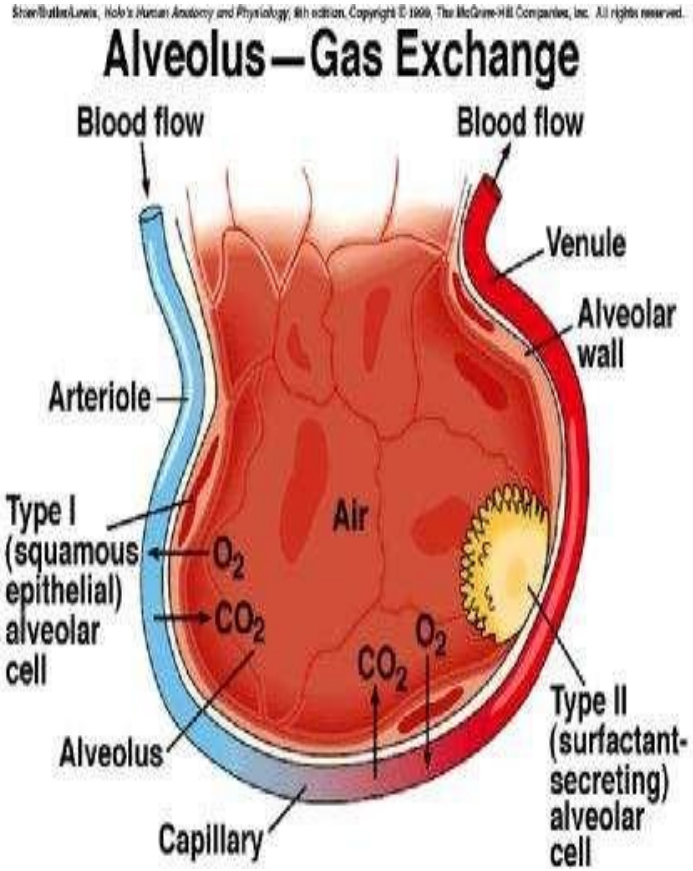
➢ **Smooth muscles:**

- Increase in number as we go distally, bronchiole (highest).

4- Gas exchange

➢ Alveolus:

- It has 2 type of cells:
  - Type 1 (97%).
  - Type 2 (3%).
- Gas exchange occur in **type 1 cells** of the alveolus.
- **Type 2 cells** are:
  - Cuboidal cells
  - Secrete **surfactants**: decrease surface tension in the alveolus, which help in inflation of the alveolus
- Only a small portion of the capillary make a very thin membrane with the alveolus (*respiratory membrane/ blood-air barrier*), which consist of:
  - Endothelial cell wall (Capillary).
  - Type 1 alveolar cell wall (Alveoli).
  - Fused basal lamina (basement membrane of both capillary and alveoli) .

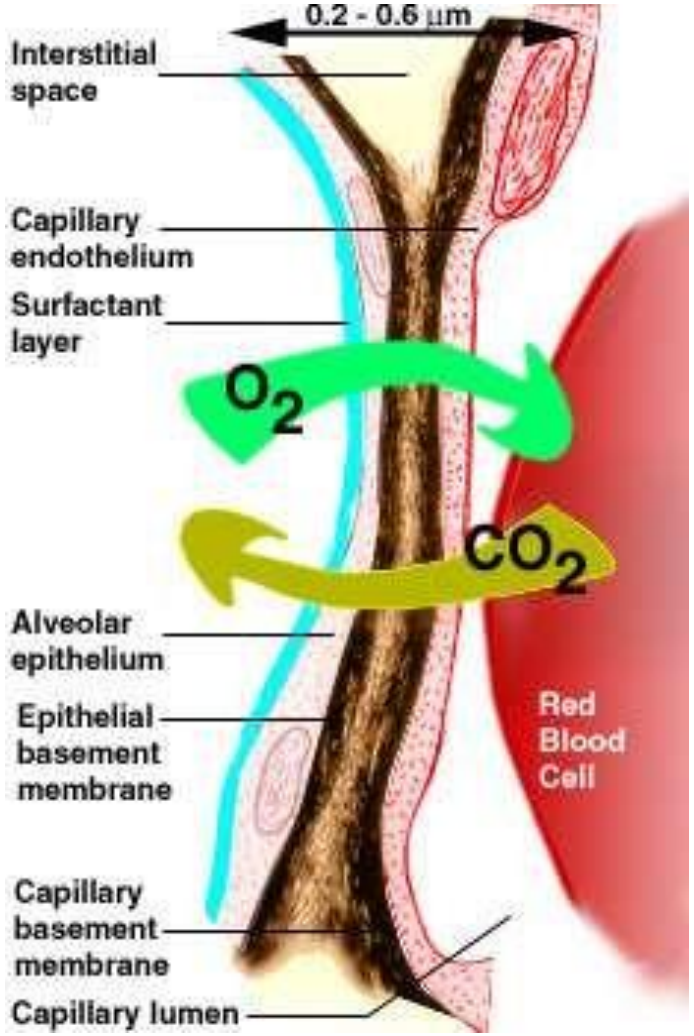


Dr.'s figure:

4- Gas exchange

➢ Gas Exchange process:

1. **Pulmonary Arterioles** carry **deoxygenated blood** to the lungs.
2. **Gas exchange** occur between **type 1 cells** and capillary **endothelial cells** (simple squamous).
3. **CO_2** diffuses into the alveoli, while **O_2** diffuses into the blood so that the venule contain blood with 100% oxygen saturation.
4. **The resulting oxygenated blood** is collected by pulmonary venules, which merge to form the 4 **pulmonary veins** leaving the lungs



Dr.'s figure:

4- Gas exchange

- **Relate to the CVS:**
  - **Blood pass through:** Right atrium → Right ventricle → Pulmonary arteries → Pulmonary arterioles → Capillary (Gas exchange) → Pulmonary venules → Pulmonary veins → Left atrium → Left ventricle → Ascending aorta → Arch of aorta → Descending aorta → All cells of the body.
- **Relate to the HLS:**
  - Red blood cells contain **hemoglobin**, which carries oxygen and reflects the power of blood (oxygen-carrying capacity of blood). Normal hemoglobin levels vary by sex: males 14–16 g/dL and females 12–14 g/dL.

4- Gas exchange

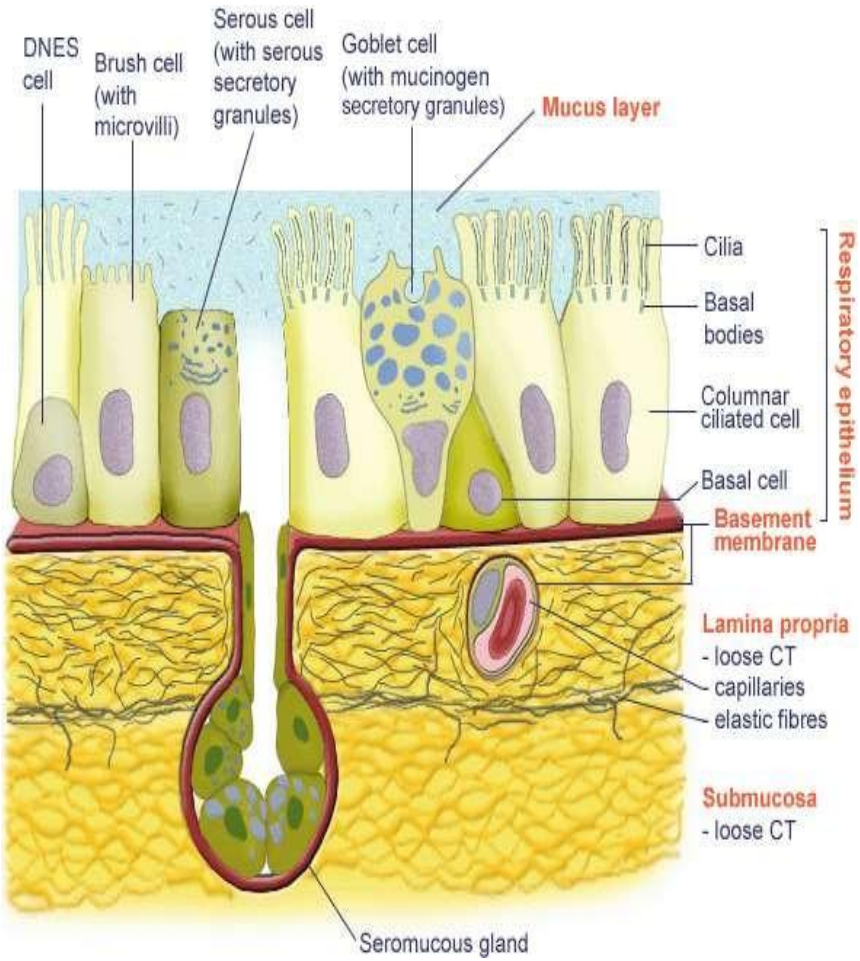
➢ **Clinical correlation:**

- After birth, doctors must assess the level of pulmonary surfactant, which is essential for proper lung inflation.
- **Fetal oxygenation**:
  - **Before birth**, the embryo receives oxygen through maternal blood. **After birth**, the newborn must initiate breathing. **To stimulate this**, doctors may gently tap the back or legs, triggering sensory impulses that reach the **respiratory center** in the brain. This center then sends motor impulses to the **diaphragm**, causing it to descend, which **reduces intrathoracic pressure** and allows air to rush into the lungs.
  - The baby's first cry indicates that the lungs are filled with air. Insufficient surfactant can lead to **respiratory distress syndrome**, where the newborn struggles to breathe

