Breathing and Exchange of Gases

Indirect breakdown of simple molecules like glucose

or,

Intake of O_2, breathing of complex nutrients in cell release of energy, trapping of energy & convert in ATP called respiration.

The process of exchange of Oxygen (O_2) from the atmosphere with carbon dioxide (CO_2) produced by the cells is termed as breathing which is commonly known as respiration.

Respiratory Organs

- Lungs
- Gills
- Skin
- Tracheal tube

Types of Respiration

- Pulmonary respiration
- Branchial respiration
- Cutaneous respiration
- Tracheal respiration

* During [winter sleep] hibernation & [summer sleep] Aestivation, Amphibians like frogs respire through skin, buccal cavity + Lungs. {Cutaneous respiration}

Organisms	Respiratory Organs
Lower Invertebrate: Sponges	Entire body surface → By simple diffusion
Lower Invertebrate: Coelenterates	Entire body surface → By simple diffusion
Lower Invertebrate: Flatworms (Platyhelminthes)	Entire body surface → By simple diffusion {mostly Parasites}
Roundworms (Aschelminthes)	Entire body surface → By simple diffusion {mostly Parasites}
Earthworms (Annelida)	Moist Cuticle → Cutaneous respiration (by skin)
Aquatic arthropods (Prawn)	Gills

Arthropods	Aquatic arthropods (Prawn)	Gills
	Insects (Cockroach)	& Tracheal tubes
	Arachnids (Spider, Scorpion)	Book Lungs
	Aquatic molluscs	feather like gills
	Hemichordates	Gills
Chordates	Fishes	Gills
	Amphibians	Lungs
	Reptiles	Lungs
	Birds	Lungs
	Mammals	Lungs
*	Echinodermata	water vascular system

→ Human Respiratory System

- → developed from endoderm
- → The Pathway of air in the respiratory system occurs as:
  - (i) Conducting Pathway
    External nostrils → nasal passage → nasal chamber → Pharynx → Glottis → Larynx → Trachea → Primary bronchi → Secondary bronchi → Tertiary Bronchi → Initial bronchioles → Terminal bronchioles.
  - (ii) Respiratory Pathway
    Duct of Alveoli → Alveoli
- → nasal chamber open in the Pharynx.
- → Common passage of food & air → PHARYNX.
- → opening of the trachea → GLOTTIS
- → 1st part of trachea → LARYNX.
- → Another name of trachea → wind pipe
- → Larynx → nature → Cartilaginous
- → production of Sound → at larynx (also called sound box)

→ Stopping the entry of food in larynx, while swallowing
↓
EPIGLOTTIS {Thin elastic cartilaginous flap}
→ Covers the glottis

→ Trachea → straight tube
↓
Extends up to the mid-thoracic cavity

→ Trachea divides at 5th thoracic cavity
↓
into right & left primary bronchi

→ As bronchi undergoes suvral repealed division → formation of secondary & tertiary bronchi & bronchioles takes place.

→ The Tracheae, primary, secondary and tertiary bronchi as well as initial bronchioles are supported by C-shaped (Incomplete Cartilaginous

→ Cartilaginous ring prevents
↓
Collapse of wall of the trachea.
↓
made up of Hyaline Cartilage

→ Each terminal bronchiole gives rise to a no. of Alveoli.

→ Alveoli
- → very thin
- → Small irregularly walled
- → Vascularized bag like structures

→ LUNGS → network of primary bronchi, secondary bronchi tertiary bronchi, bronchioles and alveoli.
→ Inner surface area → 100 m^2

→ Human lungs covered by double layered Pleura with Pleural fluid b/w them.
→ reduces friction on lung surface

→ Conducting part bring air to body temperature. foreign body, Humidifying

→ Actual diffusion of O_2 & CO_2 takes place b/w blood & atmospheric air by exchange of gases.

