بسم الله الرحمن الرحيم

DOPAMINE SCIENTIFIC TEAM

HISTOLOGY

MID | Lecture 2

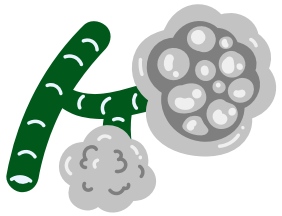
Histology of the Lower Respiratory Tract

Written by: Mohammad Khazalah

Reviewed by: Abdulrahman Khw

﴿ وَلَقَدْ نَعْلَمُ أَنَّكَ يَضِيقُ صَدْرُكَ بِمَا يَقُولُونَ ﴿٩٧﴾ فَسَبِّحْ بِحَمْدِ رَبِّكَ وَكُن مِّنَ السَّاجِدِينَ ﴾

سبحان الله وبحمده، سبحان الله العظيم



رحم الله عمر عطية..

اللهم اغفر له وارحمه، وعافه واعف عنه، وأكرم نزله ووسع مدخله، واغسله بالماء والثلج والبرد، ونقه من الذنوب والخطايا كما ينقى الثوب الأبيض من الدنس، اللهم وجازه بالحسنات إحسانًا وبالسيئات عفوًا وغفرانًا

إنا لله وإنا إليه راجعون

وَلِلَّهِ الْأَسْمَاءُ الْحُسْنَى فَادْعُوهُ بِهَا

المعنى: الذي انتهى علمه إلى الإحاطة ببواطن الأشياء وخفاياها كما أحاط بظواهرها.

الورود: ورد في القرآن (٤٥) مرة.

الشاهد: ﴿ قَالَ نَبَّأَنِيَ ٱلْعَلِيمُ ٱلْخَبِيرُ ﴾ [التحريم:٣].

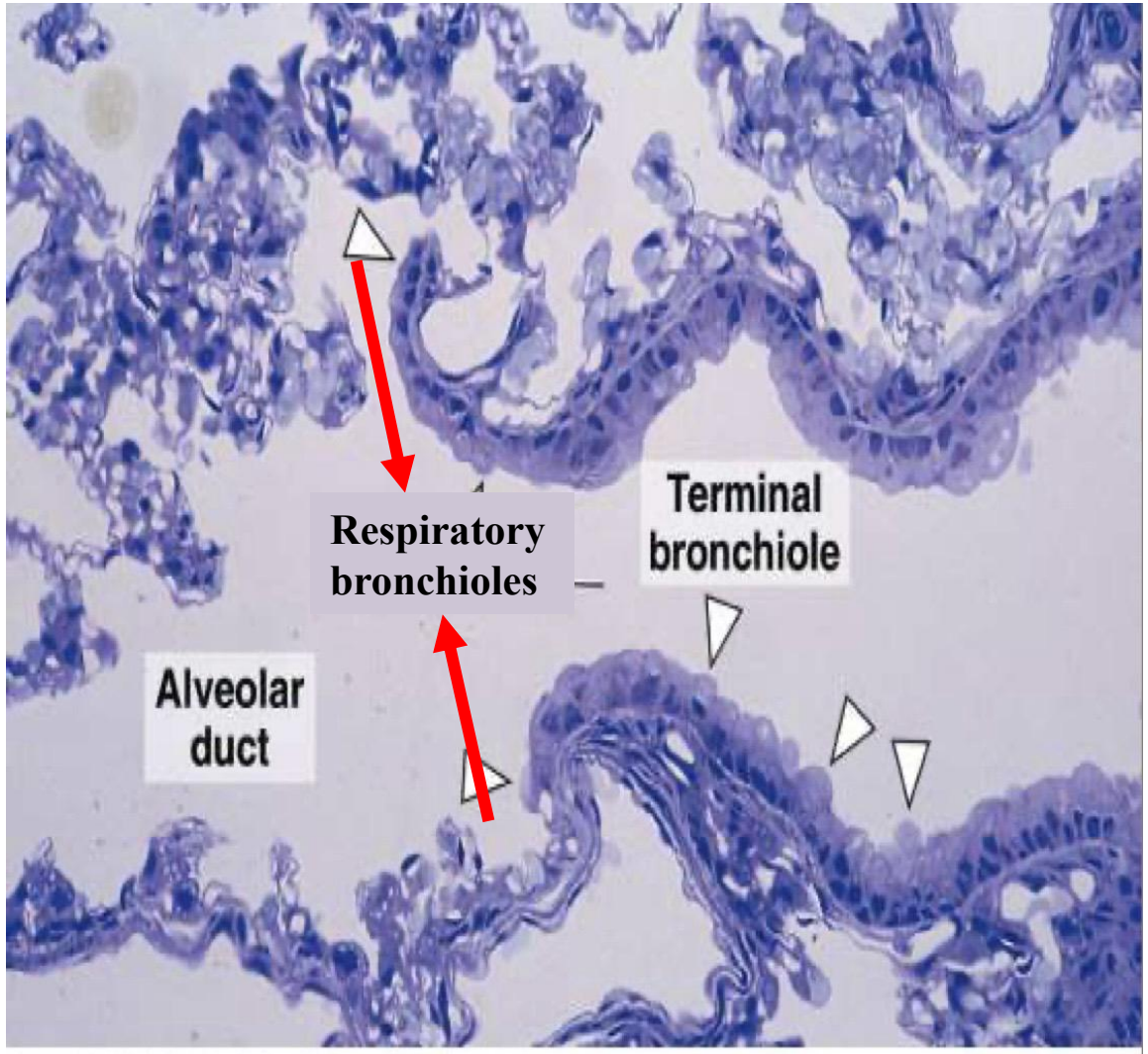
٥٥

اضغط هنا لشرحٍ أكثر تفصيلًا

Lower respiratory tract

Bronchioles

- Bronchioles begin at a diameter of approximately **5 mm or less**, branching further into smaller passages. These are categorized into **large bronchioles** (about **1 mm**) and **small bronchioles** (averaging **0.5 mm**)
- **Note**: Bronchioles **lack** both **glands** and **cartilage**. **Goblet cells** are **few** in these passages and are replaced by **clara cells.**
- The **lining epithelium** transitions **from ciliated pseudostratified columnar** (in large bronchioles) to **ciliated simple columnar**, eventually becoming **ciliated simple cuboidal** in the smaller bronchioles
- **No lymphatic nodules**



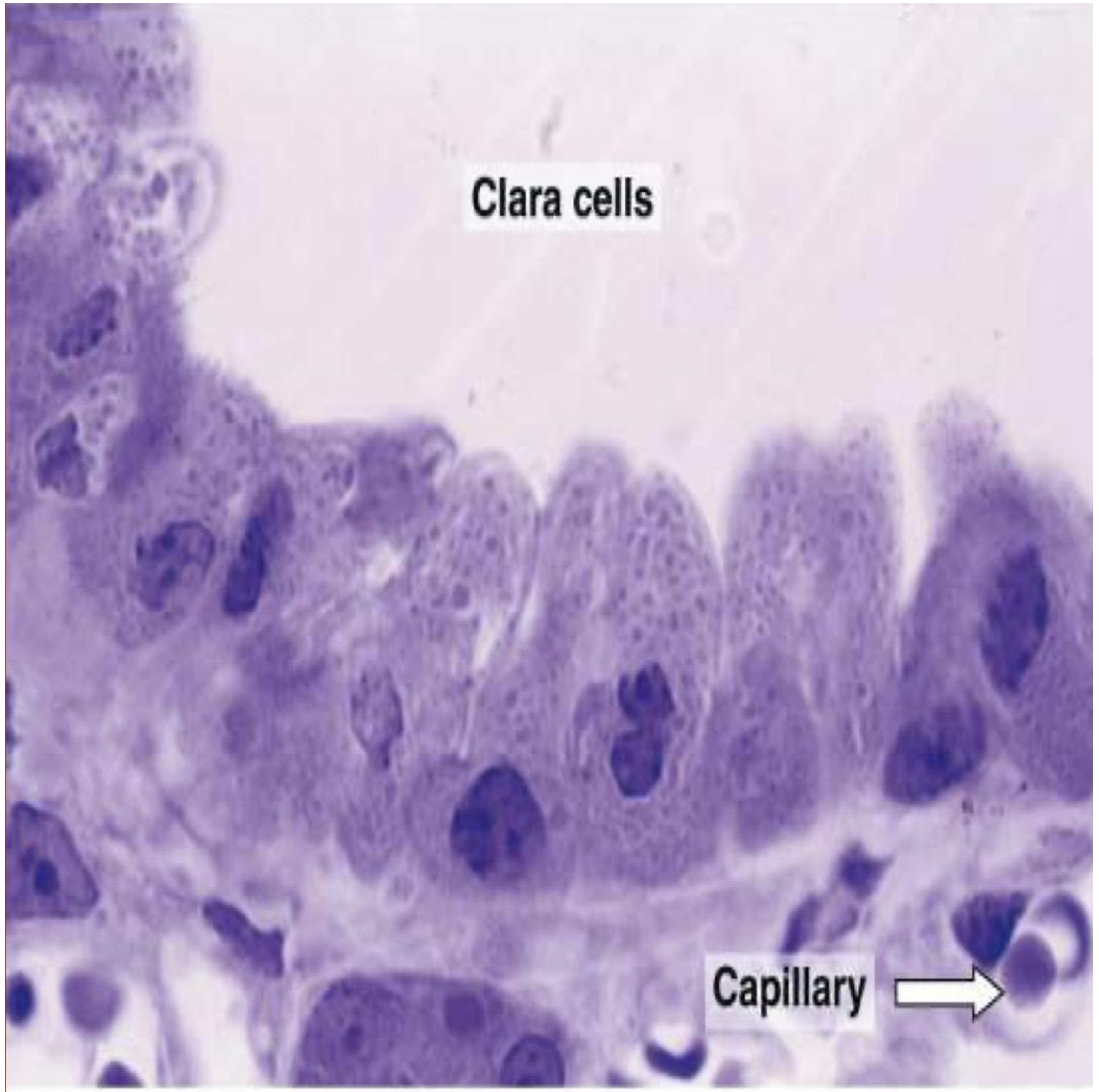
Copyright ©2006 by The McGraw-Hill Companies, Inc.
All rights reserved.

Dr.'s figure:

Bronchioles

Clara cells

- Simple **cuboidal** cells **without cilia**
- Clara cells are located within the **terminal** and **initial respiratory** bronchioles. They contain **secretory granules at their apex** that protect against bacterial inflammation and oxidative pollutants
- These cells contribute to **surfactant** production, and form specialized clusters known as **neuroepithelial bodies**.
- These bodies receive **cholinergic nerve endings** and function as **chemoreceptors** that monitor changes in oxygen and CO2 levels.



Copyright ©2006 by The McGraw-Hill Companies, Inc.
All rights reserved.

