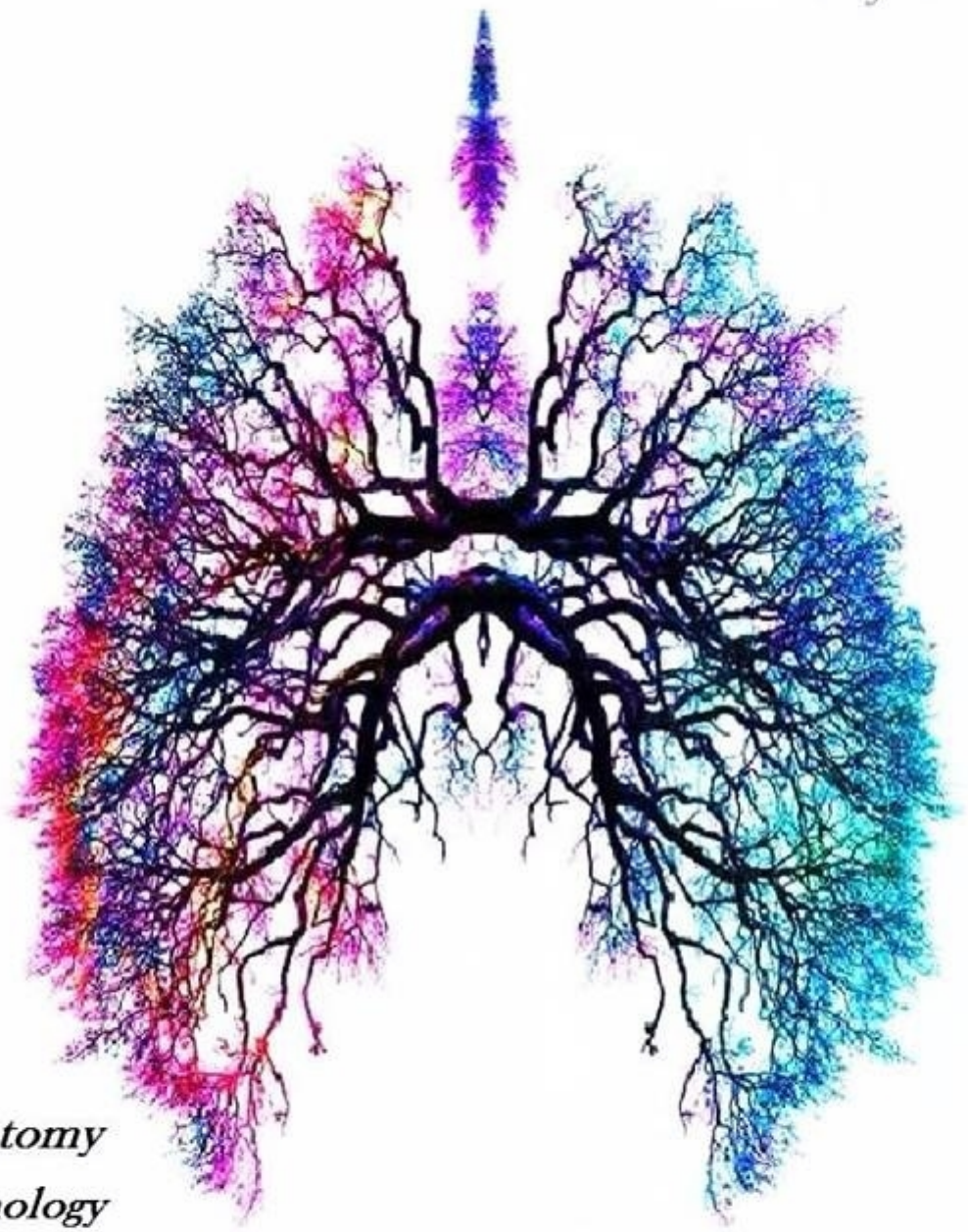
RESPIRATORY SYSTEM

Cover by: Aseil Khatib



- ○ Anatomy
- ○ Pathology
- ○ Physiology
- ○ Pharmacology
- ○ Microbiology
- ○ PBL
- ● Histology

Dr Name: Dr. Al- Muhtaseb
Lecture # 1 (Histology)
Done By: Mohammed AbuBaker

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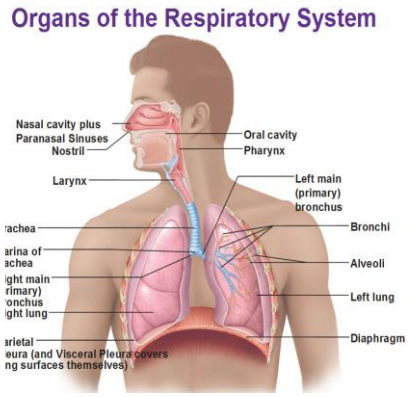
The Upper Respiratory Tract

The arrangement of information isn't the same as the record

The respiratory system is divided into a number of organs, which are; nose, nasopharynx, larynx, trachea, main bronchus (right & left) and Lungs (right & left) which have billions of alveoli.



One of the most important distinctive features of respiratory system histology is that, it contains cartilage (Hyaline cartilage). The anterior part of the nose is made up of cartilage, larynx is made up of cartilage (resembles a box of cartilage), trachea contains a C-shaped Hyaline cartilage, and bronchi have cartilage. The bronchioles don't have cartilage; it is replaced by smooth muscles and elastic fibers.

