RESPIRATORY SYSTEM

- **CONDUCTING PORTION**
- **RESPIRATORY PORTION**

Dr Shahab ...

- **CONDUCTING SYSTEM**
- NASAL CAVITY
- NASOPHARYNX
- LARYNX
- TRACHEA
- BRONCHI
- BRONCHIOLES
- AND TERMINAL BRONCHIOLES.

To provide a conduit through which air can travel to and from the lungs

To condition the inspired air.

CONDITIONING OF AIR

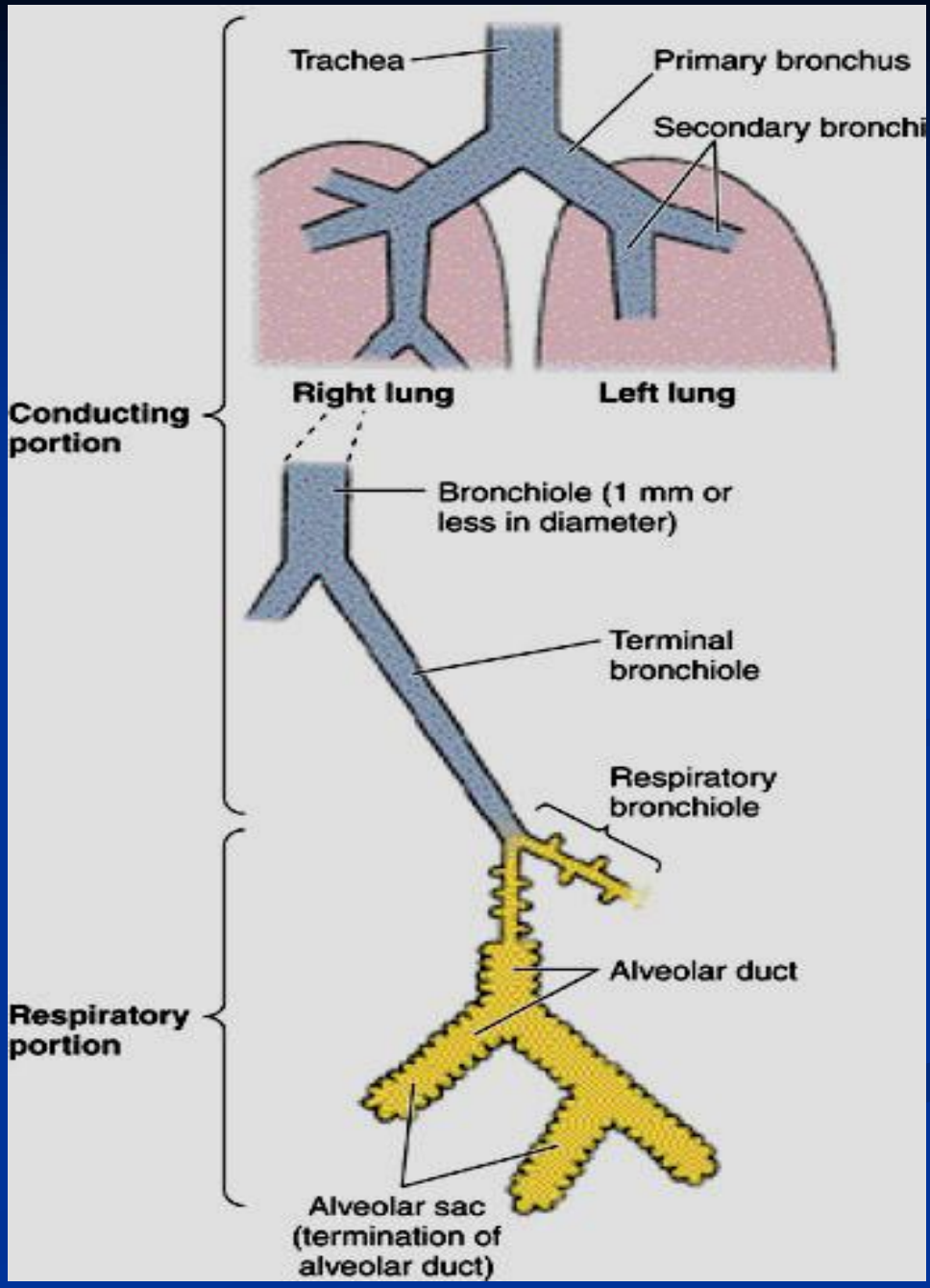
The Respiratory Epithelium Of The Conducting Portion Has Numerous Mucous And Serous Glands.

A very rich vascular network in the lamina propria

Presence of large *vibrissae*.

The air is moistened and warmed and coarse particles of dust are removed before the air reaches the alveoli.

The main divisions of the respiratory tract. The natural proportions of these structures have been altered for clarity; the respiratory bronchiole, for example, is in reality a short transitional structure.



RESPIRATORY EPITHELIUM

Most of the conducting portion is lined with pseudo-stratified cilliated columnar epithelium, and is known as respiratory epithelium.

Typical respiratory epithelium consists of five cell types;

Cilliated Columnar Cells;

The most abundant type. each cell has about 300 cilia on its apical surface. beneath the cilia in addition to the basal bodies are numerous small mitochondria that supply ATP for ciliary beating.

Mucous goblet cells;

The second most abundant cell type. The apical portion of these cells contains ,the mucous droplets composed of glycoprotein.

Brush cells;

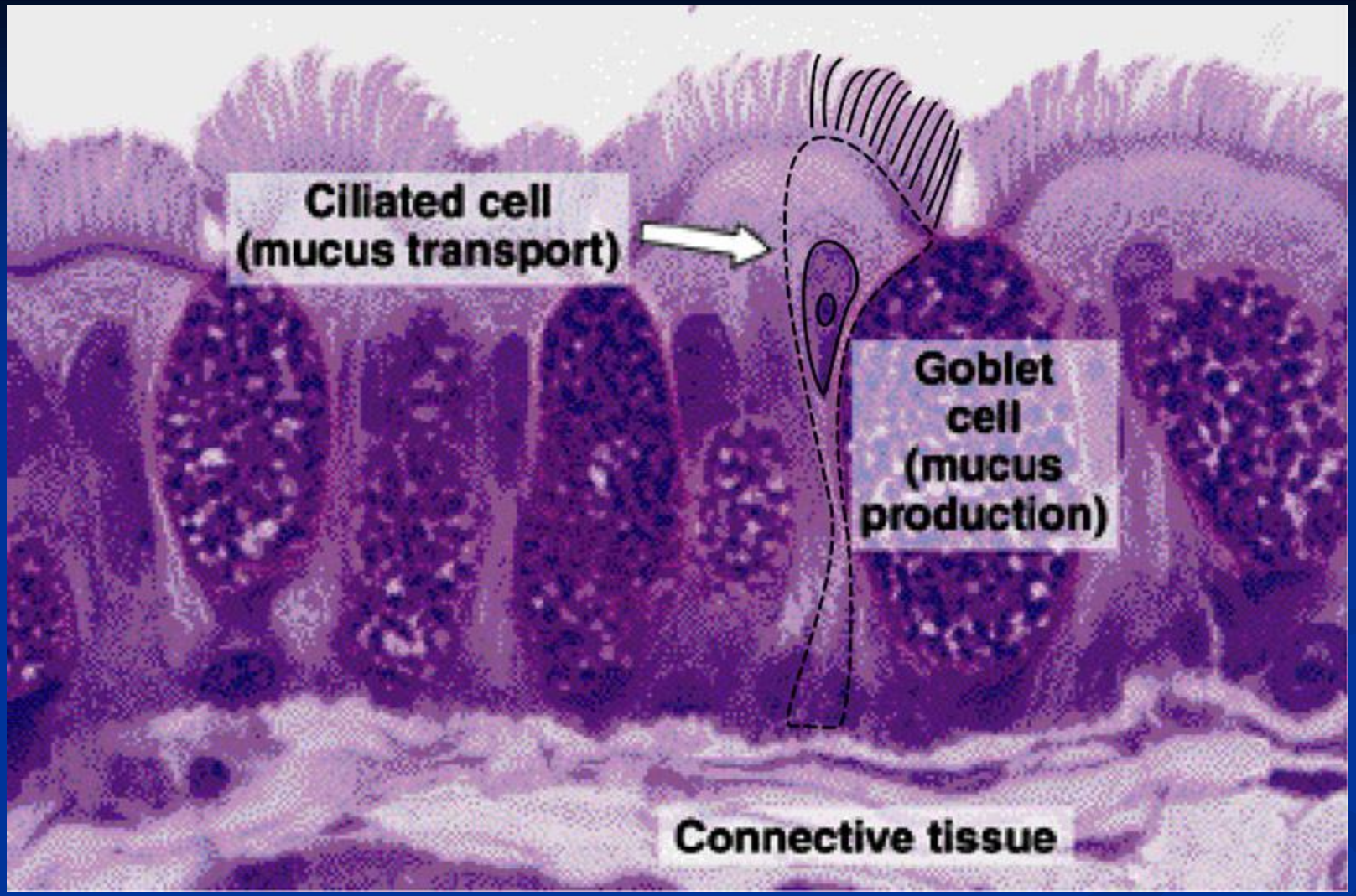
These are the remaining columnar cells. they have numerous microvilli on their apical surface. brush cells have afferent nerve endings on their basal surfaces and are considered to be sensory receptors.

Basal (short) cells;

Are small rounded cells that lie on the basal lamina, but donot extend to the luminal surface of the epithelium. they are believed to be generative stem cells that undergo mitosis and subsequently differentiate into other cell types.

Granule cells ;

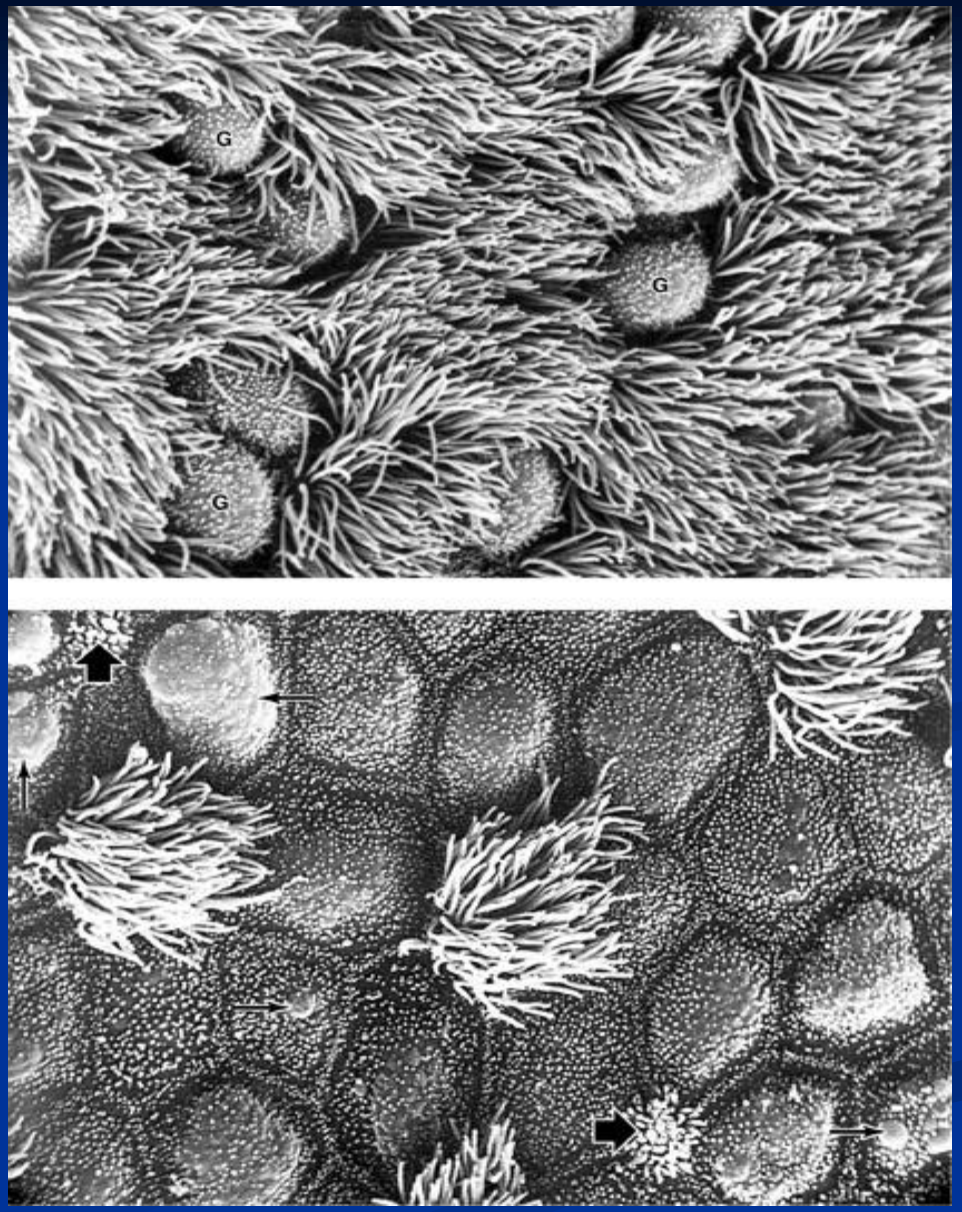
They resemble basal cells except that they posses numerous granules 100-300 nm in diameter with dense cores. they belong to cells of diffuse neuroendocrine system.



Photomicrograph illustrating the main components of the respiratory epithelium. Pararosaniline—toluidine blue (PT) stain. High magnification.

Scanning electron micrographs of the surface of respiratory mucosa. Top: Most of the surface is covered with cilia. G, goblet cells. x2500.

Bottom: Subsurface accumulations of mucus are evident in the goblet cells (thin arrows). Thick arrowheads indicate brush cells. x3000.



The nasal cavity

Vestibule

It is the most anterior and dilated portion of the nasal cavity.arround the inner surface of the nose are numerous sebaceous and sweat glands. thick short hair called ***vibrissae,*** that filter out large particles from the inspired air.

Nasal fossae

The lateral wall of each nasal cavity has three bony shelf like projections called conchae.of the superior ,middle and inferior conchae, only the middle and inferior conchae are covered with respiratory epithelium. the superior conchae are covered with specialized ***olfactory epithelium.***

It is a pseudo stratified epithelium composed of three type of cells. in human upto 100um thick and about 10^2 cm in area.

1. ***The supporting cells;***

Have broad ,cylindrical apexes and narrower bases. on their free surfaces are microvili submerged in a fluid layer.

The supporting cells contain a light yellow pigment that is responsible for the color of the olfactory mucosa.

Well developed junctional complexes bind the supporting cells to the subjacent olfactory cells.

2. The basal cells;

Are small and spherical or cone shaped and form a single layer at the base of the epithelium.

3. The olfactory cells;

Present between the supporting cells and basal cells.

