Doctor.021

no. 2

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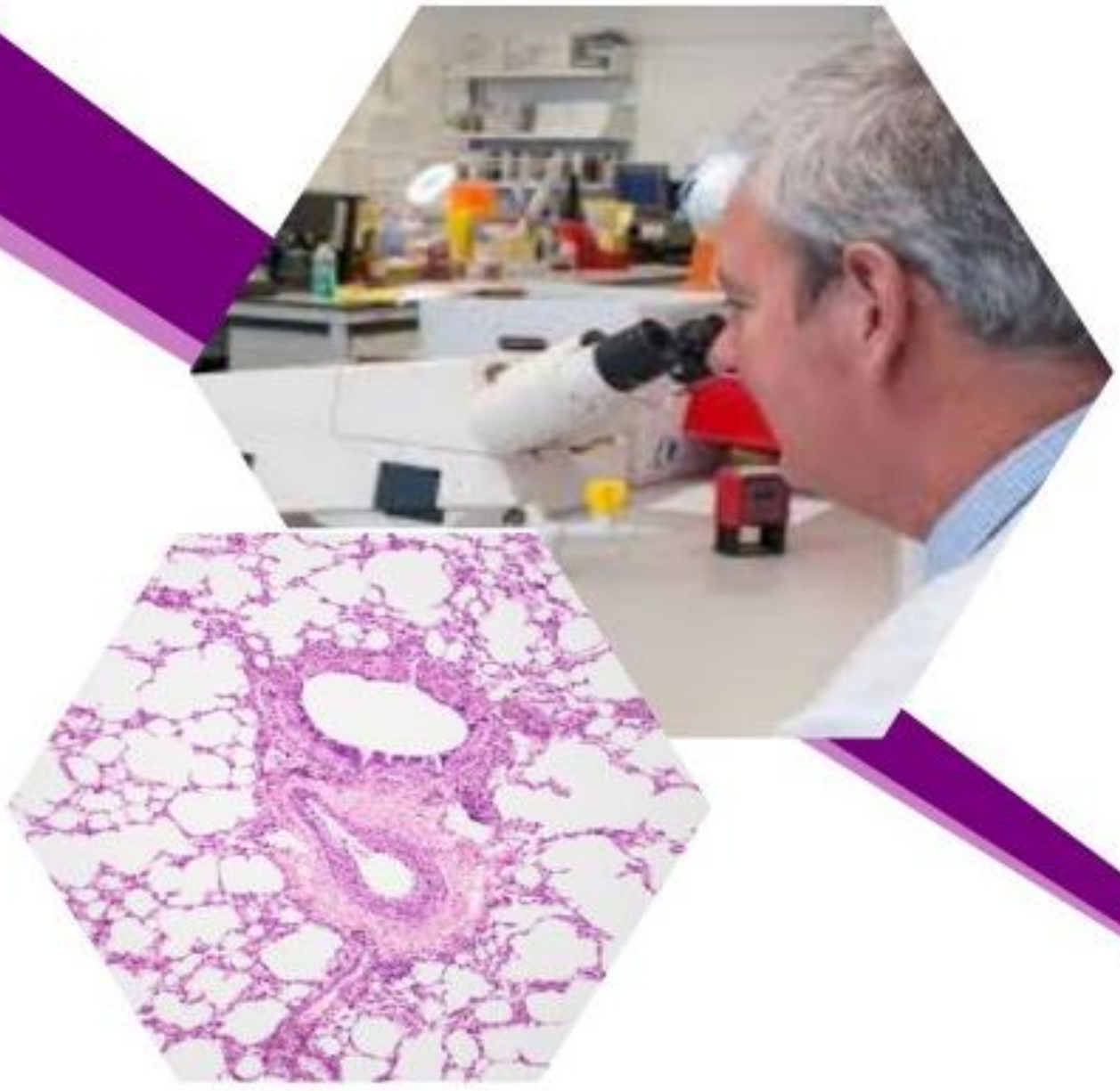
HISTOLOGY