→ A person normally respiration or breathe 12 to 16 time in a minute

→ Respiration → catabolic < Amphibolic

Amphibolic → Anabolic → Energy Produced
Amphibolic → Catabolic → Energy Used

Inspiration → when pressure of air inside lungs in less than atmospheric Pressure.
Active Process

Expiration → vice-versa
Passive Process

Pressure difference b/w lungs & atmosphere or Pressure gradient

⇓

maintain by Diaphragm & Intercostal muscle

Intercostal muscle → External, Internal

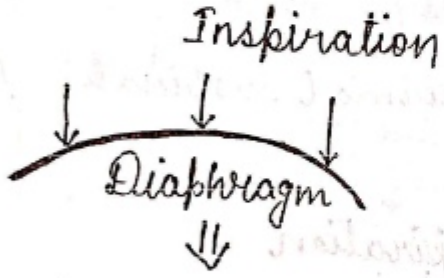
* Boundaries of Thoracic Chamber or air-tight chamber or Ribcage.
  - → Dorsal side → vertebral Column
  - → Ventral side → Sternum
  - → Lateral side → Ribs
  - → Lower side → Diaphragm

An Occupational respiratory Disorder
→ Silicosis

* During Inspiration

(i) Inspiration initiate by
↓
Contraction of diaphragm
↓
which increases the thoracic volume
↓
In Dorsoventral dirn

(ii) Contraction of External Intercostal muscle lift up the Ribs & sternum
↓
Increase the thoracic volume
↓
In Anteriioposterior dirn



→ In normal condition or, after expiration
- Relax
- Dome shape

→ During Inspiration
- Contract
- flat

⇓
Thoracic volume
⇓
Increase in dorsoventral dirn

* NOTE

Muscle Contract during Inspiration
└→ External Intercostal muscle

Muscle relax during Inspiration
└→ Internal Intercostal muscle.

Muscle Contract during Expiration
└→ Internal Intercostal muscle.

Muscle relax during Expiration
└→ External Intercostal muscle.

↦ Abdominal muscle are used during deep breathing
or,
Strength of breathing increase by abdominal muscle.

↦ Respiratory Volume and Capacity :-

① Tidal Volume → a person during normal respiration / Breathing

Inspiration → Expiration

Used air 500 ml or 0.5 l.

→ after 1 minute
- → 12 X 500 ml ⇒ 6000 ml or 6 lit.
- → 16 X 500 ml ⇒ 8000 ml or 8 lit.

② Inspiratory reserve volume
- → additional volume
- → Forcible Inspiration
- → value ⇒ 2500 ml – 3000 ml
  2.5 lit – 3 lit

③ Expiratory reserve volume
- → additional volume
- → Forcible expiration
- → value → 1000 ml – 1100 ml
  1 lit – 1.1 lit

④ Residual volume
- → volume of air remains in lungs after forcible expiration.
- → value → 1100 ml – 1200 ml
  1.1 lit – 1.2 lit

→ By adding of different volume obtained capacities :-

① Inspiratory capacity
- → Inspiration after normal expiration.
- → value → T.V + I.R.V
  500 ml + 2500 ml ⇒ 3 lit or 3000 ml
  or,
  500 ml + 3000 ml ⇒ 3.5 lit or 3500 ml

⑪ Expiratory capacity
- → Expiration after normal Inspiration
- → value → 500 ml + 1000 ml ⇒ 1500 ml or 1.5 lit
  or,
  500 ml + 1100 ml ⇒ 1600 ml or 1.6 lit

⑪ Functional residual volume
- → volume of air remaining in lungs after normal expiration.
- → value → R.V + E.R.V
  1100 + 1000 ⇒ 2100
  1100 + 1100 ⇒ 2200
  1100 + 1100 ⇒ 2300

RANGE
2100 – 2300

(IV) Vital capacity

→ Inspiration after forcible expiration or breathout
or,
Normal expiration after forcible inspiration or breathe in.

Tidal volume + Inspiratory reserve volume + Expiratory reserve volume.

500 + 2500 + 1000
= 4000 ml

500 ml + 3000 ml + 1100 ml ⇒ 4600 ml

4000 ml — 4600 ml
or,
4 l — 4.6 l

(V) Total lung capacity (TLC)

→ Total volume of air accumulated in lungs after forcible inspiration.

T.V + I.R.V + E.R.V + R.V
(500 + 2500 + 1000 + 1100) ml
⇒ 5100 ml

(500 + 3000 + 1100 + 1200) ml
⇒ 5800 ml
or,
5.1 l to 5.8 l

→ Calculation of capacity (Case-I)

T.V + I.R.V + E.R.V + R.V = Total lungs capacity
Vital capacity + R.V = Total lung capacity

