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FREE READY RECKONER

All India Engineering & Medical Entrance

FORMULA HAND BOOK

PHYSICS

FORMULA HAND BOOK

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PHYSICS

1. UNIT AND MEASUREMENT

- **Fundamental Units :**

Sr. No.	Physical Quantity	SI Unit	Symbol
1	Length	Metre	m
2	Mass	Kilogram	Kg
3	Time	Second	S
4	Electric Current	Ampere	A
5	Temperature	Kelvin	K
6	Luminous Intensity	Candela	Cd
7	Amount of Substance	Mole	mol

- **Supplementary Units :**

Sr. No.	Physical Quantity	SI Unit	Symbol
1.	Plane Angle	Radian	r
2	Solid Angle	Steradian	Sr

(1). Distance of an object by parallax method, $D = \dfrac{\text{Basis}}{\text{Parallax angle}}$

(2). Absolute error = True value – Measured value $= [\Delta a_n]$

(3). True value = Arithmetic mean of the measured values

$$a_{mean} = \frac{a_1 + a_2 + ... + a_n}{n}$$

(4). Relative error in the measurement of a quantity $= \dfrac{\Delta a_{mean}}{a_{mean}}$

(5). Percentage error $= \dfrac{\Delta a_{mean}}{a_{mean}} \times 100$

(6). Maximum permissible error in addition or subtraction of two quantities $(A \pm \Delta A)$ and $(B \pm \Delta B)$:
$= \Delta A + \Delta B$

(7). When $z = \dfrac{a^p \cdot b^q}{c^r}$, then maximum relative in z is $\dfrac{\Delta z}{z} = p\dfrac{\Delta a}{a} + q\dfrac{\Delta b}{b} + r\dfrac{\Delta C}{C}$

2. MOTION IN A STRAIGHT LINE

(1). For objects in uniformly accelerated rectilinear motion, the five quantities, displacement x, time taken t, initial velocity v_0, final velocity v and acceleration a are related by a set of kinematic equations of motions. These are

$$v = v_0 + at$$

$$x = v_0 t + \frac{1}{2} a t^2$$

$$v^2 = v_0^2 + 2ax$$

The above equations are the equations of motion for particle. If the position of the particle at t = 0 is 0. If the particle starts at $x = x_0$ i.e. if it is at x_0 at t = 0, then in the above equation x is replaced by $(x - x_0)$.

(2). The relative velocity of an object moving with velocity v_A w.r.t. an object B moving with velocity v_B is given by

$$v_{AB} = v_A - v_B$$

3. MOTION IN A PLANE

(1). Law of cosines, if $\vec{R} = \vec{P} + \vec{Q}$ then $R = \sqrt{P^2 + Q^2 + 2PQ\cos\theta}$

Here, $\theta =$ angle between $\vec{P}$ and $\vec{Q}$

(2). Direction of $\vec{R} \Rightarrow \tan\alpha = \frac{Q\cos\theta}{P + Q\sin\theta}$: $\alpha =$ angle between $\vec{R}$ and $\vec{P}$

(3). Position of an object at time t, if it is initially at $\vec{r}_0$, having initial velocity v_0 and moving with constant acceleration $\vec{a}$, is

$$\vec{r} = \vec{r}_0 + \vec{v}_0 t + \frac{1}{2}\vec{a}^2$$

4. LAWS OF MOTION

(1). Force: $\vec{F} = \frac{d\vec{p}}{dt} = m\frac{d\vec{v}}{dt} + \vec{v}\frac{dm}{dt}$, when m is constant $\vec{F} = m\frac{d\vec{v}}{dt} = m\vec{a}$

(2). Conservation of linear momentum: $\sum \vec{p}_i = \sum \vec{p}_j$

(3). For motion of a car on level road maximum safest velocity is $v_{max} = \sqrt{\mu_s Rg}$

(4). For motion of a car on banked road maximum safest velocity is $v_{max} = \sqrt{\left[Rg\frac{(\mu_s + \tan\theta)}{1 - \mu_s \tan\theta}\right]}$

Angle of banking: $\theta = \tan^{-1}\frac{v^2}{rg}$

5. WORK ENERGY AND POWER

(1). The **work-energy theorem** states that for conservative forces acting on the body, the change in kinetic energy of a body equal to the net work done by the net force on the body.

$$K_f - K_i = W_{net}$$

Where K_i and K_f are initial and final kinetic energies and W_{net} is the net work done.

(2). For a conservative force in one dimension, Potential energy function V(x) is defined such that

$$F(x) = -\frac{dV(x)}{dx}$$

(3). Average power of a force is defined as the ratio of the work, W, to the total time ***t*** taken.

$$\Rightarrow P_{av} = \frac{W}{t}$$

(4). The instantaneous power is defined as the limiting value of the average power as time interval approaches zero. $P = \frac{dW}{dt}$

Power can also be expressed as

$P = \vec{F} \cdot \frac{d\vec{r}}{dt} = \vec{F} \cdot \vec{v}$ here, $d\vec{r}$ is displacement vector.

(5). Work done by Constant Force :

$W = F \cdot \vec{S}$

(6). Work done by multiple forces

$\sum \vec{F} = \vec{F}_1 + \vec{F}_2 + \vec{F}_3 + ...$

$W = [\sum F] \cdot S$ ...(i)

$W = F_1 \cdot \vec{S} + \vec{F}_2 \cdot \vec{S} + \vec{F}_3 \cdot \vec{S} + ...$

Or $W = W_1 + W_2 + W_3 + ...$

(7). Work done by A variable force

$dW = \vec{F} \cdot d\vec{s}$

(8). Relation between momentum and kinetic energy

$K = \frac{P^2}{2m}$ and $P = \sqrt{2\,m\,K}$; P = Linear momentum

(9). Potential energy

$\int_{U_1}^{U_2} dU = -\int_{r_1}^{r_2} \vec{F} \cdot d\vec{r}$ i.e., $U_2 - U_1 - \int_{r_1}^{r_2} \vec{F} \cdot d\vec{r} = -W$

$U = -\int_{\infty}^{r} \vec{F} \cdot d\vec{r} = -W$

(10). Conservative Forces

$$F = \frac{U}{r}$$

(11). Work-Energy theorem

$$W_C + W_{NC} + W_{PS} = \Delta K$$

(12). Modified Form of work-Energy Theorem

$$W_C = -\Delta U$$

$$W_{NC} + W_{PS} = \Delta K + \Delta U$$

$$W_{NC} + W_{PS} = \Delta E$$

(12). Power

The average power $(\bar{P}$ or $P_{av})$ delivered by an agent is given by $\bar{P}$ or $p_{av} = \frac{W}{t}$

$$P = \frac{F \cdot dS}{dt} = F\frac{dS}{dt} = \vec{F} \cdot \vec{v}$$

6. SYSTEM OF PARTICLES AND ROTATIONAL MOTION

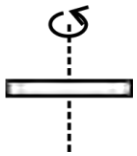
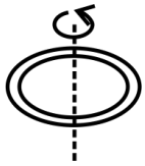
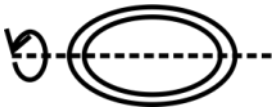
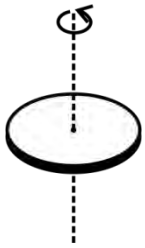
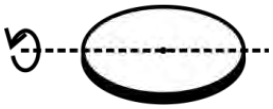
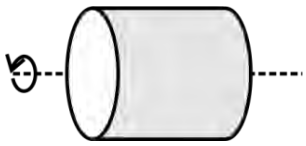
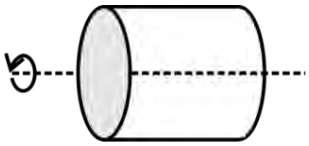
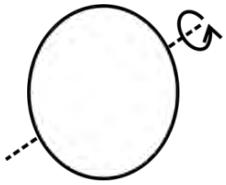
(1). According to the theorem of perpendicular axes moment of inertia of a body about perpendicular axis is $I_z = I_x + I_y$,

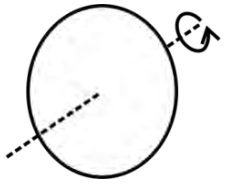
Where I_x, I_y, I_z, are the moment of inertia of the rigid body about x, y and z axes respectively x and y axes lie in the plane of the body and z-axis lies perpendicular to the plane of the body and passes through the point of intersection of x and y.

(2). According to the theorem of parallel axes $I = I_C + Md^c$

Where I_C is the moment of inertia of the body about an axis passing through its centre of mass and d is the perpendicular distance between the two axes.