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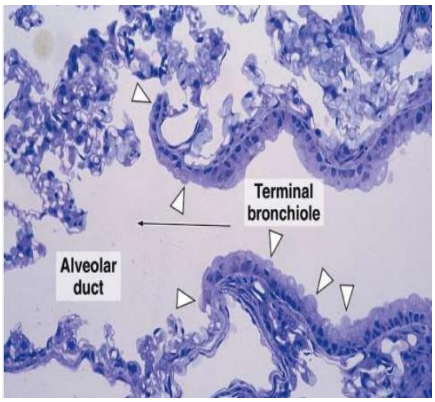
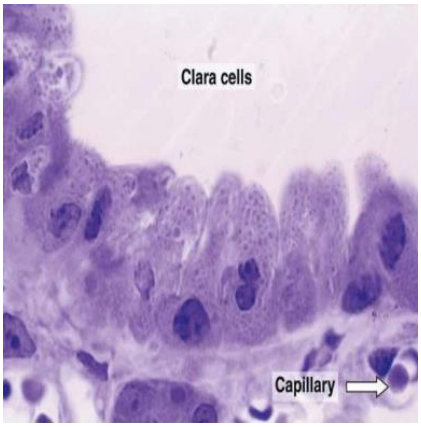
Bronchioles



- **intralobular airways with diameters of 5 mm or less**
- **Large (1 mm) small (0.5mm)** it starts at 5mm then branches even more to a narrower bronchiole, so it ranges for 1mm to .5 mm**.**
- **have neither cartilage nor glands in their mucosa.**
- **No lymphocyte,** actually it's no **lymphocytic nodule**, there are lymphocytes in all of the respiratory tract.
- **only scattered goblet cells within the epithelium of the initial segments.** The goblet cells are replaced by clara cells as we move distally.
- **In the larger bronchioles, the epithelium is ciliated pseudostratified columnar.** As we move distally it **decreases in height and complexity to become ciliated simple columnar or cuboidal epithelium in the smaller terminal bronchioles (gradual change).**

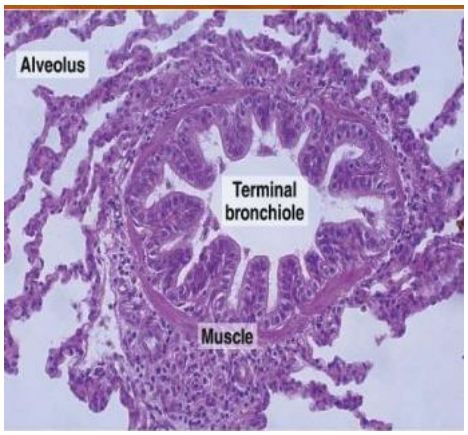


- **The epithelium of terminal bronchioles also contains Clara cells which are devoid of cilia, have secretory granules no lymphatic nodules in their apex known to secrete proteins that protect the bronchiolar lining against oxidative pollutants and inflammation.**
- **They produce one of the components of the surfactants and act as reserve cells.**
- **Bronchioles also exhibit specialized regions called neuroepithelial bodies.**
- **groups of cells (80-100) that contain secretory granules and receive cholinergic nerve endings** it contains chemoreceptors which detects changes in CO2 & O2.

- **Their function is poorly understood, but they are probably chemoreceptors 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**

The clara cells are seen in the terminal bronchioles and at the beginning of the respiratory bronchioles.

