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Histology

Respiratory
Module



The Respiratory System is divided into 2 portions:

A-Conducting portion:

- Nose (nasal cavity / nasal sinuses)
- Nasopharynx, larynx, trachea.
- Bronchial tree:
- Bronchioles :
(Till Terminal bronchioles)

B- Respiratory portion

where gas exchange takes place

- Respiratory bronchioles
- Alveolar ducts
- Alveolar sacs
- Alveoli

Respiratory Epithelium

pseudostratified columnar ciliated epithelium

lines Most of nasal cavity & respiratory system's conducting portion

respiratory epithelium has five major cell types:

1-Ciliated columnar cells (30%):

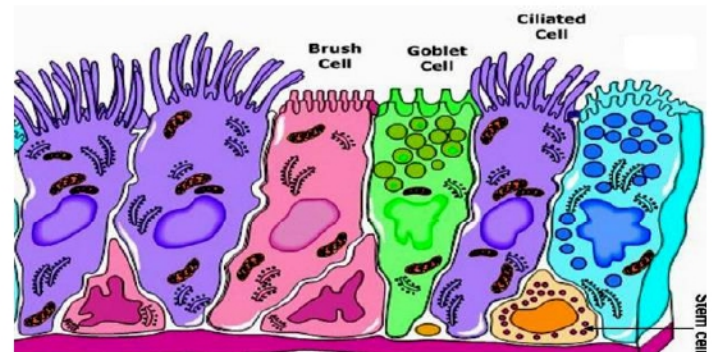
- The **most abundant** ,
- Apical surface → each has 250-300 cilia → beat toward pharynx
→ expel mucous & dust particles.
- cilia have shaft , basal body & rootlets

2-Goblet cells (30%):

- Numerous
- basal nuclei
- E.M : few microvilli, Golgi apparatus & apical membrane bounded mucin granules..

3-Basal cells (stem cells) (30%):

- Small rounded , lie on the basal lamina but don't reach the surface
- **mitotically active cells** → differentiate into ciliated & goblet cells.



4-Brush cells (3%):

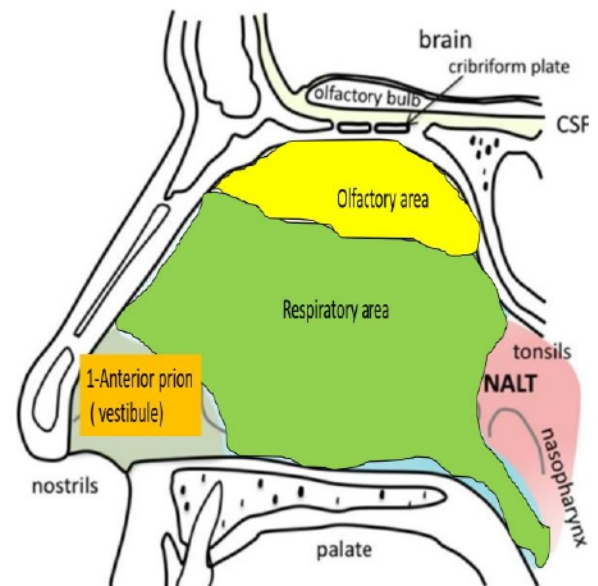
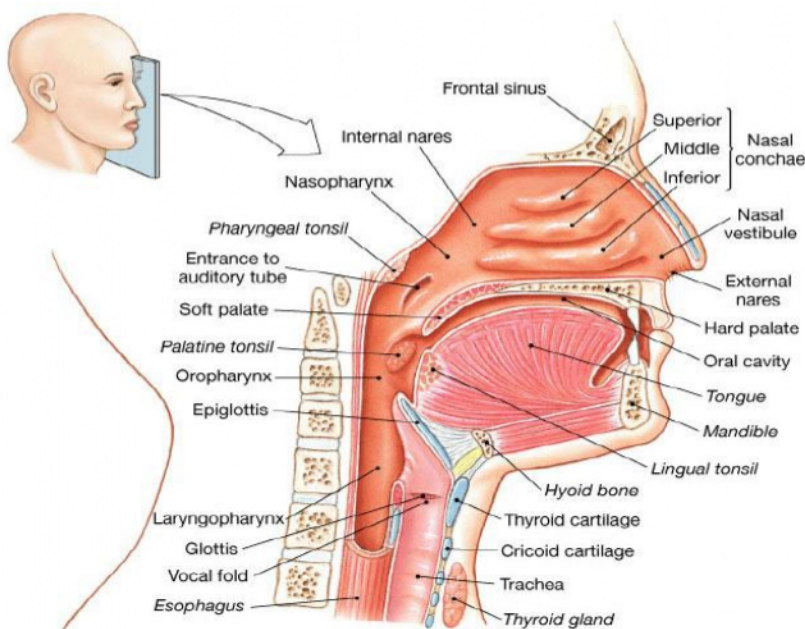
- columnar cells with numerous apical microvilli.
- have afferent nerve endings on their basal surfaces.
- may act as **chemo receptors**.

