

## + Motivational Corner:

A thousand disappointments in the past cannot equal the power of one positive action right now. Go ahead and go for it.



# Histology of the Lower and upper Respiratory Tract (Nasal cavity, Paranasal sinuses, Larynx, Trachea, Bronchi, Bronchioles) & the Lung

## Objectives

**By the end of this lecture, the student should be able to describe:**

**the microscopic structures of:**

- Vestibule of the nasal cavity.
- Respiratory mucosa of the nasal cavity.
- Nasal septum.
- Olfactory mucosa of the nasal cavity.
- Mucosa of the paranasal sinuses.
- Larynx.

**The microscopic structures of the wall of:**

- Trachea.
- Primary or extrapulmonary bronchi.
- Intrapulmonary (secondary and tertiary) bronchi.
- Bronchioles.

**The microscopic structures of :**

- Inter-alveolar septum.
- Alveolar phagocytes.
- Pleura.

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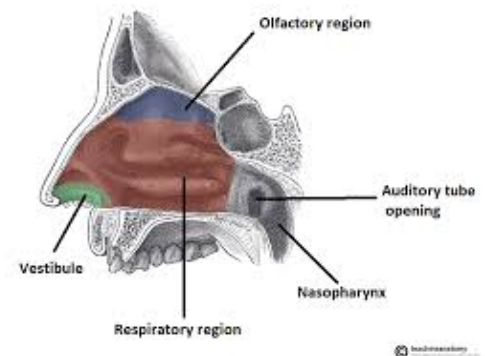
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# UPPER RESPIRATORY TRACT

CONDUCTING PORTION	RESPIRATORY PORTION
<ol style="list-style-type: none"> <li>1- Nasal cavity.</li> <li>2- Nasopharynx.</li> <li>3- Larynx.</li> <li>4- Trachea.</li> <li>5- Primary bronchi (extra-pulmonary bronchi).</li> <li>6- Intrapulmonary bronchi:               <ul style="list-style-type: none"> <li>- 2ry bronchi (lobar bronchi).</li> <li>- 3ry bronchi (segmental bronchi).</li> </ul> </li> <li>7- Primary bronchioles (pre-terminal bronchioles).</li> <li>8- Terminal bronchioles.</li> </ol>	<ol style="list-style-type: none"> <li>1- Respiratory bronchioles.</li> <li>2- Alveolar ducts.</li> <li>3- Alveolar sacs.</li> <li>4- Pulmonary alveoli.</li> </ol>

## NASAL CAVITY



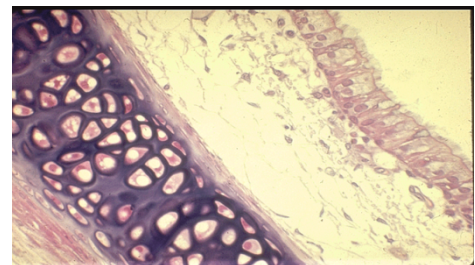
◆ Nasal septum divides the nasal cavity into two halves (right and left)

## RESPIRATORY EPITHELIUM:

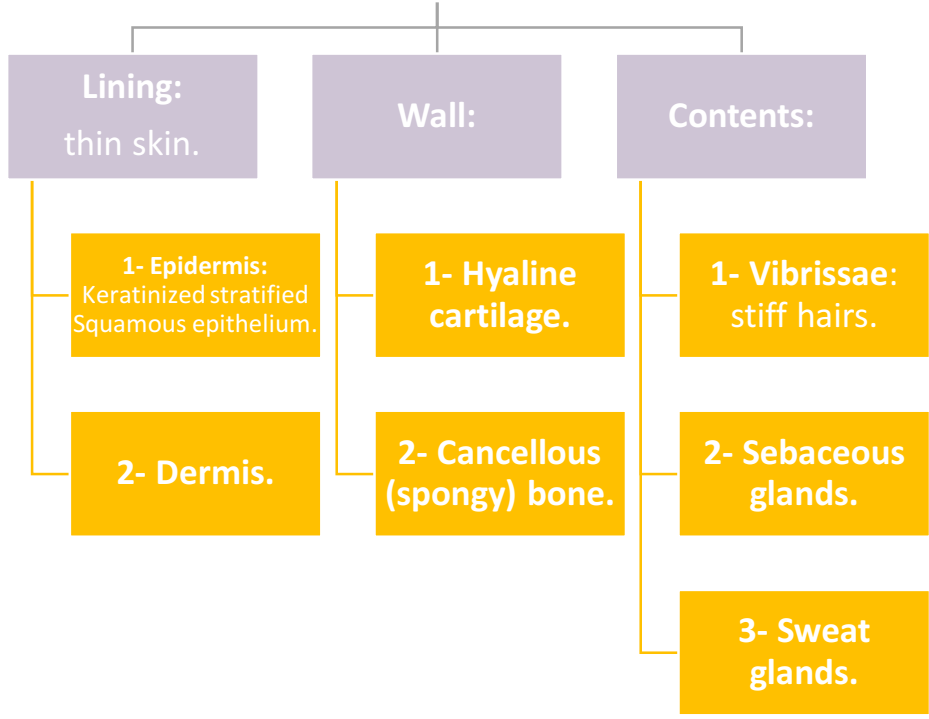
- Pseudo-stratified
- ciliated columnar epithelium
- with goblet cells

**Main types of cells (all touch the basement membrane):**

- 1- Ciliated columnar cells.
- 2- Goblet cells.
- 3- Basal cells: are stem cells.
- 4- DNES cells: e.g. serotonin.



# VESTIBULE OF NASAL CAVITY



## RESPIRATORY REGION OF THE NASAL CAVITY:

### MUCOSA (MUCOUS MEMBRANE):

#### EPITHELIUM

Pseudo-stratified ciliated columnar epithelium with goblet cells (Respiratory epithelium).