T.L.C — V.C ⇒ R.V

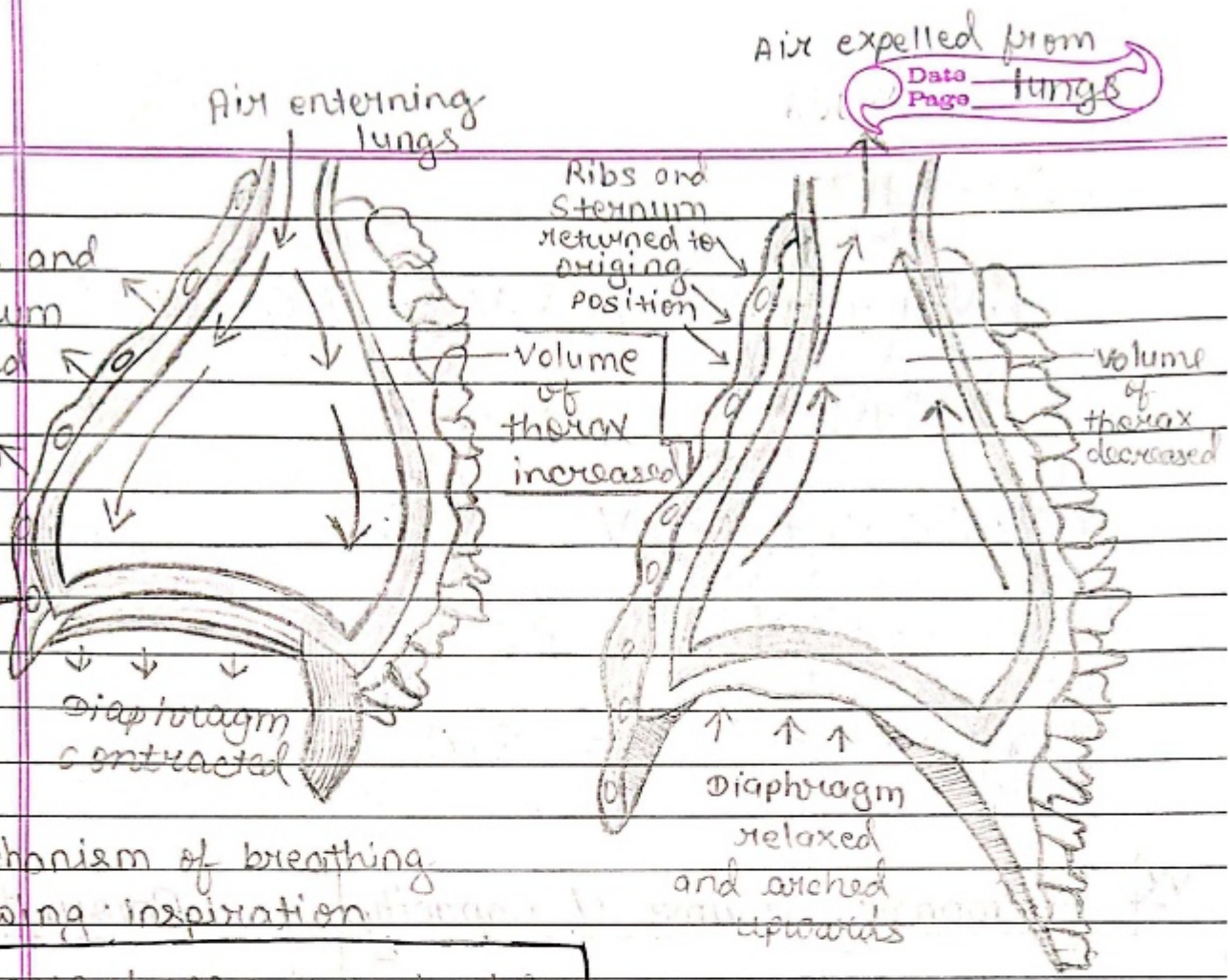
T.L.C — R.V ⇒ V.C

Case - II

→ T.V + I.R.V + E.R.V ⇒ V.C { Vital Capacity }
→ I.C + E.R.V ⇒ V.C
→ E.C + I.R.V ⇒ V.C
→ V.C − I.R.V ⇒ I.C
→ V.C − E.R.V ⇒ E.C

* Pulmonary Vol. of Capacity	Amount
Tidal Volume	500 ml
Inspiratory Reserve volume (I.R.V)	2500 – 3000 ml
Inspiratory Capacity (I.C)	3000 – 3500 ml
Expiratory Reserve volume (ERV)	1000 – 1100 ml
Expiratory Capacity	1500 – 1600 ml
Residual volume (RV)	1100 – 1200 ml
Functional Residual Capacity (FRC)	2100 ml – 2300 ml
Vital Capacity (VC)	4000 – 4600 ml
Total Lung Capacity (TLC)	5100 – 5800 ml