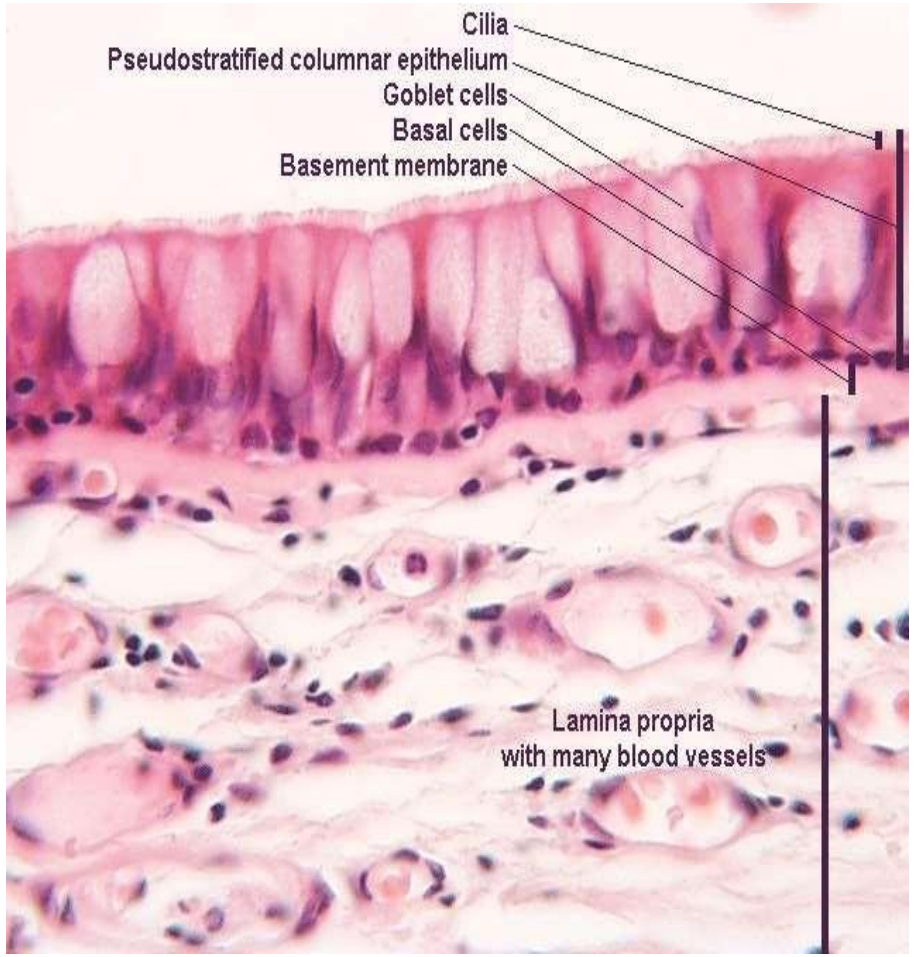
5- Reparatory epithelium

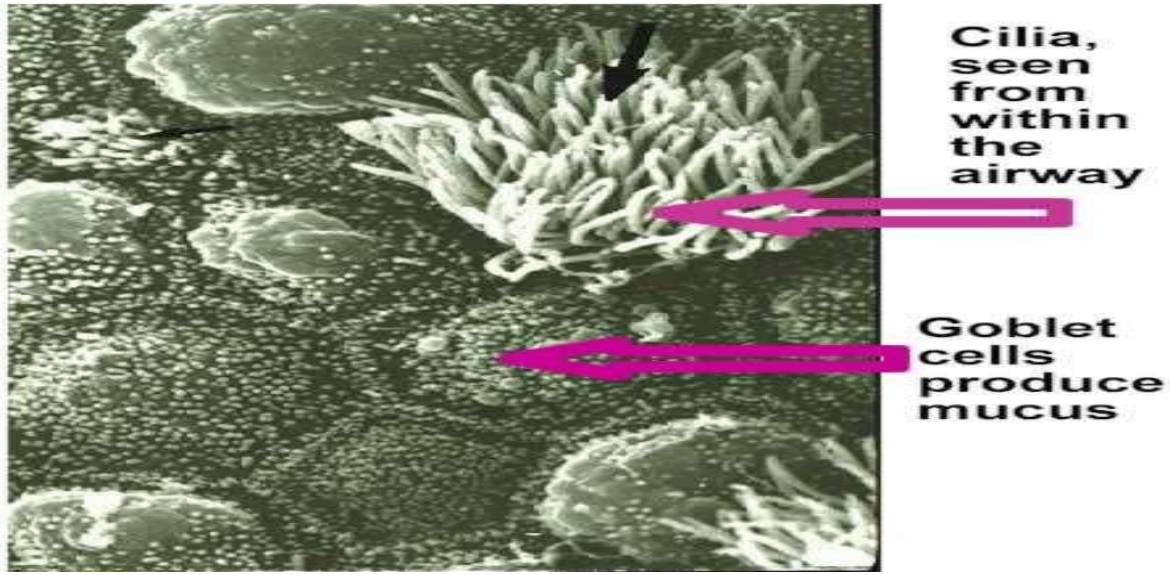
➢ Respiratory epithelium:

- It is lined by pseudostratified ciliated columnar epithelium and contains **goblet cells**, which can be seen under the light microscope. It also has a **thick basement membrane.**
- In addition to goblet cells, four other cell types *(so 5 type of cells in total)* can be identified by **electron microscopy**:
  - **Basal cells**: Located on the basement membrane and do not reach the epithelial surface; they act as reserve (stem) cells and undergo mitosis.
  - **Brush cells:** Characterized by microvilli on their apical surface and has sensory receptors.
  - **Serous cells:** Contain secretory granules.
  - **Diffuse neuroendocrine (DNES)/ granular cells:** Also called Kulchitsky cells; they regulate secretory functions.



Dr.'s figure:


Cilia
Pseudostratified columnar epithelium
Goblet cells
Basal cells
Basement membrane
Lamina propria
with many blood vessels


Cilia, seen from within the airway
Goblet cells produce mucus

Dr.'s figures:

5- Reparatory epithelium

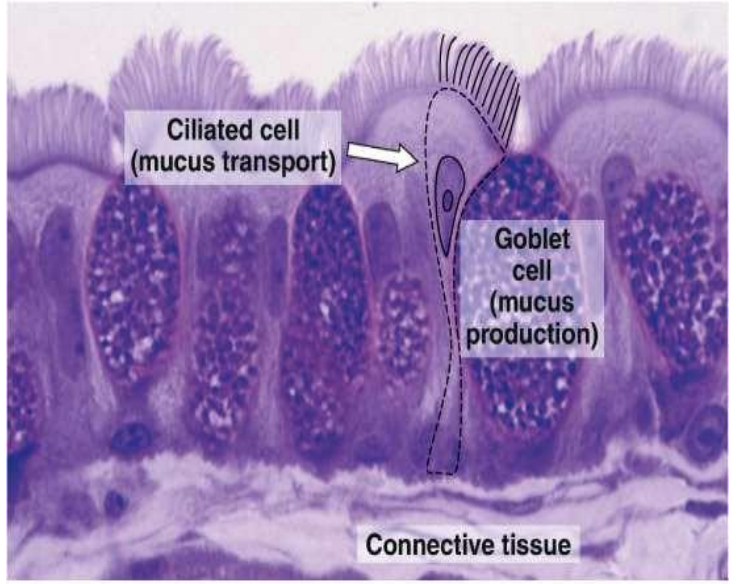
➢ **Pseudostratified columnar cells:**

- Most abundant cells.
- Each cell has about 300 cilia on its apical surface.
- Provide Outward movement in one direction.
- Contains:

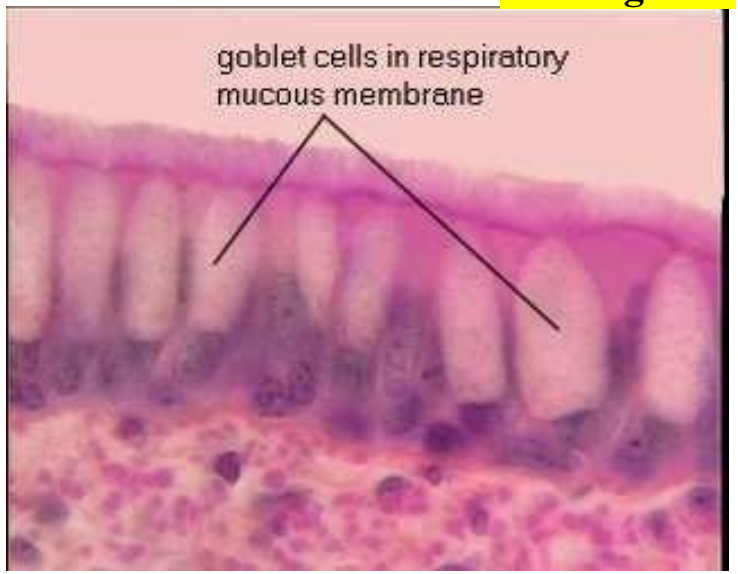
1. **Basal body:**
   - Attached to the columnar cells.
   - located at the base of cilia.
2. **Apical mitochondria:**
   - Below the basal body.
   - Large in number.
   - Provide the energy (ATP) for cilia motility.