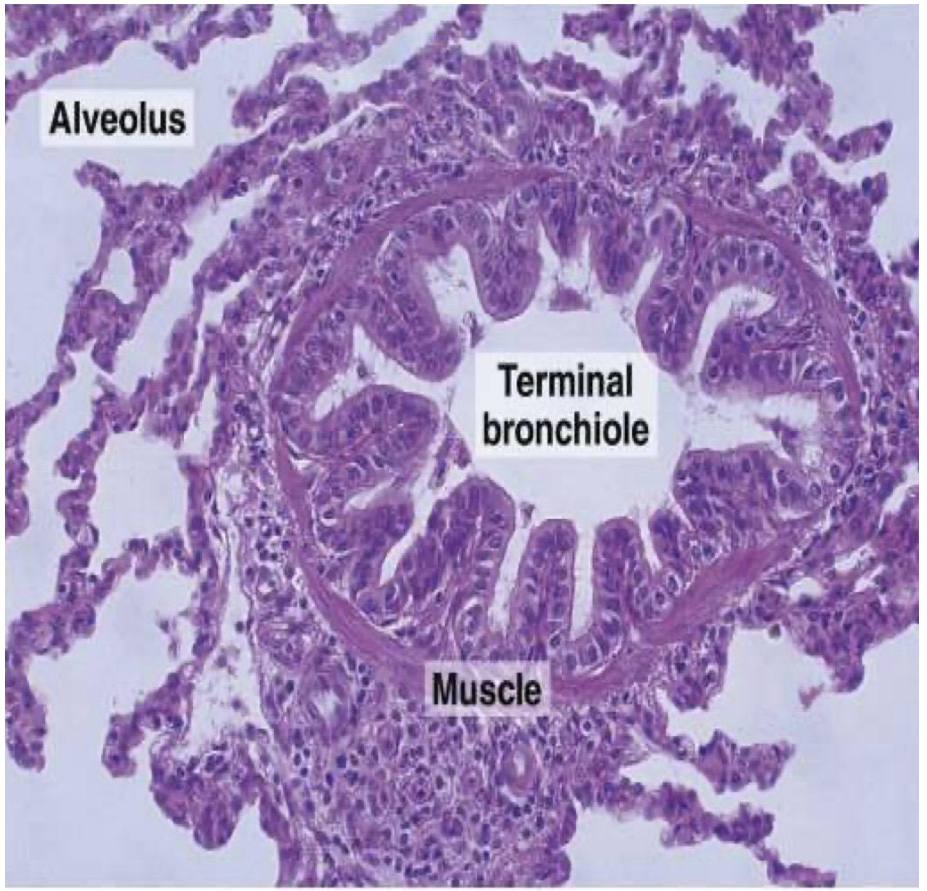
Expected exam question about Clara cells, in the quiz

Dr.'s figure:

Bronchioles

Terminal bronchioles

- The terminal bronchioles exhibit **prominent mucosal folding** due to the presence of **spiral** and **circular smooth muscle** and **elastic fibers** within the **lamina propria.**
- The epithelium transitions to **simple ciliated columnar** or **cuboidal cells**.
- Physiologically, the **sympathetic** nervous system triggers **bronchodilation**, whereas the **parasympathetic** nervous system (via the **vagus** nerve) causes **bronchoconstriction**.
- Clinical Note: In an asthma emergency, (the patient is unable to breath) adrenaline is administered because it mimics sympathetic action, inducing rapid bronchodilation to restore airflow.



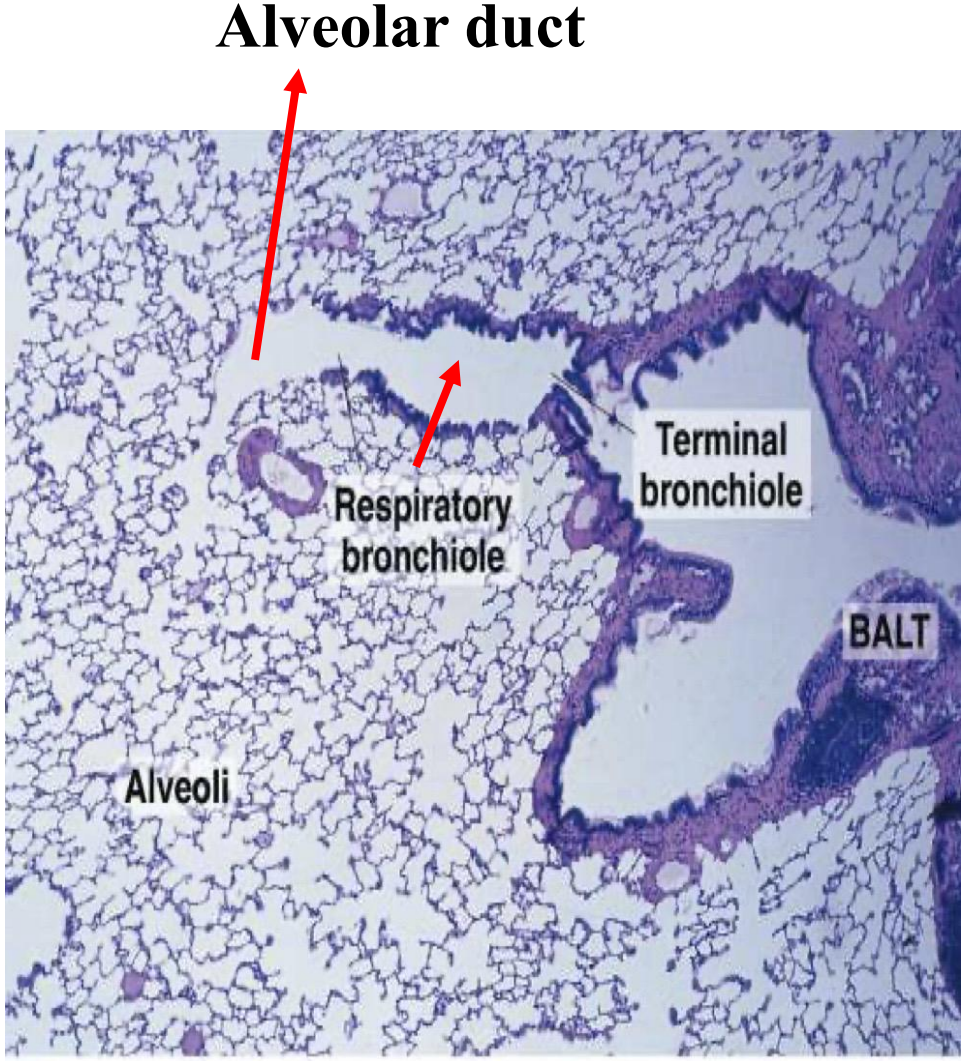
Copyright ©2006 by The McGraw-Hill Companies, Inc.
All rights reserved.

Dr.'s figure:

Bronchioles

Respiratory bronchioles

- **Terminal bronchioles** maintain a **closed**, **circular lumen**, whereas **respiratory bronchioles** feature an interrupted wall (**open lumen**) as they open into **alveolar ducts.**
- The **lining** of the respiratory bronchioles **begins** as **simple cuboidal** epithelium (containing both **ciliated** and **non-ciliated Clara cells**) and transitions **distally** into **simple squamous epithelium.**
- As the airways progress, **mucosal folding decreases** alongside a **reduction** in **smooth muscle,** which eventually appears only as **'knobs'** or **'tags'** at the **alveolar openings**.
- While **gas exchange begins** in the **respiratory bronchioles**, it occurs **primarily** within the **alveoli**.

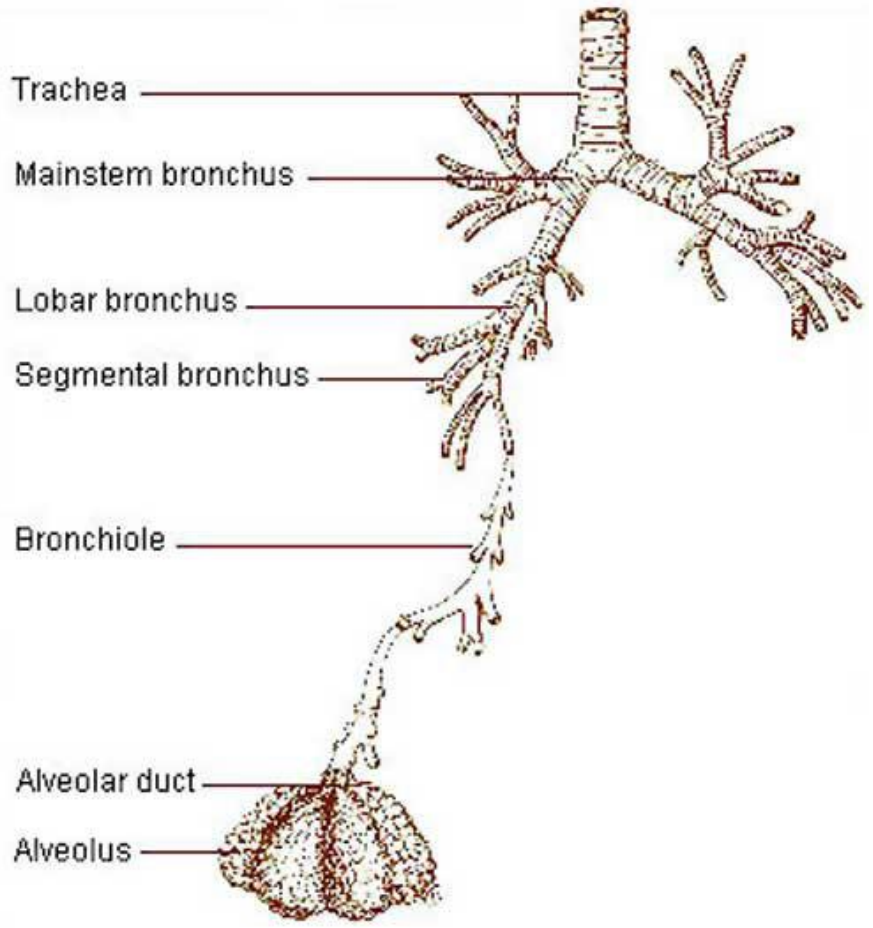


Copyright ©2006 by The McGraw-Hill Companies, Inc.
All rights reserved.