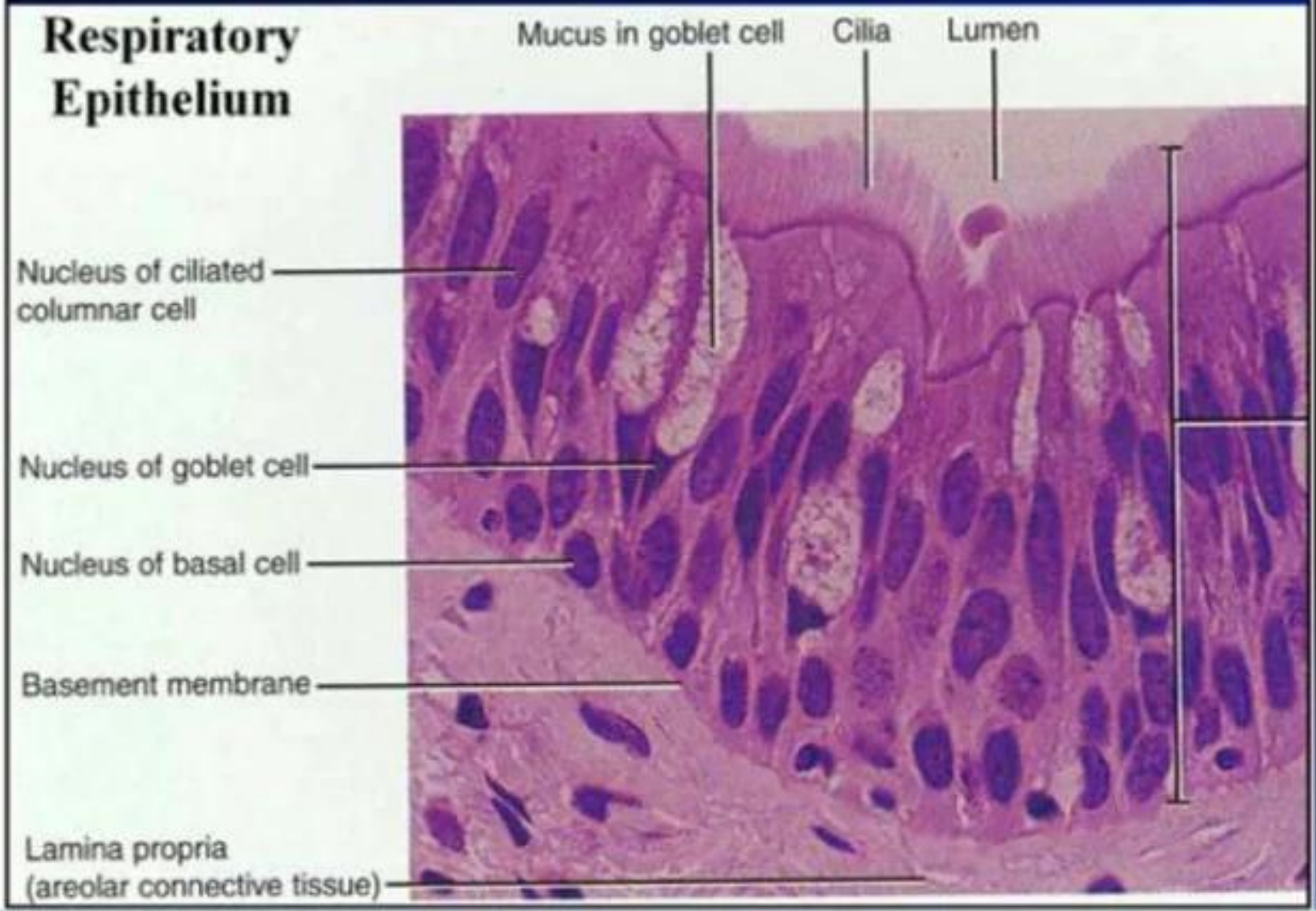
Bipolar neurons, whose nuclei lie below the nuclei of the supporting cells.

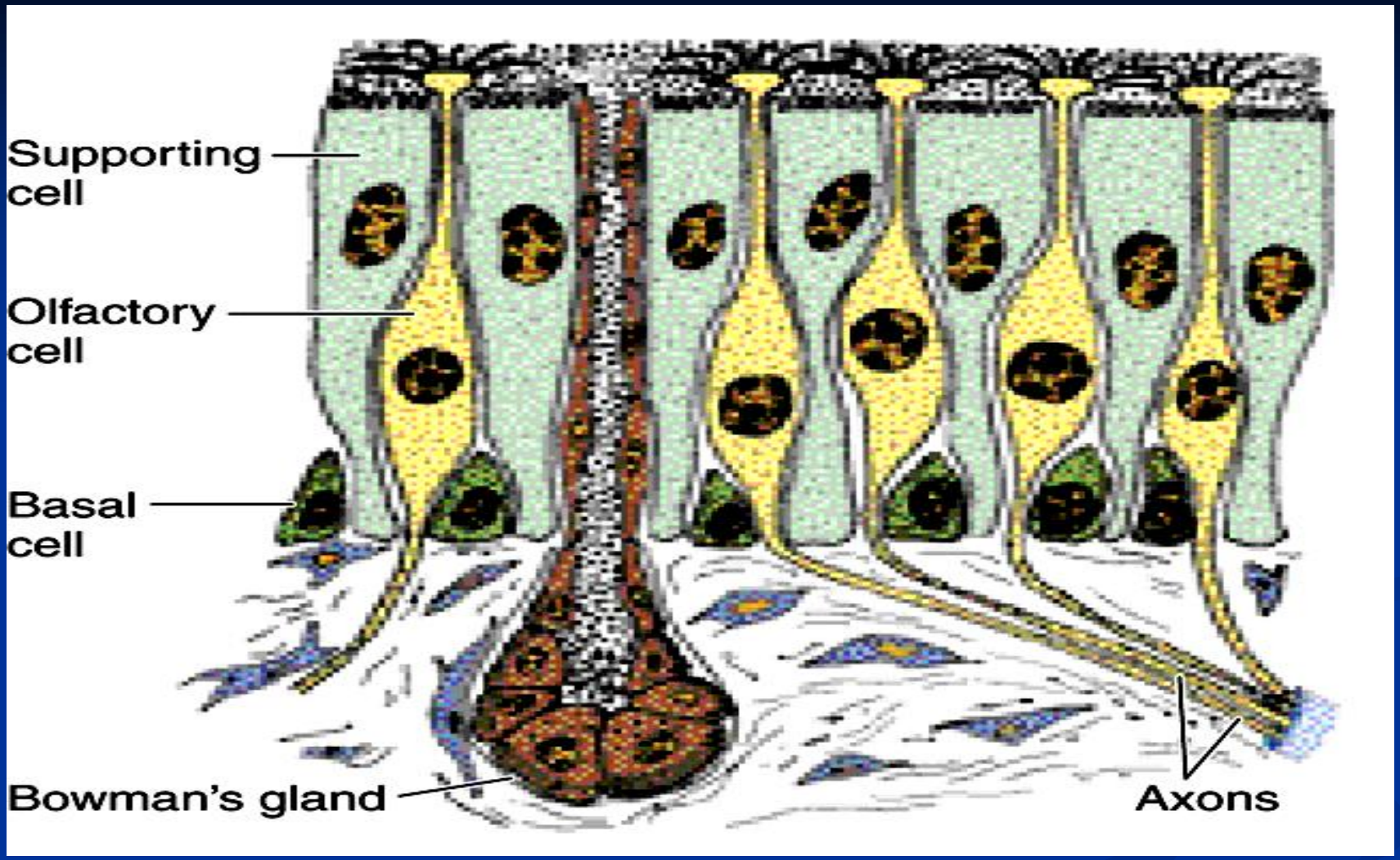
Their apexes (dendrites) possess elevated and dilated areas from which arise six to eight cilia. the cilia are very long and non motile and respond to odoriferous substances by generating a receptor potential. the cilia increase the receptor surface considerably.

The afferent axons of these bipolar neurons unite in small bundles directed toward the brain, where they synapse with neurons of the brain ***olfactory lobe***

The lamina propria of the olfactory epithelium possesses the ***glands of bowman***. their secretion produces a fluid environment around the olfactory cilia that may clear the cilia, facilitating the access of new odoriferous substances.

Pseudostratified ciliated columnar epithelium





Olfactory mucosa showing the 3 cell types (supporting, olfactory, and basal) and a Bowman's gland.

BRONCHIAL TREE

- The trachea divide into two ***primary bronchi*** that enter the lungs at hilum.after entering the lungs, the primary bronchi give rise to three bronchi in the right lung and two in the left lung.
- Each of these supply a pulmonary lobe, these ***lobar bronchi*** divide repeatedly ,giving rise to smaller bronchi, whose terminal branches are called ***bronchioles***.
- Each bronchiole enters a pulmonary lobule, where it branches to form 5 to 7 ***terminal bronchioles.***

TRACHEA

The trachea is lined with a typical respiratory mucosa.

In the lamina propria are 16-20 C –shaped rings of hyaline cartrilage,that keep the lumen open .

There are numerous seromucous glands that produce a more fluid mucous.

The open ends are located posteriorly and a fibroelastic ligament and bundle of smooth muscle bind to the perichondrium and bridge the open ends of these C shape cartilages.

The ligament prevents overdistension of the lumen and the muscle allows regulation of the lumen.

Contraction of the muscle and the resultant narrowing of the tracheal lumen are involved in the cough reflex.

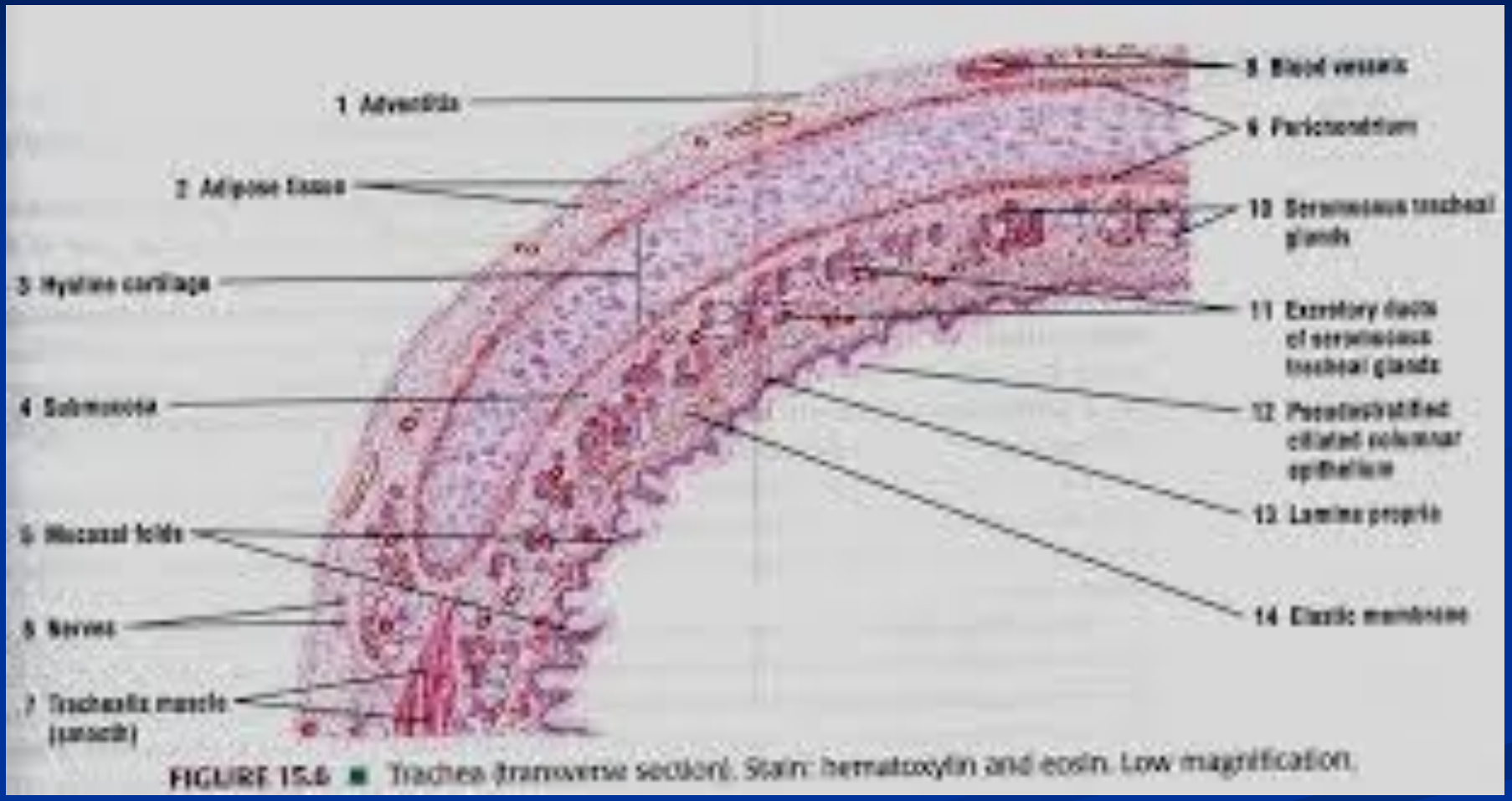
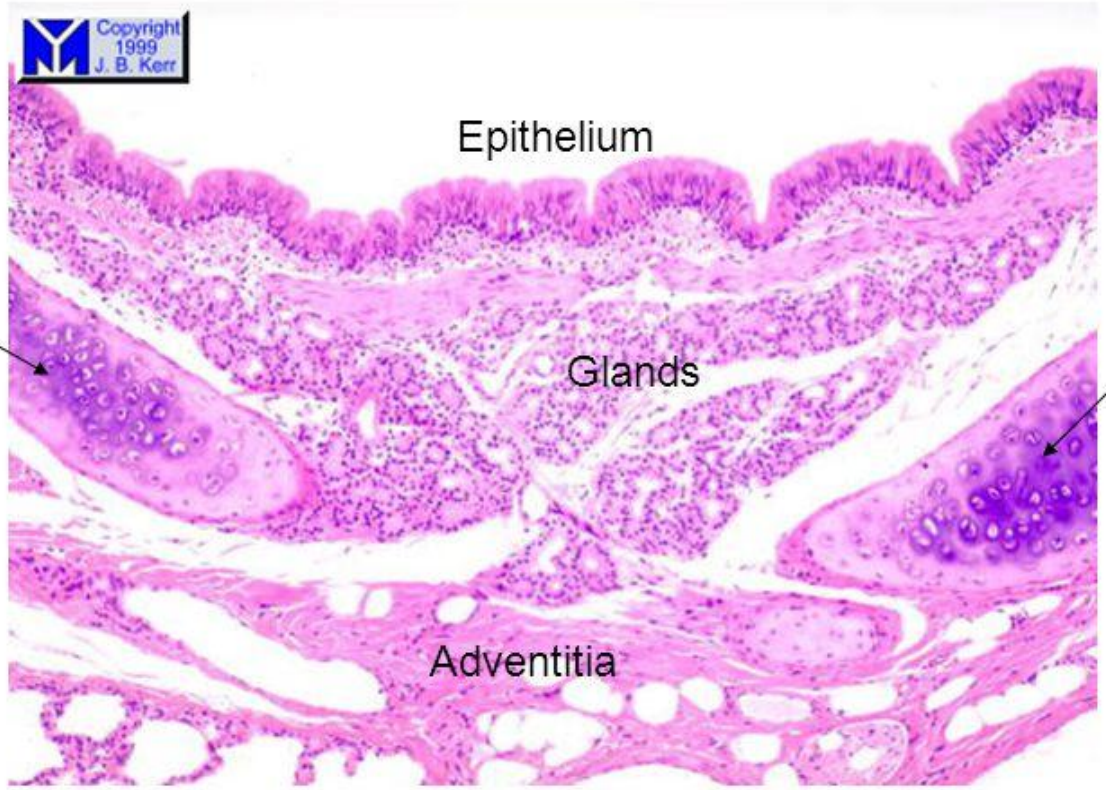


FIGURE 15.6 ■ Trachea (transverse section). Stain: hematoxylin and eosin. Low magnification.

- The primary bronchi generally have the same histological appearance as the trachea.
- Proceeding toward the respiratory portion the histological organization of both the epithelium and the underlying lamina propria becomes simplified. it must be stressed that this simplification is gradual and there is no abrupt transition.

Bronchus and Bronchial Tree

The bronchus is similar to the trachea, but branching into the lungs, and the C-shaped cartilage rings are replaced by plates. The epithelium is still pseudostratified, ciliated columnar, but height decreases.



