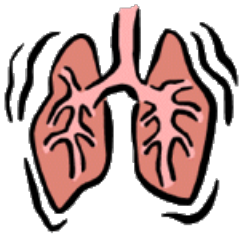
Revision Notes on Breathing and Exchange of Gases

Pulmonary Volumes and Capacities

There are following respiratory volumes and capacity:

(i) **Tidal volume (TV)**: It is volume of air normally inspired or expired in one breath (i.e. inspiration and expiration) without any extra effort. It is about 500 ml in normal healthy adult. In infants it is 15 ml and in fetus it is 0 ml.



(ii) **Inspiratory reserve volume (IRV) :** By taking a very deep breath, you can inspire a good deal more than 500 ml. This additional inhaled air, called IRV is about 3000 ml.

(iii) **Expiratory reserve volume (ERV) :** If you inhale normally & then exhale as forcibly as possible, you should be able to push out 1200 ml of air in addition to 500ml. of T.V. The extra 1200 ml is called ERV.

(iv) **Residual volume (RV):** Even after expiratory reserve volume is expelled, considerable air remains in the lung, this volume, which cannot be measured by spirometry, and it is called residual volume is about 1200 ml.

(v) **Dead space**: Portion of tracheobronchial tree where gaseous exchange does not occur is called dead space. It is also called conductive zone. Dead space is 150 ml.

(vi) **Functional residual capacity (FRC):** It is the amount of air that remains in the lungs after a normal expiration. It is about 2300 ml.

FRC = ERV + RV

= 1100 + 1200 = 2300 ml.

(vii) **Vital capacity (VC):** This is the maximum amount of air that can be expired forcefully from his lungs after first filling these with a maximum deep inspiration. It is about 4600 ml.

VC = IRV + TV + ERV

= 3000+500+1100 = 4600 ml.

(viii) **Total lung capacity (TLC):** TLC is the sum of vital capacity (VC) and residual volume (RV). It is about 5800ml.

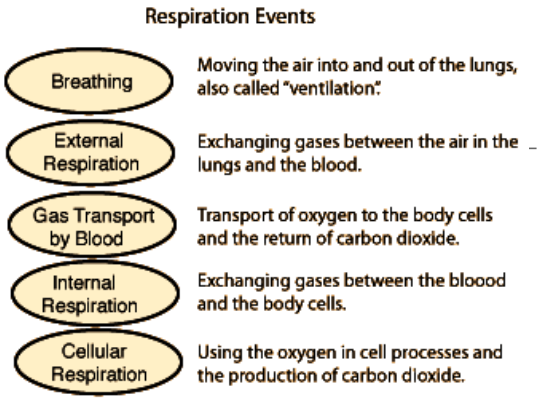
TLC = VC + RV

= 4600 + 1200 = 5800 ml.

(ix) **Inspiratory capacity (IC):** It is the total amount of air a person can inspire by maximum distension of his lungs.

I.C. = TV + IRV

= 500 + 3000 = 3500 ml.



Process of Respiration

The process of respiration is completed in 4 steps:

(i) Breathing or ventilation

(ii) Exchange of gases or External respiration

(iii) Transport of gases

(iv) Cellular respiration

(i) Ventilation or breathing:

Breathing is movement of thorax, expansion (inflation) and deflation of lungs and flow of air into the lungs and from the lungs. It is extracellular, energy consuming and physical process. Sum of inspiration and expiration is called respiratory movement. There are two steps of breathing:

(a) **Inspiration:** Intake of fresh air in lungs from outside. It is an active process. Blood pressure increases during later part of respiration.

(b) **Expiration:** Out flow of the air from the lungs is called expiration. When expiration occurs, the inspiratory muscles relax. As the external intercostal relax, ribs move inferiorly and as the diaphragm relaxes, its dome moves superiorly owing to its elasticity.

(c) **Mechanism of ventilation/breathing:**

Inspiration

Enlargement of thoracic cavity due to action of muscles of inspiration
↓
Lungs follow the enlargement of thoracic cavity and expand.
↓
Expansion of lungs leads to reduction of air pressure within the lungs than the atmospheric pressure.
↓
Air from the outside, where pressure of air is high, comes inside the lungs.
↓
At the top point of inspiration contraction of inspiratory muscles suddenly stops. ← Impulses from CNS
↓

Expiration

Inspiratory muscles relax and also due to elastic recoil, lungs shrink.
↓
Air pressure within lungs exceeds atmospheric air pressure.
↓
Air is expelled out into the atmosphere.

