CBCS GENERAL THIRD SEM

UNIT:3 RESPIRATION: PULMONARY VENTILATION,RESPIRATORY VOLUME AND CAPACITIES,TRANSPORT OF OXYGEN AND CARBONDIOXIDE IN THE BLOOD

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Respiration refers to the mechanisms for obtaining oxygen from the air and delivering it to the tissues, while eliminating carbon dioxide from the body. It is related to cellular respiration, the biochemical processes that consume this oxygen and generate the carbon dioxide in the course of making adenosine triphosphate (ATP). Respiration in the former sense involves four processes:

(1) breathing, or ventilation of the lungs;
(2) gas exchange between air and blood in the lungs;
(3) gas transport in the blood; and
(4) gas exchange between the blood and target tissue

Respiratory Anatomy

The respiratory system consists of:

(1) the nasal cavity, which warms, cleans, and humidifies inhaled air;

(2) the pharynx , where the respiratory and digestive systems meet and then diverge again;

(3) the larynx , or voice box, which contains the vocal cords;

(4) the trachea, or windpipe, a tube about 12 centimeters (4.7 inches) long and 2.5 centimeters (just less than an inch) wide that passes behind the heart and branches like a Y at its lower end;

(5) bronchi and bronchioles, air tubes that begin at the fork of the trachea and divide into smaller and smaller divisions within each lung;

(6) alveoli, millions of tiny air sacs in the lung.