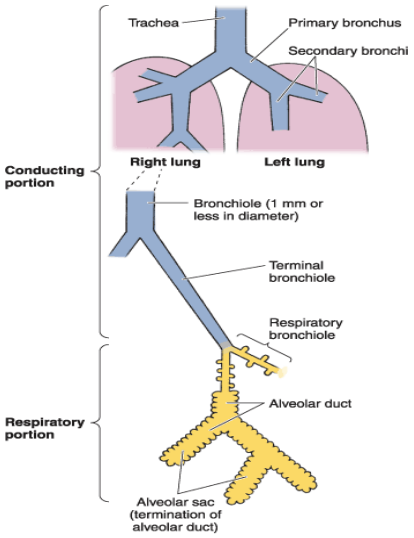
The lungs are made up mainly of elastic tissue for the function purpose (inflation and deflation).

The respiratory tract mainly contains cartilage; especially its upper part in order to function as a hollow tube for the passage of air (always opened, it doesn't collapse as we see in the GI tract for example in the esophagus; its lumen remains collapsed until deglutination and swallowing).

The first thing you check when a patient comes to the emergency is his respiration, and if he had no respiration you directly put an endo-tracheal tube for him to open the passage of air, because brain cells die after 2-5 mints after the cut of oxygen (brain damage). If you were home and one had obstruction of the respiratory tract you would do tracheostomy immediately, by making and incision in the suprasternal notch on the anterior aspect of the neck and opening a direct airway through an incision in the trachea. The resulting hole serves independently as an airway or as a site for a tracheostomy tube to be inserted.

The respiratory tract is divided into two parts, an upper part; its main function is conduction of air and a lower part; its main function is respiration (gases exchange for O_2 and CO_2).

We have a transitional area lying between the conducting and respiratory parts. The transitional area here doesn't appear suddenly, it appears gradually



The blood air barrier is present around the alveoli. Each lung contains billions of alveoli. Each alveolus is surrounded by a network of capillaries. These networks are the sites of gases exchange between blood capillaries and alveoli.

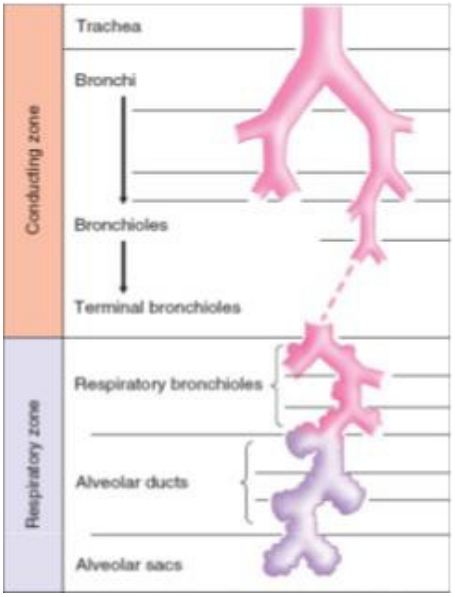
In the past, if someone had lung cancer they used to remove the whole lung, after that they started to do lobectomy (Left lung is made up of 2 lobes while right lung is made up of 3 lobes). Nowadays, they remove a segment of the lung; it's called bronchopulmonary segment. Each lung has 10 segments, and each one of these segments has its own blood supply, lymphatics, venous drainage and alveoli.

Smoking is a major risk factor for respiratory system diseases. 90% of lung cancer cases are due to smoking. Also, cigarettes contain nicotine which damages a type of protein called dynein, which is an important protein for the movement of cilia (from inside to outside), leading to some disease like bronchitis and eventually to cancers.

The common epithelium in the respiratory tract is pseudostratified ciliated columnar epithelium (nose, trachea and bronchi). As we reach the bronchioles it is transformed to simple columnar ciliated and as we go distally it changes into simple cuboidal ciliated epithelium and more distally toward the lungs, it changes into Clara cells (no cilia) and finally in the wall of the alveoli it becomes simple squamous (for gases exchange).

The cilia is very important for the removal of dust and any foreign particle that get into the respiratory tract, and this function is impaired

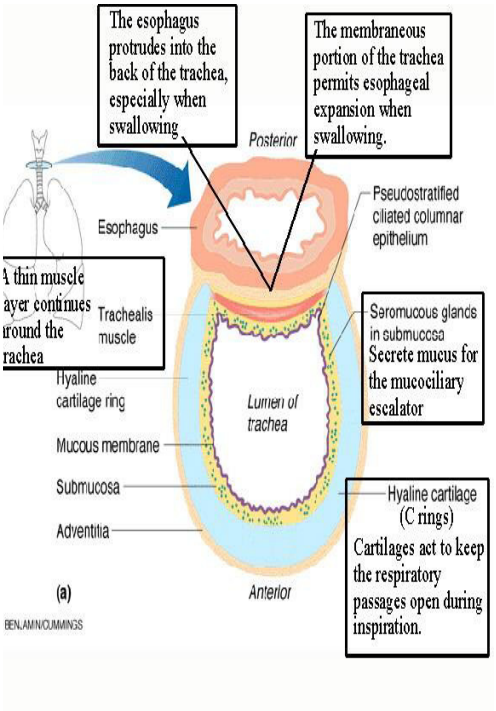
by the nicotine found in cigarettes which causes damage to the protein dynein.



The respiratory tract is divided into conducting and respiratory parts. The bronchioles share in the two parts (region of transition); the terminal bronchioles in the conducting part and the respiratory bronchioles in the respiratory part.

The bronchi are divided into 1ry, 2ry and 3ry; the 1ry is extra pulmonary (outside the lung) while the 2ry and 3ry are intrapulmonary (inside the lung).

The esophagus lies behind the trachea and the recurrent laryngeal nerve lies between them.