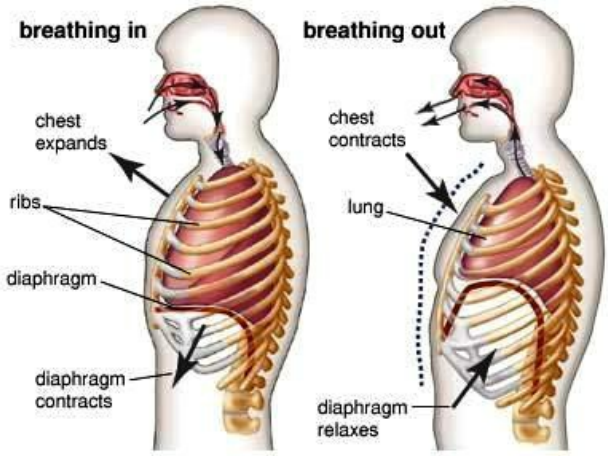
(ii) **Exchange of gases:**

(a) **Exchange of gases in lungs:** It is also called external respiration. In this gaseous exchange oxygen passes from alveoli to pulmonary capillary blood and CO_2. Comes to alveoli from pulmonary capillary.

(2) **Release of CO_2 by the blood:** The P_{CO2} (partial pressure of carbon dioxide) of blood reaching the alveolar capillaries is higher than the P_{CO2} of alveolar air. Therefore, carbon dioxide diffuses from the blood of alveolar capillaries into the alveolar air.

(b) **Exchange of gases in tissues:** In the tissues, exchange of gases occurs between the blood and the tissue cells. This exchange occurs via tissue fluid that bathes the tissue cells. The blood reaching the tissue capillaries has P_{O2} higher than that in the tissue cells and P_{CO2} lower than that in the tissue cells.

(iii) **Transport of gases:** Blood carries O2 from respiratory organs to the tissue cells for oxidation and CO2 from tissue cells to respiratory organs for elimination. Blood should be slightly alkaline to help the transport of O2 and CO2 properly.



Difference between breathing and respiration

Breathing (Ventilation)	Respiration
It is a physical process.	It is a biochemical process.
It is simply an intake of fresh air and removal of foul air.	It involves exchange of gases and oxidation of food.
No energy is released rather used.	Energy is released that is stored in ATP.
It occurs outside the cells, hence it is an extra-cellular process.	It occurs inside the cells, hence it is an intra-cellular process.
No enzymes are involved in the process.	A large number of enzymes are involved in the process.
Breathing mechanism varies in different animals.	Respiratory mechanism is similar in all animals.
It is confined to certain organs only.	It occurs in all living cells of the body.

Partial pressures of respiratory gases in mm Hg

Gas	Inspired air	Alveolar air	Venous blood	Arterial blood	Expired air	Tissue cells
Oxygen	158	100 – 105	40	95 – 100	116	20 – 40
Carbon dioxide	0.3	40	46	40	32	45 – 52
Nitrogen	596	573	573	573	565	–

Composition of three samples of air

Gases	Inspired air	Expired air	Alveolar air	Gain / loss %
Oxygen	20.84%	15.70%	13.6%	Gain 5.14%
Carbon dioxide	0.04%	4.00%	5.3%	Loss 3.96%
Nitrogen	78.62%	74.50%	74.9%	Gain 4.12%
Water	0.5%	6.2%	6.2%	Loss 5.7%

For the control of respiration following respiratory centres are found in hind brain

Type of centre	Location	Function
Inspiratory centre	Medulla oblongata	Inspiration (2 second active condition)
Respiratory centre	Medulla oblongata	Expiration (3 second inactive condition)
Apneustic centre	Pons	Slow and deep inspiration
Pneumotaxic centre	Pons	Control other centres and produce normal quite

Pneumotaxic centre	Pons	Control other centres and produce normal quite breathing
Gasping centre	Pons	Sudden and shallow respiration

Oxygen content: Total volume of O2 in 100 *ml*. of whole blood *i.e.* volume of O2 in physical solution form and oxyhaemoglobin form. It is equal to 19.7 + 0.3 = 20 *ml* of oxygen.

Oxygen capacity: Maximal amount of O2 that can be held by the blood at 760 *mm Hg* pressure and 37^0C. Oxygen capacity is about 20 *ml*/100 *ml.*