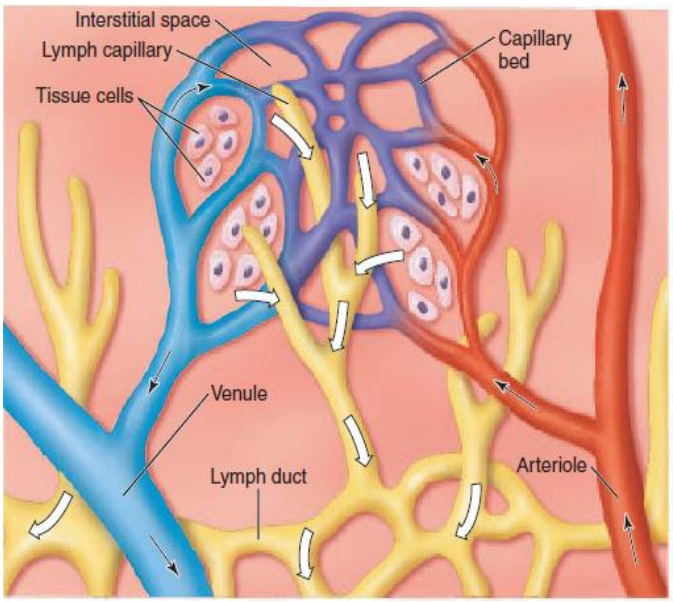
**Animal physiology- /2022-2023 /2nd semester**

Lecture 3

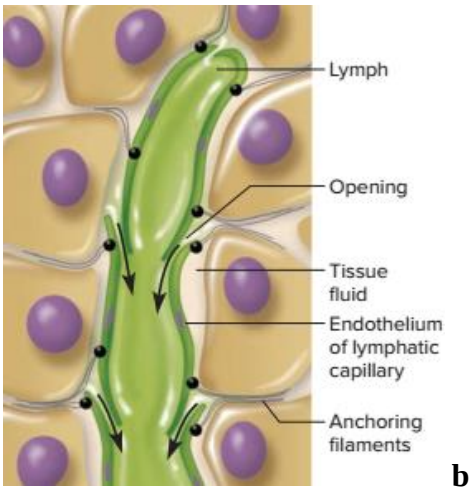
**Lymphatic System**

Lymphatic vessels absorb excess interstitial fluid and transport this fluid (now called lymph) to ducts that drain into veins. Lymph nodes, and lymphoid tissue in the thymus, spleen, and tonsils produce lymphocytes, which are white blood cells involved in immunity. The lymphatic system has three basic functions: (1) it transports interstitial fluid, initially formed as a blood filtrate, back to the blood,(Fig.3-1,3-2,3-3,3-4,3-5).
(2) it transports absorbed fat from the small intestine to the blood.
(3) its cells—called lymphocytes—help to provide immunological defenses against disease-causing agents.

The smallest vessels of the lymphatic system are the lymphatic Capillaries. Lymphatic capillaries are microscopic closed-ended tubes that form vast networks in the intercellular spaces within most organs (fig.3-1-a). Because the walls of lymphatic capillaries are composed of endothelial cells with porous junctions, interstitial fluid, proteins, microorganisms, and absorbed fat (in the intestine) can easily enter (fig.3-1-b).




**a**




**b**

Figure 3-1: **a**-The relationship between blood capillaries and lymphatic capillaries. Notice that lymphatic capillaries are blind-ended. They are, however, highly permeable, so that excess fluid and protein within the interstitial space can drain into the lymphatic system**.** **b**-Uptake of tissue fluid by a lymphatic capillary

Once fluid enters the lymphatic capillaries, it is referred to as lymph. From merging lymphatic capillaries, the lymph is carried into larger lymphatic vessels called lymph ducts (fig.3-2). Lymphatic vessels have a tunica interna with an endothelium and valves. Their walls are thinner and their valves are closer together than those of the veins (fig.3-3). Fluid movement within these vessels occurs as a result of peristaltic waves of contraction. The lymph ducts eventually empty into one of two principal vessels: the thoracic duct or the right lymphatic duct. These ducts drain the lymph into the left and right subclavian veins, respectively (fig.3-4).Thus interstitial fluid, which is formed by filtration of plasma out of blood capillaries is ultimately returned to the cardiovascular system.