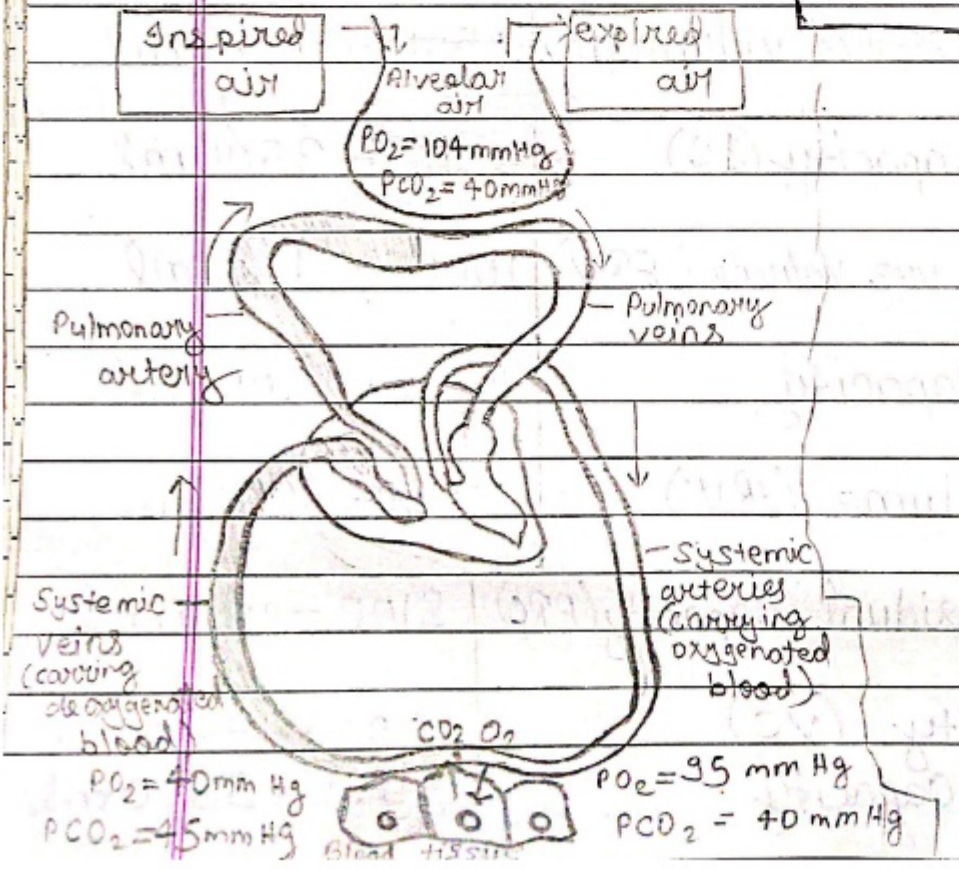
Data
Page



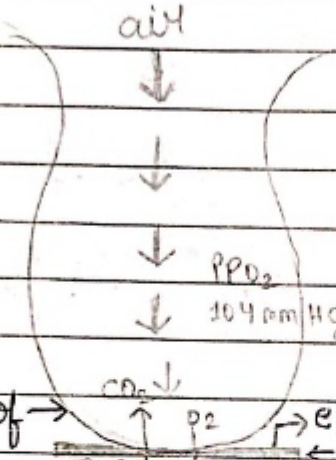
* Mechanism of breathing showing inspiration

* Mechanism of breathing showing expiration.

* Exchange of gases at the alveolus and the body tissue with blood and transport of oxygen & CO_2.



Exchange of gases



exchange of O_2 & CO_2 by simple diffusion between blood & atmosphere

→ epithelium of alveoli
← Basement membrane
↕ endothelium layer of blood vessel or capillary

] 3 layer Respiratory membrane diffusion membrane thickness > 1 mm

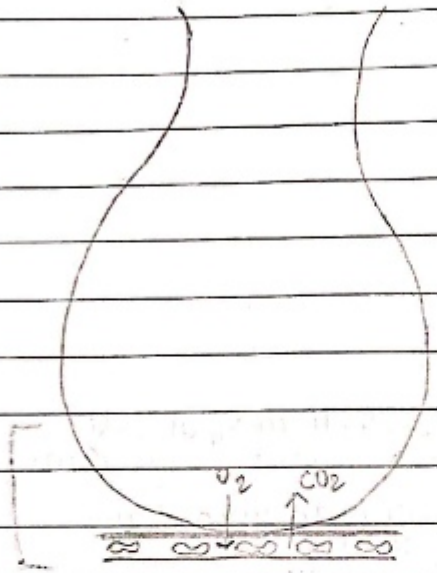
* Exchange of O_2 & CO_2 Based on

- Solubility of gas in blood
- Thickness of respiratory membrane
- Pressure of gases or partial pressure of gases.