BRONCHI

- Each primary bronchus divides dichotomously 9-12 times, with each branch becoming progressively smaller until it breaches a diameter of about 5 mm
- the mucosa of the bronchi is similar to the mucosa of the trachea.
- The bronchial cartilage is more irregular in shape. In larger portions of the bronchi ,the cartilage rings completely encircle the lumen.
- As bronchial diameter decreases, the cartilage rings are replaced by isolated plates,. or islands of hyaline cartilage.
- Beneath the epithelium the lamina propria is a layer of crisscrossing bundles of spirally arranged ,smooth muscle. bundles of smooth muscles become more prominent near the respiratory zone.

- The lamina propria is rich in elastic fifers and contains an abundance of mucous and serous glands, whose ducts open into the lumen.
- Numerous lymphocytes are found both within the lamina propria, and among the epithelial cells.
- Lymphatic nodules are present and are particularly numerous at the branching points of the bronchial tree.

BRONCHIOLES

- Intralobular airways with diameter of 5 mm or less, have neither cartilage nor glands in their mucosa.
- There are only scattered goblet cells within the epithelium of the initial segments.
- In the larger bronchioles, the epithelium is psuedostratified ciliated columnar, which decreases in height and complexity to become ciliated simple columnar or cuboidal epithelium in the smaller terminal bronchioles.

The epithelium of terminal bronchioles also contains ***Clara cells***. Which are devoid of cilia, have secretory granules in their apex, and are know to secrete proteins that protect the bronchiolar lining against oxidative pollutants and inflammation.

Bronchioles also exhibit specialized regions called ***Neuroepithelial Bodies*** . these are formed by groups of 80 -100 cells that contain secretory granules and receive cholinergic nerve endings. Their function is poorly understood, but they are probably chemoreceptor that react to changes in gas composition within the airway. They also seem involved in the reparative process of airway epithelial cell renewal after injury.

Bronchiolar lamina propria is composed largely of smooth muscle and elastic fibers. The musculature of both the bronchi and the bronchioles is under the control of the vagus nerve and the sympathetic nervous system. Stimulation of the vagus nerve decreases the diameter of these structures; sympathetic stimulation produces the opposite effect.

Respiratory Bronchioles

- Each terminal bronchiole subdivides into two or more respiratory bronchioles that serve as regions of transition between the conducting and respiratory portions of the respiratory system.

- The respiratory bronchiolar mucosa is structurally identical to that of the terminal bronchioles, except that their walls are interrupted by numerous saclike alveoli where gas exchange occurs. Portions of the respiratory bronchioles are lined with ciliated cuboidal epithelial cells and Clara cells..

- But at the rim of the alveolar openings the bronchiolar epithelium becomes continuous with the squamous alveolar lining cells (type 1 alveolar cells).
- Preceding distally along these bronchioles, the alveoli increase greatly in number, and the distance between them is markedly reduced. Between alveoli, the bronchiolar epithelium consists of ciliated cuboidal epithelium; however, the cilia may be absent in more distal portions. Smooth muscle and elastic connective tissue lie beneath the epithelium of respiratory bronchioles

Q ; What Is Education?

Ans;

Education is an organized system, through which we waste half of our life…. to learn, how to waste the remaining half of our life.

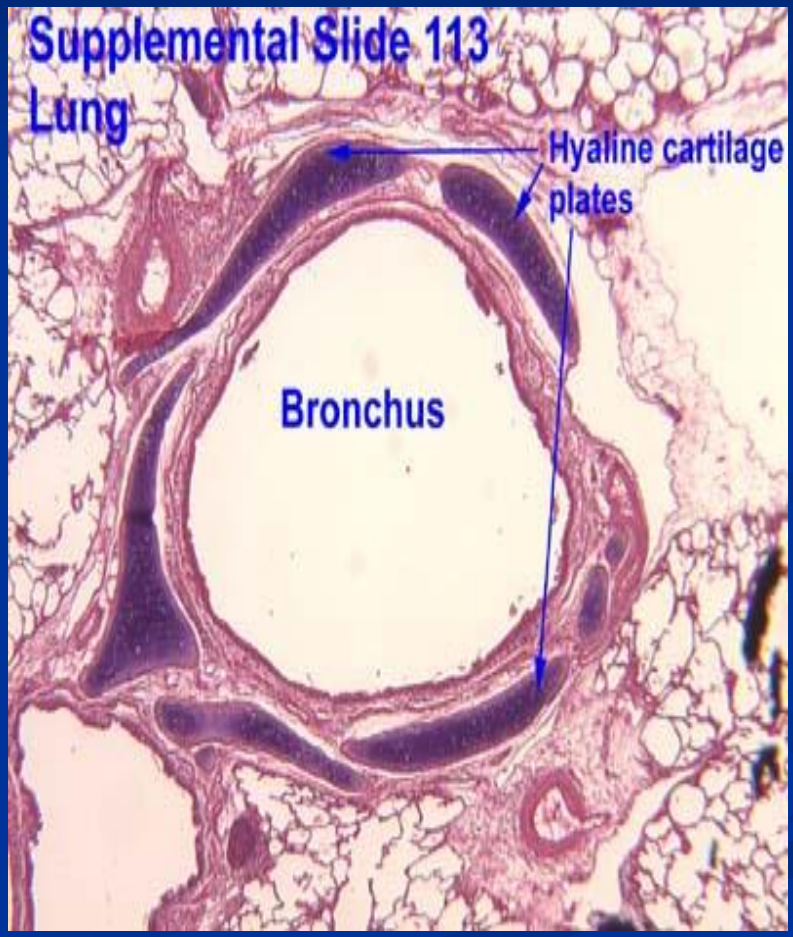
RESPIRATORY SYTEM

LECT 2

Dr Shahab

Bronchus

- **Principal bronchus**
  -same as trachea
- **Secondary /Lobar bronchus**
  -Irregular hyaline cartilage
  -Pseudo stratified ciliated columnar
- **Tertiary /Segmental bronchus**
  -Columnar epithelium
  -Patches of cartilage



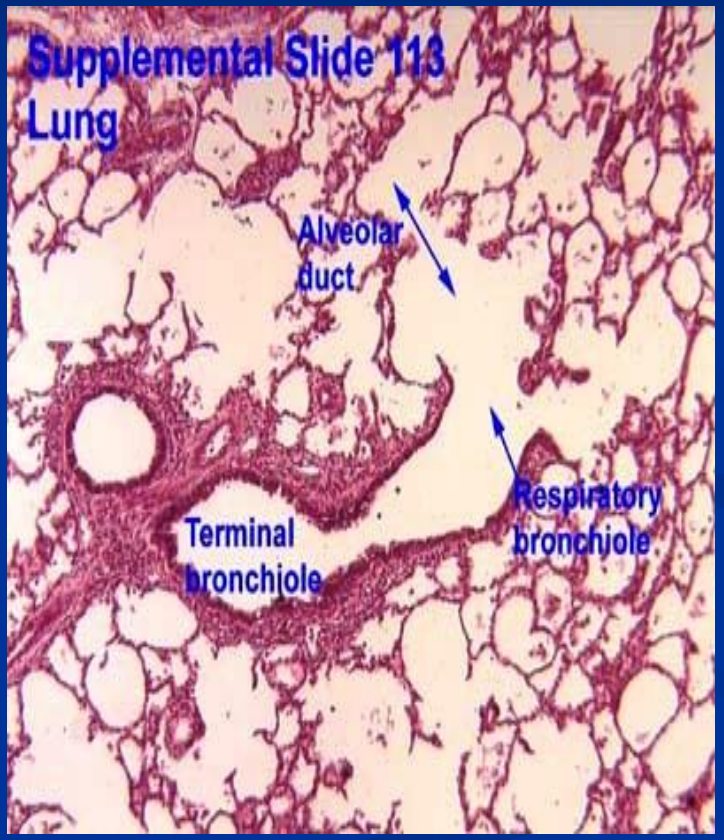
Changes as bronchi become smaller

- **Cartilage**-irregular and smaller. Absent in bronchioles.
- **Muscle**- increases as bronchi becomes smaller.(Spasm of these muscles bring difficulty in breathing in allergic conditions)
- **Sub epithelial Lymphoid Tissue**-increases with decrease in the diameter of bronchi.
- **Glands**-few. Absent in the walls of capillaries.
- **Epithelium**- pseudostratified ciliated columnar epithelium in principal bronchi later simple ciliated columnar,non-ciliated columnar and later cuboidal in respiratory bronchioles

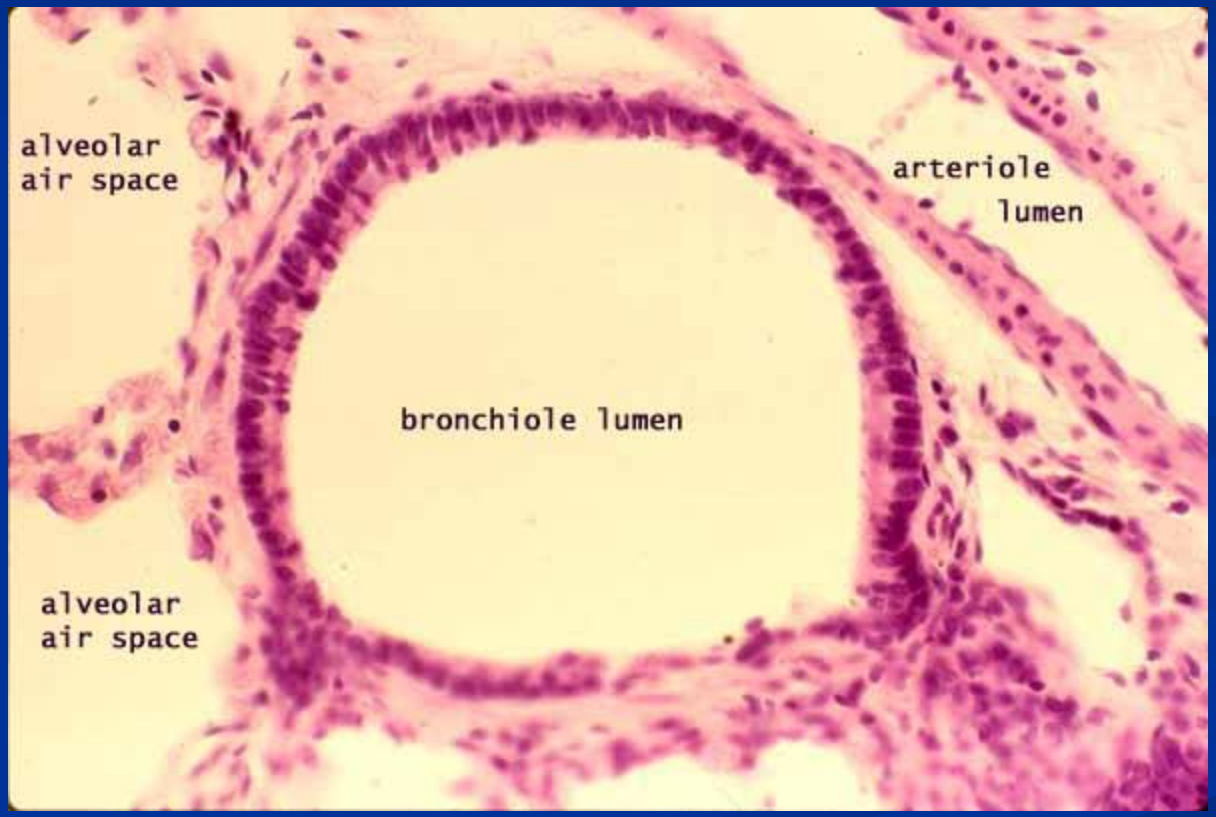
Bronchiole

- **Terminal bronchiole**
  - -Columnar epithelium
  - -No cartilage
  - - smooth muscle +
  - -Clara cells present

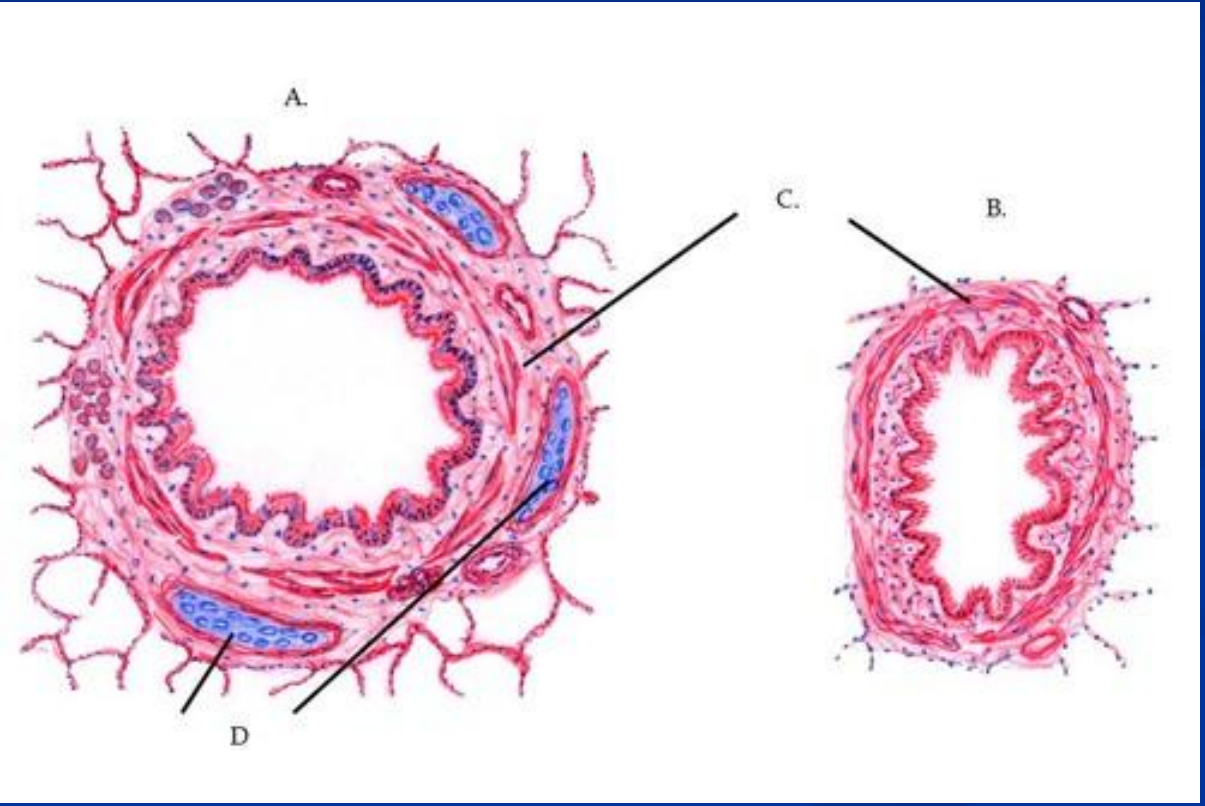
- **Respiratory bronchiole**
  - -Cuboidal epithelium
  - -No mucous gland