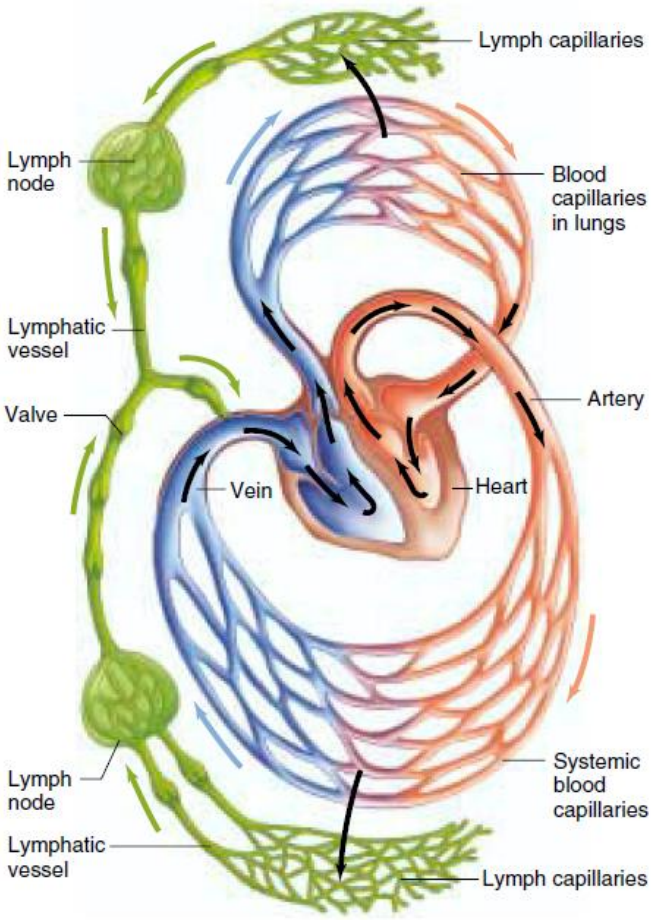



Figure 3-2:The lymphatic system (green) in relation to the cardiovascular system (blue and red).The lymphatic system is a one-way system from interstitial fluid to the cardiovascular system.