Dr.'s figure:

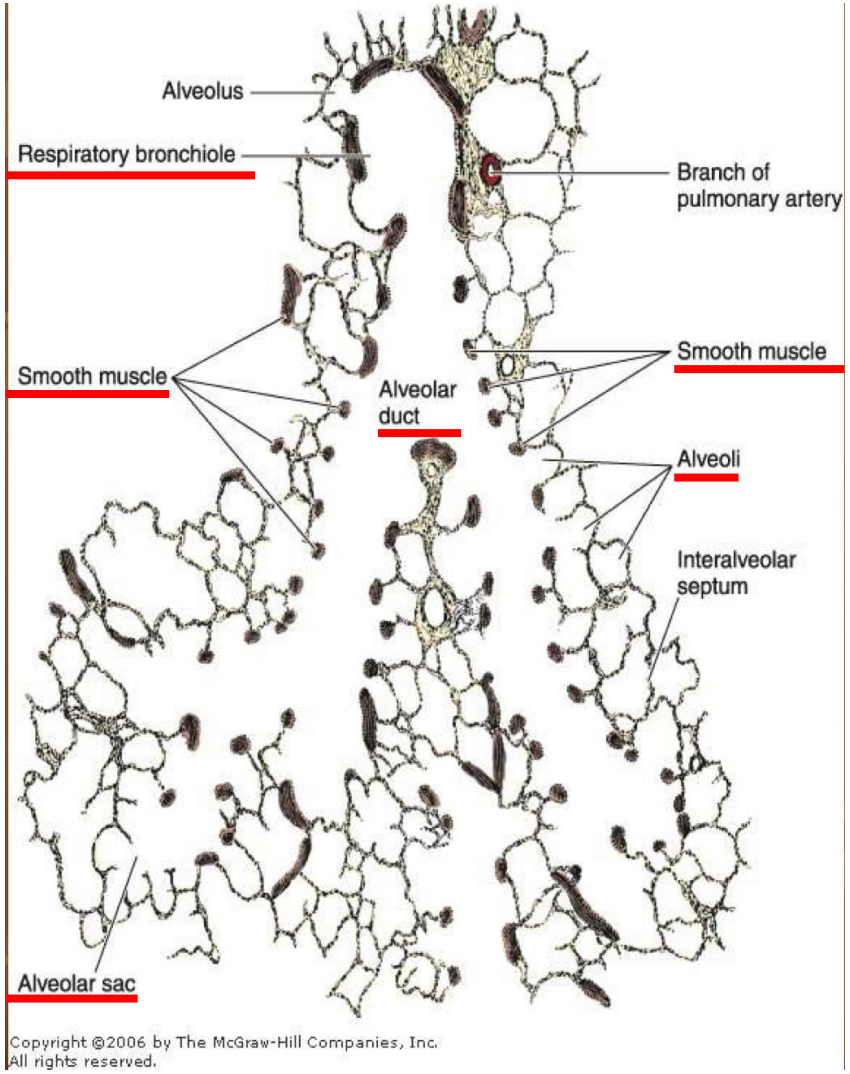
Bronchioles
Alveolar Ducts

- **Between** these **alveoli**, **elastic fibers** provide the necessary **recoil** for **lung inflation** and **deflation**.
- Finally, the **alveolar ducts** lead into **atria** (**2 alveolar ducts**), which serve as the **entry** point to the **alveolar sacs.**
- The **matrix** is rich in **reticular** and **elastic fibers**, which provide **support** for the **alveolar duct** and **alveoli.**

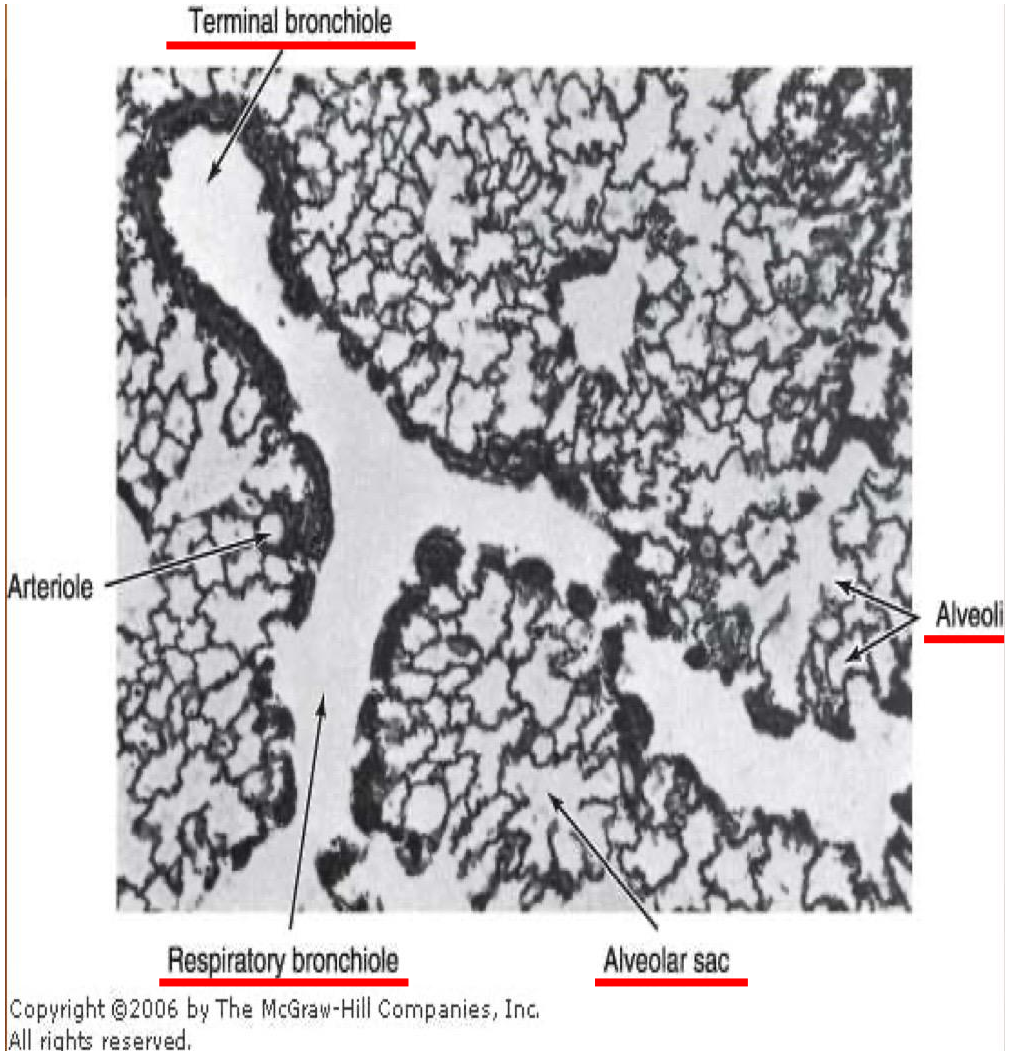


Have a good look into these pictures

Alveolar duct



Respiratory bronchiole

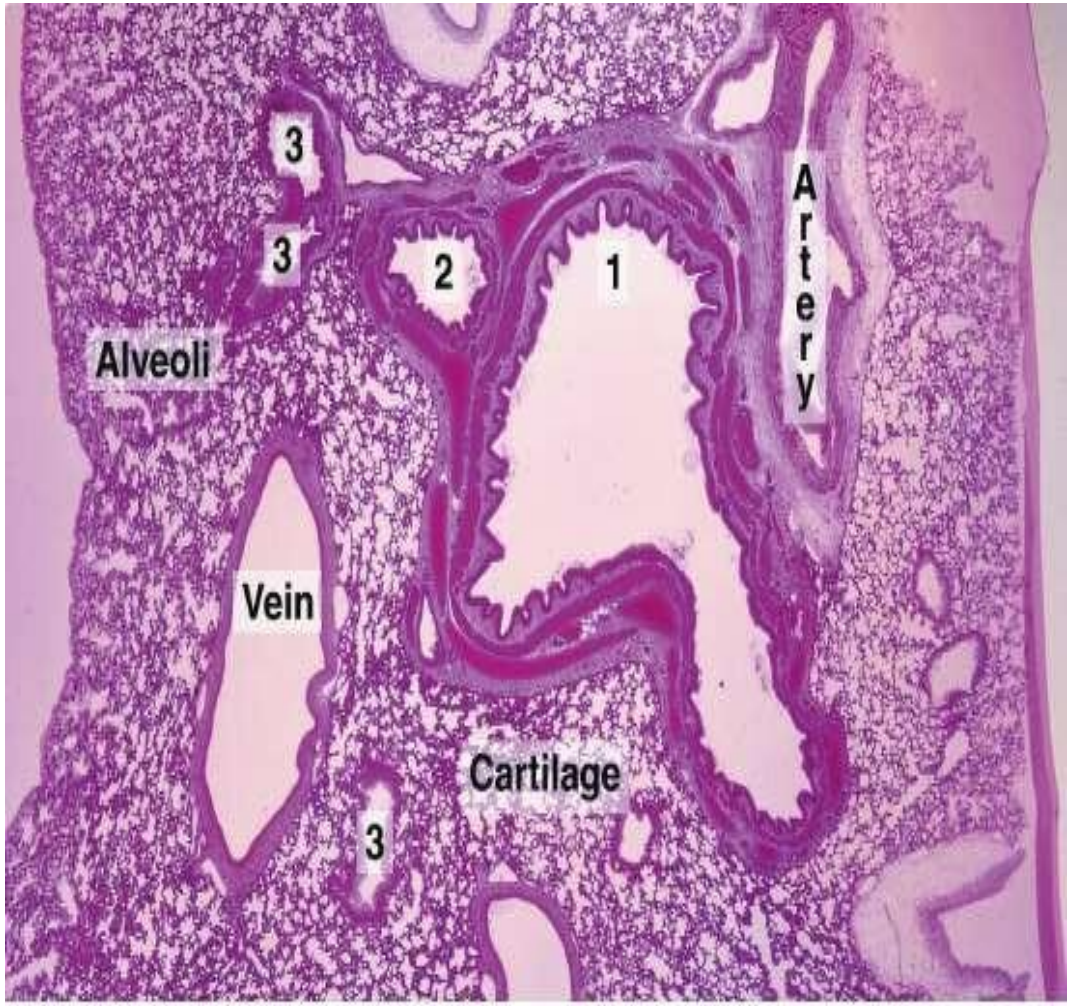


Dr.'s figures:

Alveoli

- Alveoli are **saclike evaginations** (approximately **200um** in diameter) that provide the lung with its characteristic **spongy soft** structure

- The tissue **between individual alveoli** is known as the **interalveolar septum/wall**. While the **'alveolar wall'** refers to the **thin barrier** of a **single alveolus.**
- The **'interalveolar septum'** is the **partition shared** between **two adjacent alveoli**.



Copyright ©2006 by The McGraw-Hill Companies, Inc.
All rights reserved.

