

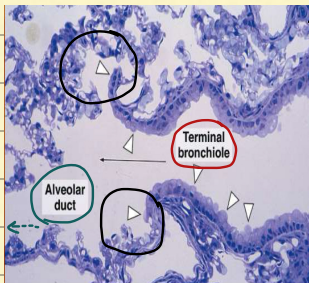
Histology of bronchioles :-

* Diameter of bronchioles at the beginning = 5 mm or less

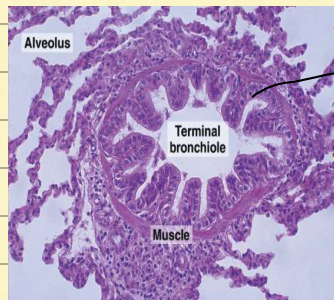


Then they branch more to give narrower bronchioles

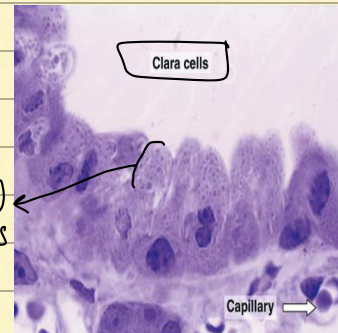
Their diameter → the large ≈ 1 mm / the small ones ≈ 0.5 mm



in black:
respiratory
bronchioles



Foldings
in mucosa



Secretory
granules

* Bronchioles → No glands + No cartilage

↳ Goblet cells are very few & replaced by Clara cells

Clara cells: * simple cuboidal cells without cilia

* have secretory granules in their apex ⇒ their secretions have 2 effects:-

- 1- against the bacteria that produce inflamm. + oxidative pollutants
- 2- Production of some proteins that are important for surfactants formation

* Exhibit specialised region called: neuroepithelial bodies

* Receive cholinergic nerve endings (related to chemoreceptors that depend on changes in $O_2 + CO_2$)

* Are seen in terminal + respiratory bronchioles

* Lining epi in

terminal bronchioles ⇒ Simple columnar ciliated + simple cuboidal ciliated
(after being pseudostratified columnar ciliated in the large bronchioles)
(the changes happen gradually, No sudden changes)

⇒ & as we move distally; clara cells amounts increase

* No lymphatic nodules (but there are scattered lymphocytes in all RT) respiratory tract

* In terminal bronchioles → We have prominent foldings in the mucosa
(conducting part of RT)

↓ WHY?

Bcz the lamina propria has ribbons of smooth muscles + elastic fibers
spiral + circular → (hence the folding)

Remember! smooth muscles increase in bronchioles

& they are responsible for asthma disease through their contraction → Narrowing of the lumen

⇒ While the cartilage in bronchi prevents the lumen narrowing

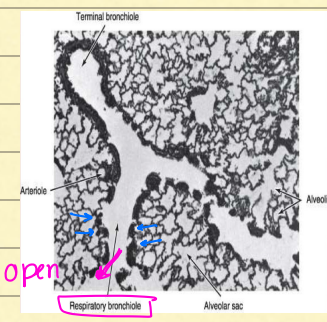
* ANS → Sympathetic ⇒ Dilatation of bronchioles
 * ANS → Parasympathetic (vagus) ⇒ Constriction of bronchioles

↳ So in asthmatic patients coming to the emergency department due to an almost complete closure of the airways

↓
 We give them adrenaline → Bronchodilation (working as the sympathetic N.S)

* Changes as we go from terminal to respiratory bronchioles

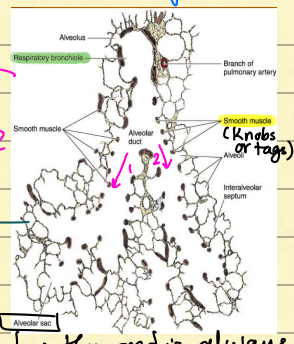
- Terminal:
 - 1- Closed bronchiole (rounded/circular lumen)
 - ↳ opens into 1/2 respiratory bronchioles (but are still called: closed)
 - 2- Simple cuboidal ciliated/non-ciliated (clara cells)
 - 3- Spiral smooth m. + circular
 - 4- Prominent folding of the mucosa
- Respiratory:
 - 1- Open bronchiole (opens into the alveolar duct) (not circular lumen)
 - 2- Simple Squamous epi
 - 3- Knobs/tags of smooth muscles (in the openings of the alveoli)
 - 4- Decreased foldings in mucosa → Due to ↓ smooth muscles + not circular
 - 5- We have gas exchange ✓ → in the surrounding alveoli that are present at the end of respiratory bronchioles



in blue:
tags of smooth muscles

respiratory bronchiole: opening into 2 alveolar ducts + 2 (atria)