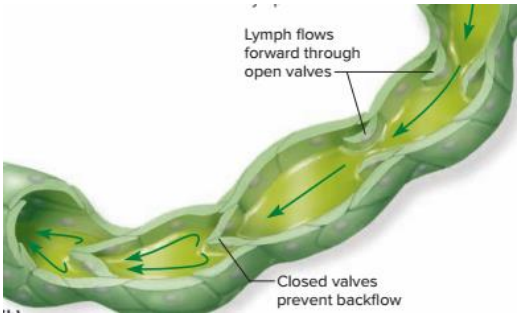



Figure fig.3-3: Valves in the lymphatic vessels

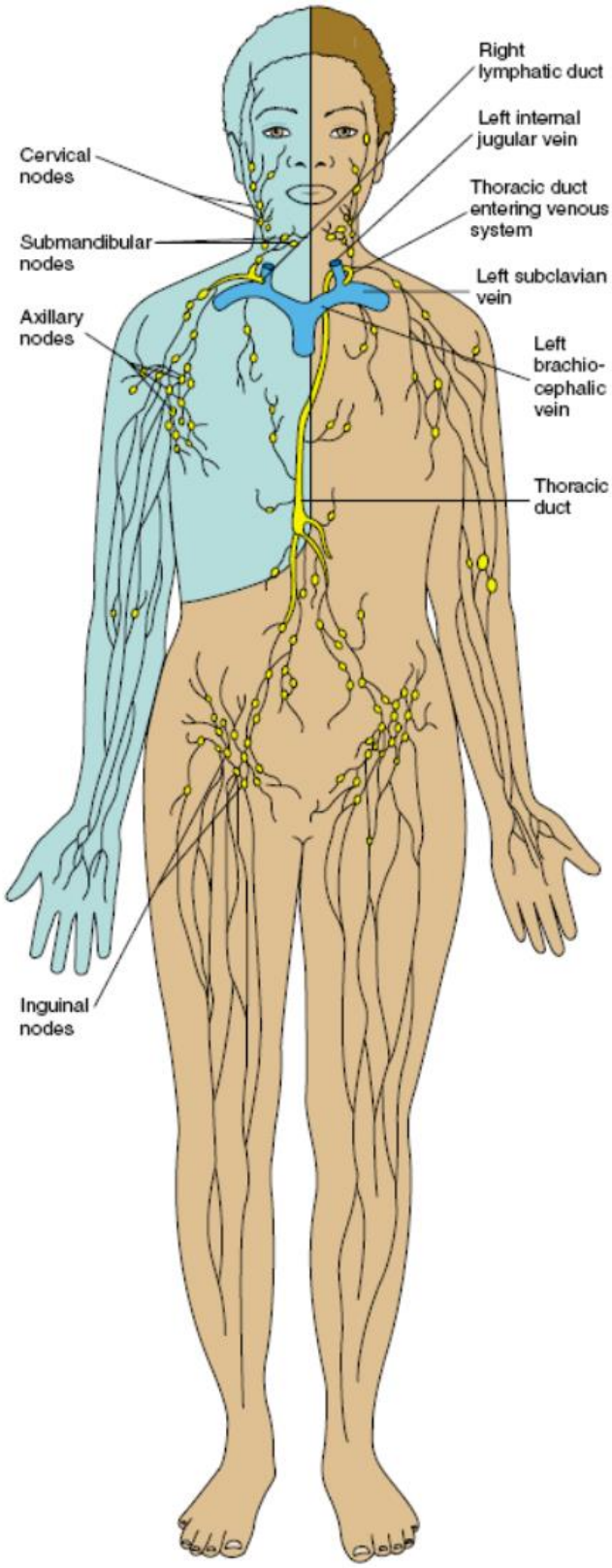



Figure 3-4 : Operation of the valves to ensure a one-way flow of lymph. lymph from the brown area drains through the thoracic duct, lymph from the blue area enters the right lymphatic duct.

Figure 3-5: Lymphedema. On the right is a 52-year-old woman with severe lymphedema of the legs and feet; on the left, for comparison, is a 21-year-old woman without edema. Blockage of lymphatic vessels is one of several causes of edema.

## Respiratory system

Respiration is the (gases exchange) exchanges of oxygen and carbon dioxide between an organism and the external environment. The gas exchange between blood and external environment is called external respiration, and The gas exchange between blood and cells of the body is called internal respiration. Utilization of oxygen in the metabolism of organic molecules by cells often termed cellular respiration**.**

### Methods of respiration

1-Aquatic respiration
a- Skin or integumentary respiration
b- Gill or Branchial respiration
2- Aerial respiration
a- Trachial respiration
b- Lung or pulmonary respiration

## Composition of Air

Air is a mixture of gases, each of which contributes a share, called its partial pressure, to the total atmospheric pressure (table 3-1). Partial pressure is abbreviated P followed by the formula of the gas. The partial pressure of nitrogen is $PN_2$, for example. Nitrogen constitutes about 78.6% of the atmosphere; thus at 1 atm of pressure, $PN_2$ =78.6% x760 mm Hg = 597 mmHg. Dalton's law states that the total pressure of a gas mixture is the sum of the partial pressures of the individual gases. That is, $PN_2$ + $PO_2$+ $PH_2O$+ $PCO_2$ = 597.0+ 159.0+ 3.7+ 0.3 =760.0 mm Hg. These partial pressures are important because they determine the rate of diffusion of a gas Alveolar air can be sampled with an apparatus that collects the last 10 mL of expired air. Its gaseous make up differs from that of the atmosphere because of three influences: (1) the airway humidifies it, (2) the air exchanges $O_2$ and $CO_2$ with the blood, and (3) freshly inspired air mixes with residual air left from the previous respiratory cycle. These factors produce the composition shown in table 3-1.