The layers of the trachea are:

Mucosa (pseudostratified ciliated columnar epithelium, lamina propria, and muscularis mucosa)

Submucosa (connective tissue rich in blood vessels, lymphatic's, and sero-mucous glands)

The supportive or cartilaginous layer (hyaline cartilage and smooth muscle)

Adventitia or serosa (connective tissue)

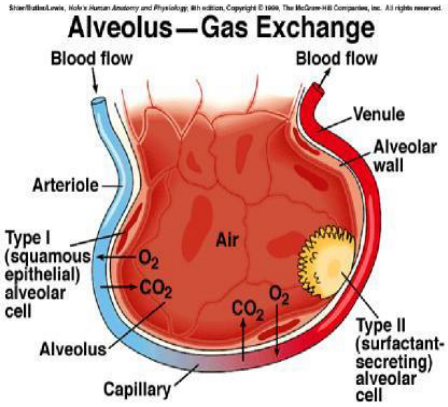
Goblet cells start with large number but as we go distally, the number is reduced, and once we reach the bronchioles, they become scattered

and disappear. Also there are sero-mucous glands with the same story; they decrease in number as we go distally. But, for the smooth muscles and elastic tissue both as we go distally increasein number.

Cartilage also changes as we go distally, in the nose there is some cartilage and bone (nasal bone), in the larynx there is hyaline cartilage (plates) and elastic cartilage, in the trachea there is C shaped hyaline cartilage (to prevent the collapse to keep the passage of air), but as we reach the bronchioles there is no cartilage, no goblet cells, no glands and the elastic fibers number increases (they are found with high amount in the lungs because they are needed for inflation and deflation).

The respiratory system organs have other functions than the respiration and gases exchange. For example, in the nose we have smelling sensation (olfactory function; the 1st cranial nerve (olfactory nerve) performs the action of smelling sensation). The vestibule which is the most anterior and dilated portion of the nasal cavity is rich in thick short hairs, or vibrissae, which function to trap and filter out large particles from the inspired air. The mucosa of the nose is rich in blood vessels, especially the venous blood and this contributes to moisturizing and warming of the air. In the nose we have the paranasal sinuses which are responsible for the resonance of the voice.

The alveoli are the most important parts of the respiratory system because each alveolus is surrounded by a network of capillaries and the largest bed of capillaries is found around the alveoli; so they could serve their function which is exchange of gases.



The wall of the alveolus is composed of Type 1 alveolar cells (simple squamous epithelium) mainly, and the capillary wall is also made up of simple squamous fenestrated epithelium (endothelium), between them we have fused basal lamina in order to make the respiratory membrane very thin so it serve to ease the function of gas exchange.

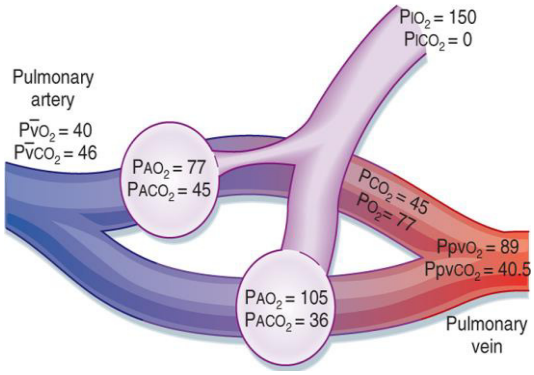
Alveoli also have another type of cells; Type 2 alveolar cells. This type of cells is surfactant secreting; which functions to distend the alveoli once

the gases exchange occur. This kind of cells starts to function at the age of 8 months in embryo (in the 8th and 9th months there is surfactant secretion in the embryo), and is very important for the baby once he is delivered so he could breathe and all alveoli could distend.

If these Type 2 alveolar cells were deficient or absent; the baby may die or have what we call Respiratory Distress Syndrome.

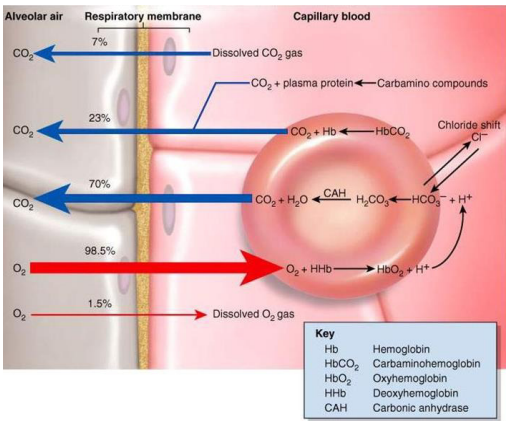
In the cardiovascular system, we learned that the venous circulation starts from the right ventricle of the heart through the pulmonary trunk.

The pulmonary trunk continues its pathway until it reaches the alveoli as arterioles carrying CO_2 with a concentration of 45mmHg. Then gases exchange occurs between the capillaries and alveoli. Then the capillaries form venules, and these venules are rich in O_2 with a concentration of 95-105mmHg. Then these venules form the 4 pulmonary veins.