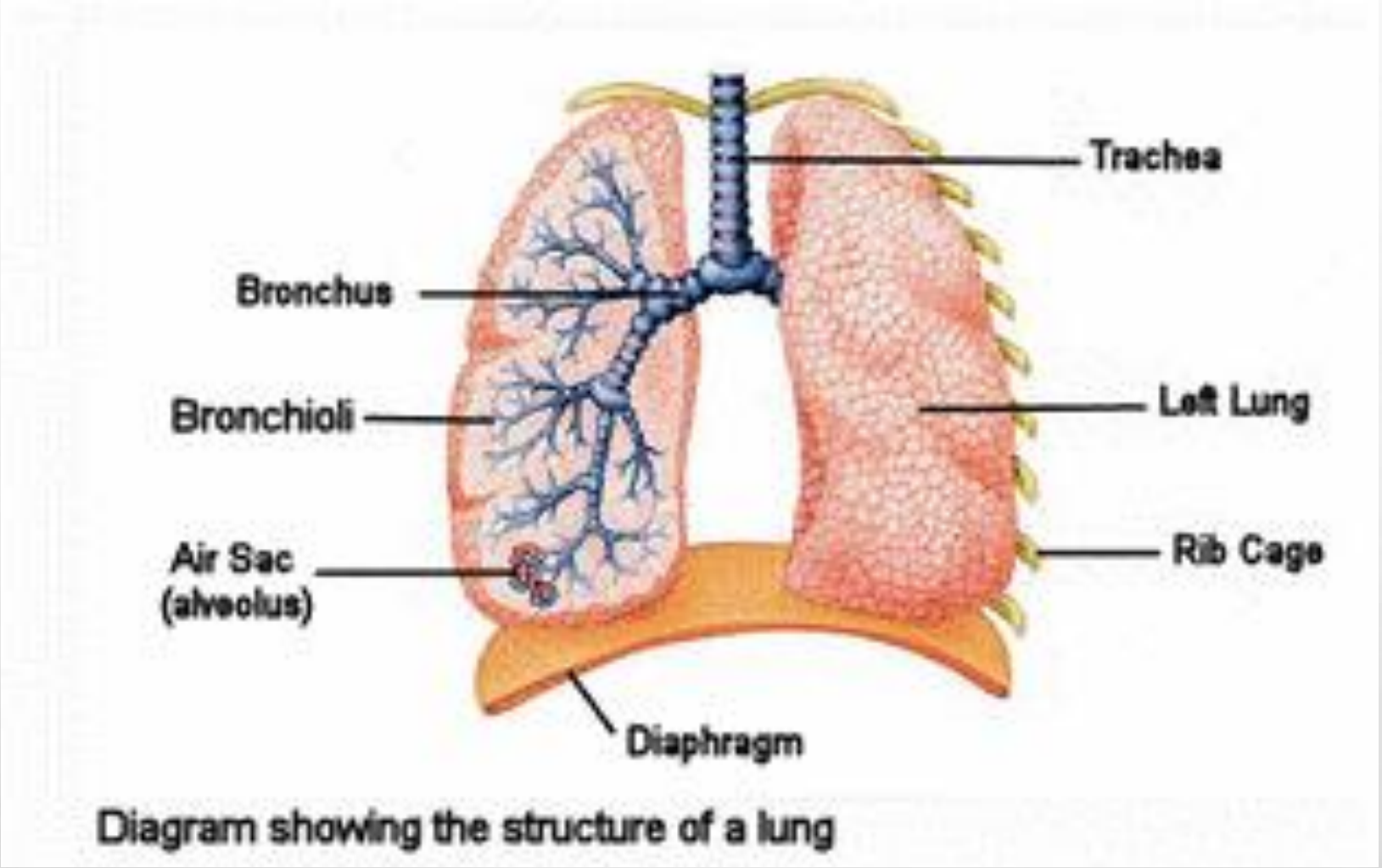
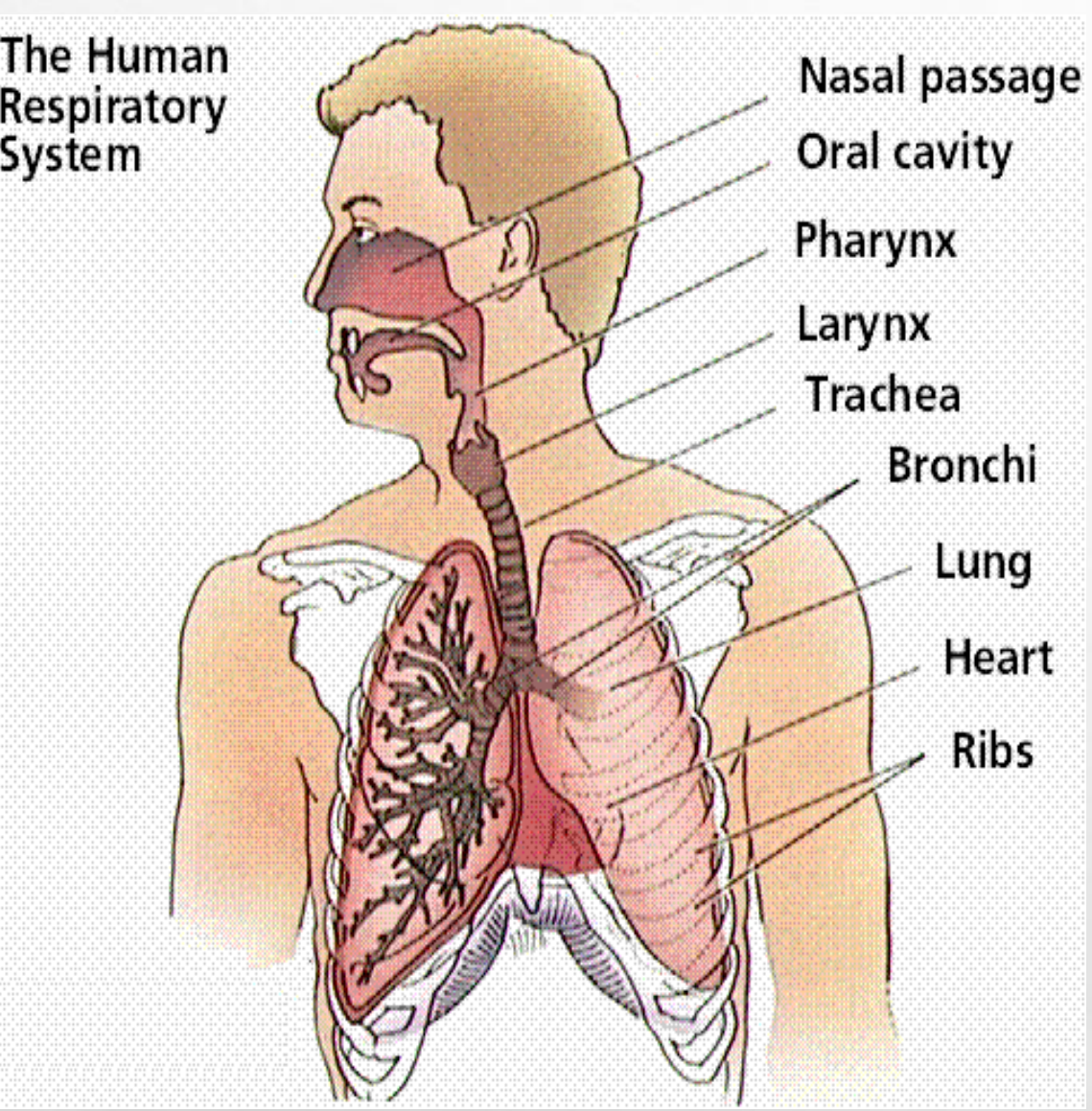