Elastic fibers

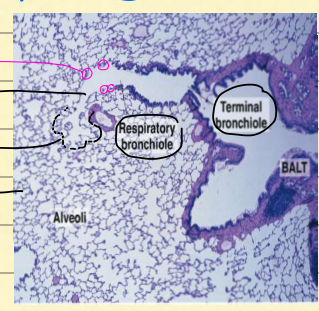


Knobs / tags of smooth

Alveolar duct

Alveolar sac

many alveoli (Opening into the open lumen)



↳ the end is always closed by the alveolar sac

* When the respiratory bronchiole opens into 2 alveolar ducts → We call this: **Atrium**

* Between the alveoli many:

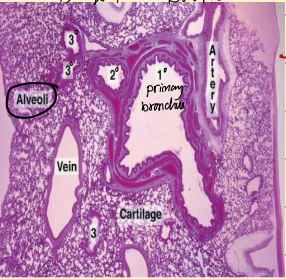
- elastic fibers (for inflation + deflation of the lung)
- reticular fibers

 or in the matrix

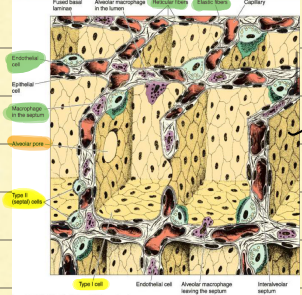
↳ Function: support for alveolar ducts + alveoli (to prevent rupture)

* The ends of the alveolar ducts: Alveolar sacs (alveoli sacs)

1, 3 & 4 → Bronchi



- * Alveoli:
 - sac-like invaginations
 - Diameter: 200 micrometer (um)
 - Spongy/soft in the lung (bcz they're filled with air with elastic fibers in between)
 - Between 2 alveoli: interalveolar septum (septom)
 - Alveolar wall: the whole wall of the alveolus (Wall)



All these cells are: simple squamous epi (together they form the alveolar walls)
 Bcz the majority of the alveolar cells are type 1 (simple squamous cells)
 You should differentiate between alveolar wall + alveolar septum

* Types of alveolar cells
 → Type 1 pneumocytes: simple squamous cells
 → Type 2 pneumocytes: Secrete the surfactants
 → Are called: septal cells

* in alveolar walls → 97% type 1 (main) / 3% type 2
 * in septum or corners → 16% type 2 (main) / 8% type 1

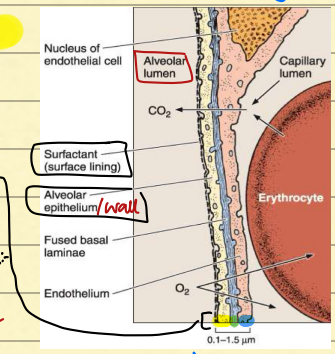
* Other cells/structures in the wall :-
 1- Endothelial cells of the capillaries → (in septum + wall) of the capillaries in the interstitium

2- Interstitium =
 → Connective tissues (- Fibers: reticular + elastic, - cells: Fibroblasts + mpgs + mast cells)
 → Capillaries (For gas exchange) called: Dust cells

3- Alveolar pores → connecting adjacent alveoli (in the interalveolar septum)
 → to deliver O₂ between 2 adjacent alveoli (↑ Balance between them)
 → Diameter: 10-15 um (micrometer)
 → Importance: Equalizing the air pressure between the neighbouring alveoli

* Respiratory membrane / Blood-air barrier (in a part of the septum)
 → Between the capillary (endothelial cells) + type 1 alveolar cells
 → its importance: Gas exchange through it (CO₂ from capillary to the alveoli / O₂ → from alveoli to capillary)

- Consists of :-
 1- The surface lining & the cytoplasm of alveolar cells (type 1) → (mainly the surfactant layer)
 2- Fused basal lamina → (Basal lamina of both endothelial cell + type 1 alveolar cell)
 3- The cytoplasm of endothelial cells



→ Importance of the surfactant layer that lines the alveolar wall of type 1 cells → Very imp. in facilitating inflation of the alveoli (في الانتفاخ)

→ Total thickness of this barrier = 0.1 - 1.5 um (very thin)

* Intralveolar septum :-

↳ Contains :-

- 1- Interstitium : → - Capillaries (endothelial cells)
(just like the alveolar wall) - Fibroblasts + mast cells
- Macrophages

2- Type 1 alveolar cells → 8%.

3- Type 2 alveolar cells → 16% ⇒ Hence are called: septal cells

4- Leukocytes

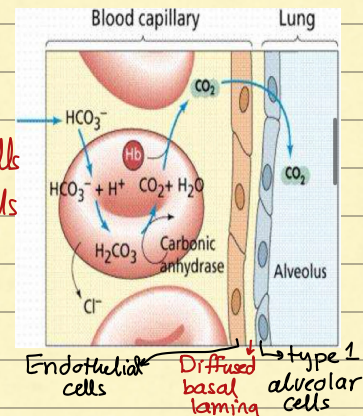
↳ Almost special to the septum (type 1+2 ⇒ special to the septum in these percentages!)