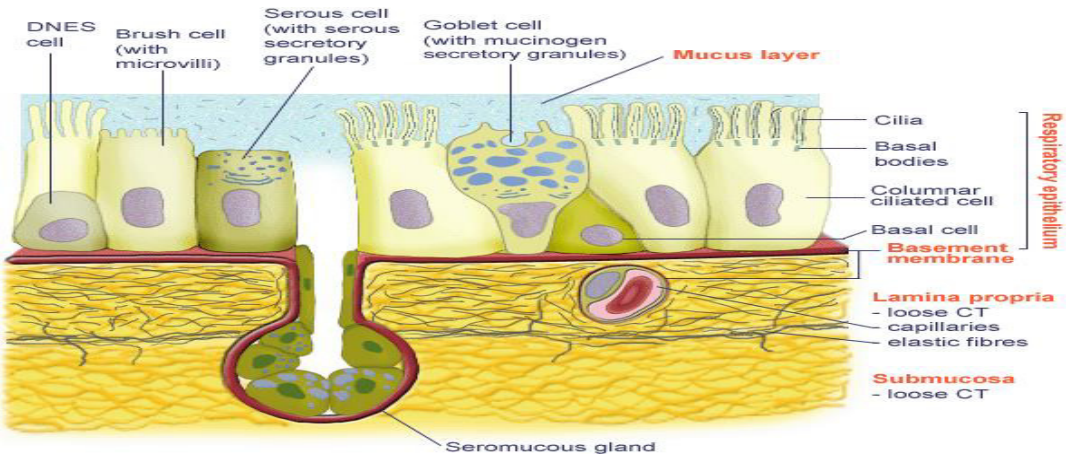
These 4 pulmonary veins enter the left atrium carrying the oxygenated blood. Then this blood goes through the left ventricle → the ascending aorta → the arch of the aorta → the descending aorta → all cells of the body.

The RBCs take the O_2 and combine it with hemoglobin. For the CO_2, when it enters the blood; 7% get dissolved in the plasma, 23% combine with hemoglobin, and 70% are converted to CO_2 and protons by carbonic anhydrase.



The respiratory epithelium generally is ciliated pseudostratified columnar epithelium and it contains 5 kinds of cells; the most important one is the pseudostratified ciliated. The respiratory tract epithelium contains goblet cells; it's numerous at the upper part and decreases in number

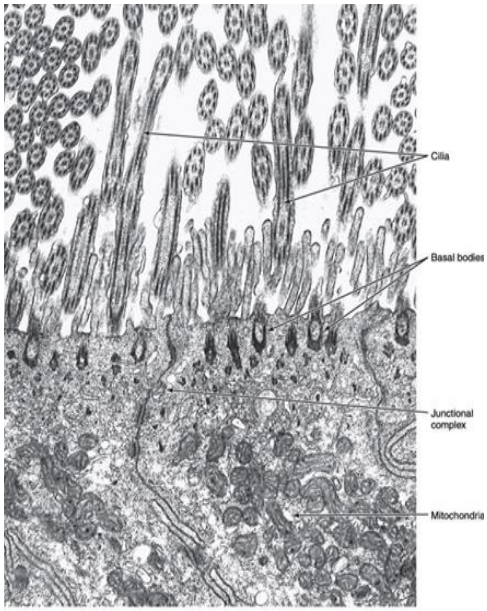
as we go distally through the respiratory tract, and they disappear at the bronchioles (absent at the bronchioles).



The kinds of cells found in the respiratory tract epithelium are:

All of them are resting on the basement membrane, but not all of them reach the lumen.

- Ciliated pseudostratified columnar epithelium; most abundant type. Each cell has about 300 cilia attached to the basal bodies, on its apical surface. Rich in mitochondria, which supply the ATP needed for the cilia movement.

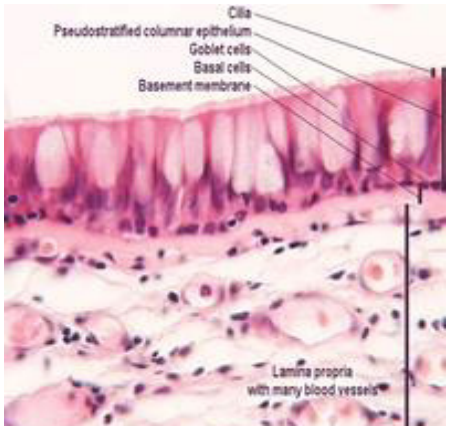


Dynein; is a protein important for the movement of cilia. Nicotine impairs the production of this protein which leads to stoppage of cilia movement and chronic infection in the respiratory tract.

Immotile cilia syndrome or Kartagner Syndrome; one of its causes is the nicotine which causes deficiency in dynein. This syndrome is characterized by immotile cilia and causes infertility in men and chronic respiratory tract infections in both sexes. Also, it's found more in men.

- The goblet cells; found in the gastrointestinal tract as well. They are apical mucous droplets composed of glycoproteins and contain polysaccharides. They decrease in number as we go distally through the respiratory tract and absent in bronchioles.

- The basal cells or stem cells; so called because they rest on the basement membrane and don't reach the lumen. They are characterized by mitosis, and can replace other cells; they have the ability to differentiate into other cells types found within the epithelium (reserve cells).



- The serous cells; have serous secretory granules
- The brush cells; have numerous microvilli on their apical surface and they have sensory receptors.
- The small granule cells; they are of the diffuse neuroendocrine system cells (DNES)and also called kulchitsky cells; responsible for the local stimulation and secretion of the serous and mucous glands.

The layers of the respiratory tract are:

- Mucosa; epithelium resting on the basement membrane (the basement membrane of the respiratory tract is characterized by being thick), goblet cells found in the apical part, lamina propria, and muscularis mucosa (smooth muscle).

- Submucosa; is connective tissue rich in blood vessels and lymphatics that houses mucous and seromucous glands.

- Supportive layer; smooth muscle and cartilage. They cartilage decreases as we go distally and absent in the bronchioles, while the smooth muscle increases as we go distally and found as a thick spiral layer in the bronchioles.

- Adventitia or serosa; connective tissue coverings.

