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# Breathing and exchange of gases Handwritten Notes

# Human Physiology

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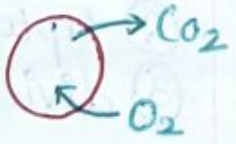
# CHAPTER :- 17 BREATHING AND EXCHANGE OF GASES

Glucose, amino acids, fatty acids ↓ (Indirectly) Energy ] $O_2$




→ **Breathing (Respiration)** → process of exchange of $O_2$ from the atmosphere with $Co_2$ produced by cells.

* **Respiratory Organs** → depending on their habits and level of organisation.

① Simple Diffusion → lower invertebrates like, Sponges, Coelentrates, flatworms.

② Moist Cuticle → Earthworm

③ Network of Tubes → Tracheal tubes → Insects.

④ Gills (Vascularised Structure) → (Brancial Respiration)
↳ Aquatic Arthropods, Molluscs, Fishes.

⑤ Lungs (Pulmonary respiration) → Terrestrial forms, birds, amphibians, reptiles, mammals.

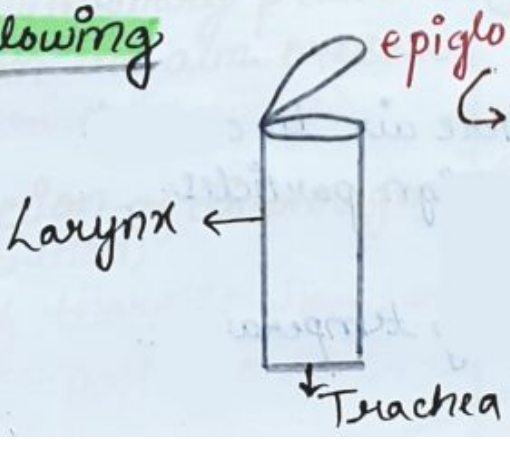
⑥ Moist Skin (Cutaneous Respiration) → Frog

* **Human Respiratory System:**

External Nostrils (pair) → Nasal passage → Nasal Chamber → Pharynx (common passage for food and air) → Larynx (Sound box) (Cartilaginous box) → Trachea.

* **Swallowing**

epiglottis → Thin elastic cartilaginous flap.
↳ To prevent entry of food into larynx



## * Trachea

supported by incomplete cartilaginous rings.

1. Straight Tube
2. Upto the mid-thoracic Cavity.
3. divides at level of 5th thoracic Vertebra

Right primary Bronchi — Left primary Bronchi

repeated divisions

Primary Bronchi
↓
Secondary Bronchi
↓
Tertiary Bronchi
↓
Bronchioles
↓
Thin terminal Bronchioles
↓

give rise to no. of very thin, irregular-walled and vasculated bag like structure (ALVEOLI)

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## * Lungs

→ branching network of bronchi, bronchioles, alveoli.
→ Two lungs.
→ covered by double layered pleura with pleural fluid b/w them.
→ Reduces friction on lung surface.

**Outer Pleura**
close contact with thoracic lining.

**Inner pleura**
contact with the lung surface.

→ ext. nostrils ↓ upto terminal bronchioles

**Conducting part**

1. transport atmosphere air to alveoli.
2. clears it from foreign particles.
3. Humidifies.
4. brings air to body temperature.

→ alveoli and their ducts ] Respiratory or exchange part.
↓
actual diffusion of $O_2$ and $CO_2$ b/w blood and atm. air.

→ Lungs situated → Thoracic Chamber (Anatomically air tight)

| Dorsally | Ventrally | Laterally | Lower Side |
|---|---|---|---|
| ↓ | ↓ | ↓ | ↓ |
| Vertebral Column | Sternum | Ribs | dome-shaped diaphragm. |

→ Anatomical Setup. → any change in vol. of thoracic cavity will reflect in lung (pulmonary) cavity.
→ such arrangement is essential for breathing, as we can't directly alter pulmonary volume.