* Gas exchange:

↳ O_2 : is transported from type 1 alveolar cells to Endothelial cells
 CO_2 : (opposite): from endothelial cells to Type 1 alveolar cells

↳ CO_2 is related to carbonic anhydrase in erythrocytes

Extra: ($CO_2 + H_2O \xrightarrow{\text{carbonic anhydrase}} H_2CO_3 \rightarrow HCO_3^- + H^+$)



* Number of alveoli in the lungs ⇒ 300 millions alveoli

↳ Their surface area (for all alveoli) ⇒ 140 m² (Huge! For gas exchange)

* Capillary endothelial cells (endothelial lining of capillaries)

↳ Extremely thin

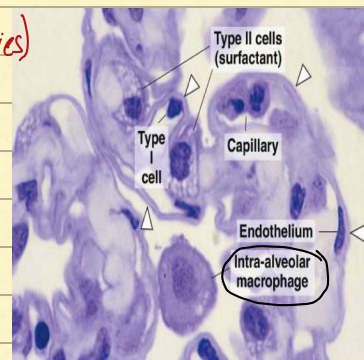
↳ Can be confused with type 1 alveolar cells
(Bcz they are both simple squamous epi)



Then how to differentiate them??

* Many RBCs around → Endothelial cells

* No RBCs → Type 1 alveolar cells



↳ Non-fenestrated endothelial cell (Remember: types of endothelial cells
Fenestrated → Non-fenestrated)

↳ Characteristic feature (wajah):-

↳ Clustering of organelles → Around their nuclei

Mitochondria + Golgi for e.g

⇒ While the rest of the cytoplasm is empty ⇒ (to contain O_2)

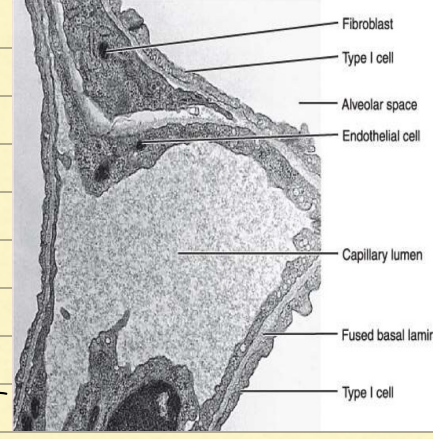
↳ Have pinocytotic vesicles inside them

⊗ similar to type 1 alveolar cells

* Type 1 alveolar cells

- ↳ 97% of alveolar walls
- ↳ 8% of the septum
- ↳ Size ≈ 25 nanometer (nm)
- ⊗ Also their organelles are clustered around their nuclei (like the Golgi complex)
- ↳ Part of the blood-air barrier
- ⊕ Also have pinocytotic vesicles

⊕ similar to endothelial cells

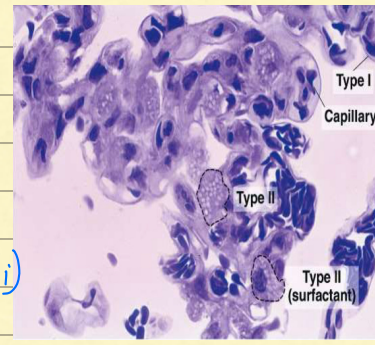


↳ Between type 1 & type 2 alveolar cells we have

- 1- Desmosomes
- 2- Occluding junctions

* Type 2 alveolar cells

- ↳ cuboidal cells
- ↳ Larger than type 1
- ↳ Desmosomes and occluding junctions with type 1 cells
- ↳ Secrete the surfactants
 - ↳ (imp in decreasing the surface tension in alveoli)
 - ↳ Helps in inflation (يساعد في التوسيع)

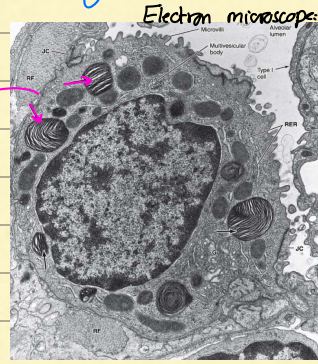


↳ Characteristic feature (وَجْهَة) *

↳ Undergoes mitosis & division ⇒ So: Replacement of type 1 + 2 cells

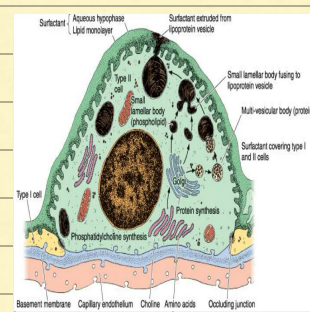
↳ In electron microscope: Type 2 has lamellar bodies

