

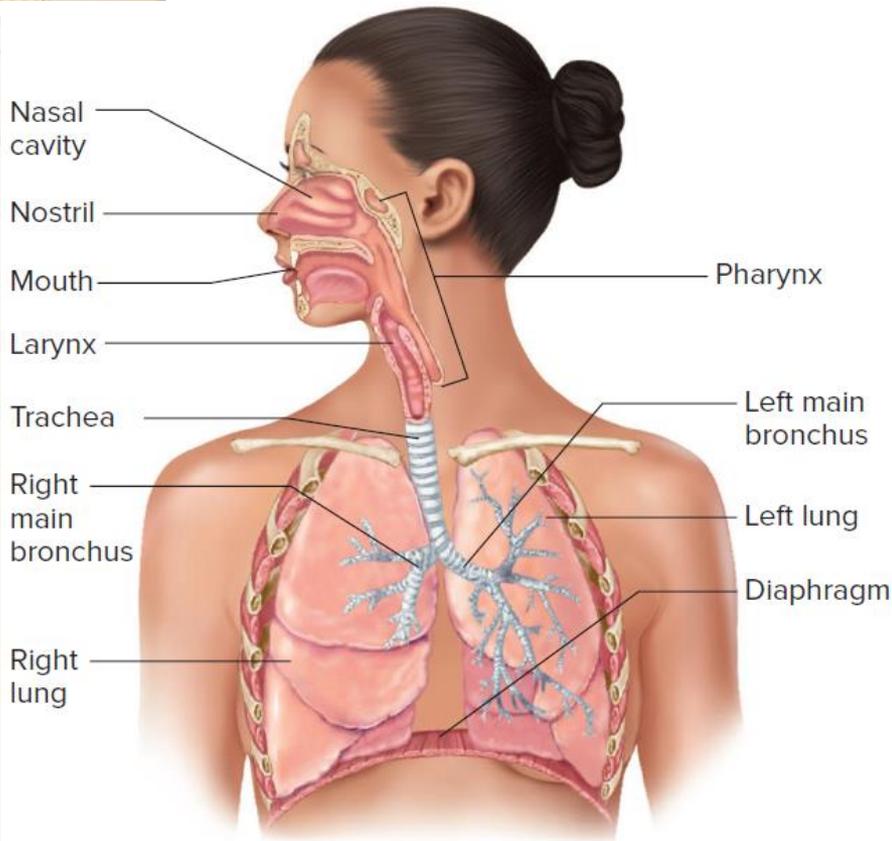
B.Sc. (H) Biochemistry
IIInd Year, IVth Sem
Human Physiology
Respiratory System

Organization of the pulmonary system

Lecture-1 & 2

Dr. Prabha Arya

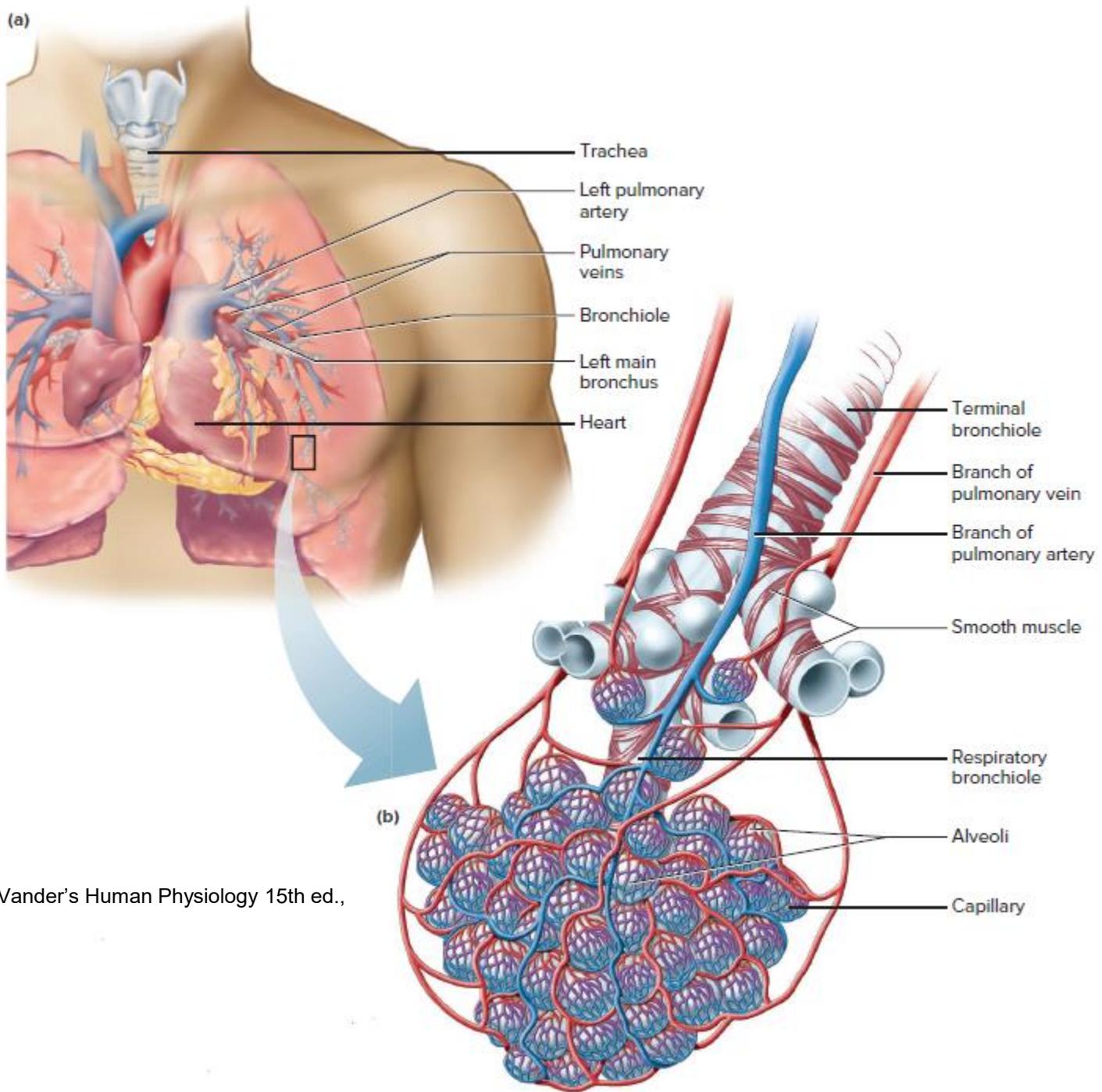
Respiratory System



Vander's Human Physiology 15th ed.,

- Consists of an **upper respiratory tract (nose to larynx)** and a **lower respiratory tract (trachea onwards)** .
- **Conducting portion** transports air.
 - includes the nose, nasal cavity, pharynx, larynx, trachea, and progressively smaller airways, from the primary bronchi to the terminal bronchioles
- **Respiratory portion** carries out gas exchange.
 - composed of small airways called respiratory bronchioles and alveolar ducts as well as air sacs called alveoli

(a)



Vander's Human Physiology 15th ed.,

Respiratory System Functions

1. supplies the body with oxygen and disposes of carbon dioxide
2. filters inspired air
3. produces sound
4. contains receptors for smell
5. rids the body of some excess water and heat
6. helps regulate blood pH

Breathing

- Breathing (pulmonary ventilation). consists of two cyclic phases:
- **inhalation**, also called inspiration - draws gases into the lungs.
- **exhalation**, also called expiration - forces gases out of the lungs.