Table 1: Moment of inertia of some symmetrical bodies

	Body	Axis	Figure	M.I.
(1)	Rod (Length L)	Perpendicular to rod, at the midpoint centre of mass		$\frac{ML^2}{12}$
(2)	Circular ring (radius R)	Passing through centre and perpendicular the plane		MR^2
(3)	Circular ring (Radius R)	Diameter		$\frac{MR^2}{2}$
(4)	Circular Disc (radius R)	Perpendicular to the disc at centre		$\frac{MR^2}{2}$
(5)	Circular Disc (radius R)	Diameter		$\frac{MR^2}{4}$
(6)	Hollow cylinder (radius R)	Axis of cylinder		MR^2
(7)	Solid cylinder (radius R)	Axis of cylinder		$\frac{MR^2}{2}$
(8)	Solid sphere (radius R)	Diameter		$\frac{2}{5}MR^2$

(9)	Hollow sphere (radius R)	Diameter		$\frac{2}{3}MR^2$

(3). Relation between moment of inertia (I) and angular momentum $\vec{L}$ is given by $\vec{L} = I\,\vec{\omega}$

(4). Relation between moment of inertia (I) and kinetic energy of rotation is given by

$$K.E._{rotation} = \frac{1}{2}I\omega^2$$

(5). Relation between of inertia (I) and torque $(\vec{\tau}) \Rightarrow \vec{\tau} = I\vec{\alpha}$

(6). If no external torque acts on the system, the total angular momentum of the system remains unchanged $I_1\omega_1 = I_2\omega_2$

(7). Position vector of centre of mass of a discrete particle system

$$\vec{r}_{CM} = \frac{m_1\vec{r}_1 + m_2\vec{r}_2 + ... + m_n\vec{r}_n}{m_1 + m_2 + ... + m_n} = \frac{\sum_{i=1}^{n} m_i r_i}{\sum_{i=1}^{n} m_i}$$

Where m_i is the mass of the i^{th} particle and $\vec{r}_i$ is the position of the i^{th} particle corresponding $x_{CM} \cdot y_{CM}$ and z_{CM} co-ordinates are

$$x_{CM} = \frac{\sum_{i=1}^{n} m_i n_i}{\sum_{i=1}^{n} m_i},\quad y_{CM} = \frac{\sum_{i=1}^{n} m_i y_i}{\sum_{i=1}^{n} m_i},\quad z_{CM} = \frac{\sum_{i=1}^{n} m_i z_i}{\sum_{i=1}^{n} m_i}$$

(8). Velocity of centre of mass, $\vec{v}_{CM} = \frac{\sum_{i=1}^{n} m_i\vec{v}_i}{\sum m_i}$

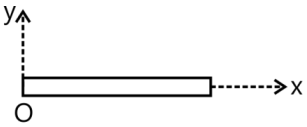
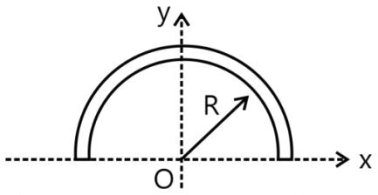
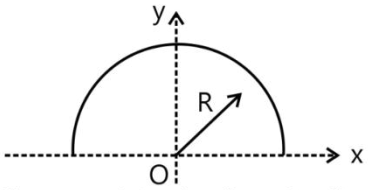
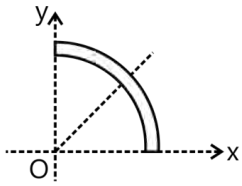
(9). Acceleration of CM, $\vec{a}_{CM} = \frac{\sum_{i=1}^{n} m_i\vec{a}_i}{\sum_{i=1}^{n} m_i}$

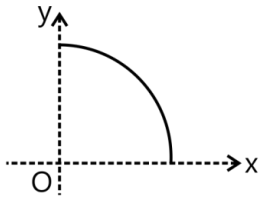
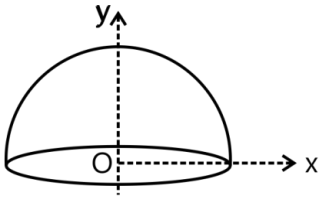
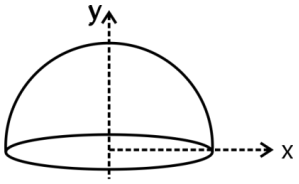
(10). Momentum of system, $\vec{P} = \vec{P}_1 + \vec{P}_2 + ... + \vec{P}_n = \left(\sum_{i=1}^{n} m_i \right) \vec{v}_{CM}$

(11). Centre of mass of continuous mass distribution

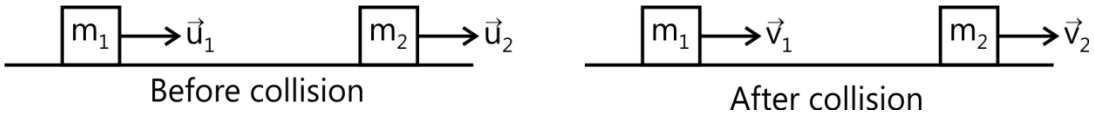
$$\vec{r}_{CM} = \frac{\int dm \vec{r}_e}{dm},\ x_{CM} = \frac{\int x\, dm}{\int dm},\ y_{CM} = \frac{\int y\ dm}{\int dm},\ z_{CM} = \frac{\int z dm}{\int dm}$$

(12). Given below are the positions of centre of mass of some commonly used objects.

S.No.	Object	Location of centre of mass
i.	 Uniform rod of length L	$x_{CM} = \frac{L}{2},\ y_{CM} = 0,\ z_{CM} = 0$
ii.	 Uniform semicircular ring of radius R	$x_{CM} = 0,\ y_{CM} = \frac{2R}{\pi},\ z_{CM} = 0$
iii.	 Uniform semicircular disc of radius R	$x_{CM} = 0,\ y_{CM} = \frac{4R}{3\pi},\ z_{CM} = 0$
iv.	 Uniform quarter of a ring of radius R	$x_{CM} = \frac{2R}{\pi},\ y_{CM} = \frac{2R}{\pi},\ z_{CM} = 0$

v.	 Uniform quarter of a disc of radius R	$x_{CM} = \frac{4R}{3\pi}, y_{CM} = \frac{4R}{3\pi}, z_{CM} = 0$
vi.	 Uniform spherical shell of radius R	$x_{CM} = 0, y_{CM} = \frac{R}{2}, z_{CM} = 0$
vii.	 Uniform spherical of radius R	$x_{CM} = 0, y_{CM} = \frac{3R}{8}, z_{CM} = 0$

(13). Head-on collision



Velocity of bodies m_1, m_2 after collision are

$$\vec{v}_1 = \left(\frac{m_1 - em_2}{m_1 + m_2}\right)\vec{u}_1 + \frac{m_2(1+e)}{m_1 + m_2}\vec{u}_2 \quad ; \quad \vec{v}_2 = \left(\frac{m_2 - em_1}{m_1 + m_2}\right)\vec{u}_2 + \frac{m_1(1+e)}{m_1 + m_2}\vec{u}_1$$

Here e is coefficient of restitution.

Loss in kinetic energy, $\Delta KE = \frac{1}{2}\frac{m_1 m_2}{m_1 + m_2}(\vec{u}_1 - \vec{u}_2)^2(1 - e^2)$

(14). For elastic collision $\Delta KE = 0$ and e = 1, then velocities after collision are

$$\vec{v}_1 = \left(\frac{m_1 - m_2}{m_1 + m_2}\right)\vec{u}_1 + \left(\frac{2m_2}{m_1 + m_2}\right)\vec{u}_2 \quad ; \quad \vec{v}_2 = \left(\frac{m_2 - m_1}{m_1 + m_2}\right)\vec{u}_2 - \frac{2m_1}{m_1 + m_2}\vec{u}_1$$

(15). For perfectly inelastic collision, e = 0, then velocities after collision are

$\vec{v}_1 = \vec{v}_2 = \dfrac{m_1\vec{u}_1 + m_2\vec{u}_2}{m_1 + m_2}$ and loss in kinetic energy is $\Delta KE = \dfrac{1}{2}\dfrac{m_1 m_2}{m_1 + m_2}(\vec{u}_1 - \vec{u}_2)^2$

7. GRAVITATION

(1). Newton's universal law of gravitation $F = \dfrac{Gm_1m_2}{r^2}$

In vector form, $\vec{F} = \dfrac{Gm_1m_2}{r^2}\cdot(\vec{r})$

(2). According to Kepler's II[nd] law $\dfrac{\overrightarrow{dA}}{dt} = \dfrac{\vec{L}}{2m}$

(3). According to Kepler's III[rd] law $T^2 = \dfrac{4\pi^2}{GM}R^3 \Rightarrow T^2 \propto R^3$

Where, T = Time period of revolution, and R = Semi-major axis of the elliptical orbit.

Newton's universal law of gravitation $F = \dfrac{Gm_1m_2}{r^2}$

(4). Acceleration due to gravity 'g' is $g = \dfrac{GM_e}{R_e^2}$

(5). Variation of g at altitude 'h' is $g_h = g\left[\dfrac{R_e}{R_e + h}\right]^2$

If $h << R$ then, $g_h = g\left[1 - \dfrac{2h}{R_e}\right]$

(6). Variation of g at depth 'd' is $g_d = g\left[1 - \dfrac{d}{R_e}\right]$

(7). Gravitational potential energy $U = W_{AB} = -GMm\left[\frac{1}{r_2} - \frac{1}{r_1}\right]$

If, $r_1 = \infty$, $r_2 = r \Rightarrow U = -\frac{GMm}{r}$

8. MECHANICAL PROPERTIES OF SOLIDS

(1). Elongation produced in rod of length 'L' due to its own weight is $\Delta L = \frac{\rho g L^2}{2Y} = \frac{MgL}{2AY}$

(2). Thermal Stress $Y\ \alpha\ \Delta\theta$

(3). Elastic potential energy density $U = \frac{1}{2}(\text{stress}) \times (\text{strain})$

(4). Bulk modulus, $B = -V\frac{\Delta P}{\Delta V}$

(5). Compressibility $= \frac{1}{B}$

(6). Restoring couple per unit twist $= \frac{\pi\eta r^4}{2\ell}$

(7). $\sigma = -\frac{\Delta r / r}{\Delta L / L}$

(8). Relation between $Y, B, S \Rightarrow Y = \frac{9BS}{3B + S}$

(9). Relation between Y, B, η, $Y = 3B(1 - 2\eta)$

(10). Relation between Y, S $Y = 2S(1 + \sigma)$

(11). Poisson's Ratio $\eta = \frac{3B - 2S}{6B + 2S}$

(12). Depression at the middle of a beam $y = \frac{Wt^3}{4Ybd^3}$

(13) Sheer Modulus $S = \frac{Fh}{Ax}$

(14) Relation between B, S, η, $B = \frac{2S(1 + \eta)}{3(1 - 2\eta)}$

9. MECHANICAL PROPERTIES OF FLUIDS

(1). Relative density of a substance $\rho_{rel} = \frac{\rho_{substance}}{\rho_{water \text{ at } 4^oC}}$

(2). Gauge pressure $P_g = \rho gh$

(3). Apparent weight of a body of density σ in a fluid of density ρ

$W' = W\left(1 - \frac{\rho}{\sigma}\right)$, W = weight of the body in air

(4). Equation of continuity Av = constant

Here, A = cross-sectional area of pipe and v = fluid velocity

(5). Bernoulli's equation: At any point in a streamline flow

$$P + \rho gh + \frac{1}{2}\rho v^2 = constant$$

Here, P= pressure, v = fluid velocity and ρ is density.