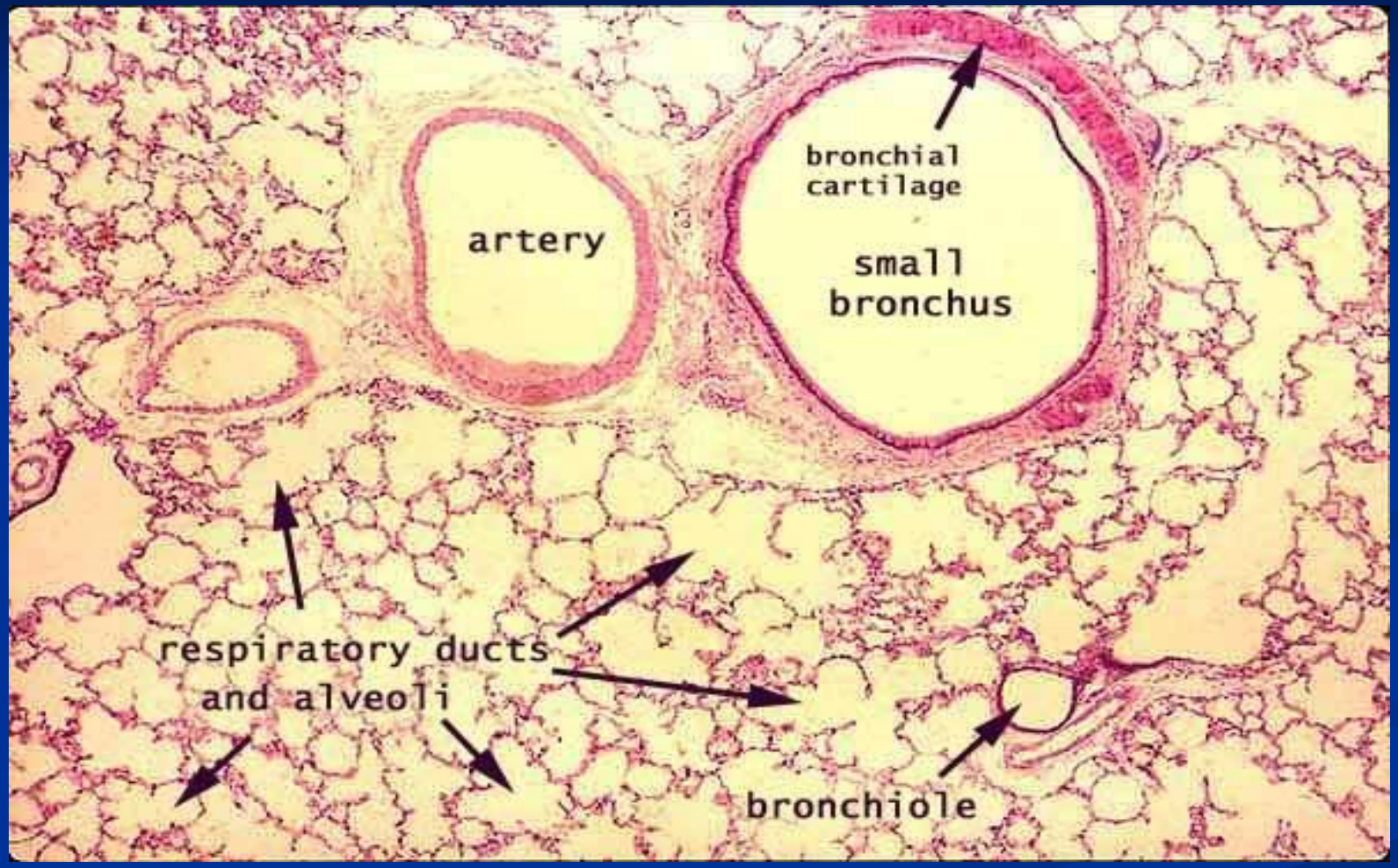


Bronchiole


alveolar
air space
arteriole
lumen
bronchiole lumen
alveolar
air space

Bronchus and Bronchiole




bronchial
cartilage
artery
small
bronchus
respiratory ducts
and alveoli
bronchiole

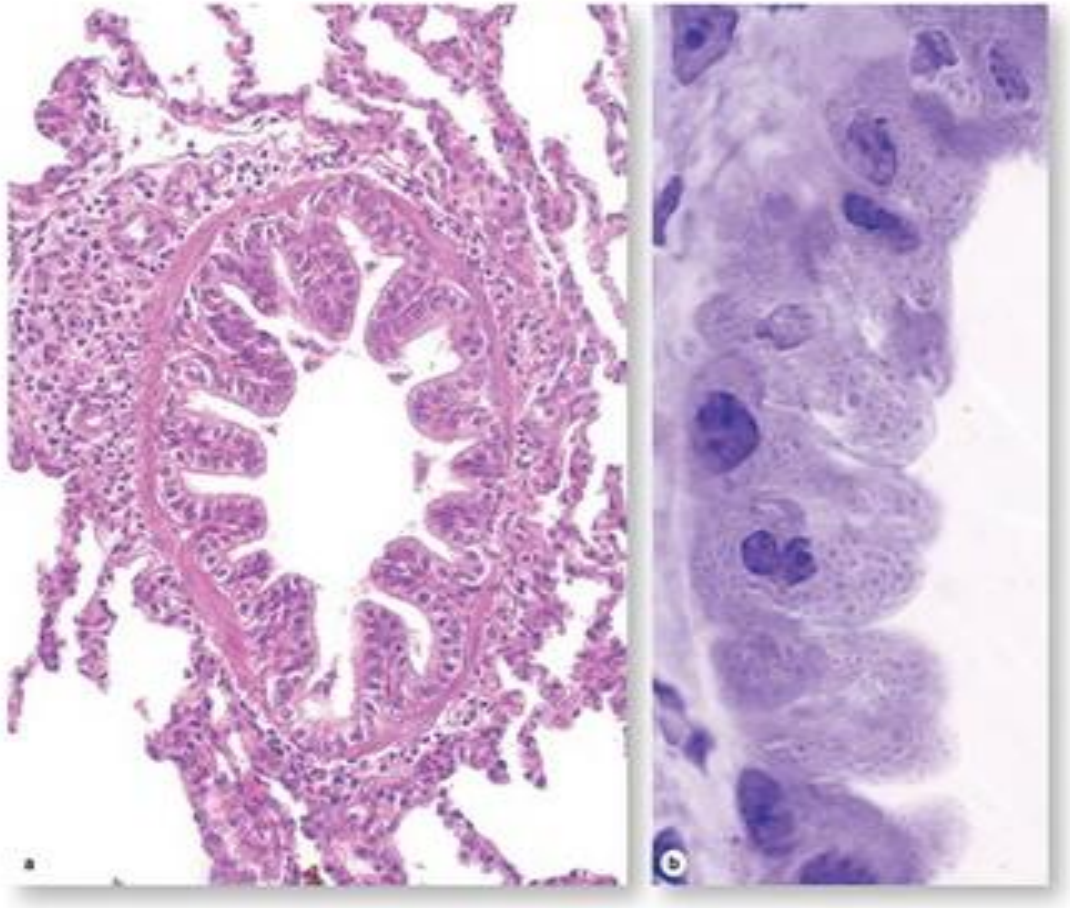
Bronchiole

Differences between Bronchi and Bronchioles

Bronchioles

- No glands
- No cartilage
- No goblet cells
- Thick smooth muscle layer
- Presence of Clara cells
- Many elastic fibers

Terminal Bronchiole



Terminal Bronchiole

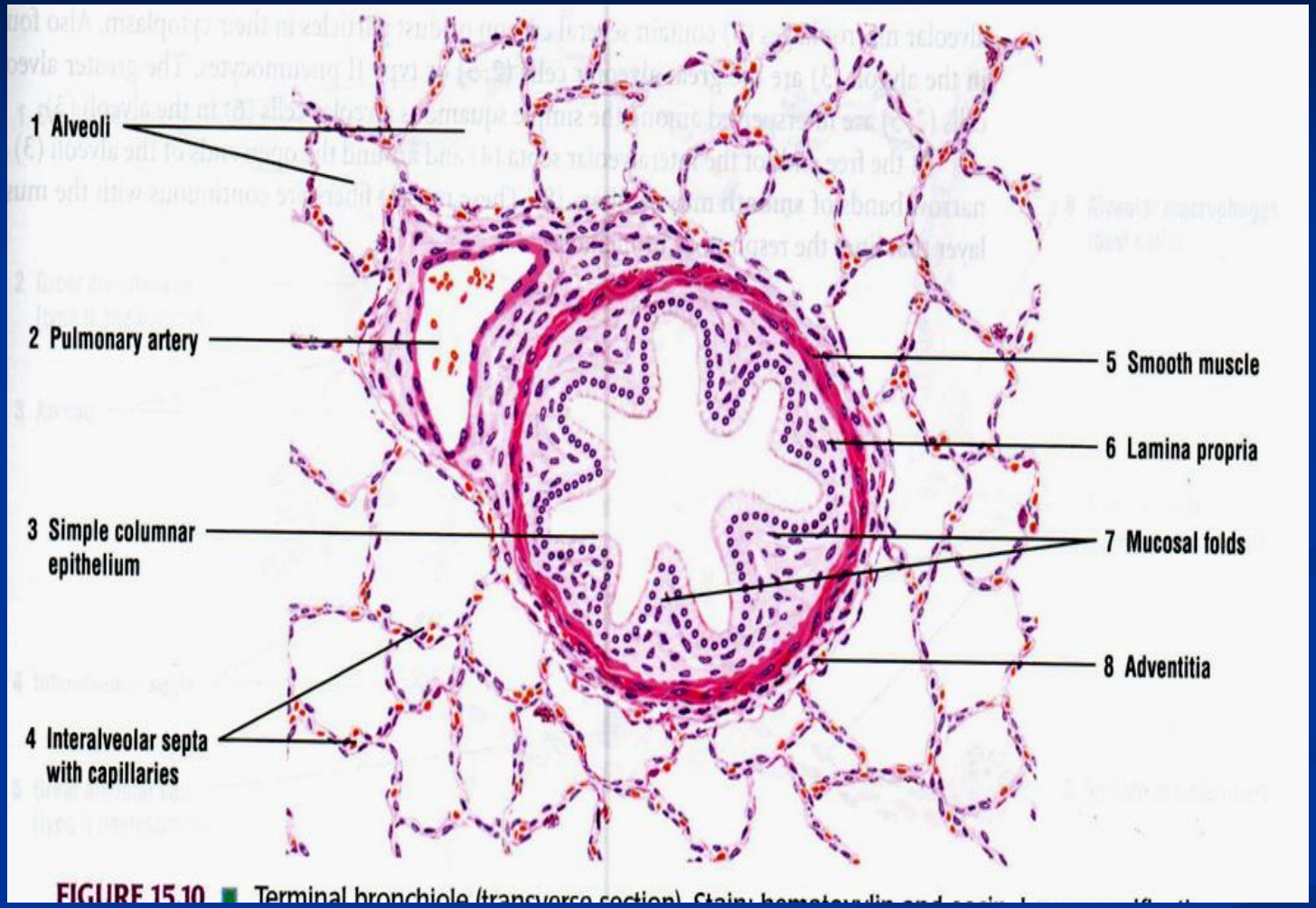
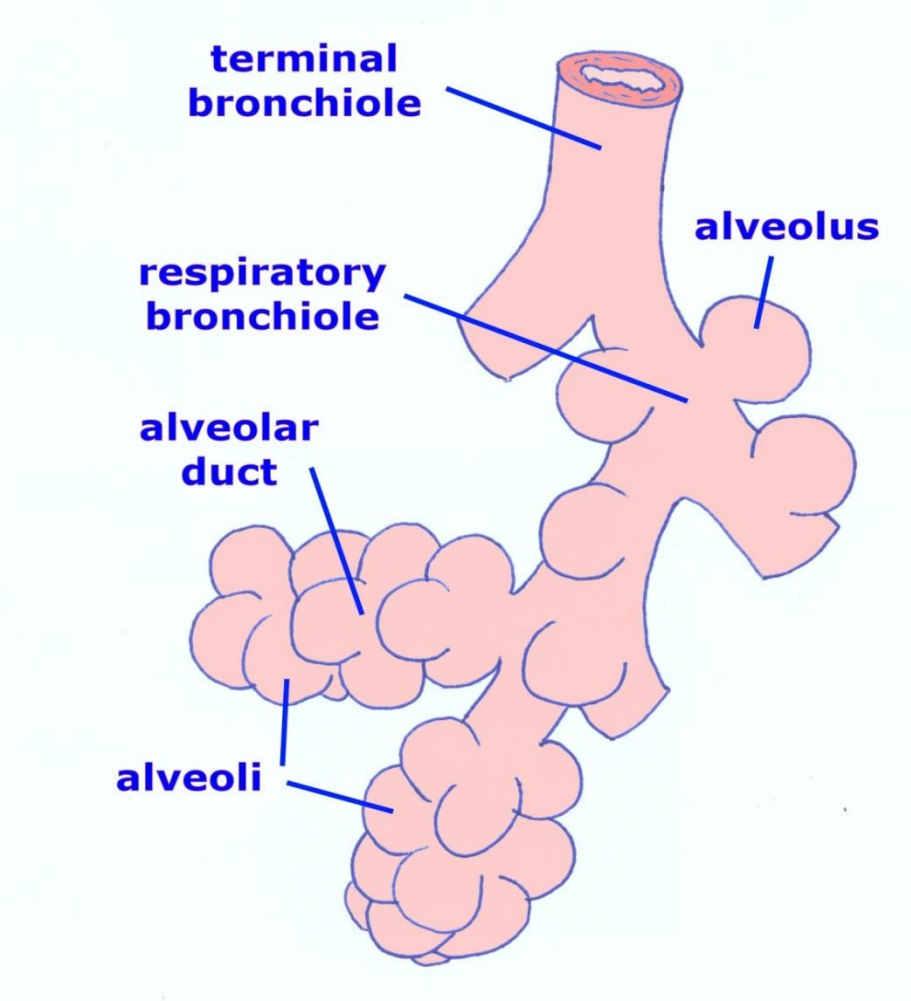
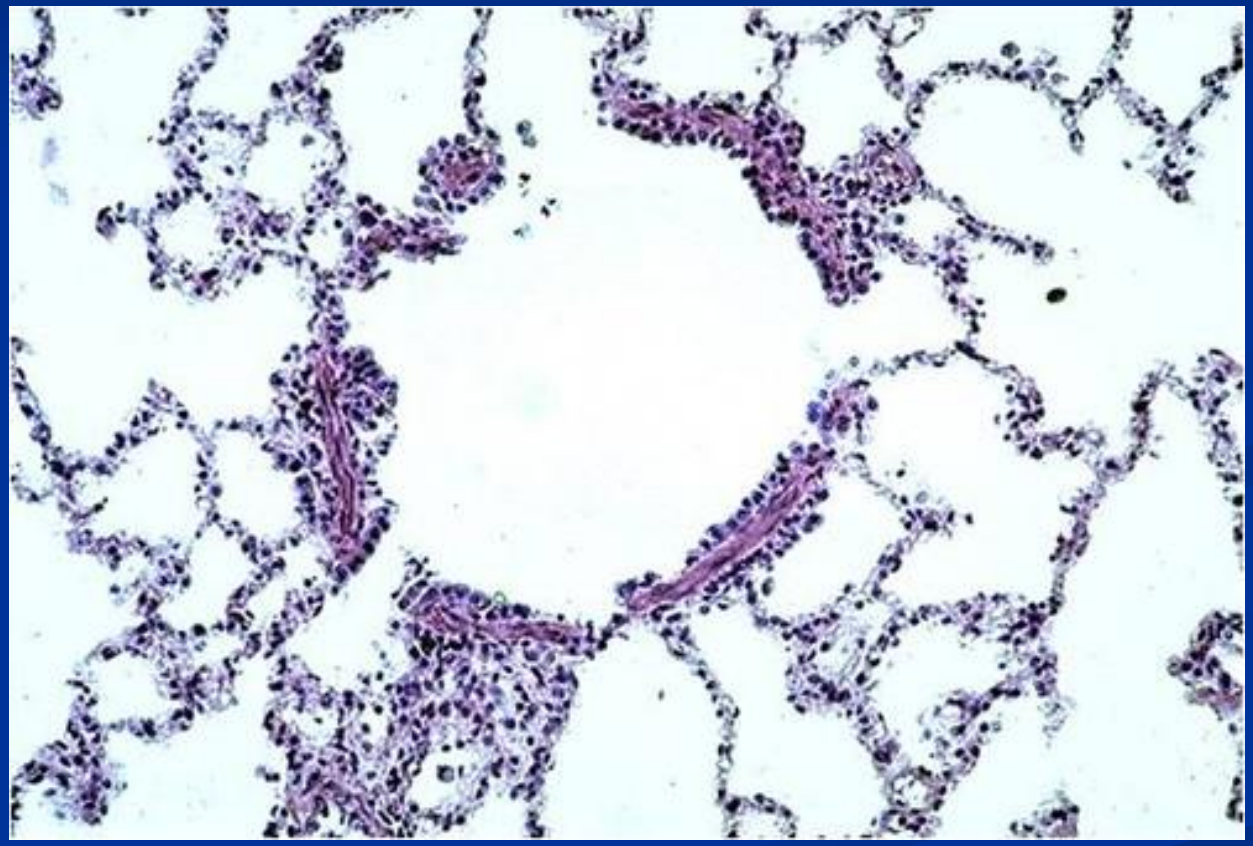


FIGURE 15.10 ■ Terminal bronchiole (transverse section). Stain: hematoxylin and


terminal bronchiole
alveolus
respiratory bronchiole
alveolar duct
alveoli

Respiratory Bronchiole



	Trachea	Bronchus	Tertiary bronchus	Bronchiole	Respiratory bronchiole
Epithelium	Pseudostratified	➔	Columnar	➔	Cuboidal
Goblet cells	+++	++	++	+	Absent
Clara cells	Absent	Absent	Absent	+	+
Muscularis mucosae	Absent	+	++	+++	+++
Mucous glands	+++	++	+	Absent	Absent
Cartilage	+++	++	+	Absent	Absent
Alveoli	Absent	Absent	Absent	Absent	+

Cells seen in the respiratory passages

- Goblet cells
- Non-ciliated serous cells
- Basal cells
- Cells of Clara
- Brush cells
- Argyrophil Cells similar to diffuse endocrine cells of gut
- Lymphocytes

Goblet cells: numerous and secrete mucous. Mucous traps the dust particles and is moved by ciliary action towards pharynx.