#### LAMINA PROPERIA

**(Sub-epithelial C.T.):**  
contains:  
 1- Large arterial plexuses & venous sinuses (Highly vascularized C.T.)  
 3- Many seromucous glands (acini).  
 4- Abundant lymphoid elements:  
 Including occasional lymphoid nodules, plasma cells & mast cells.

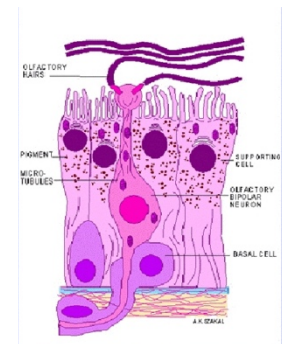
## PARANASAL SINUSES:

- **Lining:**
  - 1- Respiratory epithelium.
  - 2- Lamina propria.
    - **Clinical Application:** Sinusitis.

**SINUSITIS** is an inflammation, or swelling, of the tissue lining the sinuses. Normally, sinuses are filled with air, but when sinuses become blocked and filled with fluid, germs (bacteria, viruses, and fungi) can grow and cause an infection. Conditions that can cause sinus blockage include the common cold, allergic rhinitis (swelling of the lining of the nose), nasal polyps (small growths in the lining of the nose), or a deviated septum (a shift in the nasal cavity)

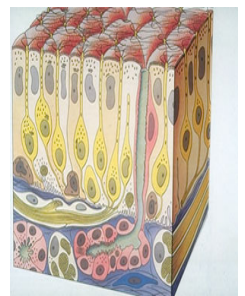
# OLFACTORY REGION:

SITE	
<ol style="list-style-type: none"> <li>1. Roof of nasal cavity.</li> <li>2. Upper part of nasal septum.</li> <li>3. Over superior concha.</li> </ol>	
STRUCTURE	
OLFACTORY EPITHELIUM:	LAMINA PROPRIA:
<p><b>Pseudo-stratified columnar epithelium.</b></p> <ol style="list-style-type: none"> <li>1. <b>Olfactory cells</b> (olfactory nerve cells)</li> <li>2. <b>Sustentacular</b> (supporting) cells.</li> <li>3. <b>Basal cells:</b> Pyramidal in shape, basal in position and act as stem cells.</li> </ol>	<p>Highly vascular loose to dense C.T.</p> <p><b>Contains:</b></p> <ol style="list-style-type: none"> <li>1. <b>Bowman's glands</b> (olfactory glands): serous acini.</li> <li>2. Bundles of unmyelinated <b>nerve fibers.</b></li> <li>3. axons of <b>olfactory nerve cells</b> + Schwann-like cells (glial cells).</li> <li>4. Rich vascular plexus. Numerous <b>lymphoid elements.</b></li> </ol>