## The airways and blood vessels

During inspiration air passes through either the nose (the most common site) or mouth into the pharynx, then to the larynx, The larynx opens into a long tube, the trachea, which in turn branches into two bronchi (singular, bronchus), one of which enters each lung. Within the lungs, there are more than 20 generations of branching, each resulting in narrower, shorter, and more numerous tubes, the names of which are summarized in fig.3-6. The airways beyond the larynx can be divided into two zones:

1- The conducting zone extends from the top of the trachea to the beginning of the respiratory bronchioles; it contains no alveoli and there is no gas exchange with the blood.
2-The respiratory zone, which extends from the respiratory bronchioles on down, contains alveoli and is the region where gases exchange with the blood (fig. 3-6, 3-7, 3-8)).

## Ventilation

Ventilation is defined as the exchange of air between the atmosphere and alveoli.

**Inspiration** (inhalation) is the movement of air from the external environment through the airways into the alveoli during breathing**.**
**Expiration** (exhalation) is movement in the opposite direction.

## Mechanics of Breathing

### Muscles of Inspiration

The diaphragm is the most important muscle for inspiration. When the diaphragm contracts, the abdominal contents are pushed down ward produce an increase in intrathoracic volume, which lowers intrathoracic pressure and initiates the flow of air into the lungs. During exercise the external intercostal muscles and accessory muscles (sternocleidomastoid and scalense) may also be used for more vigorous inspiration**. External intercostal muscles** cause the ribs to rotate upward and outward. Therefore the increase in anterio-posterior diameters increase. **Sternocleidomastoid** lift the sternum outward. **Scalenese** lift the first two ribs (fig.3-9).

### Muscles of Expiration

Expiration normally is a passive process. During exercise or in diseases in which airway resistance is increased (e.g., asthma), the expiratory muscles may aid the expiratory process. The muscles of expiration include the i**nternal intercostal muscles**, which pull the ribs downward and inward. The **abdominal muscles**, which compress the abdominal cavity and push the diaphragm up (fig.3-9).

Table 3-1: Composition of Inspired (atmospheric) and Alveolar Air

| Gas | Inspired Air* | | Alveolar Air | |
|---|---|---|---|---|
| $N_2$ | 78.62% | 597.0 mmHg | 74.9% | 569.0 mmHg |
| $O_2$ | 20.84% | 159.0 mmHg | 13.6% | 104.0 mmHg |
| $H_2O$ | 0.50% | 3.7 mmHg | 6.2% | 47.0 mmHg |
| $CO_2$ | 0.04% | 0.3 mmHg | 5.3% | 40.0 mmHg |
| Total | 100.00% | 760.0 mmHg | 100.0% | 760.0 mmHg |