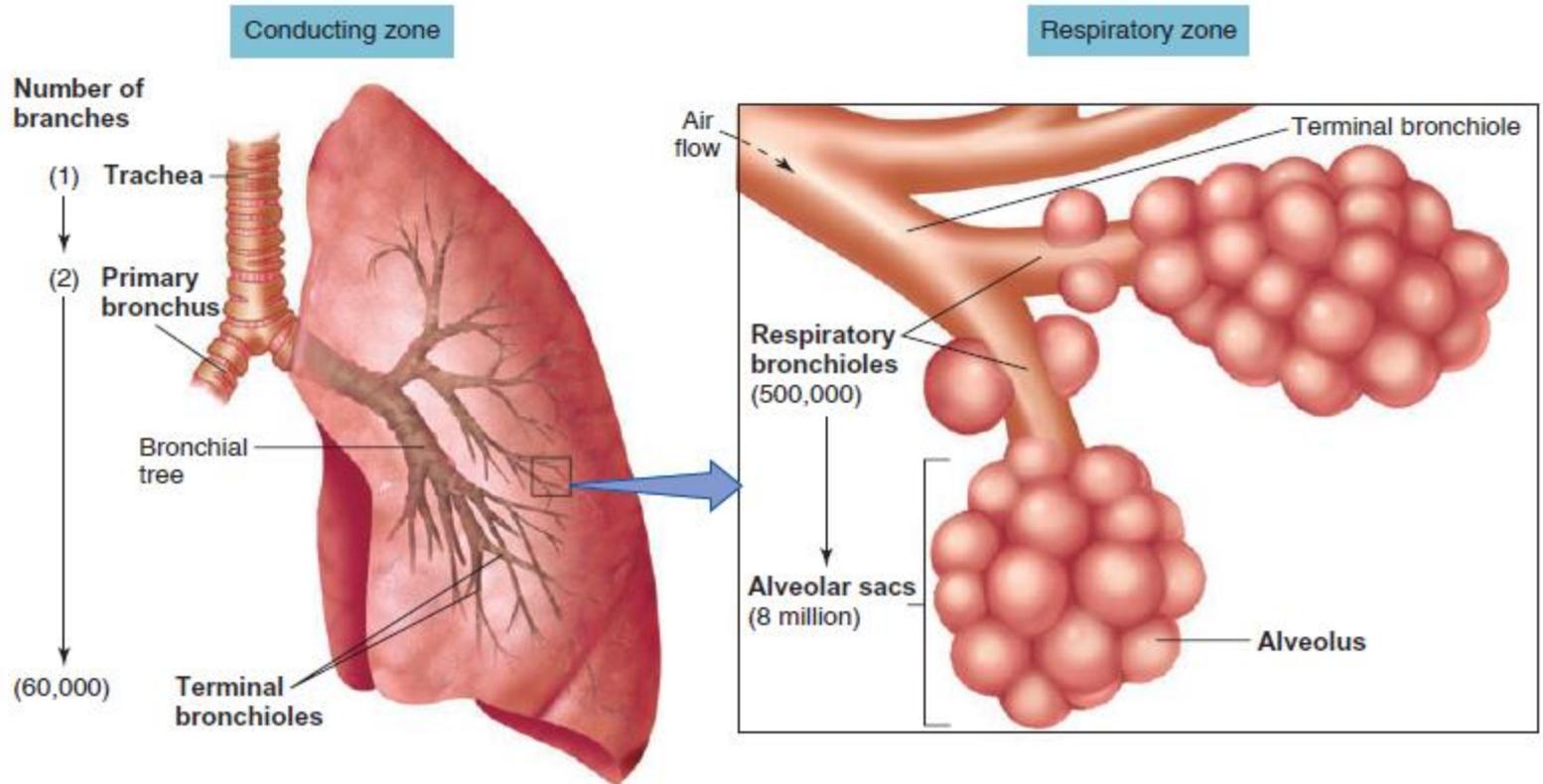
The Respiratory Tract

- Consists of a conducting zone:
 - from nasal cavity to terminal bronchioles
- Consists of a respiratory zone:
 - from respiratory bronchioles to alveoli

Alveoli:- These are air-filled pockets within the lungs

- where all gas exchange takes place

Conducting zone and respiratory Zone



Conducting zone and respiratory Zone

| | Name of branches | Number of tubes in branch |
|------------------|-------------------------|----------------------------|
| Conducting zone | Trachea | 1 |
| | Bronchi | 2 |
| | | 4 |
| | | 8 |
| | Bronchioles | 16 |
| | Terminal bronchioles | 32 ↓ 6×10^4 |
| Respiratory zone | Respiratory bronchioles | ↓ 5×10^5 |
| | Alveolar ducts | ↓ |
| | Alveolar sacs | ↓ 8×10^6 |

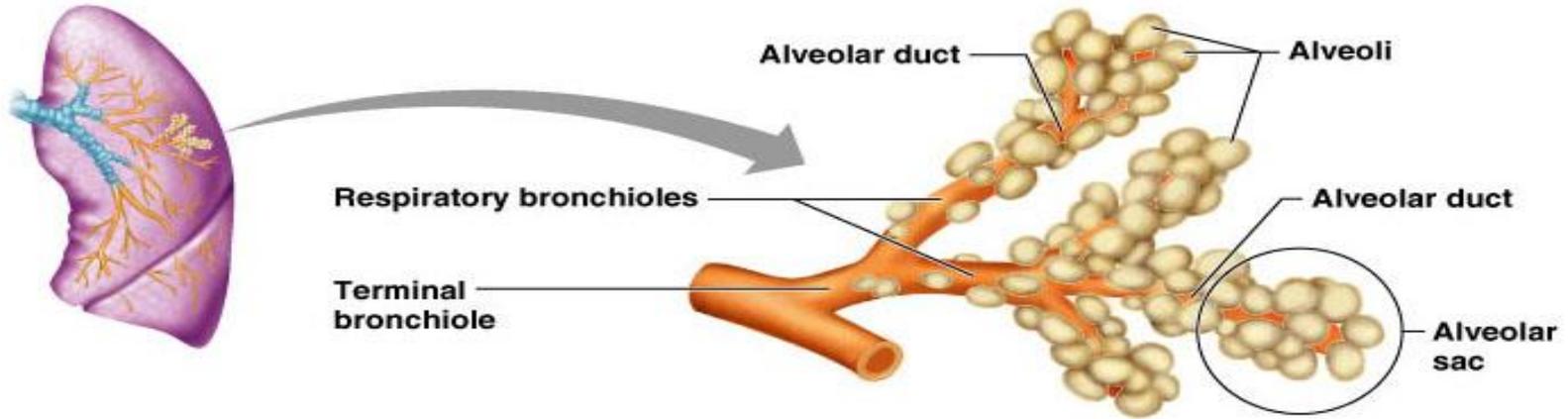
Conducting zone

- **Conduction zone** extends from the top of the trachea to the beginning of the respiratory bronchioles.
 - Consists of nasal cavity to terminal bronchioles.
 - This zone contains no alveoli and has exchange with the blood.
- The airways beyond the larynx can be divided into two zones. The **conducting zone** extends from the top of the trachea to the end of the terminal bronchioles.
- This zone contains no alveoli and does not exchange gases with the blood.

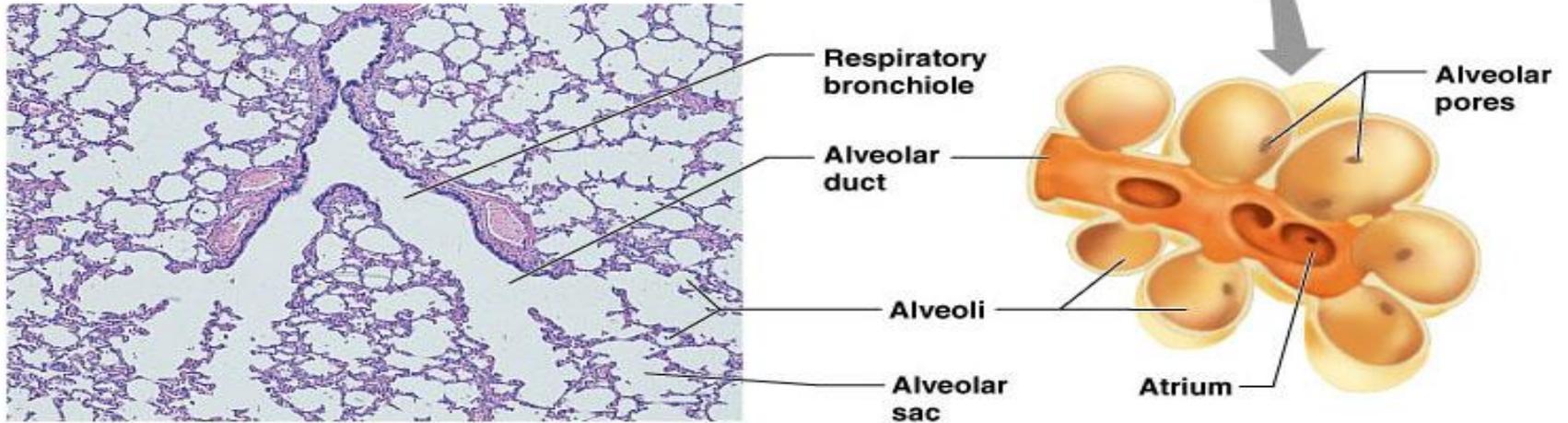
Respiratory zone

- It extends from the bronchioles down.
- The **respiratory zone** is where gas is exchanged
 - Consists of alveoli, alveolar sacs, alveolar ducts and respiratory bronchioles

Respiratory Zone



(a)

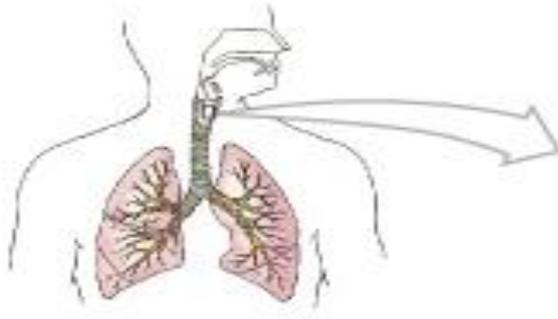


(b)

