6/02/18

Breathing & Exchange of Gases

Respiration :→

→ Breaking of respiratory fuel ⟶ energy.

→ O_2 taken in and CO_2 given out.

Types

Aerobic

→ O_2 reqd.

$C_6H_{12}O_6 \xrightarrow{O_2} CO_2 + H_2O + E$

38 ATP
− 2 ATP
36 ATP

(i) glycolysis
$C_6 \rightarrow 2PA$

(ii) Link Rxn
$2PA \rightarrow$ Acetyl Co-A

(iii) Kreb's Cycle
Acetyl CoA $\rightarrow CO_2$

(iv) ETC.

(v) Oxidative phosphorylation
↓
ATP

Anaerobic

→ in absence of O_2.

a) In Yeast

Glu ⟶ 2PA ⟶ $2CO_2$ + C_2H_5OH + 2ATP

b) In Muscles/RBC

Glu ⟶ 2PA ⟶ 2 Lactic Acid + 2ATP

(II) Type II :→

(i) Direct Respiration → Amoeba

(ii) Indirect → Mammals etc

Steps involved in respiration :→

(i) Breathing / ventillation.

(ii) Exchange of respiratory gases b/w alveoli & Blood.

(iii) Transport of respiratory gases by blood.

(iv) Exchange b/w blood & Tissue.

(v) Using O_2 → glucose breakdown to release energy

Characteristics of Respiratory Surface :→

→ Thin.
→ Moist.
→ Highly Vascular
→ Presence of Respiratory Pigments.
→ Large Surface Area.

Pigments :-

(i) Haemoglobin → Fe
(ii) Haemoerythrin — Fe → Annelida
(iii) Haemocyanin — Cu → Molluscs.
(iv) Echinochroome — Echinoderms
(v) Vanadium → Coelomic fluid of Protochordate.

Organ for Respiration :→

(i) Skin → Cutaneous respi.
Ex! → Earthworm & Frog
(ii) Tracheae → Tracheal resp.
Ex! → Insects.

(iii) Gills → Bronchial resp.
Ex!→ Fishes, Prawns, Tadpoles.

(iv) Lungs → Pulmonary resp.
Ex!→ Higher vertebrates.

(v) Book Lungs → Scorpions & Spiders

(vi) Book Gills → Limulus.

v.vi (vii) Pulmonary Sac → Molluscs.
(Mantle)

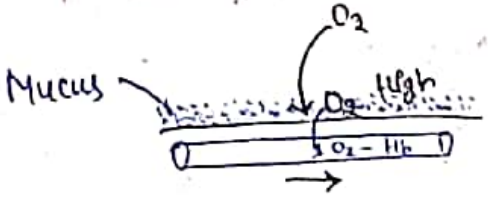
Cutaneous Respiration :→

→ Respiratory Organ → Skin.

Ex!→ Earthworm, frog (in water) or during Hibernation.

In Earthworms!→

→ Thin layer
→ vascular
→ Pigment – Hb. (Hb is in plasma not RBC)
→ Moist → by mucus & Coelomic fluid.



$O_2 + Hb = OxyHb.$
(in plasma)

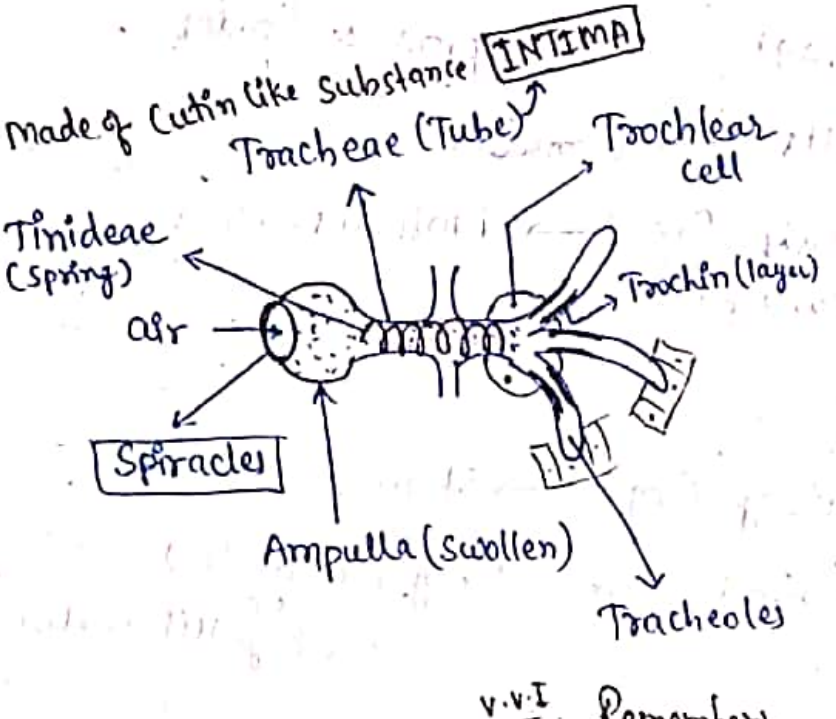
Note!→
In absence of Oxygen,
Earthworms die due to Asphyxiation.
(O_2 Starvation).

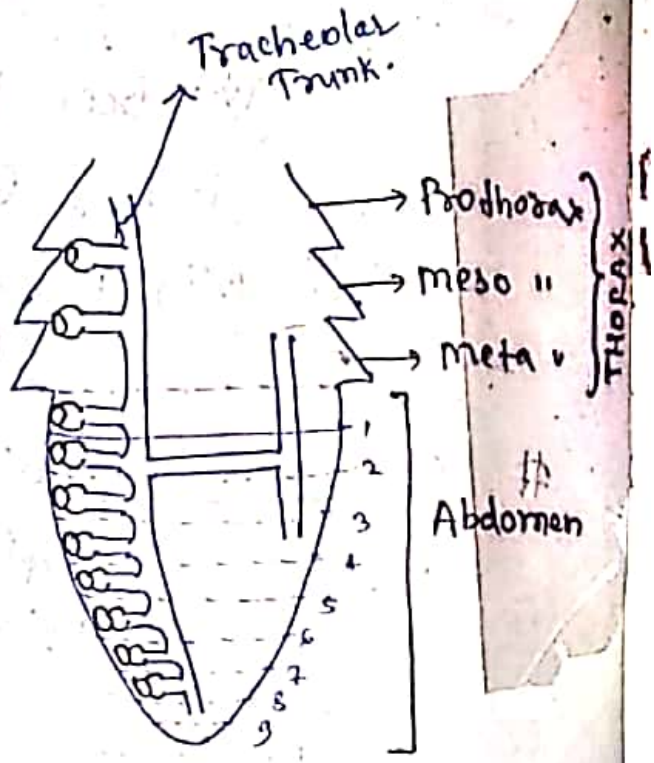
Tracheary / Tracheal Respiration :-

→ Helping Structure Tracheae.

→ Ex → Insects, cockroaches.

In Cockroach :-





V.V.I Remember :- → Total 10 Spiracles
* 2 at Thorax
* 8 at Abdominal.

→ 1st Thoracic & 1st Abdominal → Always Open.

Mech :-

Cockroach :- Inhalation & Exhalation

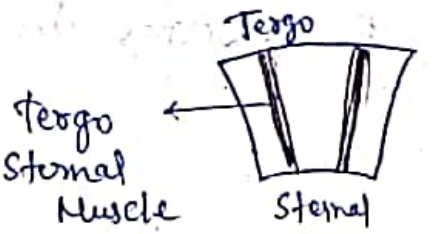
Inhalation → Passive Process (No ATP Reqd)

Exhalation → ATP → Active Process
* By Contraction of
* Tergo-sternal Muscle → Volume ↑ Pressure ↓

Note :-

In case of Humans :-

Inhalation = Active (ATP)
Exhalation = Passive



Brancheal Respiration :→

→ Helping Structure Gills.