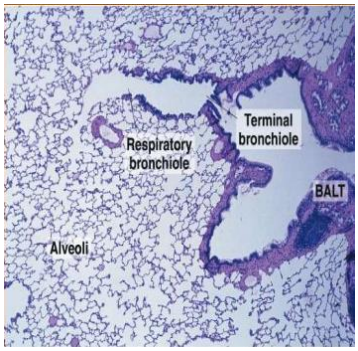
In the terminal bronchiole we can see folding of mucosa due to the presence of smooth muscle (it is responsible for asthma when the lumen becomes narrower in addition to it not having cartilage)



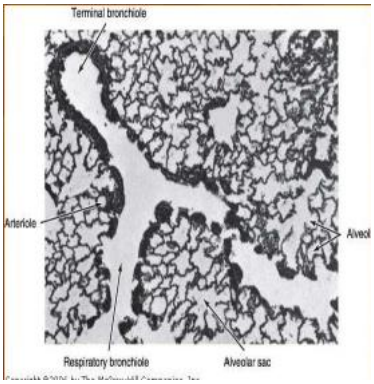
- **lamina propria is composed largely of smooth muscle and elastic fibers (**spiral and circular and folds)
  the lining epithelium of the terminal bronchi in the pic is simple columnar or cuboidal ciliated as seen in the pic.
- **musculature of both the bronchi and the bronchioles is under the control of the vagus nerve and the sympathetic nervous system.**
- **Stimulation of the vagus nerve decreases the diameter of these structures** (parasympathetic causes bronchoconstriction) **; sympathetic stimulation produces the opposite effect(bromchodialtion) so when patient with asthma come to hospital we give him adrenaline).**

Respiratory Bronchioles

The terminal bronchiole(conductive part) is a closed bronchiole (rounded closed lumen) In contrast to the respiratory which is open (not circular and open at an alveolar duct).



- **Each terminal bronchiole subdivides into two or more respiratory bronchioles.**
- **serve as regions of transition between the conducting and respiratory portions of the respiratory system.**
- **mucosa is structurally identical to that of the terminal bronchioles.**
- **their walls are interrupted by numerous saclike alveoli where gas exchange occurs. and foldings decrease**

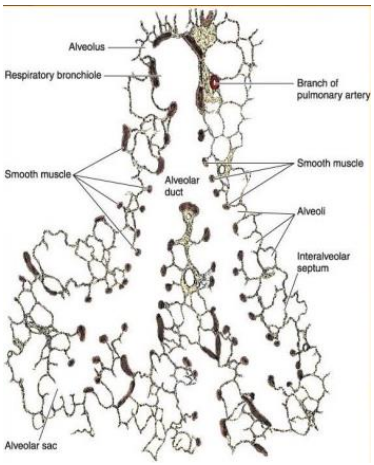


- **lined with ciliated cuboidal epithelial cells and Clara cells** (non-ciliated cuboidal), **but at the alveolar openings the bronchiolar epithelium becomes continuous with the** simple **squamous alveolar lining cells.**
- **Between alveoli, the bronchiolar epithelium consists of ciliated cuboidal epithelium.**
- **Smooth muscle and elastic connective tissue lie beneath the epithelium.** The smooth muscle changes its shape from large folding to become knobs of smooth muscle on the opening of alveoli. (where gas exchange can occur)

Alveolar Ducts

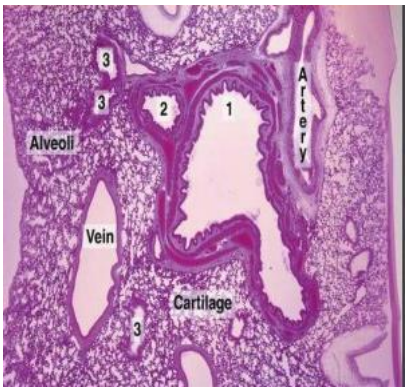
- **Both the alveolar ducts and the alveoli are lined with extremely attenuated squamous alveolar cells.** When there are 2 alveolar ducts its called atria.
- **In the lamina propria surrounding the rim of the alveoli is a network of smooth muscle cells.**