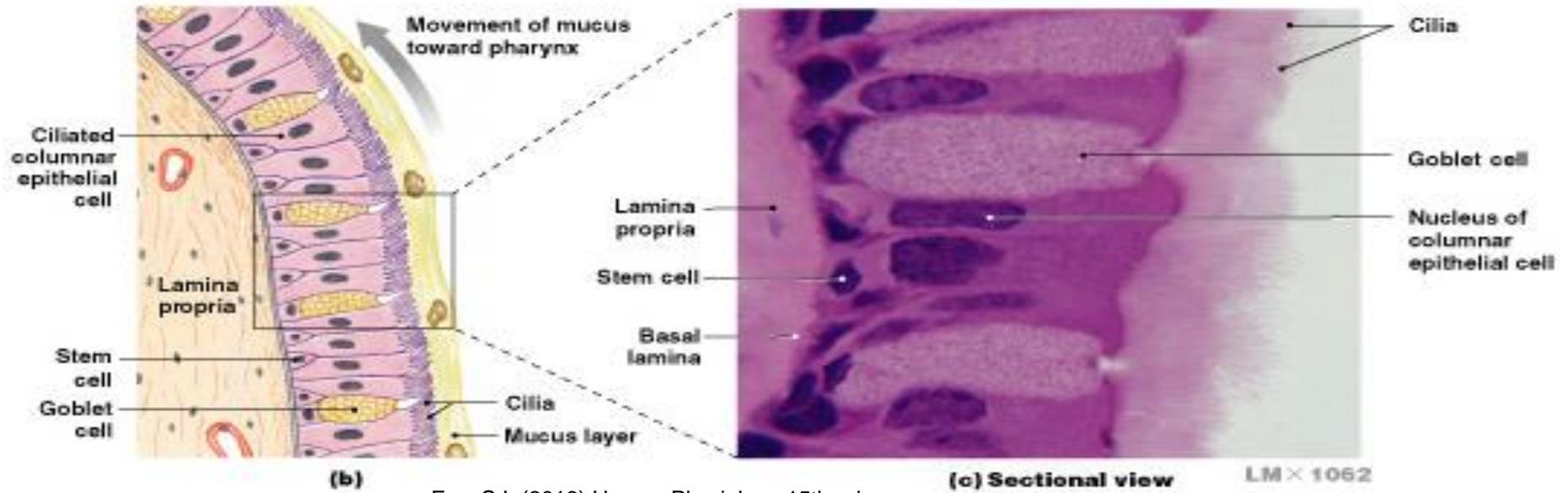
The Respiratory Epithelium

- For gases to exchange efficiently:
 - alveoli walls must be very thin ($< 1 \mu\text{m}$)
 - surface area must be very large (about 35 times the surface area of the body)
- Alveolar Epithelium
- Is a very delicate, simple squamous epithelium
- Contains scattered and specialized cells
- Lines exchange surfaces of alveoli

Respiratory epithelium

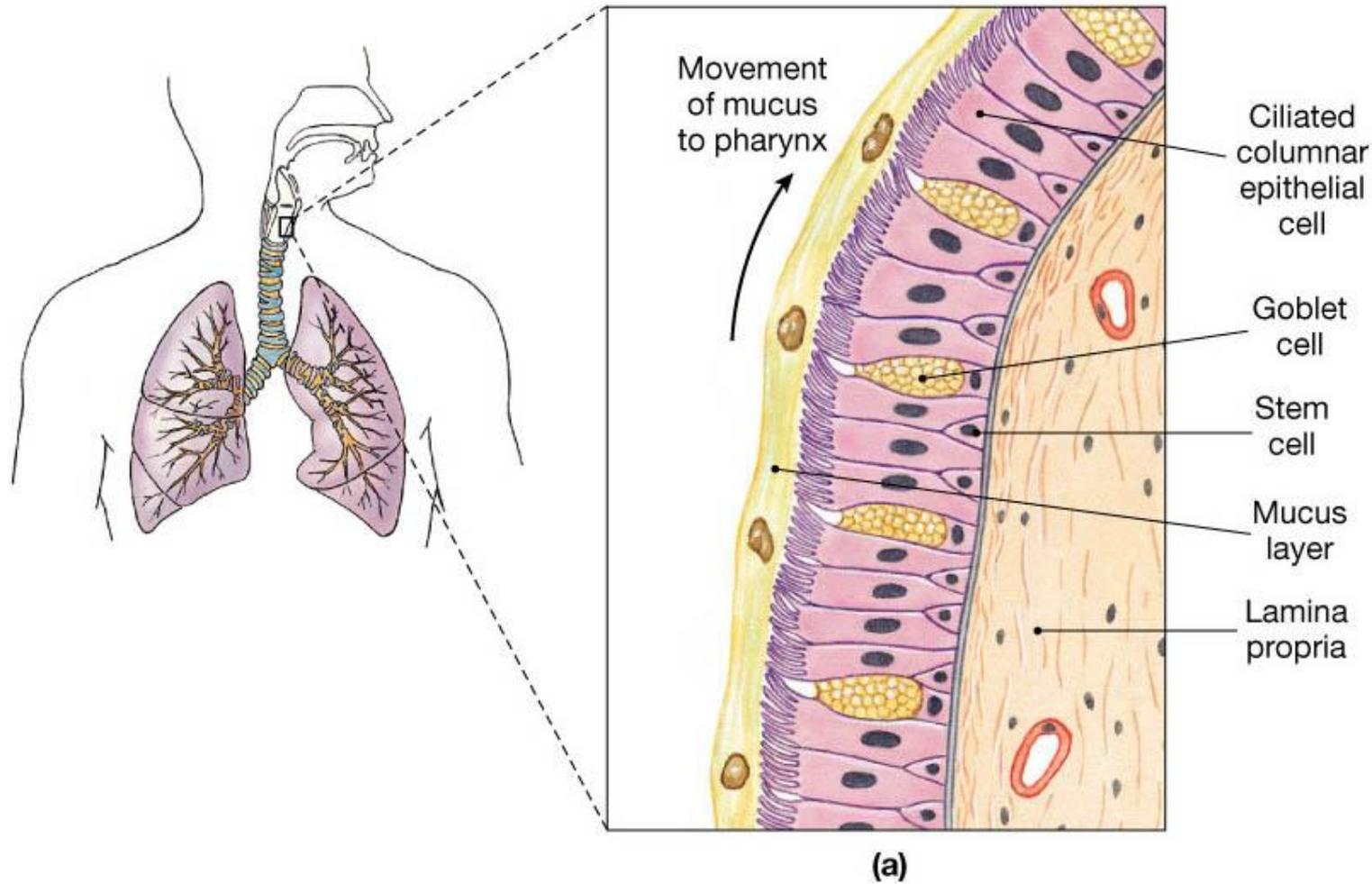


(a) Superficial view SEM $\times 1614$



Respiratory mucosa

- A layer of **pseudostratified ciliated columnar epithelial cells** that secrete mucus
- Found in nose, sinuses, pharynx, larynx and trachea
- Only present in conduction zone
- Mucus can trap contaminants
 - Cilia move mucus up towards mouth