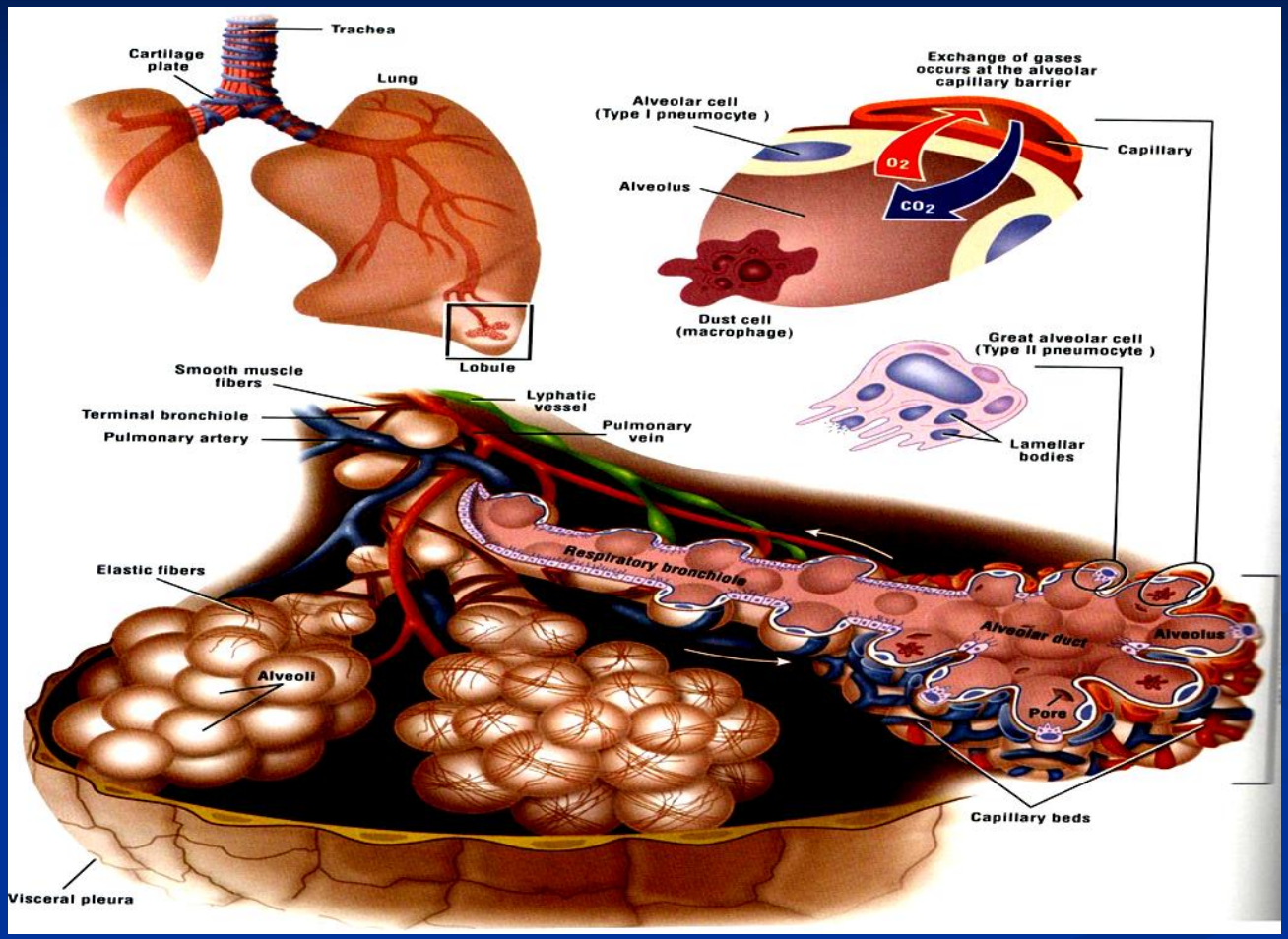
Non-ciliated serous cells: secretes watery fluid that keeps the epithelium moist

Cells of Clara: are non-ciliated cells predominantly seen in terminal bronchioles. Secrete a fluid that spreads over the alveolar surface forming a film that reduces surface tension. May function as stem cells

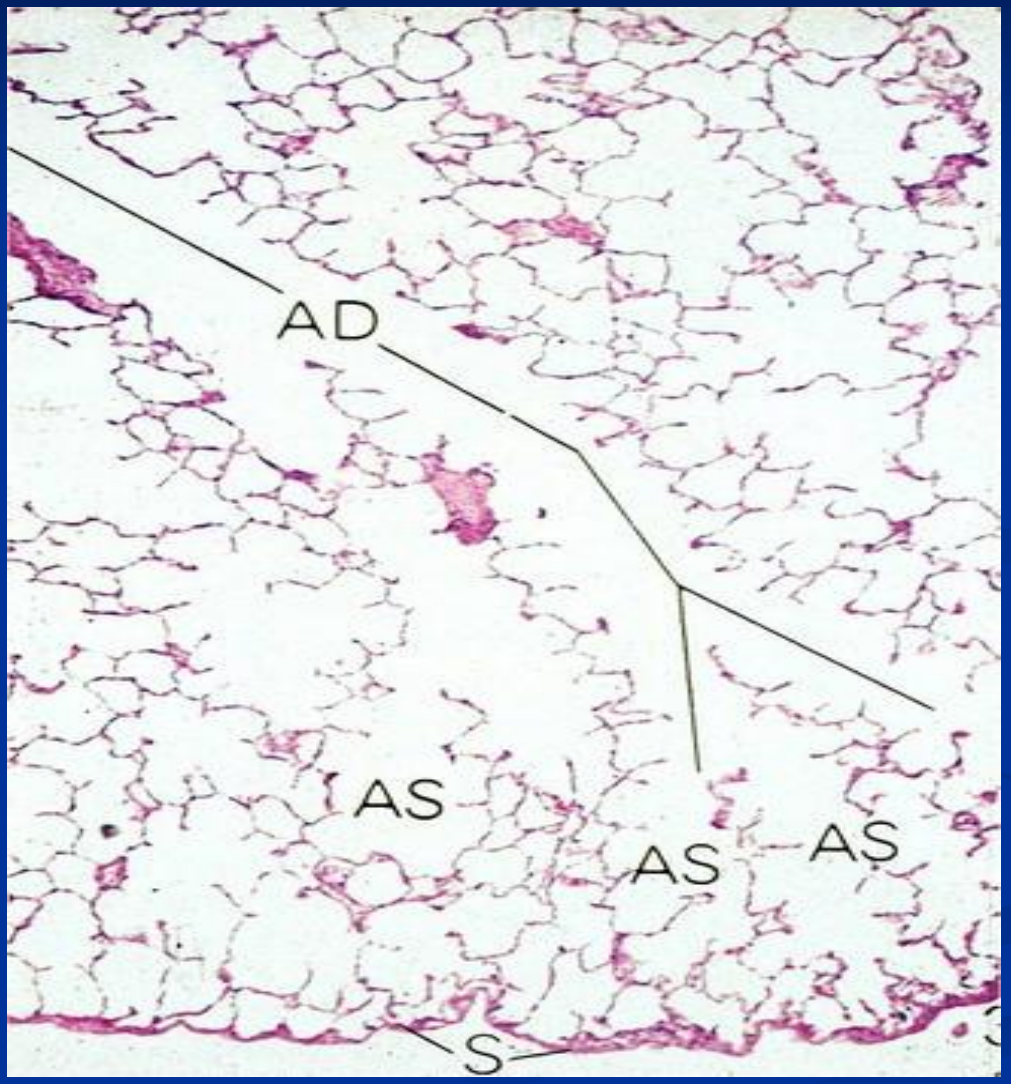
Basal cells: Multiply and transform into other cell types replace the lost cells.

Argyrophil cells: cells similar to diffuse endocrine cells of the gut containing granules, secrete hormones and active peptides including serotonin and bombesin.

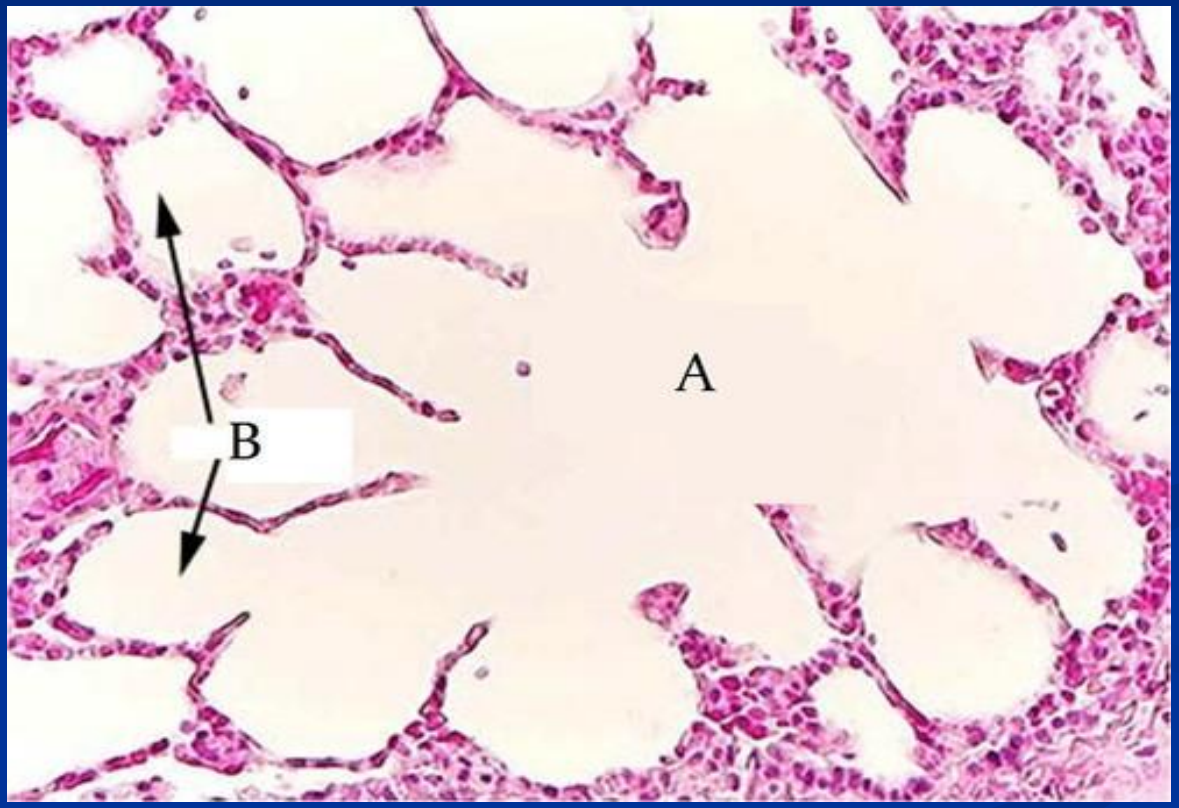
Lymphocytes and other leucoctes may be present in the epithelium.


Trachea
Cartilage plate
Lung
Lobule
Exchange of gases occurs at the alveolar capillary barrier
Alveolar cell (Type I pneumocyte)
Capillary
Alveolus
O_2
CO_2
Dust cell (macrophage)
Great alveolar cell (Type II pneumocyte)
Lamellar bodies
Smooth muscle fibers
Lyphatic vessel
Terminal bronchiole
Pulmonary vein
Pulmonary artery
Respiratory bronchiole
Elastic fibers
Alveolar duct
Alveolus
Alveoli
Pore
Capillary beds
Visceral pleura

Alveolar Ducts and Alveolar Sacs



Alveolar Sac



Alveoli

- 200 million in a normal lung
- Total area-75 square meters
- Total capillary surface area available for exchange-125square meters
- Are spongy and form the parenchyma of lung.
- Sac like evaginations present at the terminal end of the bronchial tree.