- **These sphincter like smooth muscle bundles appear as <u>knobs</u> between adjacent alveoli.**
- **Smooth muscle disappears at the distal ends of alveolar ducts.**
- **A rich matrix of elastic and reticular fibers provides the only support of the duct and its alveoli.**
- **Alveolar ducts open into atria that communicate with alveolar sacs.**
- **The elastic fibers enable the alveoli to expand with inspiration and to contract passively with expiration.** (inflation and deflation)
- **The reticular fibers serve as a <u>support</u> that prevents overdistention (**rupture**) and damage to the delicate capillaries and thin alveolar septa.**



Alveoli

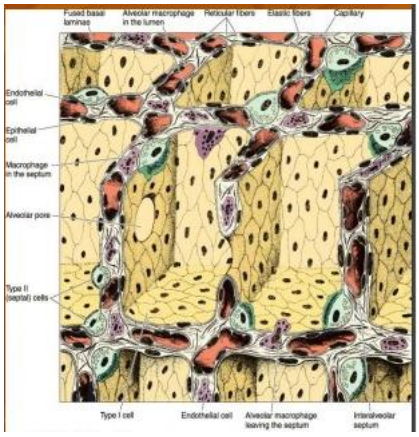
- **Alveoli are saclike evaginations (about 200 um in diameter)**
- **responsible for the spongy structure of the lungs** (all of the lung is spongy because it's filled with air & there is elastic fibers between them)
- **The structure of the alveolar walls is specialized for enhancing diffusion between the external and internal environments.**
- **each wall lies between two neighboring alveoli and is therefore called an interalveolar septum, or wall.**



Septum is what's between two alveoli & wall is the whole wall of alveolus.

Interalveolar septum

- **An interalveolar septum consists of two thin squamous epithelial layers between which lie capillaries, elastic and reticular fibers, and connective tissue matrix and cells.**
  most of the wall is made of type 1 cells (simple squamous) and type 2 cells make only 3% of cells in the wall.
  But in the septum alone there is more type 2 cells, almost 16% is type 2(septal cells) surfactant releasing septal cells that reside in the corners.



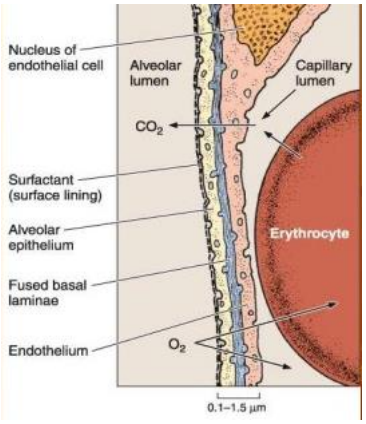
- **The capillaries and connective tissue (**which means it contains macrophages, fibroblastic cells ,mast cells…) **constitute the interstitium.**
- **Within the interstitium of the interalveolar septum is found the richest capillary network in the body.**
- **The interalveolar septum contains pores.** Which distribute the air in the alveoli and maintain the balance. **10-15 um in diameter, that connect neighbouring alveoli.These pores equalize air pressure in the alveoli and promote the collateral circulation of air when a bronchiole is obstructed.**

Blood-air barrier

It is between the capillary (endothelial cells) & type 1 alveolar cells.

- **Air in the alveoli is separated from capillary blood by three components referred to collectively as the blood-air barrier.**

(The components of respiratory membrane or the BAB)



1. the surface lining and cytoplasm of the alveolar cells

2. the fused basal laminae of the closely apposed alveolar (type 1) **and endothelial cells**

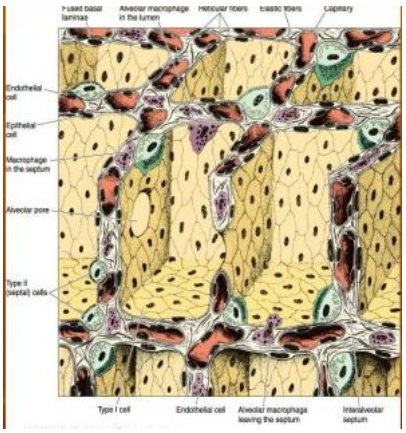
3. cytoplasm of the endothelial cells

- **The total thickness of these layers varies from 0.1 to 1.5 um.**

The alveolar wall is lined by surfactant layer which helps in inflation. This is where gas exchange occurs.

