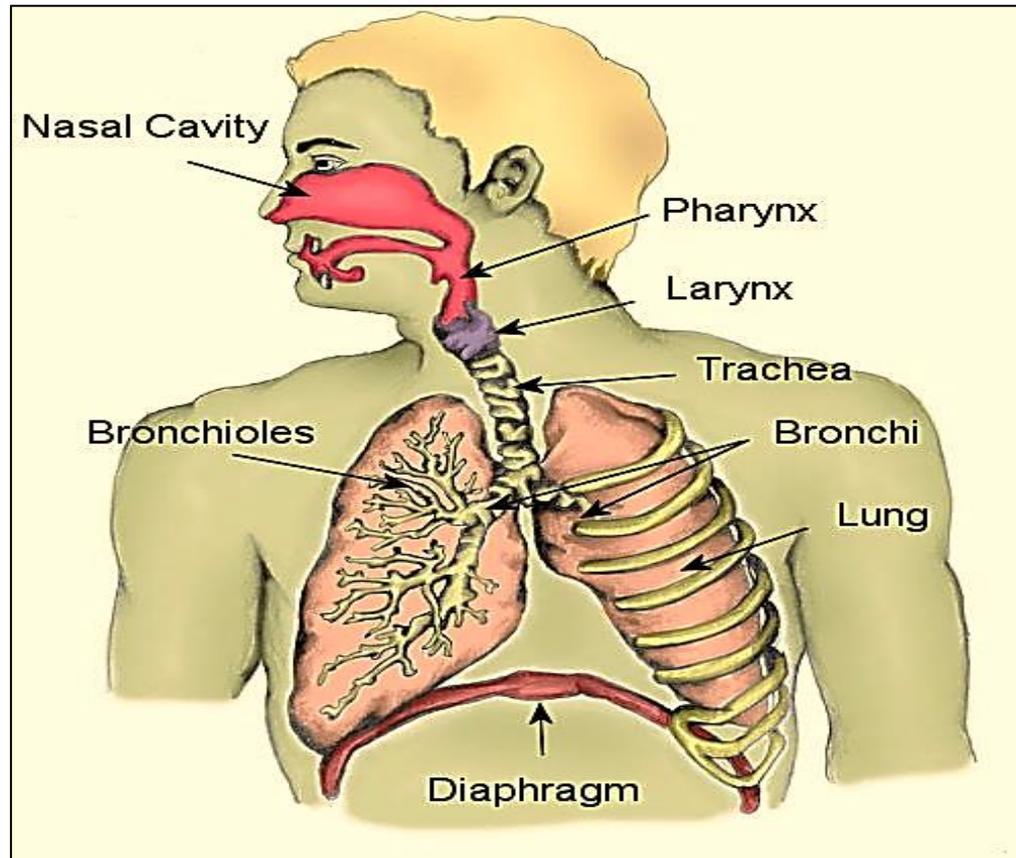


WELCOME THIRD YEAR CLASS



The respiratory system



Objectives of studying the respiratory system:

- Provides tissues for gas exchange between air and blood



- Provides chemoreceptors involved in sense of smell



- Produces sounds (Phonation)



Learning objectives:

- 1- Recognize & describe the cellular components of respiratory epithelium
- 2- Understand the structure & function of conchae
- 3- Recognize & describe the cellular components of olfactory epithelium
- 4- Describe components of the vocal cords
- 5- Recognize & understand function of epiglottis
- 6- List the tubes that make up the conducting and respiratory portions
- 7- Distinguish between a bronchus, bronchioles & respiratory bronchiole
- 8- List all components that make up the interalveolar septum
- 9- Distinguish between type I & type II alveolar cells , macrophage and endothelium
- 10- Describe the two separate blood supplies to the lung & understand their function

Respiratory system

```
graph TD; A[Respiratory system] --> B[Conducting portion]; A --> C[Respiratory portion]; B --> D[Conduct, filters, warms & moistens air]; C --> E[Gas exchange & secretion of Surfactant]
```

Conducting portion

Conduct, filters, warms & moistens air

Respiratory portion

Gas exchange & secretion of Surfactant

- **Types of epithelium in the respiratory system:**

1- Non- K stratified squamous epith. → found at nostrils, lingual surface of epiglottis, & true vocal cords

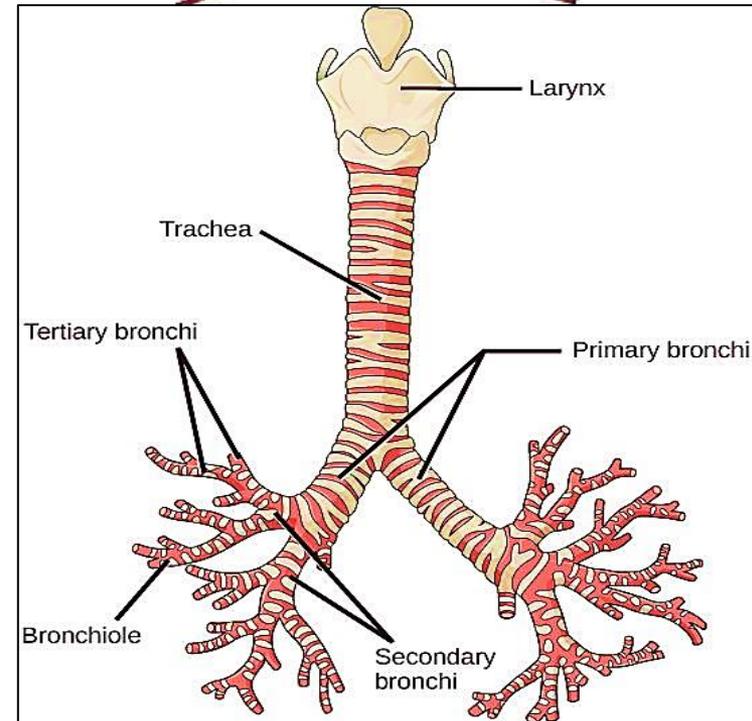
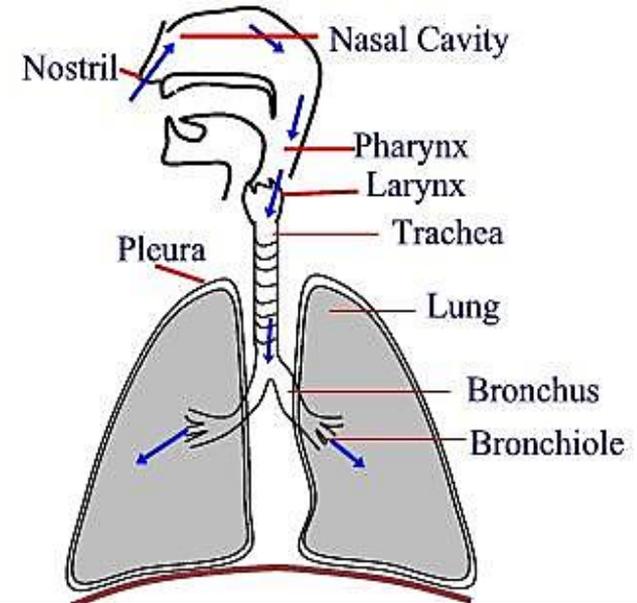
2- Respiratory epith. Cover most of the conducting portion of the respiratory tract

3- Olfactory epith. Contains chemoreceptors of smell sensation → superior conchae

4- Alveolar epith. Found in Respiratory portion / alveoli where gas exchange

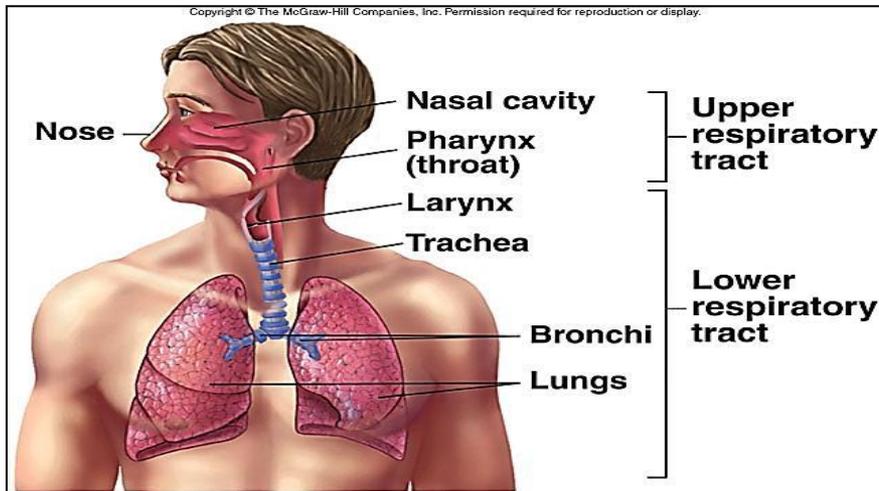
➤ A- Parts of The conducting portion :

- Nasal cavities & sinuses
- Nasopharynx
- Larynx
- Trachea
- Bronchi (Rt & Lf)
- 2ry , 3ry bronchi
- Bronchioles
- Terminal bronchioles



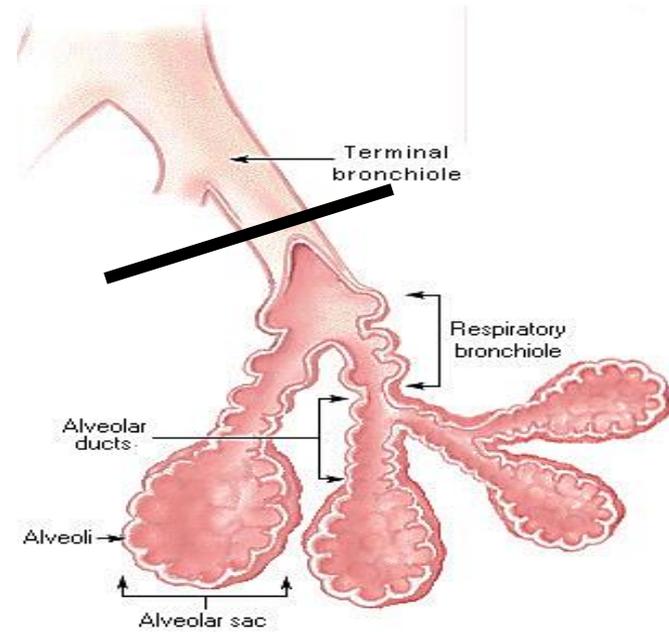
Structure / Function relation in Conducting portion

- Cartilage to prevent collapse → Maintain an open lumen
- Elastic fibers & smooth ms. fibers for flexibility → Ability to accommodate expansion & contraction
- Respiratory epithelium → Filtering, moisturizing & warming of inspired air



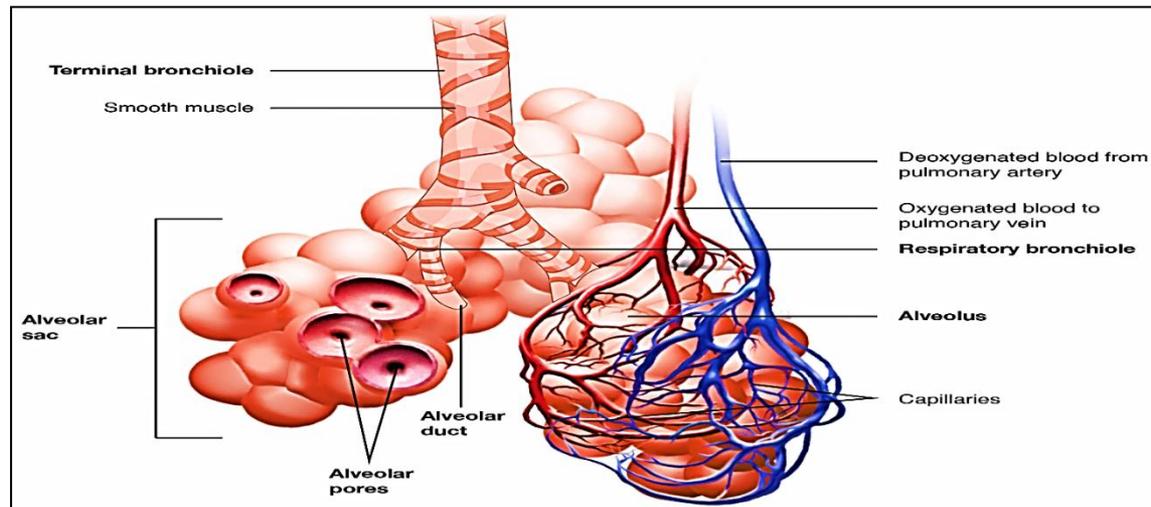
➤ B- Parts of The respiratory portion :

- Respiratory bronchioles
- Alveolar ducts
- Alveolar sacs
- Alveoli



Function of respiratory portion:

Gas (O_2/CO_2) exchange between blood & inspired air
Production of surfactant



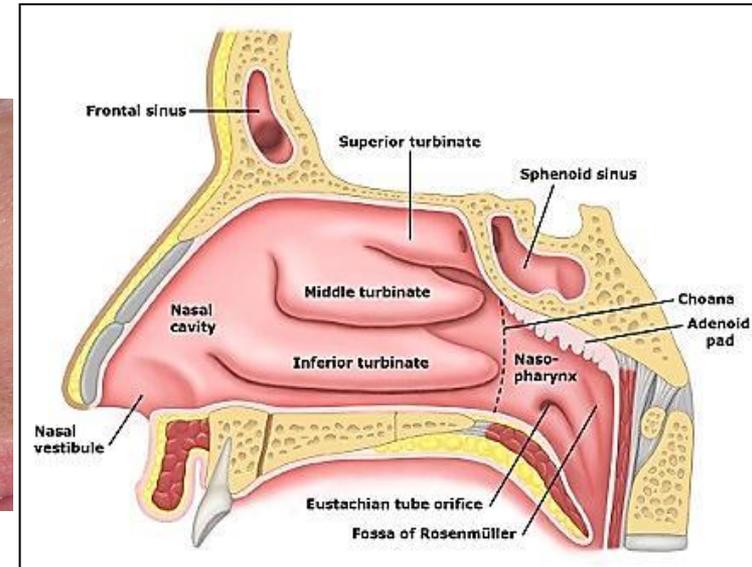
A- Conducting portion

Nasal cavities: separated by a septum (cartilaginous & bony) parts

each consists of: vestibule & nasal fossa

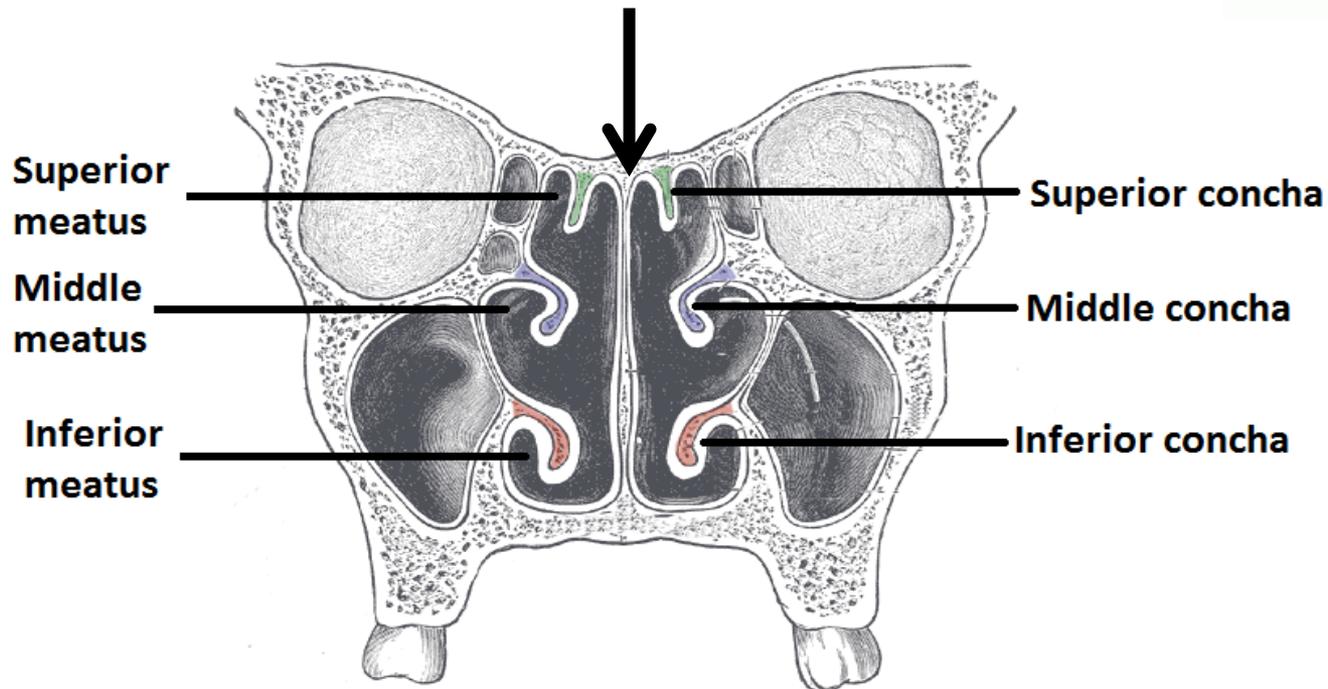
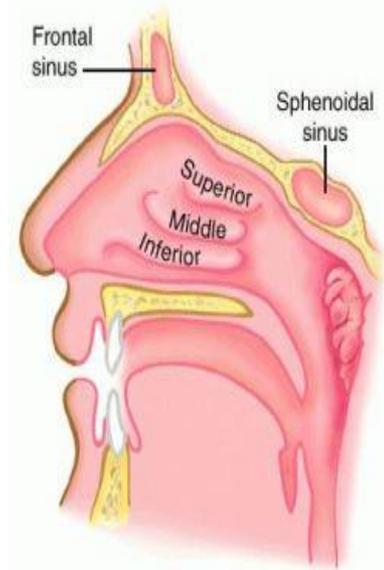
Vestibule:

- Is the anterior part
- Lined e **thin skin**
deeper changes → **non - keratinized st. squ. epithelium**
- hair filters out large dust particles



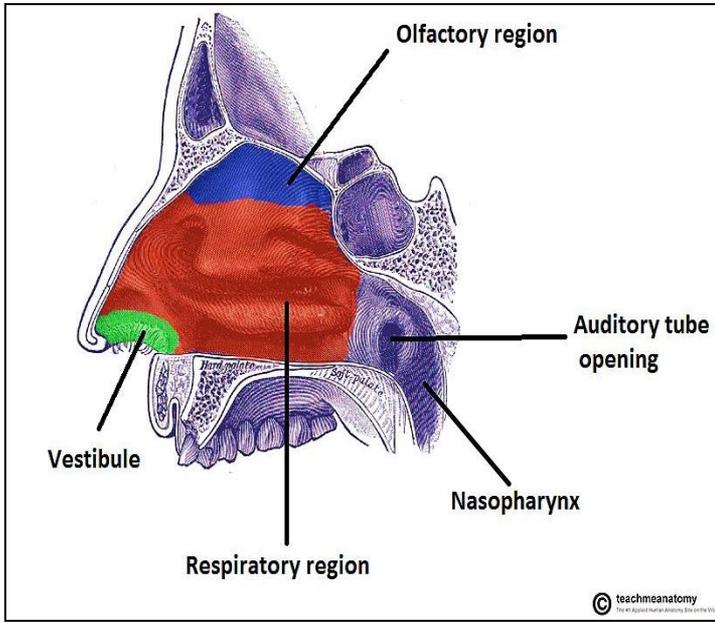
Nasal fossae:

- 2 cavities separated by nasal septum
- Their lateral walls contain 3 bony projections (conchae) superior, middle, inferior

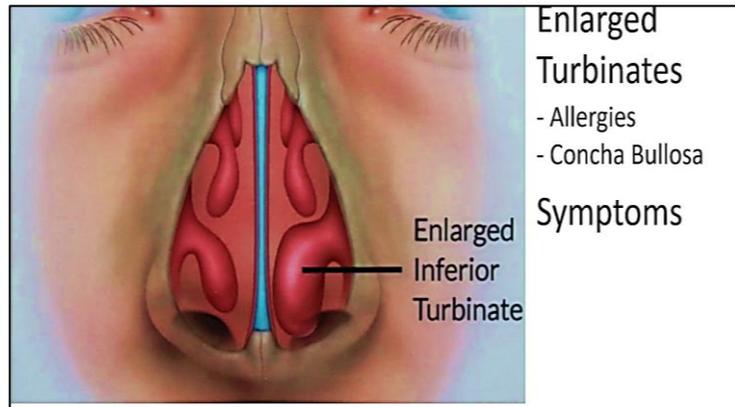


- Superior one covered e **Olfactory epithelium**
- Middle & inferior covered e **respiratory epithelium**

- The conchae slow flow of air & increase the surface area of respiratory epithelium for conditioning of the inspired air



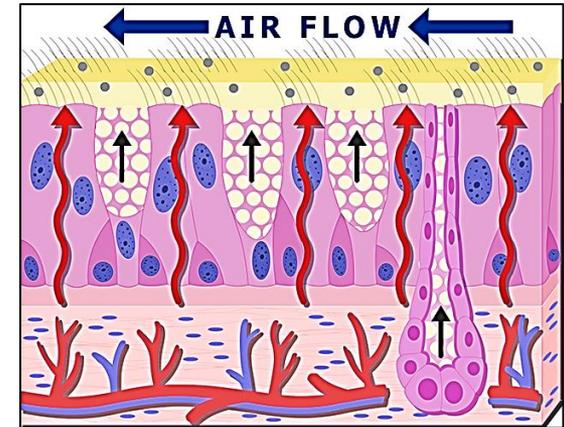
- lamina propria beneath RS epith. rich with superficial venous plexus (**swell bodies**)



Swell bodies:

Loops of venous plexus located in of lamina propria of the respiratory epithelium of the nasal cavities

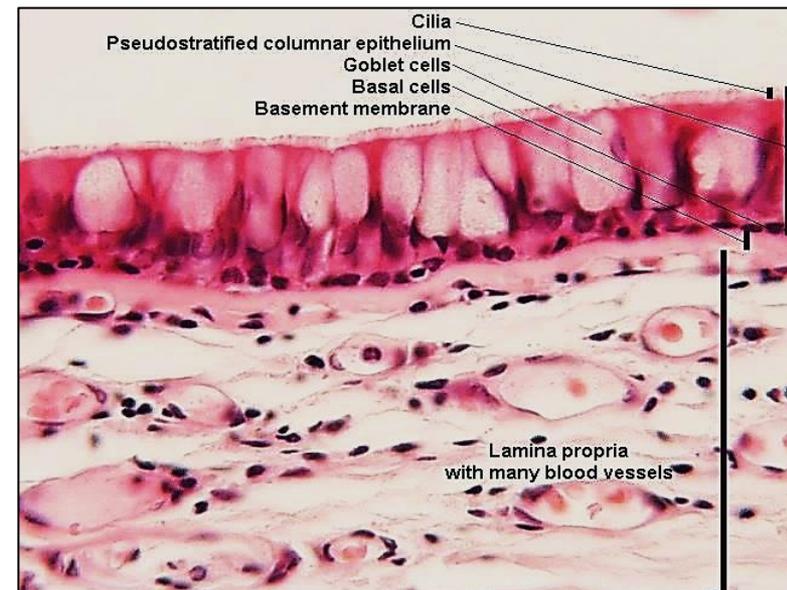
1- Important for conditioning & warming of inhaled air → “counter current flow”



2- Due to their thin wall & proximity to the surface **nosebleed** occurs so common

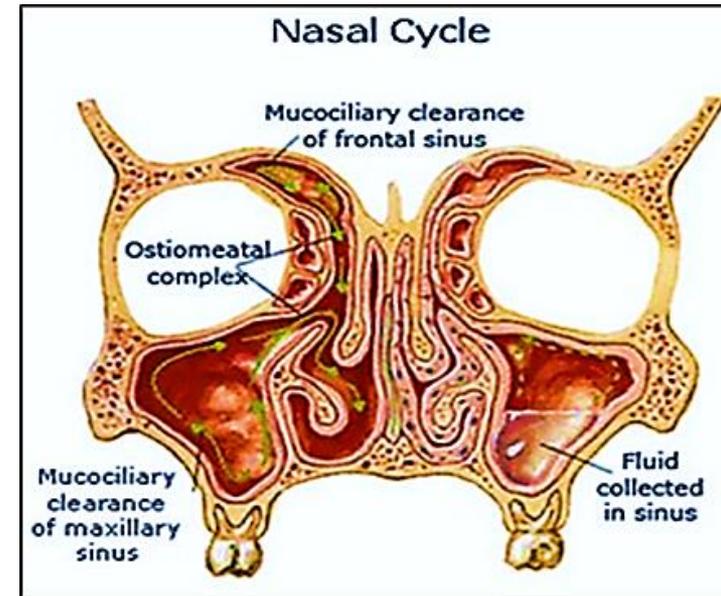
3- Responsible for **nasal cycle**

4- Allergic reactions & inflammation can cause sever engorgement of swell bodies in both fossa



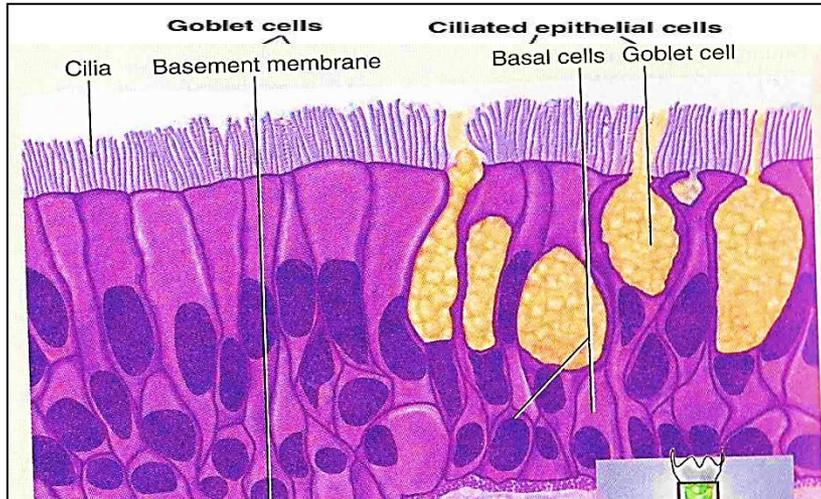
Nasal cycle:

- Every 20-30 min. rhythmic cycles of physiological congestion & decongestion occurs in the mucosa of the nasal cavities. Normally we are not aware of it
- When Swell bodies in lamina propria of one nasal cavity become engorged with blood → distention of conchal mucosa → ↓ flow of air → allowing the engorged Res. Epith. To recover from dehydration
- The cycle under the control of autonomic nervous system

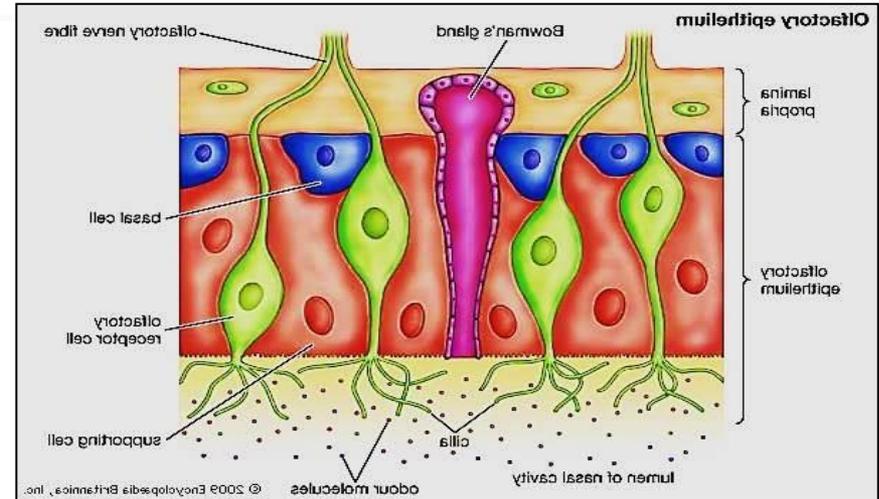


Q:What is the difference between the respiratory & olfactory epithelium?

RESPIRATORY



OLFACTORY



The respiratory epithelium:

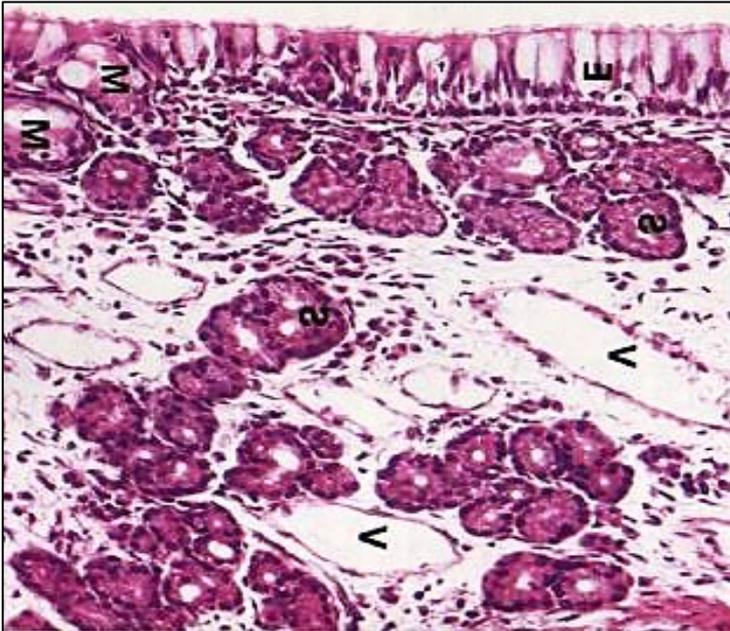
- Pseudostratified columnar ciliated e goblet cells

The olfactory epithelium:

- Pseudostratified columnar e chemoreceptors & NO
goblet cells

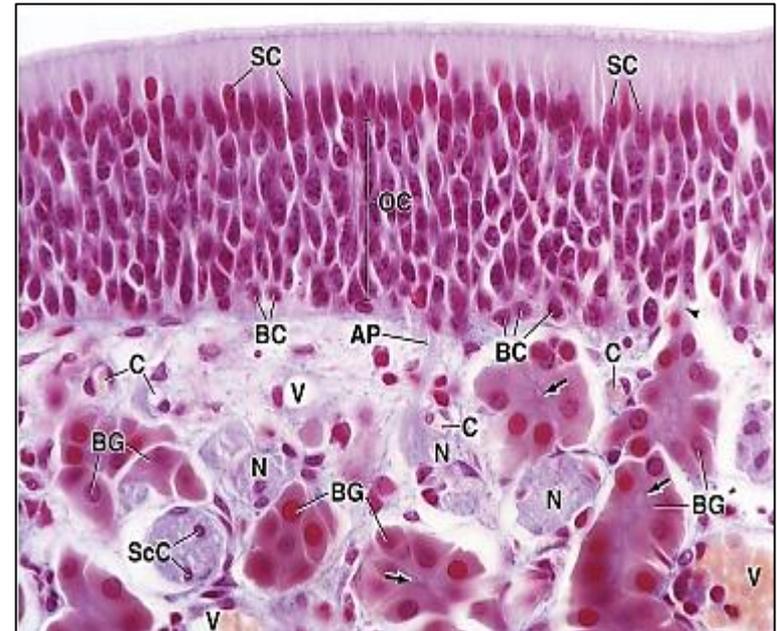
Respiratory mucosa

- Epithelium
- Lamina propria
- Nasal glands (M & S)
- Blood vessels



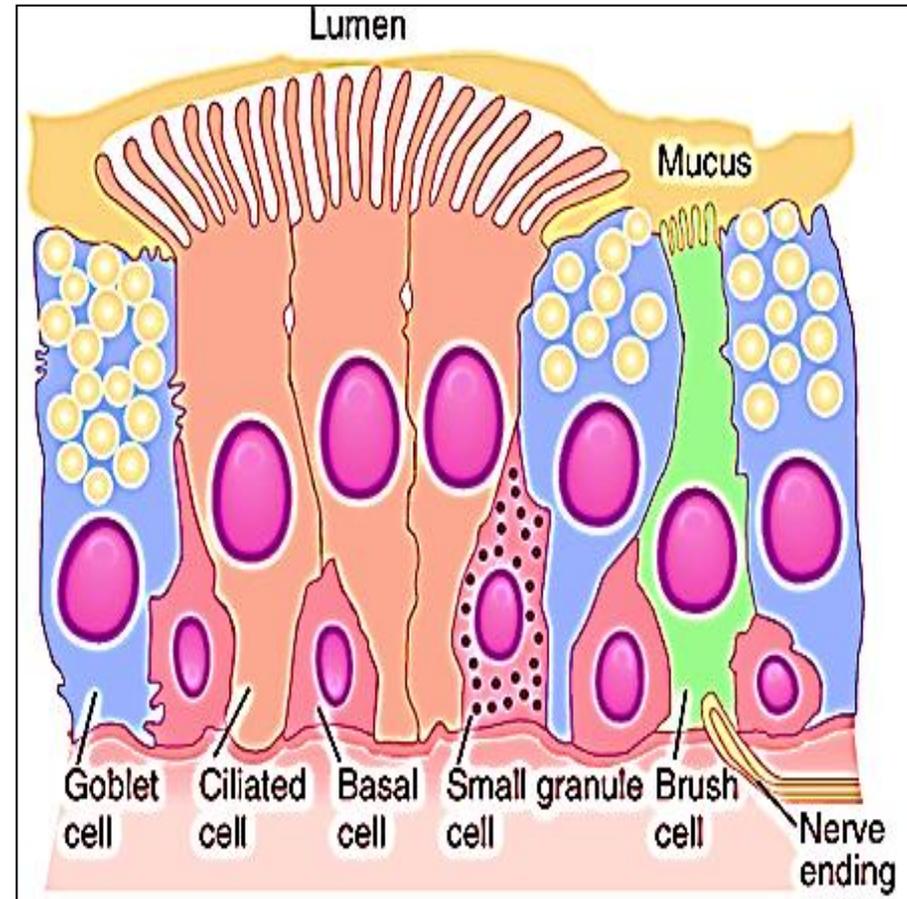
Olfactory mucosa

- Epithelium
- Lamina propria
- Olfactory glands (S only)
- Blood vessels



The respiratory epithelium

- Lines most of the conducting portion
- **5 types of cells** are present:
 - 1- Columnar ciliated cells**
 - 2- Goblet cells**
 - 3- Brush cells**
 - 4- Basal (stem) cells**
 - 5- Granule cells (NE cells)**



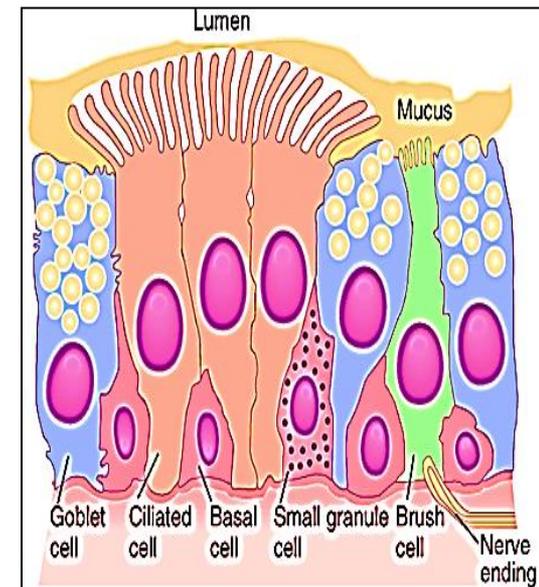
1- **Columnar ciliated cells** : most cells, have **motile cilia** (300) on apical surface (unidirectional beating)

2- **Goblet cells**: secrete mucus, cover surface to trap bacteria & dust

3- **Brush cells**: columnar cells e **apical microvilli**, have basal afferent nerve endings that communicate e trigeminal nerve 5th → give sensory information about the mucosa = (chemosensory receptors)

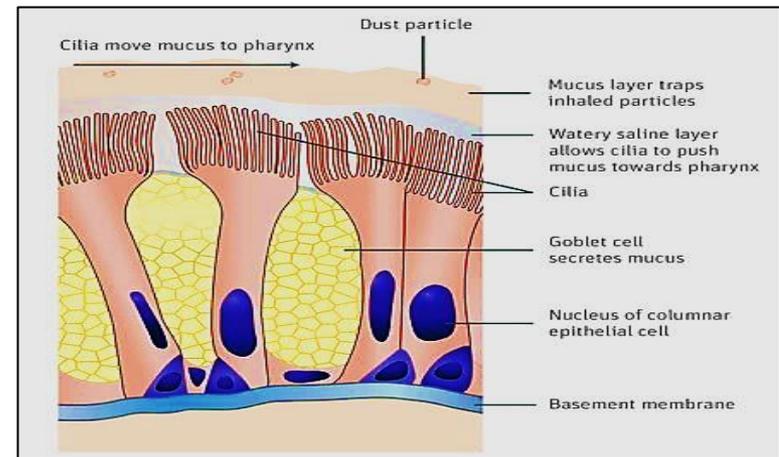
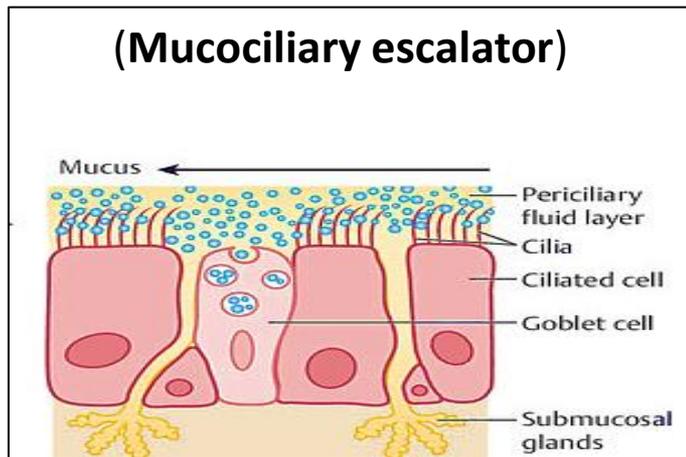
4- **Basal cells**: small cells, act as stem cells

5- **Granule cells**: (neuro-endocrine cells): have basal cytoplasmic granules, secrete hormones (serotonin & catecholamine) → regulate the caliber & secretions of airways



- **Granular cells**: during development they exert a local mitogenic effect, they influence the lengthen of the individual airway branches. In adult they provide local regulation of bronchial or vascular muscle tone in response to hypoxia or hypercapnia
- **Serotonin** is a cilio- stimulatory i.e. increase ciliary beat frequency (CBF)
- **Serotonin** induces the release of Ach from columnar ciliated cells → release of Ca & ATP → ↑CBF .
- **Serotonin** cause ↑in periciliary liquid & thus facilitate **mucoiliary clearance**
- **Serotonin** cause ↑in periciliary liquid & thus facilitate **mucoiliary clearance**
- **serotonin** induces vasoconstriction in pulmonary vasculature → role in **Pulmonary hypertension**

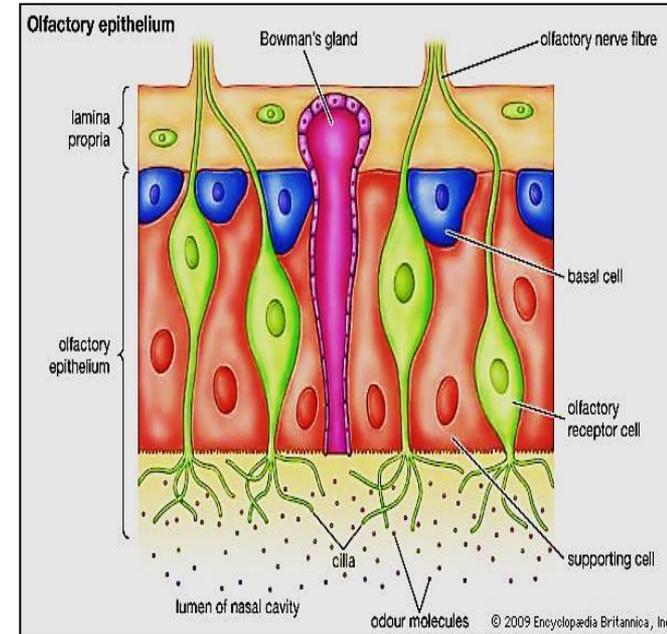
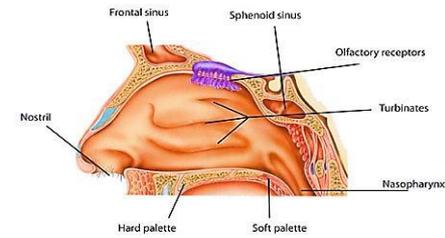
- The respiratory epithelium rests on lamina propria contain many Nasal glands (serous & mucus) + BV
- The serous sec. serve to facilitate movement of cilia of mucous sec. serve to catch inhaled dirt & bacteria particles inhaled



- **The blood vessels** serve to warm the inspired air (humidity of the lung can be maintained)
- **In smokers the proportion of ciliated cells to goblet cells is altered (↑ goblet) to trap gaseous pollutants**

The olfactory epithelium

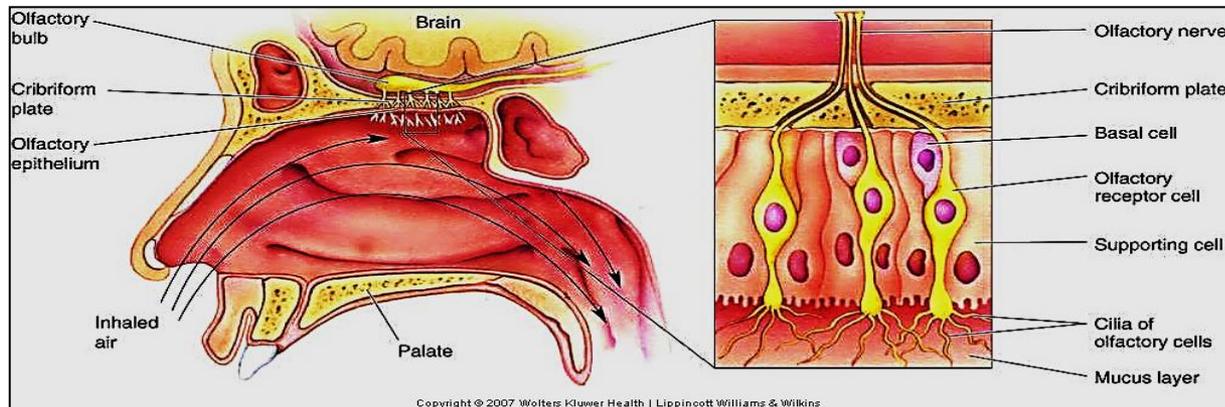
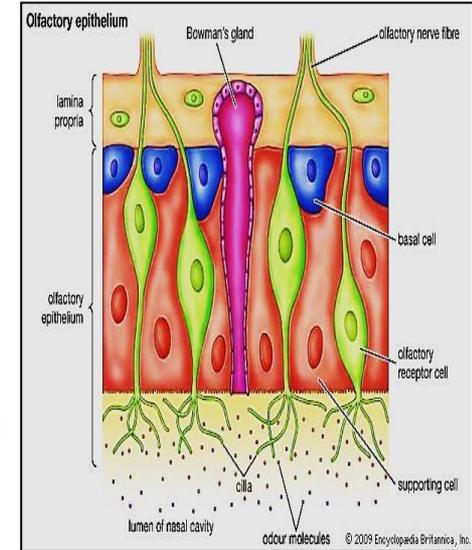
- Covers the roof of nasal cavities & superior conchae.
- Contains **chemoreceptors of smell**
- **3 types of cells** are present:
 1. **Olfactory neurons**
 2. **Supporting (sustentacular) cells**
 3. **Basal cells**



- The olfactory epithelium rests on lamina propria contains:
 - ✓ **BV & olfactory nerve fibers**
 - ✓ **Bowman's glands** secrete constant flow of **serous fluid** → surface → facilitate dissolve of odoriferous substance

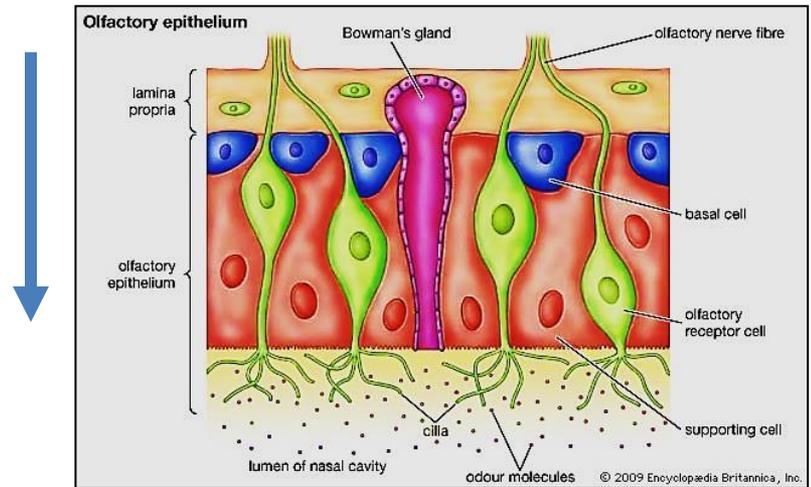
1- Olfactory neurons:

- Bipolar nerve cells (renew 30- 60 days) i.e (regenerative neuronal tissue !!)
- Their dendrites extend toward surface → end in swellings (olfactory vesicles) from which cilia arise
- These cilia (10-20) are very long & non motile. It provides large surface for transmembrane chemoreceptors
- Their axons pass to lamina propria to form olfactory n. fibers