→ Ex:→ Fishes, Prawn, Tadpoles.

Types of Gills :→

I. On the basis of visibility of gills.

External
→ Seen from outside
Ex:→ Cartilagenous Fishes, Tadpoles

Internal
→ Not visible from outside
Ex:→ Bony Fishes

II. On the basis of attachment site :-

a) Podobranch → attached to appandages.

b) Aurthrobranch → " to the membrane.

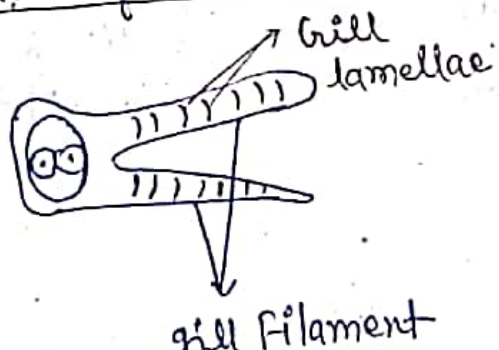
c) Pleurobranch → " " " lateral side.

III. On the basis of gill filaments :→

a) Hemibranch → only 1 row (half gills)

b) Holobranch → 2 row of gill filaments.
↳ complete gills.

Structure of Gills :→



Compare the differences b/w air/water :→

(i) H_2O is 800 time dense.

(ii) O_2 in water is 30 times less soluble than in air.

(iii) Rate of diffusion is 5 Lakh times less than as compared to air as a medium

Adaptations :→

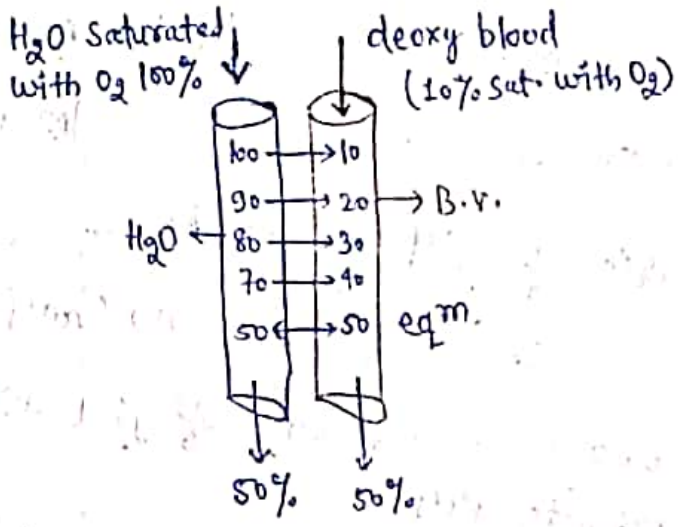
→ Counter-current Mechanism.

→ By maintaining continuous water flow on the gills.

Counter-current Mechanism :→

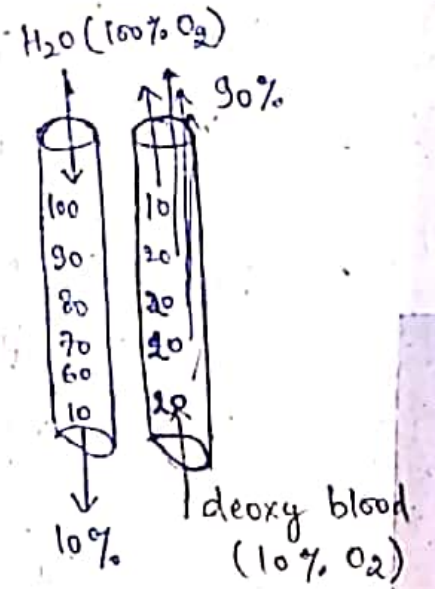
→ more efficient way of absorption of O_2 by B.V.

→ Flow of H_2O & blood is in opp. dirn.



(50% O_2 absorbed)

CO-CURRENT



(90% O_2 absorbed)

COUNTER-CURRENT

Pulmonary Respiration :→

→ Helping structure = lungs.

→ Ex!→ Amphi, Reptiles, Birds & Mammals.

Respiration in Humans :→

* Skin → thick, to prevent water loss by ~~evaporation~~ evaporation.

1.5 – 2 m^2

* Lungs →

Alveoli → very thin
→ lined by simple squamous epi.
→ Moist
→ Higher vascular.
→ Respiratory pigment Hb.

Surface Area 50 – 75 m^2

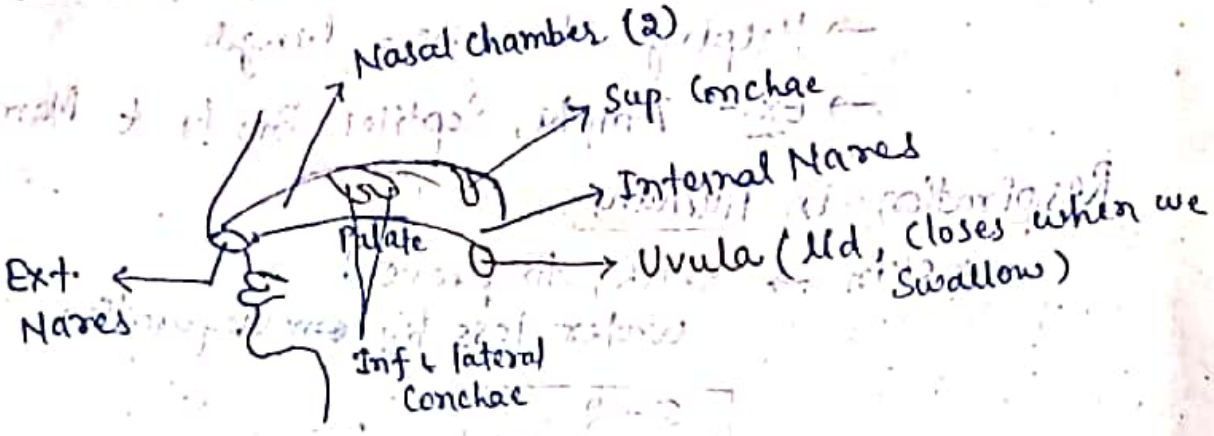
Organs involved in Respiration :→

(1) Respiratory Tract :→
→ External Nares.
→ Nasal chambers — (2) → vestibular chamber
→ Respiratory "
→ olfactory "
→ Internal Nares.
→ Nasopharynx
→ Larynx (voice Box)
→ Trachea
→ Bronchi
→ Bronchioles
→ Alveoli

(2) Lungs.

(3) Diaphragm

Respiratory Tract:- (Nasal chamber) :-



→ There are two Nasal Chambers.
→ Each nasal chamber is divided into 3 other chambers:→

(i) vestibular chamber :→
→ Filteration of Air.
→ lined by Hair & Mucus Membrane.

(ii) Respiratory chamber :→
→ lined with Mucus membrane
→ Vascular.
→ Acts as an air-conditioner.

* when we inhale cold air:-
Blood supply too much Yes → heat radiation to air & air gets warmer.

* when we inhale warm air :→
Air → More Mucus
→ Mucus evaporates → Heat is taken from that air.

(iii) Olfactory chamber :→
→ Smell.
→ lined with sensory membrane (olfactory cells).
⇓
Schneiderian Membrane.