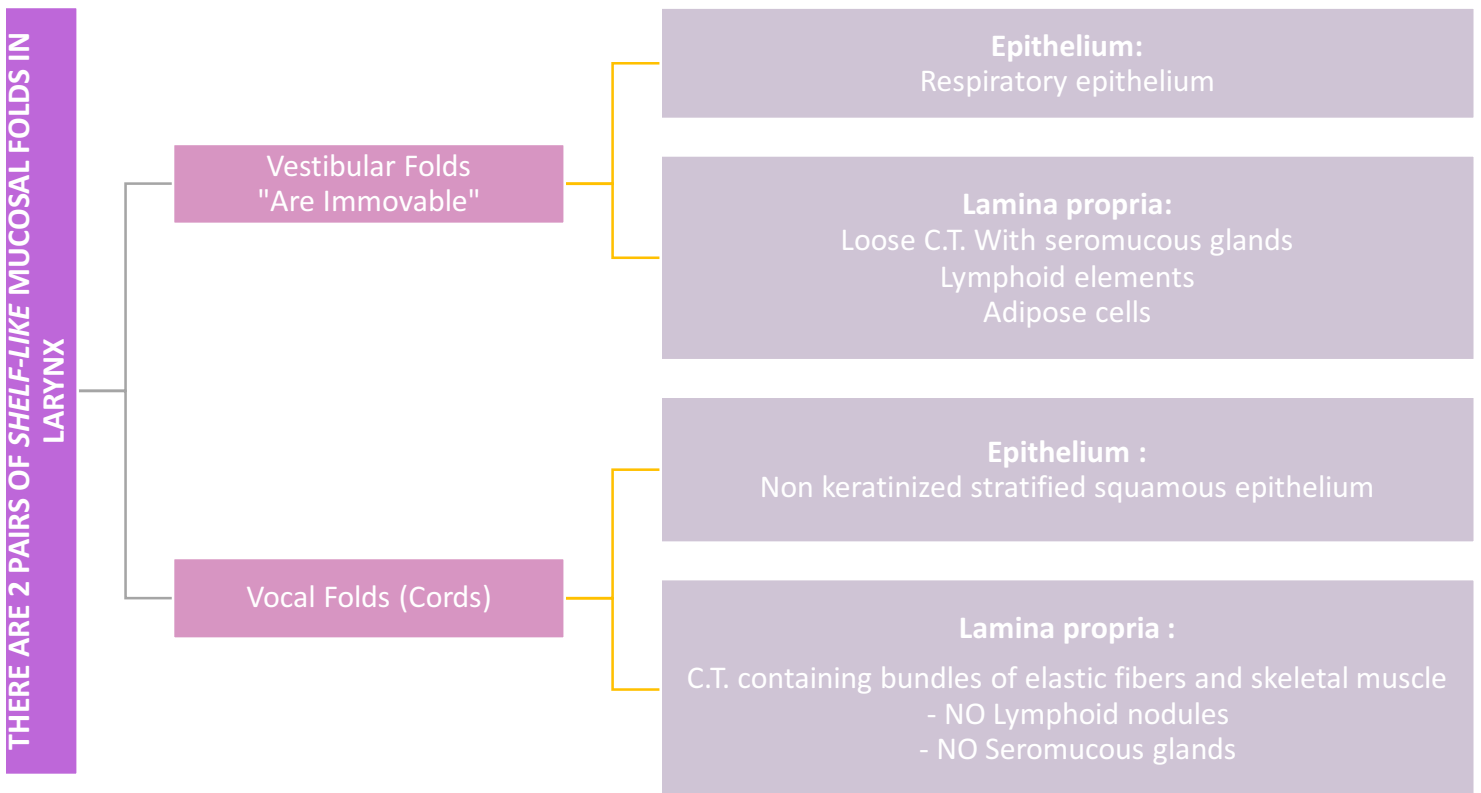
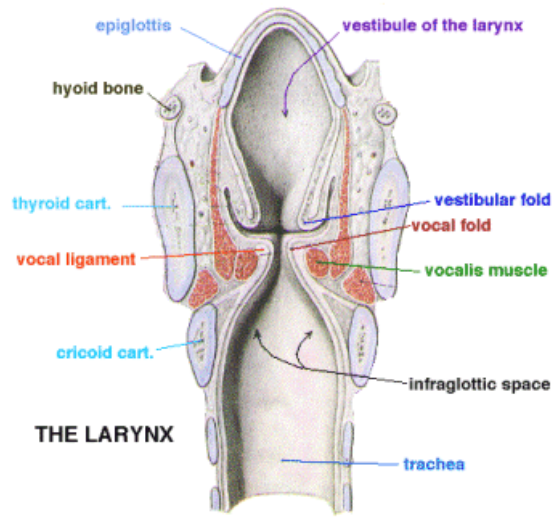
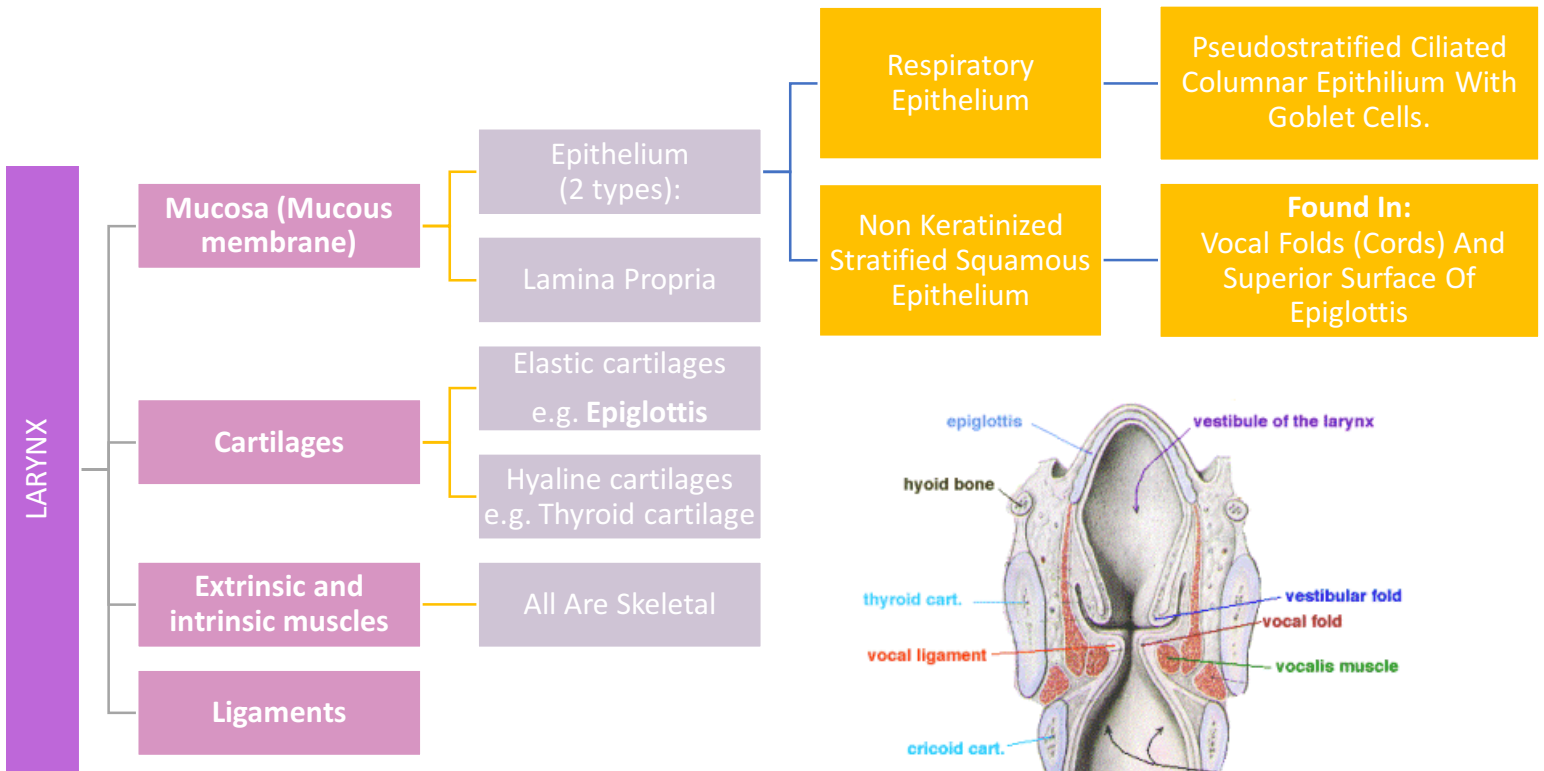
# OLFACTORY EPITHELIUM:

OLFACTORY CELLS	SUSTENTACULAR (SUPPORTING) CELLS
<ul style="list-style-type: none"> <li>• Are <b>bipolar neurons</b></li> <li>• <b>Dendrite</b> has olfactory vesicle that has nonmotile cilia.</li> <li>• <b>Axons</b> are unmyelinated with Schwann-like cells.</li> <li>• Axons will collect in the lamina propria to form bundles of nerve fibers. Bundles will collect to form the olfactory nerve.</li> </ul>	<p>are columnar cells.</p> <p><b>Function:</b></p> <ul style="list-style-type: none"> <li>• Physical support and nourishment for olfactory cells.</li> </ul>





# LARYNX:



# HISTOLOGY OF THE TRACHEA:

## MUCOSA

**Epithelium:**  
Respiratory epithelium

**Lamina propria:**

- **Elastic lamina:**
- It is formed of elastic fibers.
- It separates lamina propria from submucosa.

## SUBMUCOSA

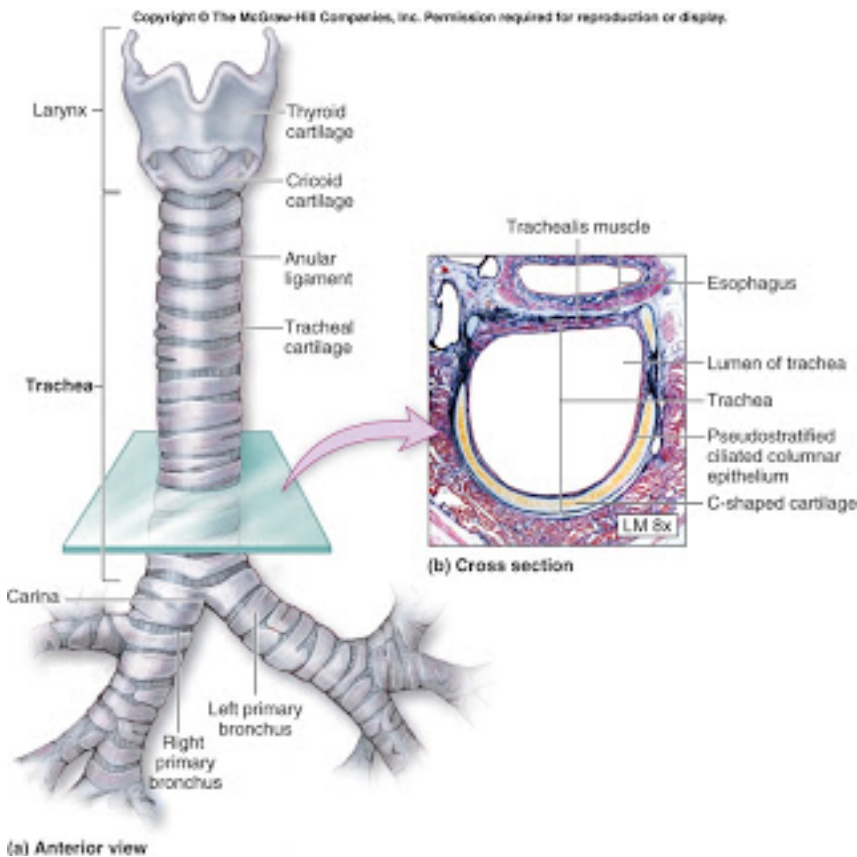
- Connective tissue
- Numerous mucous & seromucous glands.
- Lymphoid elements

## ADVENTITIA

Fibroelastic C.T.

**C-shaped rings (12-16) of hyaline cartilage.**

Trachealis muscle (bundle of smooth muscle fibers) connects the 2 ends of each C-shaped (incomplete ring of cartilage to allow movement)



# 1-Extrapulmonary Bronchus

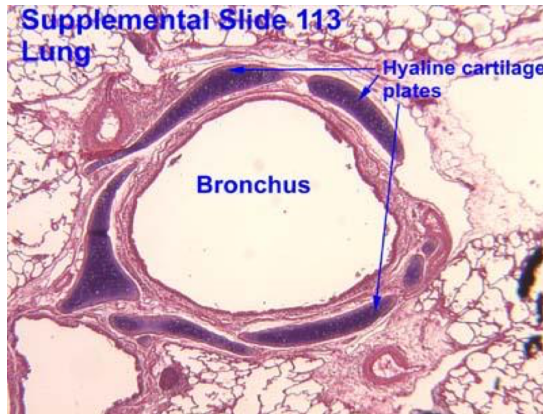
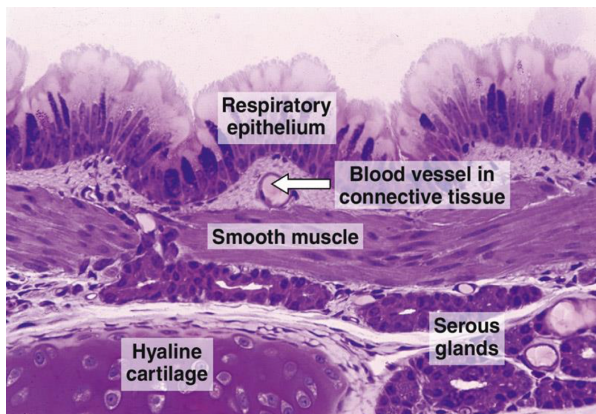
## (1ry Bronchus):

Generally have the same histological appearance as the trachea.