2- Supporting cells (neuroglia):

- Tall columnar cells e wide apex narrow base
- Their free surface has **microvilli**
- Tight junctions bind these cells e olfactory cells.
- They secrete **odorant binding proteins &** express **abundant ion channels** → role in signal conduction of smell sensation . These cells play role in smell loss (anosmia) in COVID 19



3- Basal cells:

- Small pyramidal cells e basophilic cytoplasm
- Act as stem cells for both olfactory & supporting cells

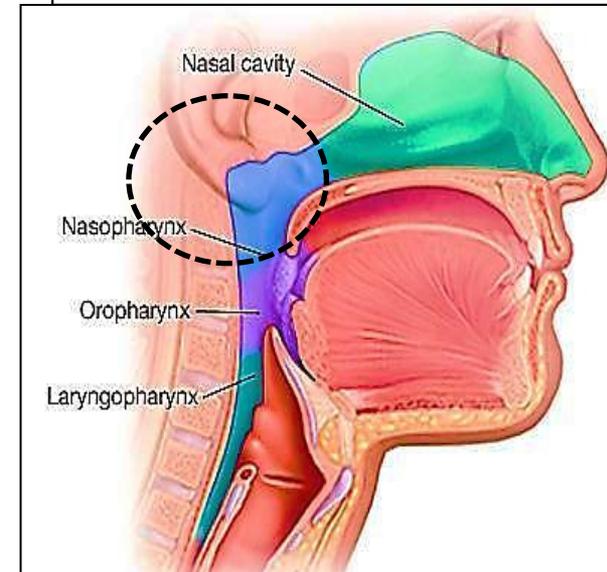
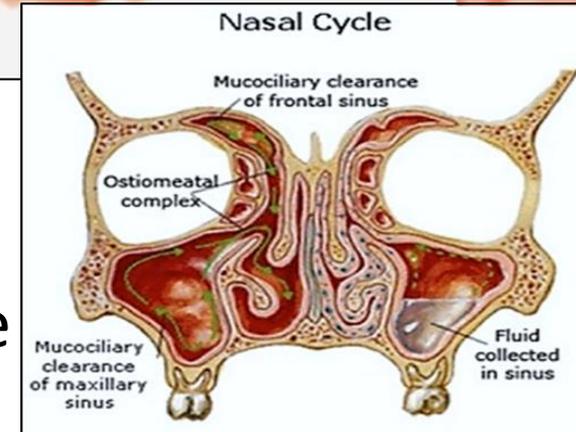
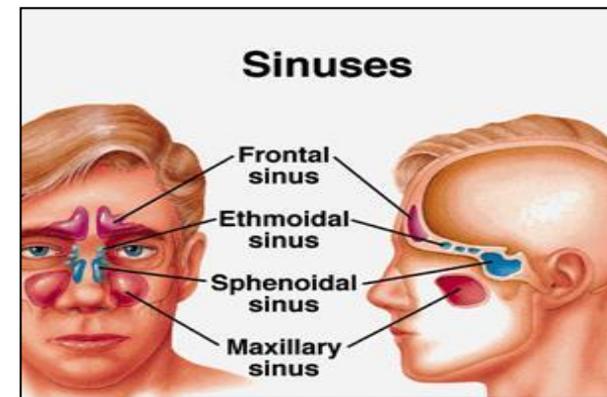
Paranasal sinuses (Bilateral)

- Frontal, Ethmoidal, Sphenoidal
Maxillary
- These cavities **open in nasal cavities**
- Lined e **thin** respiratory epith.
e few goblet cells

Chronic sinusitis = immotile cilia syndrome

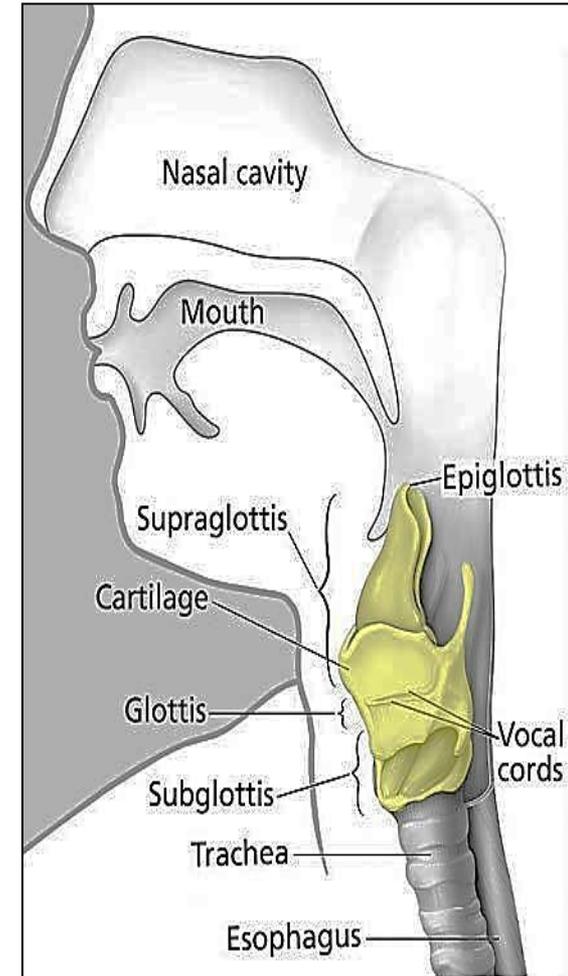
Nasopharynx

- Lined e respiratory epithelium
- Its lamina propria contains
**pharyngeal tonsil & openings of
Eustachian tubes**



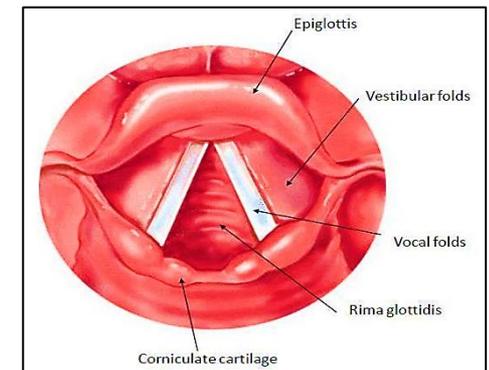
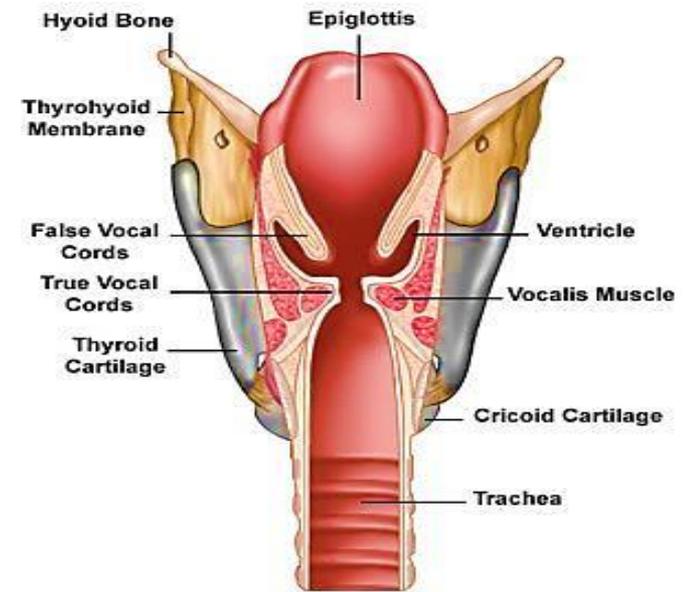
Larynx:

- At the beginning of trachea (4x4cm)
- Its beginning is guarded by epiglottis
- Has 2 functions:
 - ✓ production of voice (vocal cords)
 - ✓ Prevent food & fluid from entering the Trachea through the epiglottis (Epiglottis has elastic cartilage)
- It is lined with **respiratory epithelium**



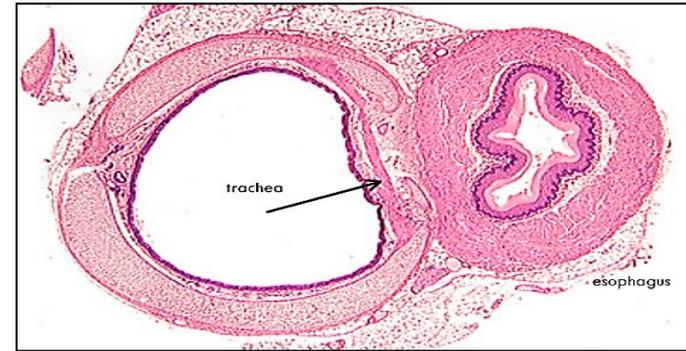
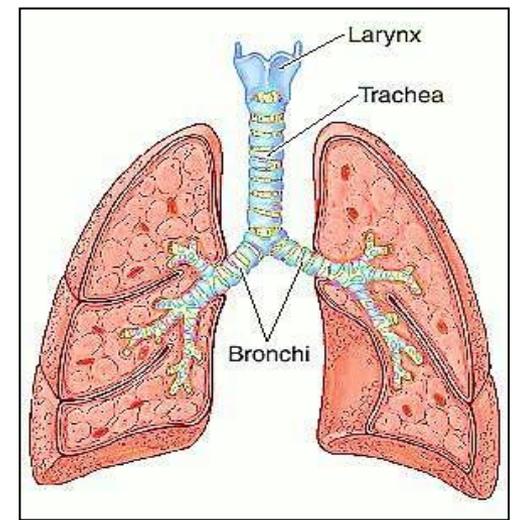
Vocal cords:

- 2 pairs of mucosal folds extend in lumen of larynx
- False vocal cords (Upper pair)
 - called (**vestibular folds**)
 - covered e **respiratory epith.**
 - guard against entrance of food into larynx (made of vestibular ligament)
- True vocal cords (Lower pair)
 - covered e **non-keratinized stratified squamous epith.**
 - made of **ligaments (vocal lig.)** & **skeletal ms. (Vocalis ms.)**
 - tension of cords & distance between them produce sound



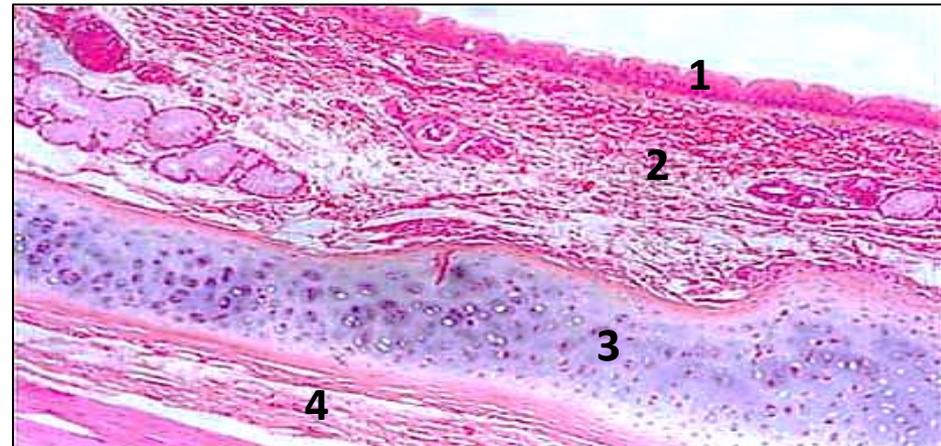
Trachea

- Tube (12- 14 cm) extends from larynx to bifurcation of bronchi
- Kept open by about 20 C- shaped (horse shoe) cartilage rings (hyaline cartilage)



- Its wall is formed of 4 layers:

1. Mucosa
2. Submucosa
3. Hyaline cartilage
4. Adventitia

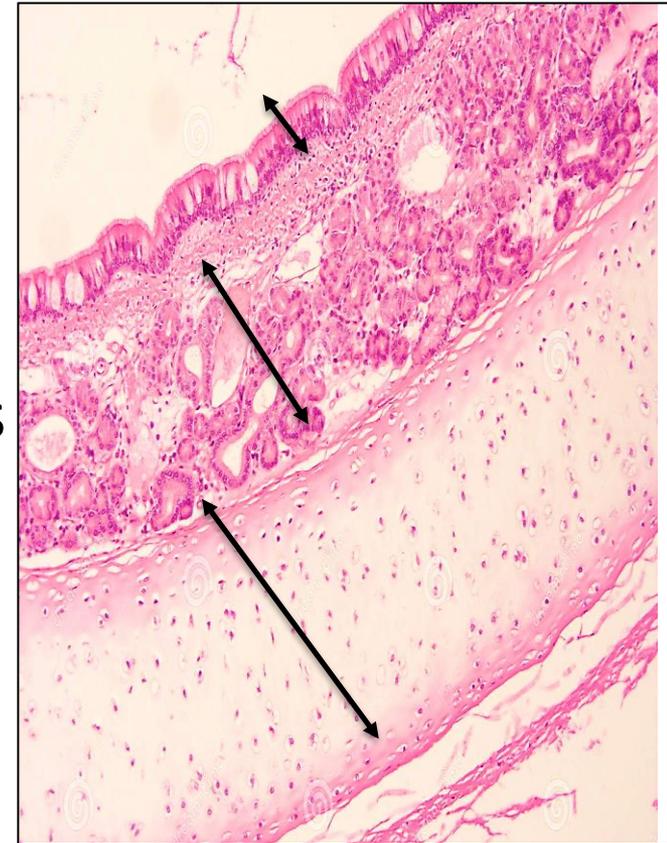


Wall of trachea:

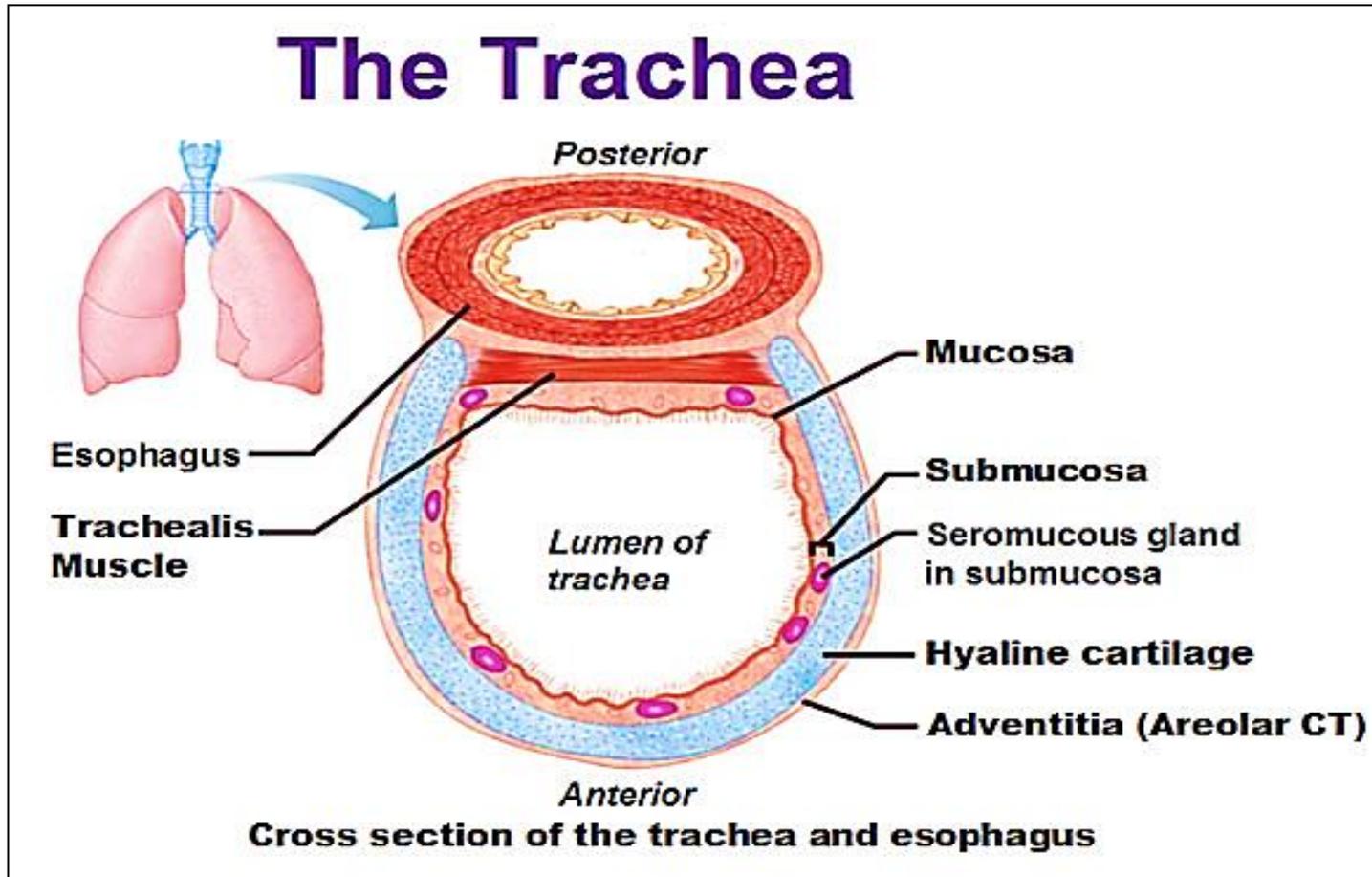
- Mucosa: epithelium – lamina propria – elastic fibers

