- **Airway resistance** $R = \frac{8 \eta L}{\pi r^4}$ (highest on medium sized bronchi)
  - r^4 → resistance (Bronchodilator / Bronchoconstrictors)

- **Spirometry**
  - **Volumes**
    - Tidal volume (VT):- 500 mL
    - Inspiratory reserve volume (IRV):- 3000 mL
    - Expiratory reserve volume (ERV):- 1200 mL
    - Residual volume (RV):- 1200 mL
  - **Capacites**
    - Inspiratory capacity (IC):- $V_T + IRV$ = 3500 mL
    - vital capacity (VC):- IC + ERV = 4700 mL
    - functional Residual capacity (FRC):- ERV + RV = 2400 mL
    - Total lung capacity (TLC):- All volumes = 5900 mL.

- **volume of physiologic dead space:-**

$$V_D = V_T \times \frac{PaCO_2 - P_ECO_2}{PaCO_2 \; (P_ACO_2)}$$

V_T → Tidal volume

- assumptions
  - All expiratory CO_2 from functiong alvolei
  - No CO_2 from inspired air
  - The dead space don't add CO_2

- **minute ventilation:-** VT × RR (Breath/min)
  - VT → Tidal volume
- **alveolar ventilation:-** $(V_T - V_D) \times RR$ (Breath/min)
  - V_D → volume of physiologic dead space
  - RR → Respiratory Rate

- **FEV_1 / FVC**
  - Normal:- 80% (0.8)
  - obstructive:- ↓↓FEV_1 (mild ↓FVC), <80%
  - Restrictive:- ↓FVC (mild ↓FEV_1), ≥80%

- **Boyel's Law:-** $P_1 V_1 = P_2 V_2$ * P×V is constant.

- **Dalton's Law**
  - Dry gas:- $P_x = P_B \times f$
    - P_B → total pressure (760 mmHg)
    - f → fractional concentration → for O_2:- 0.21
  - Humidified gas:- $P_x = (P_B - P_{H_2O}) \times f$
    - P_{H_2O} → water vapor pressure (47 mmHg)

- **Henry's Law:-** Dissolved gas (N_2):- $C_x = P_x \times$ solubility
  - C_x → concentration of dissolved gas
  - solubility → for O_2 = 0.003
  - → for CO_2 = 0.07

- **Fick Law** :- simple diffusion
  - ΔP :- Driving force
  - diffusion Coaefficent (D) :- molecular weight & solubility (x 20 CO_2)
  - Surface Area (A) :- ↓ in emphysema
  - membrane thicking (ΔX) :- ↑fibrosis or edema.

$$V_x = \frac{D \times A \times \Delta P}{\Delta X}$$

V_x → volume of gas transfered per time.

- **Diffusion capacity (DL)** = $(D + A + \Delta X)$ → $V_x = DL \times \Delta P$
  - CO_2 :- 17 mL/min/mmHg
  - O_2 :- 21 mL/min/mmHg (17 x 1.23)

- Thicking of Respiratory membrane :- 0.2 – 0.6 micrometer (↑ in fibrosis/edema)
- Surface Area :- 70 m^2 (↓ in emphysema).
- Blood in capillaries :- 60 – 140 mL (↓ in anemia, ↑ in excersice).
- diamiter of capillaries :- 5 micrometer

- **Venous Blood**
  - P_vCO_2 = 46 mmHg
  - P_vO_2 = 40 mmHg

- **Artiral blood**
  - P_aCO_2 :- 40 mmHg
  - P_aO_2 :- 100 mmHg

★ Not tottaly true Because of physiologic shunt
  - Broncial veins
  - Coronary veins

- **Diffusion Limited Gas exchange** :- diffusion countinue as ΔP is there (fibrosis)
- **preffusion limited Gas exchange** :- diffusion stops (equlibrium), (↑preffusion → ↑exchange), Normally O_2.

- **Dissolved O_2** = ΔP x Solubility = 100 mmHg x 0.003 = 0.3 mL O_2/100mL (x by CO (5L) ⇒ 15 mL O_2/Min) (2%)
- **O_2 content** = (O_2-binding x saturation (%)) + Dissolved O_2
  - 1g Hb → 1.34 mL O_2
  - 15g Hb → 20 mL O_2

- **Dissolved CO_2** = ΔP x Solubility = 40 mmHg x 0.07 = 2.8 mL CO_2/100 mL

- **O_2-hemoglobin curve**
  - Normal P_{50} = 25 mmHg
  - shift to right :- ↓affinity, ↑P_{50}
    - ★ ↑metabolic
    - ↑CO_2
    - ↑H^+ (↓PH)
      - ↑CO_2 and ↑H^+ → Bohr effect
    - ↑Temp
    - ↑2-3 BPG
    - Hemoglobin S
  - shift to Left :- ↑affinity, ↓P_{50}
    - ★ ↓metabolic
    - ↓CO_2
    - ↓H^+ (↑PH)
    - ↓Temp
    - ↓2-3 BPG
    - Hemoglobin F
    - CO :- x 240 affinity.

- **Respiratory exchange ratio:-** $\frac{\text{Rate of } CO_2 \text{ output (4)}}{\text{Rate of } O_2 \text{ uptake (5)}} \approx 0.8$
  - → Charbohydrate = 1
  - → fat = 0.7

- **carbaminohemoglobin (CO_2 + Hb):-**
  - → In tissue side:- $CO_2 + H_2O \rightarrow H_2CO_3 \rightarrow H^+$ (Bind with deoxyHb) $+ HCO_3^-$ (exchange with CL^-)
  - → In Lung side:- HCO_3^- (exchange with cl^-) $+ H^+ \rightarrow H_2CO_3 \rightarrow CO_2 + H_2O$
  - ★ **Haldane effect:-** O_2 + Hb → kick out CO_2.

- **Lung circulations**
  - → Broncial:- ↑pressure, ↓flow
  - → pulmonary:- ↓pressure, ↑flow

- **pulmonary flow** $= CO = \frac{\Delta P}{R}$ (↓R)
  - → Regulated by PAO_2:- ↓PAO_2 → ↓radius by Vasoconstriction → ↑R → ↓flow.
  - → Thrombxane A_2:- Vasoconstrictor.
  - → prostacycline:- Vasodilator (Locally).
  - → Leukotrines:- airway constrictor.

- **Distribution of pulmonary blood flow:-** gravitational (↓apex, ↑Base).
  - → Zone 1:- $P_A \geq P_a > P_v$
  - → Zone 2:- $P_a > P_A > P_v$ (as systemic)
  - → Zone 3:- $P_a > P_v > P_A$

- $\frac{V}{Q}$ → Normally:- 80% (0.8), $P_aO_2 = 100$, $P_aCO_2 = 40$ mmHg.
  - → Zone 1:- ↓Q, ↓V, ↑$\frac{V}{Q} \approx 3$, ↑P_aO_2 = 130 mmHg, ↓P_aCO_2 = 28.
  - → Zone 3:- ↑Q, ↑V, ↓$\frac{V}{Q} \approx 0.6$, ↓P_aO_2 = 89 mmHg, ↑P_aCO_2 = 42 mmHg.

  - **Defects**
    - → 1) pulmonary embolism (Dead space):- $Q = 0$, $\frac{V}{Q} = \infty$, $P_AO_2 = 150$, $P_ACO_2 = 0$
      - No P_aO_2 & P_aCO_2.
    - → 2) Airway obstruction (shunt):- $V = 0$, $\frac{V}{Q} = 0$, $P_aO_2 = 40$, $P_aCO_2 = 46$
      - No P_AO_2 & P_ACO_2