(6). Coefficient Of viscosity $\eta = \frac{F\ell}{vA}$

Here, F = Viscous force, ℓ = Separation between two lamina, A = Area of each lamina and v = Relative velocity of two lamina

(7). According to Stokes'law $F = -6\pi\eta av$

Here, a = radius a ball or drop and v = velocity of ball or drop

(8). Formula for Terminal velocity is $v_T = \frac{2a^2}{9\eta}(\rho - \sigma)g$

Where, ρ = density of falling body, σ = density of fluid and η = coefficient of viscosity

(9). Reynolds number. $R_e = \frac{\rho vd}{\eta}$ where, d = diameter of the pipe

(10). Excess pressure inside a liquid drop or a cavity of radius R is $\Rightarrow P_i - P_0 = \frac{2S}{R}$ where S is surface tension

(11). Excess pressure inside an air bubble is $P_i - P_0 = \frac{4S}{R}$

(12). Height of a liquid in a capillary tube is $h = \frac{2S\cos\theta}{r\rho g}$

Where, θ = angle of contact, ρ = density of the liquid and g = acceleration due to gravity

10. THERMAL PROPERTIES OF MATTER

(1). Conversion of temperature from one scale to other.

(a) From $^{\circ}C \leftrightarrow {}^{\circ}F$ $\quad t_C = \frac{5}{9}(t_F - 32)$, & $t_F = \frac{9}{5}t_C + 32$

(b) From $^{\circ}C \leftrightarrow {}^{\circ}K$ $\quad T = t_C + 273.15$, & $t_C = T - 273.15$

(c)) From $^{\circ}F \leftrightarrow {}^{\circ}K$ $\quad t_F = \frac{9}{5}T - 459.67$, & $T = \frac{5}{9}t_F + 255.37$

Where T, t_C, t_F, stand for temperature reading on Kelvin scale, Celsius scale, Fahrenheit scale respectively.

(2). $\beta = 2\alpha$, $\gamma = 3\alpha$ (Relation between α, β, γ)

(3). (a) $Q = \frac{kA(T_1 - T_2)t}{x}$

Where Q is the amount of heat that flows in time t across the opposite faces of a rod of length x and cross-section A. T_1 and T_2 are the temperatures of the faces in the steady state and k is the coefficient of thermal conductivity of the material of the rod.

(b) $Q = -kA\left(\frac{dT}{dx}\right)t$ Where $\frac{dT}{dx}$ represents the temperature gradient.

(c) $H = \frac{dQ}{dt} = -kA\left(\frac{dT}{dx}\right)$ H is called the heat current.

(4). (a) Coefficient of reflectivity is $r = \frac{Q_1}{Q}$

(b) Coefficient of absorptivity $a = \frac{Q_2}{Q}$

(c)Coefficient of transitivity $t = \frac{Q_3}{Q}$

Where Q_1 is the radiant energy reflected, Q_2 is the radiant energy absorbed and Q_3 is the radiant energy transmitted through a surface on which Q is the incident radiant energy

(5). (a) $\ln \frac{(T_1 - T_0)}{(T_2 - T_0)} = Kt$

(b) $\frac{(T_1 - T_2)}{t} = K\left(\frac{T_1 \times T_2}{2} - T_0\right)$

The above two equations represents Newton's law of cooling. Here, t is the time taken by a body to cool from T_1 to T_2 in a surrounding at temperature T_0.

11. THERMODYNAMICS

(1). First law of thermodynamics $\Delta Q = \Delta U + \Delta W$

(2). Work done, $\Delta W = P\Delta V$

$\therefore \quad \Delta Q = \Delta U + P\Delta V$

(3). Relation between specific heats for a gas $C_p - C_r = R$

(4). For isothermal process, (i) according to Boyle's law PV = constant

According to Charles law (For volume) $V \propto T$ constant and Charles law (for pressure) $P \propto T$

And (ii) Work done is $W = \mu RT \ln \frac{V_2}{V_1} = 2.303\ \mu RT \log \frac{V_2}{V_1}$

(5). For adiabatic process, (i) According to Boyle's law PV^{γ} = constant Where, $\gamma = \frac{C_p}{C_v}$

And (ii) Work done is $W = \frac{P_1V_1 - P_2V_2}{\gamma - 1} = \frac{\mu R\left[T_1 - T_2\right]}{\gamma - 1}$

(6). Slope of adiabatic = γ (slope of isotherm)

(7). For Carnot engine,

(i) Efficiency of engine is $\eta = 1 - \frac{Q_2}{Q_1} = 1 - \frac{T_2}{T} \qquad \left(\because \frac{Q_1}{Q_2} = \frac{T_1}{T_2}\right)$

(ii) And work done is $W = Q_1 - Q_2 \qquad \therefore \eta = \frac{W}{Q_1}$

(8). For Refrigerator

(i) Coefficient of performance is $\beta = \frac{Q_2}{Q_1 - Q_2} = \frac{Q_2}{W} \qquad \Rightarrow \beta = \frac{1-\eta}{\eta}$

(9). For Heat pump $r = \frac{Q_1}{W} = \frac{Q_1}{Q_1 - Q_2} = \frac{1}{\eta}$

12. KINETIC THEORY OF GASES

(1). Ideal gas equation is $PV = \mu RT$ where μ is number of moles and R is gas constant

Pressure exerted by ideal gas on container is $P = \frac{1}{3}\frac{mM}{V}\overline{v^2}$

(2) R.M.S. velocity $v_{rms} = \sqrt{\frac{3k_BT}{m}}$ (3). Average velocity $v_{av} = \sqrt{\frac{8K_BT}{\pi m}}$

(4). Most probable velocity $v_{mp} = \sqrt{\frac{2K_BT}{m}}$

(5). Mean free path $(\vec{\lambda}) = \frac{1}{\sqrt{2}n\pi d^2}$

Where n = number density and d = diameter of molecule

Table 2: Some important points about molecules of gas

S.No.	Atomicity	No. of degree of freedom	C_p	C_v	$\gamma = \frac{C_P}{C_v}$
1.	Monoatomic	3	$\frac{5}{2}R$	$\frac{3}{2}R$	$\frac{5}{3}$
2	Diatomic	5	$\frac{7}{2}R$	$\frac{5}{2}R$	$\frac{7}{5}$
3.	Linear molecule (Triatomic)	7	$\frac{7}{2}R$	$\frac{5}{2}R$	$\frac{7}{5}$
4.	Non-linear molecule (Triatomic)	6	4R	3R	$\frac{4}{3}$

(6). For mixture of gas, molar specific heat at constant volume is given by $C_{v(mix)} = \frac{n_1C_{v_1} + n_2C_{v_2}}{n_1 + n_2}$

Where n_1 and n_2 are number of moles of two gases mixed together C_{v_1} and C_{v_2} are molar specific heat at constant volume of 2 gas.