Interalveolar septum

- **Within the interalveolar septum, anastomosing pulmonary capillaries are supported by a meshwork of reticular and elastic fibers.**



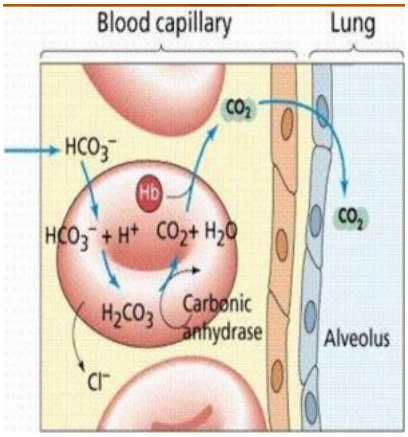
- **These fibers are arranged to permit expansion and contraction of the interalveolar septum.**
- **are the primary means of structural support of the alveoli.**
- **The basement membrane, leukocytes, macrophages, and fibroblasts can also be found within the interstitium of the septum.**
- **The fusion of two basal laminae produced by the endothelial cells and the epithelial (alveolar) cells of the interalveolar septum forms the <u>basement membrane.</u>**

Cells in the interstitium :-

- **Endothelial cells (capillaries) 30 %**
- **Fibroblasts and mast cells 36%**
- **Macrophages 10 %**
- **Type I cells 8 %**
- **Type II cells 16%** also called septal cells.
- **leukocytes**

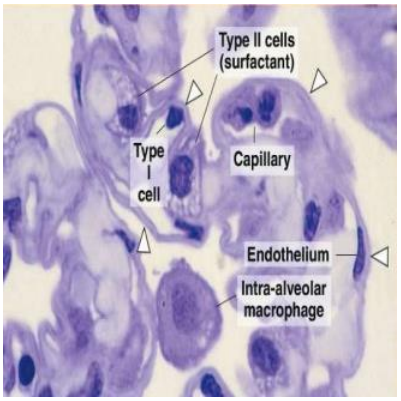
Gas exchange

- **O2 from the alveolar air passes into the capillary blood through the blood-air barrier and CO2 diffuses in the opposite direction.**
- **Liberation of CO2 from H2CO3 is catalyzed by the enzyme carbonic anhydrase present in erythrocytes.**
- **The approximately 300 million alveoli in the lungs considerably increase their internal exchange surface, which has been calculated to be approximately 140 m2.**



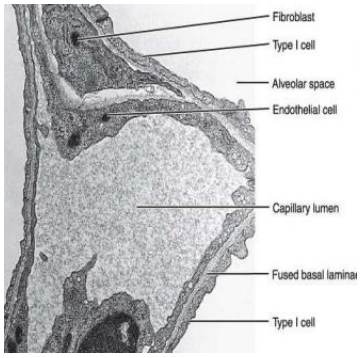
Capillary endothelial cells

- **extremely thin and can be easily confused with type I alveolar epithelial cells**. (because they are both simple squamous, we can distinguish between them by seeing RBCs in endothelial cells)
- **endothelial lining of the capillaries is continuous and not fenestrated.**
- **Clustering of the nuclei and other organelles allows the remaining areas of the cell to become extremely thin increasing the efficiency of gas exchange.**
- **The most prominent feature of the cytoplasm in the flattened portions of the cell is numerous pinocytotic vesicles.**



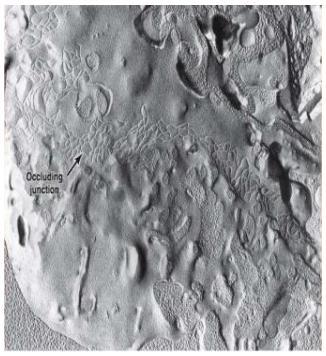
Type I cells

- **squamous alveolar cells**
- **extremely attenuated cells that line the alveolar surfaces**
- **Type I cells make up 97% of the alveolar surfaces (type II cells make up the remaining**



3%). Hence the difference in numbers compared to the septum.