→ Respiration Steps :→

1. Breathing / pulmonary Ventilation by which atmospheric air is drawn in and $CO_2$ rich alveolar air released out.
2. Diffusion of gases ($O_2$ and $CO_2$) across alveolar membrane.
3. Transport of gases by blood.
4. Diffusion of $O_2$ and $CO_2$ b/w blood and tissues.
5. Utilisation of $O_2$ by cells and release of $CO_2$ → Cellular respiration
   ↳ for catabolic reactions

## * Mechanism of Breathing.

| Inspiration | Expiration |
|---|---|
| ① atm. air is drawn in | ① alveolar air is released out |
| → movement occurs by creating a pressure gradient b/w lungs and atmosphere. | |
| ② intra-pulmonary pressure less than the atm. pressure (-ve pressure in lungs) | ② intra-pulmonary pressure more than the atm. pressure. |
| ③ Contraction of diaphragm (Initiation) ↑ vol of thoracic chamber in antero-posterior axis. | ③ Relaxation of diaphragm |

| | |
|---|---|
| (4) Contraction of external inter-coastal muscles lifts ribs and sternum ↑↑ the volume in dorso-ventral axis. | (4) Inter-coastal muscles returns diaphragm and sternum to normal position. |
| (5) Pulmonary Volume ↑↑ Intra pulmonary pressure ↓↓ air move into the lungs. | (6) ↓↓ thoracic volume. ↑↑ intra pul. pressure expulsion of air |

→ ability to ↑↑ the strength of inspiration and expiration by additional muscles in abdomen.
→ 12/16 times / min → Rate.
→ Volume can be estimated by Spirometer. (Clinical assesment of pul. function)

## * Respiratory Volumes and Capacities.

(1) Tidal Volume (TV) → Volume of air inspired / expired during a normal respiration. It is approx. 500 mL.
→ Healthy man can inspire/expire approx 6000 to 8000 mL of air per minute.

(2) Inspiratory Reserve Volume (IRV) → Additional Volume of a person can inspire by a forcible inspiration. This averages 2500 mL to 3000 mL.

(3) Expiratory Reserve Volume (ERV) → Additional Volume of air, a person can expire by a forcible expiration. This averages 1000 mL to 1100 mL.

(4) Residual Volume (RV) → Volume of air remaining in the lungs even after a forcible expiration. This averages 1100 mL to 1200 mL.

→ By adding up a few respiratory volumes described above, one can derive various pulmonary capacities, which can be used in clinical diagnosis.

⑤ Inspiratory Capacity (IC) → Total volume of air a person can inspire after a normal expiration. This includes tidal volume and inspiratory reserve volume. (TV + IRV)

⑥ Expiratory Capacity (EC) → Total volume of air a person can expire after a normal expiration. This induces tidal volume and expiratory reserve volume (TV + ERV)

⑦ Functional Residual Capacity (FRC) → Volume of air that will remain in lungs after a normal expiration. This includes ERV + RV.

⑧ Vital Capacity (VC) → Maximum volume of air a person can breath in after a forced expiration. This includes ERV, TV and IRV or maximum volume of air a person can breathe out after a forced inspiration.

⑨ Total Lung Capacity (TLC) → Total volume of air accommodated in lungs at the end of forced inspiration. This includes RV, ERV, TV and IRV or Vital Capacity + residual volume.