(7) For mixture of gases with $n_1, \& n_2$ moles the following relation holds true.

$$\frac{n_1 + n_2}{\gamma - 1} = \frac{n_1}{\gamma_1 - 1} + \frac{n_2}{\gamma_2 - 1}$$

13. OSCILLATIONS

(1) Displacement equation for SHM $x = A \sin(\omega t + \phi)$ Or

$x = A \cos[\omega t + \phi]$ where A is amplitude and $(\omega t + \phi)$ is phase of the wave

(2). Velocity in SHM $v = A\omega \cos \omega t$ and $v = \omega\sqrt{A^2 - x^2}$

(3). Acceleration in SHM is $a = -\omega^2 A \sin \omega t$ and $a = -\omega^2 x$

(4). Energy in SHM is

(i) Potential energy $U = \frac{1}{2} m\omega^2 x^2$ (ii) Kinetic energy $K = \frac{1}{2} m\omega^2 (A^2 - x^2)$

(iii) Total energy $E = \frac{1}{2} m\omega^2 A^2$

(5). For Simple pendulum

(i) Time period of pendulum is $T = 2\pi\sqrt{\frac{L}{g}}$ (ii) If L is large $T = 2\pi\sqrt{\frac{1}{g\left[\frac{1}{L} + \frac{1}{R}\right]}}$

(iii) $\frac{\Delta T}{T} = \frac{1}{2}\frac{\Delta L}{L}$ (iv) Accelerated pendulum $T = 2\pi\sqrt{\frac{L}{g + a}}$

(6). For torsional pendulum, time period of oscillation is $T = 2\pi\sqrt{\frac{I}{k}}$; where I is moment of inertia

(7). For physical pendulum, time period of oscillation is $T = 2\pi\sqrt{\frac{I}{mgd}}$; where I is moment of inertia of body about axis passing through hinge and, d : Distance of centre of mass from hinge

(8). Damped simple harmonic motion

(i) Force action on oscillation body is $m \cdot \frac{d^2x}{dt^2} = -kx - b\frac{dx}{dt}$

(ii) Equation of motion is $x = Ae^{-u/2m}\cos(\omega' t + \phi)$ Where $\omega' = \sqrt{\frac{k}{m} - \frac{b^2}{4m^2}}$

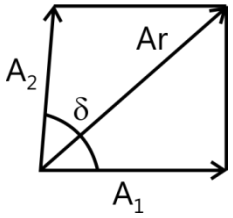
(9). Forced oscillator

(i) Force acting on body is $\frac{md^2x}{dt^2} = -kx - bv + F_0 \sin \omega t$

(ii) Equation of motion is $x = A \sin [wt + \phi]$ Where $A = \frac{F_\phi}{m\sqrt{(\omega^2 - \omega_0^2)^2 + \left(\frac{b\omega}{m}\right)^2}}$

(10). Superposition of Two SHM's

(i) In same direction



$x_1 = A_1 \sin \omega t$ and $x_2 = A_2 \sin (\omega t + \delta)$

Resultant amplitude is $A_r = \sqrt{A_1^2 + A_2^2 + 2A_1A_2 \cos \delta}$

(ii) In perpendicular direction

$x_1 = A_1 \sin \omega t$ and $y_1 = A_2 \sin(\omega t + \phi)$

(a) Resultant motion is SHM along straight line, if $\phi = 0$ or $\phi = \pi$

(b) Resultant motion is circular, if $\phi = \frac{\pi}{2}$ and $A_1 = A_2$

(c) Resultant motion is an (light) elliptical path, if $\phi = \frac{\pi}{2}$ and $A_1 \neq A_2$

14. WAVES

(1). Equation of a plane progressive harmonic wave travelling along positive direction of X-axis is

$y(x, t) = a \sin(kx - \omega t + \phi)$

And along negative direction of X-axis is $y(x, t) = a \sin(kx + \omega t + \phi)$

Where, $y(x,t) \rightarrow$ Displacement as a function of position x and time t,

$a \rightarrow$ Amplitude of the wave, $\omega \rightarrow$ Angular frequency of the wave,

$k \rightarrow$ Angular wave number, $(kx - \omega t + \phi) \rightarrow$ Phase,

And $\phi \rightarrow$ Phase constant or initial phase angle

(2). Angular wave number or propagation constant (k) $k = \frac{2\pi}{\lambda}$

(3). Speed of a progressive wave $v = \frac{\omega}{k} = \frac{\lambda}{T} = \lambda f$

(4) Speed of a transverse wave on a stretched string

$v = \sqrt{\frac{T}{\mu}}$ where, $T \rightarrow$ Tension in the string, and $\mu \rightarrow$ Mass per unit length

(5). Speed of sound wave in a fluid

$v = \sqrt{\frac{B}{\rho}}$ where, $B \rightarrow$ Bulk modulus, and $\rho \rightarrow$ density of medium

(6). Speed of sound wave in metallic bar

$v = \sqrt{\frac{Y}{\rho}}$ where, Y = young's modulus of elasticity of metallic bar

(7). Speed of sound in air (or gases) Newton's formula (connected)]

$v = \sqrt{\frac{v}{\rho}}$ where, $P \rightarrow$ Pressure, $\rho \rightarrow$ Density of air (or gas) and $\gamma \rightarrow$ Atomicity of air (or gas)

(8). The effect of density on velocity of sound $\frac{v_2}{v_1} = \sqrt{\frac{\rho_1}{\rho_2}}$

(9). The effect of temperature on velocity of sound $\frac{v_1}{v_0} = \sqrt{\frac{T}{T_0}} = \sqrt{\frac{273+t}{273}}$

(10). If two waves having the same amplitude and frequency, but differing by a constant phase ϕ, travel in the same direction, the wave resulting from their superposition is given by

$$y(x,t) = \left[2a\cos\frac{\phi}{2}\right]\sin\left(kx - \omega t + \frac{\phi}{2}\right)$$

(11). If we have a wave

$y_1(x,t) = a\sin(kx - \omega t)$ then,

(i) Equation of wave reflected at a rigid boundary

$y_r(x,t) = a\sin(kx + \omega t + \pi)$ Or $y_r(x, t) = -a\sin(kx + \omega t)$

i.e. the reflected wave is 180° out of phase.

(ii) Equation of wave reflected at an open boundary $y_r(x, t) = a\sin(kx + \omega t)$

i.e. the reflected wave is a phase with the incident wave.

(12). Equation of a standing wave on a string with fixed ends $y(x,t) = [2a\sin kx]\cos\omega t$

Frequency of normal modes of oscillation $f = \frac{nv}{2L}$ $n = 1,2,3.....$

(13). Standing waves in a closed organ pipe (closed at one end) of length L.

Frequency of normal modes of oscillation. $f = \left(n - \frac{1}{2}\right)\frac{v}{2L}$ $n = 1,2....$

$\Rightarrow f_n = (2n-1)f_1$

Where f_n is the frequency of n^{th} normal mode of oscillation. Only odd harmonics are present in a closed pipe.

(14). Standing waves in an open organ pipe (open at both ends)

Frequency of normal modes of oscillation $f = \frac{nv}{2L}$ $n = 1,2,3....$

$\Rightarrow f_n = nf_1$

Where f_n is frequency of n^{th} normal mode of oscillation.

(15). Beat frequency (m)

$m \rightarrow$ Difference in frequencies of two sources

$m = (v_1 - v_2)$ or $(v_2 - v_1)$

(16). Doppler's effect $f = f_0\left[\frac{v + v_0}{v + v_s}\right]$

Where, $f \rightarrow$ Observed frequency, $f_0 \rightarrow$ Source frequency,

$v \rightarrow$ Speed of sound through the medium, $v_0 \rightarrow$ Velocity of observer relative to the medium

and $v_s \rightarrow$ Source velocity relative to the medium

$\Rightarrow$ In using this formula, velocities in the directions (i.e. from observer to the source) should be treated as positive and those opposite to it should be taken as negative.

15. ELECTRIC CHARGES AND FIELDS

(1). Electric force between two charges is given by $F = \frac{q_1 q_2}{4\pi\varepsilon_0 R^2}$

And $F = q_1 E$ where $E = \frac{q_2}{4\pi\varepsilon_0 R^2}$ is the electric field due to charge q_2

(2) Electric potential energy for system of two charges is $U = -W = \frac{q_1 q_2}{4\pi\varepsilon_0}\left(\frac{1}{r_1} - \frac{1}{r_2}\right)$

For $r_2 = \infty$, $U = \frac{q_1 q_2}{4\pi\varepsilon_0 r_1}$

(3) Electrostatic potential is $\Delta V = \frac{\Delta U}{q}$

(4). Electric field on the axis of a dipole of moment $\vec{p} = 2aQ$ at a distance R from the centre is

$\vec{E} = \frac{2R\vec{p}}{4\pi\varepsilon_0(R^2 - a^2)^2}$. If R > > a then $\vec{E} = \frac{2\vec{p}}{4\pi\varepsilon_0 R^3}$

(5). Electric field on the equatorial line of the dipole at a distance R from the centre is

$\vec{E} = \frac{-\vec{p}}{4\pi\varepsilon_0(R^2 + a^2)^{\frac{3}{2}}}$. If R > > a then $\vec{E} = \frac{-\vec{p}}{4\pi\varepsilon_0 R^2}$

(6). Torque $\vec{\tau}$ experienced by a short dipole kept in uniform external electric field $\vec{E}$ is

$\vec{\tau} = \vec{p} \times \vec{E} = pE \sin 0\, \hat{n}$

(7). Perpendicular deflection of a charge q in a uniform electric field E after travelling a straight distance x is $y \frac{qEx^2}{2mv_0^2}$, where m is mass of the charge and v_0 is initial speed of perpendicular entry in the electric field.

(8). Electric flux $\phi_E = \vec{E} \cdot \vec{S} = ES \cos\theta$. Area vector $\vec{S}$ is perpendicular to the surface area.

(9). Gauss law : $\oint \vec{E} \cdot \overrightarrow{dS} = \frac{Q}{\varepsilon_0}$. Here $\vec{E}$ is the electric field due to all the charges inside as well as outside the Gaussian surface, while Q is the net charge enclosed inside Gaussian surface.

(10). Electric field due to infinitely long charged wire of linear charge density λ at a perpendicular distance R is $E = \frac{\lambda}{2\pi\varepsilon_0 R}$

(11). Electric field due to singal layer of surface charge density σ is $\frac{\sigma}{2\varepsilon_0}$. Field due to oppositely charged conducting plates is $\frac{\sigma}{\varepsilon_0}$ in between the gap but zero outside.