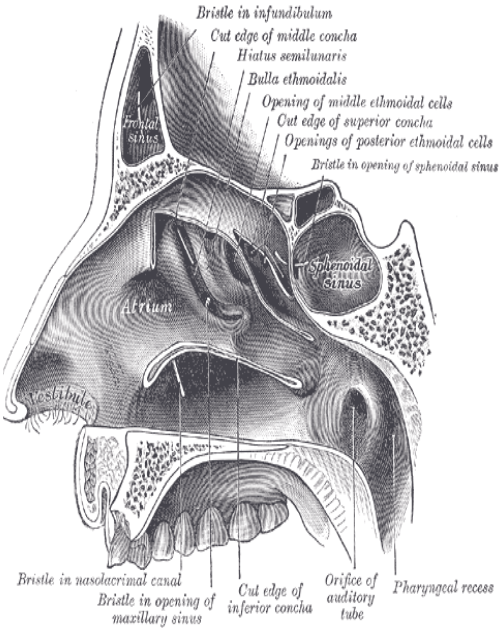
The Nasal Cavity

The nose is two cavities and between them there is a septum. Each cavity has lateral and medial walls, roof and floor. The two cavities share the medial wall which is the septum.

The nose has an anterior opening called the anterior naris and a posterior opening called the posterior naris. The anterior naris is the vestibule. The posterior naris in the Choana.

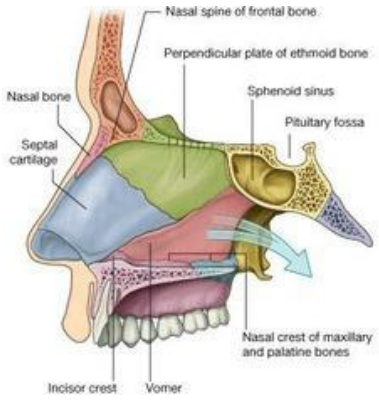
The vestibule is the most anterior and dilated portion of the nasal cavity. It's lined by skin and contains sebaceous and sweat gland. It has thick short hairs or vibrissae to trap and filter out large particles from the inspired air.

The Choana is the opening between the nose and the nasopharynx. On the lateral wall of the Choana we have the opening of Eustachian tube which passes the air to the middle ear to equalize the pressure around the tympanic membrane (ear drum).



After the vestibule we have the antrum or atrium. In the lateral wall we have three conchae and three hiatuses; they are found to increase the surface area of the lateral wall of the nose. They are rich in blood vessels to warm the incoming air.

The roof is formed by the cribriform plate of ethmoid bone. In the roof we have the olfactory region which is made up of bipolar cells for smell sensation. The floor in formed by the hard palate.

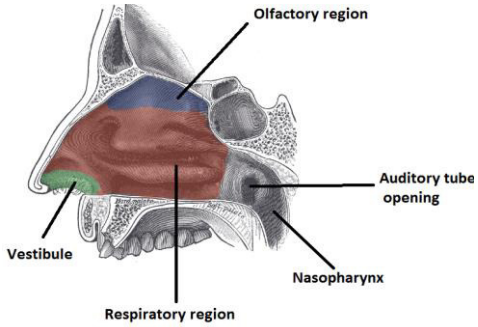


The nose anteriorly is formed by cartilage but the base is formed

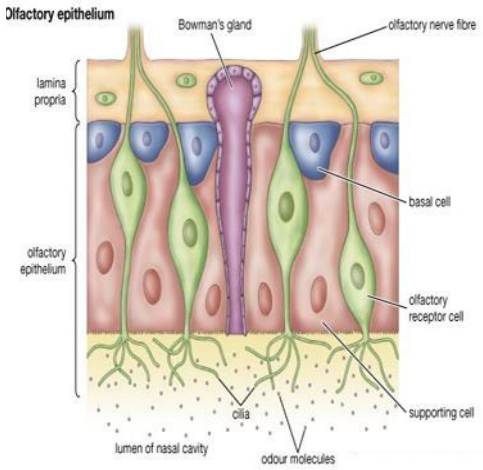
by the nasal, frontal and maxillary bones.

The nasal vestibule is lined by skin and its epithelium is keratinized stratified squamous. Within the vestibule, the epithelium loses its keratinized nature and undergoes a transition into typical respiratory epithelium before entering the nasal fossae.

The respiratory area is composed of three conchae and three hiatuses. Its epithelium is ciliated pseudostratified columnar with goblet cells. The submucosa is rich in blood vessel especially the venous blood, to warm and moisturize the air.

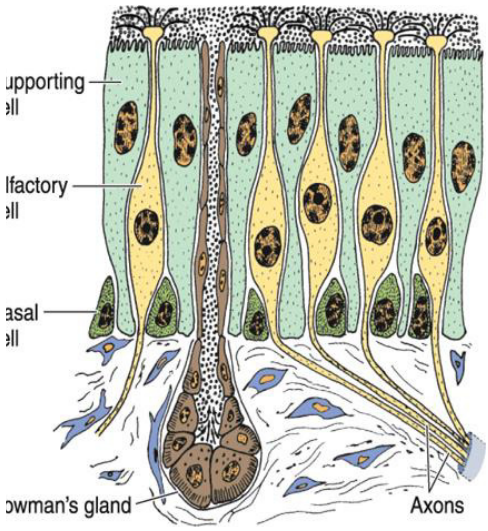


The olfactory region, which present in the upper part of the roof of the nasal cavity, has three types of cells in its mucosa which are the olfactory epithelium, corium (lamina propria), and bowmans glands.