Fox, S.I. (2018) Human Physiology 15th ed.,

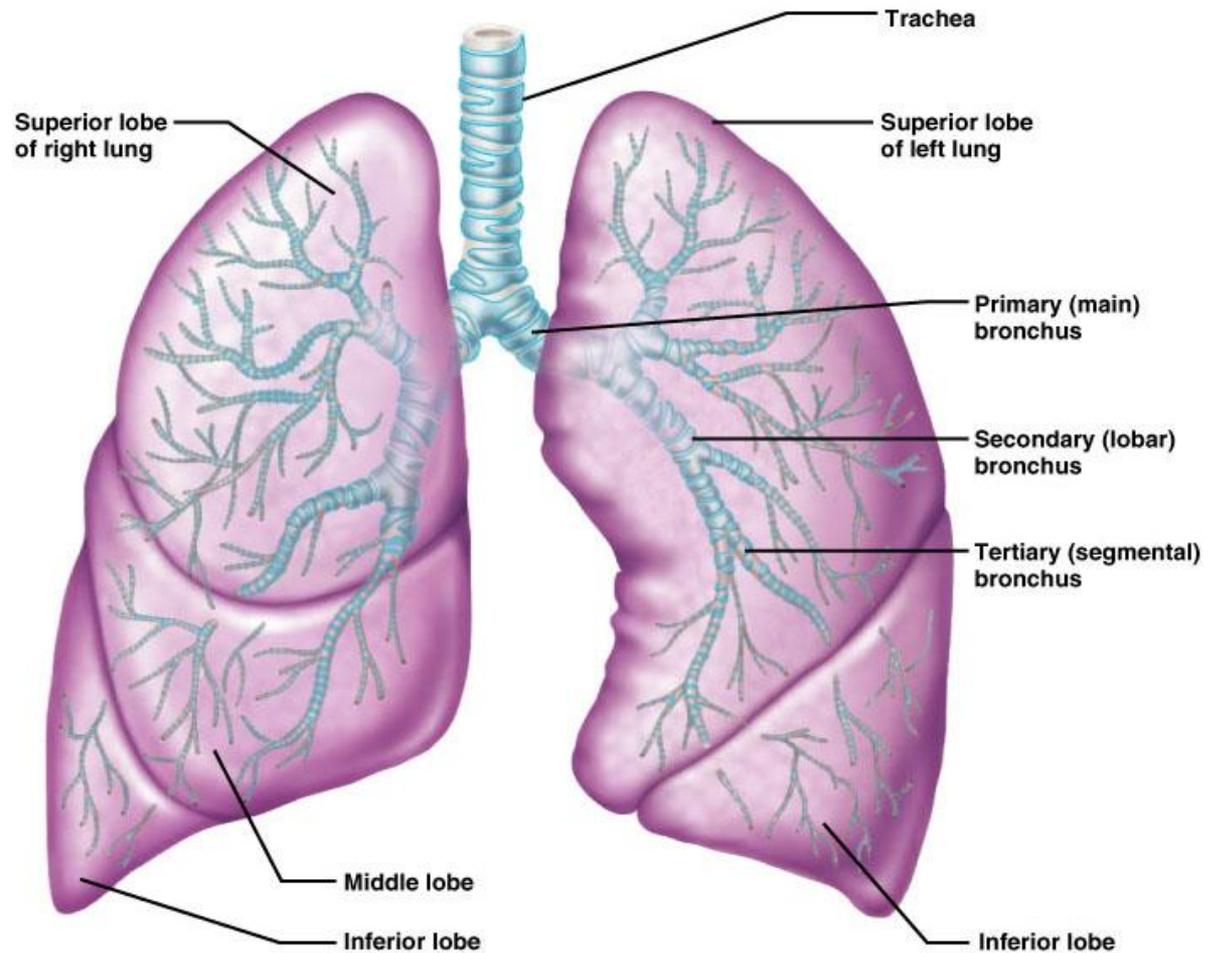
Upper Respiratory Tract

- Composed of the nose and nasal cavity, paranasal sinuses, pharynx (throat), larynx.
- All are part of the conducting portion of the respiratory system.
- This passage filter, warm and humidify incoming air

Lower Respiratory Tract

- **Conducting airways** (trachea, bronchi, up to terminal bronchioles).
- **Respiratory portion** of the respiratory system (respiratory bronchioles, alveolar ducts, and alveoli).

lower respiratory tract



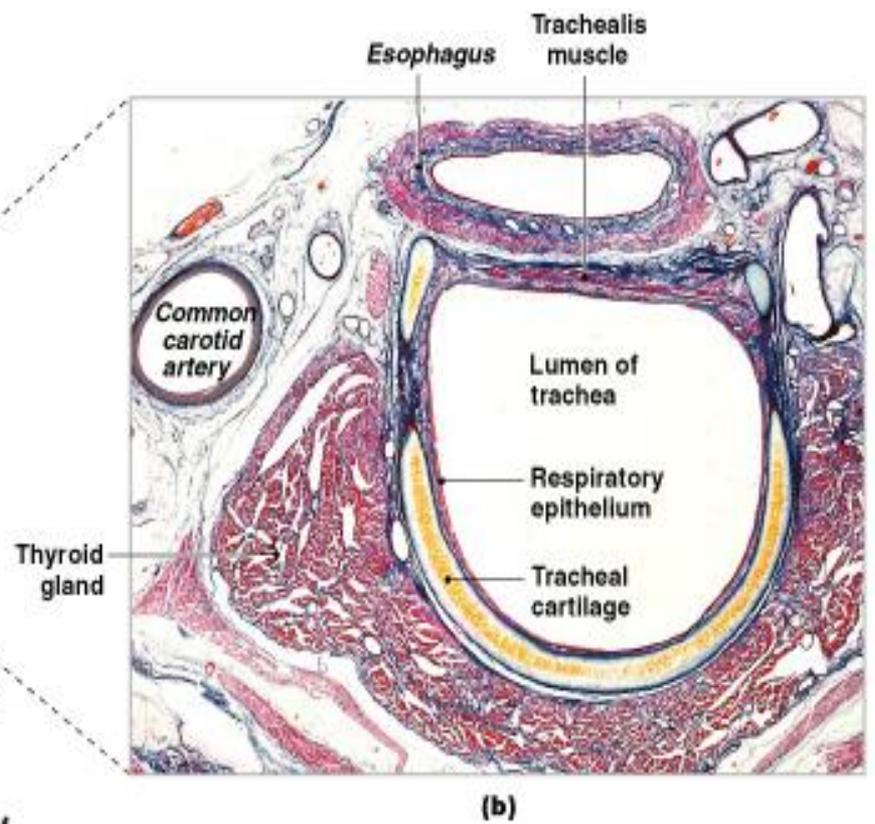
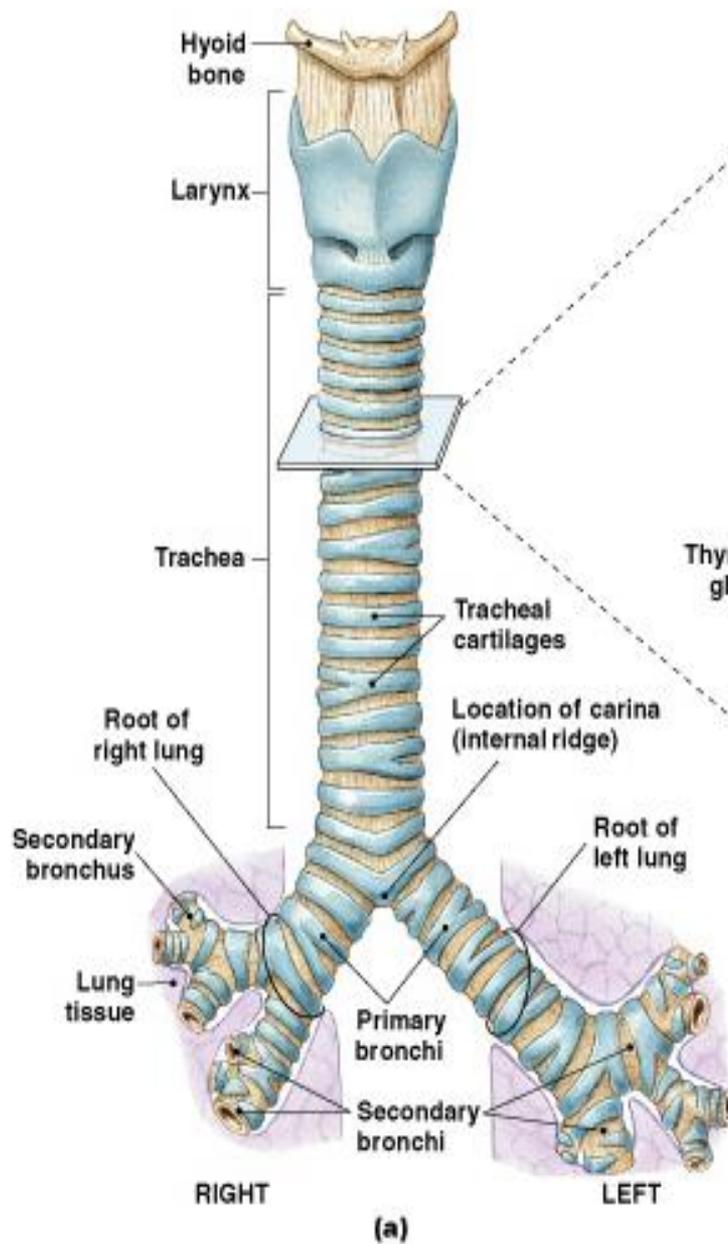
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Trachea

- A flexible tube also called **windpipe**.
- Extends through the mediastinum and lies anterior to the esophagus and inferior to the larynx.
- Anterior and lateral walls of the trachea supported by 15 to 20 C-shaped **tracheal cartilages**.
- Cartilage rings reinforce and provide rigidity to the tracheal wall to ensure that the trachea remains open at all times
- Posterior part of tube lined by **trachealis** muscle
- Lined by **ciliated pseudostratified columnar epithelium**.

Trachea

- At the level of the sternal angle, the trachea bifurcates into two smaller tubes, called the **right and left primary bronchi**.
- Each primary bronchus projects laterally toward each lung.
- The most inferior tracheal cartilage separates the primary bronchi at their origin and forms an internal ridge called the **carina**.