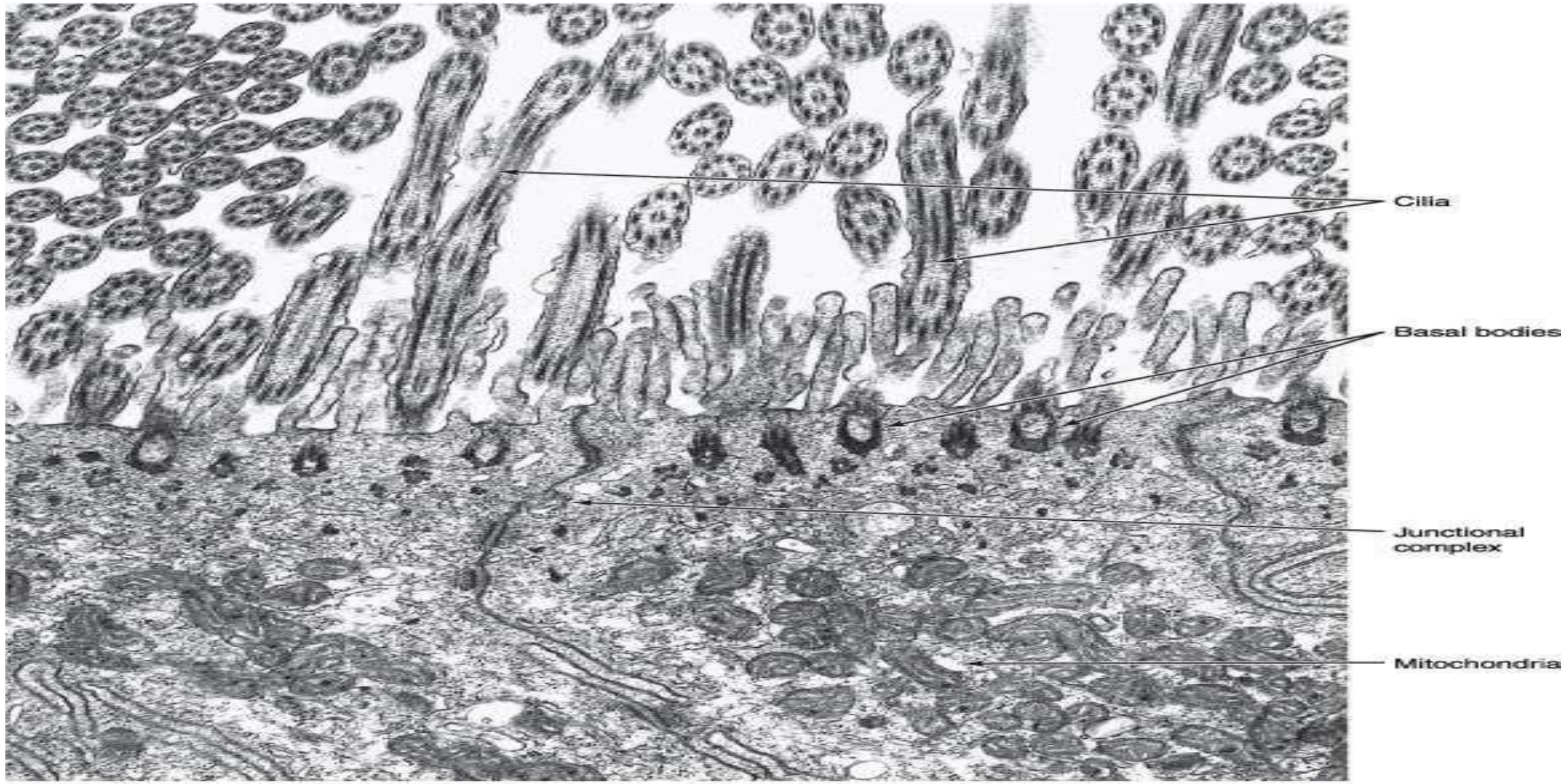
➢ **Mucous goblet cells:**

- Secret mucous for moistening and cleaning of the respiratory tract.



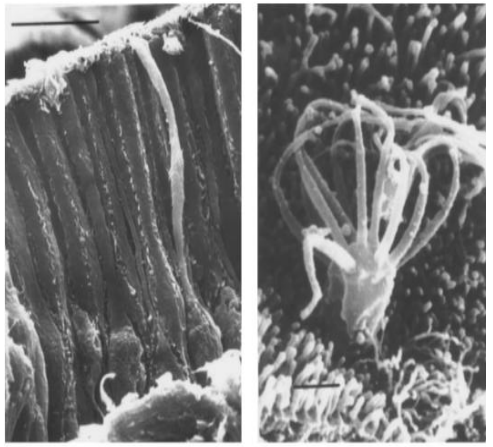
Dr.'s figures:

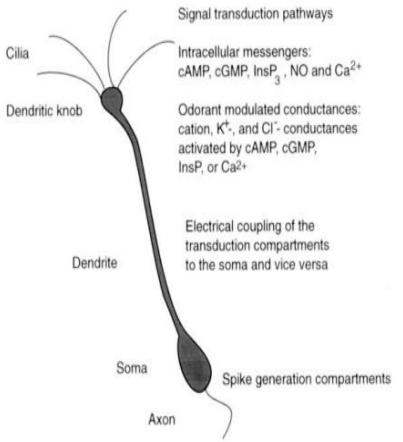




Dr.'s figure:

6- Ciliary movement





Dr.'s figure:

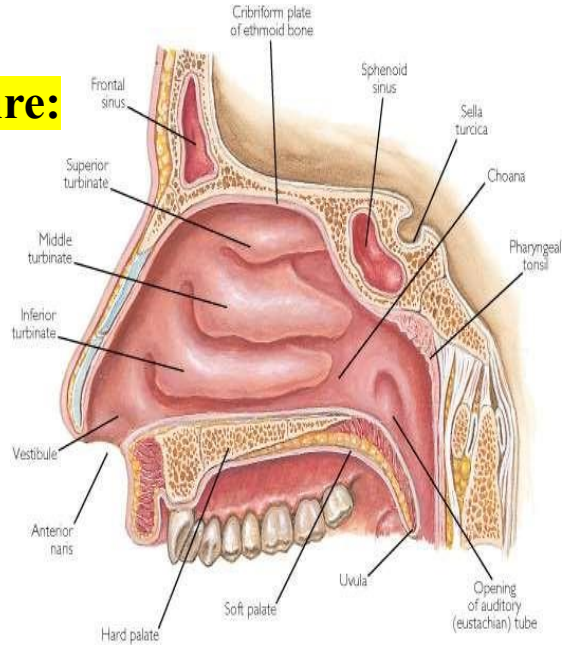
- **Dynein:**
  - Motor protein responsible for ciliary movement.
  - Present on basal bodies.
- **Clinical correlation:**
  - Smoking releases large amounts of nicotine, which **damages or inhibits dynein**. This leads to impaired ciliary motility. A condition known as **immotile cilia syndrome (Kartagener syndrome).**
  - As a result, mucociliary clearance is defective, allowing **viruses and bacteria** to remain in the respiratory tract, **causing chronic respiratory infections**.
  - Affected individuals may live for many years with repeated episodes of inflammation of the respiratory tract.
  - In males, this condition also affects the **motility of sperms**, leading to infertility.

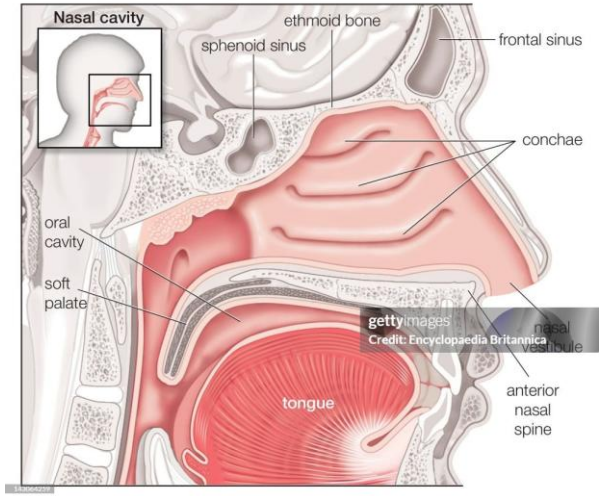
7- Nasal Cavity

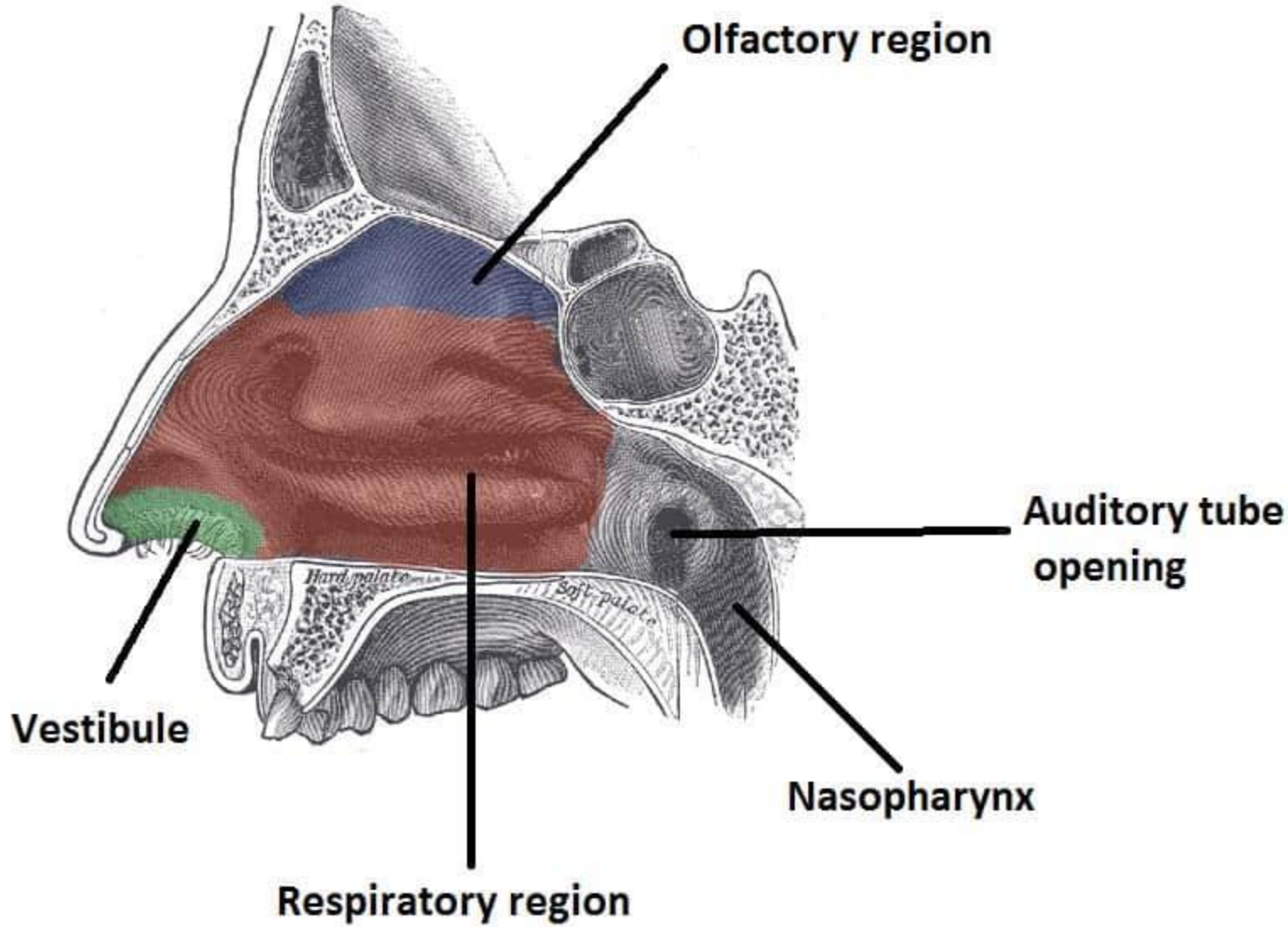
➢ **The nasal cavity is subdivided into three parts:**

1. **Vestibule:**
   - Lined by skin epithelium *(keratinized stratified squamous epithelium)*.
   - Contains vibrissae (thick hairs) for filtration of air.
   - Has sebaceous glands.
2. **Respiratory Area:**
   - Located below the superior concha and above the vestibule.
   - Lined by respiratory epithelium (pseudostratified ciliated columnar epithelium with goblet cells).
   - The submucosa contains venous plexuses and glands, which help in warming and moistening the air.
3. **Olfactory Region:**
   - Located in the roof above the superior concha.
   - Lined by olfactory (respiratory) epithelium.
   - Has bipolar olfactory cells, supporting (sustinacular) and basal cells.
   - Has bowman's glands.