- In section, they resemble a honeycomb
- Alveoli are separated by interalveolar septum lying between thin epithelial lining of two neighbouring alveoli
- Interalveolar septum contains anetwork of capillaries supported by reticular and elastic fibres, occassionally fibroblasts, macrophages and mast cells.
- Septum containspores(ALVEOLAR PORES OF KOHN) help in passage of air from one alveolus to another, thus equalizing Pressure in the alveoli

- Elastic fibres-enable the alveoli to expand during inspiration and passively contract during expiration.
- Reticular fibres support and prevent overdistention of the alveoli

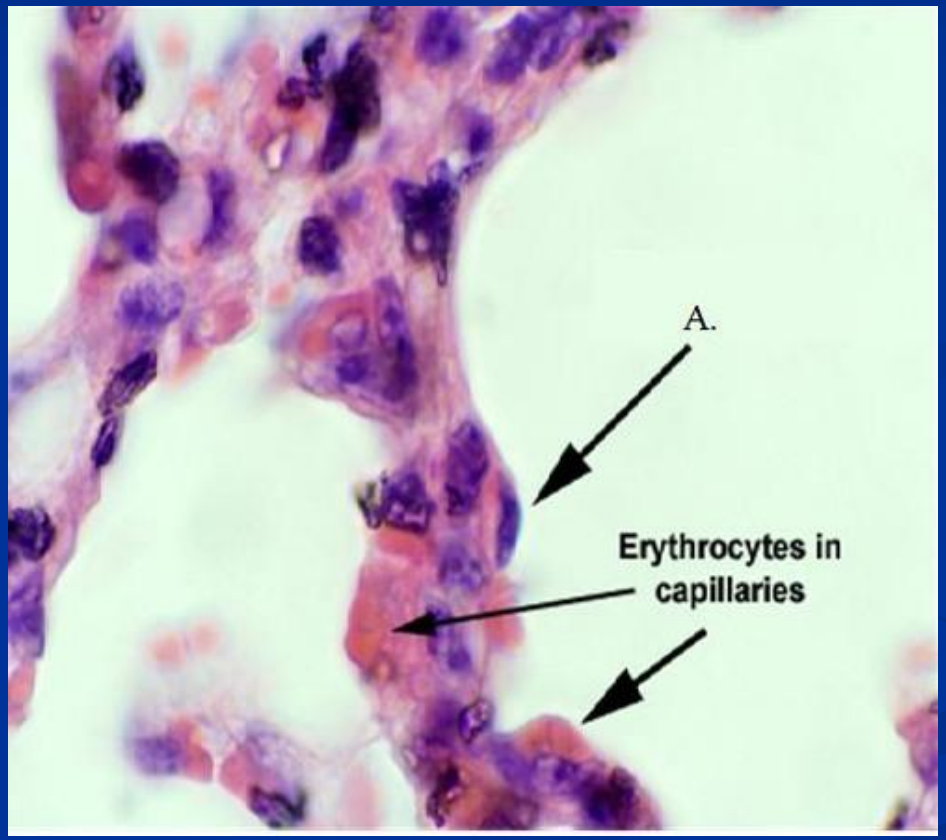
Cells in the Alveoli

- Type I Pneumocytes
- Type II Pneumocytes
- Macrophages or Dust cells

Pneumocytes

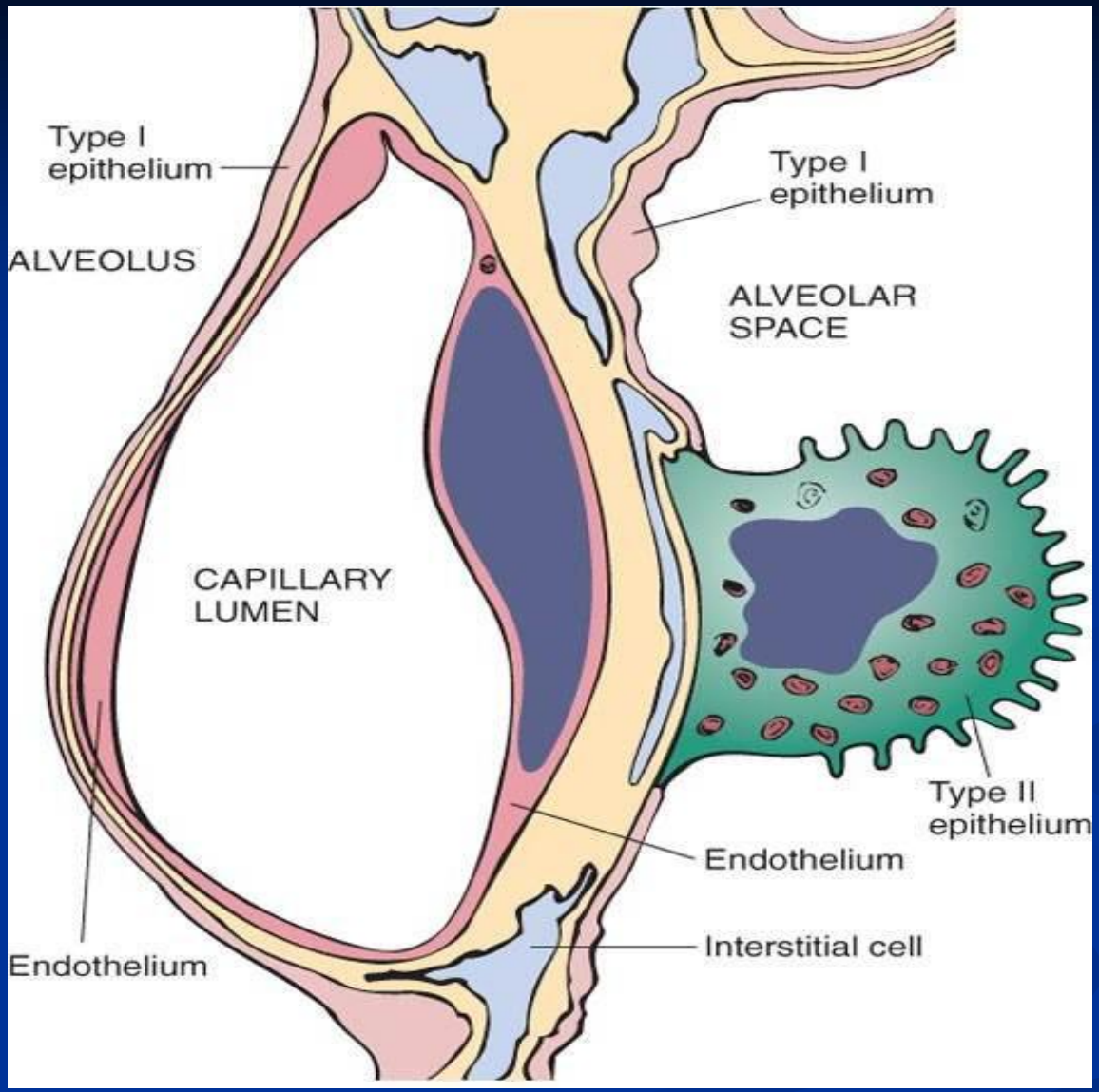
- Type I Alveolar or Type I Pneumocytes or Squamous Epithelial cells- Form the lining of 90% of the alveolar surface, numerous, squamous, thinness reduced to 0.05 to0.2 micron m, edges of the 2 cells overlap and are uniting by tight junctions- preventing leakage of blood from capillaries to the alveolar lumen
- Form Blood Air barrier

Type I Pneumocytes



Type II Alveolar or Type II pneumocytes

- Also known as Septal cells
- Rounded or cuboidal secretory cells with microvilli
- Secretory granules are made of several layers- Multilamellar bodies.
- These lamillar bodies are cytoplasmic inclusions made up of phospholipid which combines with other chemicals to form surfactant & then ooze out of the cell by exocytosis.
- Pulmonary Surfactant – is the fluid secreted that spreads over the alveolar surface
- These cells can multiply to replace damaged cells.
- Surfactant also has bactericidal properties


Type I epithelium
ALVEOLUS
Type I epithelium
ALVEOLAR SPACE
CAPILLARY LUMEN
Type II epithelium
Endothelium
Interstitial cell
Endothelium

Type I and II Pneumocytes, capillaries

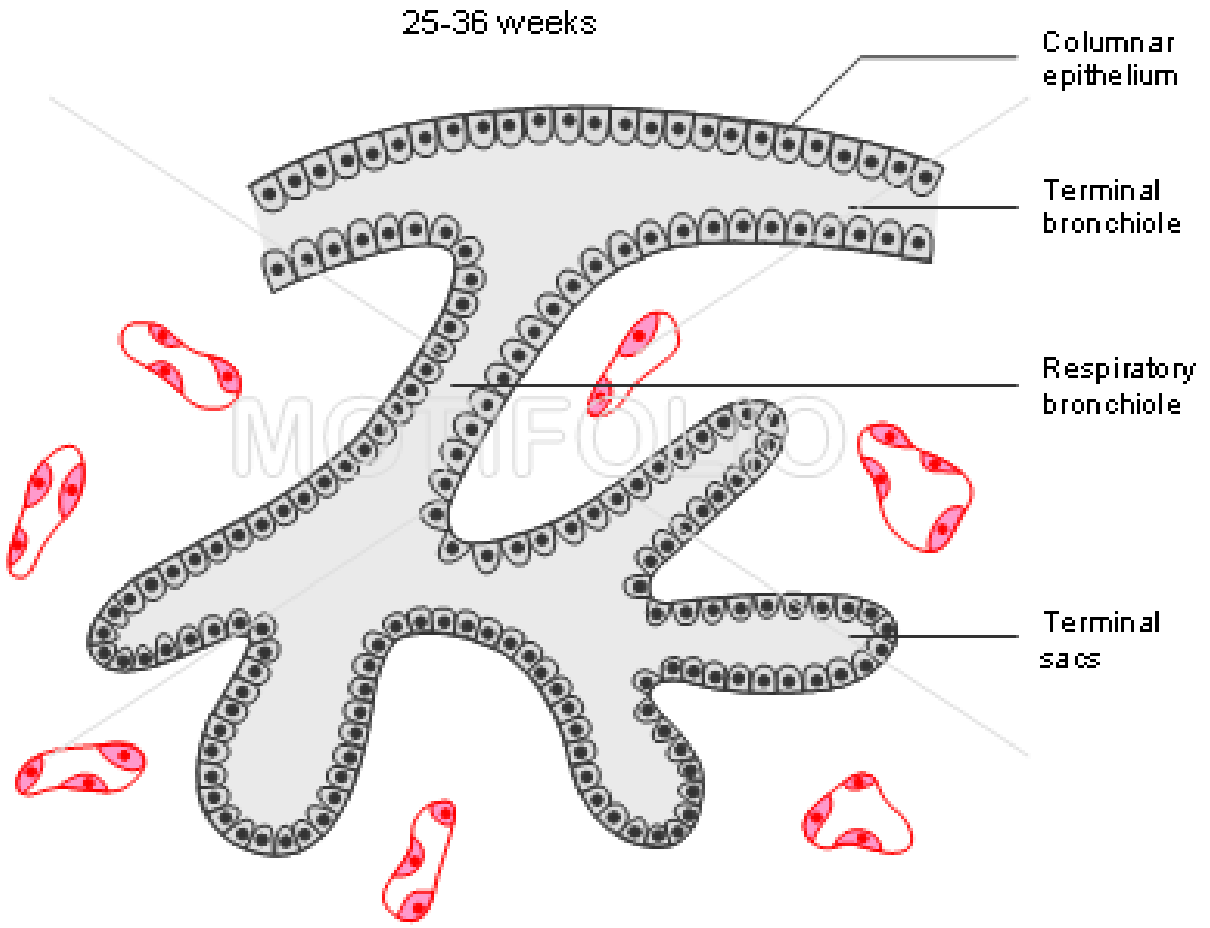
Pulmonary Surfactant

- Surfactant contains phospholipids, proteins and glycosaminoglycans, reduces the surface tension and prevents collapse of the alveolus during expiration.
- Is constantly renewed.
- Removed from the surface by Type I pneumocytes and macrophages
- The reduced surface tension in the alveoli decreases the force that is needed to inflate alveoli during inspiration.
- Therefore surfactant stabilizesthe alveolar diameters, facilitates their expansion and prevents their collapse by minimizing the collapsing forces

Blood Air Barrier

- Consist of a thin layer of surfactant
- Cytoplasm of Type I Pneumocytes
- Basement membrane of Pneumocytes
- Intervening Connective Tissue
- Basement membrane of capillary endothelial cell
- Cytoplasm of capillary Endothelial cells
- Endothelial cells of alveolar capillaries are extremely thin, have numerous projections increasing the surface area of the cell membrane exposed to blood for gaseous exchange. At places the 2 basement membranes are so fused reducing the thickness of Barrier.

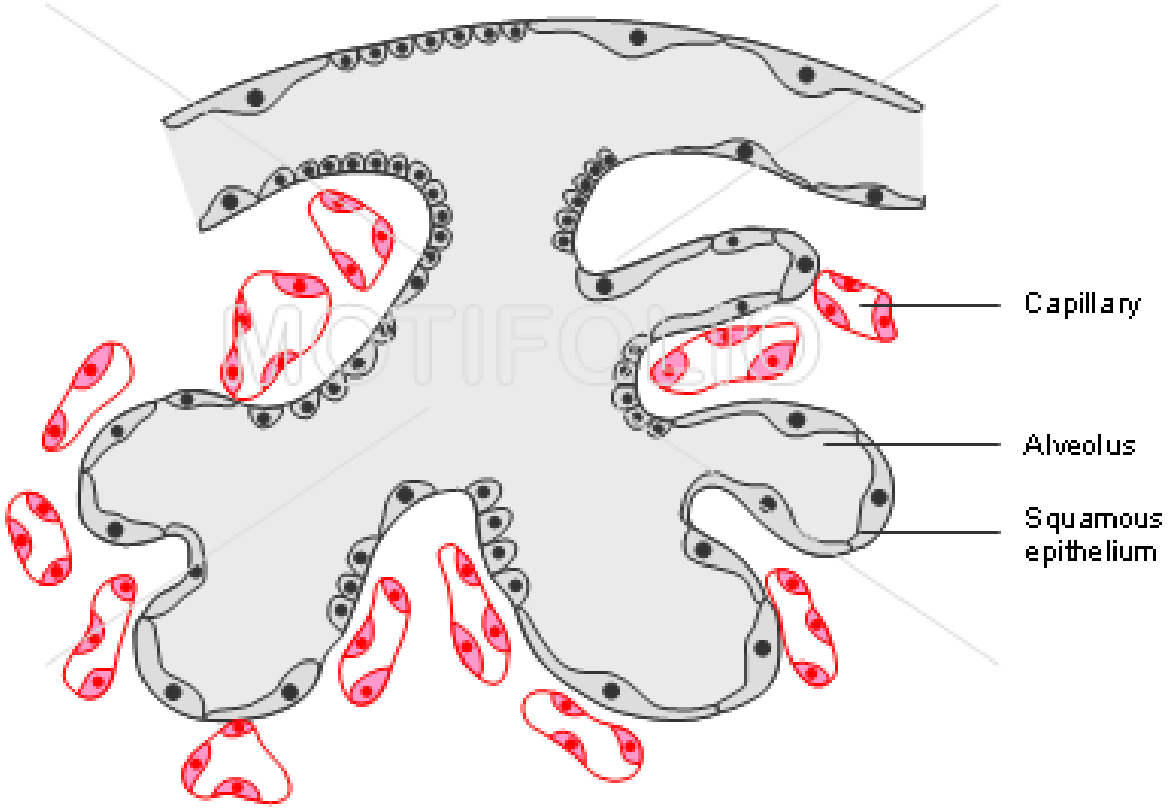
Histogenesis of the lungs and formation of the blood-air barrier