6- Serous cells 3%**5-Kulchitsky cells (DNES cell/ K cell/small granule cell) (3%):**

- Single or small groups throughout conducting airway (until bronchioles).
- **neuroendocrine cells**: → produce hormone → diffuse neuroendocrine system(DNES).
→ **calcitonin, serotonin, somatostatin, gastrin - releasing peptide (bombesin)**.
- Basal cytoplasm → have **dense cored secretory vesicles**
- afferent nerve fibers end on their bases.

N.B. **Intraepithelial Migratory cells** 1% → lymphocytes, plasma cells and leucocytes
(related to immune defense mechanism).

Nasal Cavity



right & left nasal cavities separated by → nasal septum

nasal cavity opens anteriorly by a nostril & posteriorly into the nasopharynx

nasal cavity divided into 2 parts:

- ◆ anterior portion (vestibule)
- ◆ posterior portion (nasal fossae formed of respiratory and olfactory areas)

[1] Anterior portion (vestibule):

lined with modified skin formed of:

1. Epidermis:

- Stratified squamous keratinized epithelium with short **stiff hairs (vibrissae)**
→ filtration of the inspired air
- Then respiratory epithelium
(Pseudo-stratified columnar ciliated with goblet cells)
before entering the nasal fossae.

2. Dermis: contains sweat and sebaceous glands.**[2] Posterior portion of nasal cavity (nasal fossae)**

Its lateral wall contains 3 projections called **conchae** → (superior, middle & inferior)

It is divided into 2 areas, respiratory and olfactory areas.

I. Respiratory area:

inferior 2/3 of nasal fossa

lined by mucous membrane; formed of:

- **Respiratory epithelium;** → Pseudo-stratified columnar ciliated with goblet cells
- **Lamina propria:** → dense fibroelastic connective tissue

characters:

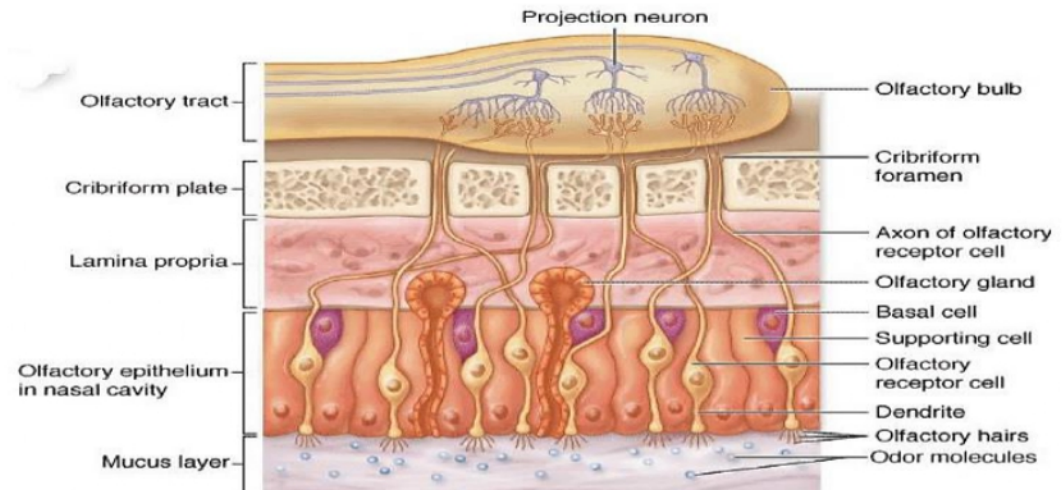
- **Highly vascularized** by arterial plexus & venous sinuses → **warm inspired air.**
- Contains **muco-serous glands:**
moisten the air & trap any minute foreign particles → removed by the action of cilia.
- rich with lymphocytes, macrophages & plasma cells
(have immune function by producing antibodies against inhaled microorganisms).
- It is adherent to the periosteum upwards and to the perichondrium downwards.

II. Olfactory area

- **Site:** covering the superior conchae & roof of the nasal cavity.
- **Lining:** lined by olfactory mucosa (organ of smell) which includes

olfactory epithelium

& thick lamina propria:



a. Olfactory epithelium

pseudo stratified epithelium with 3 types of cells:

1-Sustentacular (supporting) cells

- Have broad apex & narrow bases.
- Their free surfaces have **microvilli covered with thin film of serous fluid from Bowman's glands.**
- cytoplasm contains yellowish pigment → color of olfactory mucosa.
- They bind with adjacent olfactory cells by **junctional complexes**

2-Olfactory (chemoreceptor) cells

- sensory - bipolar nerve cells in between sustentacular cells.
- Dendrites: ending with **(olfactory vesicles)**
- Axons: unmyelinated directed to the olfactory bulb.
- **Olfactory vesicles have long, non motile cilia with no dynein arm .**
- They are stimulated by odorous substance dissolved in serous secretion

3-Basal (reserve or stem) cells

- Small cone shaped cells.
- Form a single layer at the base of the epithelium.
- They can be differentiated to form new olfactory receptor cells & sustentacular cells.