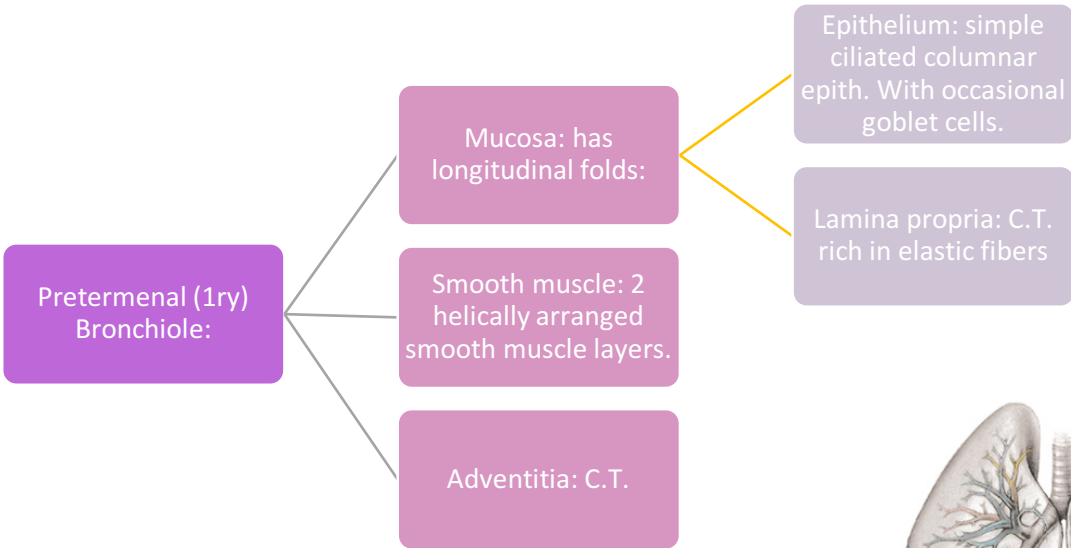
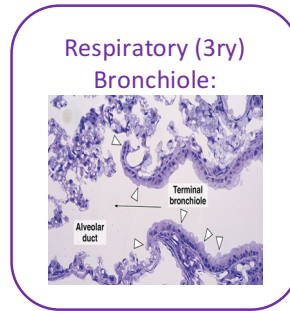
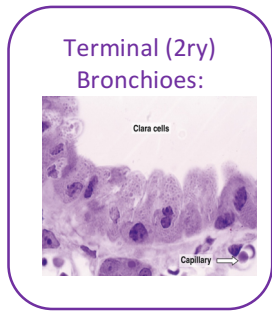
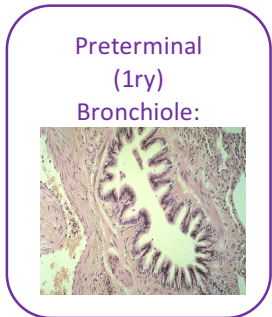
# 2-Intrapulmonary Bronchi

## (2ry and 3ry bronchi):

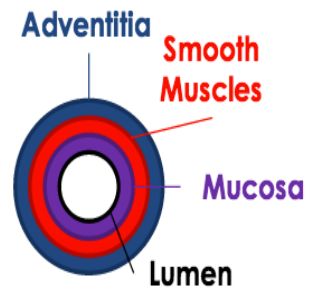
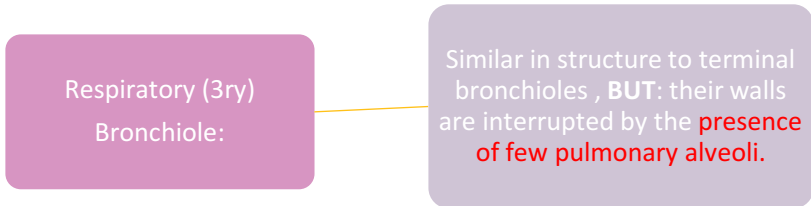
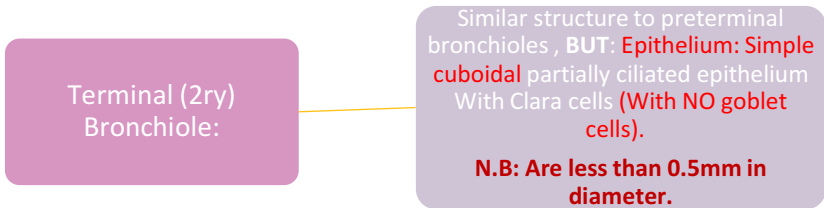
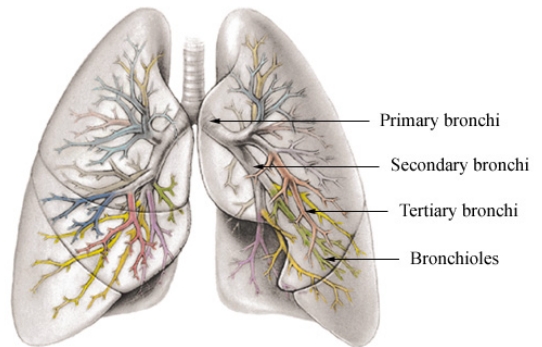
1-Mucosa	2-Muscle coat (complete)	3-Submucosa	4-Adventitia
A-Epithelium: Respiratory epith.  B-Lamina propria.  N.B No elastic lamina.	Two distinct layers of smooth muscle fibers spirally arranged in opposite direction.	C.T. Contains: A-Seromucous glands.  B-Lymphoid elements	Contents: A- loose C.T. B- Irregular plates of hyaline cartilage (complete layer).  C-Solitary lymphoid nodules.