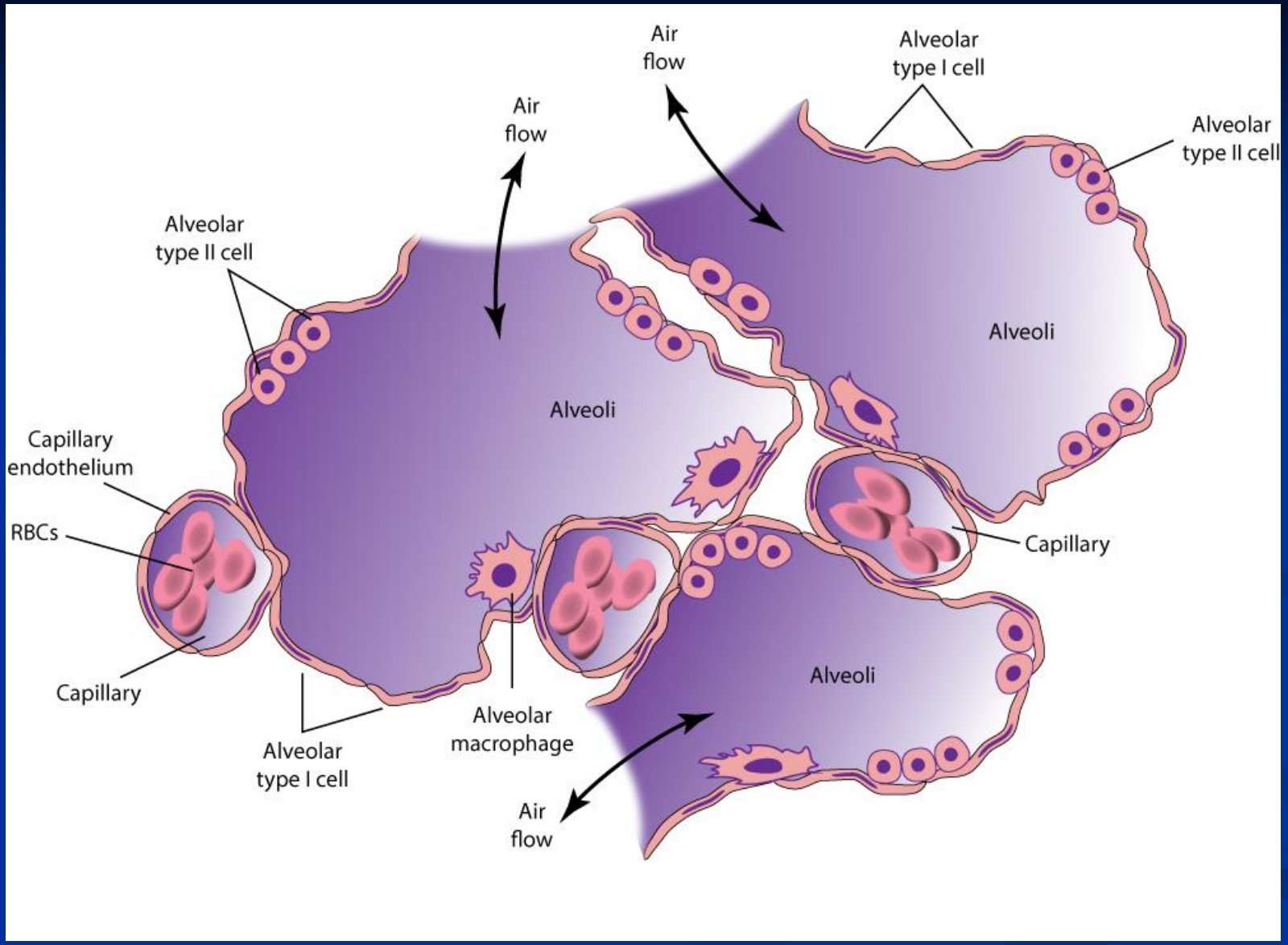
1011157

Histogenesis of the lungs and formation of the blood-air barrier

Birth-childhood

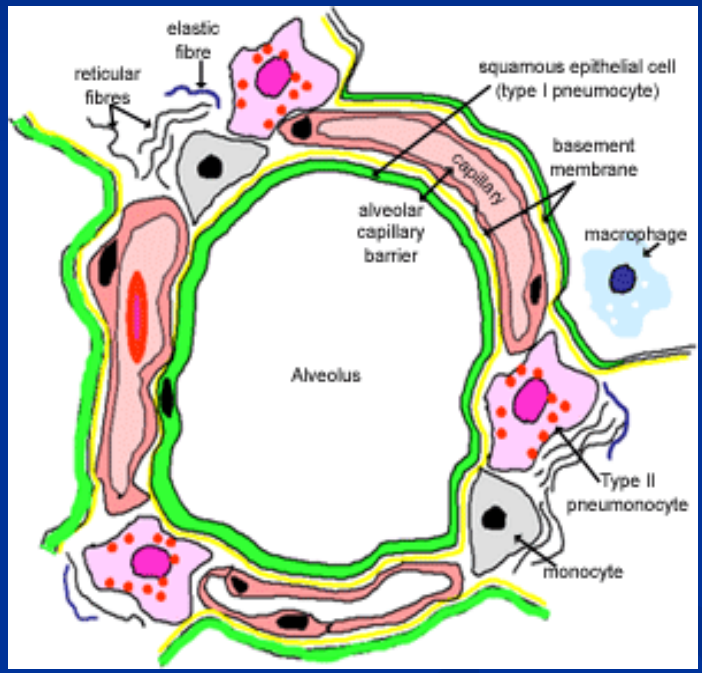


1011158


Air flow
Alveolar type I cell
Air flow
Alveolar type II cell
Alveolar type II cell
Alveoli
Alveoli
Capillary endothelium
RBCs
Capillary
Capillary
Alveolar macrophage
Alveolar type I cell
Alveoli
Air flow

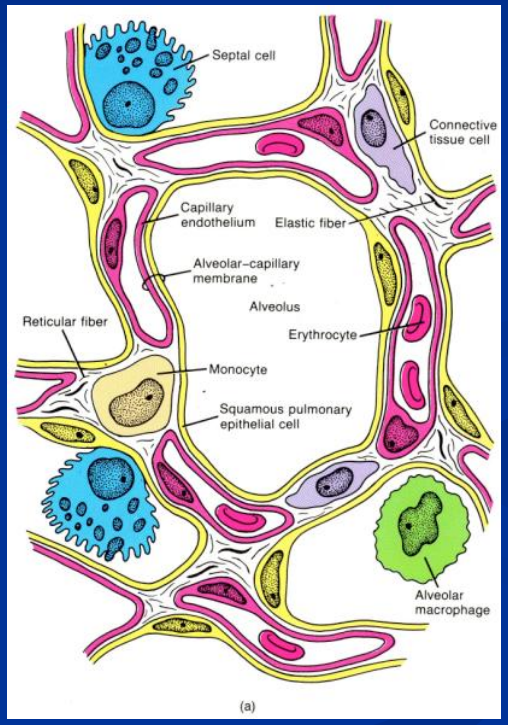
Alveolar Macrophages or Dust cells

- Derived from Monocytes and are part mononuclear phagocytic system.
- Either seen in the septa or alveoli
- Cytoplasm contains phagocytosed inhaled carbon and dust particles
- Inhaled carbon and dust particles are passed on to them from pneumocyte I through pinocytic vesicles



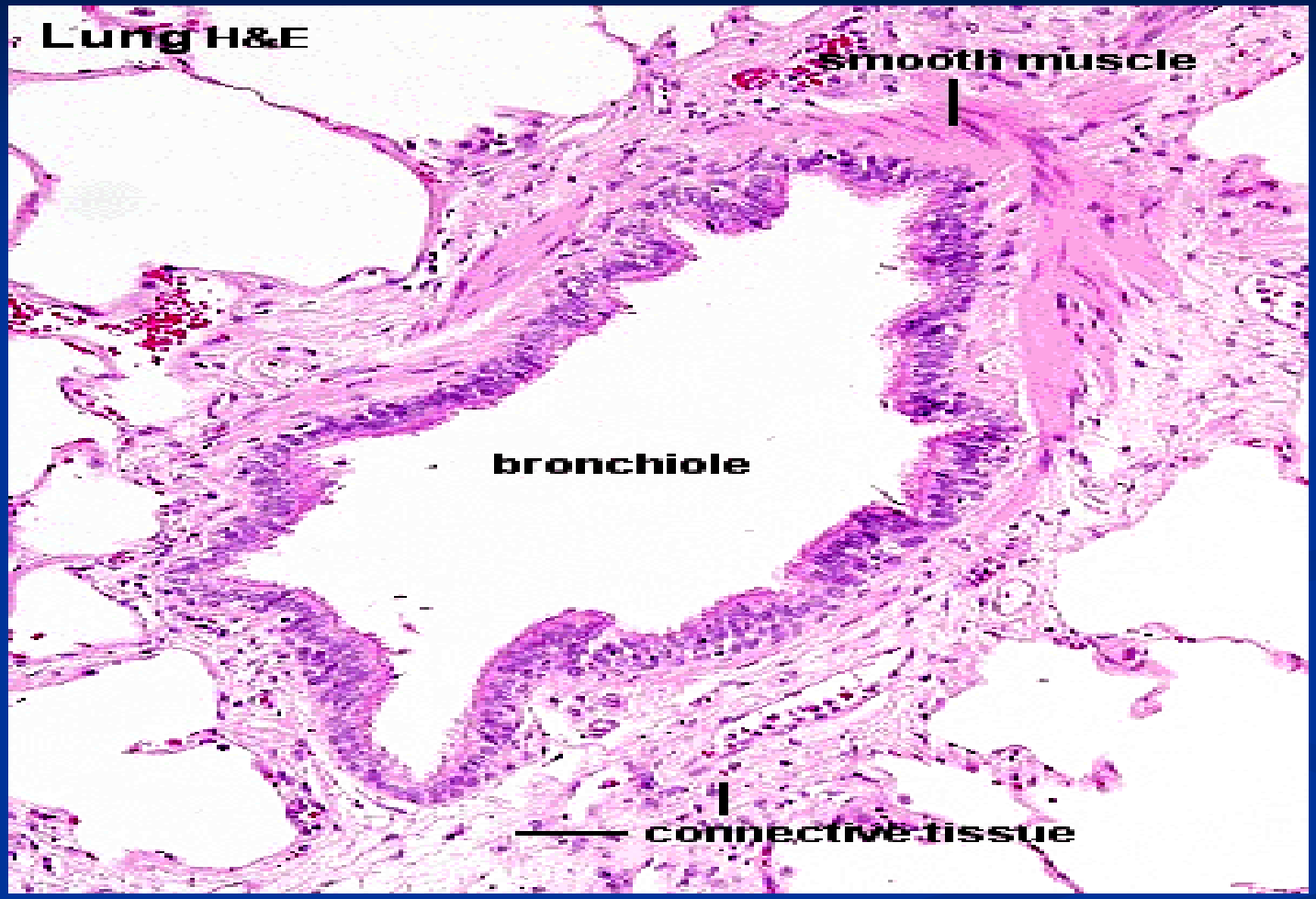
Alveolar Macrophages or Dust cells

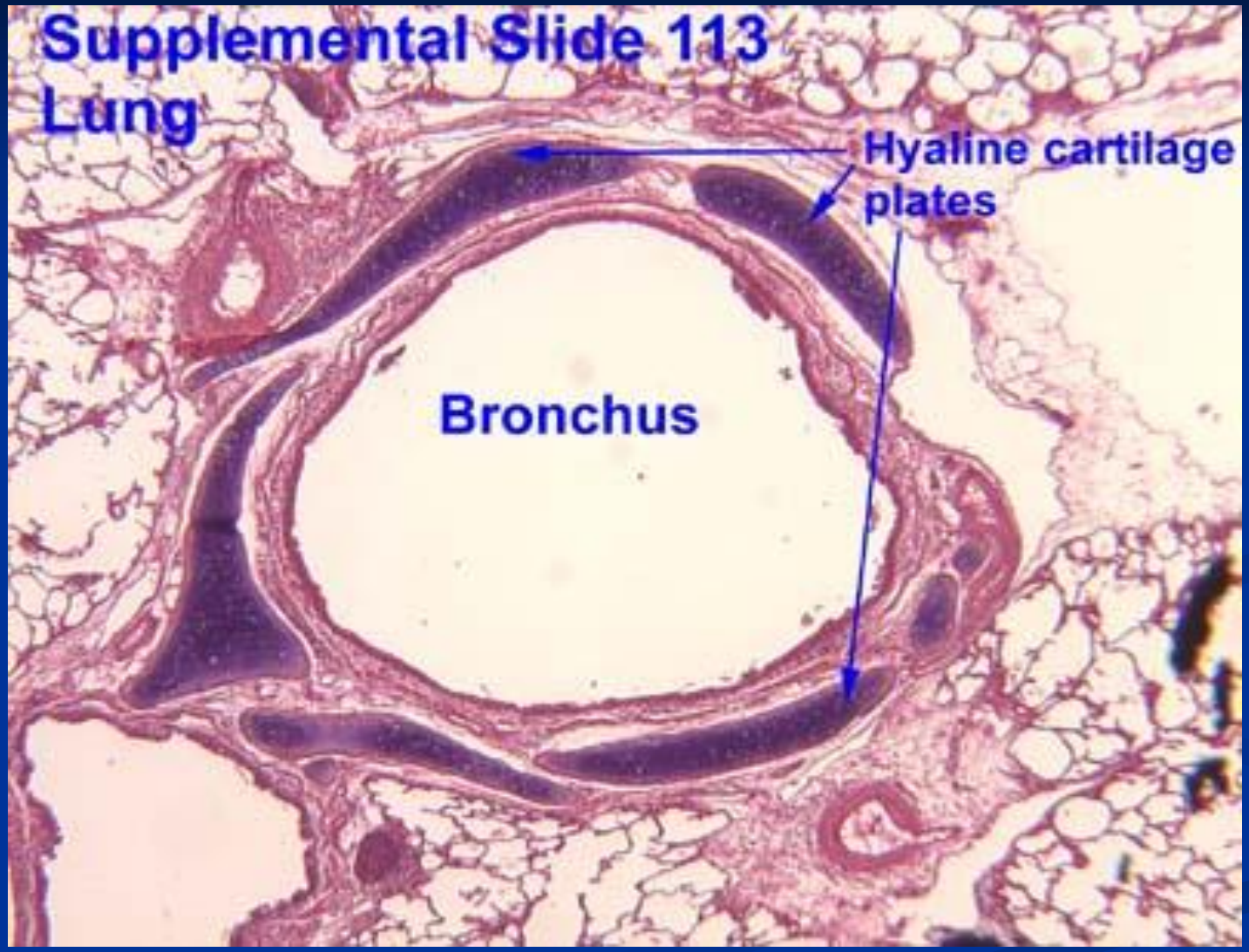
- Migrate from septum to alveolar surface and are carried to the pharynx through sputum
- Main function is to clean the alveoli of invading microorganisms and inhaled particulate matter by phagocytosis

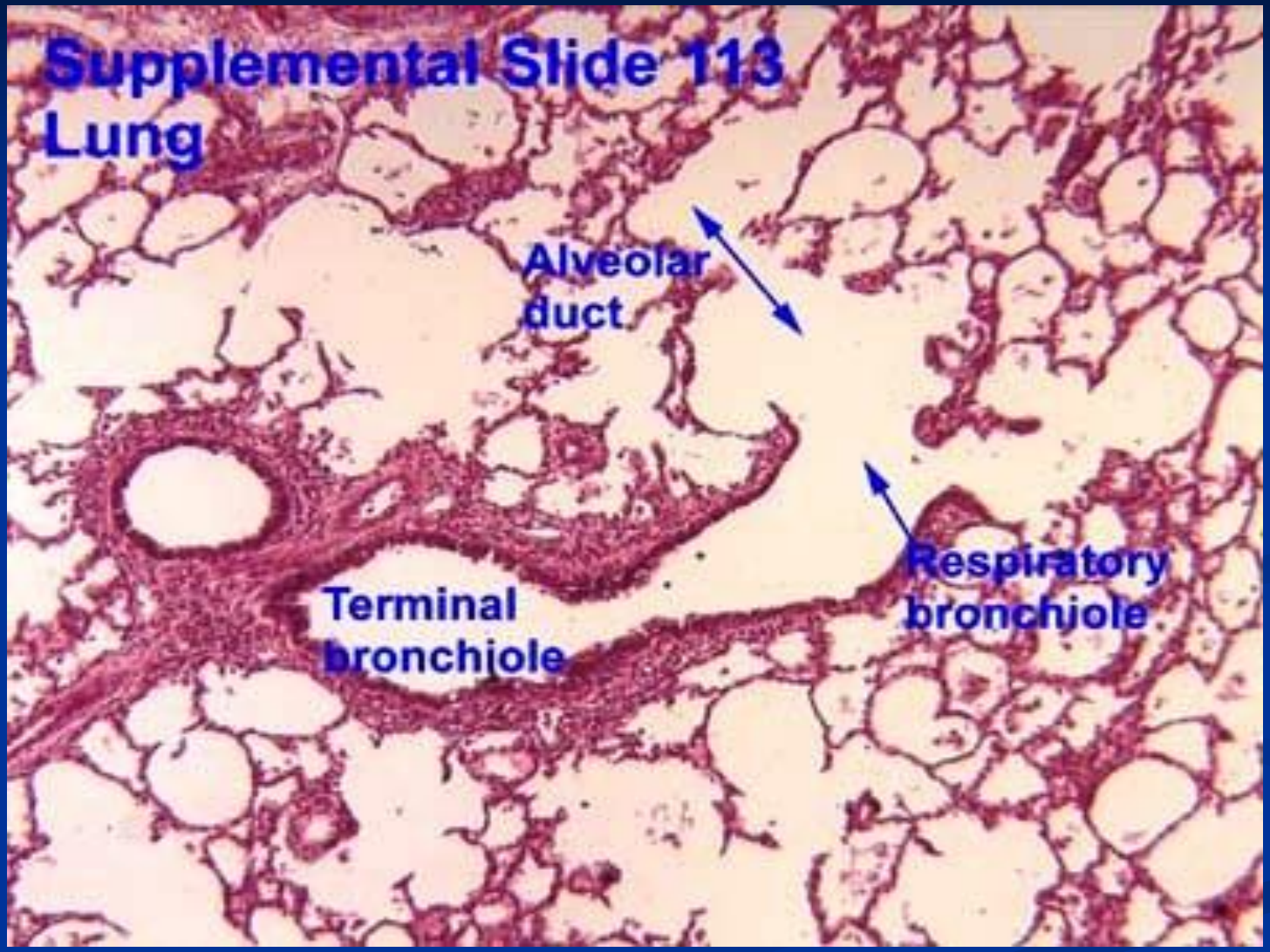


Heart failure cells

- In congestive heart failure where pulmonary capillaries are overloaded with blood, the alveolar macrophages phagocytose erythrocytes that escape from capillaries
- These cells become red brick in color because of pigment Haemosiderin and are known as heart failure cells.