N.B. This is an exception to the rule that neurons are not replaced in postnatal life

b-Lamina propria

- dense fibro-elastic connective tissue.
- **Contains serous Bowman's glands.**

Their secretion covers the olfactory cilia to clear them
 → allow perception of new odorous substances.

N.B:

Lamina propria of conchae: contains large venous plexus known as **swell bodies**. → become engorged with blood, "pseudo-erectile tissue" they reduce the flow of air to warm and moisten it.

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Paranasal sinuses:

- cavities in frontal, maxillary ethmoid & sphenoid bones
- connected to the nasal cavity
- lined with mucus memb.
- formed of
 - 1.Pseudostr. str. Col. Ciliated with few Goblet cells
 - 2.Lamina propria contains few mucus glands

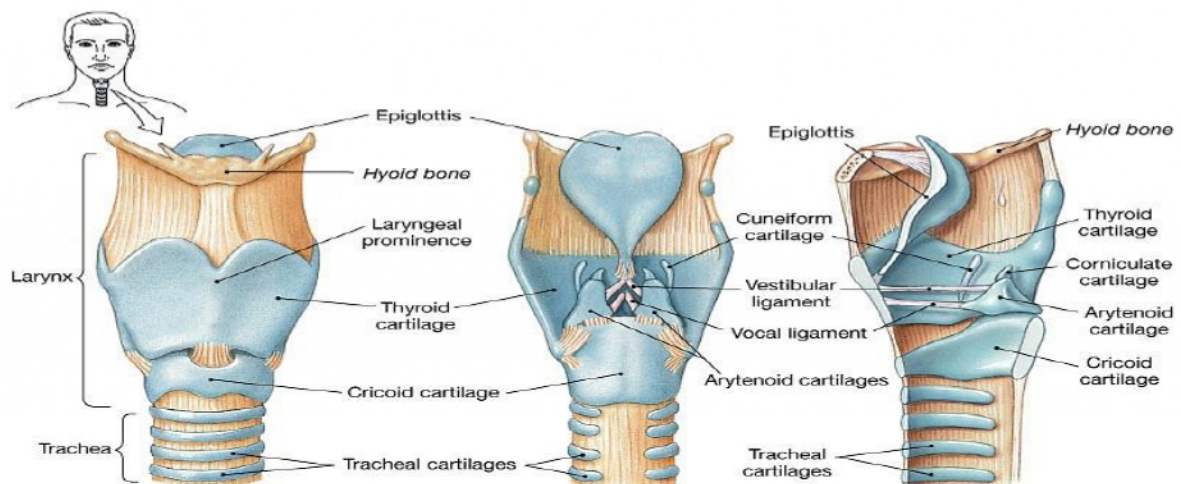
Nasopharynx

1st. Part of the pharynx

lined by mucus memb. formed of

- 1.Pseudostr. str. Col. Ciliated with Goblet cells
- 2.Lamina propria contains
 - Pharyngeal tonsils
 - Lymphocytes
 - seromucus acini

Adenoids: enlargement (hypertrophy) of the pharyngeal tonsil



Larynx

Site: between pharynx and trachea

Lining: mucous membrane formed of:

a-Epithelium: Pseudo-stratified columnar ciliated with goblet cells.

while, the vocal cords, lingual surface of epiglottis
are lined by stratified squamous non-keratinized epithelium.

b-lamina propria:

- contains mucus & serous glands.

Types of laryngeal cartilages:

1. Large cartilages are: thyroid, cricoid & most of arytenoids → hyaline cartilages.
2. Small cartilages are: Epiglottis, corniculate, cuneiform and tip of arytenoids → elastic