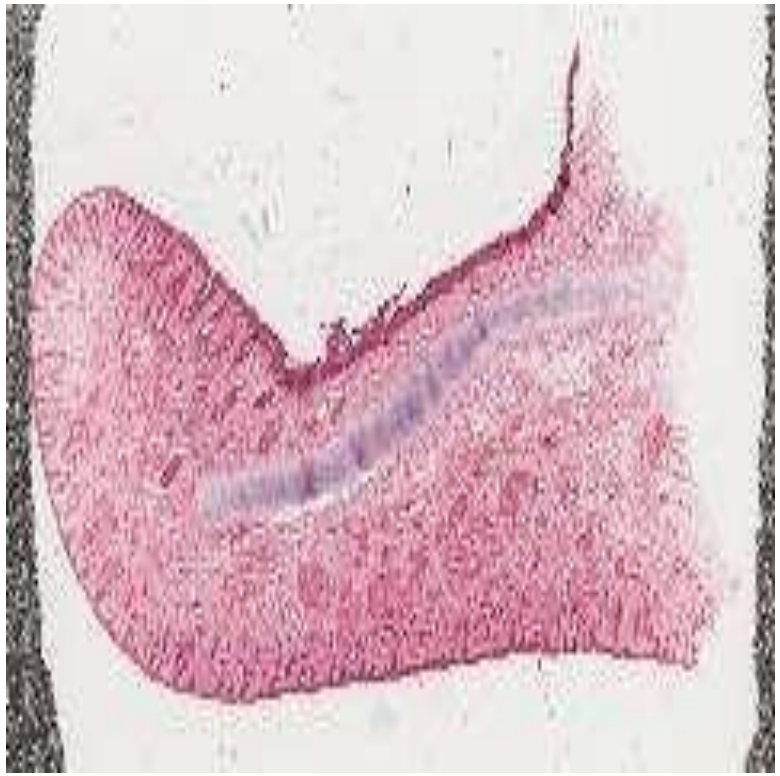
Dr.'s figure:

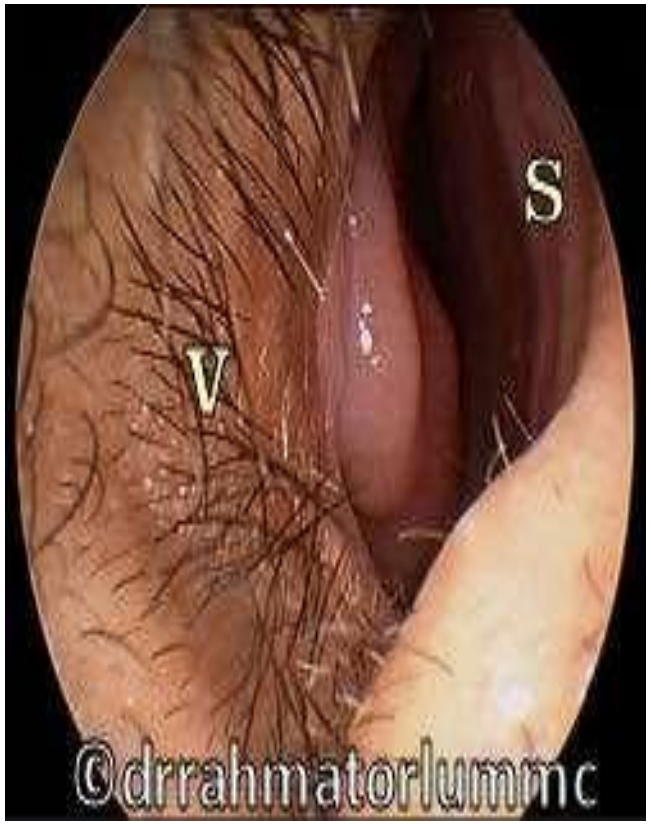






❖ Vestibule





Dr.’s figures:

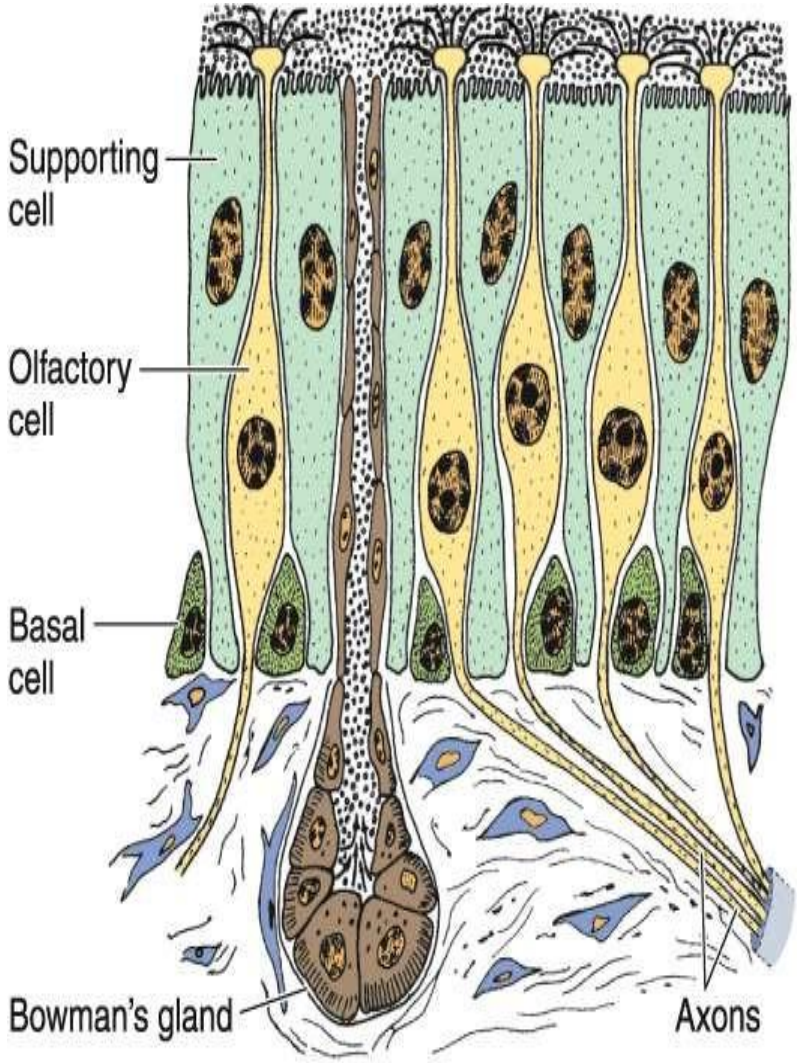
8- Olfactory region

➢ Olfactory bipolar cells:

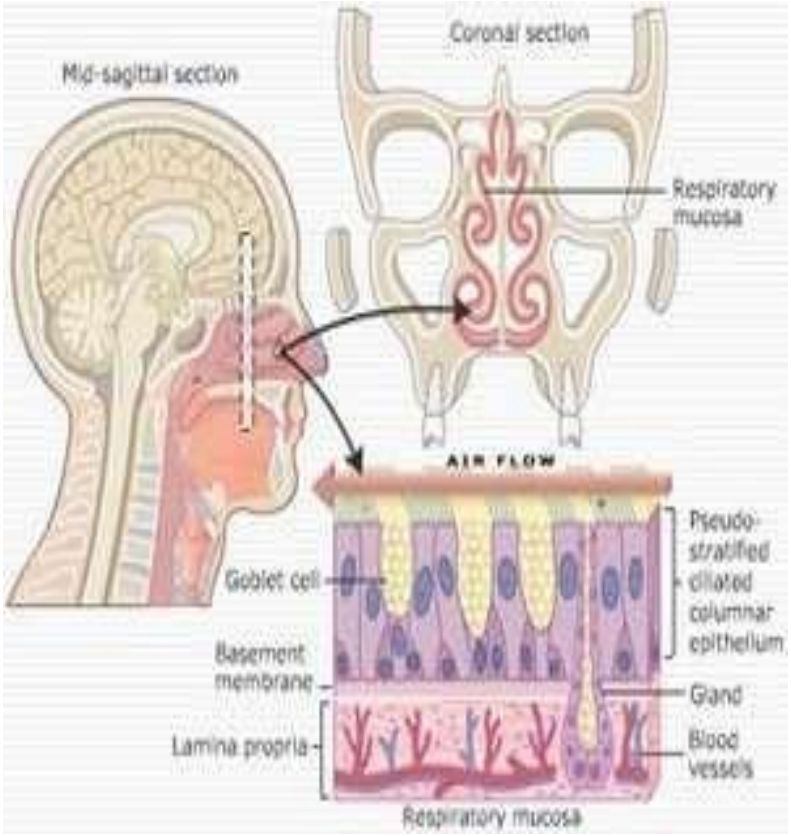
- Each olfactory cell has **two poles:**
  - The apical pole bears hair-like processes that project into the mucus covering the mucosa.
  - The basal pole gives rise to filaments of the olfactory nerve.
- These cells convert odor molecules into nerve impulses, which are transmitted to the olfactory (smell) center in the brain. The brain then recognizes and interprets the smell based on previously stored olfactory memories.

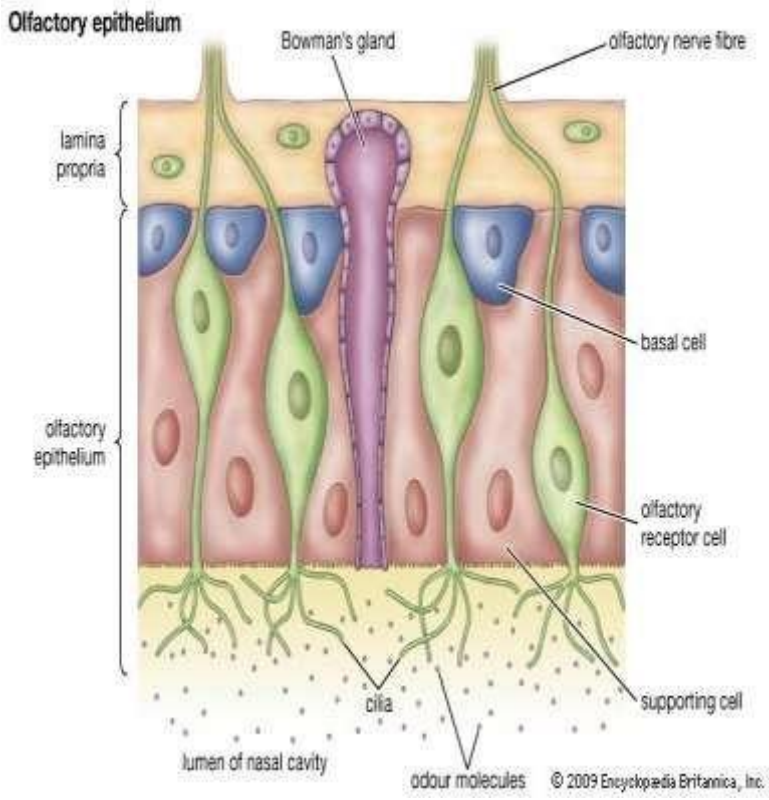
➢ Bowman's glands:

- In the submucosa and lamina propria.
- Has a duct that reach the surface of the mucosa; their Secretion dissolve the Oder.