alveoli PP_{O_2} → 104 mm Hg

deoxygenated blood $PPCO_2$ → 45 mm Hg

Total pressure = Partial pressure
(A + PP_B + PPc)



= Pressure gradient of O_2 or partial pressure (PPO_2)

Atm > alveoli > Blood > Tissue

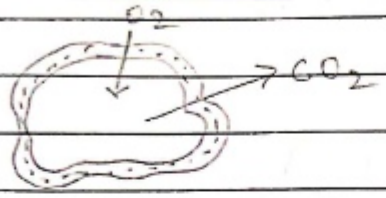
159 104 95 40
Atm → Alveoli → Blood → Tissue

= Pressure gradient of CO_2 or partial pressure ($PPCO_2$)

Tissue > Blood > Alveoli > Atm

45 45 40 0.3
Tissue > Blood > Alveoli > Atm

At tissue



- $PPCO_2$ ↑es
- H^+ ↑es
- pH ↓es
- temperature ↑es

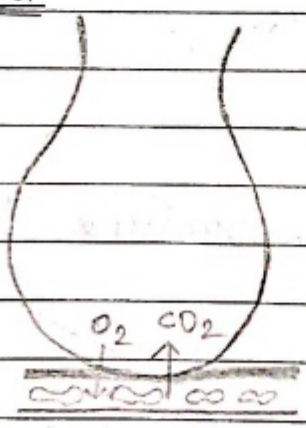
$H_2O + CO_2$ —carbonic anhydrase→ H_2CO_3 formation

$H_2CO_3 \rightarrow H^+ + HCO_3^-$ → 70%

H^+ ↑↓ Cl^- (Plasma)

Hamburge phenomena
or
Chloride shift

At alveoli



- $PPCO_2$ ↓
- → H^+ ↓
- → pH ↑
- → temperature ↓
- → $HCO_3^- + H^+$ —carbonic anhydrase (Breating)→ H_2CO_3 → $H_2O + CO_2$

(Bicarbonate ion) HCO_3^- ↑↓ Cl^- (Plasma)

↓

Reverse Cl^- shift

$pH \propto \frac{1}{H^+}$

Transport of gases

- CO_2
  - 70% bicarbonate (HCO_3^-)
  - 20-25% transport by RBCs.
  - 7% transport by plasma (dissloved state).

- O_2
  - 97% by RBCs
  - 3% by plasma in disslove state.

$CO > CO_2 > O_2$ solubility order in blood

- At alveoli
- oxyhemoglobin are produce (HbO_2)
  - $PPO_2 \uparrow$
  - $H^+ \downarrow$
  - pH ↑
  - temperature ↓

- Haemoglobin is a red-coloured iron pigment located in red-blood cells.
- Each haemoglobin carry, four oxygen molecules.
- % saturation of Hb is plotted against (PO_2) a sigmoid curve. this curve is called oxygen dissociation curve. very helpful in PCO_2, H^+ concentration etc.
- O_2 Hb is reversible manner to form oxyhaemoglobin.

- At tissue
  - oxyhaemoglobin break
    - $PPO_2 \downarrow$
    - $H^+ \uparrow$
    - $PH \downarrow$
    - temperature $\uparrow$

- At tissue carbamino hemoglobin ($HbCO_2$) are produce
  - $PPCO_2 \uparrow$
  - $H^+ \uparrow$
  - $PH \downarrow$
  - temperature $\uparrow$

- At alveoli ($HbCO_2$), are break
  - PP_{CO_2} ↓
  - H^+ ↓
  - PH ↑
  - temperature ↓