Epithelium: respiratory epithelium

- Submucosa: loose CT. BV, nerves, Lymphoid nodules, Tracheal glands
- Cartilage layer: C- shaped cartilage rings, the gap between cartilage ends connected by elastic ligament & **Trachealis *ms*** (*smooth ms*)
- Adventitia: loose CT



The Trachea

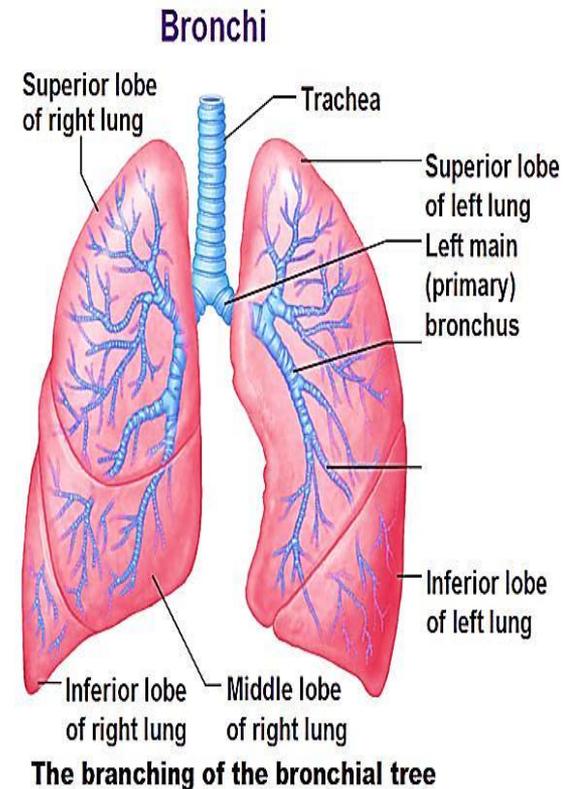


Contraction of the trachealis ms. is important for the cough reflex

Contraction → narrowing the tracheal lumen → ↑ the velocity of the expelled air → squeezed out

Bronchial tree

- ✓ Primary (Extra pulmonary) bronchi
 - ✓ Secondary (Intra-pulmonary) bronchi
 - ✓ Bronchioles
 - ✓ Terminal bronchioles
- 1ry bronchi: RT & LF → similar to trachea
(but cartilage is a complete ring)



- 2ry bronchi: within the lung → divide into 3ry bronchi
Its wall is formed of 4 layers (NO Submucosa):
 - Mucosa
 - Muscularis
 - Cartilage plates (isolated plates)
 - Adventitia

- **Mucosa**: ↑folded, respiratory epith., ↓goblet cells, lamina propria has elastic fibers & MALT (**mucosa associated lymphatic tissue**)

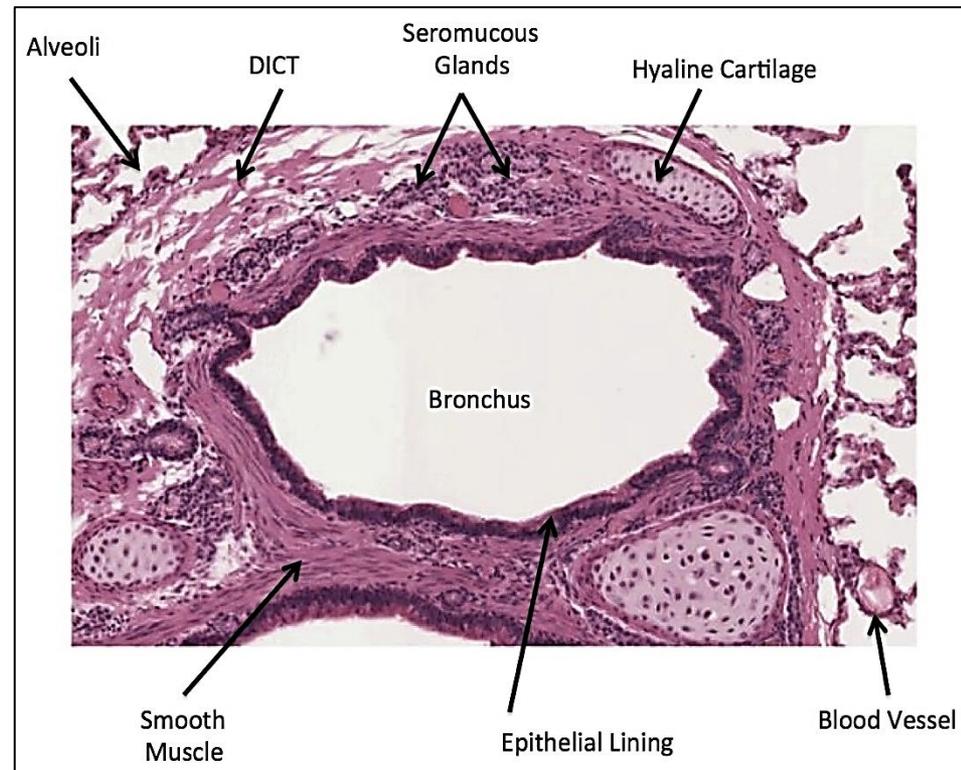
- **Musculosa**: spiral layers of smooth ms. encircling the mucosa

- **Cartilage plates**:

muco-serous glands &

lymph nodules found between cartilage plates

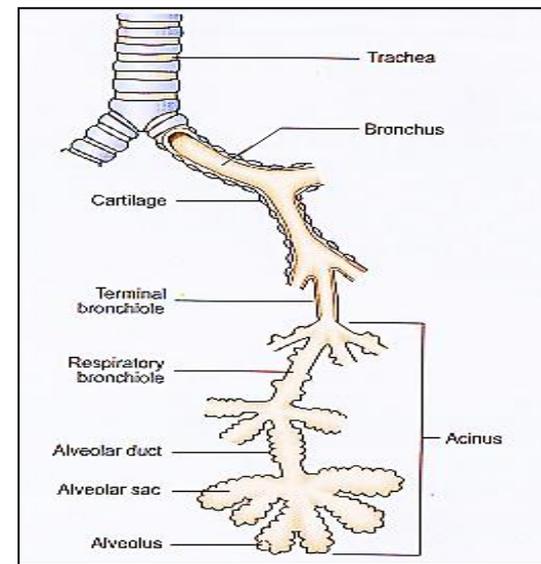
- **Adventitia**:



Structure of 2ry, 3ry bronchi

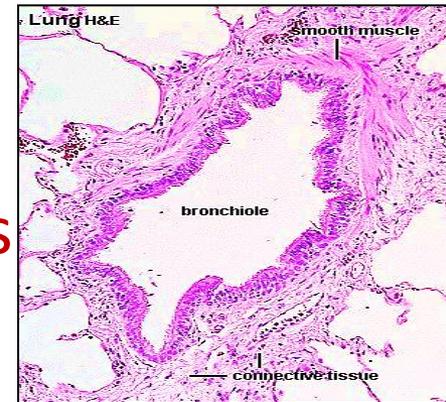
■ Bronchioles

- Small airways 5 - ↓ mm
- Its wall has (**No submucosa, No cartilage, No glands, No lymphatic nodules**)
- Its wall formed of 3 layers



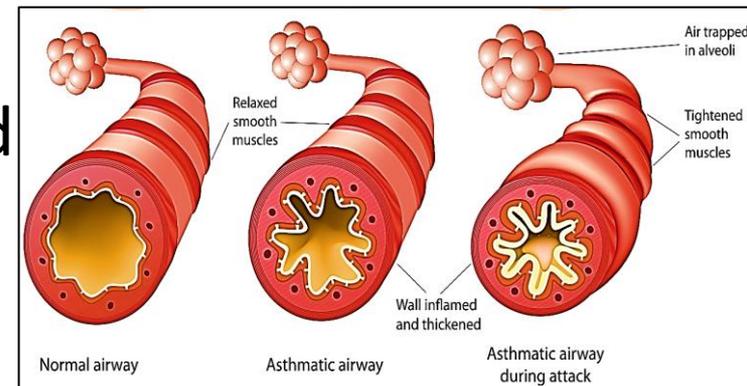
Mucosa:

- **Simple columnar ciliated** epithelium e **Clara cells & NE cells & neuroepithelial bodies** (chemosensory receptors → O₂ level)



Musculosa:

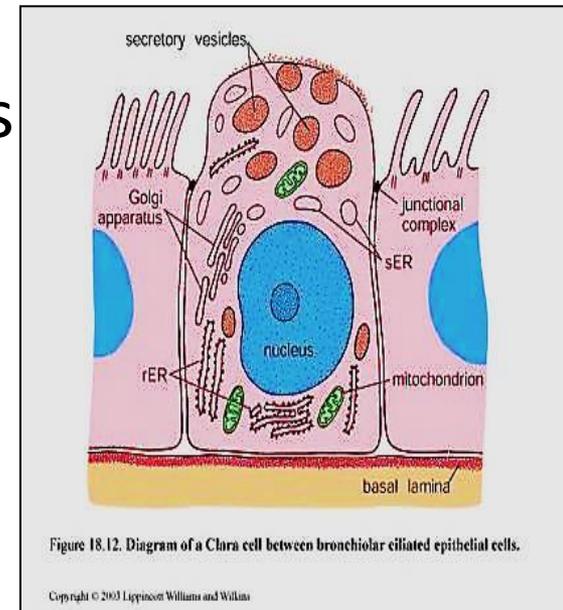
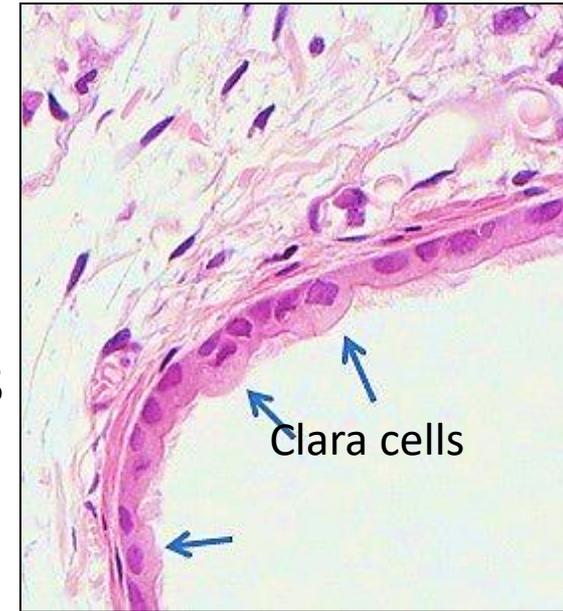
complete layer of circularly arranged smooth ms. (Asthma attacks)



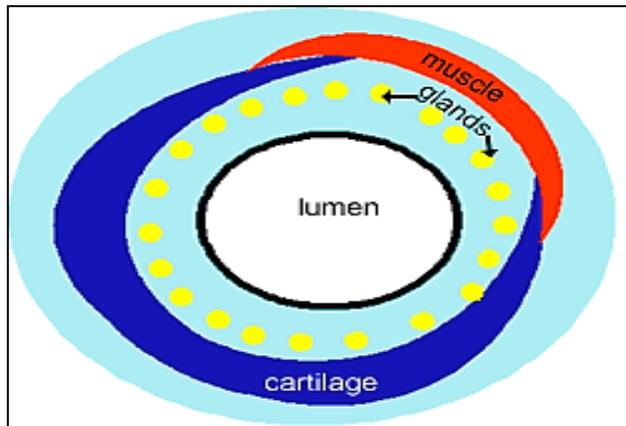
Adventitia

Clara Cells:

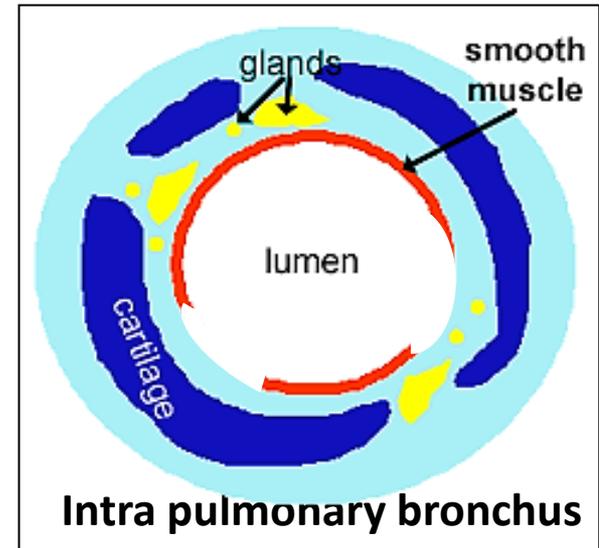
- Also called **club cells** or **bronchiolar exocrine cells**
- Dome-shaped, non-ciliated,
- Cytoplasm has lots of secretory granules (not mucus) basal rER, apical sER
- Function:
 1. Defensive role :glycoprotein granules (contain proteolyase & oxidase & cytokines)
 2. Degradation of inhaled toxins (sER)
 3. Secretion of surfactant-like substance to prevent collapse of bronchioles
 4. Act as stem cells
 5. Mutation → adenocarcinoma of lung



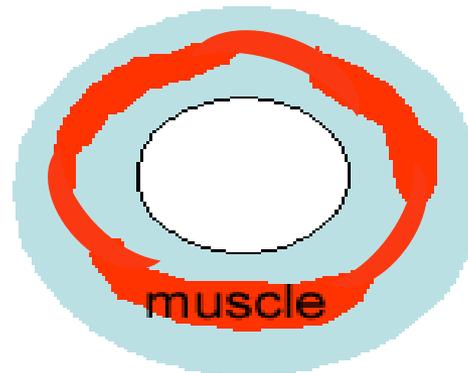
Difference between structure of wall of trachea vs. Wall of intra-pulmonary bronchi & bronchiole