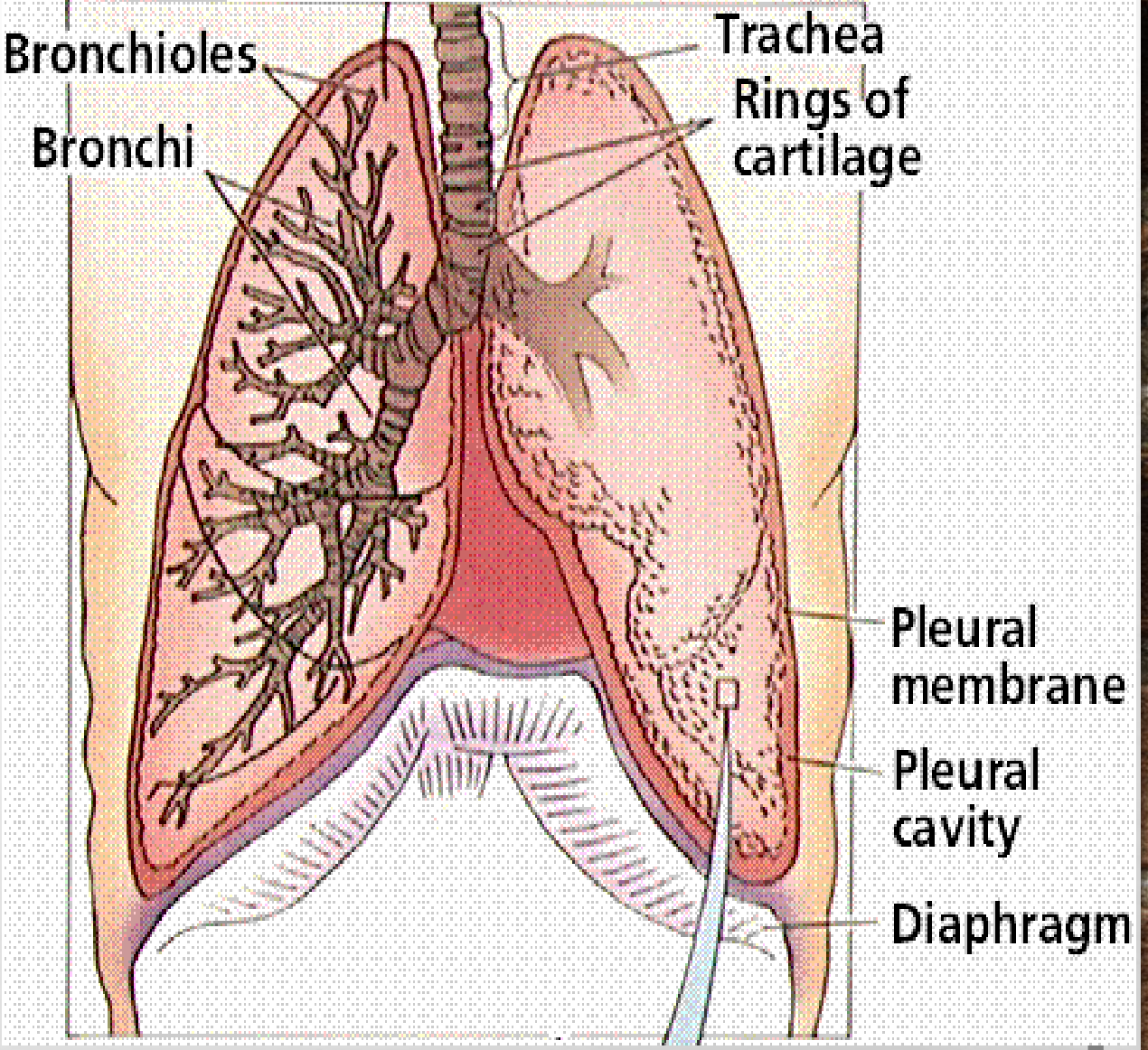
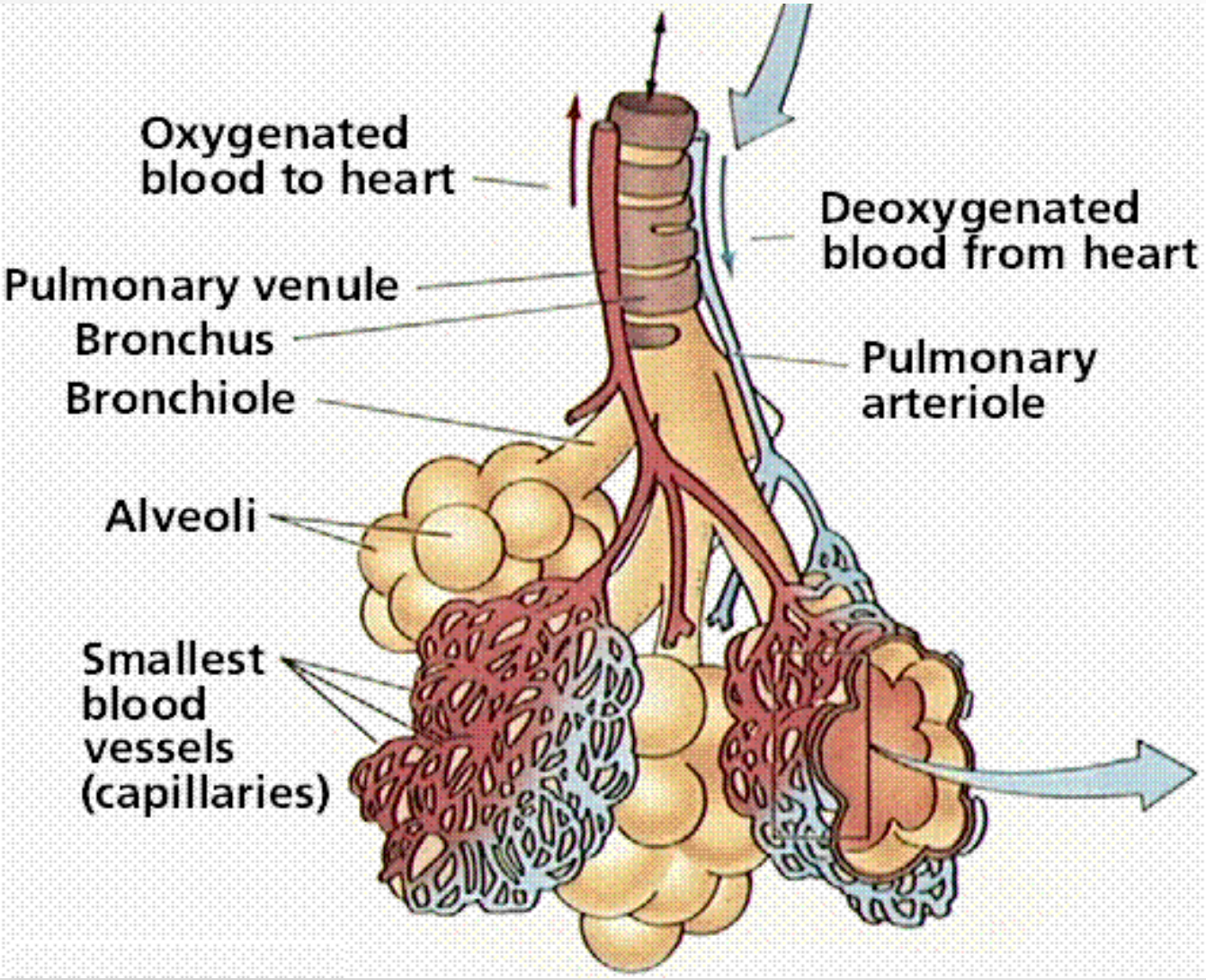