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Bronchial tree

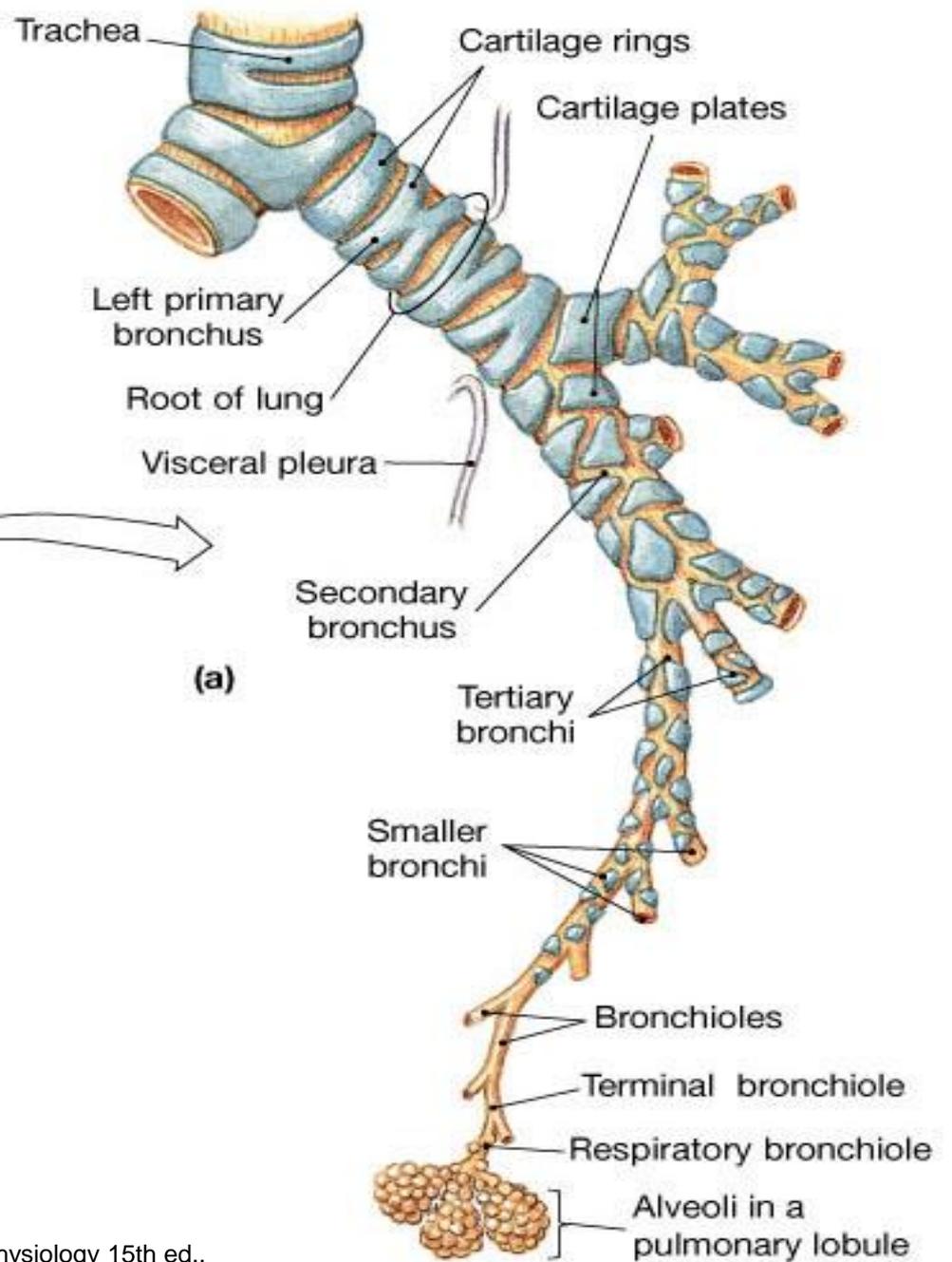
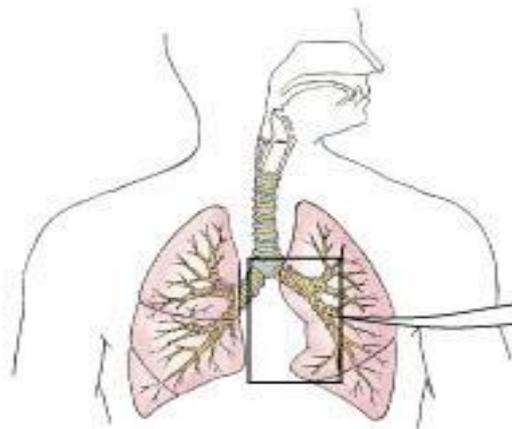
- A highly branched system of air-conducting passages that originate from the left and right primary bronchi.
- Progressively branch into narrower tubes as they diverge throughout the lungs before terminating in **terminal bronchioles**.
- **Incomplete rings of hyaline cartilage** support the walls of the primary bronchi to ensure that they remain open.
- Right primary bronchus is shorter, wider, and more vertically oriented than the left primary bronchus.
- Foreign particles are more likely to lodge in the right primary bronchus.

Bronchial tree

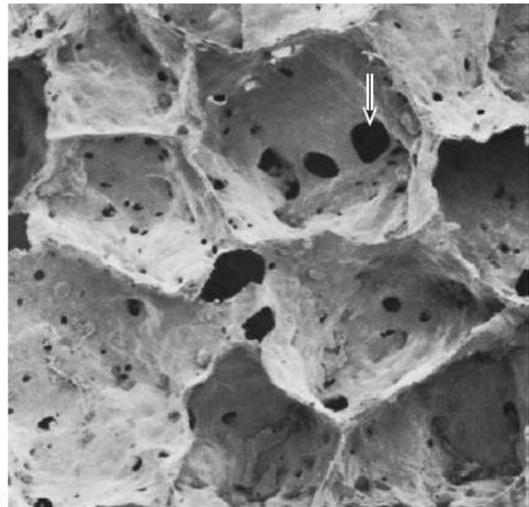
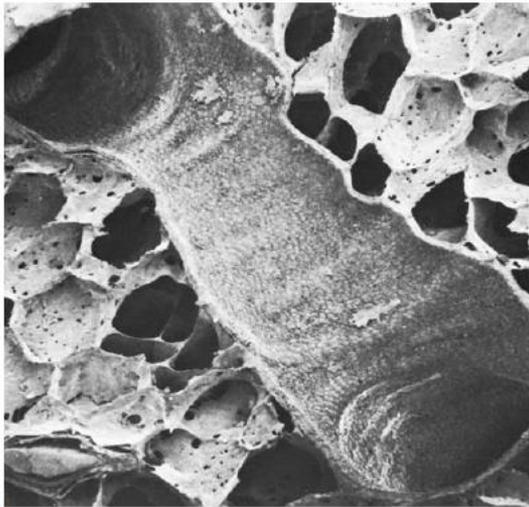
- The primary bronchi enter the **hilus** of each lung together with the pulmonary vessels, lymphatic vessels, and nerves.
- Each primary bronchus branches into several **secondary bronchi** (or lobar bronchi).
- The left lung has two secondary bronchi. The right lung has three secondary bronchi.
- They further divide into **tertiary bronchi**.
- Each tertiary bronchus is called a segmental bronchus because it supplies a part of the lung called a **bronchopulmonary segment**.

Bronchial Tree

- **Secondary bronchi → tertiary bronchi → bronchioles → terminal bronchioles**
- with successive branching amount of cartilage decreases and amount of smooth muscle increases, this allows for variation in airway diameter
- during exertion and when sympathetic division active → **bronchodilation**
- mediators of allergic reactions like histamine → **bronchoconstriction**
- epithelium gradually changes from **ciliated pseudostratified columnar epithelium to simple cuboidal epithelium** in terminal bronchioles