Dr.'s figure:


Mid-sagittal section
Coronal section
Respiratory mucosa
AIR FLOW
Goblet cell
Pseudo-stratified ciliated columnar epithelium
Basement membrane
Gland
Lamina propria
Blood vessels
Respiratory mucosa


Olfactory epithelium
Bowman's gland
olfactory nerve fibre
lamina propria
basal cell
olfactory epithelium
olfactory receptor cell
supporting cell
cilia
lumen of nasal cavity
odour molecules
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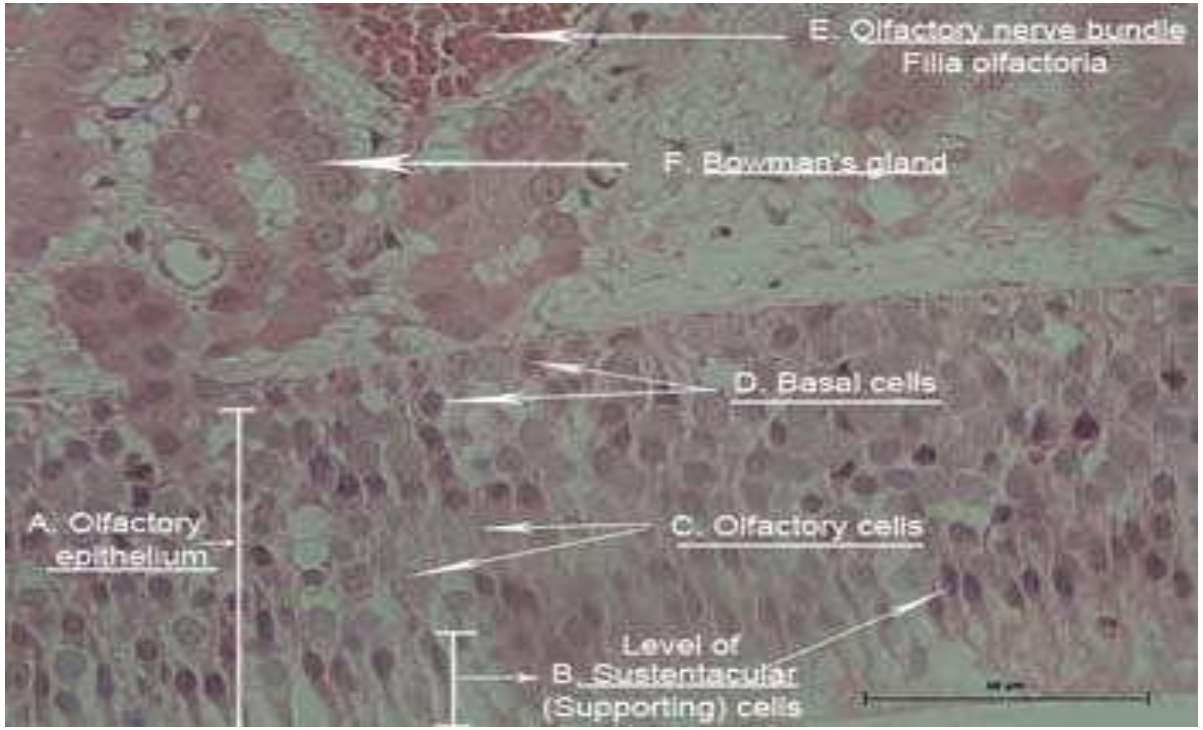
Dr.’s figures:


E. Olfactory nerve bundle
Filia olfactoria
F. Bowman's gland
D. Basal cells
A. Olfactory epithelium
C. Olfactory cells
Level of
B. Sustentacular
(Supporting) cells

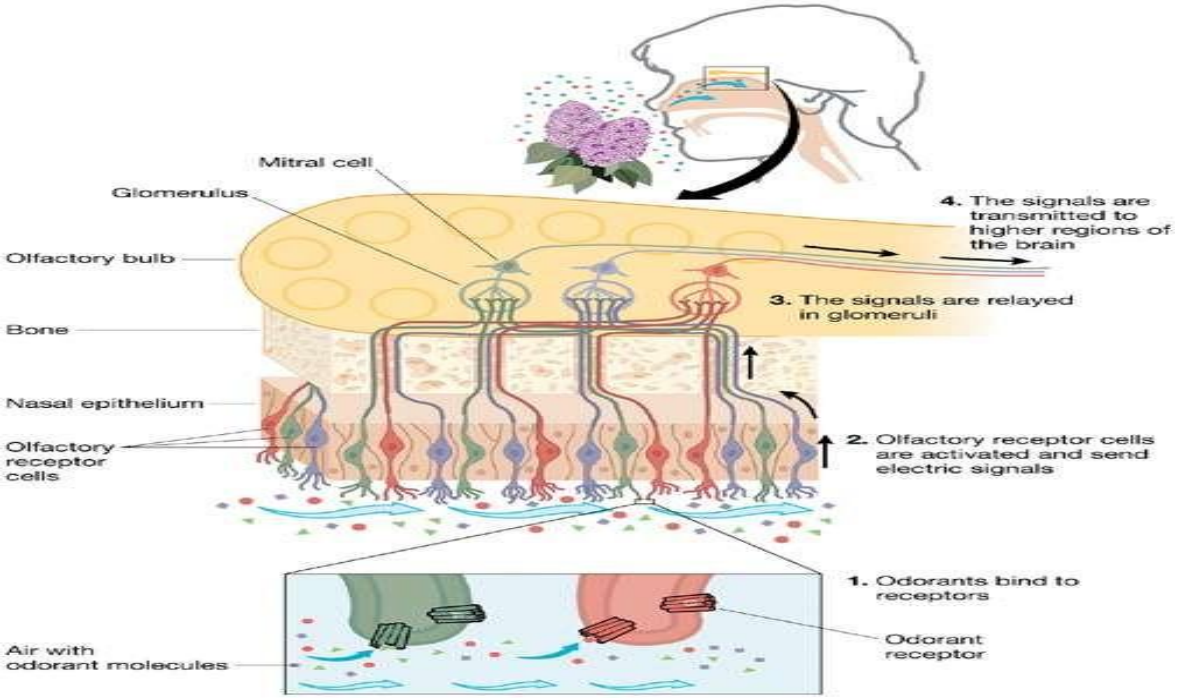

Olfactory
Epithelium
Ducts
Bowman's
Glands

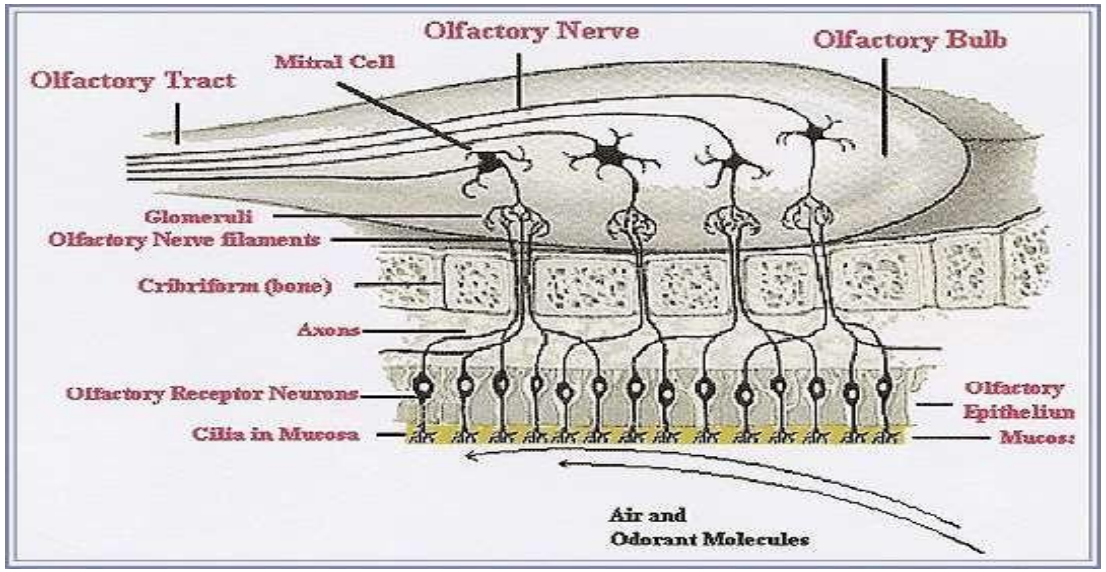
Dr.'s figures:

❖ Olfactory cells

Dr.’s figure:

❖ Olfactory





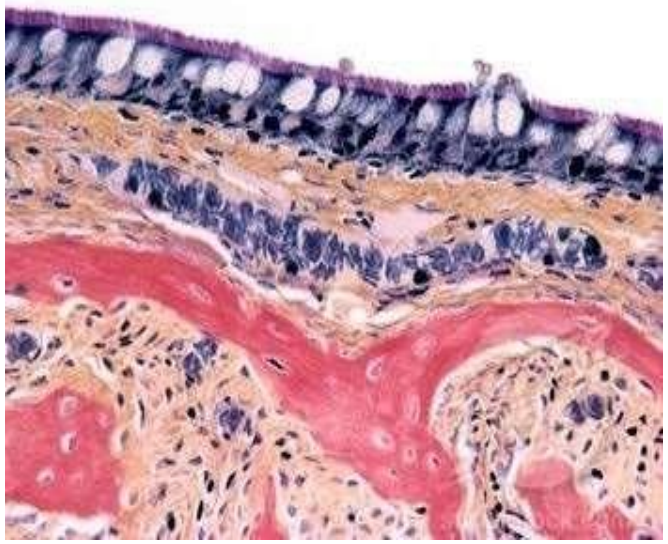
Dr.'s figures:

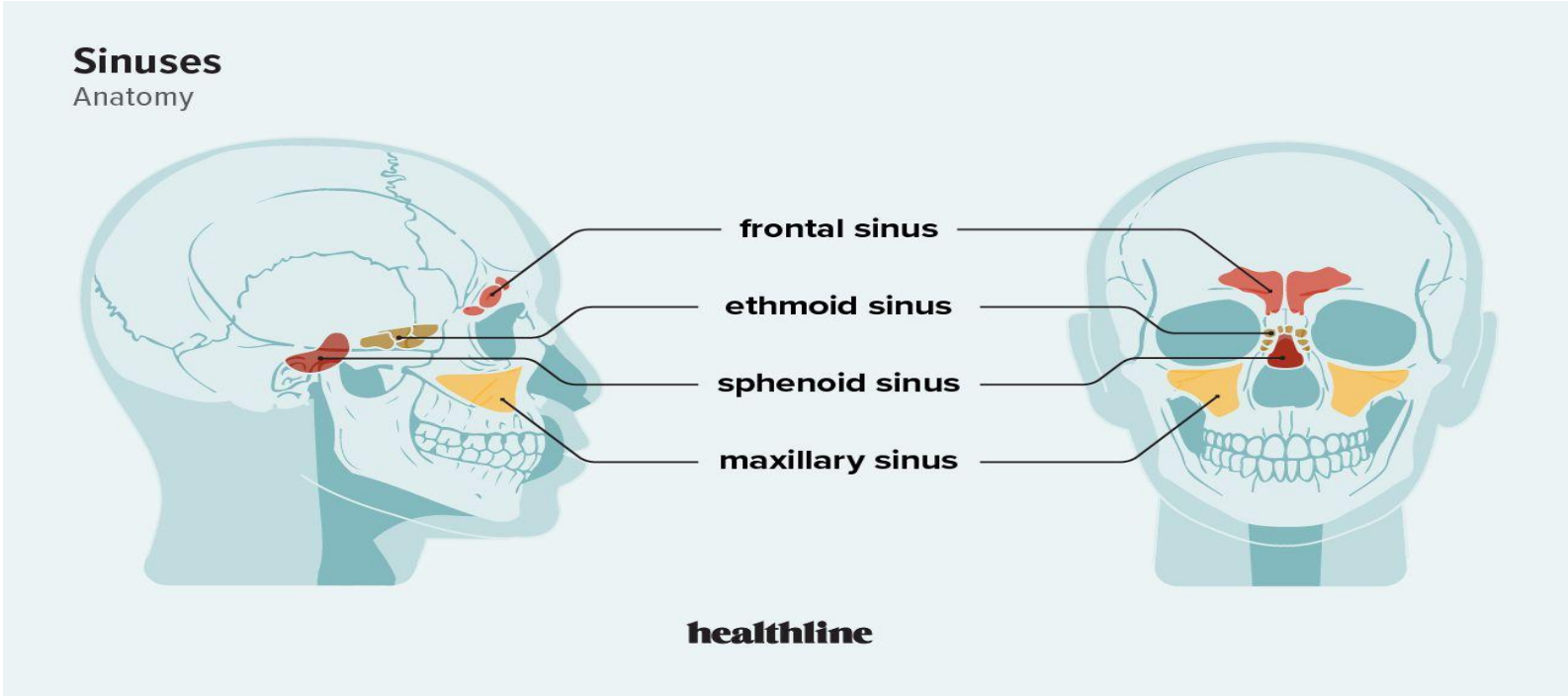
9- Paranasal Sinuses

➢ The paranasal sinuses.

- Include the **frontal**, **maxillary**, **ethmoidal**, and **sphenoidal sinuses**. They are lined by a **thin mucosa** composed of pseudostratified ciliated columnar epithelium with **few goblet** cells. The mucosa contains **few glands**, and the epithelium is closely **adherent to the periosteum** of the sinus cavity. Each sinus has a duct that opens into the **lateral wall** of the nasal cavity.

Dr.'s figure:





10- Structural changes

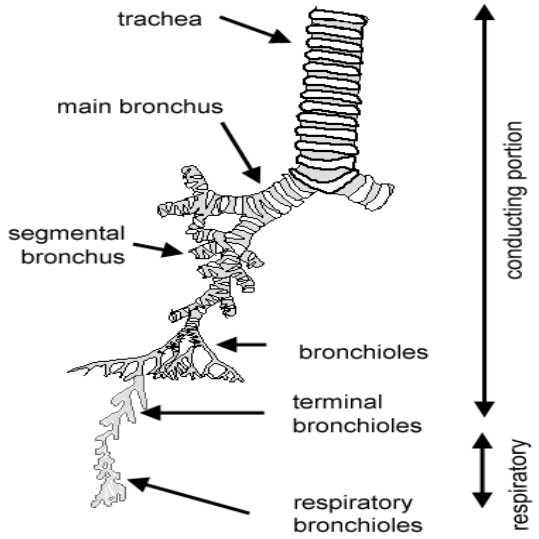
Very Important!

➢ **Structural changes in the bronchial tree *(primary, secondary, tertiary and bronchioles)*:**

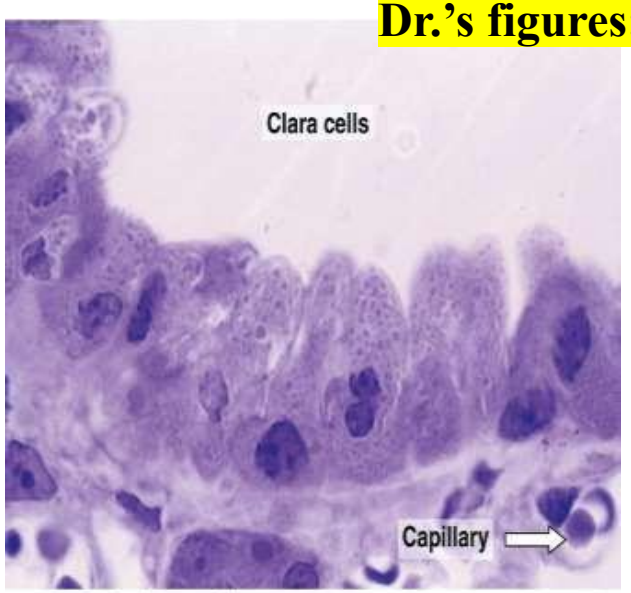
- **Epithelium:**
  - Pseudostratified ciliated columnar epithelium lines most parts of the respiratory tract.
  - In Bronchioles, epithelium is converted gradually from simple columnar ciliated to simple cuboidal ciliated.
  - In respiratory bronchiole, simple cuboidal with and without cilia → simple squamous.
- **Goblet Cells and Glands:**
  - Present in proximal parts (numerous in trachea), Decrease progressively distally, Absent at the terminal bronchiole.
- **Smooth Muscle:**
  - Increases progressively distally, Very prominent in bronchioles.
  - Present in the lung (respiratory bronchiole and between alveoli) only as small tags, insignificant patches.
- **Elastic and Reticular Fibers:**
  - Increase distally, The lung has an abundant network between alveoli.
  - Responsible for lung inflation and deflation (*elastic recoil*).
- **Lymphocytes:**
  - Scattered throughout the respiratory tract.
  - Aggregated in bronchi as BALT (lymphatic nodule). [the Dr. said bronchioles, but this is wrong]
- **Cartilage**
  - Decrease distally. *(refer to slide 10 for more details)*.

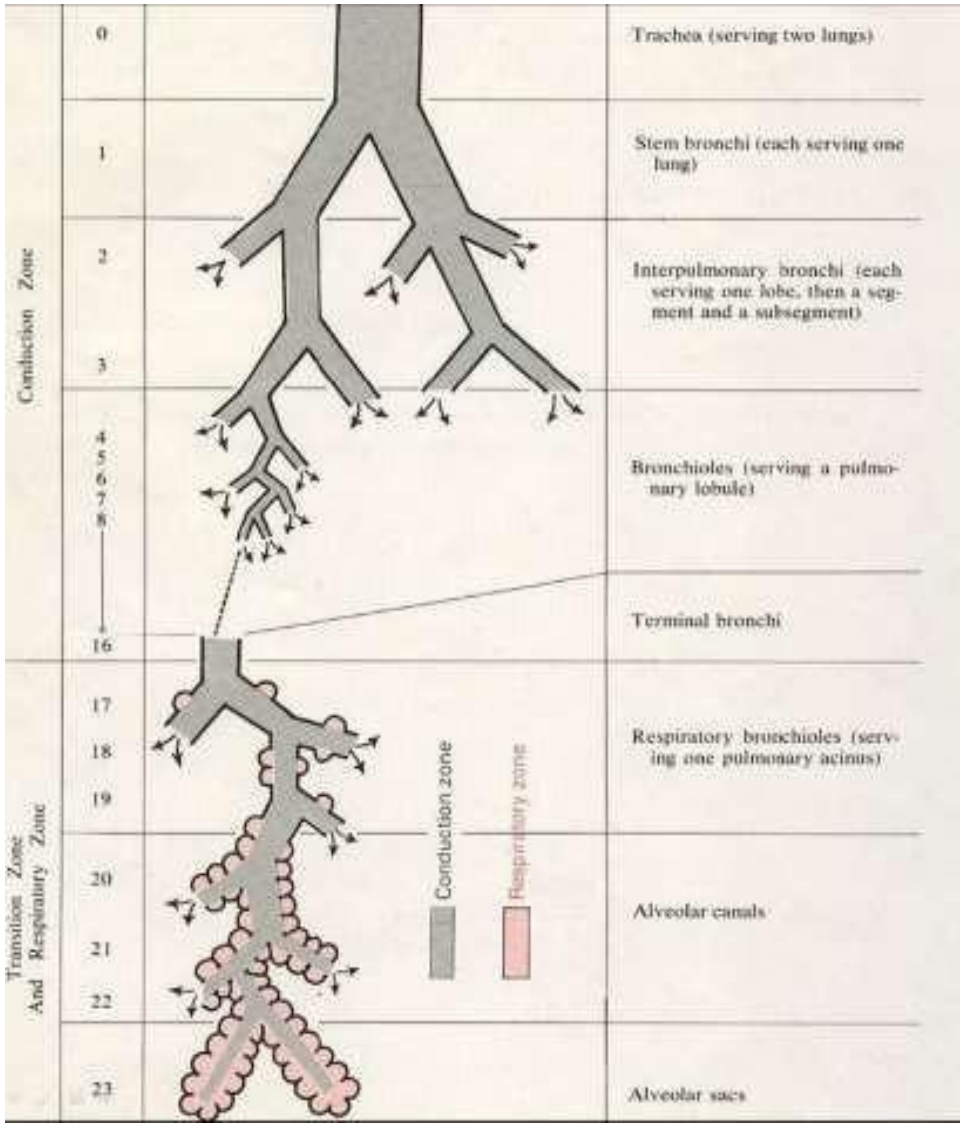
10- Structural changes

- **Each bronchiole:**
  - Divides into 5–7 terminal bronchioles.
  - Diameter decreases distally, from about 1 mm in bronchioles to approximately 0.5 mm in terminal bronchioles.
- **Clara cells:**
  - As the airway becomes smaller, goblet cells disappear and are replaced by **Clara cells.**
  - non-ciliated simple cuboidal cells.
  - Participate in formation of surfactants
  - Contain chemoreceptors and neuroepithelial bodies.
  - Found in the terminal bronchiole and at the beginning of the respiratory bronchioles, reflecting the gradual transition from cuboidal epithelium to simple squamous epithelium in the respiratory portion.