1,2,3: primary, secondary, tertiary bronchi

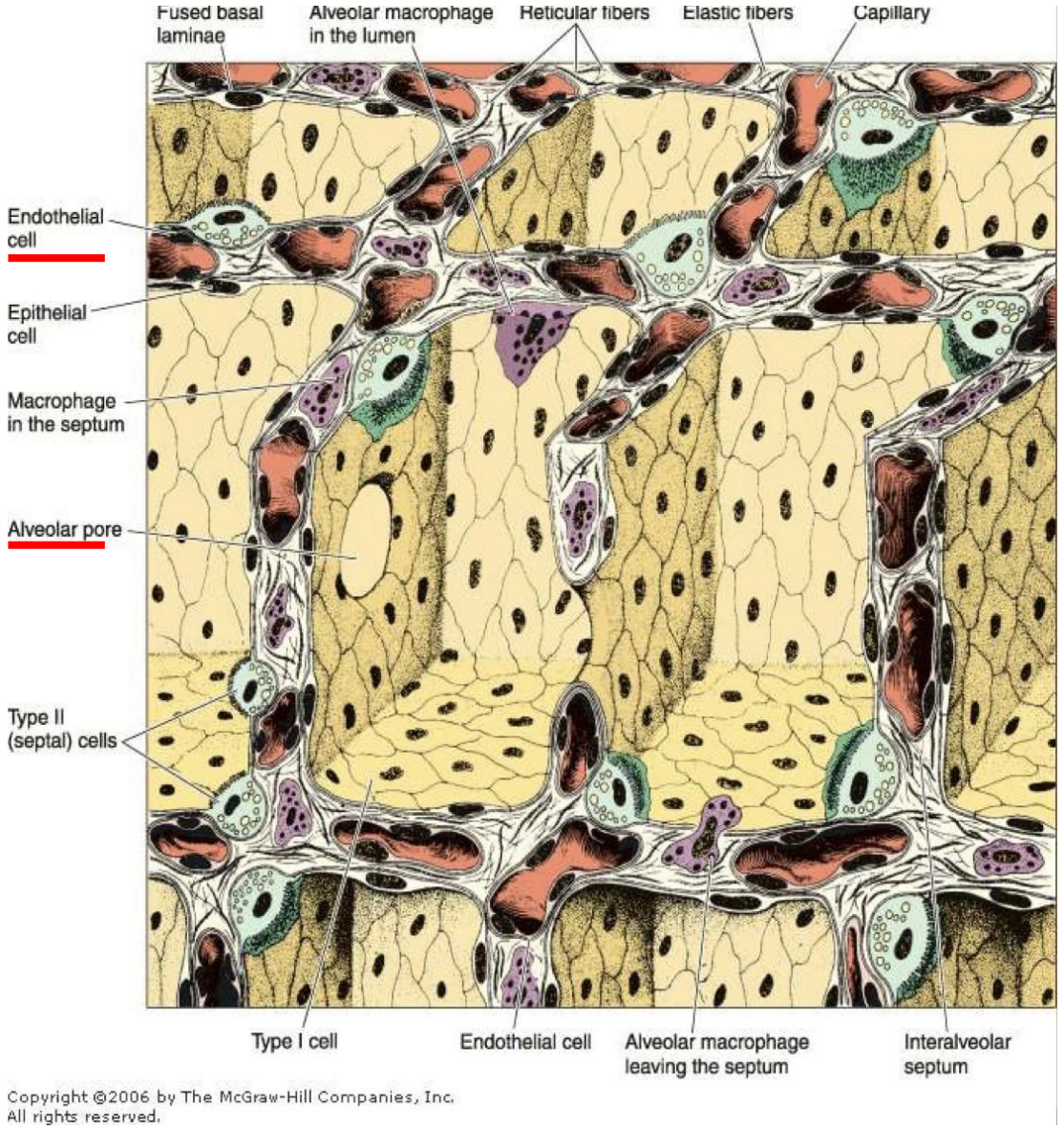
Dr.'s figure:

Alveoli

- In terms of surface area, **Type I** cells cover roughly **97%** of the **alveolar surface**, while **Type II** cells cover only **3%**. However, when considering the actual cell count within the **septum**, **Type II** cells are **more numerous** (making up about **16%** of the population compared to **8%** for **Type I**).
- These **Type II** cells—also known as **septal cells**—are more abundant at the **corners** and **within** the **septal walls.**

Interalveolar septum

- **Endothelial cells** are also present within the **alveolar walls** and **septa**, forming the lining of the extensive capillary network.
- Together, these **capillaries** and the surrounding **connective tissue** constitute the **interstitium**.
- This **interstitial space** contains various cell types, including **fibroblasts**, **macrophages** (commonly known as **dust cells**), **leukocytes** and **mast cells**, in addition to **reticular** and **elastic fibers.**



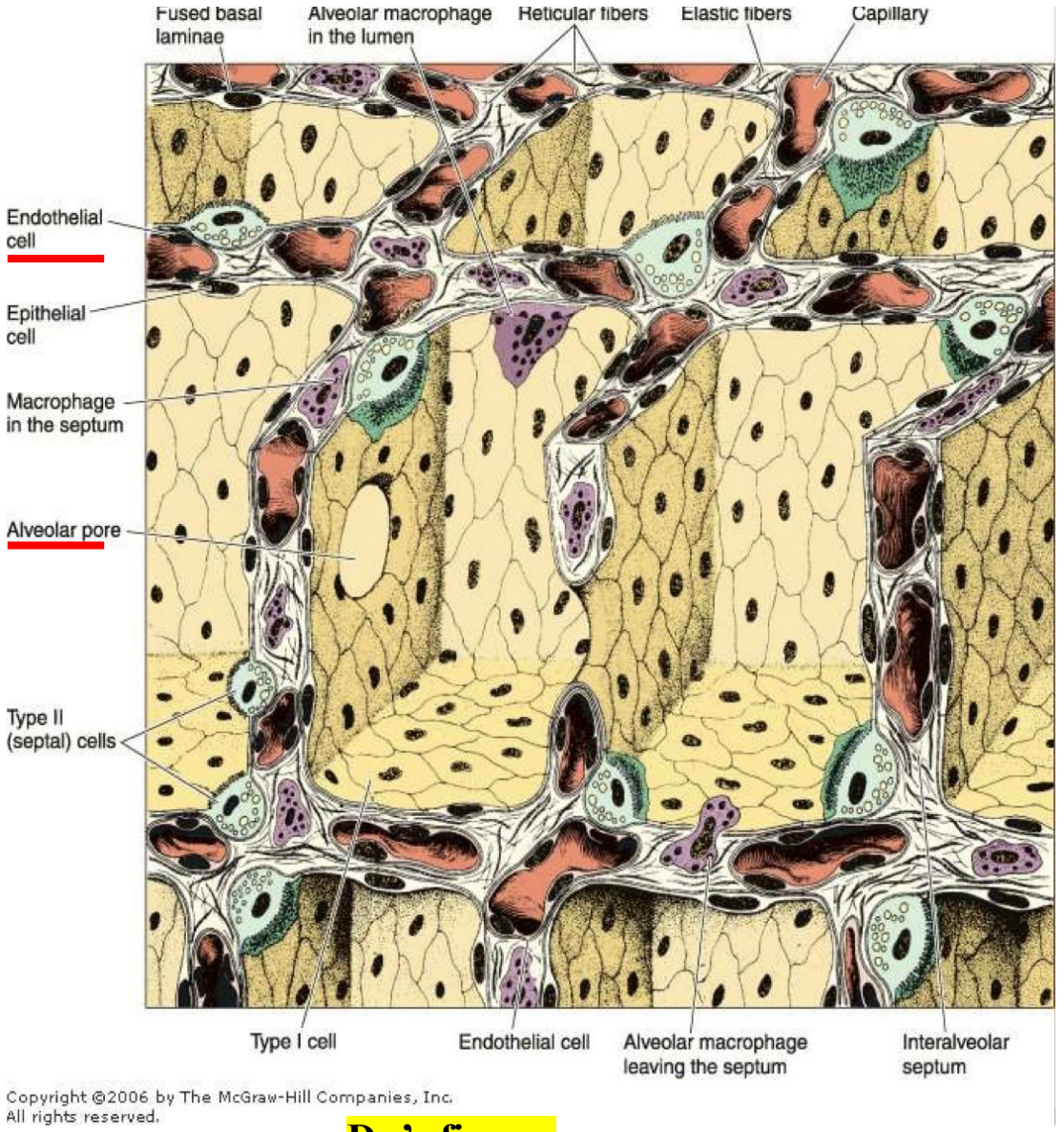
Copyright ©2006 by The McGraw-Hill Companies, Inc.
All rights reserved.

Dr.'s figure:

Interalveolar septum

- **Within** the **interalveolar septa**, adjacent alveoli are connected by **alveolar pores**, which measure **10–15 um** in diameter.

- These pores are essential for **equalizing air pressure** and ensuring the **balanced distribution** of **oxygen** between **neighboring alveoli**.



Copyright ©2006 by The McGraw-Hill Companies, Inc.
All rights reserved.

Dr.'s figure:

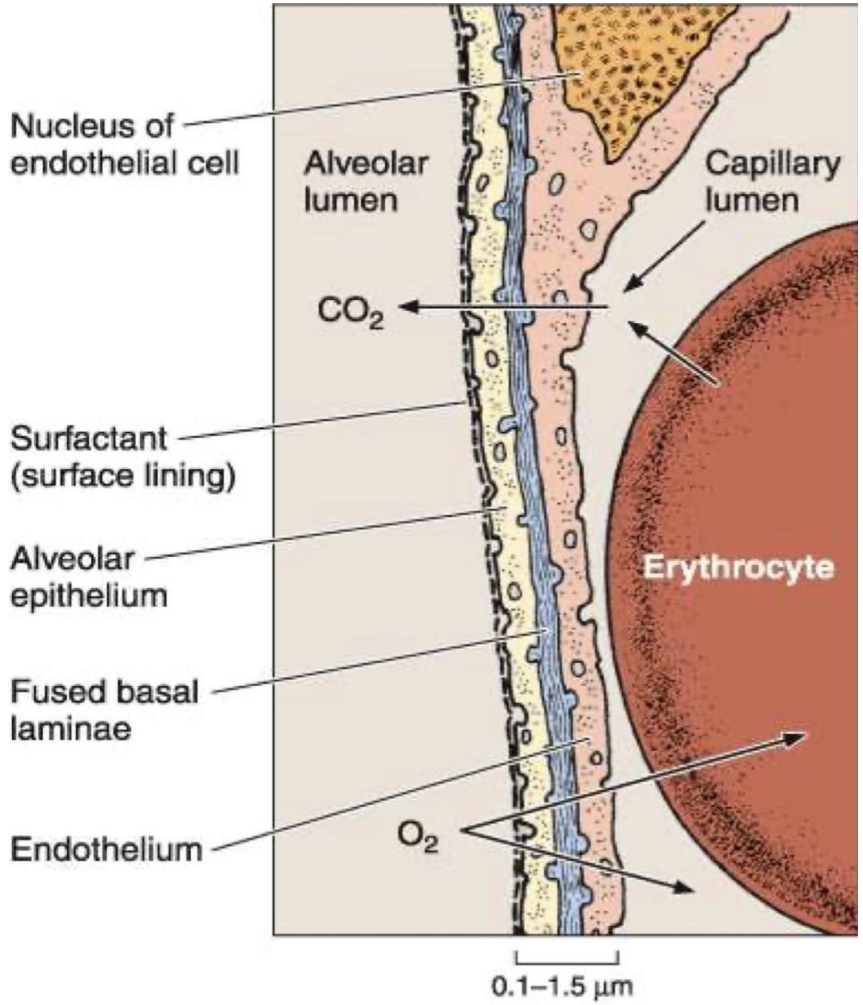
Interalveolar septum

- The **interalveolar septum** consists of the **interstitium** and the specific **cells** of the **alveolar lining**. The **interstitium** is composed of a **capillary network** and **connective tissue** containing :
  - endothelial cells (30%), fibroblasts and mast cells (36%), and macrophages (10%).

- The following cells are considered part of the **alveolar epithelium** rather than the interstitium: **Type I alveolar cells (8%)**, **Type II alveolar cells (16%),** and various **leukocytes**.