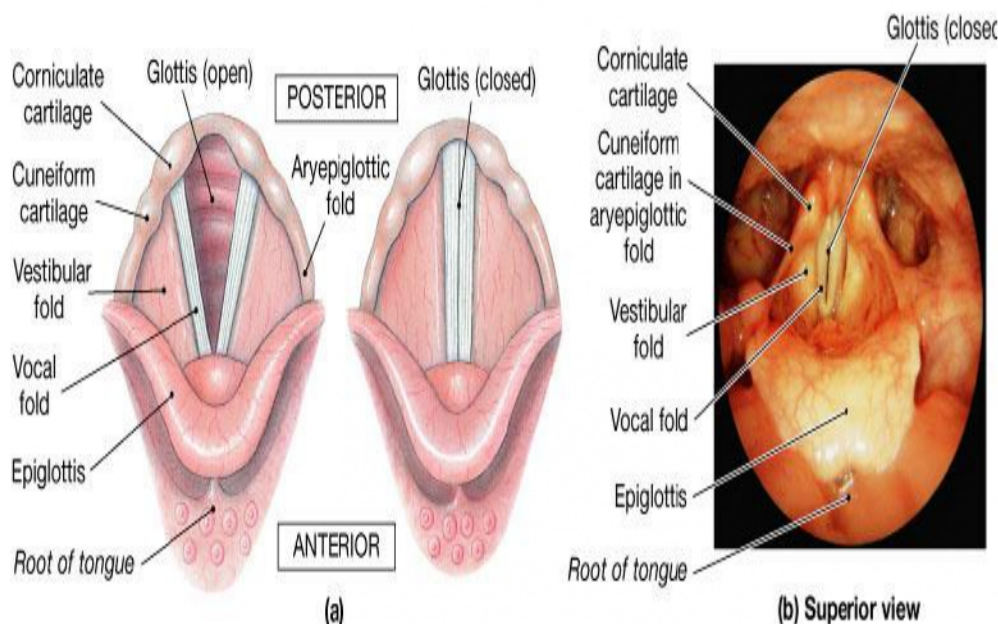
mucous membrane of larynx form two pairs of folds:

1. (Vestibular folds).

- The upper pair
- false vocal cords It is covered with **respiratory epithelium**

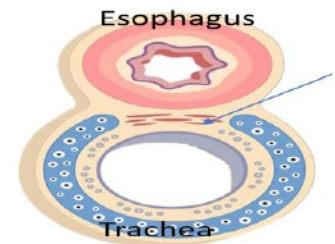
2. (vocal folds).

- The lower pair
- covered with **stratified squamous non-keratinized epithelium**.
- Its lamina propria contains bundles of elastic fibers (vocal ligament) and skeletal muscles "vocalis muscle".
- Vocalis muscles regulate the tension and length of the cords for controlling sound pitch.



Trachea (wind pipe)

- wide, flexible air tube → extends from larynx
→ ends by bifurcating into 2 main extrapulmonary bronchi.
- kept open by a series of 20 C-shaped rings of hyaline cartilages.
Rings are incomplete posteriorly → esophagus distension.



The wall of trachea:

I. Mucosa: → epithelial lining and lamina propria.

A. The lining epithelium : pseudo-stratified ciliated columnar with goblet cells (respiratory epithelium) formed of major 5 types of cells that lie a thick basement membrane

B. Lamina propria: elastic fibers, lymphocytes, and lymphatic nodules.

- Dense elastic lamina is found separating mucosa from submucosa.

II. Submucosa: dense irregular fibroelastic connective tissue.

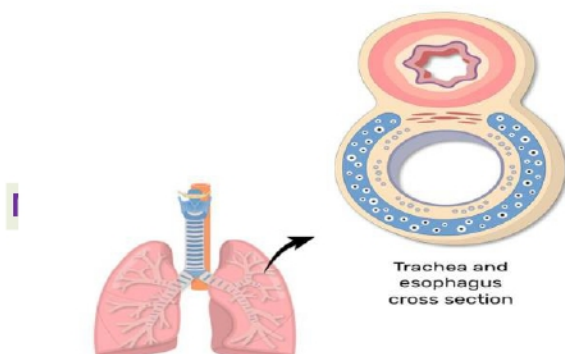
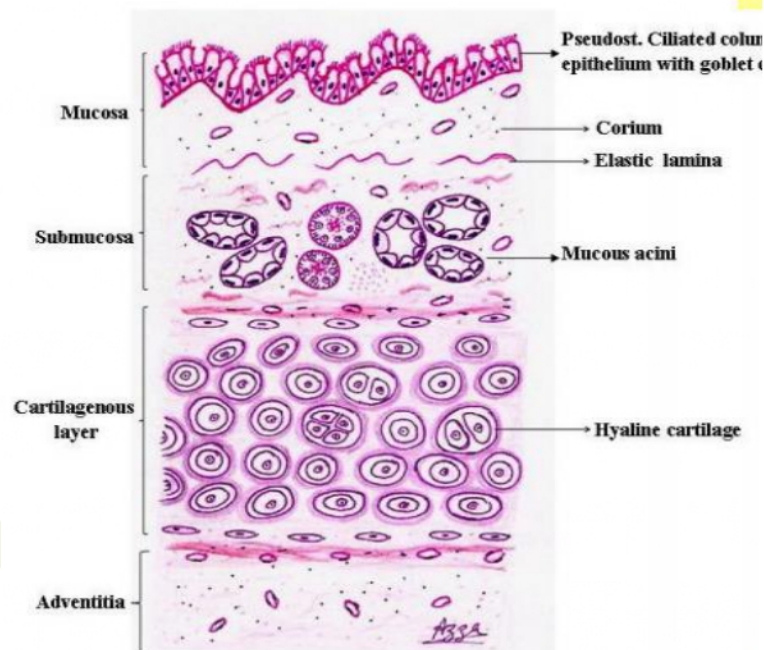
contains mucus acini with some serous secretory units → ducts open into the epithelial surface.