A scanning electron micrograph of lung tissue

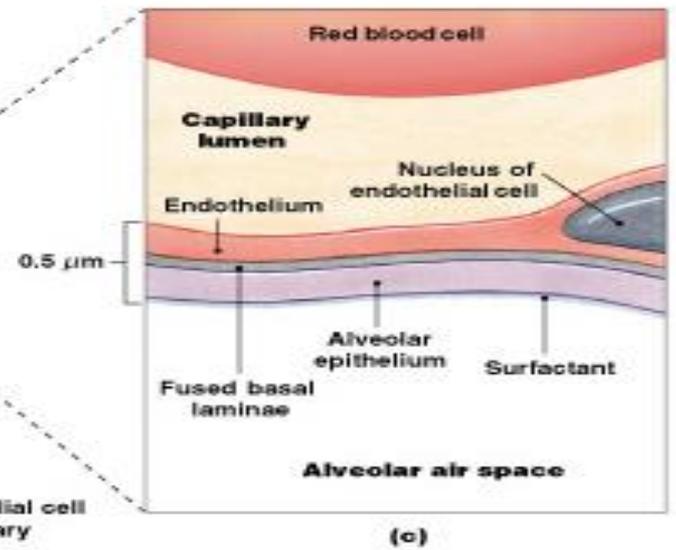
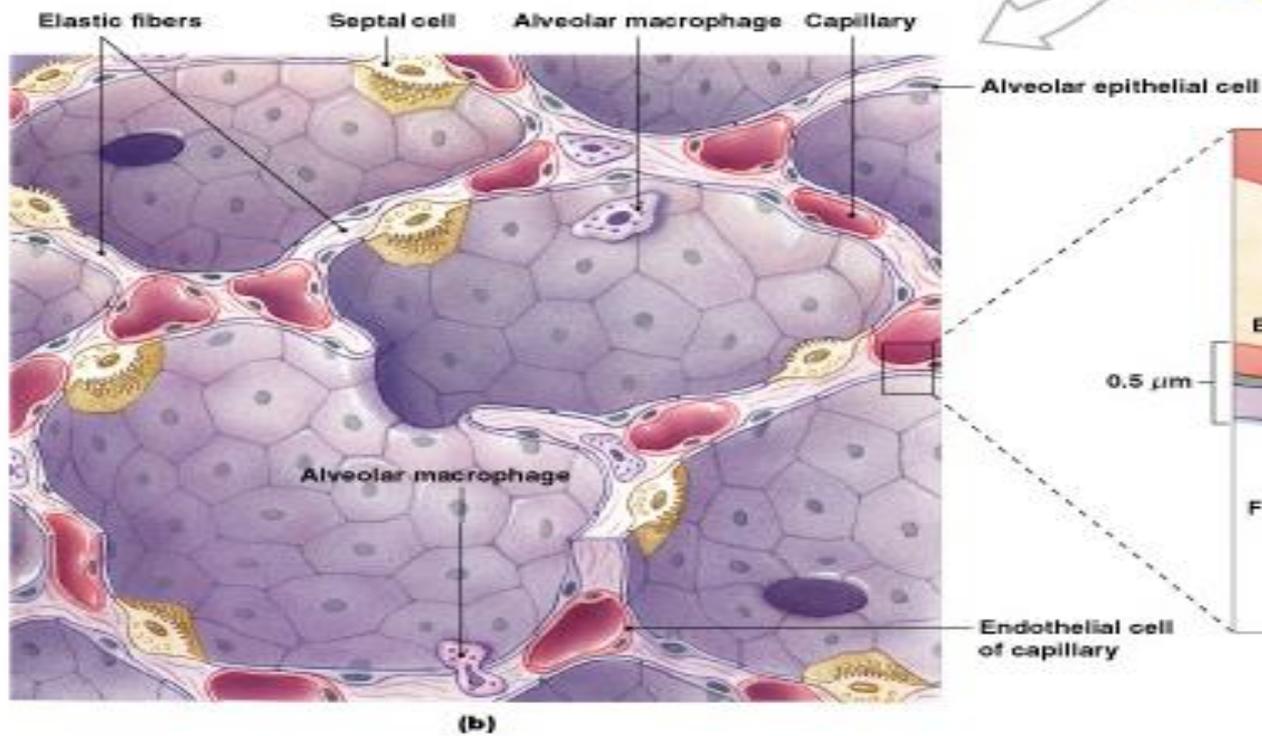
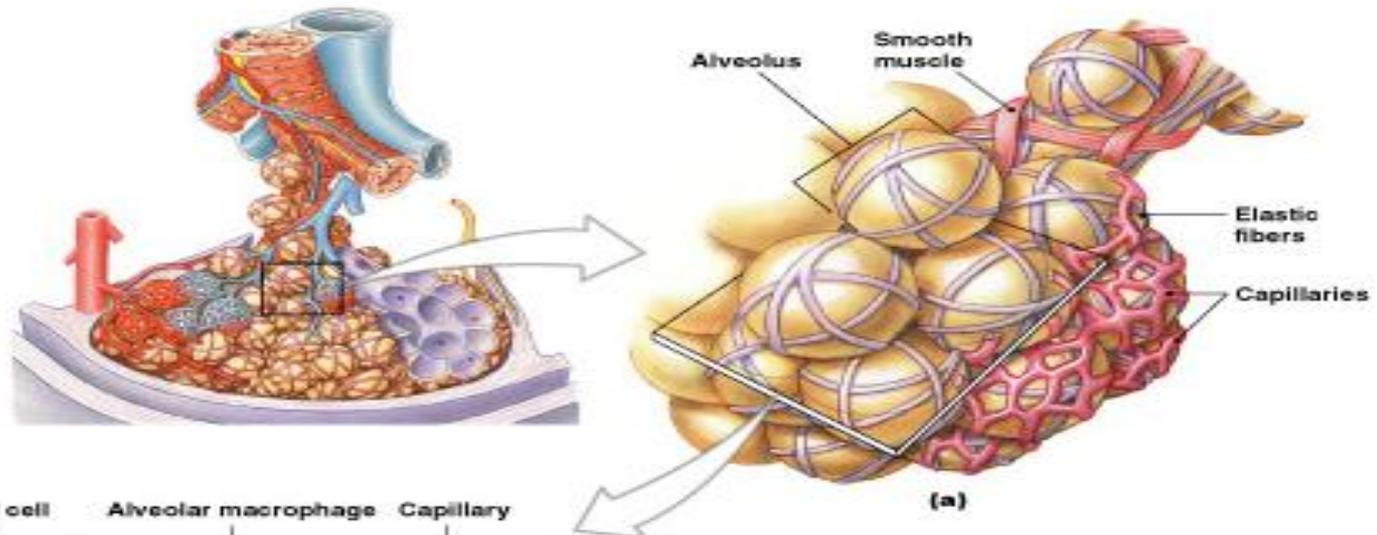


- (a) A small bronchiole passes between many alveoli.
- (b) The alveoli are seen under higher power, with an arrow indicating an alveolar pore through which air can pass from one alveolus to another.

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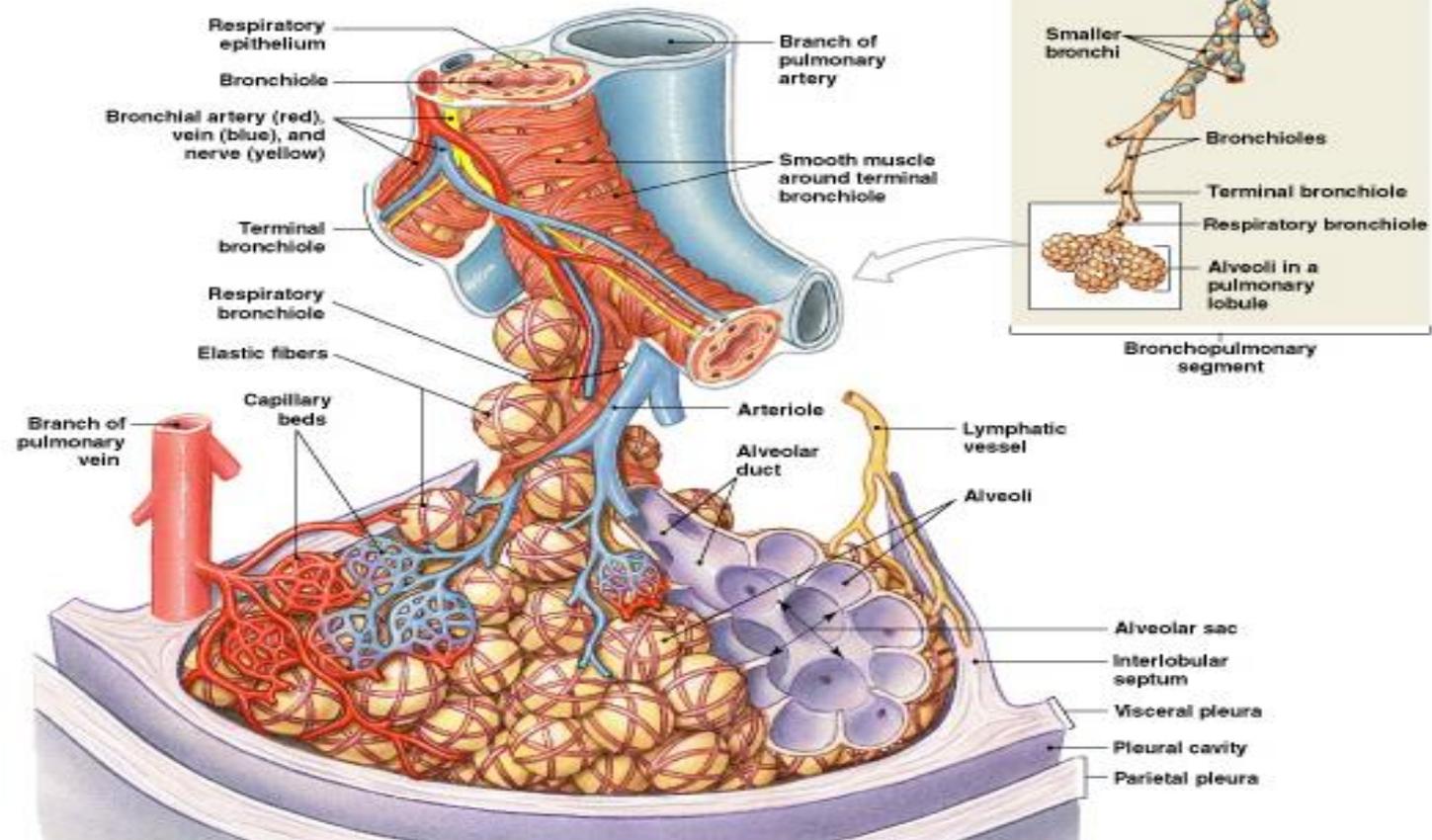
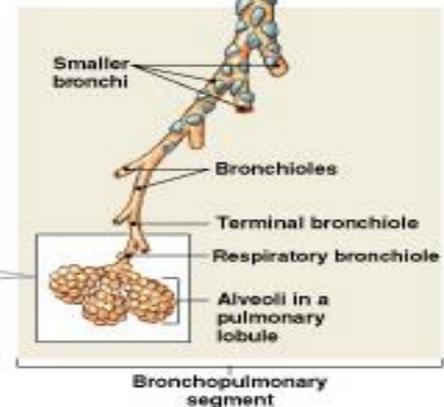
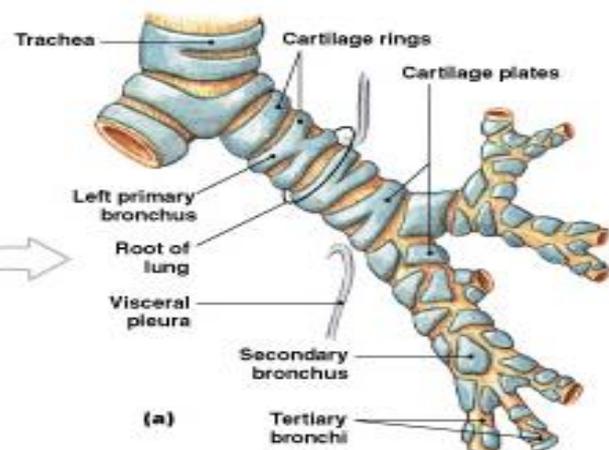
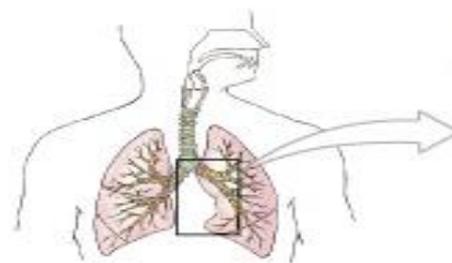
Alveolar organization