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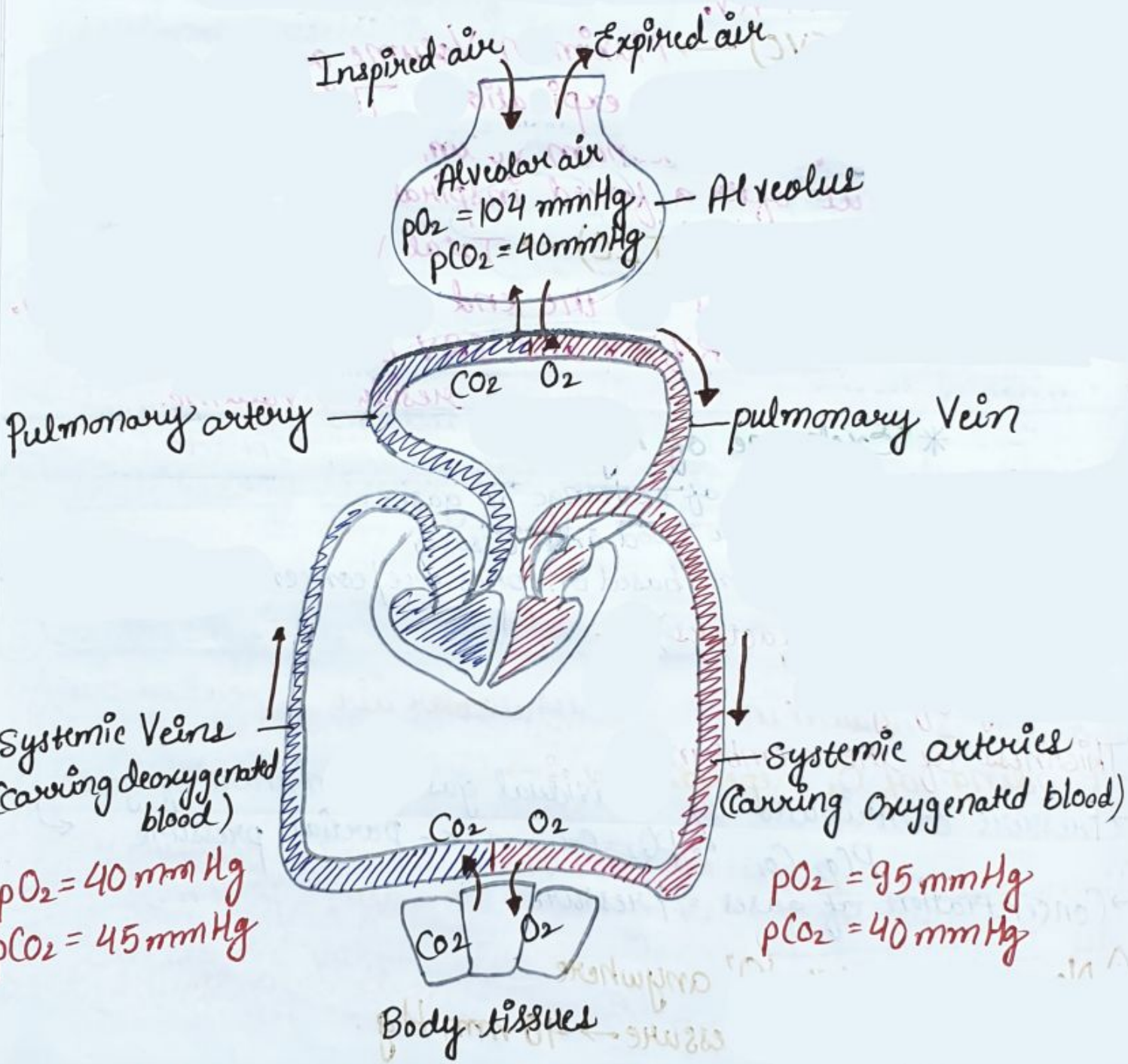
## * Exchange of Gases

→ Alveoli = primary site of exchange of gases.
→ exchanges also occur b/w blood and tissues.
→ $O_2$/$Co_2$ exchange = diffusion = based on pressure/concentration gradient
→ Rate of diffusion (factors) :→
- Solubility of gases.
- Thickness of the membrane.

→ Pressure contributed by individual gas in mixture of gases ← partial pressure ← $PO_2$ = Oxygen, $PCO_2$ = $Co_2$
→ Concentration of gases = Pressure

① No gas is ever '0' anywhere.
② Minimum partial pressure → 40 mm Hg.
③ Max. Value of $Co_2$ → 45 mm Hg.