→ To increase the surface area of Nasal chamber, scroll like folds Chonchae or Turbinals are present.

Present in Resp. cha.
- (i) Inferior chonchae / maxillo Turbinal.
- (ii) Lateral " / Ethmoturbinal.
- (iii) Superior " / Naso turbinal.
  - present in olf. chamb.

Larynx :→

→ Voice Box
→ ADAM's APPLE another name.
→ lined with ciliated columnar epithelium.
→ Vocal cord (longer in males 2.5cm)
→ small in female.

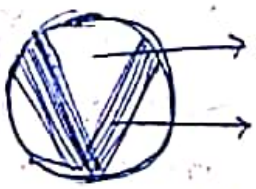
Note :→ Larynx is surrounded by 4 cartilages.

(i) Thyroid (1) → biggest
↳ Support front, upper lower

(ii) Cricoid (1) →
↳ Ring like, only lower.

(iii) Aryfenoid (2) → Smallest.
↳ Triangular back.

** From anterior part of Thyroid, arises a bilobed structure called EPIGLOTTIS.



* lined by stratified Sq. Epi.

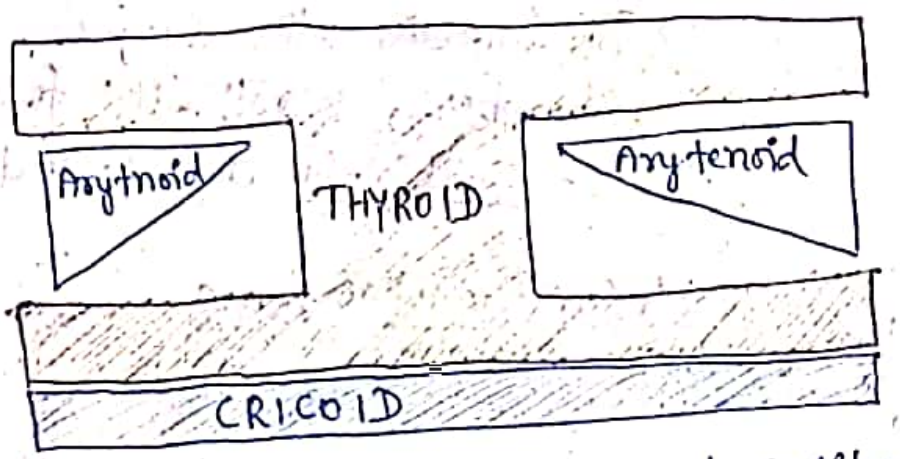
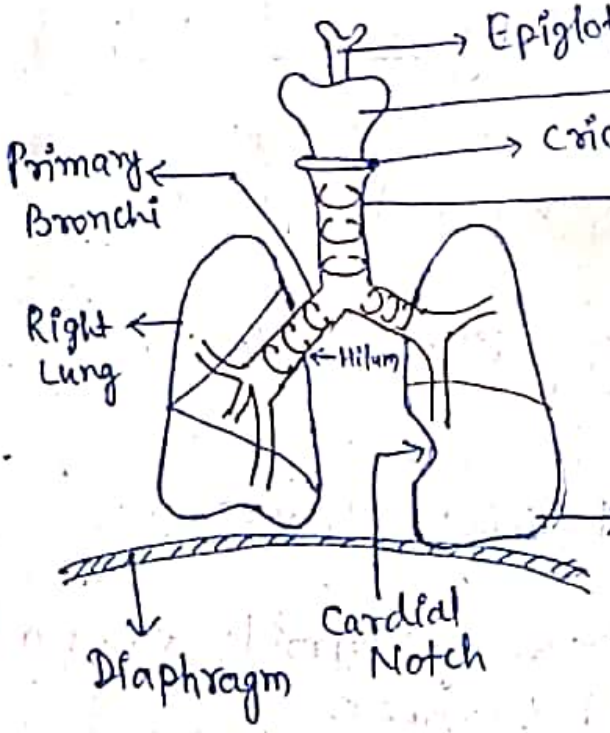


Fig:→ Position of Laryngeal Cartilages.

→ During Inhalation, vocal cords are relaxed, glottis is wide

→ During exhalation, due to contraction of Laryngeal muscles → glottis get narrow. Sound is produced due to vibration of cord.

Trachea & Bronchi :→



* lined by cilliated epi.
* Supported by 'C' shaped Cartilagenous rings
* No. of rings 16-20.

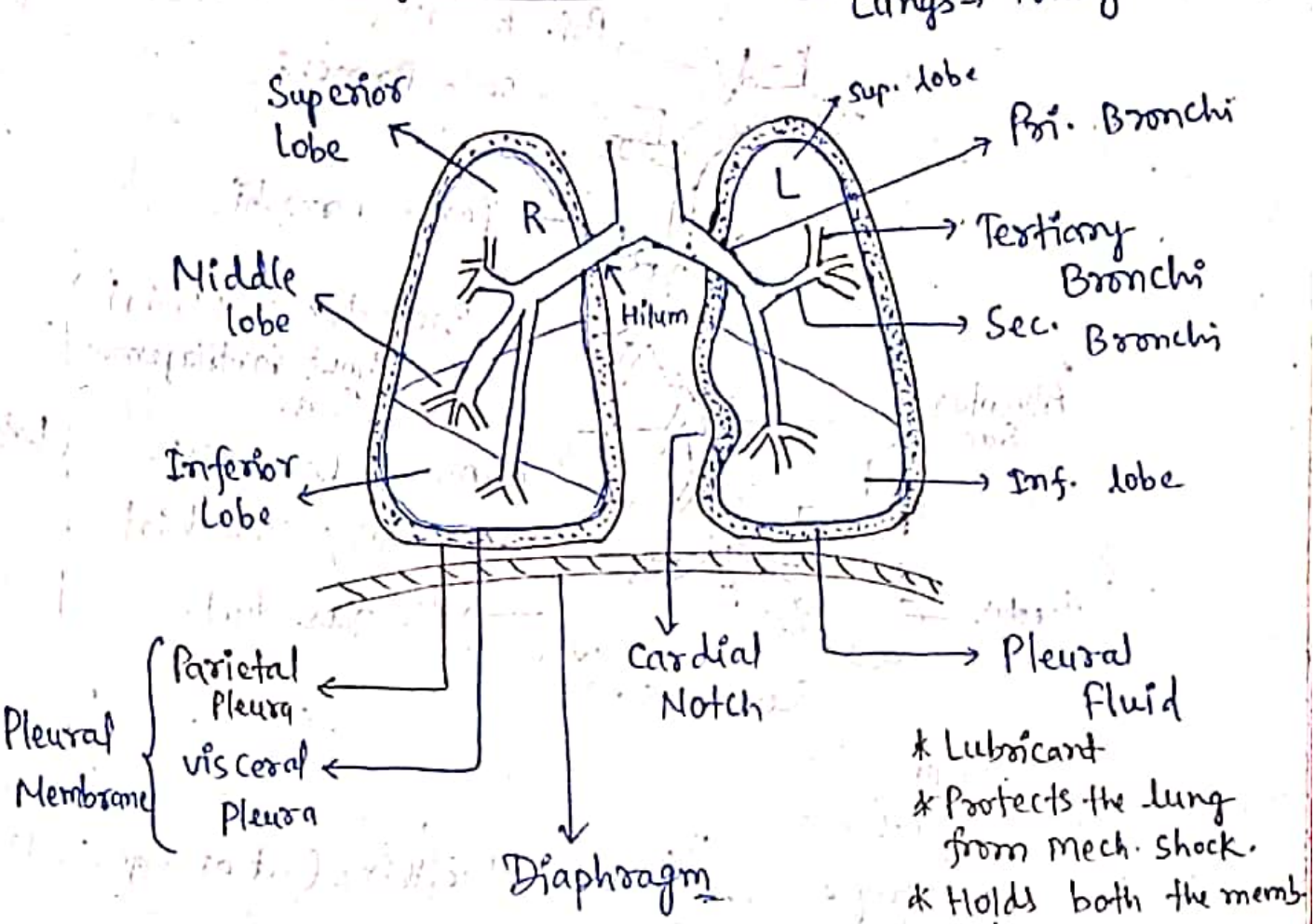
Bronchi

Right Bronchus
→ 2.5 cm long
→ wider
→ More vertical

Left Bronchus
→ 5 cm long
→ Narrower
→ More Horizontal.