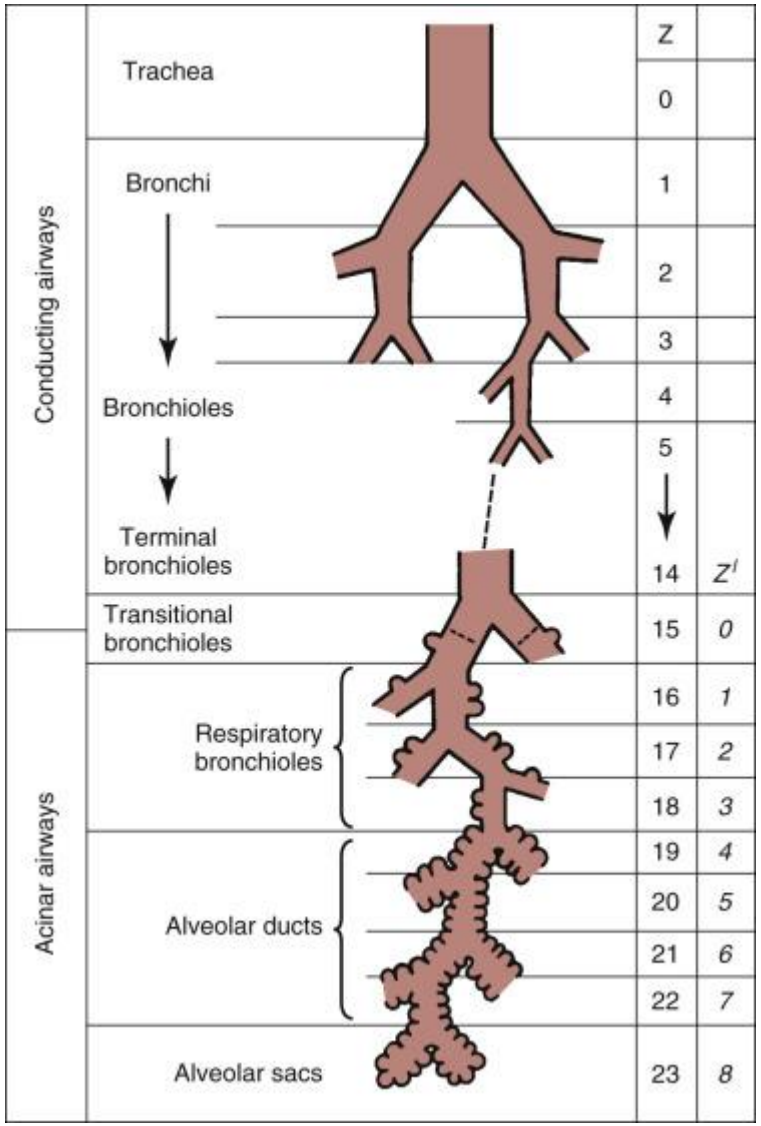


Dr.'s figures:




Conduction Zone
Transition Zone And Respiratory Zone
0
1
2
3
4
5
6
7
8
16
17
18
19
20
21
22
23
Trachea (serving two lungs)
Stem bronchi (each serving one lung)
Interpulmonary bronchi (each serving one lobe, then a segment and a subsegment)
Bronchioles (serving a pulmonary lobule)
Terminal bronchi
Respiratory bronchioles (serving one pulmonary acinus)
Alveolar canals
Alveolar sacs
Conduction zone
Respiratory zone

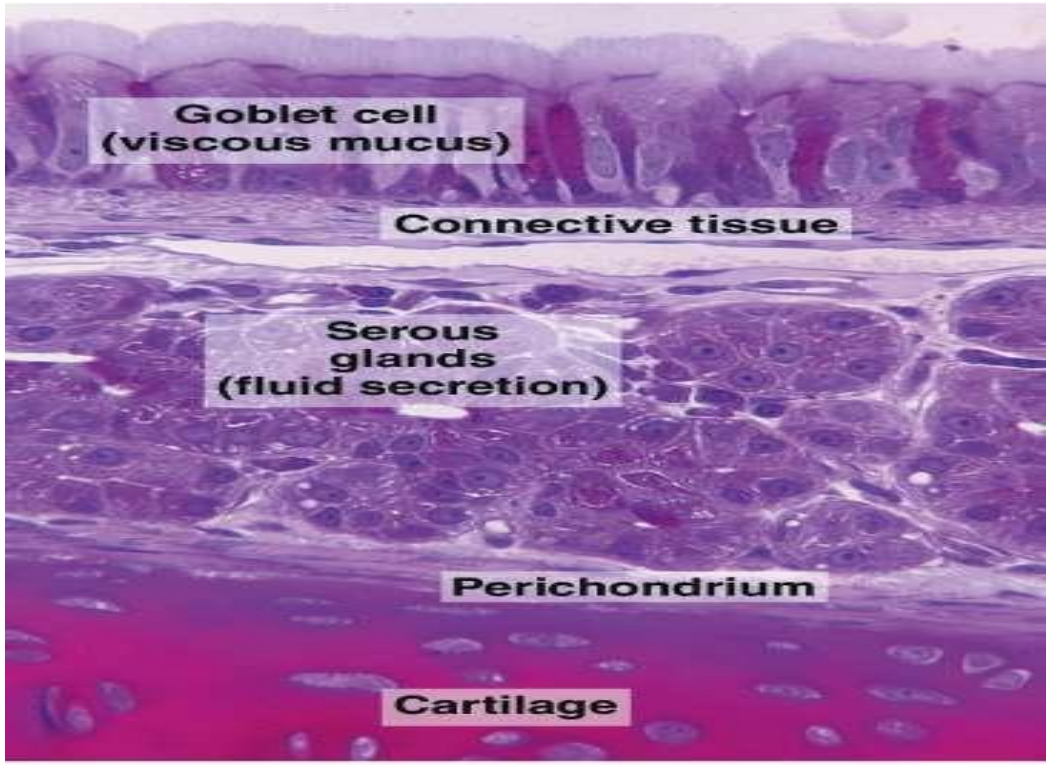
Dr.'s figure:

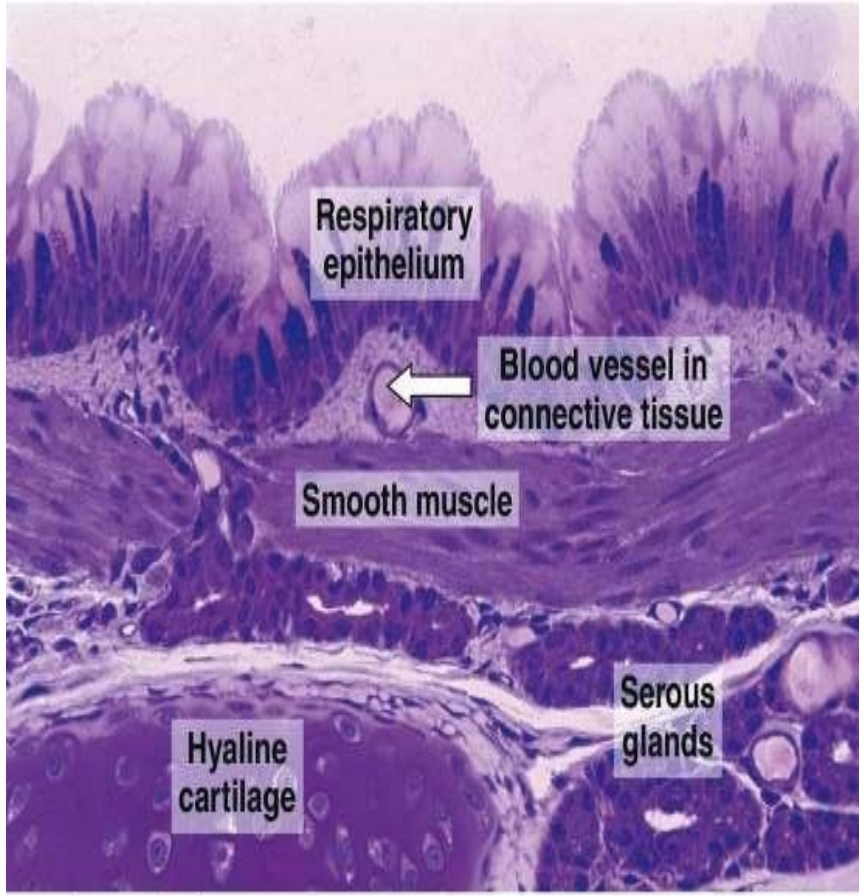

Conducting airways
Acinar airways
Trachea
Bronchi
Bronchioles
Terminal bronchioles
Transitional bronchioles
Respiratory bronchioles
Alveolar ducts
Alveolar sacs
Z
0
1
2
3
4
5
14
15
16
17
18
19
20
21
22
23
Z'
0
1
2
3
4
5
6
7
8