Blood-air barrier/ Respiratory membrane

- The **blood-air barrier** is located between the **Type I alveolar cells** and the **capillary endothelial cells,** serving as the **interface** for **gas exchange**. The **alveolar wall** is coated by a **surfactant** layer that **reduces surface tension** to **facilitate lung inflation**.
- The barrier consists of **three primary layers**:
    1. The surface lining and cytoplasm of the **Type I alveolar cells** coated by surfactant.
    2. The **fused basal laminae** of the closely apposed type 1 epithelial and endothelial cells .
    3. The cytoplasm of the **capillary endothelial cells.**
- The total thickness of this blood-air barrier ranges from 0.1 to 1.5 µm. (very thin)

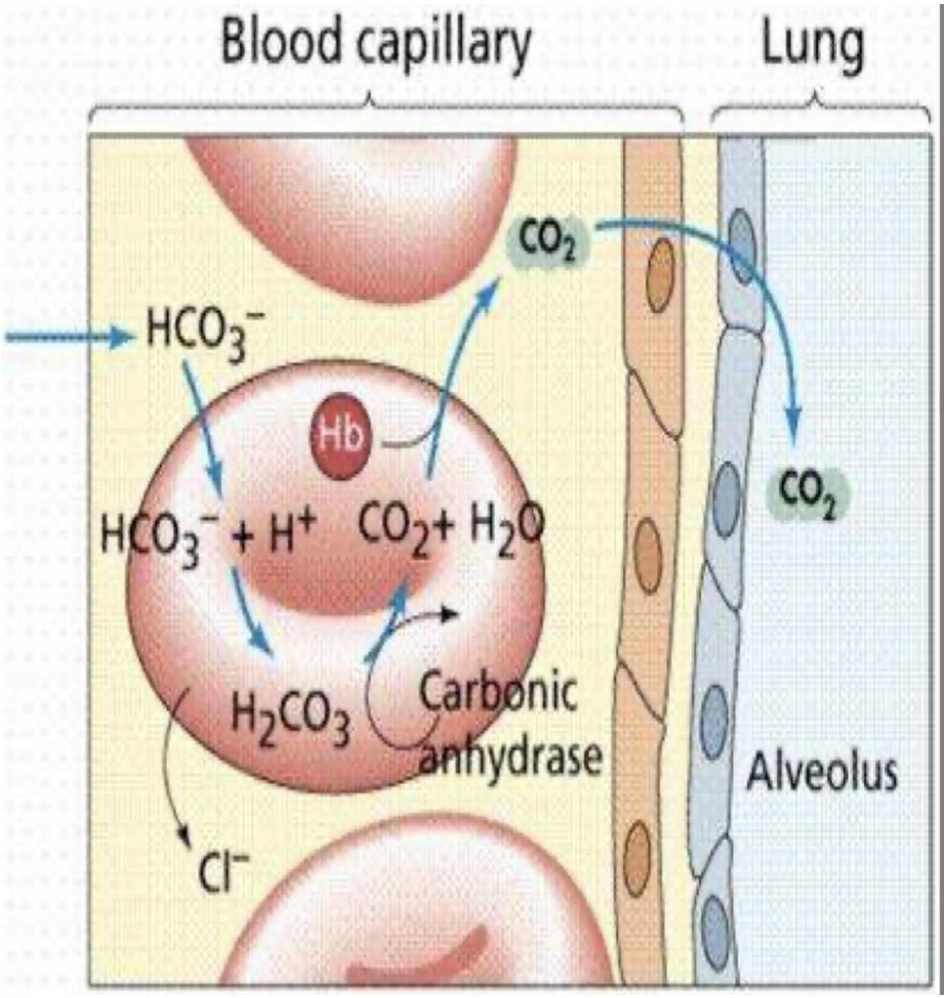


Copyright ©2006 by The McGraw-Hill Companies, Inc.
All rights reserved.

Dr.'s figure:

Gas exchange

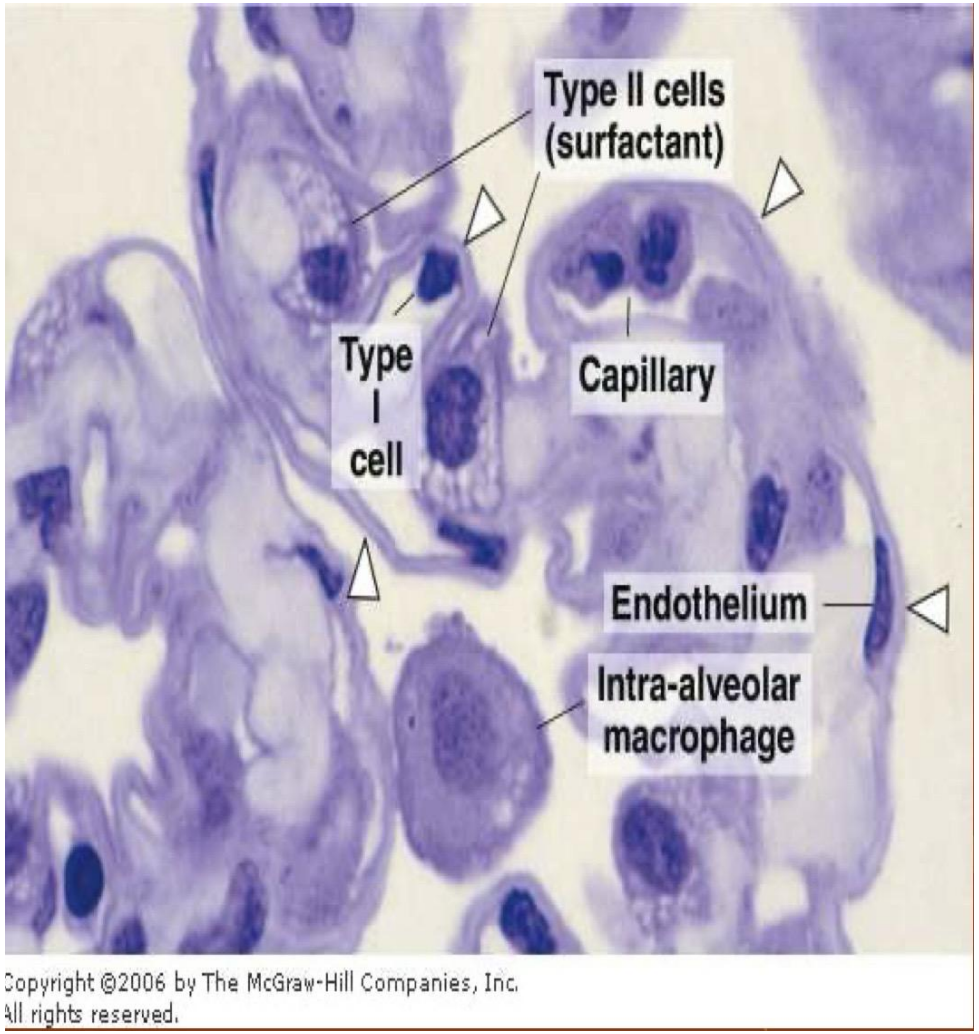
- **Gas exchange** occurs across the **blood-air barrier**, where **oxygen** diffuses **from** the **Type I** alveolar cells **into** the **capillary endothelial** cells, while **CO2** moves in the **opposite direction.** The liberation of CO2 from carbonic acid (H2CO3) is catalyzed by the enzyme carbonic anhydrase.
- The lungs contain approximately **300 million alveoli**, providing a total surface area for exchange calculated to be about 140 m2.



Dr.'s figure:

Capillary endothelial cells

- Capillary endothelial cells are **extremely thin** and can be easily **confused** with **Type I alveolar** cells, as both are **simple squamous epithelial cells**. However, these endothelial cells are **non-fenestrated.**
- To differentiate them under a microscope, observe their surroundings: **endothelial cells** are typically **adjacent** to **red blood cells** (RBCs), whereas Type I alveolar cells line the alveolar air space.
- Adjacent to the nucleus, **clusters** of **organelles** such as **mitochondria** and the **Golgi** complex, while the **rest** of the **cytoplasm** is attenuated (**empty**) to facilitate **gas exchange**. The most distinctive feature of their cytoplasm is the presence of numerous **pinocytic vesicles.**



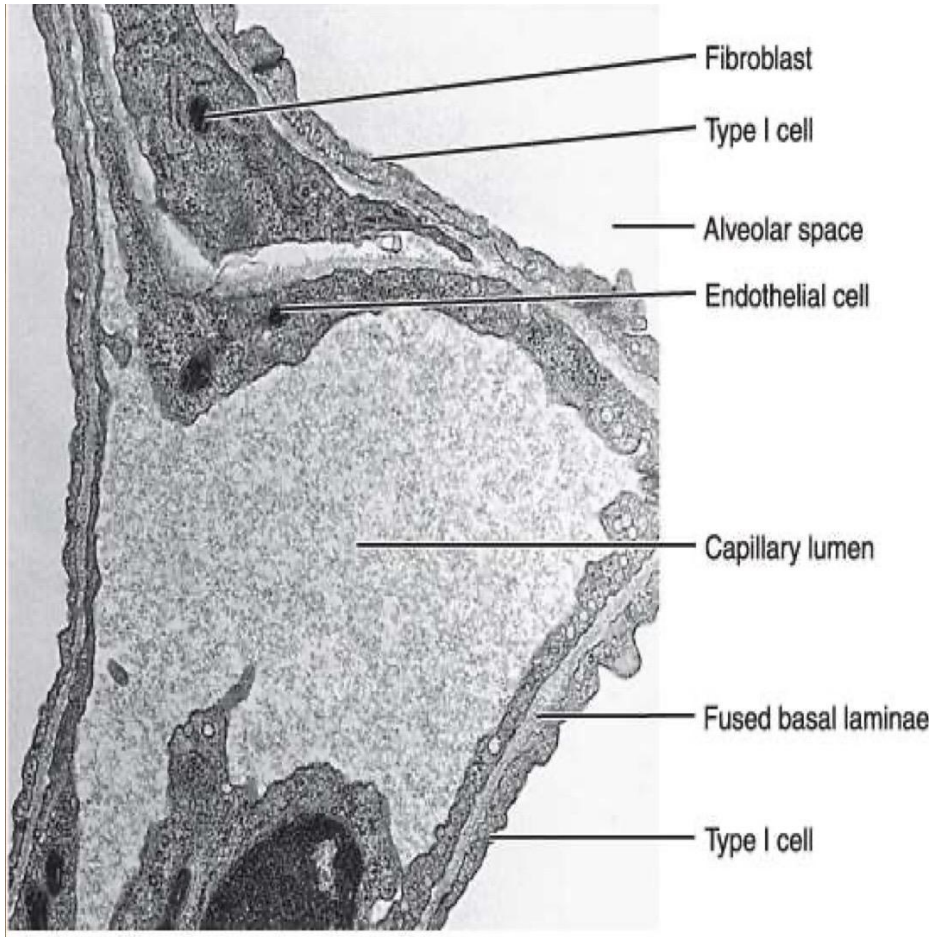
Copyright ©2006 by The McGraw-Hill Companies, Inc.
All rights reserved.