Note!→ Hilum is that area from where Bronchi enters into the lungs.

Structure of lungs :→



Note:

Right Lung	Left Lung
→ Bigger	→ Smaller
→ 3 lobes	→ 2 lobes.
→ 620 gms	→ 560 gms
→ No Cardial Notch	→ Cardial notch present

R.V.I.

Note!-

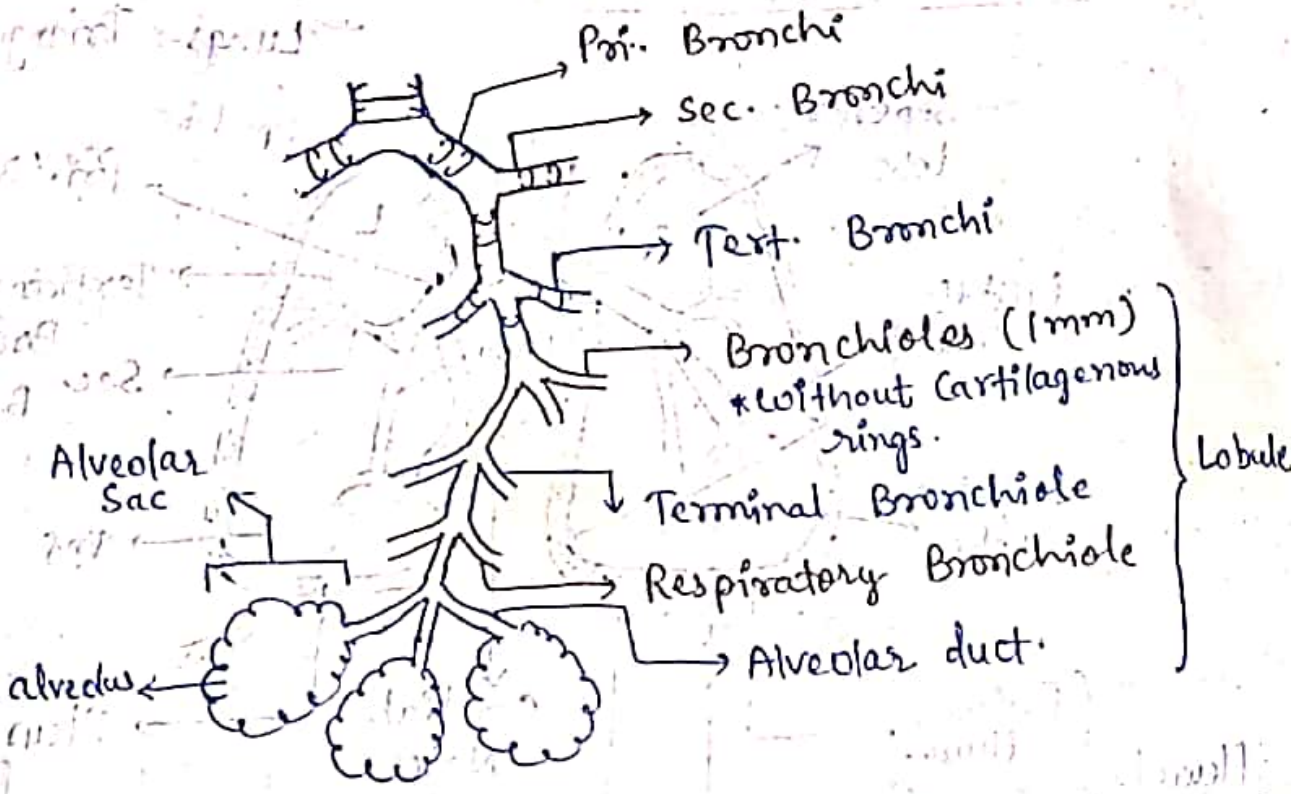
Pri. Bronchi → 2 in number.

Sec. Bronchi → 3 in R. Lung
2 in L. Lung

Tert. Bronchi → 10 in R. Lung
8 in L. Lung.

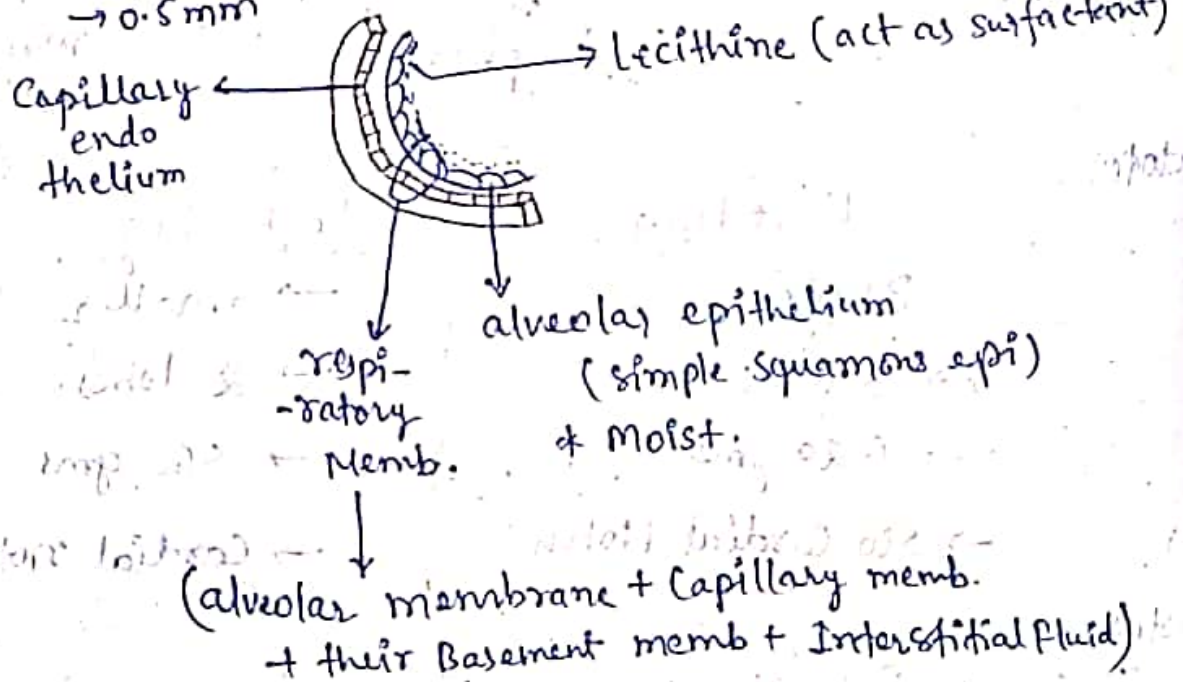
Broncheal Intercom :→

→ Network of Branching & rebranching of Pri. Bronchi



Alveolus :→

→ 0.5 mm



(alveolar membrane + Capillary memb. + their Basement memb + Interstitial fluid)