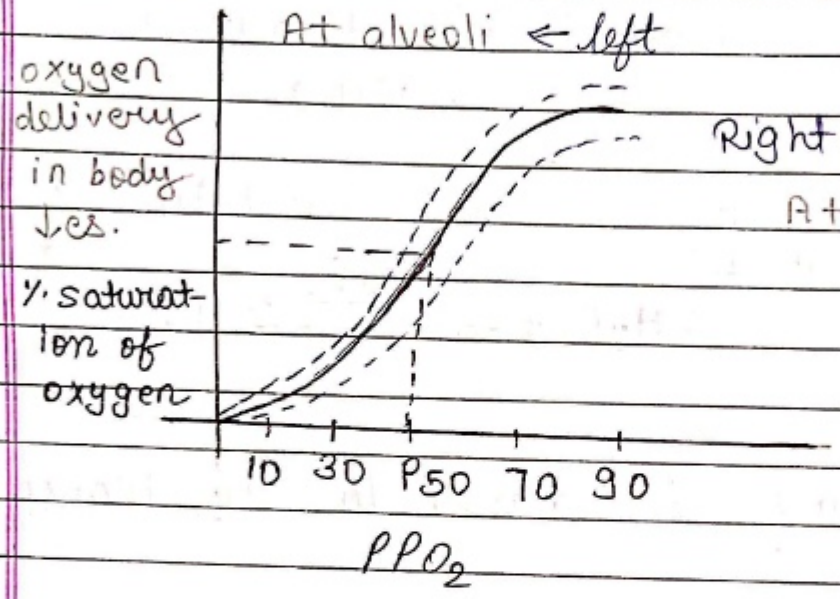
- CO_2
  - HCO_3^- > RBC > Plasma
    70%. 23%. 3%.

- O_2
  - RBC > Plasma
    97%. 7%.

- about 100 ml oxygenated blood have 20 ml oxygen.
- 100 ml oxygenated blood deliver 5 ml O_2 to the tissue
- 100 ml deoxygenated blood deliver 4 ml CO_2 to the alveoli

Oxygen dissociation curve

% Saturation of oxygen against PPO_2.



at high altitude

- oxygen density ↓es
- so, graph - left sides

↓

high altitude sickness

↓

nausea, vomiting

↓

Body compensate

↓

↑es RBCs Number = ↑es oxygen in blood

↓ (OR)

↓es the binding capacity of Hb with CO_2.

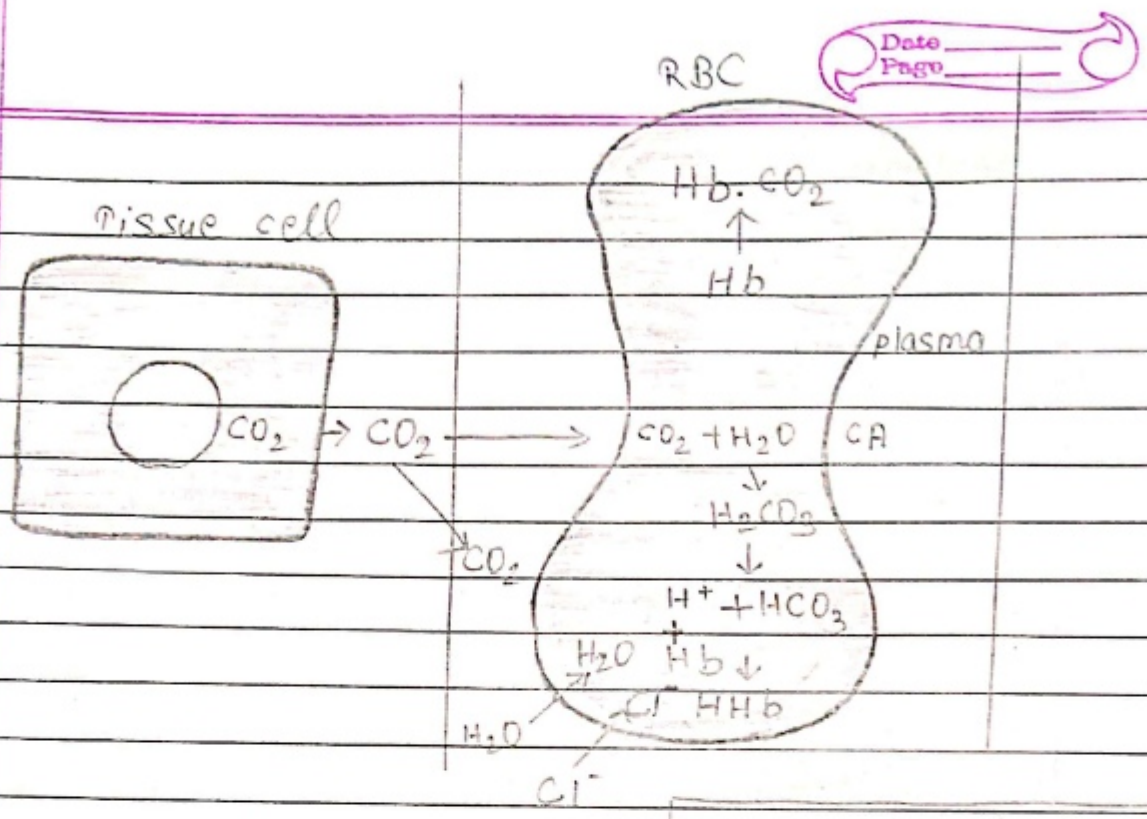
100 ml oxygenated blood = 20 ml of oxygen
↓
5 ml gives to the tissue