- Respiratory bronchioles are connected to alveoli along alveolar ducts
- Alveolar ducts end at alveolar sacs:
 - common chambers connected to many individual alveoli



Respiratory Bronchioles, Alveolar Ducts, and Alveoli

- Lungs contain small saccular outpocketings called **alveoli**.
- They have a thin wall specialized to promote diffusion of gases between the alveolus and the blood in the pulmonary capillaries.
- Gas exchange can take place in the **respiratory bronchioles and alveolar ducts** as well as in the **alveoli**, each lung contains approximately 300 to 400 million alveoli.
- The spongy nature of the lung is due to the packing of millions of alveoli together.



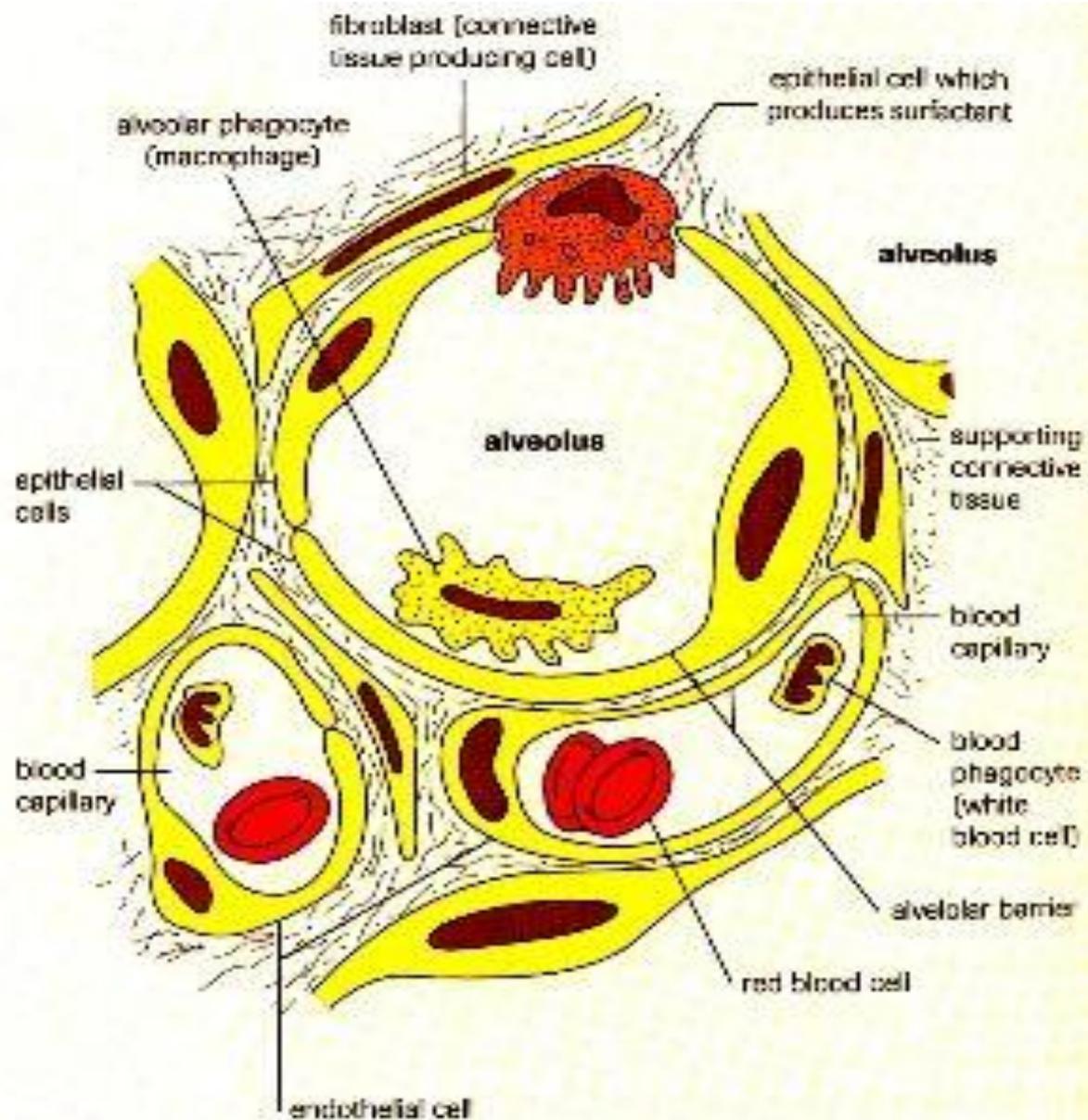
Respiratory Membrane

- squamous cells of alveoli .
- basement membrane of alveoli.
- basement membrane of capillaries
- simple squamous cells of capillaries
- **about .5 μ in thickness**

Cells in Alveolus

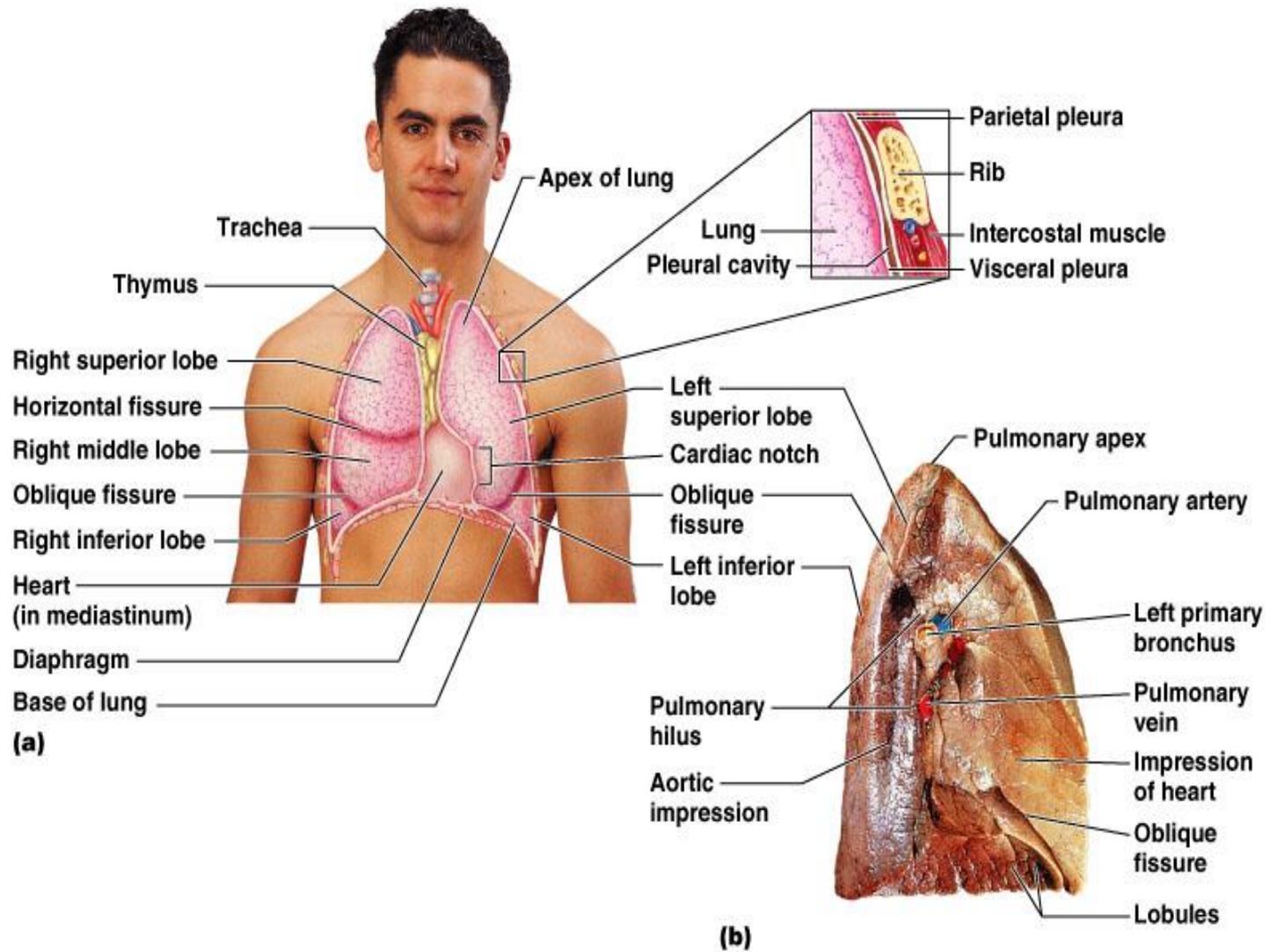
Type I cells : simple squamous cells forming lining