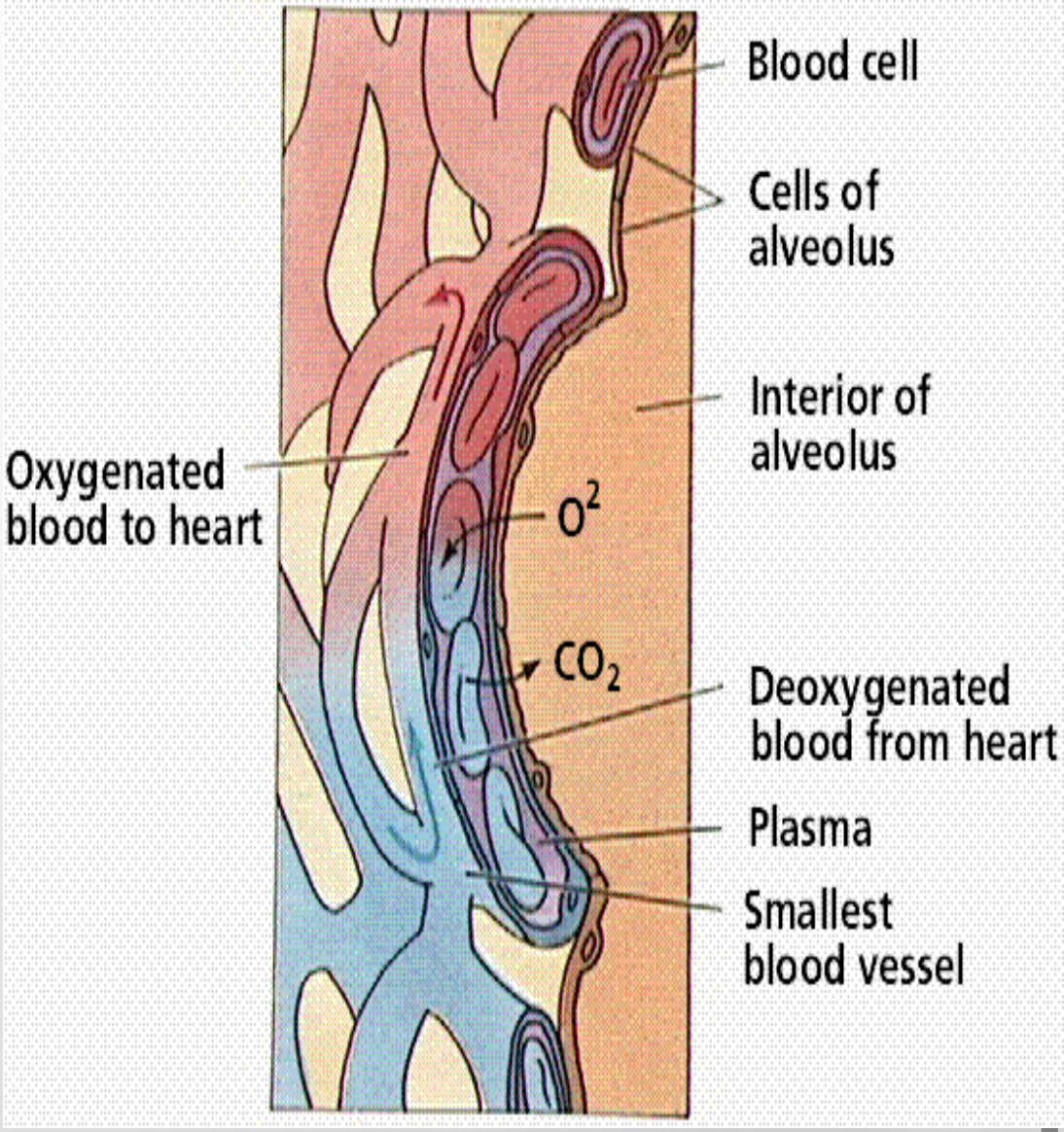
Diagram showing the structure of a lung


The Human Respiratory System
Nasal passage
Oral cavity
Pharynx
Larynx
Trachea
Bronchi
Lung
Heart
Ribs


Bronchioles
Bronchi
Trachea
Rings of cartilage
Pleural membrane
Pleural cavity
Diaphragm



The lungs and alveoli and their relationship to the diaphragm and capillaries



Gas exchange across capillary and alveolus walls.

Air enters the body through the nose, is warmed, filtered, and passed through the nasal cavity. Air passes the pharynx (which has the epiglottis that prevents food from entering the trachea).The upper part of the trachea contains the larynx. The vocal cords are two bands of tissue that extend across the opening of the larynx. After passing the larynx, the air moves into the bronchi that carry air in and out of the lungs.

Bronchi are reinforced to prevent their collapse and are lined with ciliated epithelium and mucus-producing cells. Bronchi branch into smaller and smaller tubes known as bronchioles. Bronchioles terminate in grape-like sac clusters known as alveoli. Alveoli are surrounded by a network of thin-walled capillaries. Only about 0.2 μm separate the alveoli from the capillaries due to the extremely thin walls of both structures.

The lungs are large, lobed, paired organs in the chest (also known as the thoracic cavity). Thin sheets of epithelium (pleura) separate the inside of the chest cavity from the outer surface of the lungs. The bottom of the thoracic cavity is formed by the diaphragm.

Except in the walls of the bronchi and bronchioles, the lungs have no muscle; they do not pump air in and out of themselves like the heart pumping blood, but are passively ventilated as the chest expands and contracts.