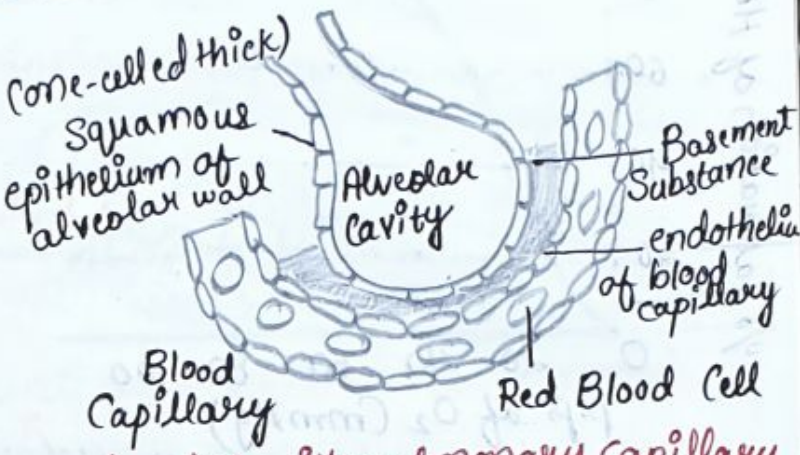
| Respiratory Gas | Atmospheric Air | Alveoli | Blood (Deoxygenated) | Blood (Oxygenated) | Tissues |
|---|---|---|---|---|---|
| $O_2$ | 159 | 104 | 40 | 95 | 40 |
| $CO_2$ | 0.3 | 40 | 45 | 40 | 45 |




→ Solubility of $CO_2$ is 20-25 times higher than that of $O_2$

## * Diffusion Membrane

① The thin squamous epithelium of alveoli.
② Endothelium of alveolar capillaries.
③ Basement Substance:
↓
- Thin Basement Membrane
- But total thickness is < 1mm.
- So, $O_2$ alveoli → tissues
- $CO_2$ tissues → alveoli




- alveolus with pulmonary capillary

## * Transport of Gases

Blood Transports

### $O_2$

① 97% RBC
② 3% dissolved state through the plasma.

### $CO_2$

① 20-25% by RBC's.
② 70% by bicarbonates.
③ 7% dissolved state through plasma.

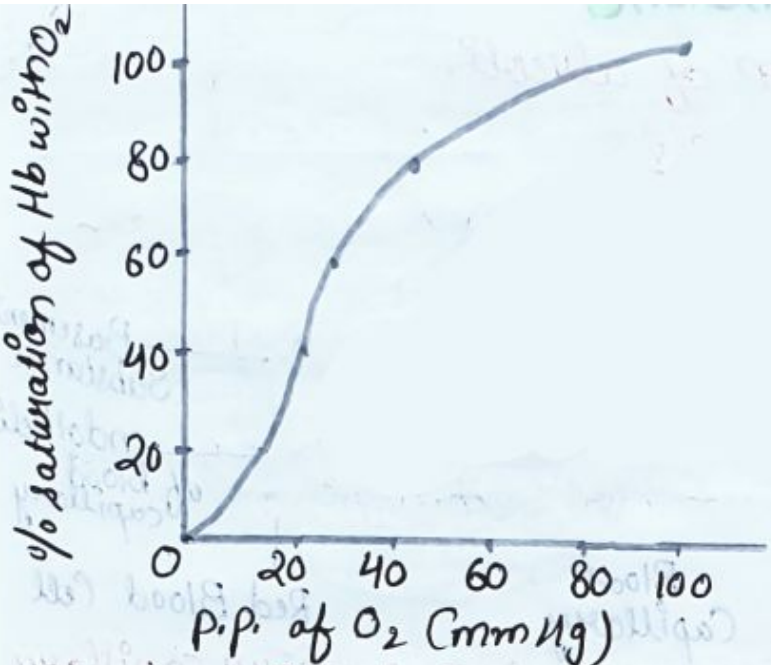
## * Transport of Oxygen

Hb → red coloured Fe containing pigment present in RCB's.

