CLASS XI

BREATHING AND EXCHANGE OF GASES MECHANISM OF BREATHING

- Breathing involves two stages : inspiration during which atmospheric air is drawn in and expiration by which the alveolar air is released out.
- Inspiration can occur if the pressure within the lungs (intra pulmonary pressure) is less then the atmospheric pressure so there is a negative pressure in the lungs than the atmospheric pressure. Similarly, expiration takes place when the intra-pulmonary pressure is higher than the atmospheric pressure.

INSPIRATION

- Inspiration is an active process .
- Normally it takes around 2 seconds.
- At the time of inspiration, contraction in diaphragm and external intercostal muscles takes place.
- Diaphragm becomes flat and is pushed towards abdominal cavity.
- Sternum moves towards ventral and anterior direction.
- Ribs move towards outside and ventral side. As a result of all these reactions, the volume of thoracic cavity is increased. So the pressure of pleural fluid over lungs is decreased. Due to the spongy nature, lungs expand. As a result of this, air pressure in the lungs is decreased as compared to atmospheric pressure. Now air rushes from outside, through respiratory track and fill is the lungs.

EXPIRATION

• Normal expiration is a passive activity. It takes around 3 seconds. During expiration, contraction (in any muscle) does not take place. During expiration, relaxation in diaphragm and external intercostal muscles takes place. As a result of this relaxation, diaphragm, sternum and ribs attain their actual (normal) position. Due to which the volume of thoracic

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cavity is decreased and pressure of thoracic cage on lungs is increased. Thus air which was filled in lungs goes outside through respiratory tract. Normal breathing is also called Abdominal breathing.

• We have the ability to increase the strength of inspiration and expiration with the help of additional muscles. This is called forceful breathing.



Fig. Mechanism of breathing showing: (a) Inspiration (b) Expiration



	Type of breathing	Muscle involved	Name of Process
			(Active/Passive)
1.	Tidal inspiration	External inter coastal muscle and Diaphragm	Active
		contract	
2.	Tidal Expiration	No muscle contract,	Passive
		External inter coastal muscle and Diaphragm	
		relax	
3.	Forceful inspiration	External inter coastal muscle and Diaphragm	Active
		contract	
4.	Forceful expiration	Internal inter coastal muscle and abdominal	Active
		muscle contract	

- Each breath consists of one inspiration and one expiration alternating with each other. The rate of respiration averages 12-16 breaths per minute in a normal adult man, at rest. Alternate inspirations and expirations are due to the rhythmic arrival and interruption of nerve impulses to inspiratory muscles.
- In **forceful expiration** requiring effort, a different group of intercostal muscles and some abdominal muscles contract to reduce the volume of thorax more than that in ordinary expiration. The consequent rise of pressure in the lungs exceeds than that in ordinary expiration.So, a larger volume of air is breathed out. Such muscles are called **expiratory muscles**.

Pulmonary Volumes and Capacities

Measurement of pulmonary volumes is done with the help of Spirometer.

- Tidal Volume (TV): Volume of air which is inspired or expired in normal breathing. It is 500 ml.
- **2. Inspiratory reserve volume [IRV]:** Volume of air which inspired forceful beyond Tidal volume. This averages 2500 mL to 3000 mL.

3. Expiratory reserve volume [ERV]: Volume of air which expired forcefully beyond Tidal volume.

This averages 1000 mL to 1100 mL.

- Residual volume [RV]: Volume of air which always remain in lungs after forceful expiration. It can not expired in any condition. This averages 1100 mL to 1200 mL.
- 5. Vital capacity of lungs [VC]: Volume of air which expired forcefully after forceful inspiration.

Vital capacity = IRV + ERV + TV= 2500 - 3000 + 1000 - 1100 + 500= 4100 - 4600 ml

6. Inspiratory Capacity [IC]: IRV + TV

= 2500 - 3000 + 500 = 3000 - 3500 ml

Functional Residual Capacity (FRC): Volume of air that will remain in the lungs after a normal expiration. This includes ERV + RV
1000 - 1100 + 1100 - 1200 = 2100 - 2300 ml

8. Total capacity of lungs:

Volume of air which can be filled in lungs.

Total capacity = Vital capacity + RV = 4000 - 4600 + 1100 - 1200 = 5100 - 5800 ml

9. Dead Space Volume: Complete volume of fresh air do not take part in gaseous exchange, while a part of this air retain in respiratory tract from external nostrils to terminal bronchiole called **dead space volume. It is 150ml.**

10. Minute respiratory volume:

Volume of air which is inspired or expired per minute in normal breathing. It is $500 \ge 12 - 16 = 6000 - 8000$ ml.

11. Alveolar ventilation:

Volume of fresh air which take part in gaseous exchange per minute.

It is 350 x 12 - 16 = 4200 - 5600 ml.

12. Expiratory Capacity (EC):

Total volume of air a person can expire after a normal inspiration. This includes tidal volume and expiratory reserve volume (TV + ERV) = 500 + 1000 - 1100 = 1500 - 1600 ml.



LUNG VOLUMES

LUNG CAPACITIES

Fig. Spirogram of lung volumes and capacities