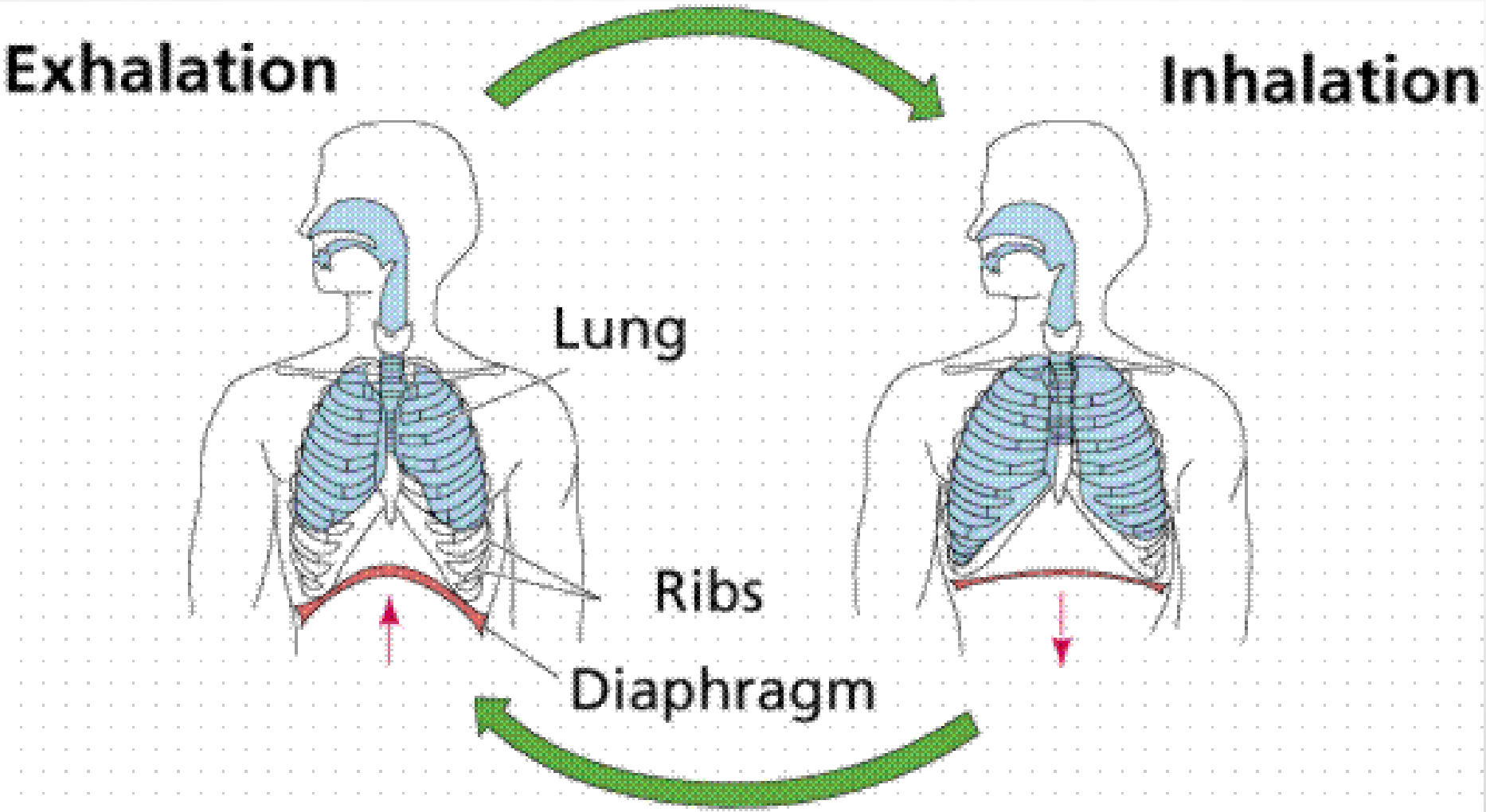
The muscles that drive pulmonary ventilation are the diaphragm, a sheet of muscle between the thoracic and abdominal cavities; the intercostal muscles between the ribs; and other muscles of the abdomen and thorax that aid the primary respiratory muscles.

Ventilation is the mechanics of breathing in and out. When you inhale, muscles in the chest wall contract, lifting the ribs and pulling them, outward. The diaphragm at this time moves downward enlarging the chest cavity. Reduced air pressure in the lungs causes air to enter the lungs. Exhaling reverses theses steps.

Pulmonary Ventilation

Ventilation is a rhythmic process, like the heartbeat, but its pacemakers are in the brainstem rather than in the chest. The medulla oblongata of the brainstem contains an inspiratory center composed of neurons that send signals to the diaphragm and external intercostal muscles.

When these muscles are stimulated, they contract and enlarge the thoracic cavity. This creates a partial vacuum in the lungs. With the atmospheric pressure outside the body now greater than the pressure in the lungs, air flows "downstream" into the lungs and inflates the



Inhalation and exhalation. Image

Usually no muscular effort is needed to exhale. When these muscles stop contracting, the elasticity of the thoracic cage (ribs, cartilages, diaphragm, and ligaments) causes it to spring back by itself, squeezing air out of the lungs.

When one needs to exhale more deeply, however, the expiratory center of the medulla sends signals to the internal intercostal muscles, which pull the ribs downward and produce an extra degree of chest compression.

The abdominal muscles also aid by increasing pressure in the abdominal cavity, pushing up on the diaphragm. These muscles are important in public speaking, singing, shouting, playing wind instruments, and blowing out candles, for example.