Mechanism of Breathing :→

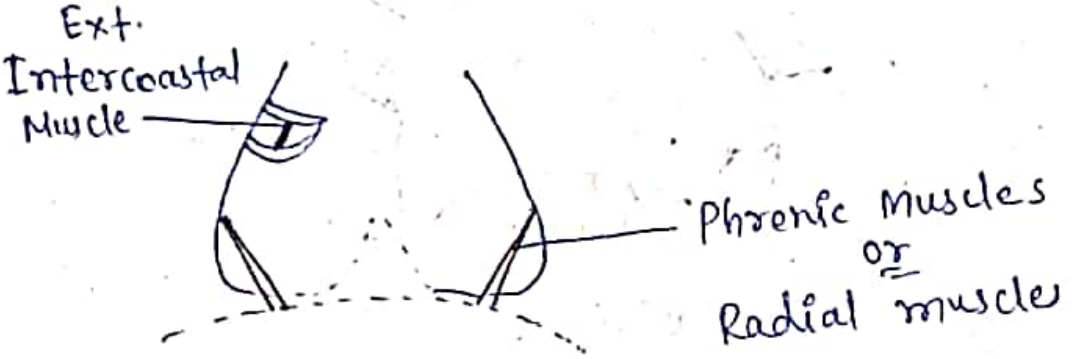
(i) Inhalation / Inspiration (Active Process)

(ii) Exhalation / Expiration (Passive Process)

* Inhalation :→

(a) Diaphragm
→ Dome shaped (Phrenic Muscles)

(b) External Intercoastal Muscle
→ 12 pairs of ribs
11 " " ext. intercoastal muscles.

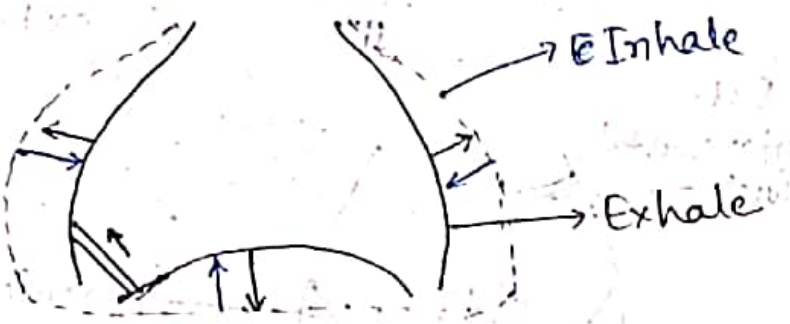


Firstly,
→ Contraction of phrenic Muscles → Diaphragm Flat
→ Vol. of thoracic Cavity ↑es
→ Pressure ↓es in alveoli → air moves from high pressure (atms) to lower pressure (lungs).

Secondly,
→ Contraction of ext. intercoastal muscle
↓
Ribcage move up & out.
↓
vol. of Thoracic Cavity ↑es.
↓
Pressure ↓es
↓
air from high press (atm) to lower press (lungs).

② Exhalation :→

→ Muscles relax
↓
Vol. of thoracic cavity ↓es.
↓
Pressure inside lungs ↑es.
↓
air move from High press. (lungs) to low press. (atm).

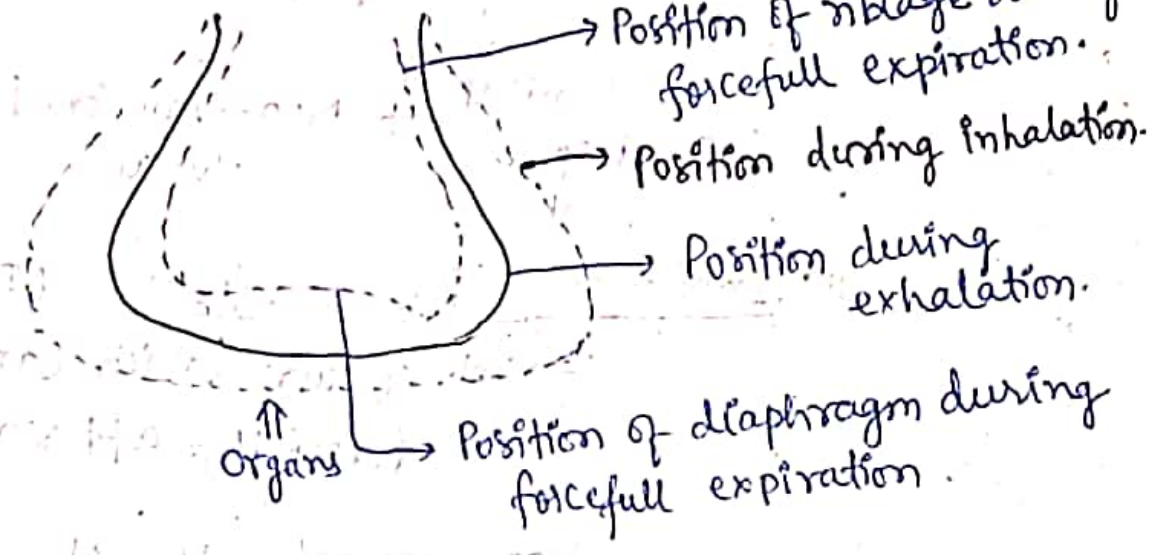


Forceful Exhalation :→

→ Active Process.
→ Two muscles are involved :-

(i) Internal Intercostal Muscles (11 Pairs)
(ii) Abdominal Muscles.

→ Contraction of these two muscles
↓
decrease in vol. of thoracic cavity.
↓
Pressure ↑es.
↓
air moves from lungs to atms.



Breathing cycle :→

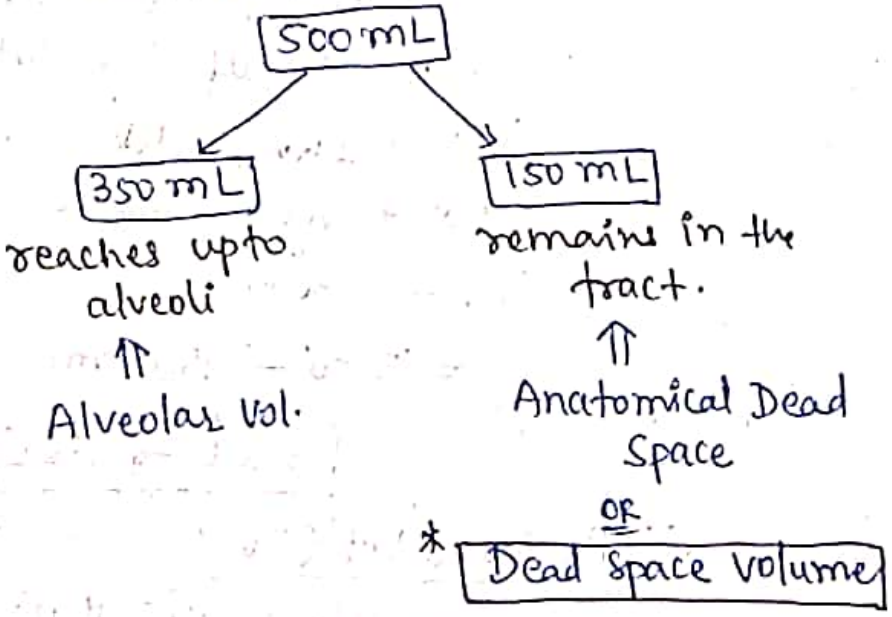
→ 1 Breathing cycle consists of
(i) Inspiration (Active)
(ii) Expiration (Passive)

→ 1 Breathing cycle take 5 seconds.
∴ 12 cycle/min (in Normal Adults).