(12). Field due to a uniformly charged thin spherical shell of radius R is $E = \frac{Q}{4\pi\varepsilon_0 r^2}$ for outside points and zero inside (r is distance from the centre of shell)

(13). Field due to a charge uniformly distributed in a spherical volume is $E = \frac{d}{dr}\left(\frac{Q}{4\pi\varepsilon_0 R^3} r^2\right) = \frac{\rho r}{3\varepsilon_0}$

for inside points and $E = \frac{Q}{4\pi\varepsilon_0 r^2}$ for outside point.

Here $\rho = \frac{3Q}{4\pi R^3}$ is volume charge density and Q is total charge inside the sphere.

16. ELECTROSTATIC POTENTIAL AND CAPACITANCE

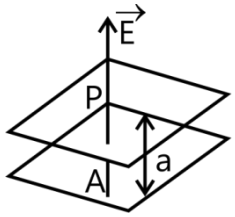
(1). **Electric potential :**

(a) Potential due to a conducting sphere of radius r with charge q (solid or hollow) at a distance r from the centre

$V = \left(\frac{1}{4\pi\varepsilon_0}\right)\frac{q}{r}$ if (r > R) or $V = \left(\frac{1}{4\pi\varepsilon_0}\right)\frac{q}{R}$ if (r = R)

or $V = \frac{1}{4\pi\varepsilon_0}\frac{q}{R}$ if (r < R)

(b) Relation between electric field potential $|\vec{E}| = \left|-\frac{\partial v}{\partial \ell}\right| = +\frac{|\partial v|}{\partial \ell}$

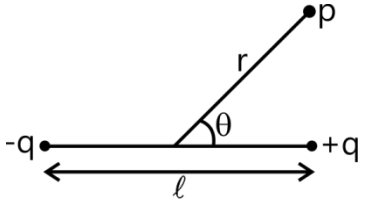


(2). **Electric dipole potential:**

(a) $V = \frac{1}{4\pi\varepsilon_0}\left(\frac{p\cos\theta}{r^2}\right)$

(b) Potential energy of a dipole in an external electric field

$U(\theta) = -\vec{P}\cdot\vec{E}$



(3). **Capacitors :**

Capacitance of a potential plate capacitor $C = \varepsilon_0 \frac{A}{d}$

(4). **Electric field energy :** (a) $U = \frac{1}{2}QV = \frac{Q^2}{2C} = \frac{1}{2}CV^2$

(b) Energy density of energy stored in electric field $u = \frac{1}{2}\varepsilon_0 E^2$

(5) **Combination of capacitors :**

(a) When capacitors are combined in series, $\frac{1}{C_{eq}} = \frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3} + ...$

(b) When capacitors are connected in parallel. $C_{eq} = C_1 + C_2 + C_3 + ...$

(c) Capacitance of spherical capacitor,

$C = 4\pi\varepsilon_0 \frac{ab}{b-a}$. (When outer shell is earthed). or

$C = 4\pi\varepsilon_0 \frac{b^2}{b-a}$. (When inner shell is earthed) or

$C = 4\pi\varepsilon_0 R$ (For a sphere of radius R)

(d) Cylindrical capacitor, $C = \frac{2\pi\varepsilon_0 \ell}{\ln\left(\frac{b}{a}\right)}$

(6). **Dielectrics :**

(a) Induced charge, $q' = q\left(1 - \frac{1}{k}\right)$ (b) Polarization $p = \frac{\text{Dipole moment}}{\text{Volume}}$

Electric dipole moment is $\vec{p} = \chi_e \vec{E}$

$\frac{\chi_e}{\varepsilon_0} = K - 1$ where χ_e is electrical susceptibility, and K is dielectric constant.

17. CURRENT ELECTRICITY

(1). Resistance of a uniform conductor of length L, area of cross-section A and resistivity ρ along its length, $R = \rho\frac{\ell}{A}$

(2). Current density $j = \frac{di}{ds}$ (3). Conductance $G = \frac{1}{R}$.

i4) Drift velocity $v_d = \frac{eE}{m}t. = \frac{i}{neA}$ (5). Current $i = neAv_d$

(6) Resistivity is $\rho = \frac{m}{ne^2t} = \frac{1}{\sigma}$ where σ is resistivity.

(7) According to Ohm's law $\vec{j} = \sigma\vec{E}$ and $V = iR$ (8) Mobility of free electrons $\mu = \frac{v_d}{E}$

(9) $\sigma = ne\mu$ (10). Thermal resistivity of material is $\rho_T = \rho_0[1 + \alpha(T - T_0)]$

(11). Potential difference across a cell during discharging $V = \varepsilon - ir = \frac{\varepsilon R}{R + r}$

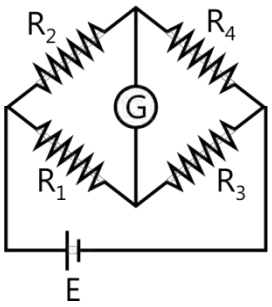
(12). Potential difference across a cell during charging $V = \varepsilon + ir$

(13) For n cells in series across load R, current through load $i = \frac{n\varepsilon}{R + nt}$

(14). For n identical cells in parallel across load R, current through load $i = \frac{n\varepsilon}{nR + r}$

(15). Wheatstone bridge network

For balanced Wheatstone bridge $\frac{R_1}{R_2} = \frac{R_3}{R_4}$



(16). If unknown resistance X is in the left gap, known resistance R is in the right gap of meter bridge and balancing length from left end is l then $X = \frac{R\ell}{100 - \ell}$

(17) **Potentiometer**

(i) Comparison of emf $\frac{\varepsilon_1}{\varepsilon_2} = \frac{\ell_1}{\ell_2}$ (ii) Internal resistance of cell $r = \left(\frac{\ell_1}{\ell_2} - 1\right) R$

18. MOVING CHARGES AND MAGNETIC FIELD

S.No.	Situation	Formula
1.	Lorentz force	$q[\vec{E} + \vec{v} \times \vec{B}]$
2.	Condition for a charged particle to go undeflected in a cross electric and magnetic field	$= \frac{E}{B}$
3.	A charge particle thrown perpendicular to uniform magnetic field (i) Path (ii) Radius (iii) Time period	(i) Circular (ii) $r = \frac{mv}{qB}$ (iii) $t = \frac{2\pi m}{qB}$
4.	A charge particle thrown at some angle to a uniform magnetic field (i) Path (ii) Radius (iii) Time period (iv) Pitch	(i) Helix (ii) $r = \frac{mv\sin\theta}{qB}$ (iii) $t = \frac{2\pi m}{qB}$ (iv) $T \cdot v\cos\theta$
5.	Cyclotron frequency	$f = \frac{qB}{2\pi m}$
6.	Maximum kinetic energy of a charged particle in a cyclotron (With R as radius of dee)	$K = \frac{q^2B^2R^2}{2m}$

7.	Force on a straight current carrying conductor in a uniform magnetic field	$\vec{F} = i(\vec{l} \times \vec{B})$
8.	Force on a arbitrary shaped current carrying conductor in a uniform magnetic field	$\vec{F} = i\int d\vec{\ell} \times \vec{B} = i\ \vec{\ell} \times \vec{B}$
9.	Magnetic moment of a current carrying loop	$\vec{M} = i\ \vec{A}$
10.	Torque on a current carrying loop placed in a uniform magnetic field	$\vec{\tau} = \vec{M} \times \vec{B}$
11.	Biot-Savart Law	$d\vec{B} = \frac{\mu_0 i}{4\pi} \frac{d\vec{\ell} \times \vec{r}}{r^3}$
12.	Magnetic field at a point distance x from the centre of a current carrying circular loop	$\frac{\mu_0 i R^2}{2(R^2 + x^2)^{3/2}}$
13.	Magnetic field at the centre of a current carrying circular loop	$\frac{\mu_0 i}{2R}$
14.	Magnetic field on the axis of a current carrying circular loop far away from the centre of the loop (Moment behaves as magnetic dipole)	$\frac{\mu_0}{4\pi} \frac{2M}{x^3}$
15.	Magnetic field on the centre of current carrying circular arc	$\frac{\mu_0}{4\pi} \frac{i}{t} \theta$
16.	Ampere's circular law	$\oint \vec{B} \cdot d\vec{\ell} = \mu_0 i$
17.	Magnetic field due to a long thin current carrying wire	$B = \frac{\mu_0 i}{2\pi r}$
18.	Magnetic field inside a long straight current carrying cylindrical conductor at a distance r from the axis.	$B = \frac{\mu_0}{2\pi} \cdot \frac{i}{R^2} \cdot r$
19.	Magnetic field outside a long straight current carrying conductor at a distance r from the axis	$B = \frac{\mu_0}{4\pi} \cdot \frac{2i}{r}$
20.	Magnetic field inside a long solenoid	$B = \mu_0 n i$

21.	Magnetic field inside a toroid	$B = \frac{\mu_0 Ni}{2\pi r}$
22.	Force per unit length between two current carrying wire	$F = \frac{\mu_0 i_1 i_2}{2\pi r}$
23.	Current sensitivity of moving coil galvanometer	$\frac{\theta}{i} = \frac{NBA}{k}$
24.	Voltage sensitivity of moving galvanometer	$\frac{\theta}{V} = \frac{NBA}{kR}$
25.	Shunt resistance required to convert galvanometer into ammeter of range i (i_g is the full scale deflected current of galvanometer)	$r_g = \frac{G}{\left(\frac{i}{i_g} - 1\right)}$
26.	Resistance required to convert galvanometer into voltmeter of range V	$R = \frac{V}{i_g} - G$