N.B. Most of the tracheal mucus comes from the underlying glands in submucosa.

III. Cartilaginous Layer: C-shaped rings of hyaline cartilage

- gap between posterior ends of incomplete C-shaped rings → bridged by bundles of sm.muscle (trachealis muscle) & fibroelastic ligament attached to the perichondrium.

IV. Adventitia: thin fibroelastic connective tissue layer that surrounds the whole organ.

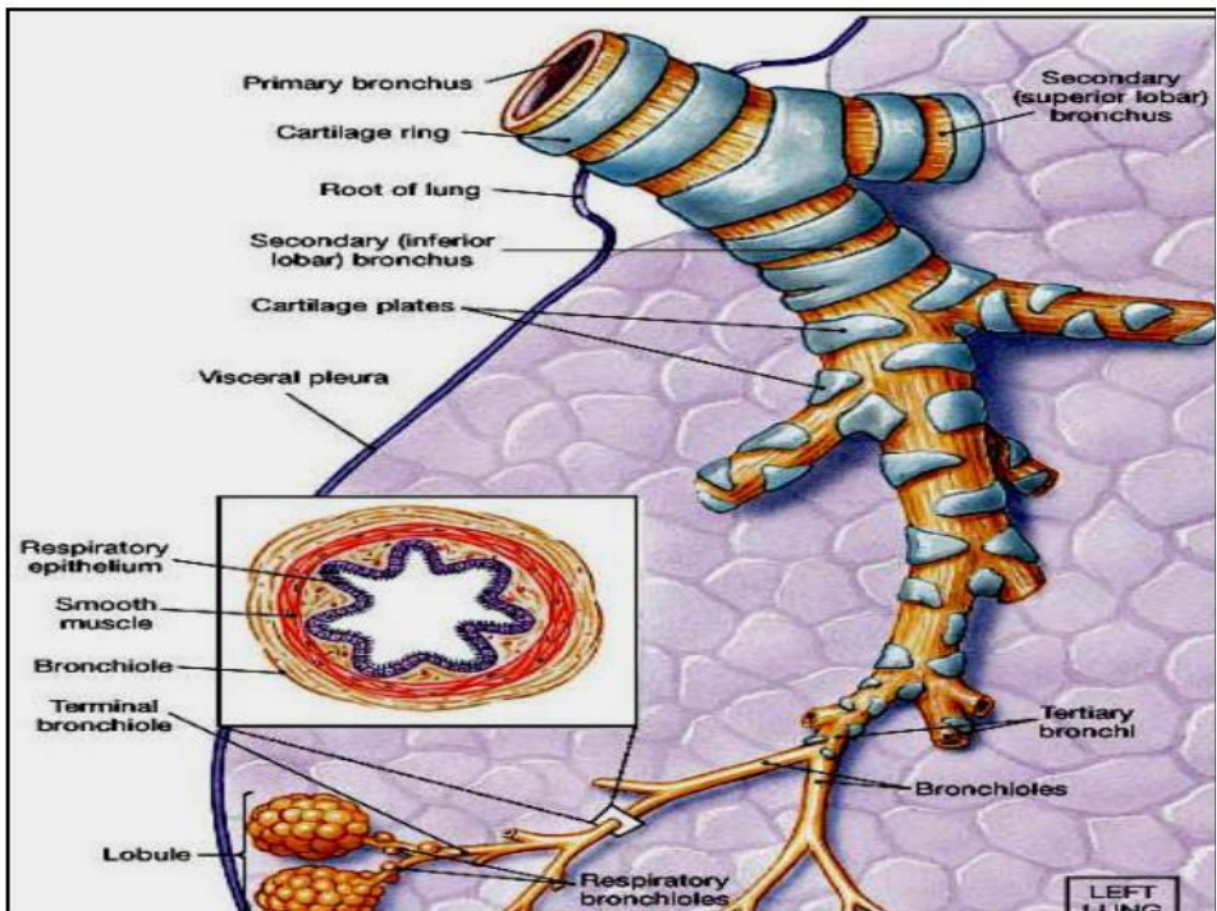


chronic irritants such as cigarette smoke & coal dust → ↑ number of goblet cells relative to ciliated cells to produce a thicker layer of mucus to remove the irritants. normal ratio (1:1)

Bronchial tree

begins at the bifurcation of the trachea → 2 main primary (extrapulmonary) bronchi
→ 2ry (lobar) & 3ry (segmental) intrapulmonary bronchi → bronchioles :
terminal bronchioles → respiratory bronchioles

Extrapulmonary bronchi (1ry): perform the same functions as trachea
resemble trachea in microscopic structure.
However, most cartilage rings completely encircle the lumen.