Lung H&E
smooth muscle
bronchiole
connective tissue


Supplemental Slide 113
Lung
Hyaline cartilage plates
Bronchus


Supplemental Slide 113
Lung
Alveolar duct
Respiratory bronchiole
Terminal bronchiole

Lung

1-Bronchus and bronchioles are present

2-Alveolar duct and alveoli-

-Simple squamous epithelium

Type 1 Pneumocytes

-*Blood Air barrier*

Type2 Pneumocytes

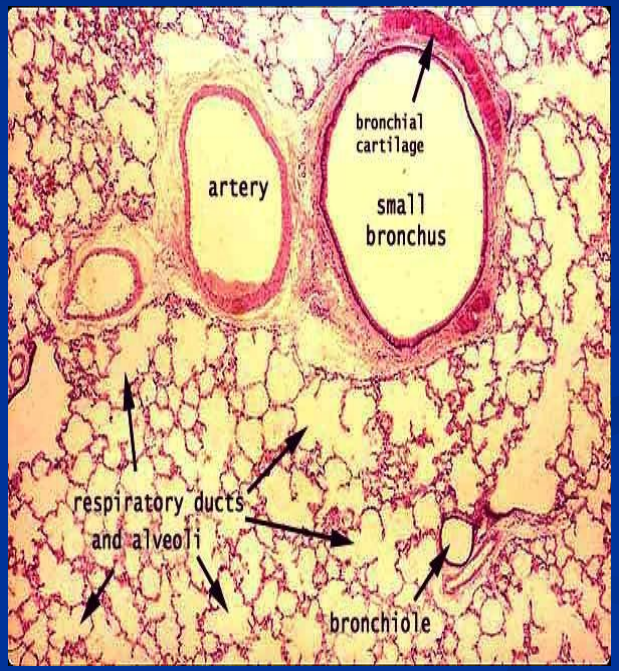
- *pulmonary surfactant*
- *lamellar bodies*

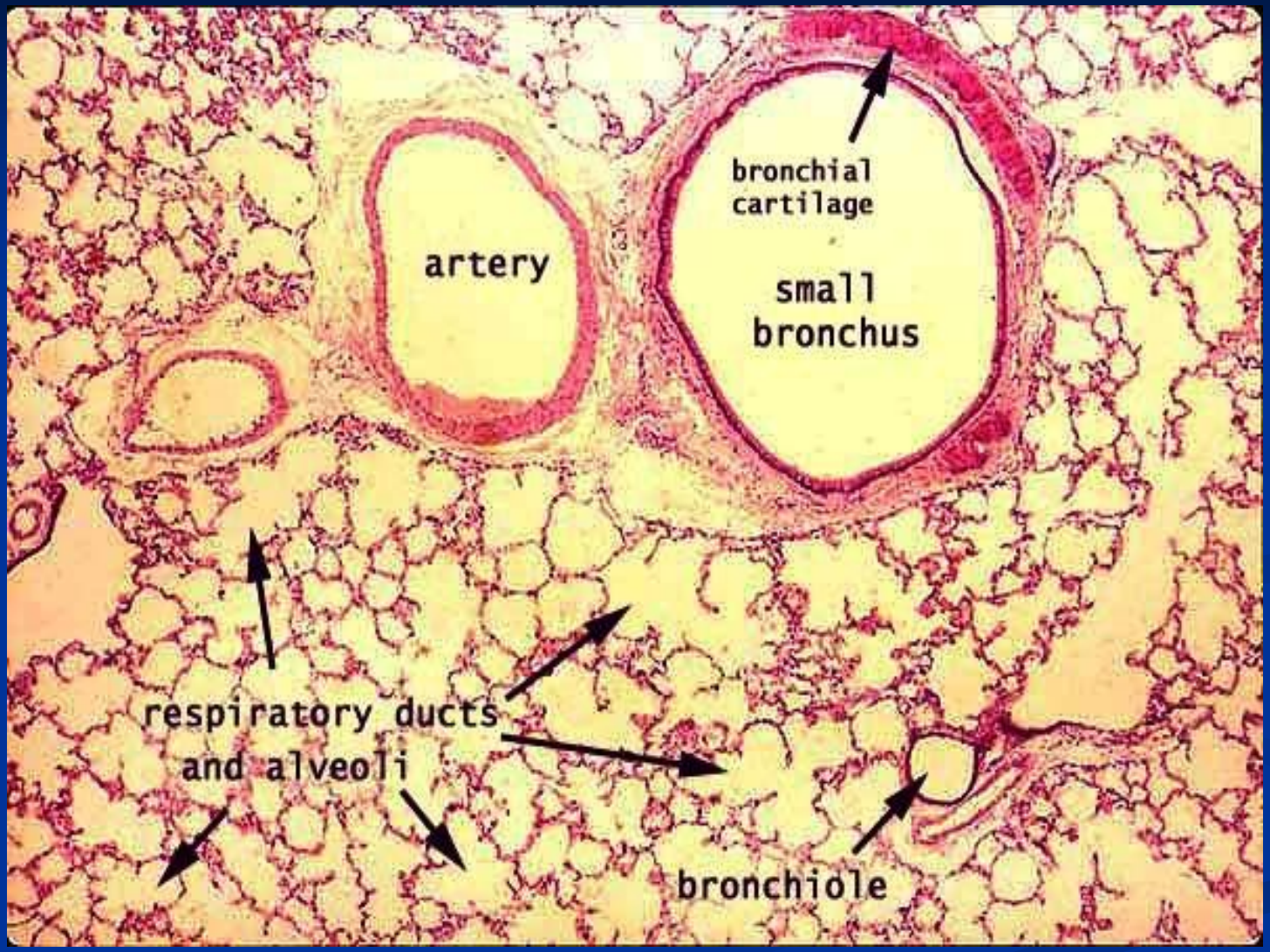
Type3Pneumocytes (brush cells)

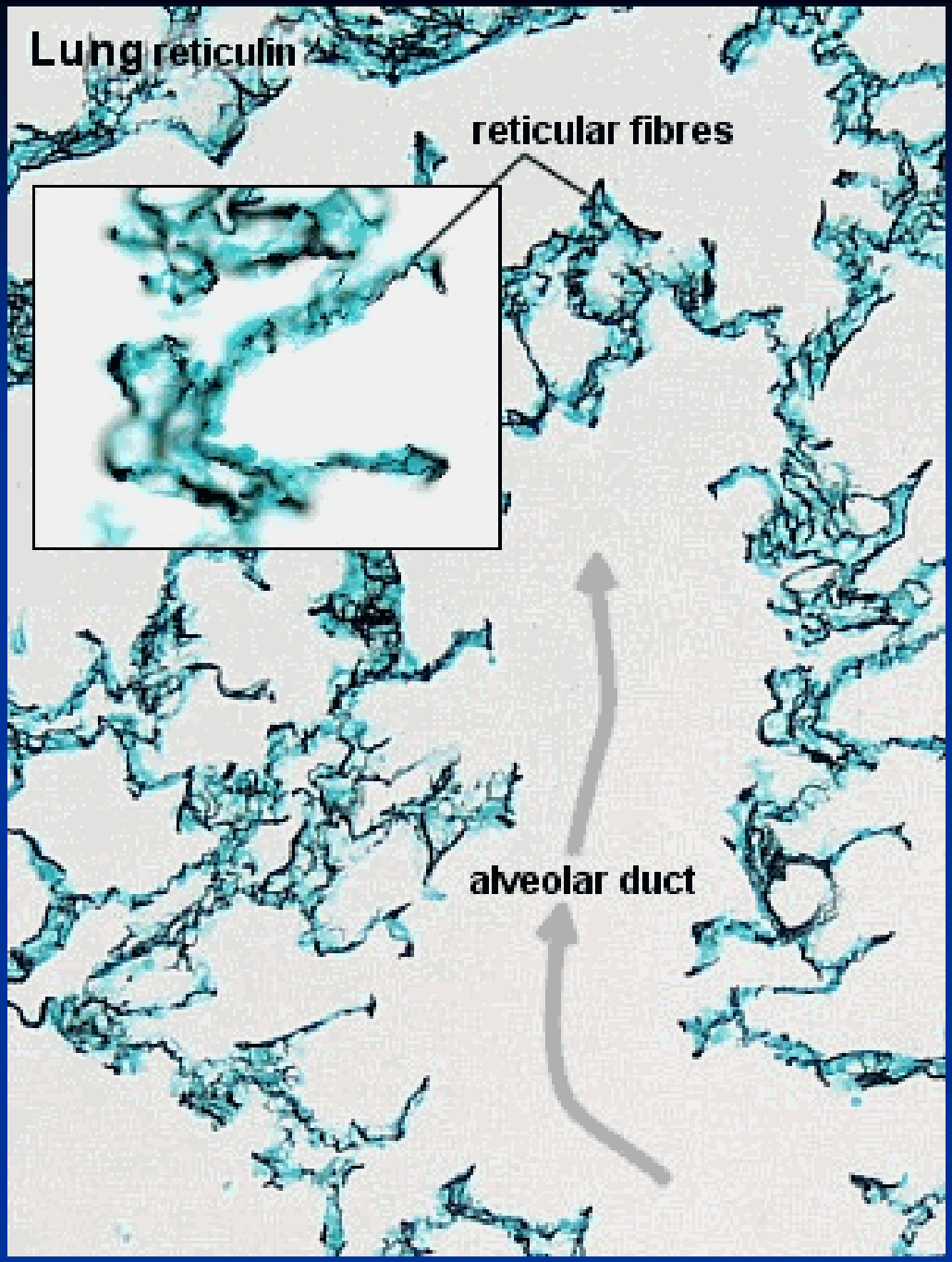
-Basement membrane

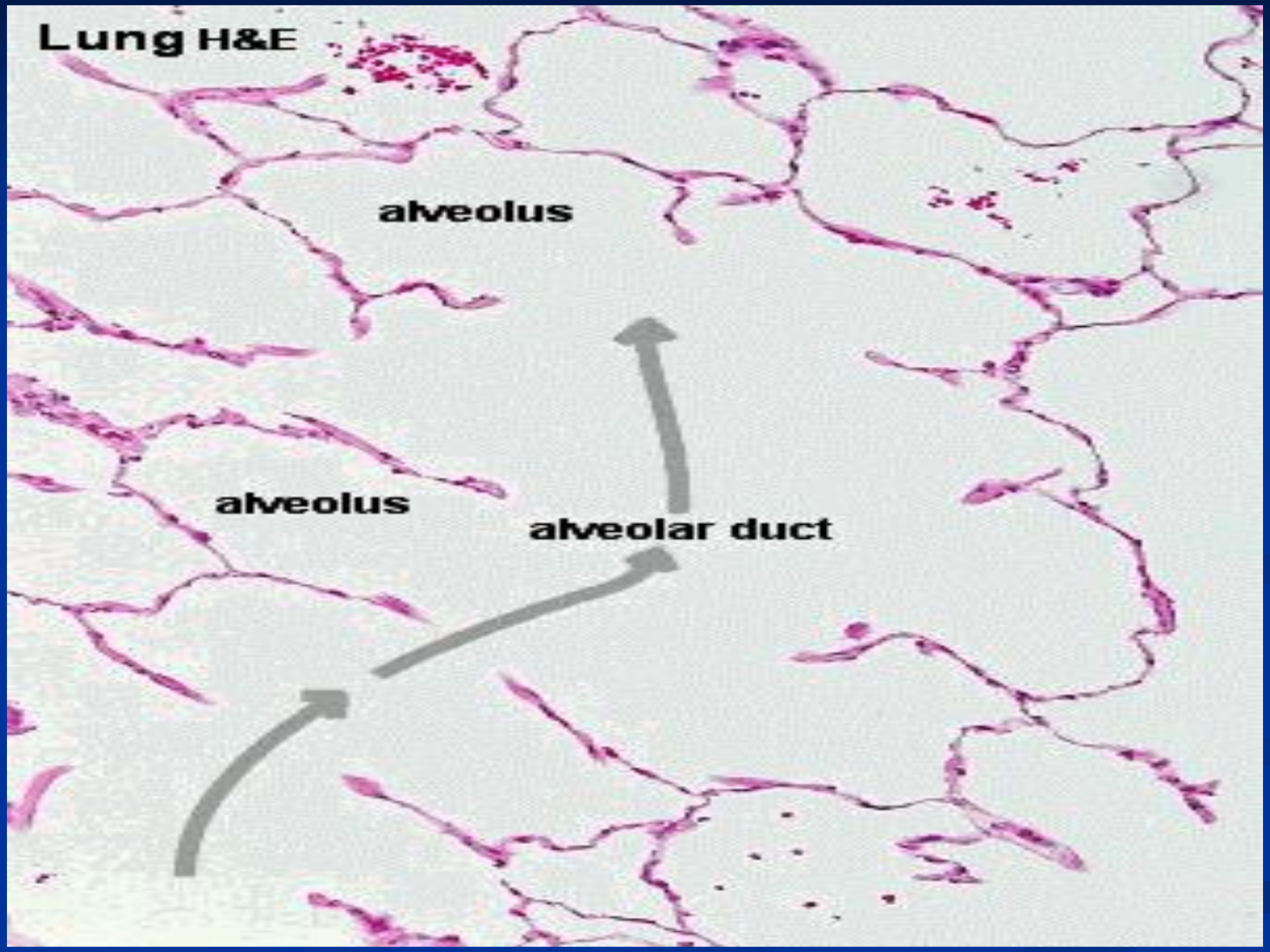
-Dust cells (Heart failure cells),

3-Inter alveolar septa & Supportive tissue




bronchial
cartilage
artery
small
bronchus
respiratory ducts
and alveoli
bronchiole


Lung reticulin
reticular fibres
alveolar duct


Lung H&E
alveolus
alveolus
alveolar duct

Clinical

- **Bronchiectasis:** Permanent dilatation of bronchi and bronchioles full of mucous. This is caused by tissue destruction secondary to infection.

- **Respiratory distress syndrome or Hyaline membrane disease:** in premature new born babies there is deficiency of surfactant as it is produced in the last week of gestation. They have difficulty in expanding the already collapsed lungs. A fibrin rich eosinophilic material called hyaline membrane lines the respiratory bronchioles and alveolar ducts of babies.Synthesis of surfactant is induced by administration of corticosteroids.


THANK
YOU