19. MAGNETISM AND MATTER

(1). **Bar magnet :** The electrostatic Analog

Electrostatics	**Magnetism**
Permittivity = $\frac{1}{\varepsilon_0}$	Permittivity = μ_0
Charge q	Magnetic pole strength (q_n)
Dipole Moment $\vec{p} = q \cdot l$	Magnetic Dipole Moment $\vec{M} = q_m l$

$F = \frac{q_1 q_2}{4\pi\varepsilon_0 r^2}$	$\vec{F} = \frac{\mu_0}{4\pi}\frac{q_{m(1)} q_{m(2)}}{t^2}$
$\vec{F} = q\vec{E}$	$\vec{F} = q_m\vec{B}$
Axial Field $\vec{E} = \frac{2\vec{p}}{4\pi\varepsilon_0 r^2}$	$\vec{B} = \frac{\mu_0}{4\pi}\frac{2\vec{M}}{r^3}$
Equatorial Field $\vec{E} = \frac{-\vec{p}}{4\pi\varepsilon_0 r^2}$	$\vec{B} = -\frac{\mu_0}{4\pi}\frac{\vec{M}}{r^2}$
Torque $\vec{\tau} = \vec{p}\times\vec{E}$	$\vec{\tau} = \vec{M}\times\vec{B}$
Potential Energy $U = -\vec{p}\cdot\vec{E}$	$U = -\vec{M}\cdot\vec{B}$
Work $W = pE(\cos\theta_1 - \cos\theta_2)$	$W = MB(\cos\theta_1 - \cos\theta_2)$

(2). Field due to a magnetic monopole $\vec{B} = \frac{\mu_0}{4\pi}\frac{q_m}{r^2}\cdot\hat{r}$

(3). B on the axial line or end on position of a bar magnet

$\vec{B} = \frac{\mu_0}{4\pi}\frac{2\vec{M}r}{(r^2 - l^2)^2}$ $\left(\text{for } r >> l, \vec{B} = \frac{\mu_0}{4\pi}\cdot\frac{2\vec{M}}{r^2}\right)$

(4). B on the equatorial line or broad side on position of a bar magnet

$B = \frac{\mu_0}{4\pi}\frac{M}{(r^2 + l^2)^{3/2}}$ $\left(\text{for } r >> l, B = \frac{\mu_0}{4\pi}\cdot\frac{M}{r^3}\right)$

(5). Time period angular SHM $T = 2\pi\sqrt{\frac{I}{MB}}$ here I is moment of inertia.

(6). Gauss's law in magnetism $\oint\vec{B}\cdot\vec{ds} = 0$

(7). For horizontal and vertical component of earth's magnetic field, $\frac{B_v}{B_H} = \tan\delta$

(8). $\tan \delta_1^{'} = \dfrac{\tan \delta}{\cos \alpha}$

(9). $\cot^2 \delta = \cot^2 \delta_1 + \cot^2 \delta_2$

(10). Magnetic intensity is $\vec{H} = \dfrac{\vec{B}}{\mu_0} = \dfrac{\vec{B}}{\mu}$

(11). Relative magnetic permittivity is $\mu_r = \dfrac{\mu}{\mu_0}$

(12). Magnetic Susceptibility $\chi_m = \dfrac{M}{H}$

(13). $\mu_r = 1 + \chi_m$

(14). $\chi \propto \dfrac{1}{(T - T_c)}$

20. ELECTROMAGNETIC INDUCTION

(1). Average induced emf $\bar{e} = \dfrac{-\Delta\phi}{\Delta t} = -\left[\dfrac{\phi_2 - \phi_1}{t_2 - t_1}\right]$

(2). Instantaneous induced emf $e_{(t)} = -\dfrac{d\phi_{(t)}}{dt}$

(3). Motional emf $= B_\perp v_\perp \ell$

(4). Motional emf $e = \int de = \int (\vec{v} \times \vec{B})\vec{dl} = (\vec{v} \times \vec{B})\vec{j}$

(5). $\int \vec{E} \cdot \vec{dl} = \dfrac{-d}{dt}\phi_B$ [$\vec{E} \rightarrow$ electric (induced) field, $\phi_B \rightarrow$ Magnetic flux]

(6). $\phi_B = Li$ $\Rightarrow$ $L \rightarrow$ self inductance of the coil

(7). Induced emf $e = -L\dfrac{di}{dt}$

(8). $L = \mu_0 \mu_r n^2 \times A \times i$ Where L coefficient of self-inductance

(9). $\phi_2 = Mi_1$ and $\theta_2 = -M\dfrac{di_1}{dt}$ Where M is co efficient of mutual inductance

(10). The emf induced (in dynamo) $e_{(t)} = BA\omega(\sin \omega t)$

(11). Mutual inductance $M = \mu_0 \mu_1 n_1 n_2 Ai$

21. ELECTROMAGNETIC WAVES

(1). Displacement current $I_D = \varepsilon_0 \frac{d\phi_E}{dt} = \varepsilon_0 \frac{d\oint \vec{E} \cdot \vec{ds}}{dt} = \frac{C dV}{dt}$

(2). Maxwell's Equation:

(a) $\oint \vec{E} \cdot \vec{ds} = \frac{q}{\varepsilon_0}$ (b) $\oint \vec{B} \cdot \vec{ds} = 0$

(c) $\oint \vec{E} \cdot \vec{dl} = -\frac{d}{dt}\phi_B = \frac{-d}{dt}\oint \vec{B} \cdot \vec{ds}$ (d) $\oint \vec{B} \cdot \vec{dl} = \mu_0 \left(I_c + \varepsilon_0 \frac{d\phi_E}{dt} \right)$

(3). $E_y = E_0 \sin(\omega t - kx)$ and $B_2 = B_0 \sin(\omega t - kx)$

$c_{vacuum} = \frac{1}{\sqrt{\mu_0 \varepsilon_0}}$; $c_{medium} = \frac{1}{\sqrt{\mu_r \mu_0 \varepsilon_r \varepsilon_0}}$

(4). $\frac{E_\phi}{B_0} = \frac{E_{RMS}}{B_{RMS}} = \frac{E}{B} = c$

(5). Average of wave I_{av} = Average energy density $\times$ (speed of light)

Of $I_{av} = U_{av} \cdot = \frac{E_0 B_0}{2\mu_0} = \frac{E_0^2}{2c\mu_0} = \frac{cB_0^2}{2\mu_0}$

(6). Instantaneous energy density $u_{av} = \frac{1}{2}\left(\varepsilon_0 E^2 + \frac{B^2}{\mu_0} \right) = \varepsilon_0 E^2 = \frac{B^2}{\mu_0}$

Average energy density $u_{av} = \frac{1}{4}\varepsilon_0 E_0^2 + \frac{B_0^2}{4\mu_0} = \frac{\varepsilon_0 E_0^2}{2} = \frac{B_0^2}{2\mu_0}$

(7). Energy = (momentum), c or $U = Pc$

(8). Radiation pressure $R.P. = \frac{I_0}{c}$ where I_0 is intensity of source (when the wave is totally absorbed)

And $R.P. = \frac{2I_0}{c}$ (when the wave is totally reflected)

(9). $I \propto \frac{1}{t^2}$ (for a point source) and $I \propto \frac{1}{r}$ (for a line source)

For a plane source intensity is independent of r.

22. RAY OPTICS AND OPTICAL INSTRUMENTS

(1). The distance between the pole and centre of curvature of the mirror called radius of curvature

$f = \frac{R}{2}$

(2). Mirror equation $\frac{1}{v} + \frac{1}{u} = \frac{1}{f}$ (u is Object distance, v is Image distance and f Focal length)

(3). Linear magnification $m = \frac{\text{size of image}}{\text{size of object}} = \frac{\text{image distance}}{\text{Object distance}} = -\frac{v}{u}$

(4). In case of lens $\frac{\mu_2}{v} - \frac{\mu_1}{u} = \frac{\mu_2 - \mu_1}{R}$

(R= Radius of curvature , μ_1 and μ_2 are refractive indices of medium)

(5). Relationship between u, v and focal length f is $\frac{1}{v} - \frac{1}{u} = \frac{1}{f}$ in case lens.

(6). Longitudinal magnification = (Lateral magnification)^2

(7) Equivalent lens

(i) Lens in contact $\frac{1}{F} = \frac{1}{f_1} + \frac{1}{f_2}$ (ii) Lens at a distance d, $\frac{1}{F} = \frac{1}{f_1} + \frac{1}{f_2} - \frac{d}{f_1 f_2}$

(8). Reciprocal of focal length is called as power of lens.

$P = \frac{1}{f(\text{in metres})} = \frac{100}{f(\text{in cm})}$

(9). For achromatic combination of two lens $\frac{\omega_1}{f_1}+\frac{\omega_2}{f_2}=0$

(10). Refractive index of material of prism $\mu=\frac{\sin\left(\frac{A+\delta_m}{2}\right)}{\sin\left(\frac{A}{2}\right)}$ (δ_m) Minimum deviation angle

(11). For small-angled prism $d=(\mu-1)A$

(where A= Angle of prism and B= Deviation angle)

(12). Dispersive power of prism for two colors (blue and red)

$$\omega=\left[\frac{\delta_v-\delta_R}{d}\right]=\left[\frac{\mu_v-\mu_R}{\mu-1}\right]$$

(13). For simple microscope,

(a) Magnification $m=1+\frac{D}{f}$ (Where D= Least distance of distinct vision. and f= Focal length)

(b) $M=\frac{D}{f}$ for image to form at infinity

(14). For compound microscope.