10- Structural changes

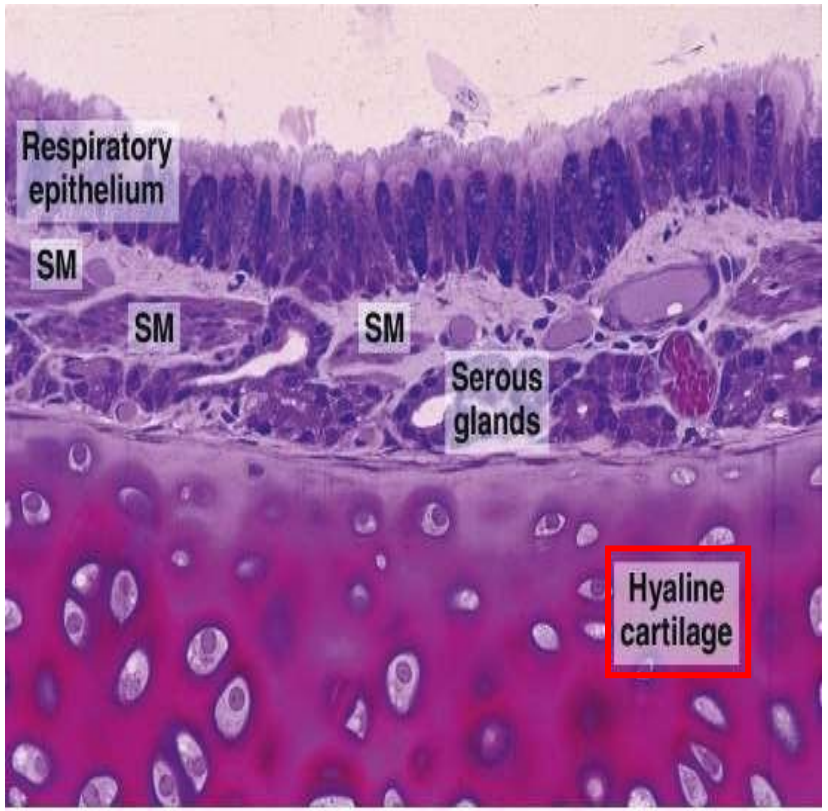
➢ **Notes:**

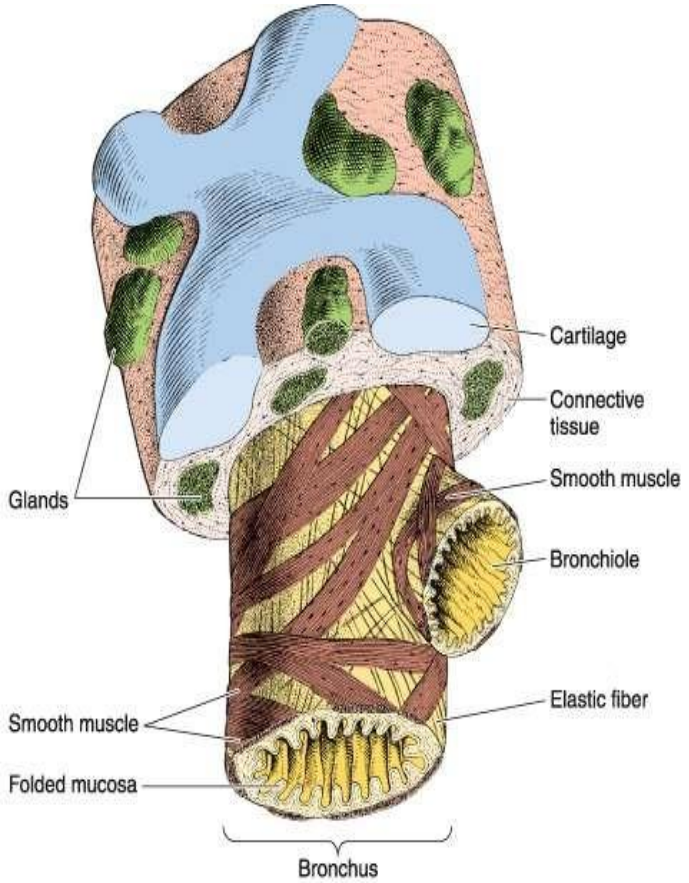
- **Cough reflex:** Coughing is initiated when a **foreign body** enters the respiratory tract.
- **Extrapulmonary bronchi**: outside the lung, which is primary bronchi.
- **Intrapulmonary bronchi**: secondary (lobar) and tertiary (segmental) bronchi, surrounded by lung tissue.



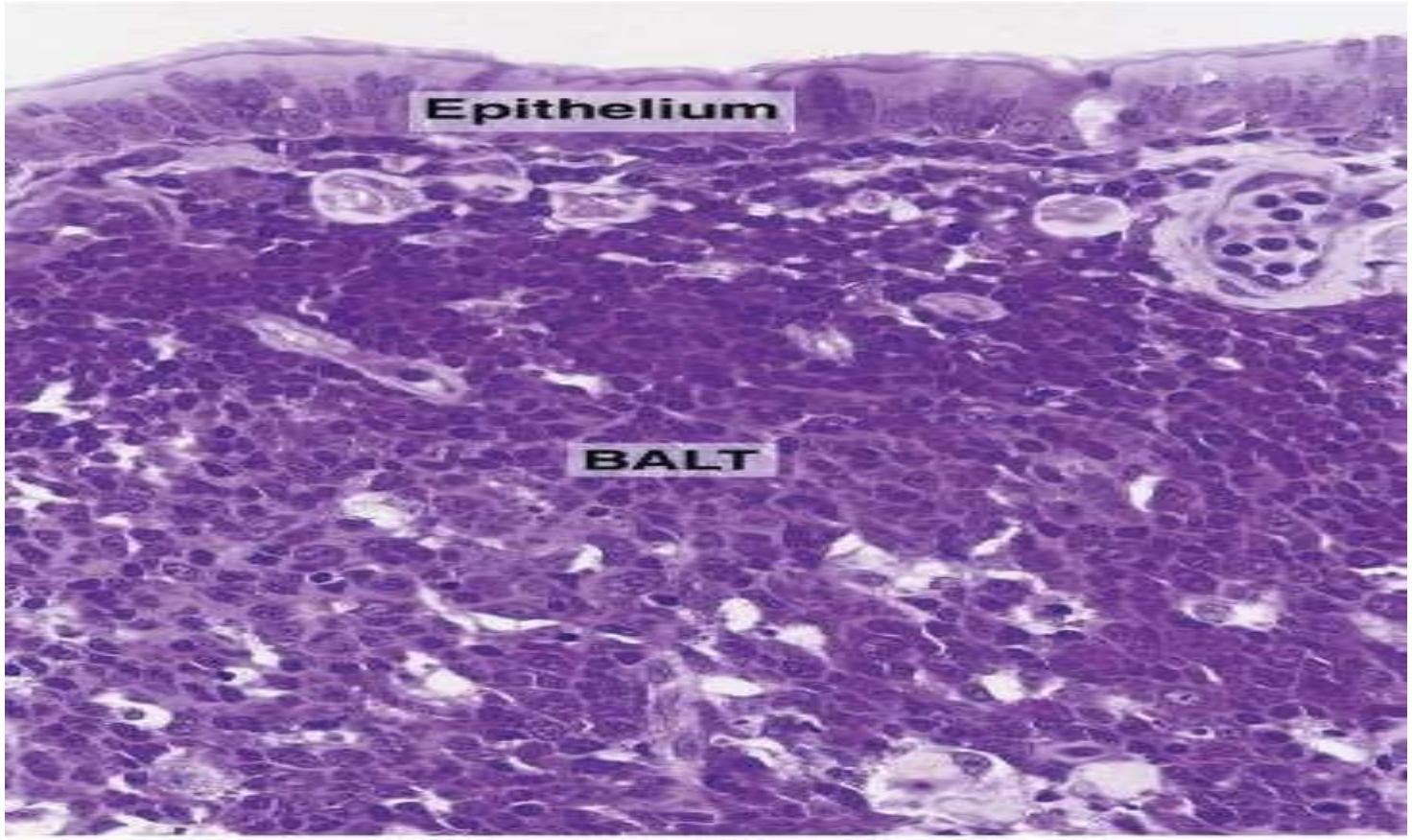


Dr.'s figures:



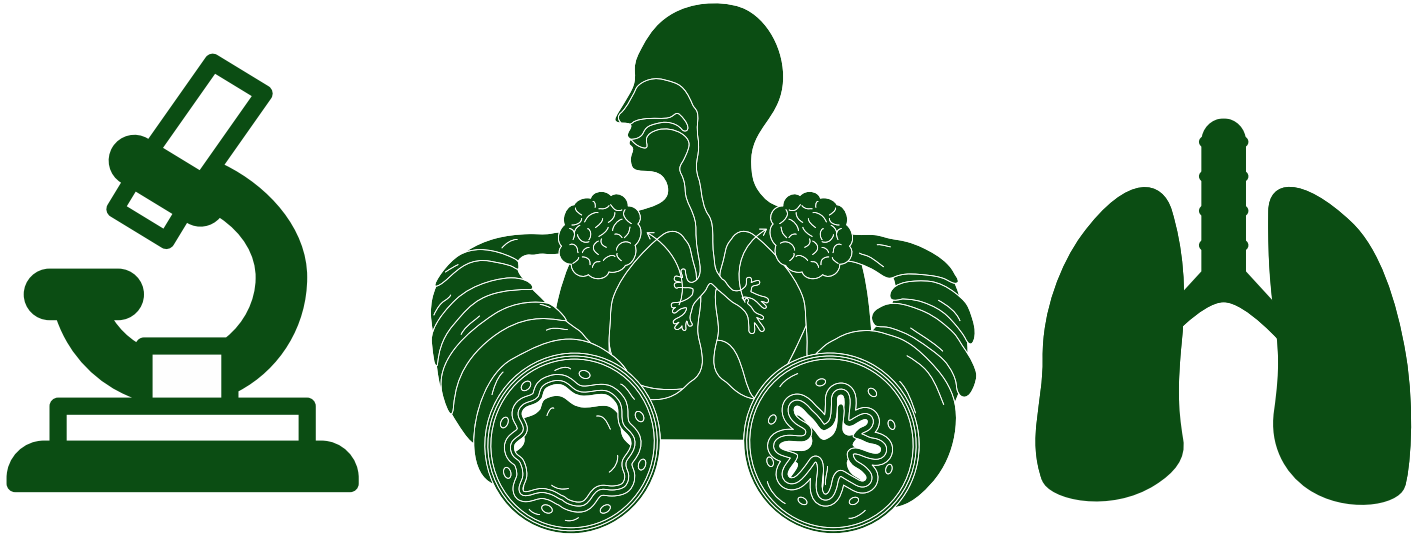


Dr.'s figures:



lymphocytes

Dr.’s figure:



HISTOLOGY QUIZ LECTURE 1

For any feedback, scan the code or click on it.

Corrections from previous versions:

Versions	Slide # and Place of Error	Before Correction	After Correction
V0 → V1	30 24	Aggregated only in bronchioles (lymphatic nodule). These cells dissolve odor molecules	Aggregated only in bronchi as BALT (lymphatic nodule). These cells convert odor molecules into nerve impulses,
V1 → V2			