$O_2 + Hb \rightarrow$ Oxyhaemoglobin
↓
Carry Max. 4 $O_2$ molecules.

→ Binding of $O_2$ depends on. :→

① partial pressure of $O_2$
② partial pressure of $CO_2$
③ Hydrogen ion
④ Temperature.




oxygen dissociation curve.

Sigmoid Curve

↙ % saturation of Hb with $O_2$

↘ with $PO_2$

↓

Oxygen dissociation Curve

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→ **Alveoli**
1. High $PO_2$
2. Low $pCO_2$
3. lesser $H^+$ concentration
4. Low temperature

] Formation of oxy-Hb.

→ **Tissues**
1. low $pO_2$
2. high $pCO_2$
3. high $H^+$ concentration
4. High temperature.

] dissociation of from oxy-Hb.

→ $O_2$ binds to Hb in lungs surface and get dissociated at the tissues.

→ Every 100 mL of oxygenated blood can deliver around 5ml of $O_2$ to the tissues.

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## * Transport of $CO_2$.

$CO_2 + Hb \rightarrow$ Carbamino-Hb (20-25%).

→ Binding depends on :—
1. partial pressure of $CO_2$.
2. Partial pressure of $O_2$.

→ Tissues ① $pCO_2$ is high
② $pO_2$ is low
] more binding of $CO_2$

→ Alveoli ① $pCO_2$ is low
② $pO_2$ is high.
] dissociation of $CO_2$

$$CO_2 + H_2O \underset{\text{carbonic anhydrase}}{\overset{\text{carbonic}}{\rightleftharpoons}} H_2CO_3 \underset{\text{carbonic anhydrase}}{\overset{\text{carbonic}}{\rightleftharpoons}} HCO_3^- + H^+$$

↓
present in RBC's (minute amount also present in plasma)

→ Tissues ① $pCO_2$ is high.
↳ $CO_2$ diffuses into blood and forms $HCO_3^-$ and $H^+$.

→ Alveoli ① $pCO_2$ is low.
opposite direction, forming $CO_2$ and $H_2O$

→ $CO_2$ trapped as $HCO_3^-$ at tissue level.

→ 100 ml deoxygenated blood delivers approx 4 ml of $CO_2$ to alveoli.

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## * Regulation of Respiration.

→ done by neural system.

① Brain
↓
Medulla
↓
Respiratory rhythm centre
↓
Baby (Superpowers) Don't Know how to Control.

] Primary responsible for respiration

② Brain
↓
Pons region
↓
Pneumotaxic centre
Dad stops
↳ moderate the functioning of respiratory rhythm centre.
↓
Neural Signal
↓
Reduces duration of inspiration
↓
alter respiratory rate.

③ Chemosensitive area → Mom Helps Baby.

↓

ajacent to rythm centre

↓

Highly sensitive to $CO_2$ and $H^+$ ions

↓

If these ↑↑

↓

Centre get activated


④ Receptors with aortic arch and carotid artery

↓

also recognise changes in $CO_2$ and $H^+$ conc.

↓

Send signals to rythm centre

→ Role of Oxygen in regulation of respiratory rhythm is quite insignificant.

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## * Disorders of Respiratory System

① Asthma → Difficulty in breathing.

↳ Causing wheezing due to inflammation of bronchi, bronchioles

② Emphysema → Chronic disorder.

↳ alveolar walls damaged and respiratory surface decreases.

↳ Major Causes → Cigarette smoking

③ Occupational Respiratory Disorders → Industries (grinding, Stone breaking)

↓

Lot's of dust

↓

defence mechanism can't fully cope with situation.

↓

Long exposure

↓

Inflammation (Fibrosis)

↓

Serious Lung damage.

Fibrosis → proliferation of fibrous tissues.

Workers must wear masks.