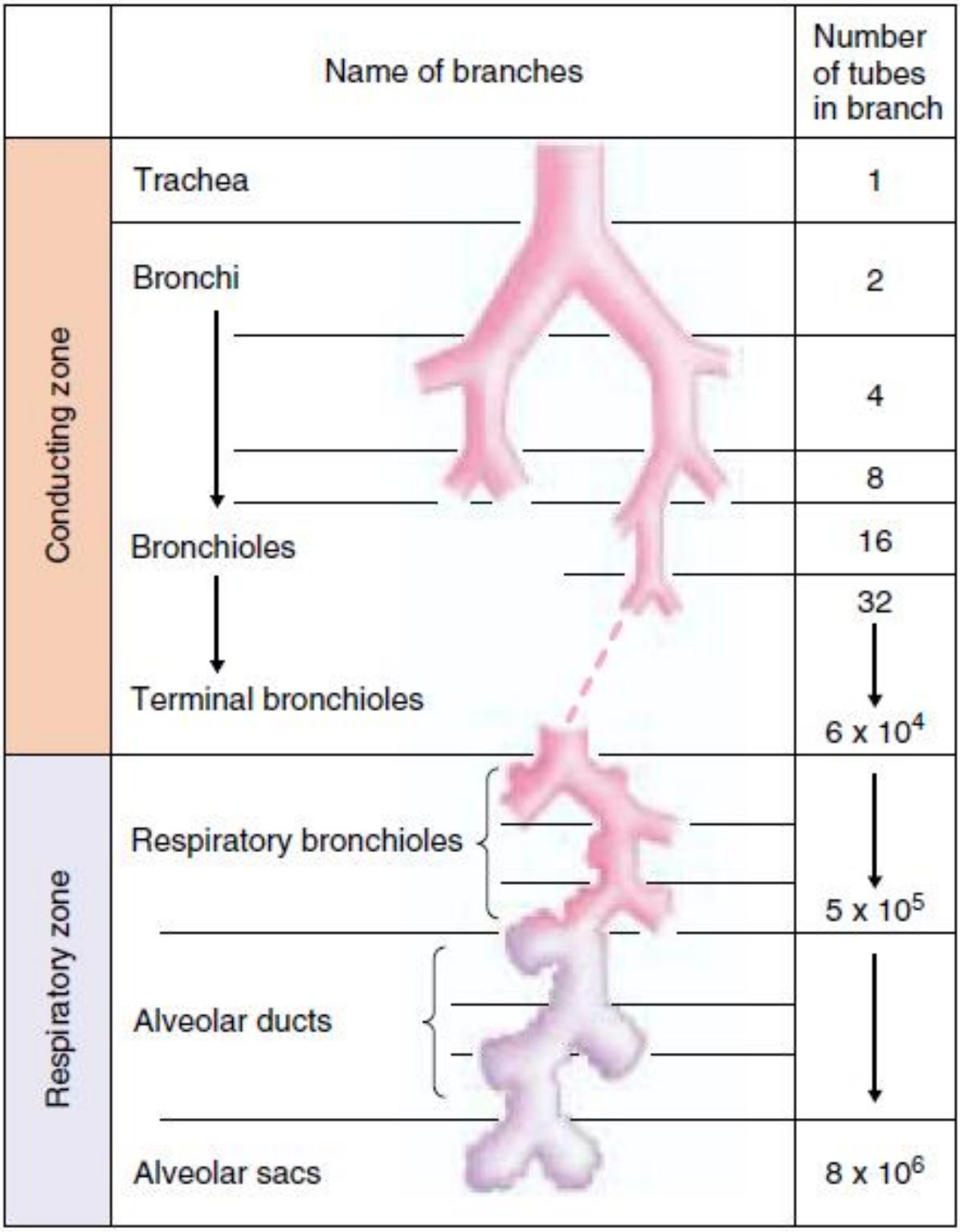



Figure 3-6: Airway branching

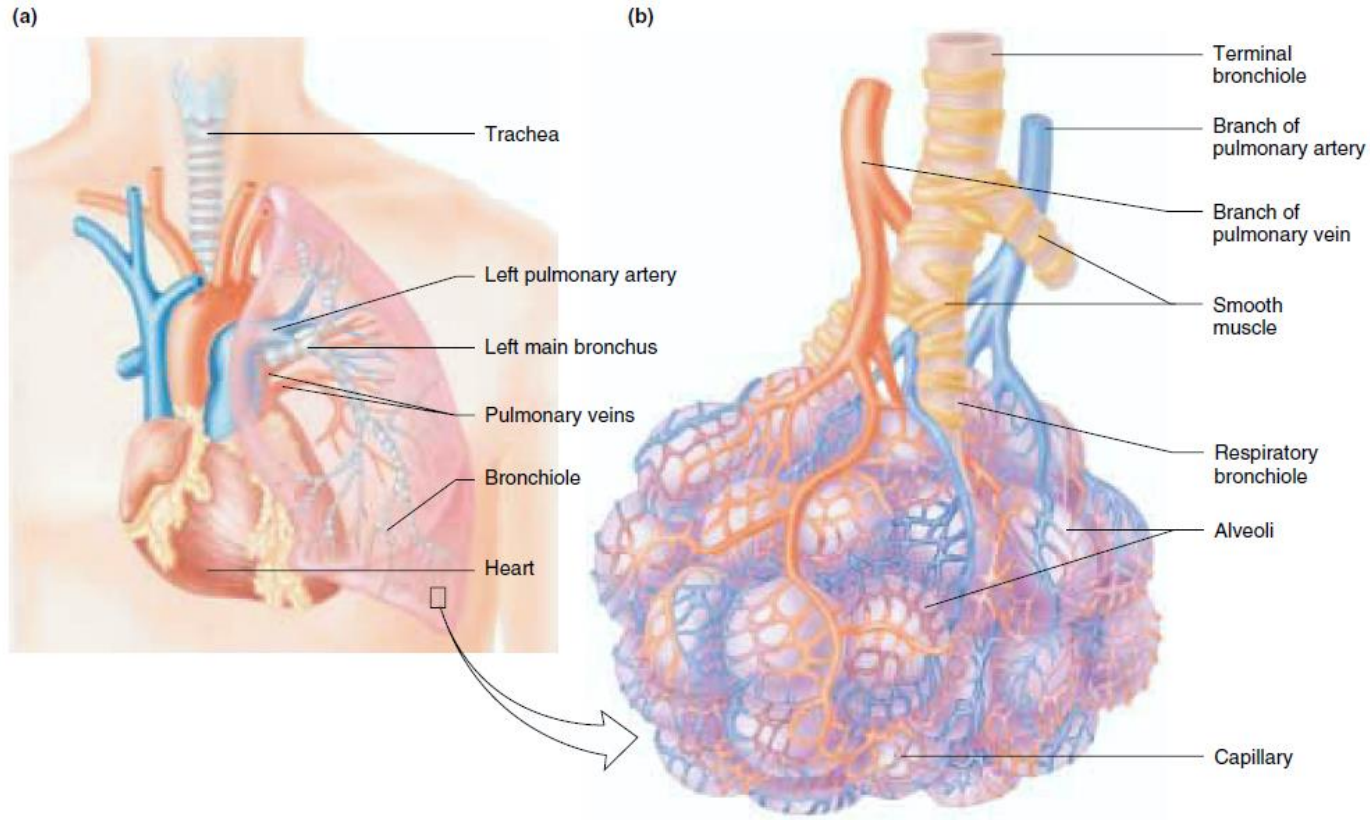



Figure 3-7: Relationships between blood vessels and airways. (**a**) The lung appears transparent so that the relationships can be seen. The airways beyond the bronchiole are too small to be seen. (**b**) An enlargement of a small section of Figure 18-5-a to show the continuation of the airways