Trachea



Intra pulmonary bronchus

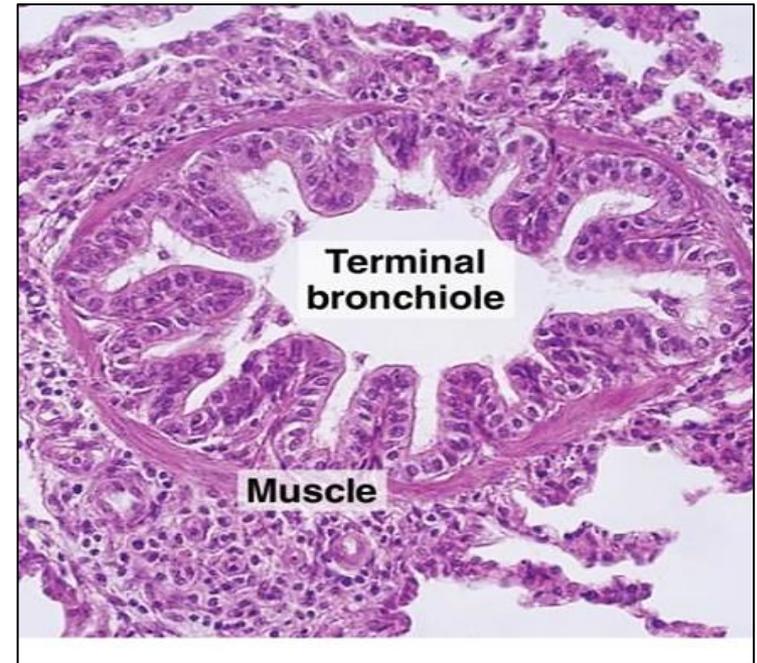
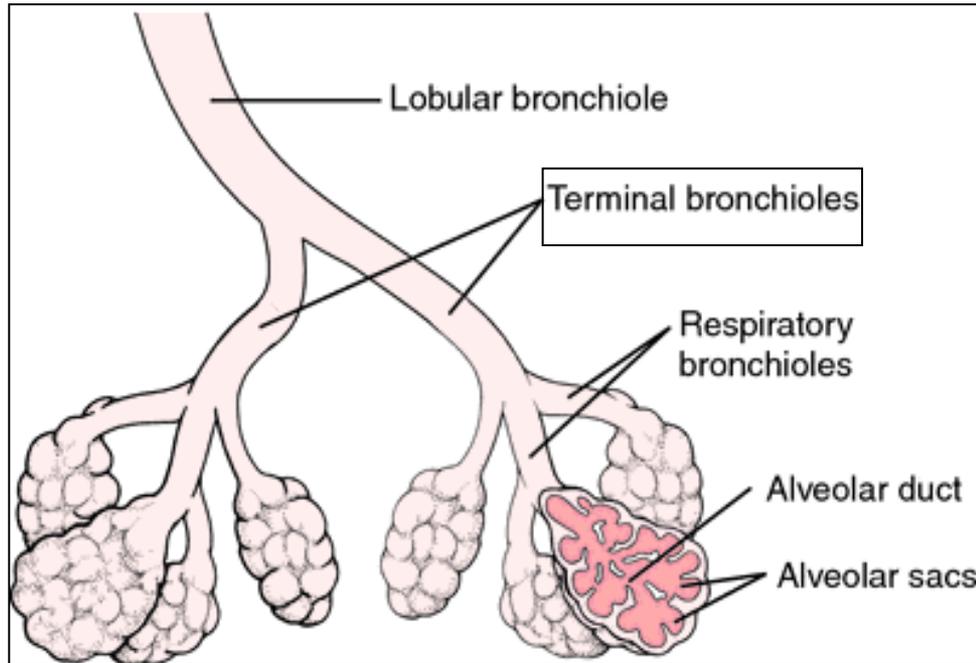


Bronchiole

N.B: Smooth muscle component increases in proportion and continuity as the air passage decreases in size. Then decrease again till disappear in the respiratory portion

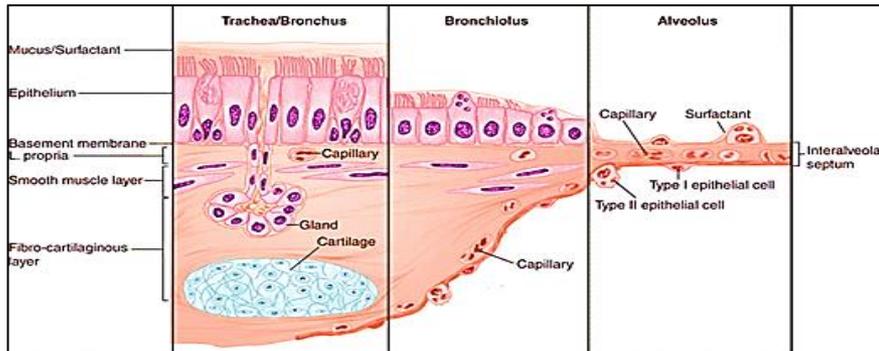
N. B: if cartilage is present, it is a "bronchus," but if cartilage is absent the airway is a "bronchiole."

■ Terminal bronchioles:



- The smallest & last part of conducting portion
- Lining epithelium: **Simple cubical ciliated e Clara cells**
- **Secondary pulmonary lobule:** is the lobule supplied by a terminal bronchiole that branches into respiratory bronchioles.

Changes occur in the epith. of conducting portion as it branches

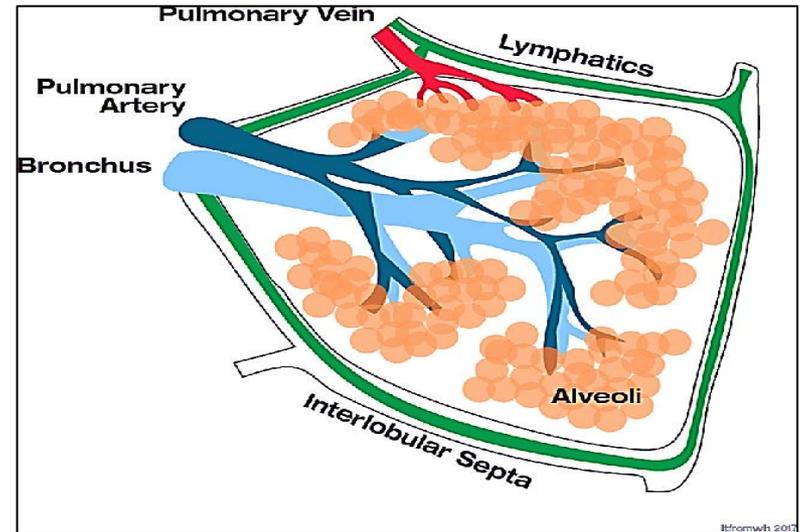


Bronchial tree can be as small as 0.5 mm diameter and as they get smaller some changes occur. First, the glands disappear, then goblet cells. There is also an epithelial transition from the pseudostratified RE to simple columnar, then to a low cuboidal type. Along the way ciliation disappears.

secretion ends before ciliation does.

Why?

Pulmonary lobule vs pulmonary acinus

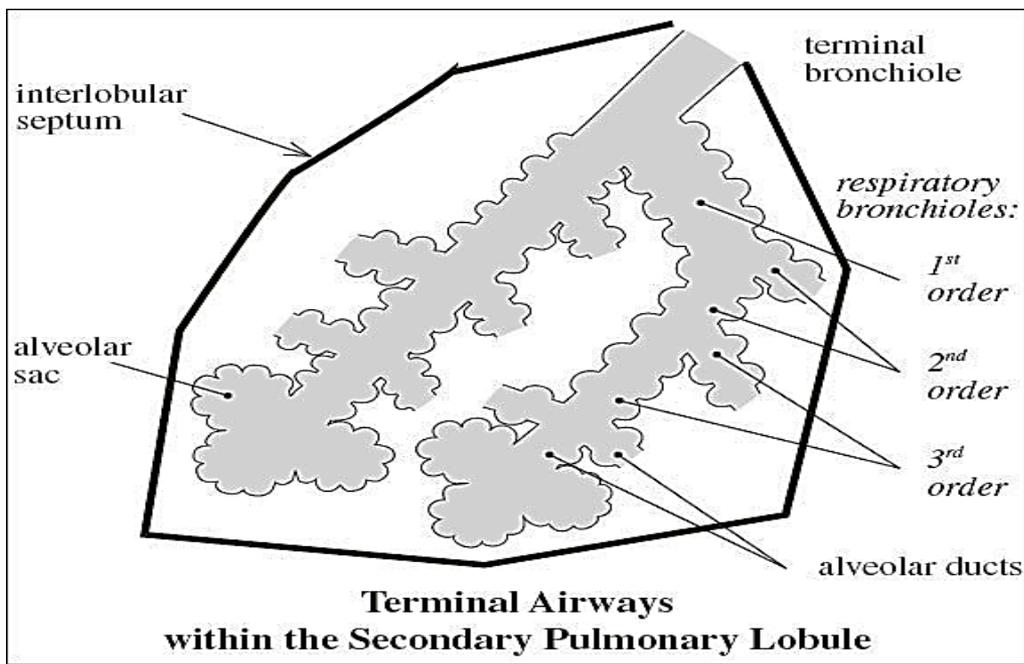
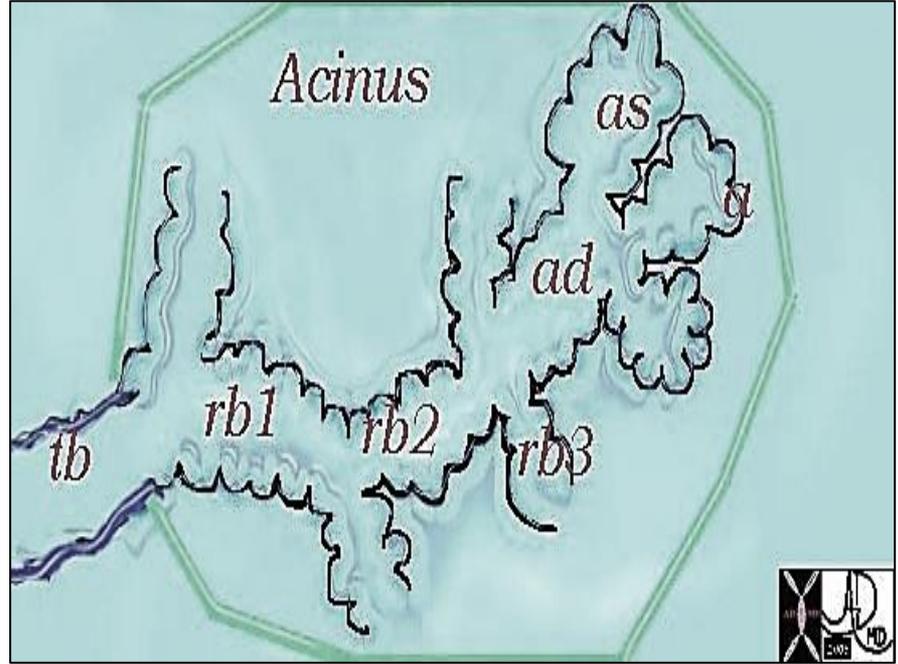
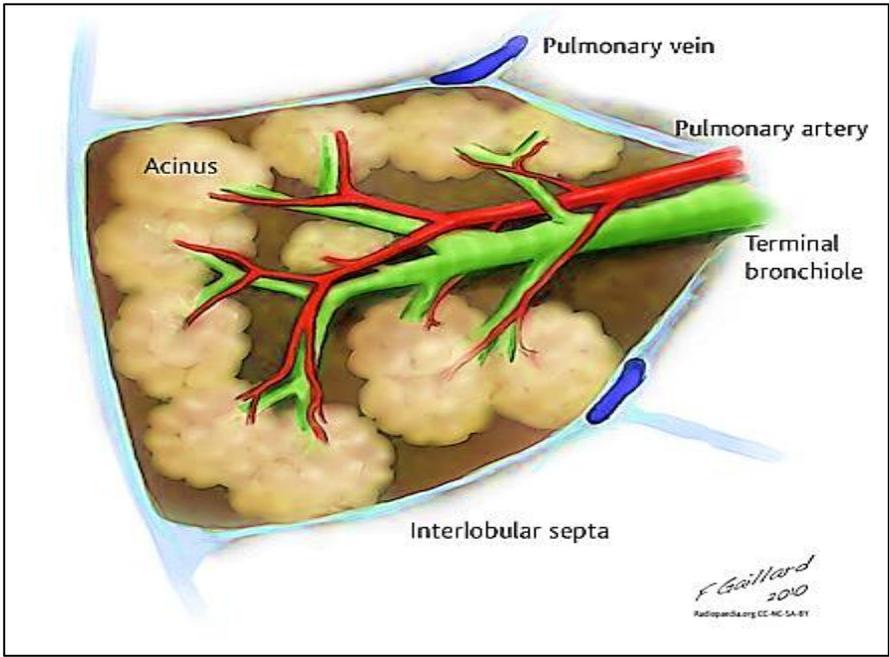


2ry Pulmonary lobule:

Bigger, lung unit supplied by 3-5 terminal bronchioles derived from single bronchus & surrounded by CT (3- 12 acini & 30- 50 1 ry L.)