The olfactory epithelium, which is ciliated pseudostratified columnar, is composed of three types of cells; the supporting (sustentacular) columnar cells, the basal cells, and the olfactory cells:

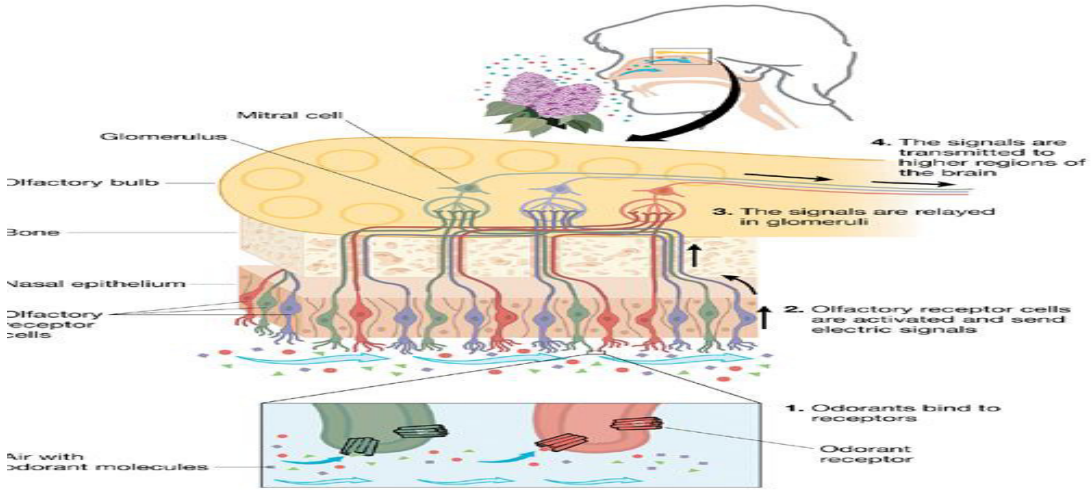
- The most important type is the olfactory cells which are bipolar neurons. They are responsible for the smell sensation. They are called olfactory cells because afferent axons of these bipolar neurons synapse with the Olfactory nerve (1st cranial nerve).



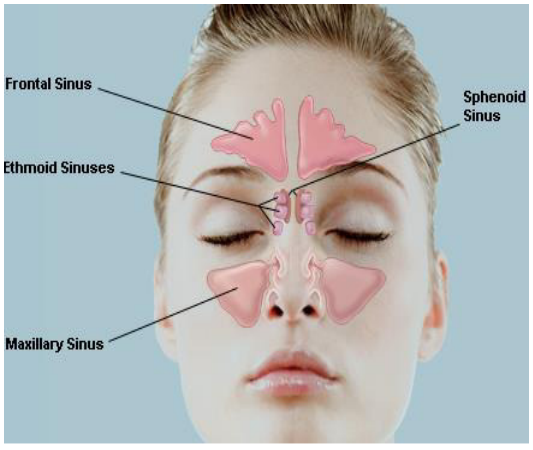
Non-motile cilia (dendrites) rise from their apexes. Their nuclei lie below the nuclei of the supporting cells.

- The basal cells are a single layer at the base of the epithelium. They are characterized by mitosis and responsible for replacing other cells. They are spherical or cone shaped.
- The supporting or sustentacular cells; function as metabolic and physical support for the olfactory cells. Their nuclei are more apically located than those of the olfactory epithelial cells. They contain a light yellow pigment and have microvilli.

In the lamina propria (Corium) we have Bowmans glands which are seromucous glands that reach the surface. They function to trap and dissolve of different substances for the bipolar neurons.



The nasal sinuses are air-filled spaces present in some of the skull bones. They are lined by respiratory mucosa. They have ducts open in the lateral wall of the nose. The function of these paranasal sinuses is the resonance of the voice.



We have 2 frontal sinuses, 6 ethmoidal sinuses, 2 sphenoidal sinuses, and 2 maxillary sinuses.

All of the sinuses have ducts that open into the lateral wall of the nose. All the sinuses have good drainage except the maxillary sinus which

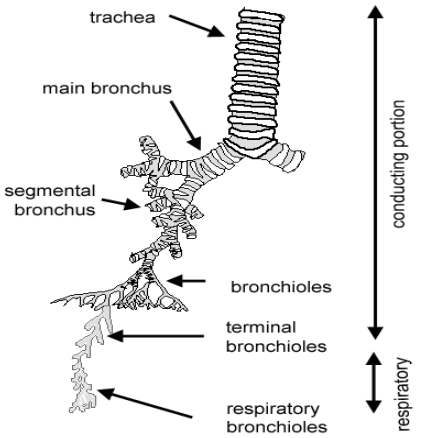
drains into the middle meatus of the nose which is above in position to it so it has a bad drainage

The paranasal sinuses have other function than resonance of the voice, that they decrease the weight of the skull.

The paranasal sinuses are lined with a thin respiratory epithelium and contain few goblet cells. The lamina propria contains only few small glands and is continuous with the underlying periosteum.