Intrapulmonary bronchi 2ry & 3ry :

- narrower than trachea.
- walls formed of :
 - **Mucosa** → heavily folded.
 - a-Epithelium** respiratory epithelium + few goblet cells.
 - b-Lamina propria** contains:
 - numerous lymphocytes, solitary lymphoid nodules
 - bundles of smooth muscle → helically arranged around the lumen between mucosa and cartilage.
Contraction of this muscle after death → causes the folded appearance of the mucosa.
 - **Cartilage plates** appear as separate islands of hyaline cartilage .
+ seromucous glands inbetween
 - **Adventitia:** → connective tissue layer surrounding the bronchi

N.B.:

Bronchus associated lymphoid tissue(BALT).

- **MALT** of the respiratory tract → found in the mucosa at the branching points of the bronchial tree
- becomes more abundant in smaller bronchi
- B lymphocytes in the lymphatic nodules are activated to plasma cells producing immunoglobulins (IgA / IgE)

Bronchioles:

Diameter : 1 mm or less . **No mucosal glands & cartilage.**

In large bronchiole → wall formed of mucosa supported by fibrous connective tissue
Mucosa

➤ **Epithelium:**

Large bronchioles are still lined (respiratory epithelium)

➤ **Lamina propria** connective tissue rich in elastic fibers + prominent smooth muscle fibers

In small bronchiole

➤ **Epithelium:** becomes simple columnar then cubical partially ciliated epithelium
 + **club cells.**

➤ **Lamina propria** still contains elastic fibers .

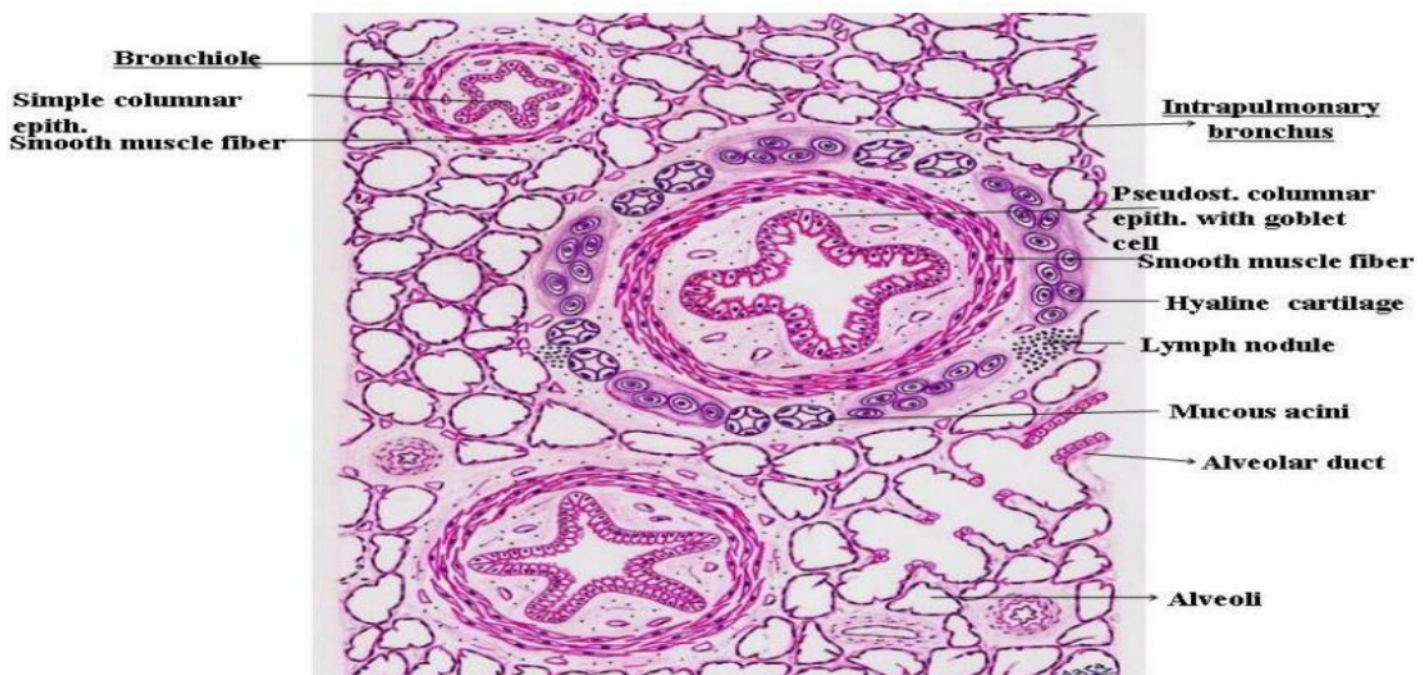
- o Several layers of smooth muscle fibers comprise a high proportion of the wall surrounded by connective tissue .