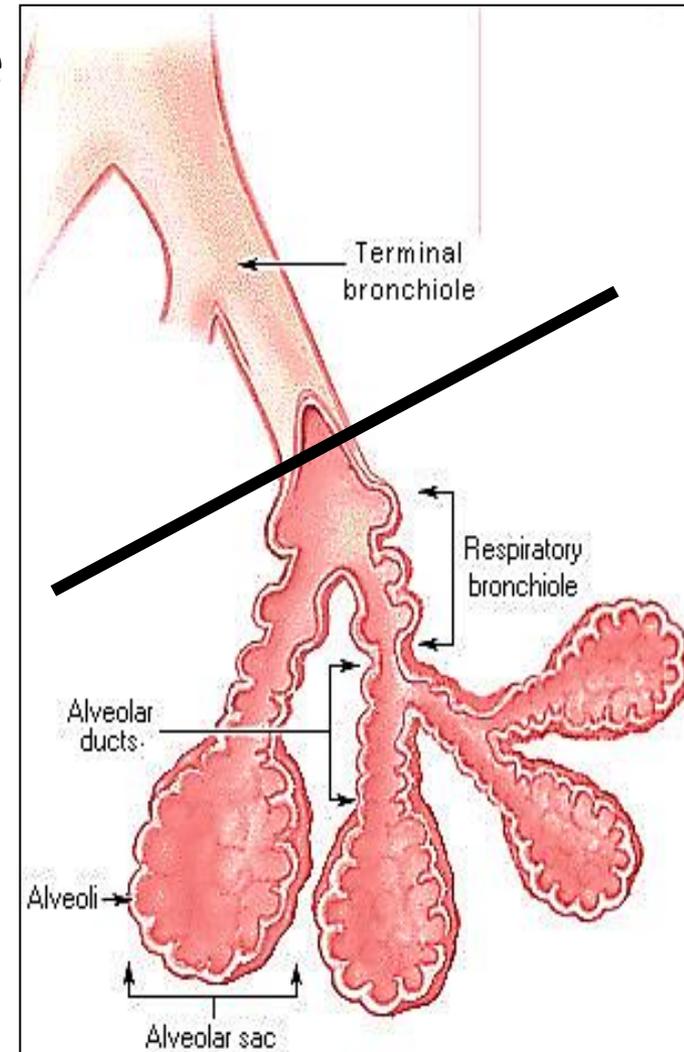
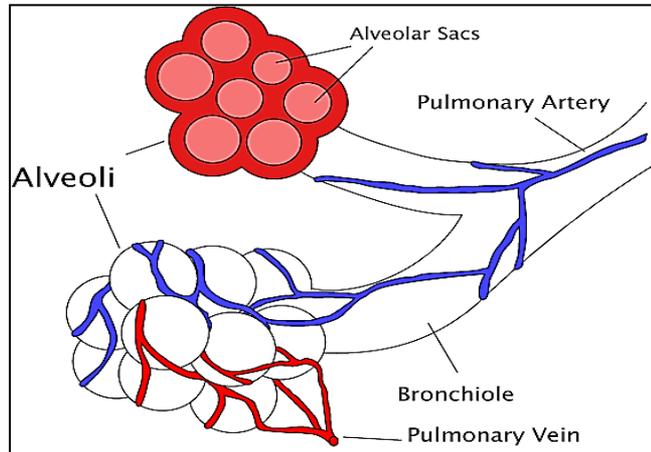
Pulmonary acinus: lung unit distal to single terminal bronchiole includes resp .B, alveolar ducts, sacs, alveoli

1ry pulmonary lobule : smaller than acinus includes lung unit distal to respiratory B, alveolar ducts, sacs, alveoli



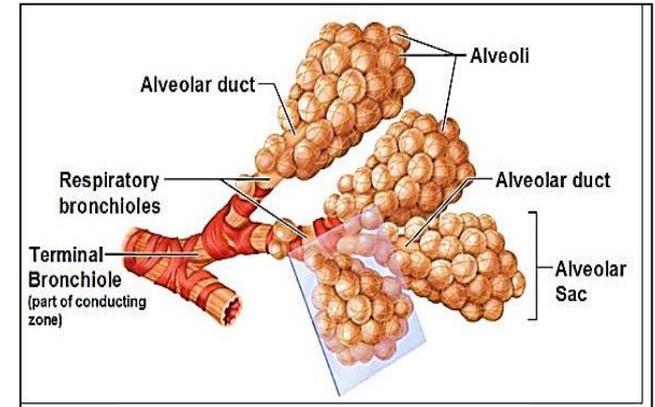
B- respiratory portion

- Is where gas exchange takes place
- Includes:
 1. Respiratory bronchioles
 2. Alveolar ducts
 3. Alveolar sacs
 4. Alveoli



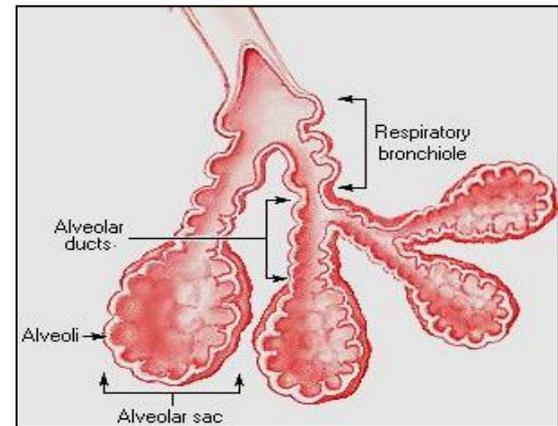
Respiratory bronchioles (RB):

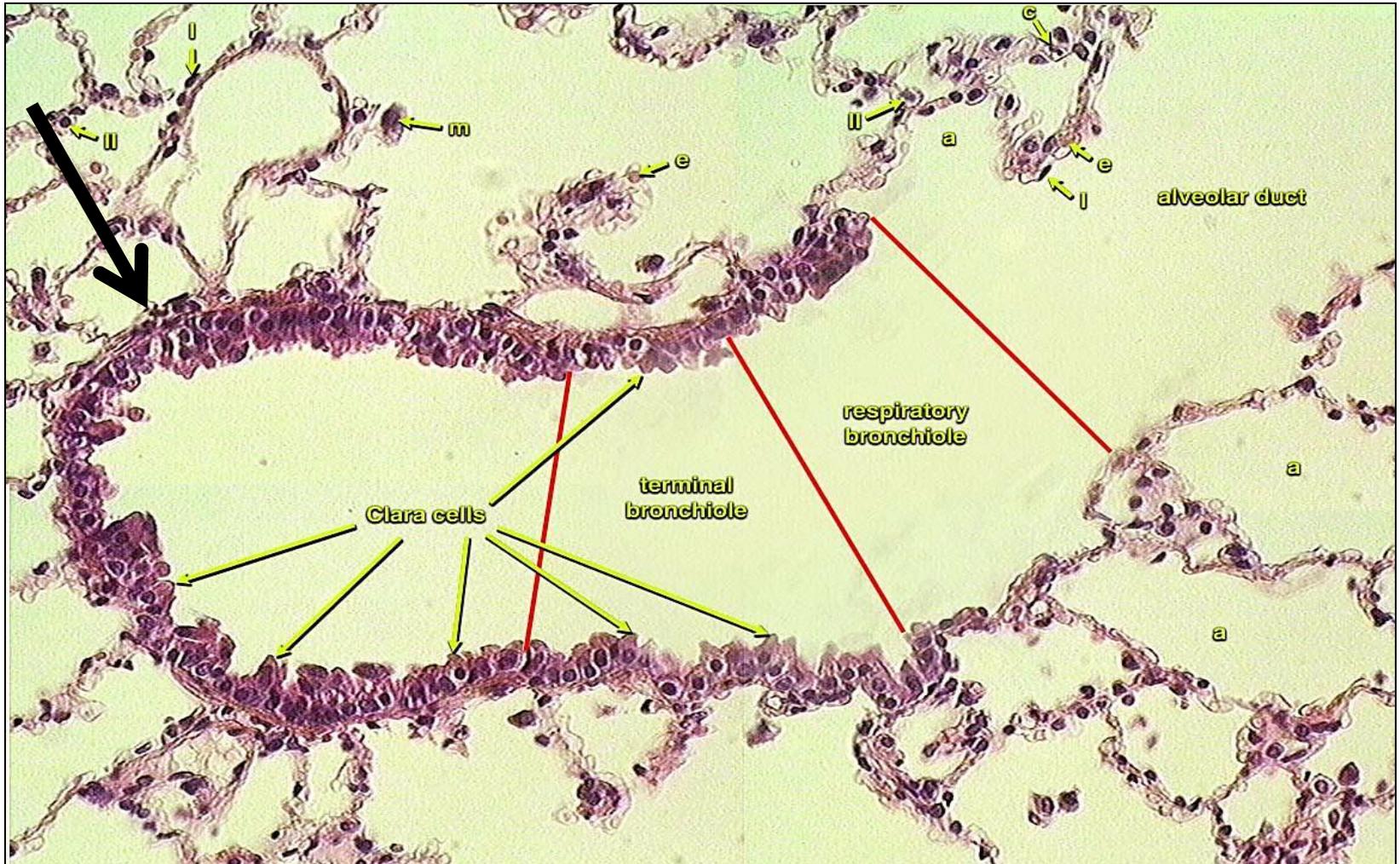
- **Transitional part** between conducting & respiratory portions, still bronchiole but shorter & thinner
- Lined with **simple cubical ciliated e**
Clara cells with Some alveoli open
in its wall



Alveolar ducts (AD):

- Alveoli open along its wall
- Lined e **squamous alveolar cells**
- At the distal end of AD **smooth m. disappear**, elastic & collagen fibers provide the only support

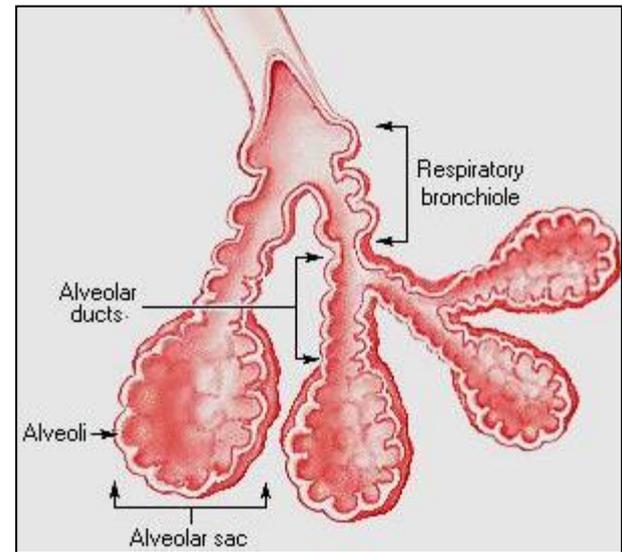




Section is showing **terminal bronchiole** and parts of the respiratory portion

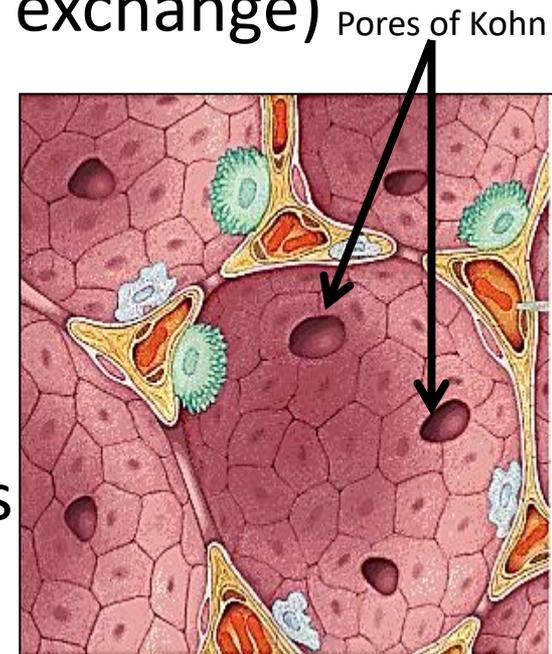
Alveolar sacs (AS):

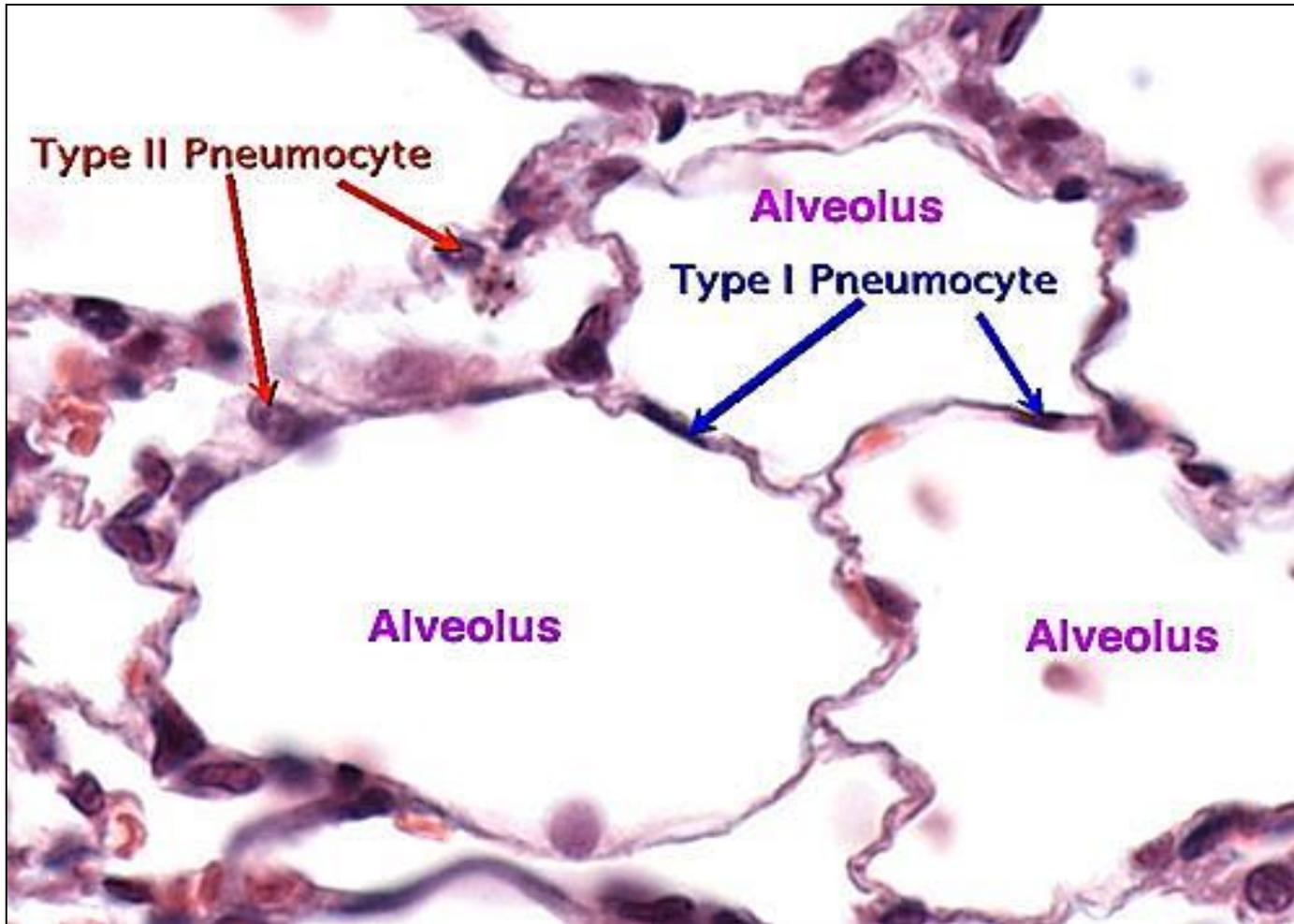
- Group of alveoli opens into common Central space
- Lined e **squamous alveolar cells**



Alveoli:

- Structural & functional units of lung (gas exchange)
- Alveoli found open into RB, AD, AS
- They separated by **inter-alveolar septa**
- **Alveolar pores of Kohn** present in walls between alveoli (collateral ventilation ??)
- Lined e **alveolar epith.** formed of **2** types of cells **type I & type II pneumocytes**