# Bronchioles:



**no cartilage no seromucous glands no lymph nodules.**



**Note:** difference between bronchioles and bronchus: bronchioles no cartilage + epithelium "simple ciliated"

**Note:** Terminal bronchiole = end of conducting portion + end of goblet cells, Goblet cells are replaced by Clara cells

**Note:** Special features of everyone of them:  
 Preterminal > Goblet cells  
 Terminal > NO goblet cells  
 Respiratory > Alveoli

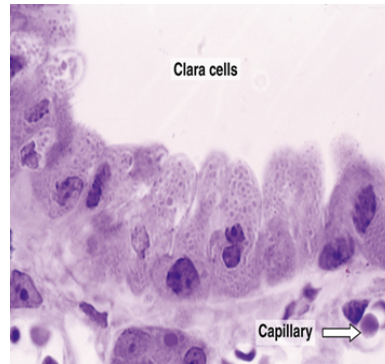


# Clara cells

Structure: columnar cells (**non ciliated**).

Function:

- Degrade toxins in inhaled air.
- Divide to regenerate the bronchiolar epith.
- **Produce surfactant-like material.**

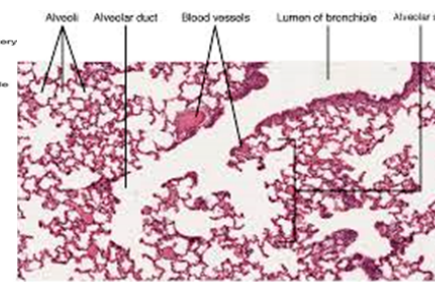
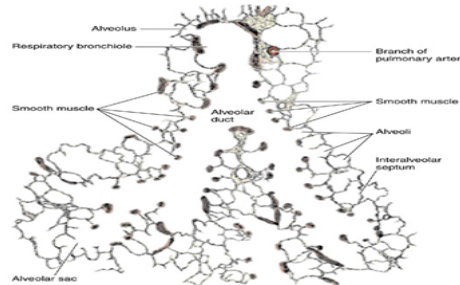


Clara cells are found in terminal and respiratory bronchioles. The domed profile of the membrane on the luminal surface and lack of cilia distinguish the clara cells.

# Alveolar ducts

The wall of alveolar ducts consist almost of pulmonary alveoli.

N.B. Alveolar duct → ends by: atrium → communicates with: 2-3 alveolar

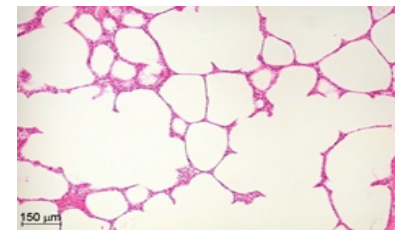
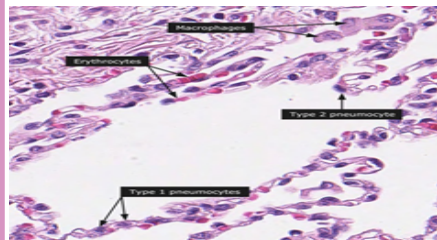


# Pulmonary Alveoli

Definition: They are small out-pouching of respiratory bronchioles, alveolar ducts & alveolar sacs.

Topics:

- \* Interalveolar septa.
- \* Alveolar epithelium.
- \* Alveolar phagocytes (Lung macrophages).



# Interalveolar septa

*Definition: The region between 2 adjacent alveoli.*

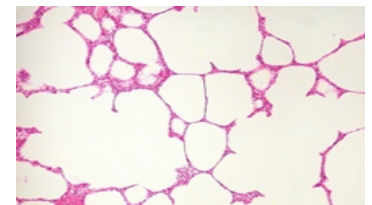
*Components:*

*(A) Alveolar Epithelium: lines both sides of interalveolar septum.*

*(B) Interstitium.*

## Interstitium of interalveolar septa:

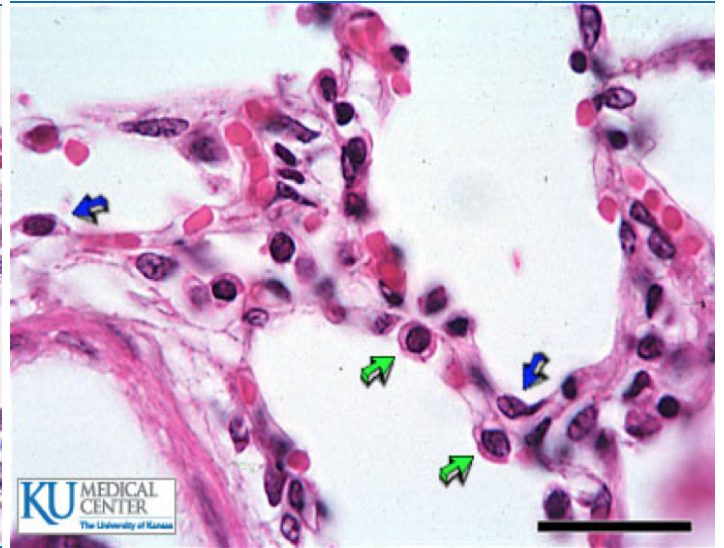
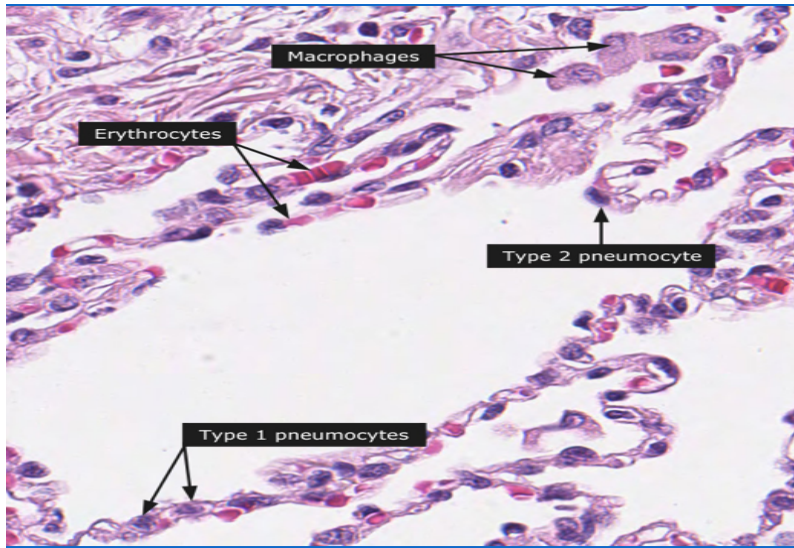
- 1- Continuous Pulmonary capillaries.
- 2- Interstitial C.T:
  - a- C.T. Fibers: elastic fibers & **type III collagen** (reticular fibers).
  - b- CT cells: Fibroblasts, macrophages, **mast cell**, lymphocytes.