- The concentration of enzyme carbonic ~~anhydar~~ anhydrase is high in red blood cells and is very less in plasma.

- Fascilitated by the enzyme in both direction:-

$$CO_2 + H_2O \xleftrightarrow{\text{carbonic anhydrase}} H_2CO_3 \xleftrightarrow{\text{carbonic anhydrase}} HCO_3^- + H^+$$

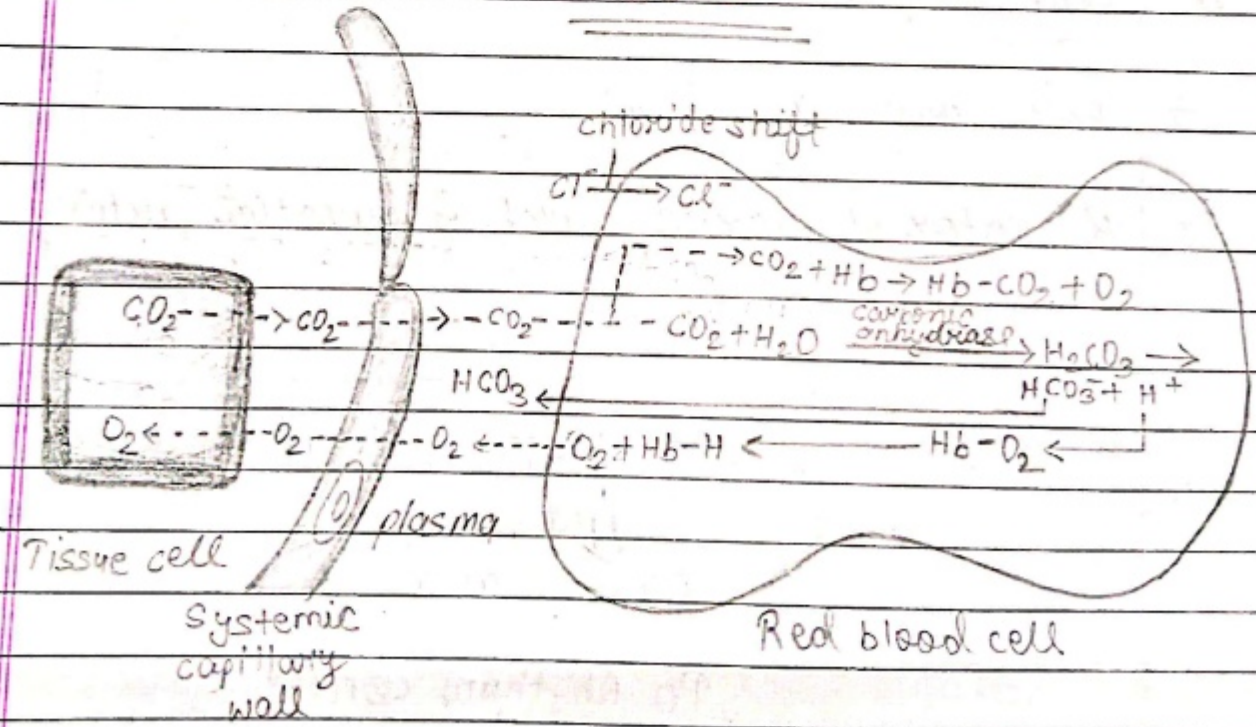
- Chloride shift is required for CO_2 transport.