Pulmonary Air Volumes / Lungs Capacities :→

(i) Tidal Volume (TV) :→

→ Normal vol. of air inhaled during resting position.



Note:→ Physiological Dead space/vol.:→

↓

Anatomical Dead space vol. + Non-functional alveoli.

(ii) Inspiratory Reserve Volume:→ (IRV)

→ vol. of air which can be taken in forcefully after normal Inhalation.

2000-3000 mL (2L-3L)

(iii) Inspiratory Capacity:→ (Ic)

→ (TV + IRV)

500 + (2000-3000) = 2500 mL - 3500 mL

(2.5L - 3.5L)

(iv) Expiratory Reserve volume:→ (ERV)

→ vol. of air exhaled after normal exhalation.

1000 mL - 1500 mL (1100 mL avg.)

(v) vital Capacity:→ (VC)

→ vol. of air forcefully exhaled after forcefull Inhalation.

TV + IRV + ERV

500 + 2000 + 1100 mL

or

3000

= 3500 - 4500 mL

3.5L to 4.5L

(vi) Residual Vol (RV):-

→ vol. of air that remains in the lungs after forcefull exhalation.

≈ 1500 mL

(vii) Functional Residual Volume :→ (FRV)

(RV + ERV)

1500 + 1100 = 2500 mL ⇐

(viii) Total Lung Capacity (TLC) :→

TLC = VC + RV

= (3500 - 1500) + 1500

= 5000 to 6000 mL (5800 mL avg.)

5L to 6L

→ All pulmonary air vol./Lungs capacity are 25-30% less in case of female.

→ Higher in atheletes.

(ix) Minute Respiratory Vol.

500ml (TV)/cycle

12 times in a minute

500 x 12 = 6000 mL (6 L/min)

(x) Alveolar Ventillation :→

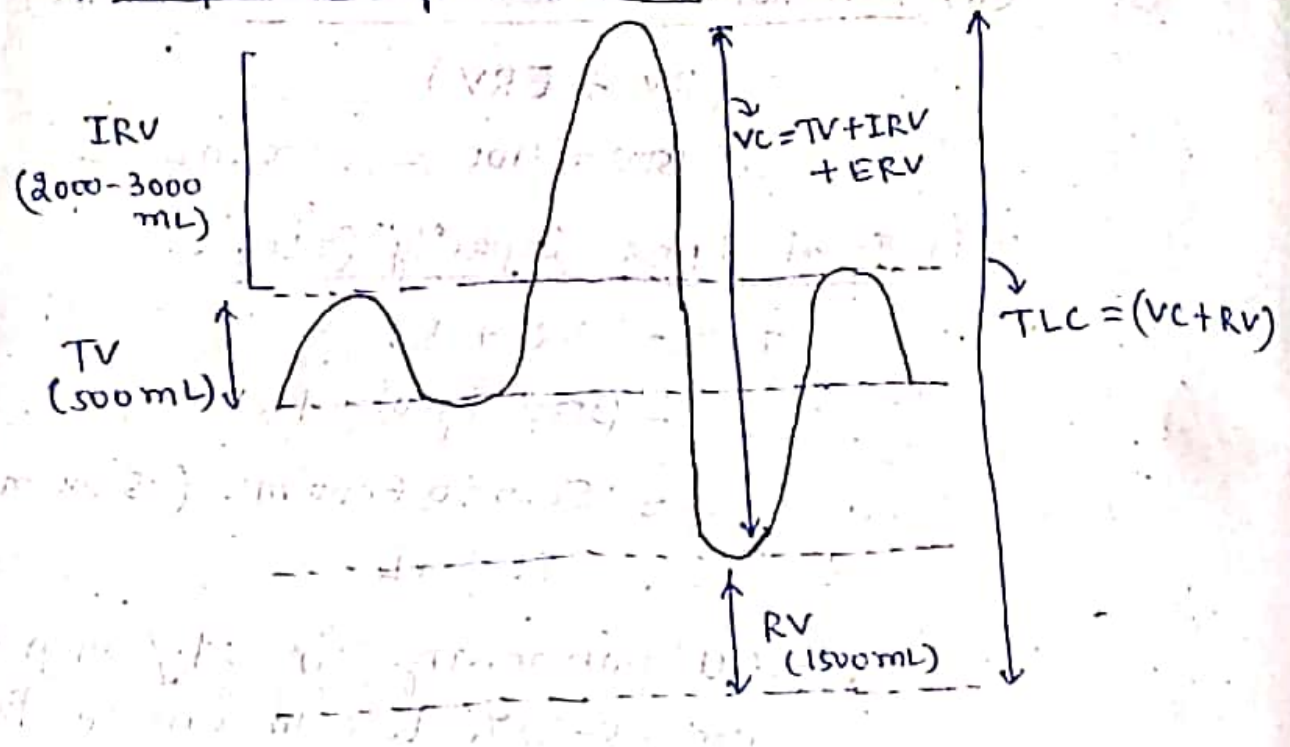
500 mL → 350 ml → alveoli

500 mL → 150 ml → dead space vol.

350 x 12

= 4200 ml Ans

* Graphical Representation :→



Exchange of gases :→

① Pulmonary Exchange (External)

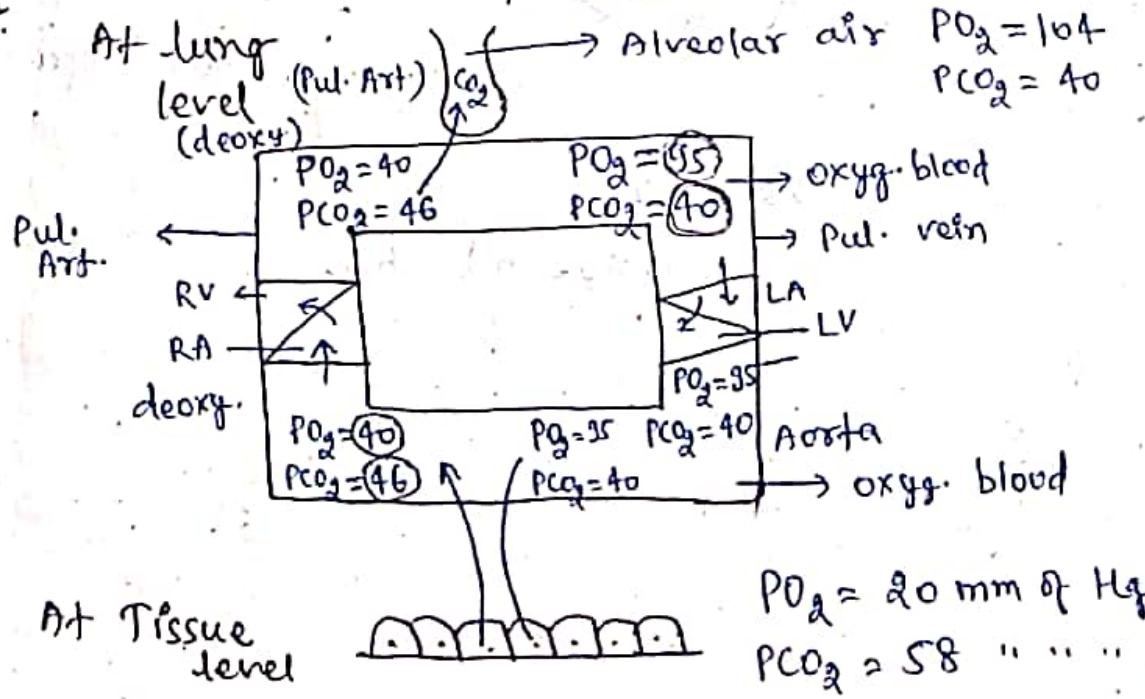
② Tissue level exchange (Internal)

** Partial Pressure :→

→ Pressure exerted by a gas in a mixture of gases irrespective of concentration of other gases.