# ALVEOLAR EPITHELIUM

1- Type I pneumocyte.

2- Type II pneumocyte.



blue arrow type I pneumocyte green arrow type II pneumocyte

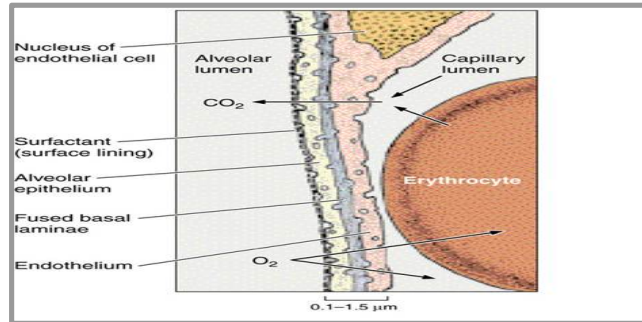
ALVEOLAR EPITHELIUM	Type I Pneumocytes	Type II Pneumocytes
	Line 95% of the alveolar surface.	Line 5% of the alveolar surfaces
COUNT	Less numerous than type II pneumocytes.	Are <b>more numerous</b> than type I pneumocytes.
L/M	Simple squamous epithelium	Are cuboidal or rounded cells, with <b>foamy cytoplasm</b> . <b>Nucleus:</b> central & rounded. <b>The cytoplasm</b> contains membrane- bound <u>Lamellar bodies</u> (contain pulmonary surfactant).
FUNCTION	Exchange of gases.	1-Synthesis & secretion of pulmonary surfactant. 2-Renewal of alveolar epithelial cells: Type II cells can divide to regenerate both type I & type II pneumocytes.

## ● BLOOD GAS BARRIER (BLOOD-AIR BARRIER):

It is the region of the interalveolar septum that is traversed by O<sub>2</sub> & CO<sub>2</sub>.

### ❖ Components:

- 1- Thin layer of surfactant.
- 2- Type I pneumocyte.
- 3- Fused basal laminae of type I pneumocytes & endothelial cells of the pulmonary capillary.
- 4- Endothelial cells of the pulmonary capillary.



## ● Alveolar phagocytes (Alveolar Macrophages) (Dust Cells)

### ❖ Sites:

- ❑ In the lumen of pulmonary alveoli.
- ❑ In the interstitium of interalveolar septa.

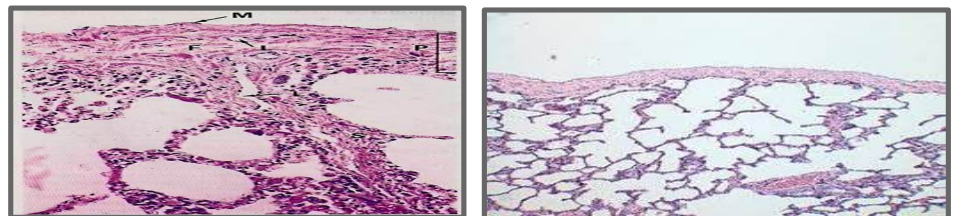
### ❖ Function:

Phagocytose particulate matter (e.g. dust) & bacteria in the lumen of pulmonary alveoli and in the interstitium of interalveolar septa.

## ● Pleura:

Is formed of two layers:

1. Parietal
2. visceral



It is formed of simple squamous mesothelium. The two layers are separated by serous fluid. The visceral layer has sub-epithelium loose C.T that extends into the lung tissue