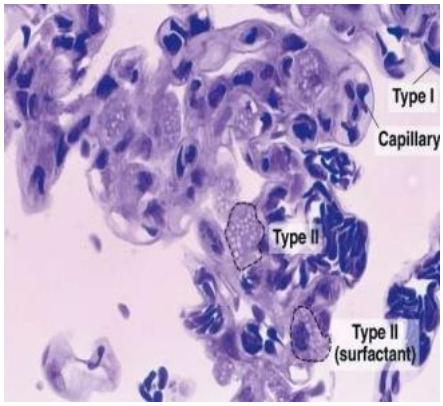
- **are so thin (sometimes only 25 nm)** that the electron microscope was needed to prove that all alveoli are covered with an epithelial lining.
- **Organelles such as the Golgi complex, endoplasmic reticulum, and mitochondria are grouped around the nucleus, reducing the thickness of the blood-air barrier, and leaving large areas of cytoplasm virtually free of organelles.**
- **The cytoplasm in the thin portion contains abundant pinocytotic vesicles,** which may play a role in the turnover of surfactant and the removal of small particulate contaminants from the outer surface.
- **In addition to desmosomes, all type I epithelial cells have occluding junctions** between type 1 & 2 that prevent the leakage of tissue fluid into the alveolar air space.
- The main role of these cells is to provide a barrier of minimal thickness that is readily permeable to gases.



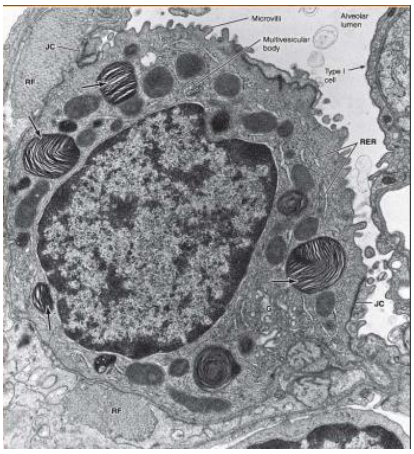
Type II cells

Again! It Secretes surfactant that helps in inflation especially in a newborn during pregnancy.

- interspersed among the type I alveolar cells with which they have occluding and desmosomal junctions.
- rounded cells that are usually found in groups of two or three along the alveolar surface at points at which the alveolar walls unite and form angles.
- rest on the basement membrane, are part of the epithelium, with the same origin as the type I cells.
- **divide by mitosis to replace their own population and the type I population.**



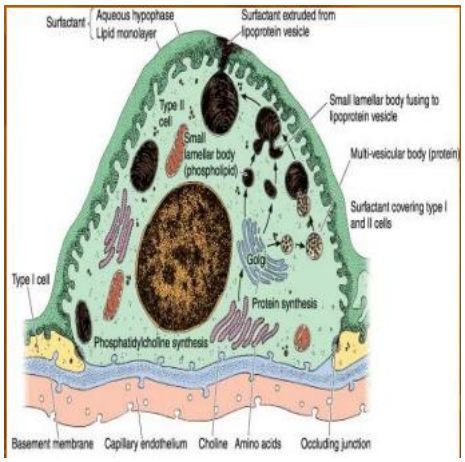
Type II cells (great alveolar cells) (septal cells)



- they exhibit a characteristic vesicular or foamy cytoplasm. These vesicles are caused by the presence of lamellar bodies.
- Lamellar bodies, which average 12um in diameter, contain concentric or parallel lamellae limited by a unit membrane.
- these bodies, which contain phospholipids, glycosaminoglycans, and proteins, are continuously synthesized and released at the apical surface of the cells.
- The lamellar bodies give rise to the pulmonary surfactant, a material that spreads over the alveolar surfaces, providing an extracellular alveolar coating, that lowers alveolar surface tension.