and the clusters of alveoli at their ends. Virtually the entire lung consists of such clusters.

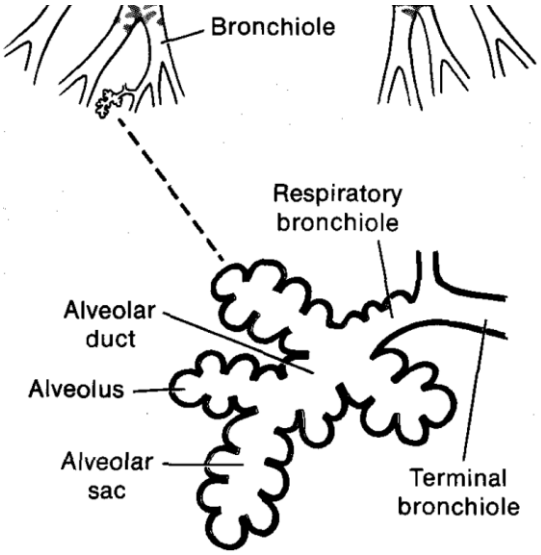



Figure 3-8: In the mammalian lung, a series of branching, progressively smaller ducts deliver air to the respiratory portion, consisting of terminal and respiratory bronchioles and alveolar ducts and sacs. Gas transfer occurs across the respiratory epithelium shown in red.