- Foamy appearance in the cytoplasm
- Contain the pulmonary surfactants that spread on the surfaces of type 1 cells



* Pulmonary surfactants:-

- ↳ contain proteins A+B+C+D
- ↳ Have bactericidal effects + Lysosomal effects (Antibacterial effects)
- ↳ Present in bronchoalveolar fluid
 - ↳ Suction of this fluid (including the surfactants within it)
 - ↳ contain other structures (than the surfactants) like macrophages



Surfactants biochemistry

* Inhalation of NO₂ ⇒ Destruction of cells esp. ⇒ type 1 alveolar cells (toxic effect)

↳ But esp. type 2 ⇒ undergoes continuous turnover with high rate
 ↳ & it's also converted into type 1 cell ⇒ replacing it

* Macrophages = Dust cells

- Seen in lung tissue + but can also be seen on the surface in pleura
- Appear as black dots all over the lung tissue
- Function: Engulfing any foreign bodies or cell debris
- Come originally from the monocytes (from the WBCs)
 - ↳ And reach the lung through the blood

↓
Present in the interalveolar septum (to perform their function: engulfing)

↓
Can sometimes reach the bronchi (through the bronchioles)

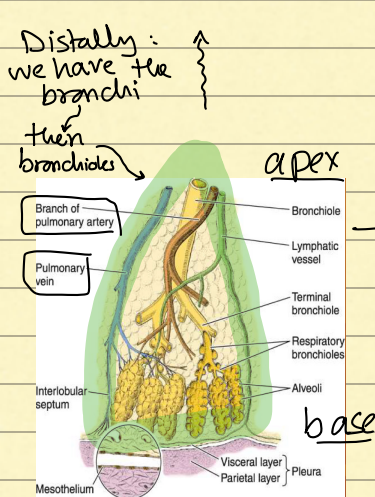
↓
Then ascending upwards to reach the pharynx

⇒ & undergo expectoration with the saliva
(Extra: Expelling substances with the saliva through the mouth)

* Which type of cells present in higher amounts in lung tissue
type 1 alveolar cells or macrophages??

Surprisingly macrophages!!

* Pulmonary BVs :-



This is the bronchopulmonary segment.

- Pyramidal in shape (has apex + base)

- Bronchi → terminal bronchioles → respiratory bronchioles → alveoli

- Also contains

• segmental pulmonary artery
(non-oxygenated blood)

• the pulmonary veins are on the 2 sides of the segment in the connective tissue

(oxygenated blood)

(capillaries → venules → veins → left atrium → left ventricle → aorta)

* While the oxygenated arterial blood supply to the lungs: Bronchial arteries
(We call them: nutrient vessels)
(branches of post. intercostal arteries → from descending thoracic aorta)

- pulmonary lymphatic vessels → eventually they go to the hilum of the lungs
 (and we call them in the hilum: mediastinal L.Ns)

Superficial → Deep

To: Thoracic duct (on left side)
 Right lymphatic duct (Right side)

Ending at the beginning of
 brachiocephalic veins ← Left
 Right

* Nerve supply

↳ Lung tissue + visceral pleura ⇒ Symp. + Parasymp.

↓
 Bronchodilation Bronchoconstriction

Pain + touch + temp
 through the afferent fibers
 (Extra: but very weak & poorly localised sensations)

* The 2 types of pleura (visceral + parietal)

↳ Have elastic fibers + reticular fibers (for inflation of the lung)

↳ Type of epithelium: mesothelial cells (simple squamous epi)

↓
 Directly below them: collagen + elastic fibers
 of the lung tissue

also for inflation
 of the lung

(Lung tissue = lung parenchyma)

لا تَنْوِيَا وَهَلْ جَزَاءُ مَن دَعَا إِلَى
 وَلا تَنْوِيَا الطَّبِيْعَ الْأَسْرَبَ :
 - صِلَاةُ الْوَالِدَيْنِ
 - عِبَادَةُ اللَّهِ الْبَلَدِ
 ... فَانْفِرْ لَهُ مَن أَحْوَجُ مَا يَكُونُ ...

* Numbers :-

- Diameter of bronchioles → 5mm or less
 (in narrower ones → from 0.5-1 mm)
- Diameter of alveoli → 200 μm
- Diameter of alveolar pores → 10-15 μm
- Thickness of blood air barrier → 0.1-1.5 μm
- # of alveoli in the lungs → 300 millions
- Total surface area of alveoli → 140 m²
- Thickness of type 1 alveolar cells → 25 nm

↳ nano