Pulmonary surfactant

- The surfactant layer consists of proteinaceous hypophase covered with a phospholipid film that is primarily composed of dipalmitoyl phosphatidylcholine and phosphatidylglycerol.



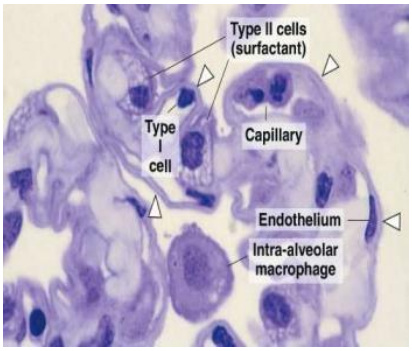
- Surfactant also contains several types of proteins (A,B,C,D)
- Pulmonary surfactant serves several major functions in the lung, but it primarily aids in reducing the surface tension of the alveolar cells.
- The reduction of surface tension means that less inspiratory force is needed to inflate the alveoli, and thus the work of breathing is reduced.
- without surfactant, alveoli would tend to collapse during expiration.

- have a bactricidal effect and lysosomal effect.
- In fetal development, surfactant appears in the last weeks of gestation and coincides with the appearance of lamellar bodies in the type II cells. (Resp. distress. Syndrome.)
- The surfactant layer is not static but is constantly being turned over.
- The lipoproteins are gradually removed from the surface by the pinocytotic vesicles of the squamous epithelial cells, by macrophages, and by type II alveolar cells.
- Alveolar lining fluids are also removed via the conducting passages as a result of ciliary activity.
- As the secretions pass up through the airways, they combine with bronchial mucus, forming a bronchoalveolar fluid.
- The bronchoalveolar fluid contains several lytic enzymes (eg, lysozyme, collagenase, -glucuronidase) that are probably derived from the alveolar macrophages.

Alveolar-Lining Regeneration

- Inhalation of NO_2 destroys most of the cells lining the alveoli (type I and type II cells).
- The action of this compound or other toxic substances with the same effect is followed by an increase in the mitotic activity of the remaining type II cells.
- The normal turnover rate of type II cells is estimated to be 1% per day and results in a continuous renewal of both its own population and that of type I cells.

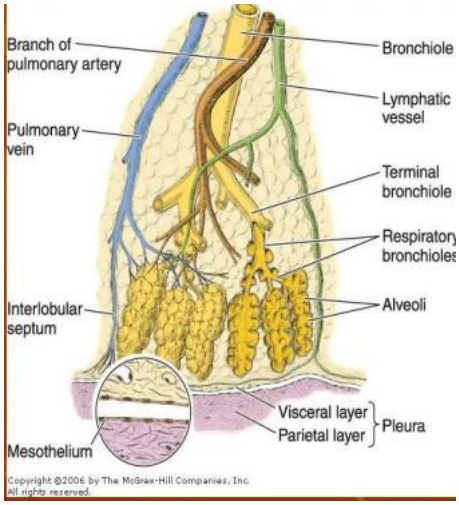
Lung Macrophages



- **also called dust cells.**
- **are found in the interior of the interalveolar septum and are often seen on the surface of the alveolus.** (seen in lung tissue and pleura). They appear as black dots filling the lung.
- **The phagocytosed debris within these cells was passed from the alveolar lumen into the interstitium by the pinocytotic activity of type I alveolar cells.**
- **The alveolar macrophages that scavenge the outer surface of the epithelium within the surfactant layer are carried to the pharynx** bronchiole →bronchi→pharynx**, where they are swallowed** with the saliva.
- **Numerous dust-laden macrophages in the connective tissue around major blood vessels or in the pleura probably are cells that have never passed through the epithelial lining.** They are more in number than type 1 cells.