## Extra notes:

- The nose is responsible for the humidification and warming of the air and also for smelling, that is important because if very hot dry air reached the delicate alveoli then it would rupture.
- Mucosa: Epithelium + CT (Lamina Propria) in wet areas.
- The highly vascularized C.T is there to help warm the air.
- Sinusitis: When you have a flu the mucus membrane becomes edematous so the opening to the nasal sinus will close, the resonance of the voice will be lost also as a result of it closing stagnation of the fluids and secretions will occur and as a result we will have an inflammation it may be acute like in the case of the flu or chronic. then the first step of sterilizing it is by the abundant typhoid elements.
- Bowman's glands: they produce the serous to make the particles easily soluble
- The dendrites that have the non-motile cilia is there so it can cover more surface area and receive more particles.
- The vocal folds are non keratinized squamous epithelium because it is movable and because it can tolerate the friction that may occur.
- The vocal folds don't contain the lymphoid nodules or the seromucous glands because they limit its movement by making it heavier.
- The trachealis muscle is responsible for the involuntary control of the diameter of the trachea.
- The opening of the C-shaped rings in the adventitia of the trachea is directed posterior.
- The trachea and bronchi have similar histological structures, the difference is only in the diameter.
- The muscles in the intrapulmonary bronchi are oblique (spirally arranged), this facilitate the control of the diameter.  
We can define the intrapulmonary bronchi from extrapulmonary bronchi histologically by:
  - Muscle coat (exist only in the intrapulmonary bronchi)
  - The cartilages of the intrapulmonary bronchi look like separated plates, not C-shaped as of those of trachea
    - Intrapulmonary bronchi does not have cartilage plates, why?  
To allow the expansion of the lung, because if it was C-shaped, The lung would expand horizontally only and then it would rupture!  
But it is okay with trachea and bronchi, because they don't dilate all the time like the lungs, they only dilate when needed to.
- How to identify a bronchiole (what are the land marks of a bronchiole)?
  - 1- there is no cartilage like in intrapulmonary and extrapulmonary bronchi
  - 2- the epithelium is simple columnar (like preterminal bronchioles), but with branching it becomes simple cuboidal (like terminal bronchioles.)  
The cilia is there in preterminal and terminal bronchioles epithelium to move out foreign bodies.
- The name "Terminal bronchioles" gives a hint that it is terminal for conducting portion and for goblet cells (there is no goblet cells there.)
- The bronchi and trachea are not formed completely by muscles, they have cartilage, this prevents the "complete obstruction" so in case of bronchial asthma, the complete obstruction doesn't happen in the bronchi, but in the bronchioles, because they don't have cartilage to splint it.
- The majority of the thickness in bronchioles is for the smooth muscles.
- Clara cells have anti toxins, which sterile air that enters the lung.
- we never find cilia in secreting cells like Clara and goblet cells.
- Alveoli are opened to each other for in case of destruction of one of them
- Some alveoli are separately open to the alveolar duct, not necessary forming sacs  
**The alveolar duct is like a potential duct (there is no wall), its wall is only formed by alveoli.**
- "Atrium" in alveolar sacs, is a hole between an alveolar duct and an alveolus.
- We never find collagen 1 in healthy lung, but if so, this means that there is fibrosis.
- Type 1 pneumocytes have simple flat nuclei, because at there site the diffusion happens
- There are two types of capillaries: 1-Fenestrated, continuous and 2-discontinuous  
In the interstitium of interalveolar septa, the capillaries must not be fenestrated (the fenestrated causes the toxins of air to get into the circulation)  
So the interstitium here has continuous pulmonary capillaries.
- Lung is covered by membranes, one of them is the pleura  
Composed of: Visceral layer which is adherent to the lung, we can't separate it  
Parietal layer is the outermost layer of the pleura. easy to separate.

## MCQs

Note: the questions are from USMLE step 1 book

1- Which cell is a type of neuron?

- a. Basal cells
- b. Brush cells
- c. Olfactory cells
- d. Sustentacular cells
- e. All of the above

2- What type of tissue makes up the epiglottis?

- a. Compact bone
- b. Spongy bone
- c. Hyaline cartilage
- d. Fibrocartilage
- e. Elastic cartilage

3- What type of epithelium lines the trachea?

- a. Simple squamous epithelium
- b. Simple cuboidal epithelium
- c. Simple columnar epithelium
- d. Stratified squamous epithelium
- e. Pseudostratified epithelium

4- Which structure is part of the conducting portion of the airway?

- a. Bronchi
- b. Alveolar ducts
- c. Alveoli
- d. Alveolar sacs
- e. Respiratory bronchioles

5- What type of epithelium lines the vestibule?

- a. Simple squamous epithelium
- b. Simple columnar epithelium
- c. Stratified squamous epithelium
- d. Ciliated pseudostratified epithelium with goblet cells
- e. Transitional epithelium

6- What is the first portion of the respiratory tree where gas exchange can occur?

- a. Alveolar duct
- b. Alveoli
- c. Alveolar sac
- d. Respiratory bronchiole
- e. Terminal bronchiole

7- Which cell type is located at the basal lamina of the olfactory mucosa?

- a. Basal cells
- b. Brush cells
- c. Olfactory cells
- d. Sustentacular cells
- e. All of the above

8- What type of tissue forms the alveoli in the lung?

- a. Simple squamous epithelium
- b. Simple cuboidal epithelium
- c. Simple columnar epithelium
- d. Stratified squamous epithelium
- e. Pseudostratified epithelium

9- In which structure does gas exchange NOT occur?

- a. Alveolar duct
- b. Alveoli
- c. Alveolar sac
- d. Respiratory bronchiole
- e. Terminal bronchiole

10- Which cell secretes surfactant?

- a. Clara cell
- b. Type I pneumocyte
- c. Type II pneumocyte
- d. Dust cell
- e. Brush cell

11- What part of the respiratory tree is the functional unit where gas exchange occurs?

- a. Alveolar duct
- b. Alveoli
- c. Alveolar sac
- d. Respiratory bronchiole
- e. Terminal bronchiole

12- What type of tissue makes up the rings of the trachea?

- a. Compact bone
- b. Spongy bone
- c. Hyaline cartilage
- d. Fibrocartilage
- e. Elastic cartilage

13- Which structure is NOT part of the conducting portion of the airway?

- a. Bronchi
- b. Larynx
- c. Trachea
- d. Larynx
- e. Respiratory bronchioles

14- What is an olfactory cell?

- a. Unipolar neuron
- b. Bipolar neuron
- c. Multipolar neuron
- d. Supporting cell
- e. None of the above

15- What type of tissue makes up the epiglottis?

- a. Compact bone
- b. Spongy bone
- c. Hyaline cartilage
- d. Fibrocartilage
- e. Elastic cartilage

16- What type of epithelium lines the vestibule?

- a. Simple squamous epithelium
- b. Simple columnar epithelium
- c. Stratified squamous epithelium
- d. Ciliated pseudostratified epithelium with goblet cells
- e. Transitional epithelium

1- C  
2- E  
3- C  
4- A  
5- C  
6- D  
7- A  
8- A  
9- E  
10- C  
11- B  
12- C  
13- E  
14- B  
15- C  
16- C