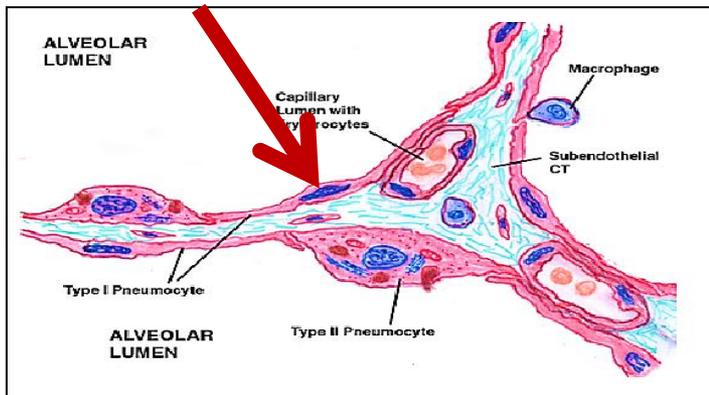




Type I and type II pneumocytes

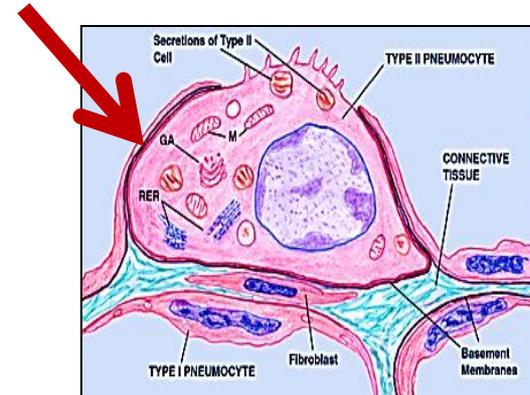
Lining epithelium of alveoli

Type I pneumocytes



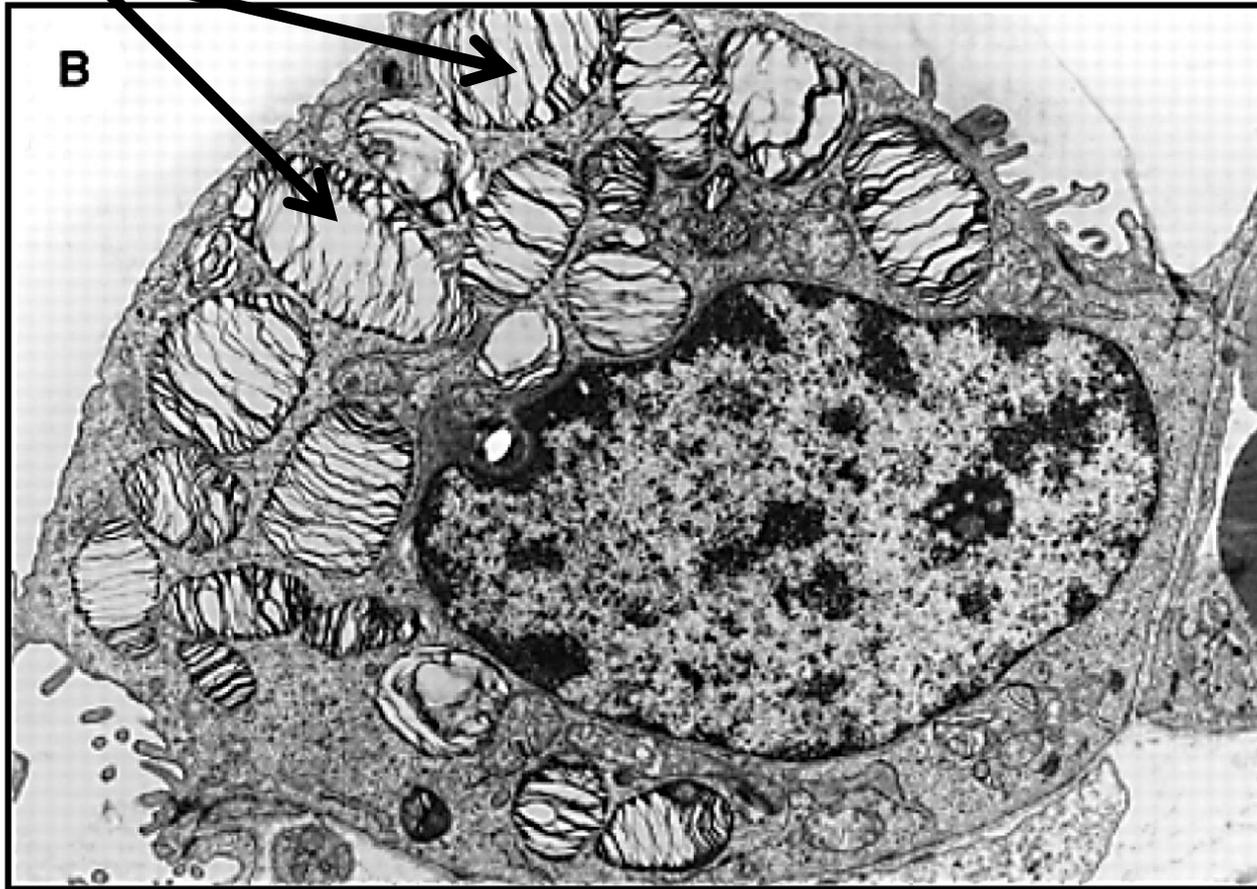
- Cover **97%** of alveolar surface
- **Flat simple squamous cells** e flat nuclei
- cytoplasm has **few organelles**
- Cells joined together by **tight junctions**
- **Gas exchange** occurs through them

Type II pneumocytes



- Cover **3%**
- **Cuboidal cells** e central nuclei & foamy cytoplasm
- Free surface has **short microvilli**
- Cytoplasm rich in **organelles, multilamellar bodies**
- **Secrete surfactant** (**↓ tension & bactericidal**)
- Act as stem cells
- Have ACE2 receptors where Covid-19 spikes attack

Multilamellar bodies

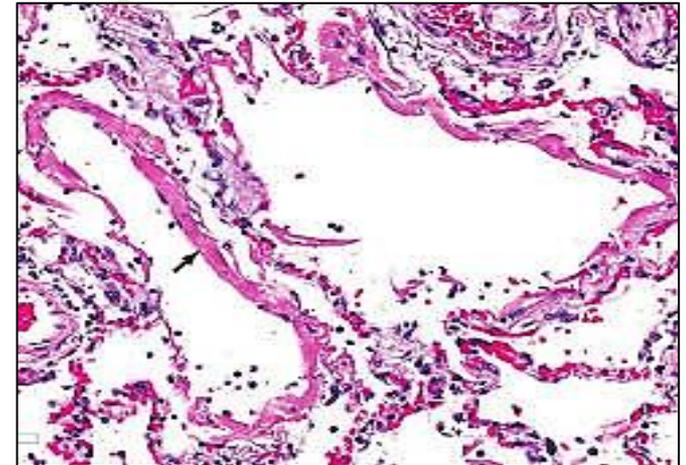


(E/M of type II pneumocyte)

Respiratory Distress Syndrome (RDS): occurs In premature babies because surfactant appears in last weeks of gestation

Interalveolar septa:

- Delicate walls separate adjacent alveoli
- Have **richest capillary network**
- **Rich in elastic & reticular fibers**
(support & prevent over expansion)
- No smooth ms. cells
- Contains extravasated leucocytes
(**monocytes**), which will migrate through the wall →
to the lumen and become alveolar macrophages (A)
- This septa is destructed in emphysema & Covid - 19



Alveolar phagocytes

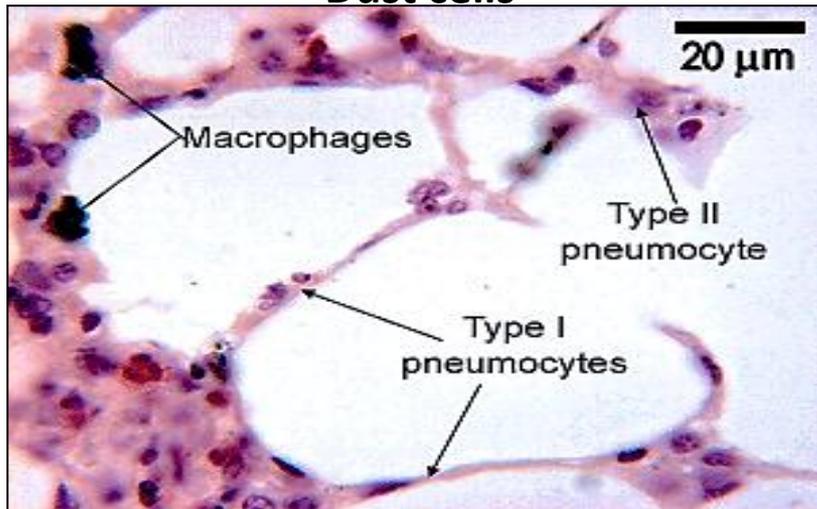
- Blood monocytes → CT in alveolar septa → lumen of alveoli → **macrophages**

- **2 types** of alveolar macrophages:

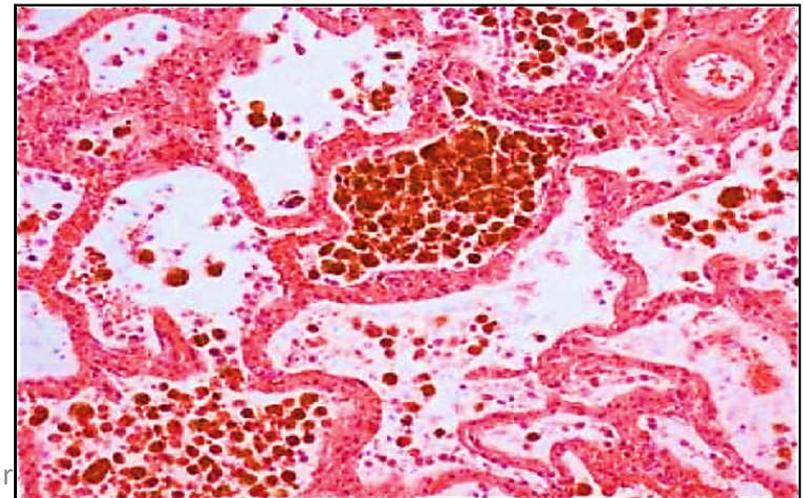
Dust cells: macrophages engulfing dust particles

Heart failure cells: macrophages engulfing erythrocytes (hemosiderin granules) found in congestive heart failure

Dust cells



Heart failure cells



Blood- air barrier (respiratory membrane)

✓ Its where O_2 & CO_2 cross for exchange

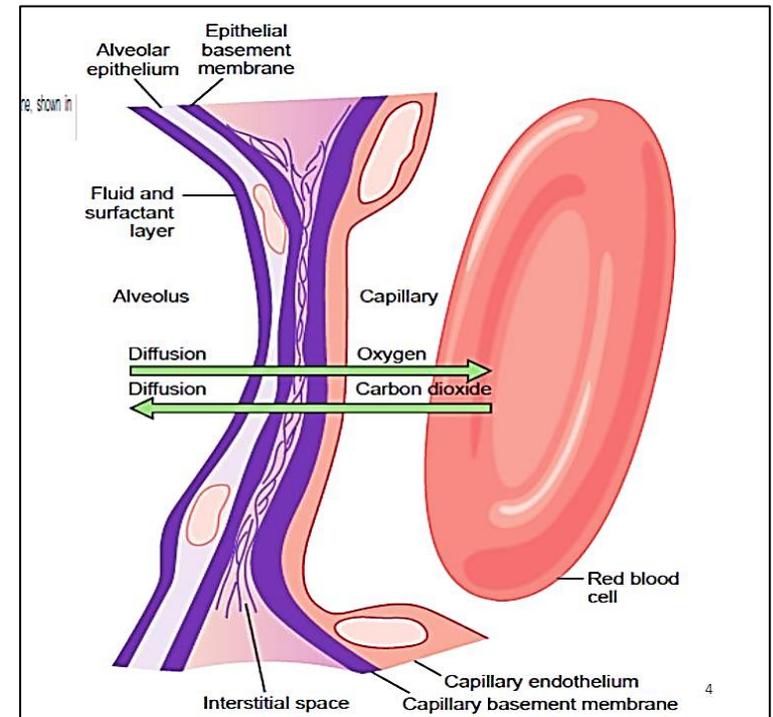
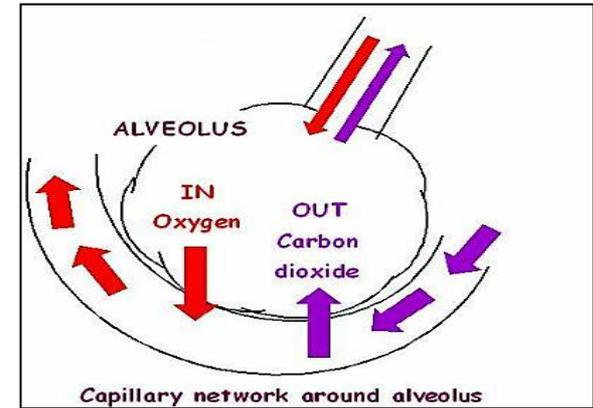
✓ Composed of 4 layers:

■ Thin film of **surfactant** on the surface

■ Cytoplasm of type I **pneumocyte**

■ **Fused basal lamina** of type I pneumocytes + capillary endothelia cells

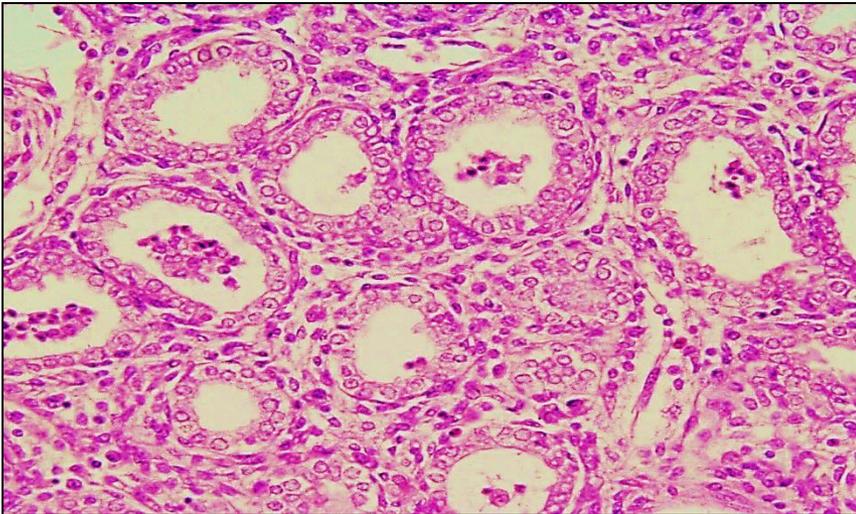
■ Cytoplasm of **endothelial cells**



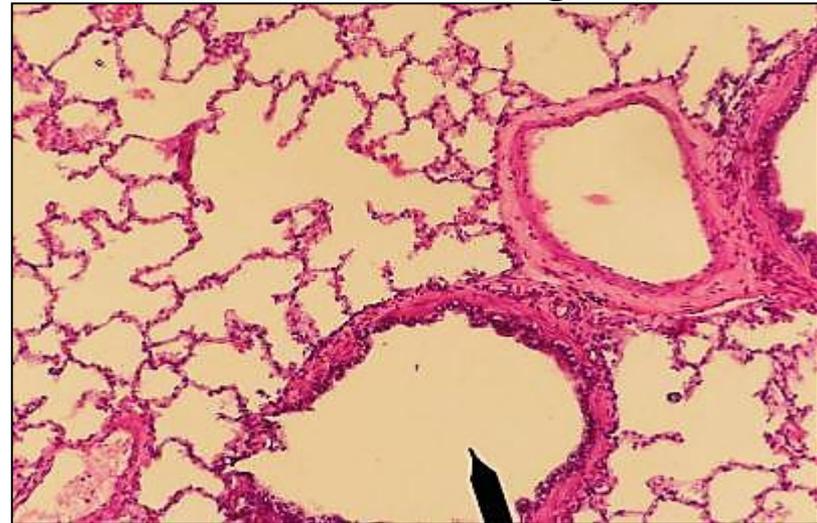
Fetal Lung

- **Lobulation** is clear due to thick CT septa
- Fetal lung **similar to gland** in histological section
- **Alveoli collapsed** lined e simple cubical epith.
- Pulmonary BV are congested
- Whole lung sinks in water

Fetal lung



Normal lung



Thank you