Pulmonary Blood Vessels

- **Circulation in the lungs includes both nutrient (systemic) and functional (pulmonary) vessels.**
- **Pulmonary arteries are thin walled as a result of the low pressures (25 mm Hg systolic, 5 mm Hg diastolic)**
- **Within the lung the pulmonary artery branches, accompanying the bronchial tree.**
- **Its branches are surrounded by adventitia of the bronchi and bronchioles.**
- **At the level of the alveolar duct, the branches of this artery form a capillary network in the interalveolar septum.**



- The lung has the best-developed capillary network in the body, with capillaries between all alveoli, including those in the respiratory bronchioles
- Venules that originate in the capillary network are found singly in the parenchyma will go to left atrium and left ventricle.
- supported by a thin covering of connective tissue and enter the interlobular septum.
- After veins leave a lobule, they follow the bronchial tree toward the hilum.
- Nutrient vessels follow the bronchial tree and distribute blood to most of the lung up to the respiratory bronchioles, at which point they anastomose with small branches of the pulmonary artery

Pulmonary Lymphatic Vessels

- follow the bronchi and the pulmonary vessels; they are also found in the interlobular septum,
- they all drain into lymph nodes in the region of the hilum (deep network)
- superficial network includes the lymphatic vessels in the visceral pleura.
- The lymphatic vessels of the superficial network drain toward the hilum. They either follow the entire length of the pleura or penetrate the lung tissue via the interlobular septum.
- Lymphatic vessels are not found in the terminal portions of the bronchial tree or beyond the alveolar ducts.

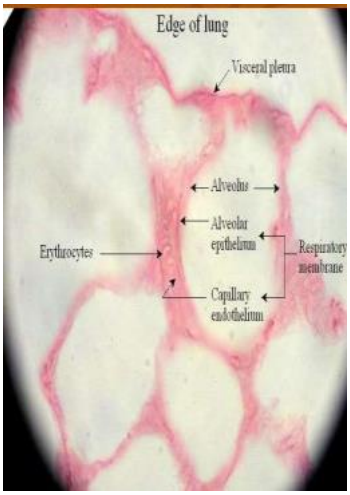
Nerves

- Both parasympathetic and sympathetic efferent fibers innervate the lungs and visceral pleura
- general visceral afferent fibers, carrying poorly localized pain sensations, are also present.

- Most of the nerves are found in the connective tissues surrounding the larger airways.

Pleura

- It consists of two layers, parietal and visceral, that are continuous in the region of the hilum.
- Both membranes are composed of mesothelial cells resting on a fine connective tissue layer that contains collagen and elastic fibers and reticular fibers.
- The elastic fibers of the visceral pleura are continuous with those of the pulmonary parenchyma.
- pleural cavity contains only a film of liquid that acts as a lubricant, facilitating the smooth sliding of one surface over the other during respiratory movements.
- This fluid is derived from the blood plasma by exudation.
- Simple squamous epithelium called mesothelium and beneath it we have collagen and elastic fibers



1. Which of the following components increase(s) as a proportion of the respiratory tract wall from trachea to alveoli?

a. Cilia
b. Elastic fibers
c. Smooth muscle
d. Cartilage
e. Goblet cells

ANS: B

2. Which structural feature distinguishes between terminal and respiratory bronchioles?

a. Alveoli

b. Cilia
c. Exocrine bronchiolar cells
d. Mucous glands in lamina propria
e. Smooth muscle

ANS: A

3. Which of the following features distinguishes a bronchus within a lung from the primary bronchi?
a. Glands in the submucosa
b. Pseudostratified ciliated columnar epithelium
c. Smooth muscle in the wall
d. Irregular plates of cartilage
e. Goblet cells in the epithelium

ANS: D

4. Which of the following is true of pulmonary surfactant?
a. Secreted by type I pneumocytes.
b. Forms layer rich in phospholipid overlying a thin aqueous phase
c. Prevents alveolar collapse by increasing surface tension.
d. Does not affect bacterial survival.
e. Is secreted by goblet cells.

ANS: B

V1