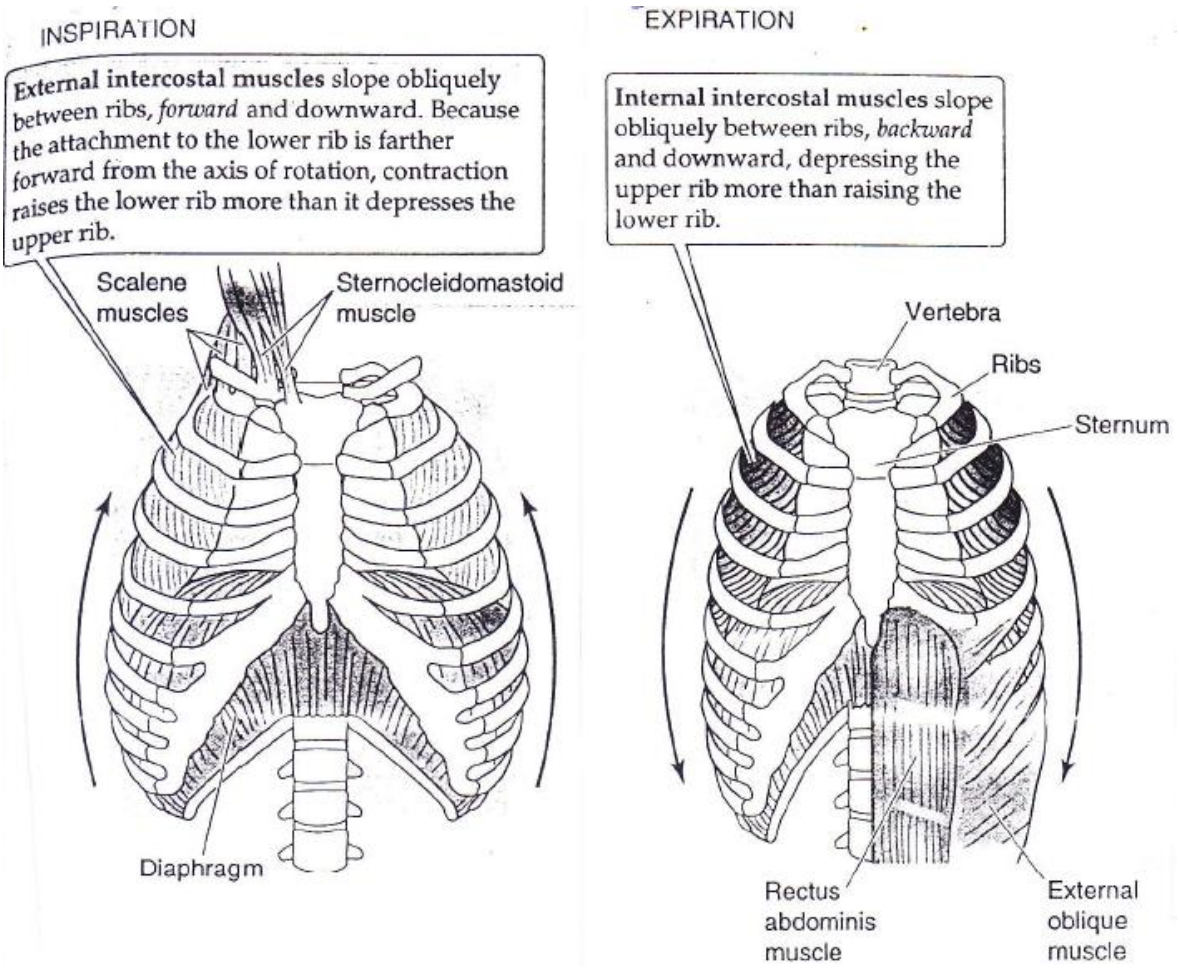



Figure 3-9: Actions of major respiratory muscles

**Questions**

1- What are the functions of lymphatic system

2- Define external respiration

3- Explain the importance of Dalton's law in study of respiratory system

4-The conducting zone extends from the top of the trachea to the beginning of -----

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