→ Gases diffuse from their higher Conc^n to lower Conc^n.

V.V.I



Transport of Respiratory Gases :→

① Transport of O_2 :→

a) O_2 as dissolved O_2 in plasma

* 1-3% only.

b) O_2 transported as oxyhaemoglobin

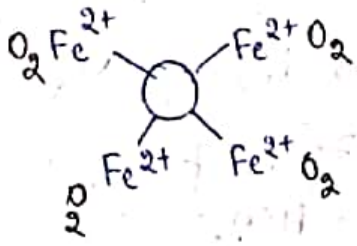
* 97-99%

Hb (Respiratory pigment) → Protein - globin

→ Fe containing (Porphrin Ring)

↳ 4 pyrole rings

↳ 1(Fe^{2+}) to each ring attached.



$O_2 + Hb \rightarrow$ Oxyhaemoglobin (temporary Short lived Complex)

favoured at:-

* High PO_2 in alveolar air.

* High PCO_2 in blood.

Note!→ Thus,

→ 1 Hb binds to four O_2 molecules.

→ 1 gm of Hb = 1.34 mL of O_2.

Que!→ If 100 mL of blood contains 15 gm of Hb. How much O_2 will be carried ?

Soln!→ 1 gm Hb = 1.34 mL O_2

∴ 1.34×15 = -- Ans -

Also,

For Male (13-18) gm Hb / 100 mL Blood.

For Female (12-16) gm Hb / 100 mL Blood.

Transport of CO_2 :→

→ By plasma & RBC (Hb).

→ 100 mL blood transport 3.7 mL of CO_2.

→ Transported in 3 forms :-

(a) As Carbonic Acid :→

* only 7% of CO_2 in form of H_2CO_3.
i.e. out of 3.7 mL only 0.3 mL

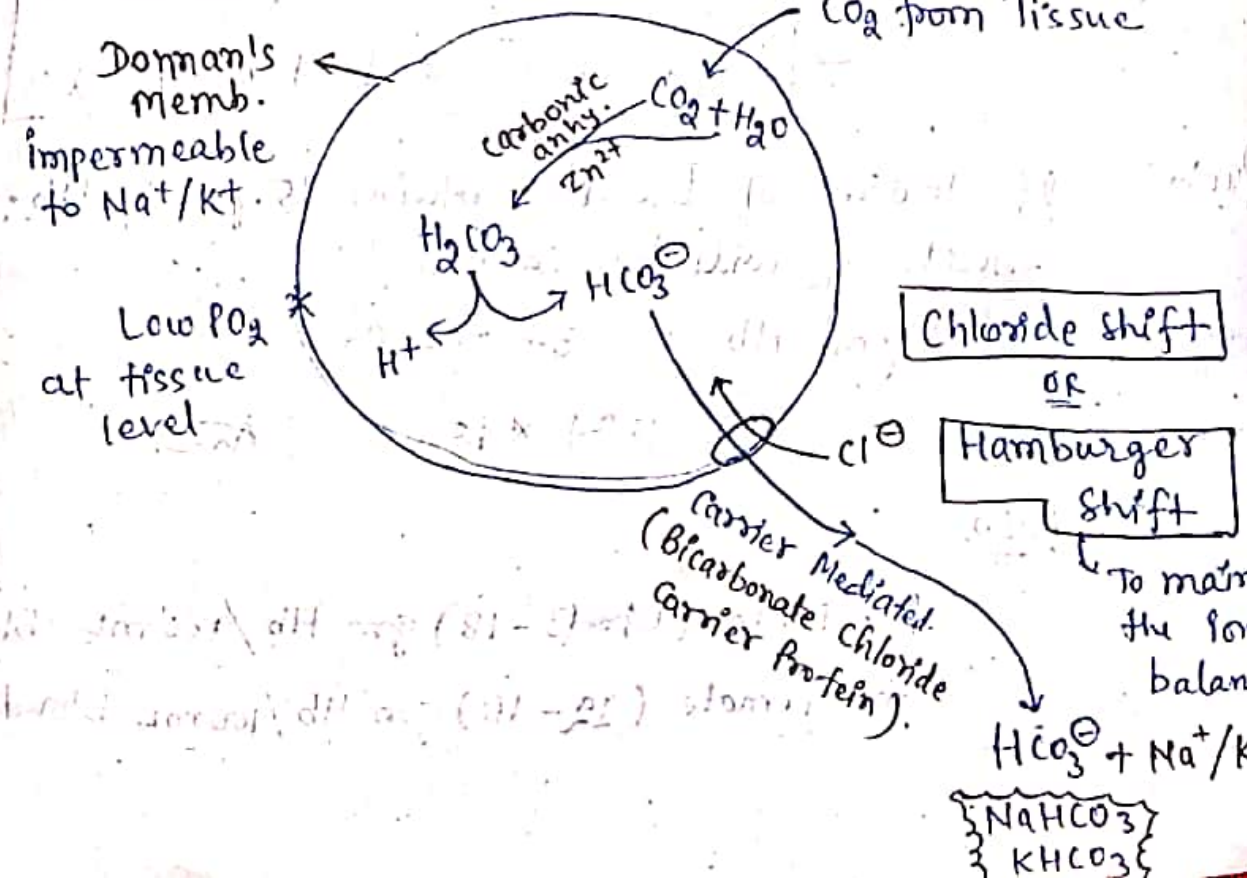
Reaction in RBC

$CO_2 + H_2O \xrightarrow[Zn^{2+}]{\text{Carbonic Anhydrase}} H_2CO_3$ ⇓ In Plasma.

(b) As Bicarbonates of Na & K :→

* 70% of CO_2 is transported as HCO_3^-

In RBC



(C) As Carbaminohaemoglobin :→

* 23% of CO_2 as Carbaminohb

CO_2 + amino group of Hb ⟶ Carbaminohaemoglobin

Transport of CO :→

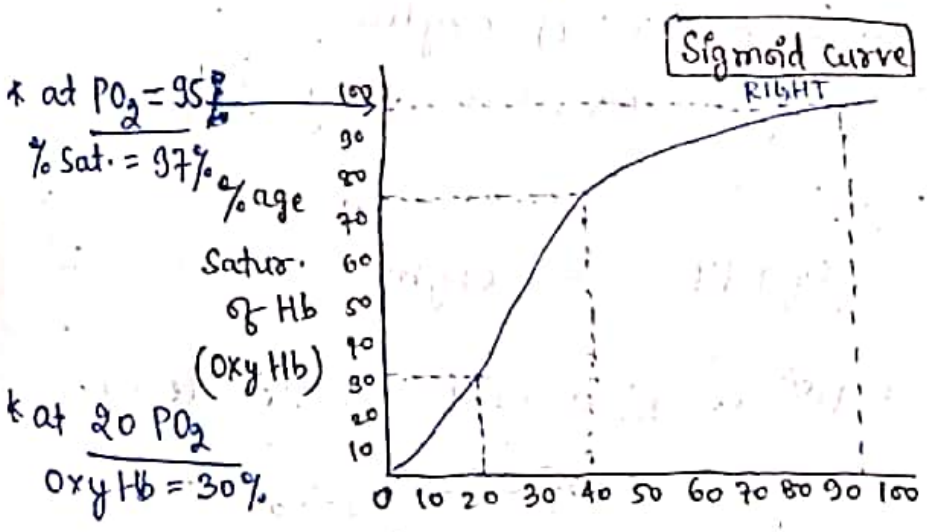
* Hb has 200 times more affinity towards CO.