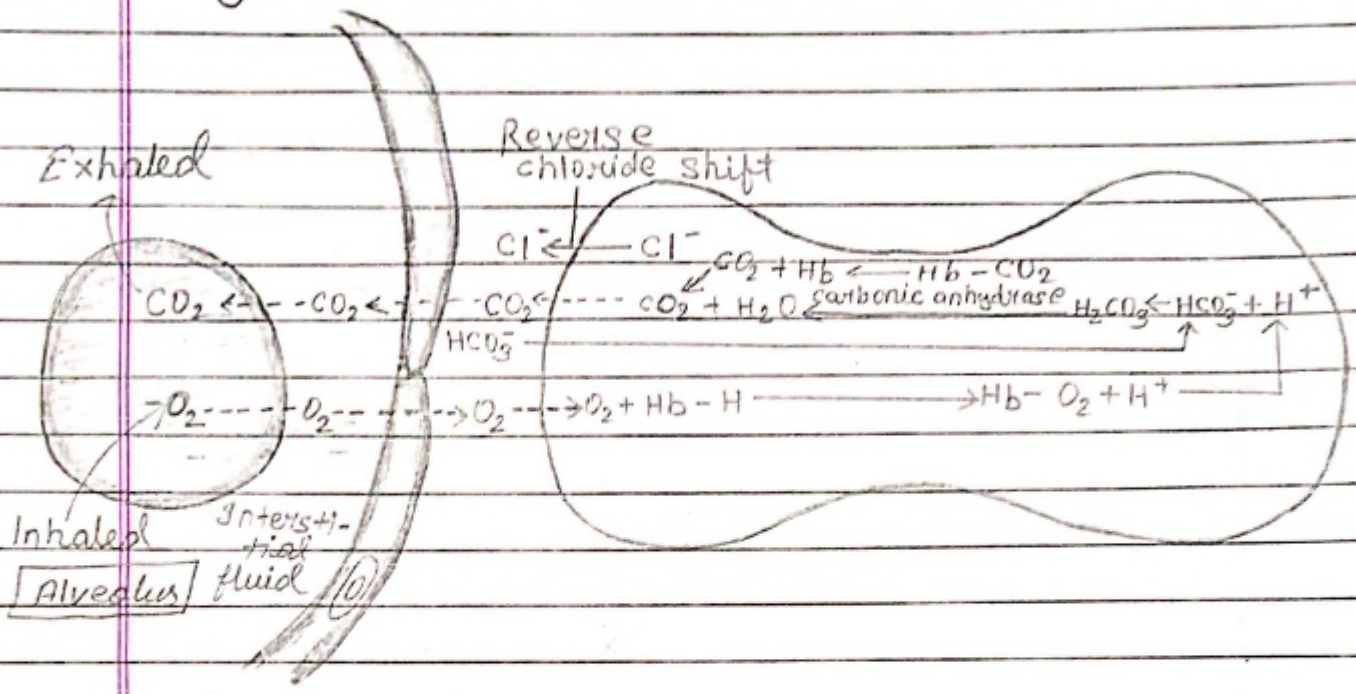
CA = carbonic anhydrase

→ Chloride shift

* Exchange of O_2 & CO_2 in systemic capillaries tissue



Regula



Regulation of Respiration

Q Why Respiration ?

→ For removal of CO_2

Receptor of aortic arch & carotid artery

↓

regonised

↓

CO_2 (concentration) H^+

↓

pass signal

↓

To Rhythem center

↓

Present in medulla (Part of Hind brain)

Date
Page

To . Rhythm center

↓

near to rhythm center

↓

chemosensitive area

↓

also regonised CO_2, H^+ concentration

↓

pass necessary signal to

↓

Medulla

other center – pneumotaxic center called pons (part of Hind Brain)

↓↓

Control the function of medulla

Disorders of respiratory System

Asthma – It is due to the inflammation of the bronchi and bronchioles, wheezing occurs during breathing and there is difficulty in breathing.

Bronchitis – This is the inflammation of the bronchi

Emphysema- A chronic disease in which the alveolar wall is damaged, which reduces the respiratory surface. Cigarette smoking in one of the main causes.

Occupational Respiratory Disorders:- In some industries, especially which involve stone grinding, milling or breaking there are so many dust particles that the body's defense mechanism cannot complete cope up with them. Long-term exposure can cause inflammation, which leads to fibrosis (proliferation of fibrous tissues), which can lead to serious damage to the lungs. workers of these industries should wear protective masks.

	Respiratory pigment	organisms	Metal ~~Heated~~	colour	location
1.	Haemoglobin	Vertebreates	Fe	Red	RBC
2.	Haemoglobin	Earthworm	Fe	Red	Plasma
3.	Haemoglobin	Some arthopods & molluses	Cu	Blue	Plasma
4.	Vanadium	Punicates	V	Green	Cells