N.B. Goblet cells disappear just before the level where cilia disappear to avoid accumulation of secretions.

Terminal bronchiole

The last parts of the air conducting system

- It is lined with simple ciliated cuboidal epithelium + non ciliated club cells
- its lamina propria still has elastic fibers and only one or two layers of smooth muscle .



Club cells (Clara cell or exocrine bronchiolar cells)

Site: Present in bronchioles lined with simple epithelium found scattered between its ciliated cells.

- L/M: **tall, non ciliated dome-shaped cell.**

- E/M:

numerous mitochondria, rER, sER, well developed Golgi apparatus and apical electron dense secretory granules.

It shows short blunt microvilli

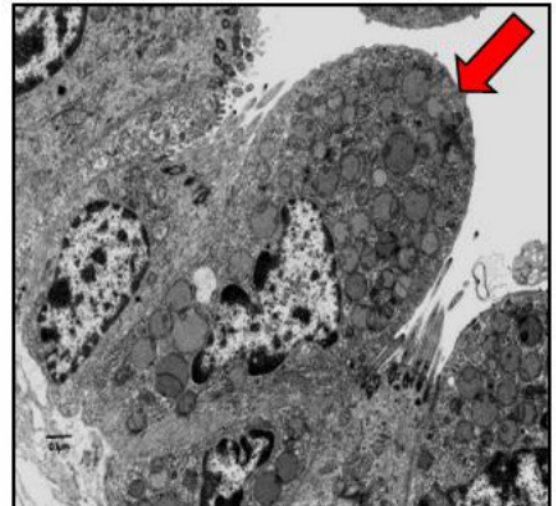
Function

1-They secrete **surfactant like protein**

2-**Detoxification** ,of inhaled compound , by SER.

3- Secretion of **antimicrobial peptides** → local immune defense

4-**Progenitor cell**, → renewal of other bronchiolar cells .

**Respiratory portion of respiratory system**

➤ It is the portion where gas exchange takes place.

➤ It includes:

- Respiratory bronchioles.
- Alveolar ducts
- Alveolar sacs.
- Alveoli.

(1) Respiratory Bronchioles

➤ Resemble terminal bronchioles but alveoli open in its wall.

➤ Lined by simple cuboidal ciliated epithelium with club cells.

➤ Beneath the epithelium elastic and smooth muscle fibers are present.

(2) Alveolar duct

- Distal ends of respiratory bronchioles branch into tubes called alveolar ducts
- Its wall is interrupted by numerous openings of alveoli and alveolar sacs.
- Lined by low cubical epithelium.
- Beneath the epithelium elastic and reticular fibers exist.
- Strand of smooth muscle fibers surrounds each alveolar opening.
- Alveolar ducts end in two or more clusters of alveoli called alveolar sacs.

Correlated functions of the alveolar duct in relation to its structure

- Elastic fibers allow the alveoli to expand during inspiration, and recoil passively with expiration.

(3) Alveolar sacs

- Group of alveoli open into common central space.

(4) Alveoli

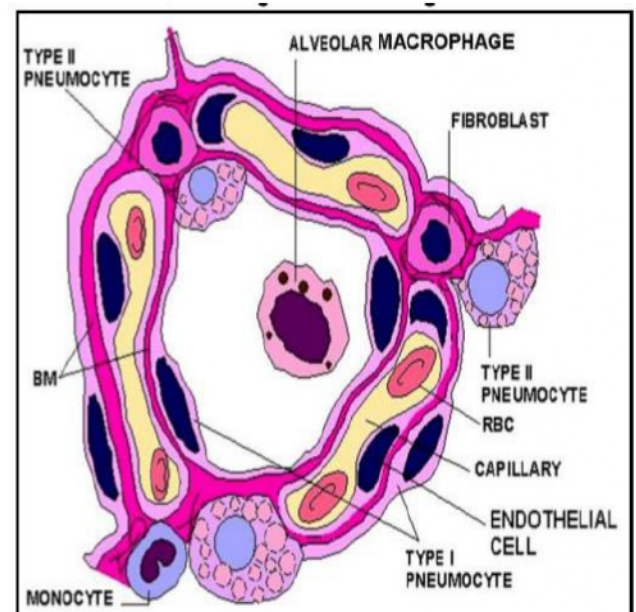
- Sac like evaginations from the respiratory bronchioles, alveolar ducts, and alveolar sacs
- interalveolar septa → Between neighboring alveoli
- They are the basic structural and functional unit of gas-exchange in the lung.
- Lined by alveolar epithelium.