The Bronchial Tree

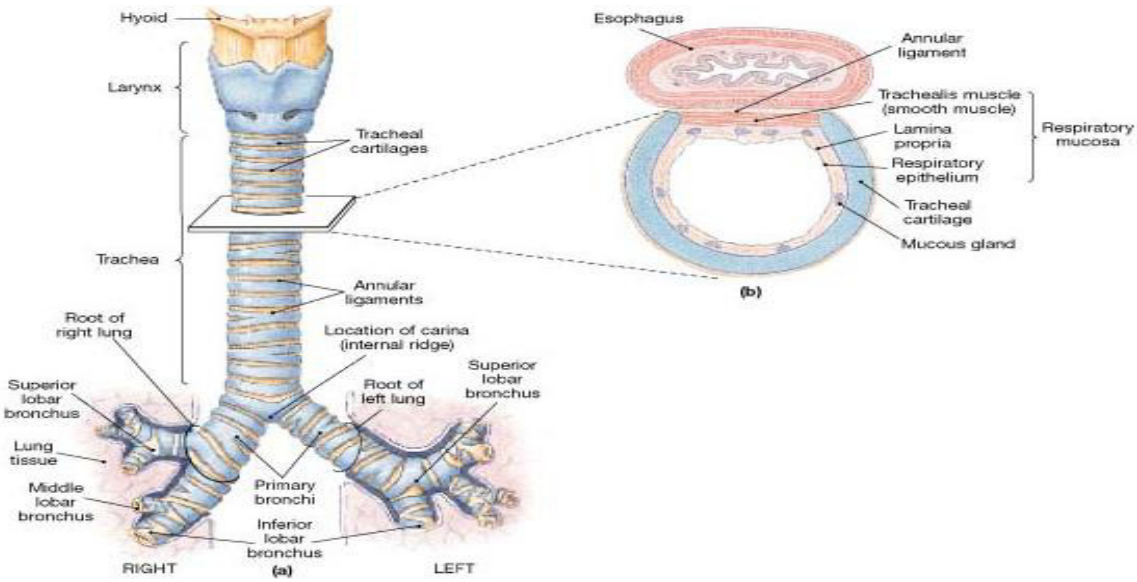
Each lung contains 10 broncho-pulmonary segments. The bronchioles are divided into two parts; conducting bronchioles (terminal bronchioles) and respiratory bronchioles. The bronchioles are rich in smooth muscles but the cartilage, goblet cells and glands are absent in them.



The trachea lies below the larynx; it starts from the 6th cervical vertebra and ends at the 4th thoracic vertebra (bifurcation point) at the level of the sternal angle.

At the level of 4th thoracic vertebra it's divided into right and left main bronchi. The right main bronchus is wider (larger), shorter, and more vertical than the left main bronchus.

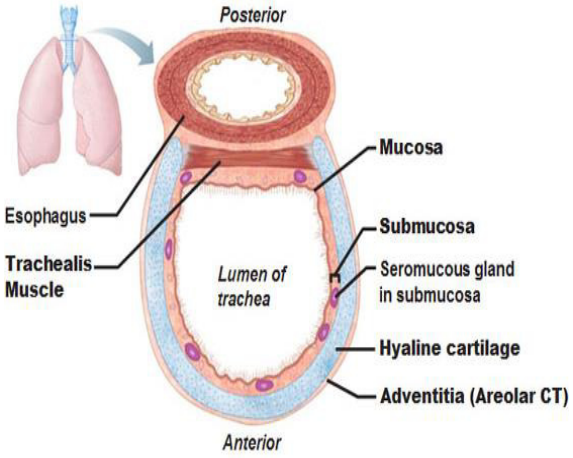
The trachea and the 1ry (main) bronchus are extra-pulmonary. We have three lobar (2ry) bronchi in the right lung and two in the left lung.



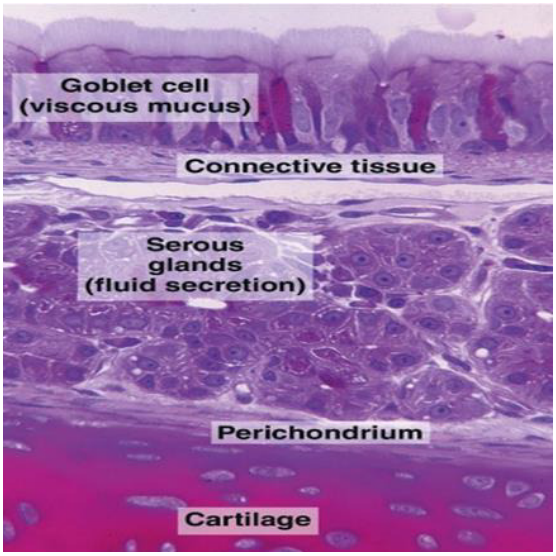
We have 10 tertiary bronchi (broncho-pulmonary segments) in each lung, and as we go distally their diameter decrease. Segmental (tertiary) bronchus is almost 5mm or less in diameter.

Each bronchiole divides into 5-7 terminal bronchioles. Terminal bronchioles diameter is 0.5 mm and they contain Clara cells (no cilia) and neruoepithelial bodies.

The trachea is lined with a typical respiratory mucosa. It has C-shaped rings of hyaline cartilage that keep the tracheal lumen open. It has fibro-elastic ligament and a bundle of smooth muscle (Trachealis) bind to the perichondrium and closes the rings posteriorly.



The fibro-elastic ligament prevents over distention of the lumen. The trachealis muscle allows bolus to pass through the esophagus without any obstruction. Contraction of the Trachealis muscle and the resultant narrowing of the tracheal lumen are involved in the cough reflex.

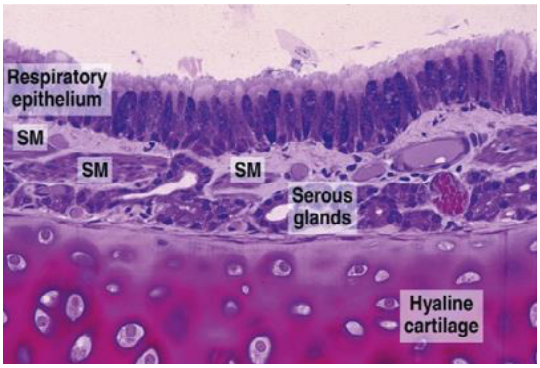


The trachea has numerous seromucous glands that produce fluid mucus and the most important function of them is to trap the dust and foreign particles.