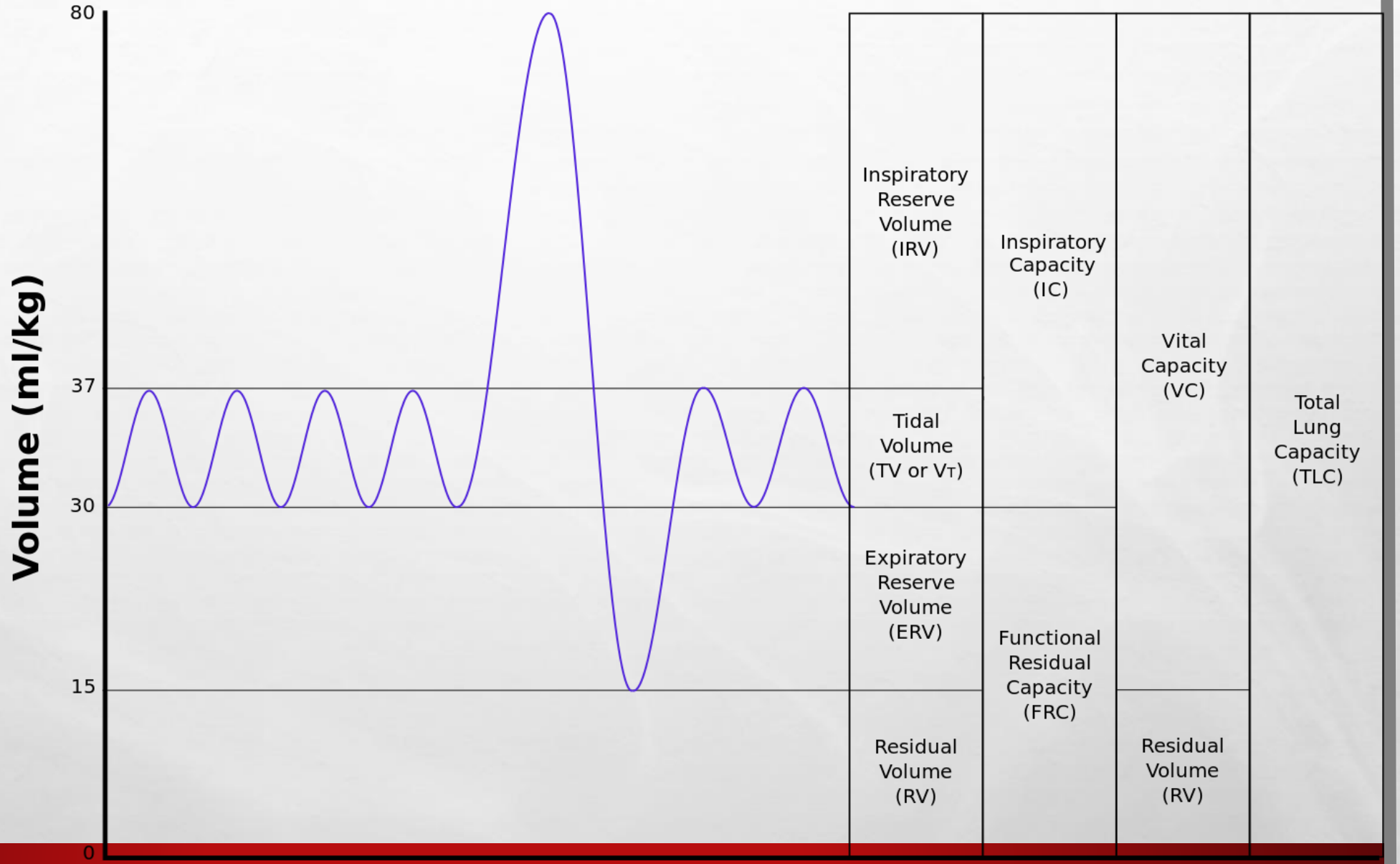
In normal, relaxed breathing, most adults inhale a tidal volume averaging 500 milliliters (16.9 fluid ounces) of air in each respiratory cycle. With maximum effort, however, one can inhale a greater amount called the vital capacity, averaging about 4,700 milliliters (almost 159 fluid ounces) in adult

RESPIRATORY VOLUME AND CAPACITIES

Lung volumes and lung capacities refer to the volume of air in the lungs at different phases of the respiratory cycle.

The average total lung capacity of an adult human male is about 6 litres of air.

Tidal breathing is normal, resting breathing; the tidal volume is the volume of air that is inhaled or exhaled in only a single such breath.


Volume (ml/kg)
80
37
30
15
0
Inspiratory Reserve Volume (IRV)
Tidal Volume (TV or VT)
Expiratory Reserve Volume (ERV)
Residual Volume (RV)
Inspiratory Capacity (IC)
Functional Residual Capacity (FRC)
Vital Capacity (VC)
Residual Volume (RV)
Total Lung Capacity (TLC)

TLC Total lung capacity: the volume in the lungs at maximal inflation, the sum of VC and RV.

TV Tidal volume: that volume of air moved into or out of the lungs during quiet breathing (TV indicates a subdivision of the lung; when tidal volume is precisely measured, as in gas exchange calculation, the symbol TV or VT is used.)

RV Residual volume: the volume of air remaining in the lungs after a maximal exhalation

ERV Expiratory reserve volume: the maximal volume of air that can be exhaled from the end-expiratory position

IRV Inspiratory reserve volume: the maximal volume that can be inhaled from the end-inspiratory level

IC Inspiratory capacity: the sum of IRV and TV

IVC Inspiratory vital capacity: the maximum volume of air inhaled from the point of maximum expiration

YOU Vital capacity: the volume of air breathed out after the deepest inhalation.

VT Tidal volume: that volume of air moved into or out of the lungs during quiet breathing (VT indicates a subdivision of the lung; when tidal volume is precisely measured, as in gas exchange calculation, the symbol TV or VT is used.)

FRC Functional residual capacity: the volume in the lungs at the end-expiratory position