Dr.'s figure:

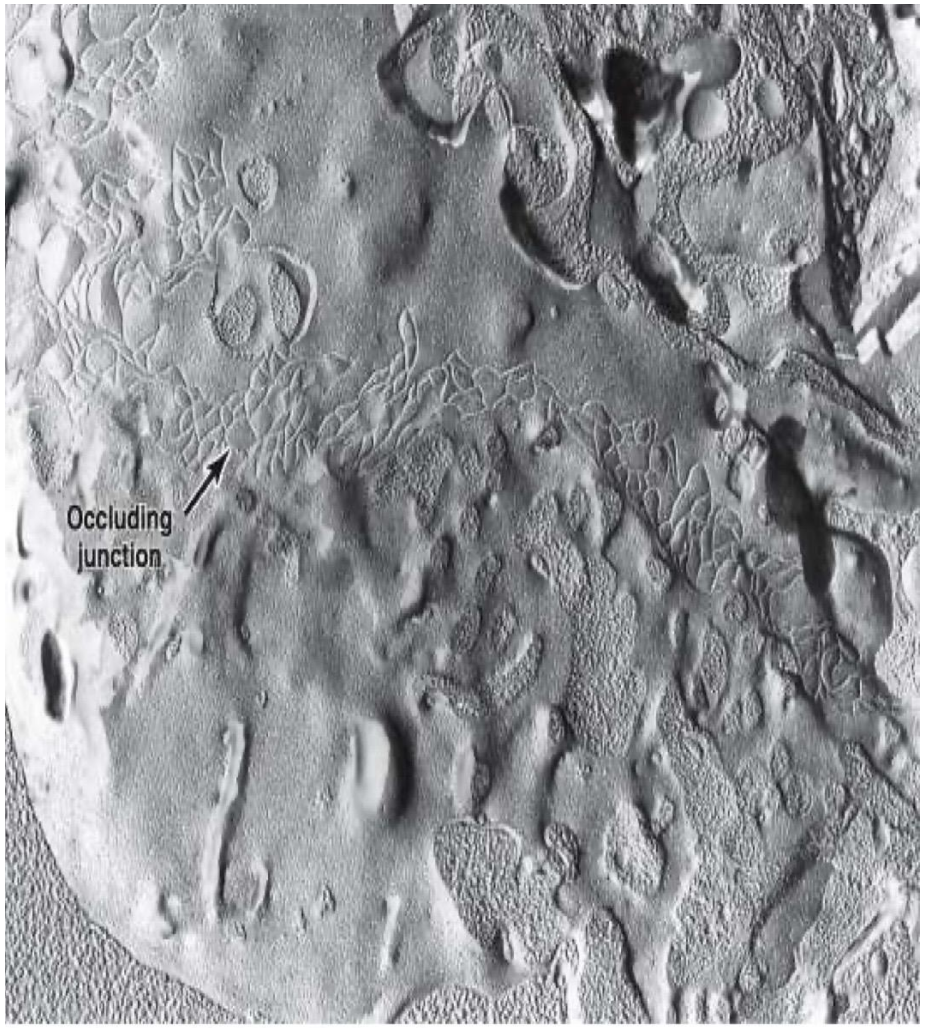
Type I Cells

- Type I cells are **simple squamous** epithelial cells that cover approximately **97%** of the **alveolar surface**.
- These cells are remarkably **thin**, with an attenuated cytoplasm measuring as little as 25 nm in width.
- **Organelles** such as the Golgi complex and mitochondria are **clustered** around the **nucleus**, leaving the peripheral cytoplasm clear.
- These cells are a critical component of the blood-air barrier.
- Type I cells contain numerous **pinocytic vesicles** and are **connected** to adjacent Type I and Type II cells via **desmosomes**. Furthermore, all Type I cells are joined by **occluding junctions.**

Type I Cells



Copyright ©2006 by The McGraw-Hill Companies, Inc.
All rights reserved.

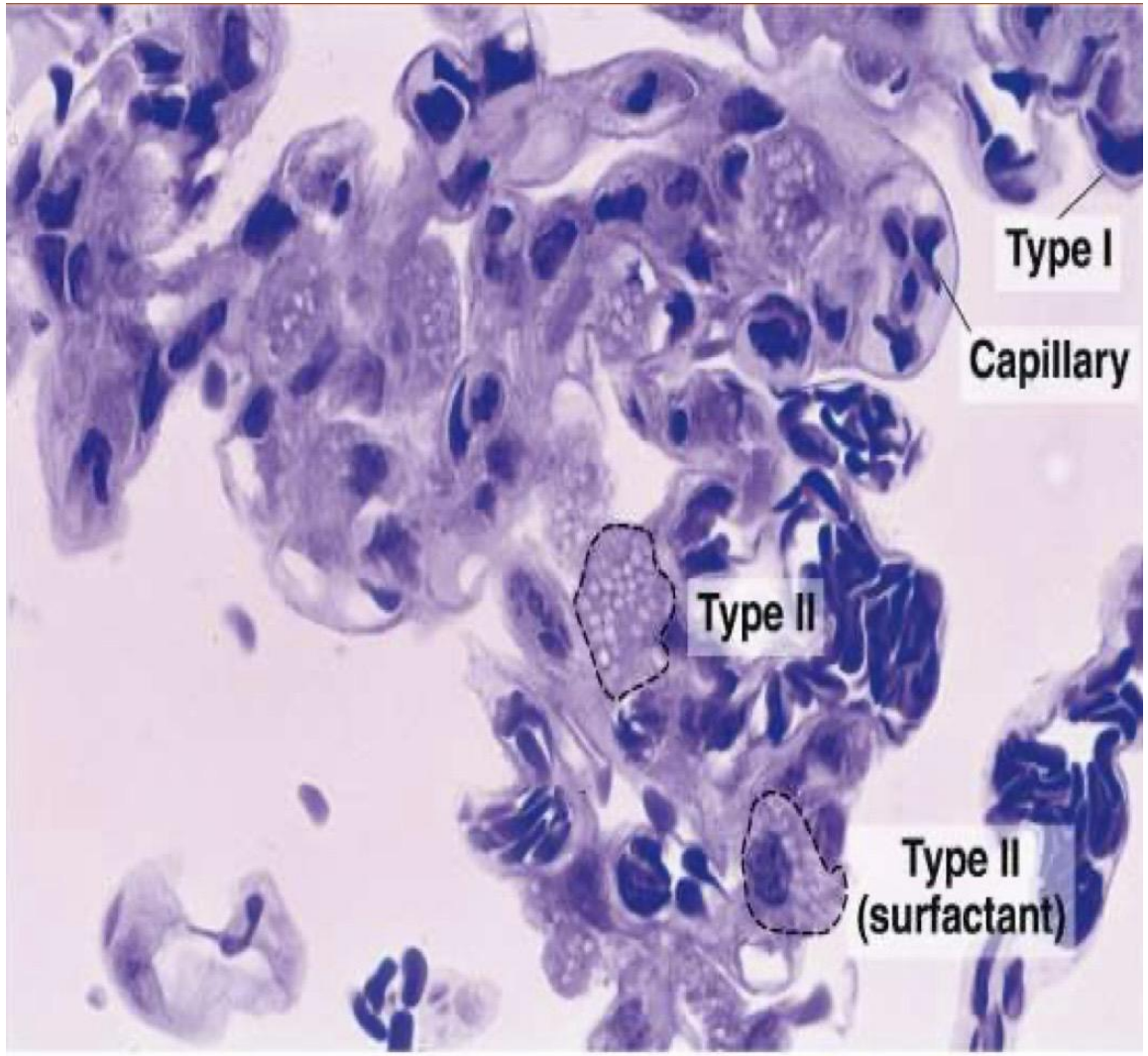


Copyright ©2006 by The McGraw-Hill Companies, Inc.
All rights reserved.

Dr.'s figures:

Type II Cells

- Type II cells are **cuboidal** cells that are **larger** than Type I pneumocytes. They are integrated into the alveolar lining via **desmosomes** and **occluding junctions** with adjacent **Type I cells**.
- Functionally, Type II cells **secrete surfactant**, which **reduces surface tension** within the alveoli—a process that is particularly critical for the first breath during the delivery of a newborn.
- Additionally, Type II cells are capable of **mitosis** and can differentiate to **replace** both **Type II** and **Type I** cells.



Copyright ©2006 by The McGraw-Hill Companies, Inc.
All rights reserved.

Dr.'s figure:

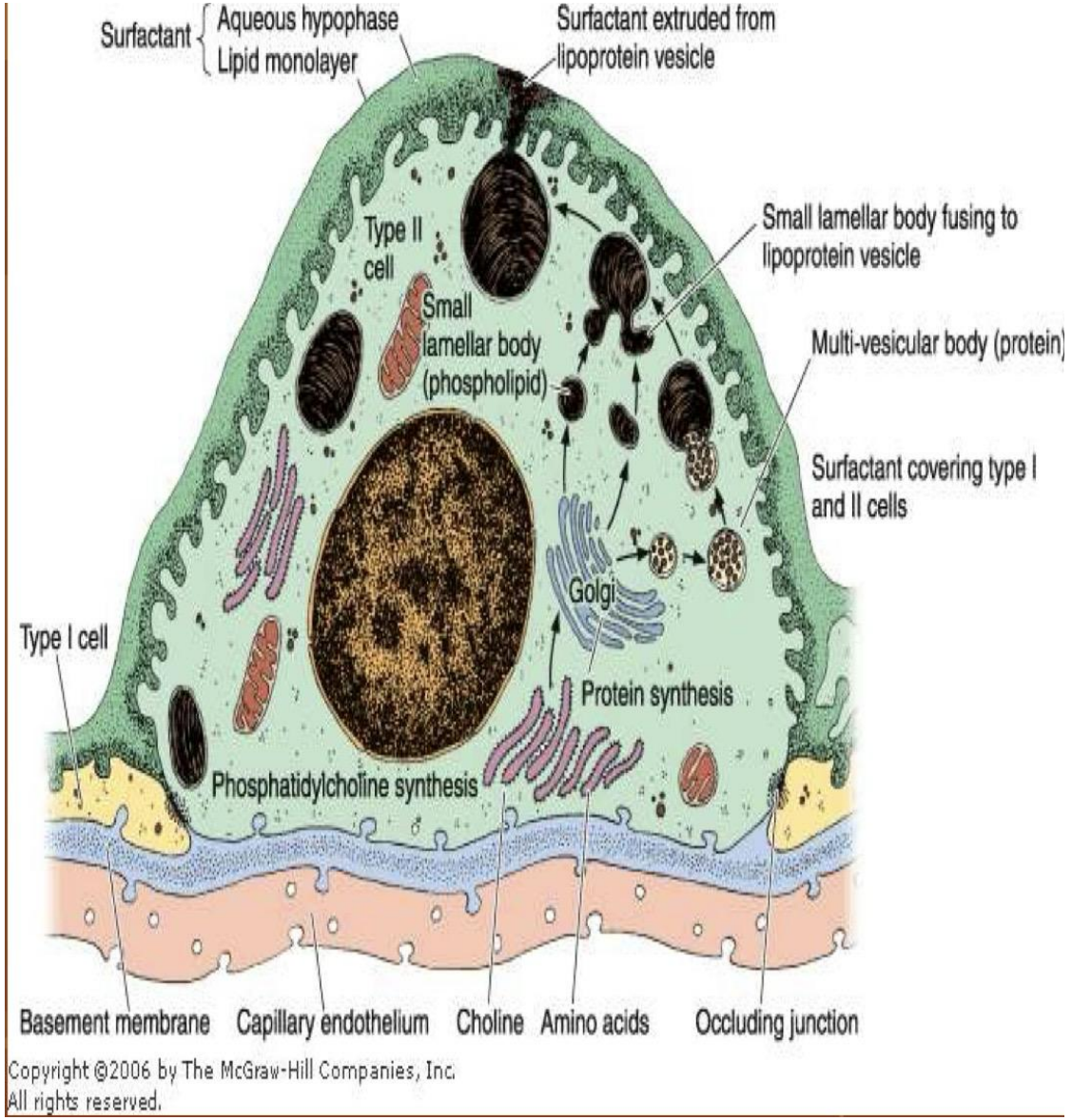
Type II Cells (great alveolar cells)

- Under electron microscopy, Type II cells are characterized by a **'foamy'** cytoplasmic appearance due to the presence of **lamellar bodies**. These specialized organelles contain **pulmonary surfactant** .