- Type II cells : or septal cells secrete **surfactant** and contains septal cells (Type II cells) that produce Surfactant- an oily secretion which
- 1) Contains phospholipids and proteins
- 2) Coats alveolar surfaces and reduces surface tension.
- Alveolar macrophages.



Gross Anatomy of the Lungs

- Each lung has a conical shape. Its wide, concave **base** rests upon the muscular diaphragm.
- Its superior region called the **apex** projects superiorly to a point that is slightly superior and posterior to the clavicle.
- Both lungs are bordered by the thoracic wall anteriorly, laterally, and posteriorly, and supported by the rib cage.
- Toward the midline, the lungs are separated from each other by the **mediastinum**.
- The relatively broad, rounded surface in contact with the thoracic wall is called the **costal surface** of the lung.



Lungs

Left lung

- divided into 2 lobes by **oblique fissure**
- smaller than the right lung
- **cardiac notch** accommodates the heart

Right

- divided into 3 lobes by **oblique and horizontal fissure**
- located more superiorly in the body due to liver on right side

Pleura and Pleural Cavities

- The outer surface of each lung and the adjacent internal thoracic wall are lined by a serous membrane called **pleura**.
- The outer surface of each lung is tightly covered by the **visceral pleura**.
- while the internal thoracic walls, the lateral surfaces of the mediastinum, and the superior surface of the diaphragm are lined by the **parietal pleura**.
- The parietal and visceral pleural layers are continuous at the **hilus** of each lung.

Pleural Cavities

The potential space between the serous membrane layers is a **pleural cavity**.

- The pleural membranes produce a thin, serous **pleural fluid** that circulates in the pleural cavity and acts as a lubricant, ensuring minimal friction during breathing.
- **Pleural effusion** – pleuritis with too much fluid

Blood supply of Lungs

- **pulmonary circulation -**
- **bronchial circulation** – bronchial arteries supply oxygenated blood to lungs, bronchial veins carry away deoxygenated blood from lung tissue → superior vena cava
- **Response of two systems to hypoxia** –
pulmonary vessels undergo **vasoconstriction**
bronchial vessels like all other systemic vessels undergo **vasodilation**

Cells of the respiratory membrane include

- Septal cells
 - Scattered in respiratory membrane
 - Septal cells produce surfactant
 - Surfactant prevents the alveoli from collapsing
- Alveolar Macrophage
 - Macrophages patrol epithelium and engulf foreign particles

Respiratory events

- **Pulmonary ventilation** = exchange of gases between lungs and atmosphere
- **External respiration** = exchange of gases between alveoli and pulmonary capillaries
- **Internal respiration** = exchange of gases between systemic capillaries and tissue cells

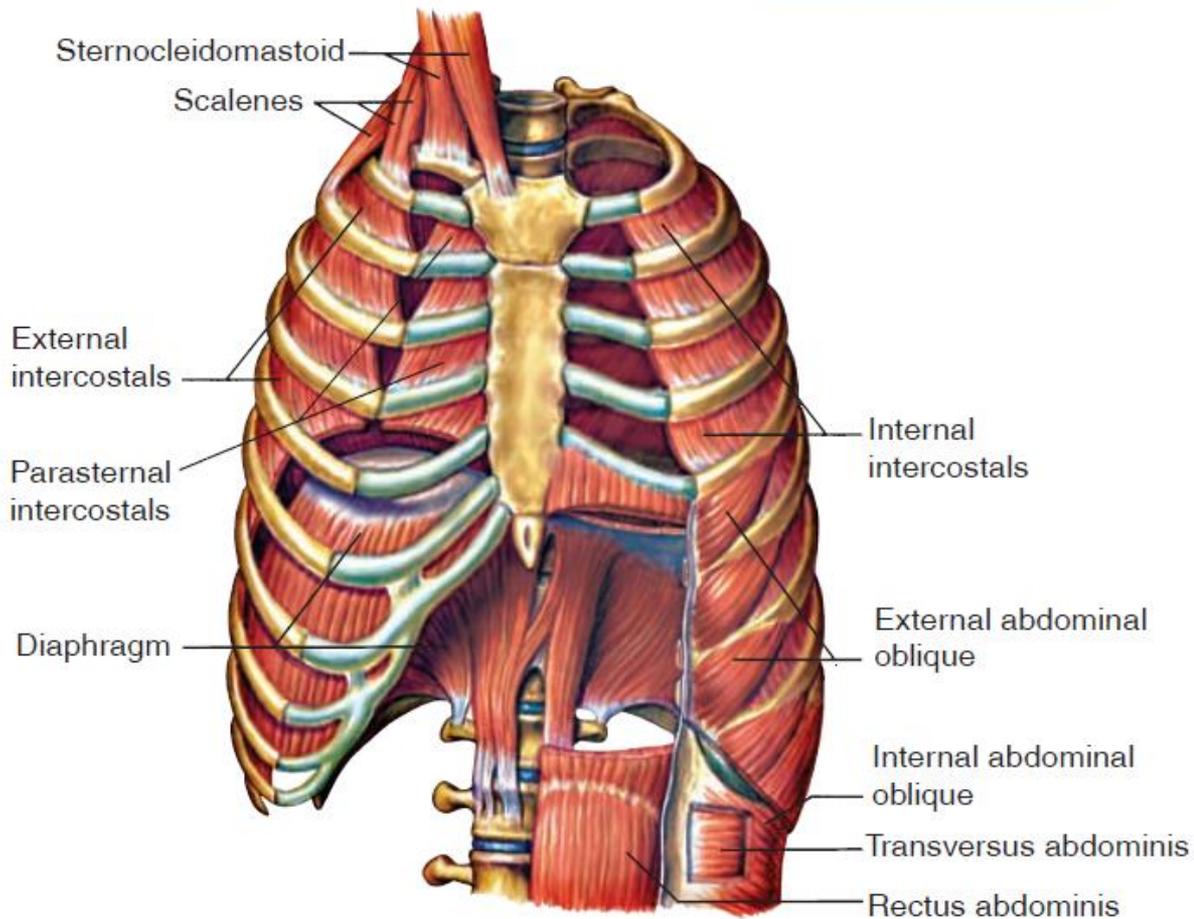
Muscles that ASSIST with respiration

- The **scalenes** help increase thoracic cavity dimensions by elevating the first and second ribs during forced inhalation.
- The ribs elevate upon contraction of the **external intercostals**, thereby increasing the transverse dimensions of the thoracic cavity during inhalation.
- Contraction of the **internal intercostals** depresses the ribs, but this only occurs during forced exhalation.
- Normal exhalation requires no active muscular effort.

Muscles of respiration

Muscles of inspiration

Muscles of expiration



Muscles that ASSIST with respiration

- Other accessory muscles assist with respiratory activities.
- The **pectoralis minor, serratus anterior, and sternocleidomastoid** help with forced inhalation,
- while the **abdominal muscles(external and internal obliques, transversus abdominis, and rectus abdominis)** assist in active exhalation.

References

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2. Widmaier, E.P., Raff, H. And strang, K.T. (2019) vander's human physiology 15th ed., Mcgraw hill international publications (new york), ISBN: 978-1259903885