Magnification of objective $M_O=\frac{v_O}{u_O}$ and Magnification of eye piece $M_e=\left(1+\frac{v_e}{f_e}\right)$

(a) $m=m_o m_e=\frac{v_o}{u_e}\left[1+\frac{D}{f_e}\right]$ for least distance of distinct vision.

(b) $m=\frac{L}{f_o}\times\frac{D}{f_e}$ for image to form at infinite.

(15). Magnifying power of telescope $m=\frac{f_o}{f_e}$ and length of telescope $=L=f_e+f_o$

23. WAVE OPTICS

(1). $\frac{\sin i}{\sin t} = \frac{\mu_2}{\mu_1} = \frac{v_1}{v_2} = \frac{\lambda_1}{\lambda_2}$ (Snell's law)

(2). Ratio of maximum to minimum intensity $\frac{I_{max}}{I_{min}} = \frac{(\sqrt{I_1} + \sqrt{I_2})^2}{(\sqrt{I_1} - \sqrt{I_2})^2}$

(3). (a) Fringe width $\beta = \frac{\lambda D}{d}$ (b) Condition of maxima $\Delta\phi = 2n\pi$ where $n = 0, 1, 2..$

(c) Condition of minima $\Delta\phi = (2n+1)\pi$ where $n = 0, 1, 2..$

(d) Intensity of any point of screen $I = 4I_0 \cos^2 \frac{\phi}{2}$

Where $\Delta\phi = \frac{2\pi}{\lambda}\Delta x$ is phase difference and Δx is path difference

(4). Doppler's effect for light $\frac{\Delta v}{v} = -\frac{v_{radial}}{c} = -\frac{\Delta\lambda}{\lambda}$

(5). Resolving power of microscope $= \frac{2\mu \sin\beta}{1.22\,\lambda}$

(6). Radius of central bright spot in diffraction pattern $r_0 = \frac{1.22\,\lambda f}{2a}$

(7). Fresnel distance $Z_f = \frac{a^2}{\lambda}$ (8) Malus law $I = I_0 \cos^2\theta$

(9) Brewster's law $\tan i_B = \mu$

24. DUAL NATURE OF RADIATION AND MATTER

(1). Einstein's photoelectric cell equation, $\frac{1}{2}mv_{max}^2 = hf - hf_0$

Where f, f_0 are frequencies of incident radiation.

(2). Work function and threshold frequency or threshold wavelength, $\phi_0 = hf_0 = \frac{hc}{\lambda_0}$

(3). Energy of photon, $E = hf = \frac{hc}{\lambda}$ (4). Momentum of photon, $P = \frac{E}{c} = \frac{h}{\lambda}$

(5). De Broglie wavelength of a material particle, $\lambda = \frac{h}{mv}$

(6). De Broglie wavelength of an electron accelerated through a potential V volt,

$\lambda = \frac{12.27}{\sqrt{V}}\ \text{Å} = \frac{1.227}{\sqrt{V}}\text{nm}$

(7). de Broglie wavelength of a particle in terms of temperature (T), $\lambda = \frac{h}{\sqrt{3mkT}}$

(8). de Broglie wavelength in terms of energy of a particle (E), $\lambda = \frac{h}{\sqrt{2mE}}$

25. ATOMS

Rutherford's Model

Distance of closest approach $r_0 = \dfrac{e^2}{4\pi\varepsilon_0 E}$ where E is the energy of α-particle at a large distance.

Bohr's Model of hydrogen atom

Postulates: (i) Radius of n^{th} orbit, $r_n = \dfrac{\varepsilon_0 h^2 n^2}{\pi m e^2}$

(ii) Orbital speed, $V_n = \dfrac{nh}{2\pi m r_n}$ (iii) Energy of n^{th} orbit, $E_n = -\left(\dfrac{me^4}{8\varepsilon_0^2 h^2}\right)\dfrac{1}{n^2} = \dfrac{13.6}{n^2}\text{eV}$

(iv) $TE = -KE$ (v) $PE = 2TE$

Rydberg's constant $\dfrac{1}{\lambda} = R\left[\dfrac{1}{n_1^2} - \dfrac{1}{n_2^2}\right]$ and $R = \dfrac{me^4}{8\varepsilon_0^2 h^3 c}$

26. NUCLEI

(1). Nuclear radius (R) is given by $R = R_0 A^{1/3}$ Here $R_0 = 1.2 \times 10^{-15}\text{m}$.

(2). Density of all nuclei is constant.

(3). Total binding energy $= [Z\, m_p + (A - Z)m_n - M]c^2$ J

(4). Av. BE/nucleon = Total B.E/A

(5). Radioactivity decay law $\dfrac{dN}{dt} = -\lambda N \Rightarrow N = N_0 e^{-\lambda t}$

(6). Half life $T_{1/2} = \dfrac{0.6931}{\lambda}$ (7). Average or mean life is $T_{av} = \dfrac{1}{\lambda} = 1.44\ T_{1/2}$.

27. SEMICONDUCTOR ELECTRONICS

- Intrinsic semiconductors : $n_e = n_h = n_i$

  Extrinsic semiconductors: $n_e n_h = n_i^2$

- Transistors : $I_e = I_b + I_c \qquad \Rightarrow \Delta I_E = \Delta I_b + \Delta I_c$

- Common emitter amplifier :

  (i) $\beta = \dfrac{I_c}{I_b}$; $\beta_{ac} = \left(\dfrac{\Delta I_c}{\Delta I_b}\right)_{vdE}$. (ii) Trans-conductance $g_m = \dfrac{\Delta I_c}{\Delta V_i}$

  (iii) AC voltage gain $= \beta_{ac} \times \dfrac{R_{out}}{R_{in}}$ (iv) Power gain = voltage gain $\times$ Current gain

- Logic Gates

  For input X and Y, output Z be given by $Z = X + Y$

  OR gate $Z = XY$ AND gate $Z = \overline{X}$

  NOR gate $Z = \overline{(X + Y)}$ NAND gate $Z = \overline{(XY)}$

  NOT gate $Z = \overline{X}$ or $Z = \overline{Y}$

  when either X or Y is present.

28. COMMUNICATION SYSTEM

(1). The maximum line of sight distance d_M between the two antennas having height h_T and h_R, above the earth, is given by $d_M = \sqrt{2Rh_T} + \sqrt{2Rh_R}$

(2). Modulation index $\mu = \dfrac{A_m}{A_e}$ where A_m and A_c are the amplitudes of modulating signal and carrier wave.

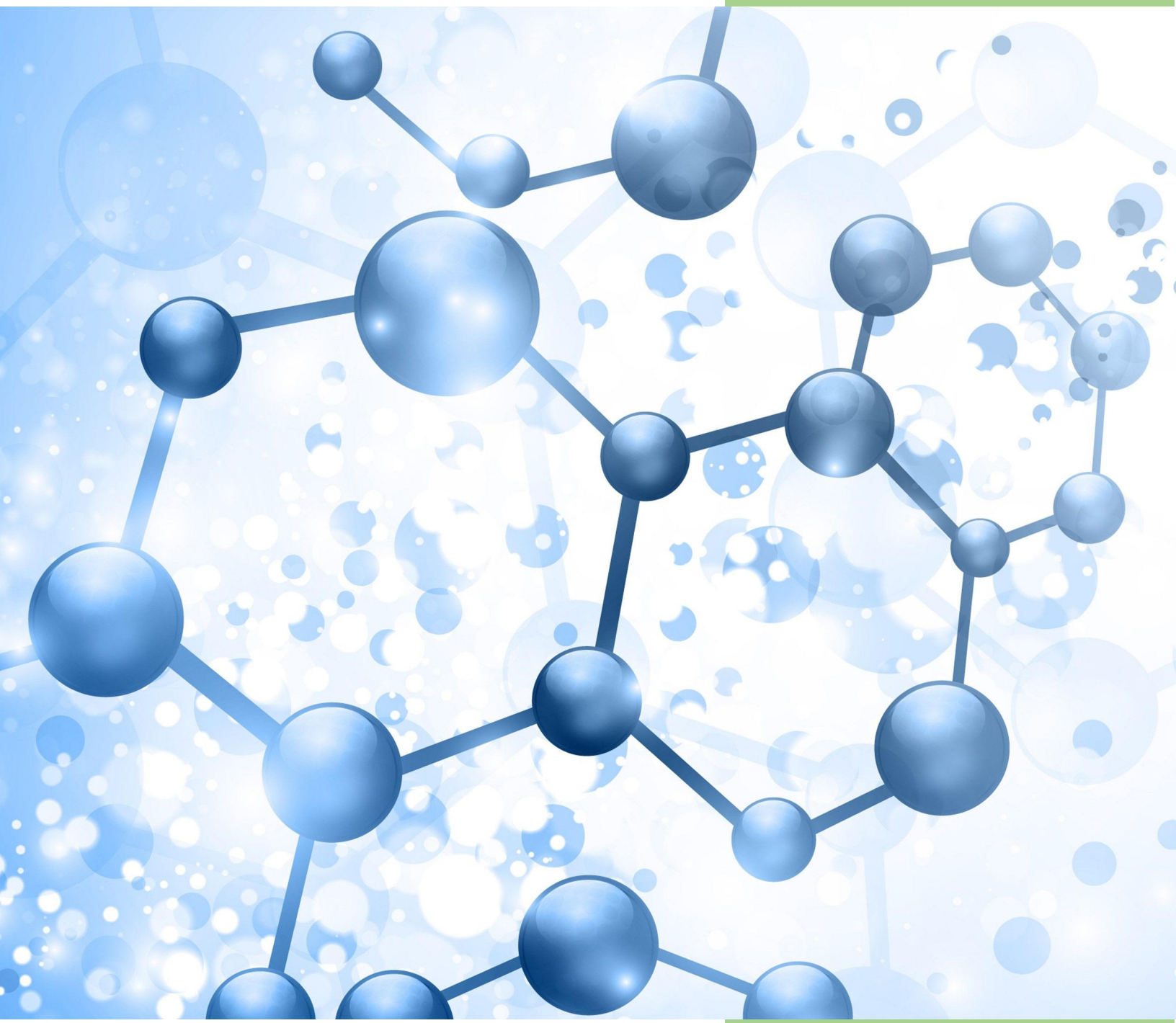
(3). In amplitude modulation $P_1 = P_2\left[1 + \dfrac{\mu^2}{2}\right]$