Dr.'s figure:

Pulmonary surfactant

- Pulmonary surfactant contains several types of proteins (Surfactant Proteins A, B, C, and D).
- Within the **bronchoalveolar fluid,** surfactant exerts **bactericidal** and lysozymal effects.
- Clinically, when a baby is delivered, the respiratory tract is suctioned to remove excess bronchoalveolar fluid (which contains surfactant and other secretions). Additionally, the bronchoalveolar fluid contains alveolar macrophages.



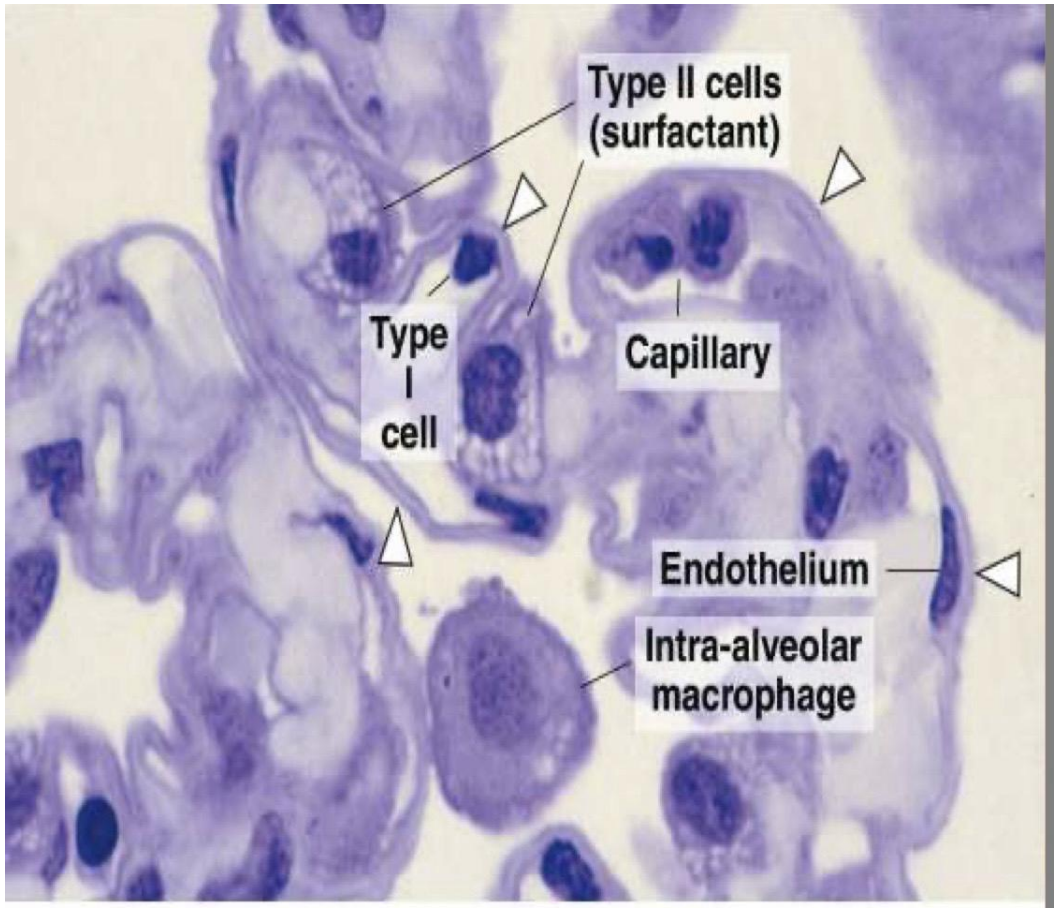
Dr.'s figure:

Alveolar-lining Regeneration

- The inhalation of nitrogen dioxide (NO2) is highly toxic, destroying the majority of the alveolar lining, specifically the **Type I** and **Type II** cells .
- However, **Type II cells** possess a **high turnover rate** and a robust regenerative capacity. Type II cells can undergo mitosis to **replace themselves** and subsequently **differentiate into new Type I cells** to restore the blood-air barrier .

Lung macrophages

- Alveolar macrophages, commonly known as **'dust cells**,' are the **most abundant** cell type in the **lung tissue**—even **outnumbering Type I** alveolar cells.
- Originating from blood **monocytes**, these macrophages are primarily found within the **interalveolar septa** and on the **pleural surface**.
- They appear as distinct **black dots** due to the accumulation of inhaled carbon and debris.

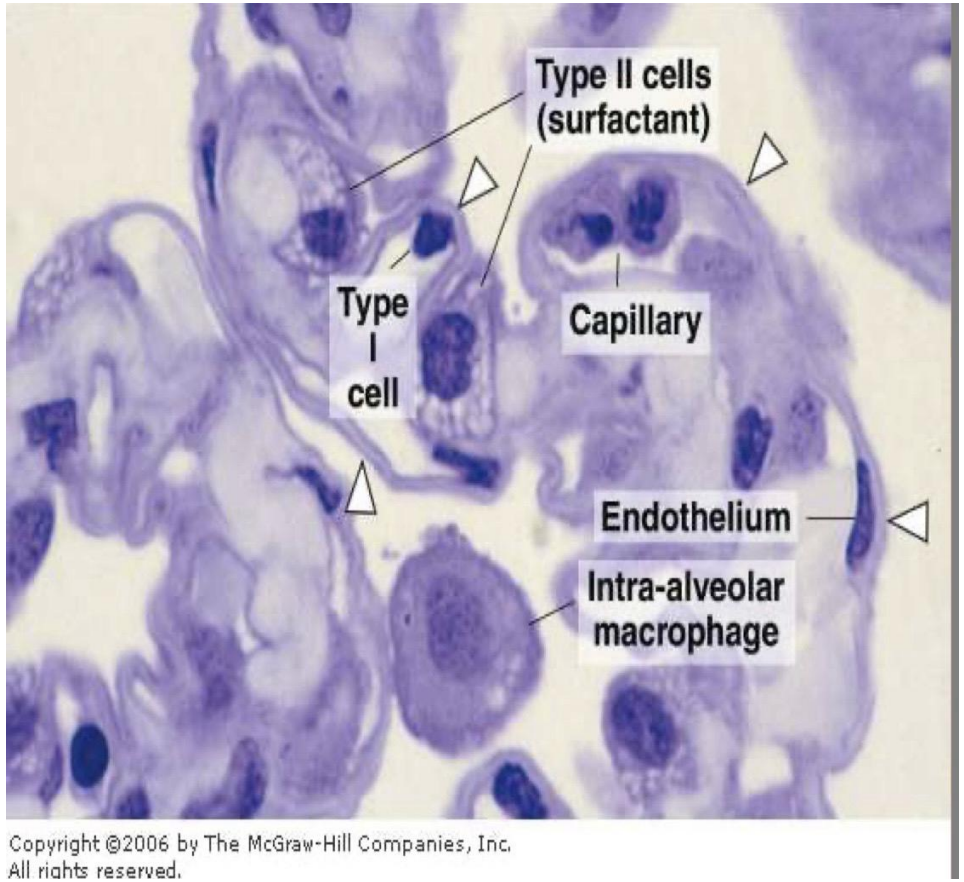


Copyright ©2006 by The McGraw-Hill Companies, Inc.
All rights reserved.

Dr.'s figure:

Lung macrophages

- Their primary function is to **phagocytose** bacteria, viruses, and foreign particles.
- Once they have engulfed debris, they can **migrate up** the respiratory tract through the bronchioles and bronchi toward the pharynx, where they are eventually expectorated in the saliva or swallowed.

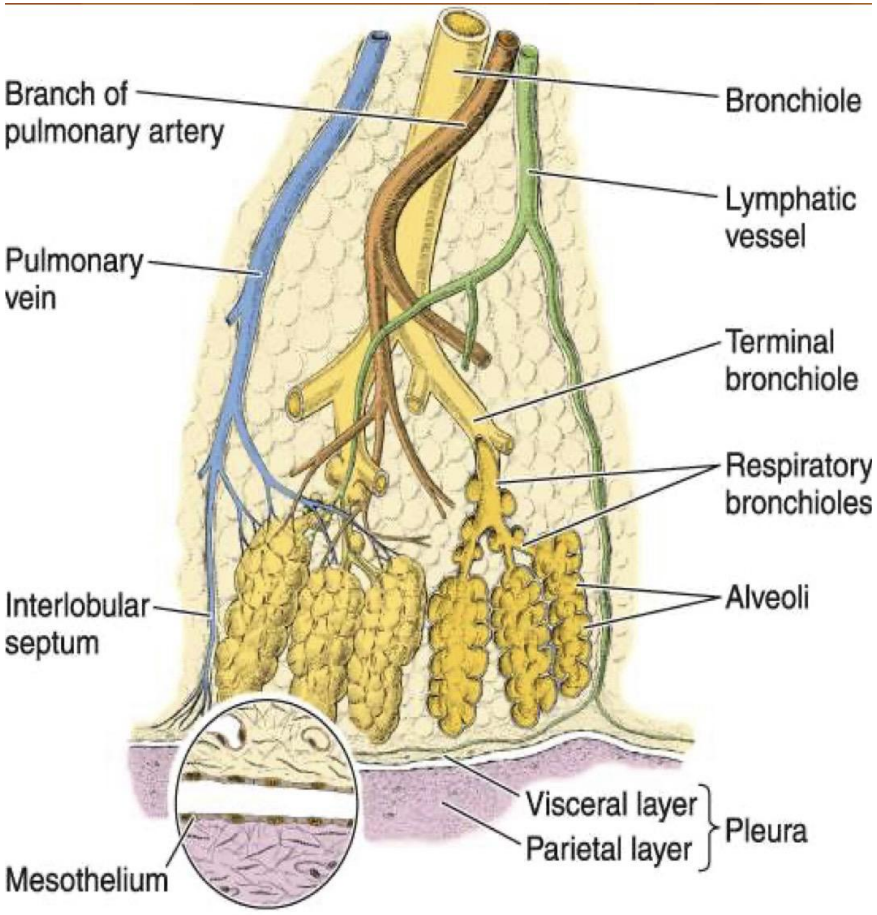


Copyright ©2006 by The McGraw-Hill Companies, Inc.
All rights reserved.