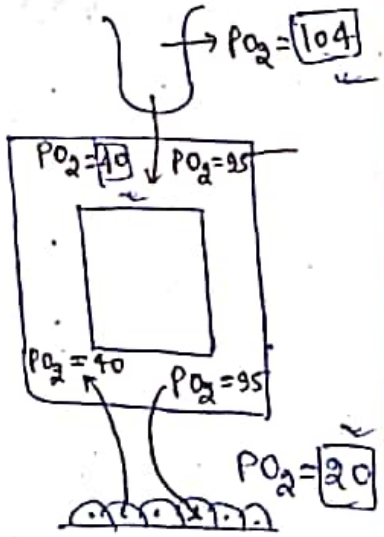
CO + Hb ⟶ Carboxyhaemoglobin (Permanent Complex)

⇒ CO Poisoning.

Oxygen Dissociation Curve :→

→ O_2 dissociation Curve is a graph representing %age saturation of Hb with O_2 at different PO_2.





* at PO_2 = 40 mm
Sat. of Hb = 75%

Remember :→

→ O_2 diss. Curve is always a Sigmoid curve

20, 40, 95, 104 of O_2 Partial Pressure.

40, 46, 58 of CO_2 partial Pressure.

Factors affecting O_2 dissociation Curve :→

① CO_2 Conc / PCO_2 :→

* with ↑ in PCO_2, O_2 diss. curve turns towards right.

& → oxyHb complex dissociates.

"BOHR'S EFFECT"

② Temperature :→

* with ↑ in temp. curve bends toward right.

③ pH :→

* at acidic pH
  ↳ curve bends to right.

Reason for release of CO_2 :→

V.V.I 1. Haldane's Effect :-

→ more Conc^n of oxyHb.

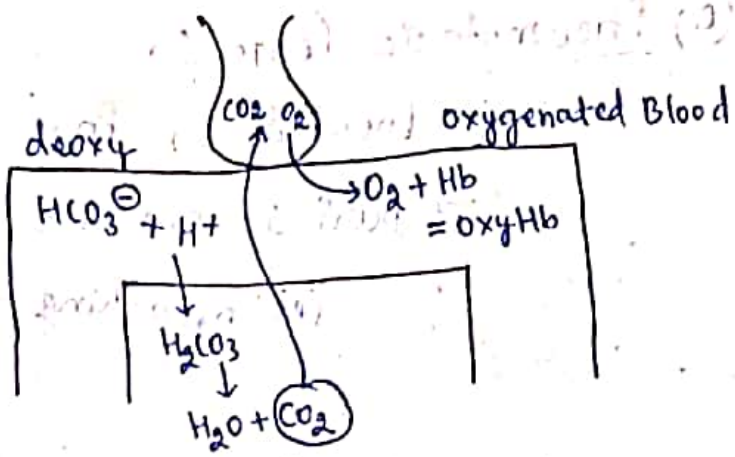
→ oxyHb acts as a strong acid.
↓
H^+

$$O_2 + Hb \longrightarrow oxyHb$$

* $H^{\oplus}$ combines with bicarbonate ions

$$H^+ + HCO_3^- \longrightarrow H_2CO_3$$

$$H_2CO_3 \xrightarrow{\text{Carbonic Anhy.}} H_2O + CO_2 \uparrow$$



2. High PO_2 Causes dissociation of Carbaminohb.
3. CO_2 is less soluble in atreal blood.
(as they are meeting on junction)

Control of Respiration :→

I. Nervous Control

→ 3 respiratory Control ~~systems~~ centers.
→ Known as RHYTHMICITY Center.

(a) Inspiratory Center :→

→ located on medulla.
→ Normal Process.
→ 1 Respiratory cycle – 5 sec.
2 sec – Inspire
3 sec – Expire

(b) Expiratory Center :→

→ on Medulla.
→ Inactive or Dormant during normal breathing.
→ Active during forcefull exhalation.

(c) Pneumotaxic Center :-

→ Located on Pons varoli

→ During exercise, activated

↑es breathing but it gets shallower

amount of O_2 going inside is less.

→ Ex:- Panting. In case of dogs

↳ tongue outside in extreme heat cond

II. Chemical Control :-

* Chemosensitive Bodies.

Carotid Bodies → at the base of Carotid sinus.

Aortic Bodies → at the base of Aorta.

→ are sensitive to PO_2 & PCO_2.

a) PCO_2 :-

→ Aortic & Carotid bodies are more Sensitive to PCO_2.

when PCO_2 ↑es ⟶ Stimulation of bodies

↓

Expiratory muscles Stimulated.

b) PO_2 :-

→ Chemosensitive bodies are less Sensitive to PO_2.

Respiratory Disorders :→

I. Infectious :→
   (a) T.B.
   (b) Pertusis
   (c) Pneumonia
   (d) Diphtheria

II. Tumours / Lung Cancer :→
   * Carcinogen = Benzpyrene

III. Obstructive Respiratory Disorders :→

(a) Allergies :→

→ Hypersensitivity of a person to an allergen. (dust, pollens, food)

Steps :→

1st → Stimulation by an allergen. (sensitization).

allergen or antigen ⟶ Antibody ⟶ bind to mast cells.

2nd → Stimulation

* Allergens bind to mast cells which are Stimulated or attached with antibody.

→ Mast cell ruptures

↓

release Histamine

3rd → Histamin Action

* Inflammation, running nose, watery eyes,

Treatment
↳ Anti-histaminic Drug.

Note! →

Allergies due to Pollens ⟶ HAY FEVER.

(b) Asthama :→

→ Bronchial spasm (inv. contraction) होता

→ lumen of Bronchi ↓es.

→ Sputum is more.
(thick mucus over lungs)

(C) Bronchitis :→

→ Weezing, Heavy breathing.

→ No or negligible Sputum.

(d) Emphysema :→

→ Reduction in alveolar respiratory surface.

→ due to tobacco smoking

(e) Hypoxia :→

→ O_2 deficiency in tissues.

Some Interesting fact about respiratory system :-

1. Gecko → only reptile to have vocal cord.
2. Syrinx → Sound producing organ in Birds.
3. Smoking reduces vital capacity.
4. Chorion (extra embryonic membs) :→ Foetal gaseous exchange.
   ↳ Foetal lung
5. Elephants → diaphragm plays more important role in breathing.

Jumping animals → Ribs plays more imp. role in breathing

Pregnant ♀ → Ribs play more imp role.

6. 60 times/min → Infants
30 " " → 12 months
24 " " → 2-5 years
12 " " → Adults

1 Breathing cycle = 5 sec.
2 sec → Inhale
3 " → Exhale

7. Rate of respiration is minimum during Sleep.

8. Diaphragm is characteristic of mammal.

9. Cartilage of santorini → enlargement on Arytenoid cartilage
Found in mammals.

10. Cough → forced expiration to expell an irritant.

11. Hiccups → sharp Inspiratory sound produced due to closure of glottis by epiglottis.

12. Yawning → Prolonged inspiration due to increased CO_2 conc^n in the lungs.

13. Hb of foetus has more affinity towards O_2 as compared to Hb of mother.

14. Birds & Chameleon → double respiration → Their lungs have air sacs.

15. Asphyxia :-
$O_2 \downarrow$ → CO_2 accumulation ↑es.
↳ may lead to death.