TRANSPORT OF OXYGEN AND CARBON-DI-OXIDE IN THE BLOOD

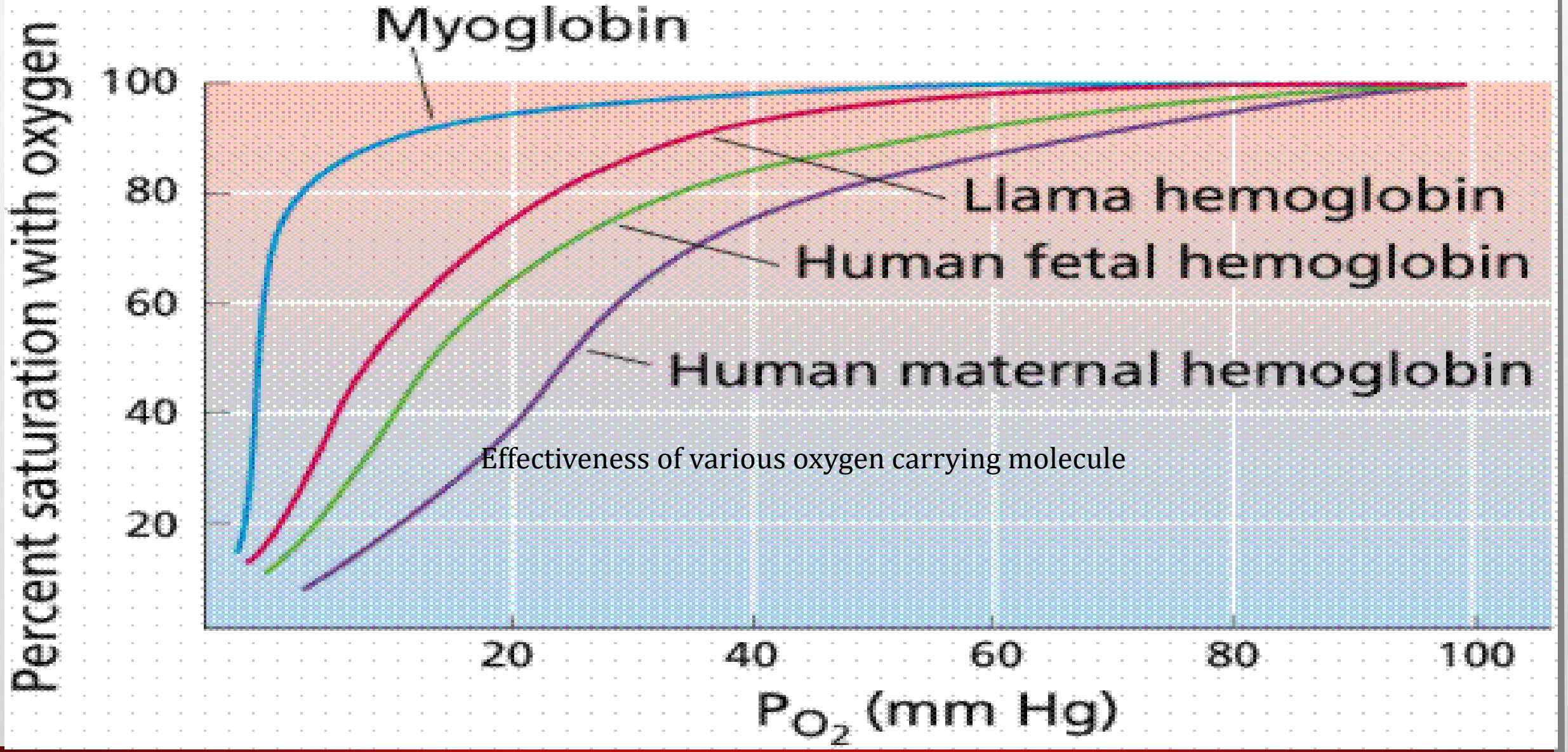
The Alveoli and Gas Exchange

Diffusion is the movement of materials from a higher to a lower concentration.

The differences between oxygen and carbon dioxide concentrations are measured by partial pressures. The greater the difference in partial pressure the greater the rate of diffusion.

Respiratory pigments increase the oxygen-carrying capacity of the blood. Humans have the red-colored pigment hemoglobin as their respiratory pigment. Hemoglobin increases the oxygen-carrying capacity of the blood between 65 and 70 times.

Each red blood cell has about 250 million hemoglobin molecules, and each milliliter of blood contains 1.25 X 1015 hemoglobin molecules. Oxygen concentration in cells is low (when leaving the lungs blood is 97% saturated with oxygen), so oxygen diffuses from the blood to the cells when it reaches the capillaries.



Effectiveness of various oxygen carrying molecule

Carbon dioxide concentration in metabolically active cells is much greater than in capillaries, so carbon dioxide diffuses from the cells into the capillaries. Water in the blood combines with carbon dioxide to form bicarbonate.

This removes the carbon dioxide from the blood so diffusion of even more carbon dioxide from the cells into the capillaries continues yet still manages to "package" the carbon dioxide for eventual passage out of the body.

In the alveoli capillaries, bicarbonate combines with a hydrogen ion (proton) to form carbonic acid, which breaks down into carbon dioxide and water. The carbon dioxide then diffuses into the alveoli and out of the body with the next exhalation.