Alveolar epithelium:

(1) Type I pneumocytes:

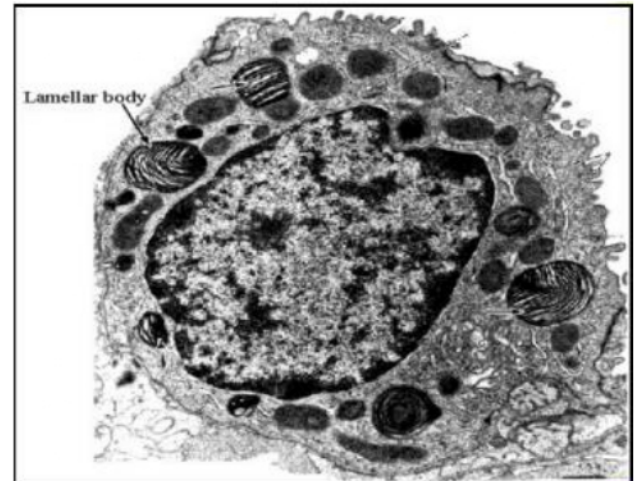
- Constitute the majority of alveolar epithelium.
- **L/M:** Simple squamous epithelium
- **E/M:**
 - Very thin cell few mitochondria, rER, Golgi apparatus.
 - Microfilaments & microtubules.
 - **Tight junctions** → prevent leakage into the lumen
- **Function: gas exchange.**

Type I cells form part of the blood-air barrier



(2) Type II pneumocytes:

- Secretory epithelial cell. Few in number **(3%)**.
Present at points where two or more alveolar walls unite
- **L/M:** Cuboidal cells, bulging into the lumen.
pale stained cytoplasm
rounded nucleus with prominent nucleolus
- **E/M:**
 - Have apical microvilli.
 - Numerous mitochondria, rER, well developed Golgi apparatus.
 - Multivesicular bodies (secondary lysosomes).
 - **Membrane-bound lamellar bodies → contain pulmonary surfactant (phospholipid material) are marker for the cell.**
 - bound to type I by tight (occluding) junctions & desmosomes
- **Function**
 - Synthesize & secrete pulmonary surfactant
 - regeneration for both types of pneumocytes



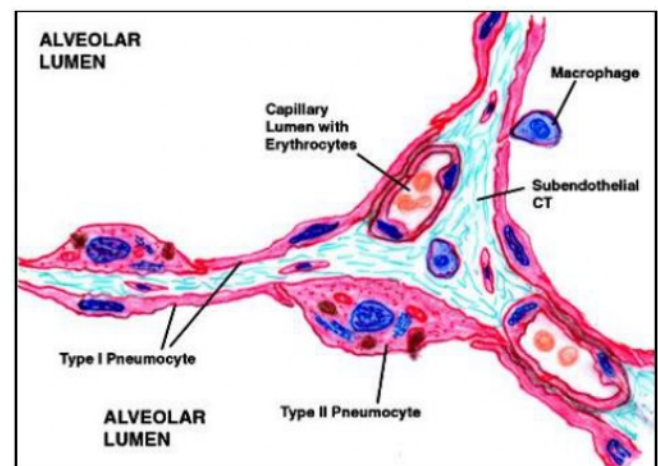
N.B. Cilia are absent from alveolar epithelium, and thus dust-trapped particles are removed by alveolar macrophage (dust cell).

Interalveolar septum

- the partition between 2 adjacent alveoli.
- These septa are interrupted by holes called alveolar pores to allow communication between adjacent alveoli.

➤ It is formed of:

1. **Alveolar epithelium** on either sides (Type I and II).
2. **Capillary network (continuous non-fenestrated)**
3. **Fused Basal lamina** of endothelium & alveolar epithelium
→ **(alveolocapillary basement membrane).**
4. **Network of elastic, reticular, collagenous** fibers, connective tissue cells (mast cells, macrophages and fibroblasts) and extravasated leucocytes



Alveolar-Capillary Barrier / Blood- Air Barrier

the area of the inter-alveolar septum through which gas exchange occurs

It is formed of:

- 1- Pulmonary surfactant.
- 2- Type I pneumocytes.
- 3- Fused basal laminae of type I pneumocytes & capillary endothelium.
- 4- Continuous endothelium of blood capillaries.

- **Function:** It allows diffusion of gases between air spaces & blood.

Alveolar Macrophages

- **Origin:** Monocytes that migrates to the lung interstitium.
- **Function:** Phagocytosis.
- **Types:**
 - **Dust cells:** phagocytose dust particles.
 - **Heart failure cells:** Lung macrophages phagocytose extravasated blood in cases of congestive heart failure.

Pleura

1. The pleura → serous membranes (serosa) associated with each lung & thoracic cavity.
2. The membrane attached to lung tissue is called the visceral pleura and membrane lining the thoracic walls is the parietal pleura.
4. Both layers are similar histologically & consist of a simple squamous mesothelium on a thin layer of connective tissue.

The connective tissue is rich in both collagen and elastic fibers and contains both blood vessels (V) and lymphatics.
5. Both layers are separated by thin film of fluid to lubricate movement.