Dr.'s figure:

Pulmonary Blood Vessels

- The bronchopulmonary segment is **pyramidal** in shape, with an apex and a base. As the airway extends distally, bronchi branch into bronchioles and eventually terminate in alveoli.
- The lung receives a dual blood supply: the **pulmonary circulation** for **gas exchange** and the **bronchial circulation** for **tissue nutrition**.
- The **pulmonary arteries** carry **deoxygenated blood** and **follow** the **branching** of the **bronchioles** within the **center** of the **bronchopulmonary segments**.
- In contrast, the **pulmonary veins** carry **oxygenated blood** from the **alveoli** and are located **within** the **connective tissue septa** at the **periphery** of these segments.

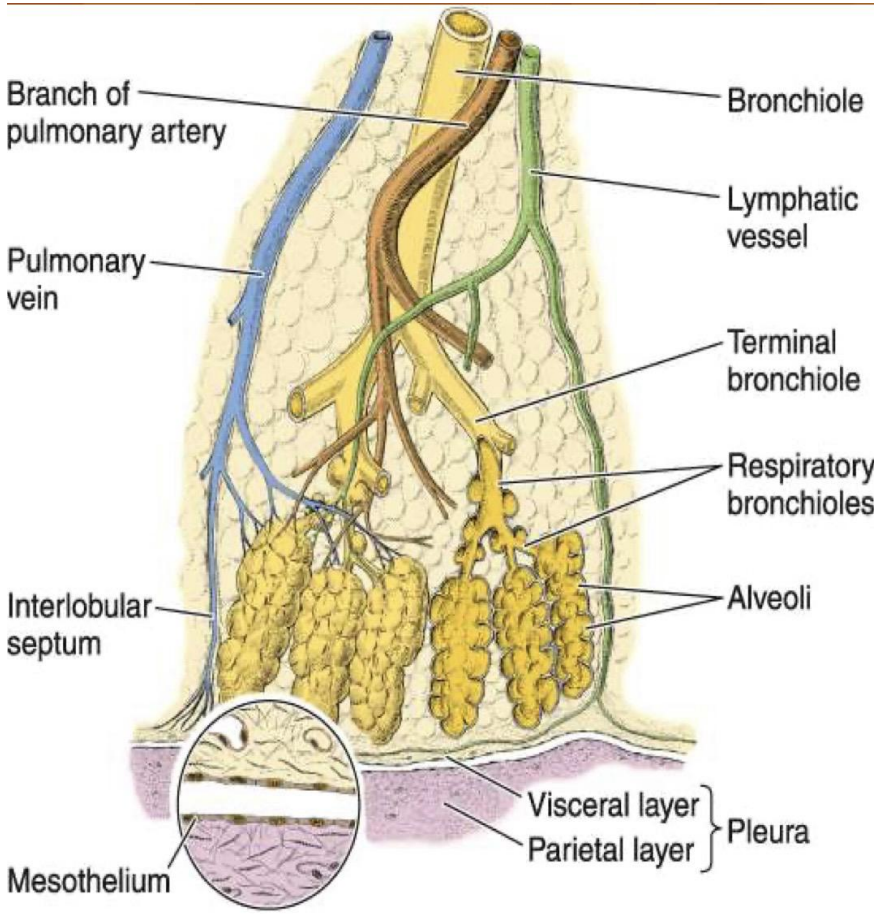


Copyright ©2006 by The McGraw-Hill Companies, Inc.
All rights reserved.

Dr.'s figure:

Pulmonary Blood Vessels

- Ultimately, **four pulmonary veins** drain into the **left atrium.**
- The **lung tissue** itself is primarily **nourished** by the **bronchial arteries** (nutrient vessels), which typically arise from the **descending thoracic aorta** or the **posterior intercostal arteries.**



Copyright ©2006 by The McGraw-Hill Companies, Inc.
All rights reserved.

Dr.'s figure:

Pulmonary lymphatic Vessels

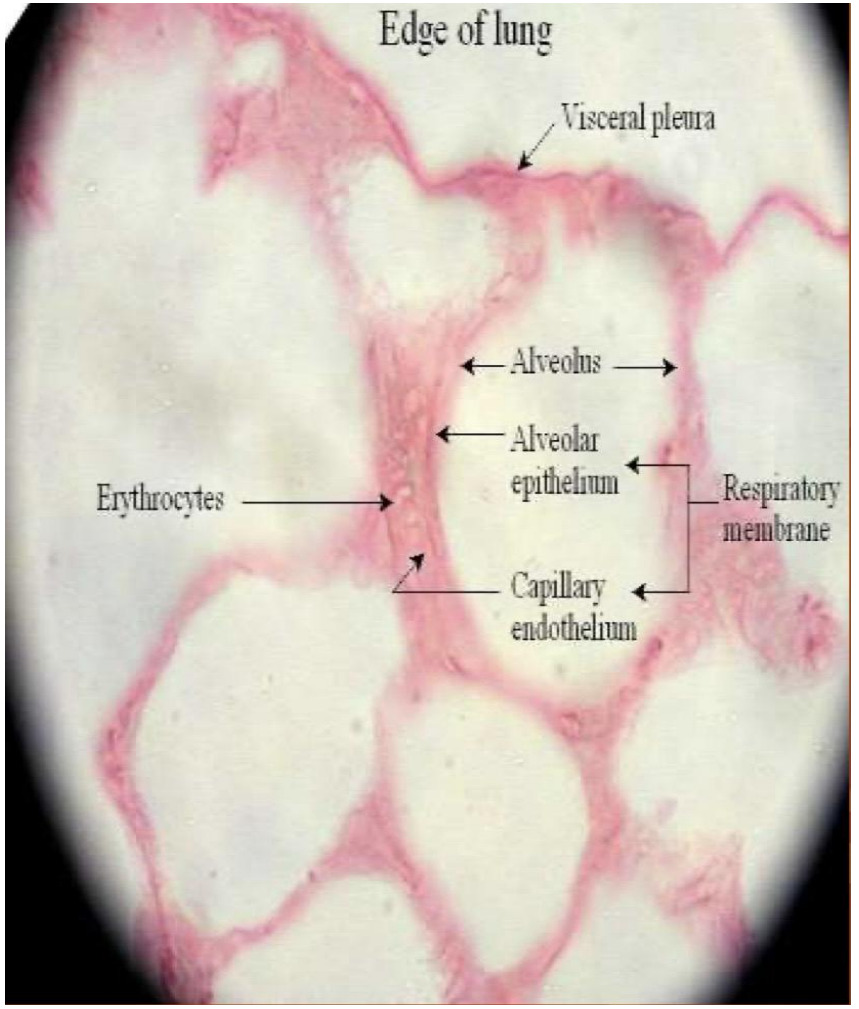
- The pulmonary lymphatic system is organized into two primary networks: the **superficial** and **deep lymphatic plexuses**.
- Lymph from both networks flows toward the **hilum** of the **lung**, before reaching the **mediastinal lymph trunks**.
- On the **left** side, the lymph eventually drains into the **thoracic duct,** while on the **right** side, it enters the **right lymphatic duct**
- Eventually, these ducts empty into the **origin of the brachiocephalic veins** on **both sides** of the body.

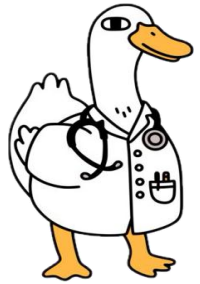
Nerves

- The **lung tissue** and **visceral pleura** receive **dual** innervation from the **autonomic** nervous system. **Sympathetic** stimulation induces **bronchodilation**, while **parasympathetic** stimulation (via the **vagus** nerve) causes **bronchoconstriction**.
- **Sensation**, including pain, touch, and temperature, is carried by **afferent fibers** that travel alongside these autonomic pathways toward the central nervous system.

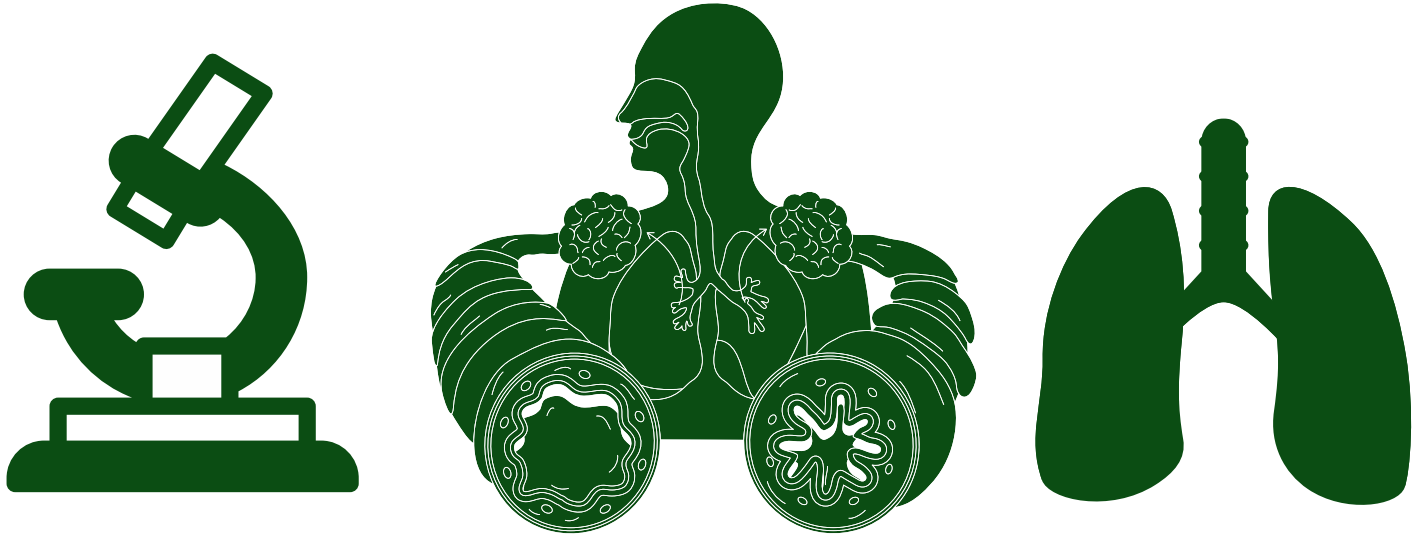
Pleura

- The pleura consists of two layers: the **visceral** pleura, which covers the lungs, and the **parietal** pleura, which lines the thoracic cavity. Both layers are composed of **mesothelium** (**simple squamous** epithelium) supported by a submesothelial layer of **collagen**, **elastic**, and **reticular fibers.**
- This connective tissue framework provides the elastic recoil and structural integrity necessary for **lung inflation** and **deflation**. The functional tissue of the lung, which includes the **alveoli** and their **associated structures**, is referred to as the **pulmonary parenchyma**.





Dr.'s figure:



HISTOLOGY QUIZ LECTURE 2

For any feedback, scan the code or click on it.

Corrections from previous versions:

Versions	Slide # and Place of Error	Before Correction	After Correction
V0 → V1	18	The **nuclei** of endothelial cells contain 	Adjacent to the nucleus
V1 → V2			