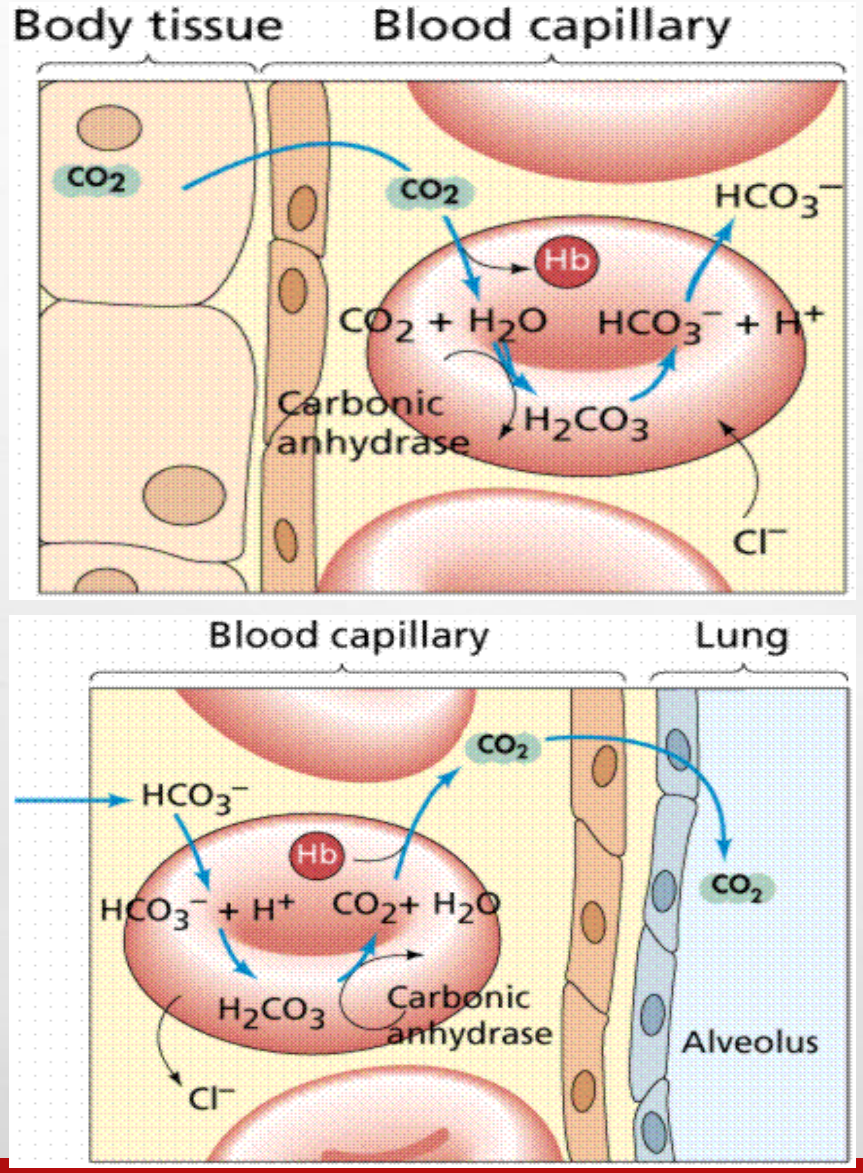
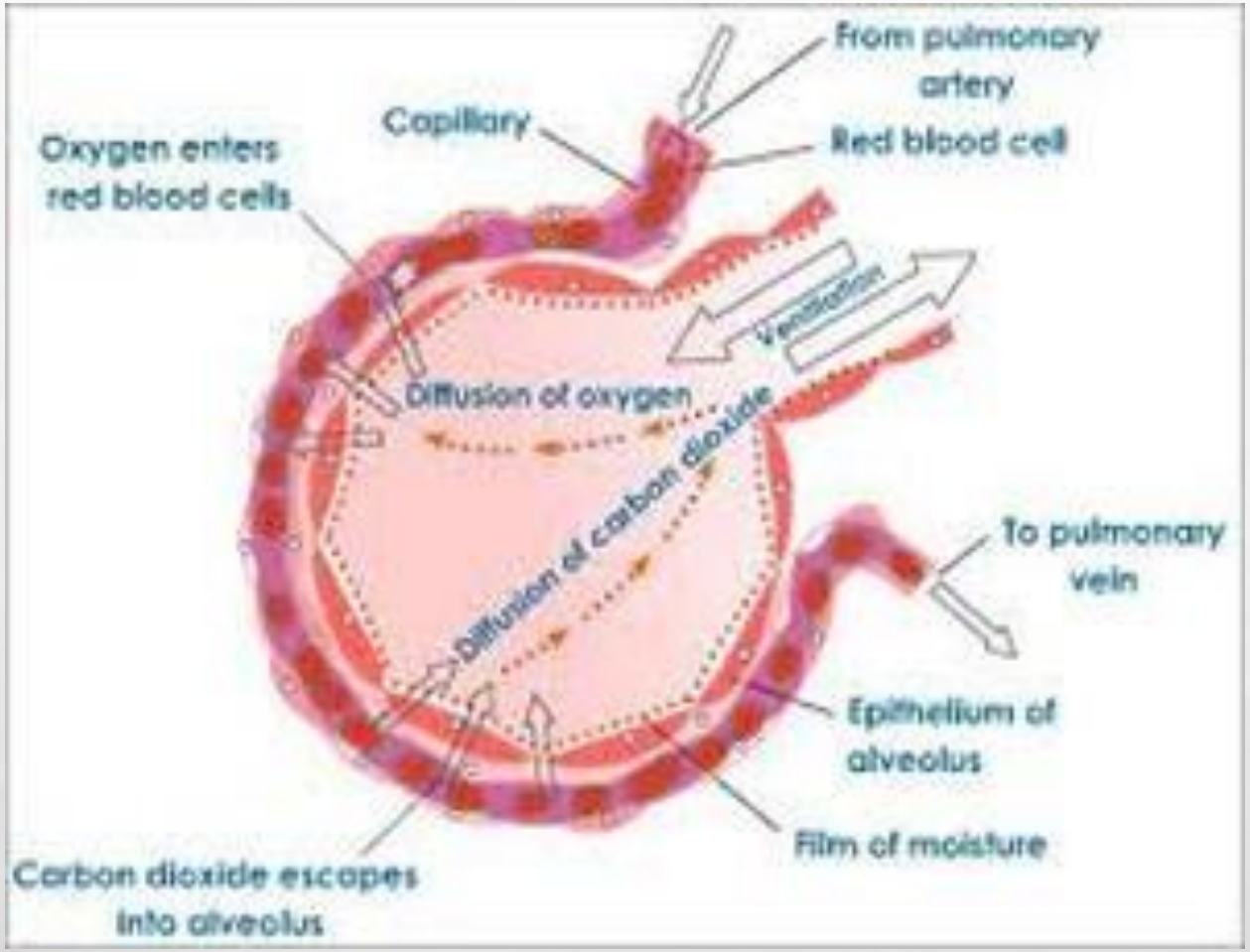


Fig:Details of gas exchange.


From pulmonary artery
Capillary
Red blood cell
Oxygen enters red blood cells
Ventilation
Diffusion of oxygen
Diffusion of carbon dioxide
To pulmonary vein
Epithelium of alveolus
Film of moisture
Carbon dioxide escapes into alveolus

Control of Respiration : Muscular contraction and relaxation controls the rate of expansion and constriction of the lungs. These muscles are stimulated by nerves that carry messages from the part of the brain that controls breathing, the medulla. Two systems control breathing: an automatic response and a voluntary response. Both are involved in holding your breath.

Although the automatic breathing regulation system allows you to breathe while you sleep, it sometimes malfunctions. Apnea involves stoppage of breathing for as long as 10 seconds, in some individuals as often as 300 times per night. This failure to respond to elevated blood levels of carbon dioxide may result from viral infections of the brain, tumors, or it may develop spontaneously.

As altitude increases, atmospheric pressure decreases. Above 10,000 feet decreased oxygen pressures causes loading of oxygen into hemoglobin to drop off, leading to lowered oxygen levels in the blood.

The result can be mountain sickness (nausea and loss of appetite).

Mountain sickness does not result from oxygen starvation but rather from the loss of carbon dioxide due to increased breathing in order to obtain more oxygen.

Thank you