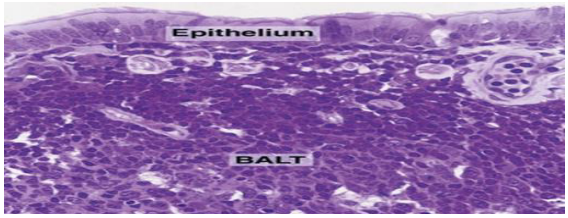
When we reach the bronchi the hyaline cartilage is arranged into plates form instead of rings. In the bronchioles the cartilage is replaced by spiral smooth muscle.

The Dr. stopped here at slide #48 and highlighted the differences between bronchi and trachea, so I will mention here the information written in the slides in a somehow summarized way.

The bronchi have narrower lumen and irregular bronchial cartilage plates. They have smooth muscle layer consisting of spirally arranged bundles between the lamina propria and submucosa. Contraction of this muscle layer is responsible for the folded appearance of the bronchial mucosa.



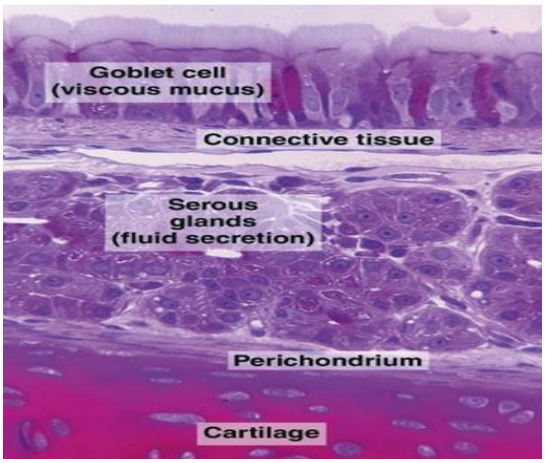
Its lamina propria is rich in elastic fibers and contains an abundance of mucous and serous glands. It has respiratory epithelium with fewer goblet cells (goblet cells disappear at the bronchioles).



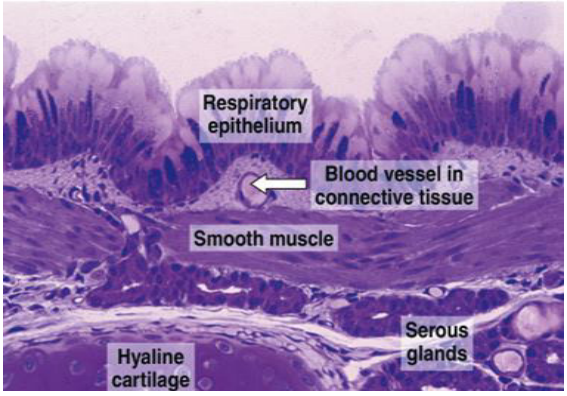
They have numerous lymphocytes and lymphatic nodules (BALT) infiltrating by the adventitia.

Structural changes in the conducting portion of the respiratory tract

The extra-pulmonary bronchi have pseudostratified ciliated columnar epithelium with goblet cells with a prominent basement membrane. They have relatively thin lamina propria. Their submucosae contain seromucous glands. They have "C" shaped hyaline cartilage rings without smooth muscle.

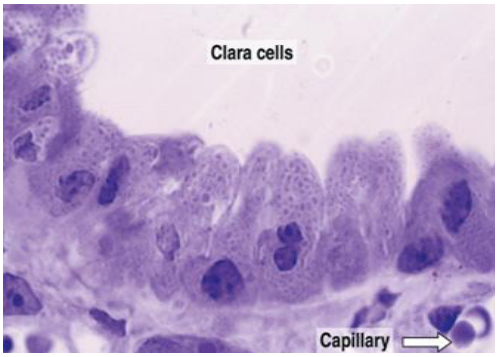


The Intra-pulmonary bronchi have pseudostratified ciliated columnar epithelium. This epithelium is changing to ciliated simple columnar in smaller branches. They have Goblet cells at all levels. Below lamina propria are interlacing

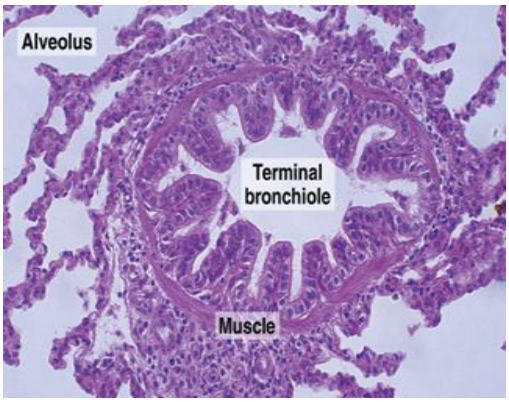


spirals of smooth muscle. Seromucous glands decrease as bronchi get smaller and plates of cartilage gradually disappear.

Bronchioles epithelium is ciliated columnar to ciliated cuboidal. Goblet cells decrease and Clara cells appear. Spirals of smooth muscle relatively heavier than elsewhere (gradually decrease in amount). They have neither seromucous glands nor cartilage.



Respiratory bronchioles have cuboidal epithelium with some cilia with Clara cells but no goblet cells. They have thin supporting wall of connective tissue and an incomplete layer of smooth muscle. Out-pocketing of alveoli starts and numbers increase at lower levels.



Bronchioles have Clara cells(no cilia). Secrete proteins that protect the bronchiolar lining against oxidative pollutants and inflammation. Have neuro-epithelial bodies containing secretory granules and receive cholinergic nerve endings, and chemoreceptors that react to changes in gas composition within the airway.

Longitudinal elastic fibers are present in the lamina propria of all segments of the bronchial system and the smaller the bronchiole the higher proportions of elastic fibers.

Dedicated to أبوكرش و الاسمر