(4). Maximum frequency can be reflected from ionosphere $f_{max} = 9(N_{max})^{1/2}$

(5). Maximum modulated frequency can be detected by diode detector $f_m = \dfrac{1}{2\pi R\mu}$

CHEMISTRY

FORMULA HAND BOOK



அம்மா கல்வியகம்

Chemistry

1. SOME BASIC CONCEPTS OF CHEMISTRY

(1). Number of molecules in W(g) of substance $= \frac{W(g) \times N_A}{GMM}$

(2). Molality (m) = $\frac{\text{No. of moles of solute}}{\text{Mass of solvent in kg}}$

(3). Number of molecules in V litre of gas at S.T.P. $= \frac{VN_A}{22.4}$

(4). Number of gram atoms = $\frac{W(g)}{GAM}$ (GAM $\rightarrow$ gram atomic mass)

(5). Number of gram molecules = $\frac{W(g)}{\text{Gram molecular mass}}$

(6). Dilution formula : $M_1V_1 = M_2V_2$

For mixing two solutions of the same substance

$M_1V_1 + M_2V_2 = M_3(V_1 + V_2)$

Molarity can be directly calculated from % by mass (w/w) if density is known

Molarity $= \frac{\% \times 10 \times d}{GMM}$

(7). Mass of 1 atom of element $= \frac{GAM}{N_A}$

(8). Mass of 1 molecule of substance $= \frac{MM}{N_A}$ (MM $\rightarrow$ Molar mass)

(9). $T(K) = T(^oC) + 273.15$

(10). Relative atomic mass = $\frac{\text{Mass of an atom of the element}}{\frac{1}{12} \times \text{Mass of an atom of carbon (C-12)}}$

(11). Number of molecules in n moles of substance $= n \times N_A$

(12). Mass % of an element in a compound $= \frac{\text{Mass of that element in 1 mole of the compound}}{\text{Molar mass of the compount}} \times 100$

(13). Mass percent $= \frac{\text{Mass of solute}}{\text{Mass of solution}} \times 100$

(14). $\frac{X_B}{1-X_B} = \frac{\text{molality} \times M_A}{1000}$ where M_A - mass of solvent

(15). Molarity (M) $= \frac{\text{No. of moles of solute}}{\text{Volume of solution in litres}} \text{mole / L}$

(16). Avogadro's No. $N_A = 6.022 \times 10^{23}$

(17). $T(^oF) = \frac{9}{5} T(^oC) + 32$

(18). Molecular mass $= 2 \times$ vapour density

(19). Mole fraction of A $= \frac{\text{No. of moles of A}}{\text{No. of moles of solution}}$

2. STRUCTURE OF ATOM

(1). Wavelength of matter wave

$$\boxed{\lambda = \frac{h}{mv}}$$

$$\lambda = \frac{h}{p}$$

$$\lambda = \frac{h}{\sqrt{2Em}}$$

Where, E = Kinetic energy

(2). Total number of nodes = n – 1

Radial nodes = n – *l* – 1

Angular nodes = *l*

(3). **Number of neutrons** = A – Z

(4). Number of subshells in n^{th} shell = n

Number of orbitals in n^{th} shell = n^2

Number of electrons in n^{th} shell = $2n^2$

Number of orbitals in subshell = $2l + 1$

Number of electrons in subshell = $2(2l + 1)$

(5). Energy of quantum of radiation according to Planck's quantum theory

$$\boxed{E = h\nu}$$

(6). $$\boxed{h\nu = h\nu_0 + \frac{1}{2}m_e v^2}$$

Einstein's photoelectric equation.

(7). **Line spectrum of hydrogen**

$\bar{\nu} = 109677\left(\frac{1}{n_1^2} - \frac{1}{n_2^2}\right) cm^{-1}$ where $\bar{\nu}$ is wave number and $\bar{\nu} = \frac{1}{\lambda}$.

Where $n_1 = 1, 2, ...$

$n_2 = n_1 + 1,\ n_1 + 2, ...$

(8). **Bohr's model of hydrogen atom**

(a) **Frequency** of radiation absorbed or emitted during transition ; $\nu = \frac{\Delta E}{h}$

$$\nu = \frac{E_2 - E_1}{h}$$

E_1 = Energy of lower energy state

E_2 = Energy of higher energy state.

(b) **Orbit angular momentum** of an electron, $\boxed{m_e vr = n \cdot \frac{h}{2\pi}}$

Where, n = 1, 2, 3,.....

(c) **Energy** of stationary states $\boxed{E_n = -2.18 \times 10^{-18}\left(\frac{Z^2}{n^2}\right) J}$

(d) **Radii** of the stationary states/orbits $\boxed{r_n = 52.9 \times \left(\frac{n^2}{Z}\right) pm}$

(9). Energy gap between the two orbits $\boxed{\Delta E = R_H\left(\frac{1}{n_i^2} - \frac{1}{n_f^2}\right)}$

Where $R_H = 2.18 \times 10^{-18}$

Where, n_i = initial orbit

n_f = final orbit

(10). **Atomic number (Z)** = Number of protons in the nucleus of an atom

= Number of electrons in a neutral atom

(11). Heisenberg's uncertainty principle

$\Delta x \times \Delta p \geq \frac{h}{4\pi}$; $\boxed{\Delta x \times m\Delta v \geq \frac{h}{4\pi}}$

(12). Speed of light is equal to the product of frequency and wavelength of light

$\boxed{c = v\lambda}$

(13). **Mass Number (A)** = Number of protons + Number of neutrons

3. STATE OF MATTER

(1). **Van der Waals Equation :** $\left(P + \frac{an^2}{V^2}\right)(V - nb) = nRT$

(2). **Combined Gas Equation :** $\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$; (n, R constant)

(3). **Dalton's Law of partial pressures :** $P_{Total} = P_1 + P_2 + P_3 + ...$

(4) **Ideal gas equation** : PV = nRT

$$M = \frac{dRT}{P}$$

(5) **Charles's Law :** $\frac{V_1}{T_1} = \frac{V_2}{T_2}$ (at constant P and n)

(6). **Avogadro's Law :** V = kn (at constant P and T)

(7). **Partial Pressure in Terms of Mole Fraction :** $P_i = x_i \; P_{total}$

(8). **Boyle's Law :** $P_1 V_1 = P_2 V_2$ (at constant T and n)

(9). Compressibility factor $Z = \frac{PV}{RT}$ (for 1 mole of Gas)

4. THERMODYNAMICS

- **First law of thermodynamics**
  $\Delta U = q + W$

- **Enthalpy of reaction**
  $\Delta H = \sum \Delta_f H^o \text{ (products)} - \sum \Delta_f H^o \text{ (reactants)}$
  By convention heat of formation of every element in its standard state is arbitrarily assumed to be zero.
  $\Delta_{sub} H^o = \Delta_{fus} H^o + \Delta_{vap} H^o$

- **Heat Capacity** Specific heat capacity $c_s = \frac{q}{m\Delta T}$
  $C = \frac{q}{\Delta T}$ molar heat capacity $c_m = \frac{q}{n\Delta T}$

- **Energy changes** $q_v \rightarrow$ heat exchange at constant volume
  $\Delta U = q_v$, $\Delta H = q_p$ $q_p \rightarrow$ heat exchange at constant pressure

- **Enthalpy**
  $H = U + pV$

- **Relation between ΔH and ΔU**
  $\Delta H = \Delta U + p\Delta V$ Or
  $\Delta H = \Delta U + \Delta n_g RT$

- $C_p - C_v = R$

  $\Delta S = \frac{q_{rev}}{T}$

  $\Delta G = \Delta H - T\Delta S$

  $\Delta G^o = -RT \ln K$

Atomicity	γ	Cp	Cv
Monoatomic	5/3	5R/2	3R/2
Diatomic	7/5	7R/2	5R/2
Triatomic non linear	4/3	4R	3R

5. EQUILIBRIUM

(1). $K_w = K_a \times K_b$

(2). $K_i = \frac{[A^+][B^-]}{[AB]}$

(3). $K_{sp} = [A^{y+}]^x \ [B^{-x}]^y$

(4). $\Delta G^o = -2.303 \ RT \log \ K$

(5). $K_a = \frac{[A^-][H_3O^+]}{[HA]}$

$K_b = \frac{[B^-][OH^-]}{[BOH]}$

(6). $K_w = \left[H^+\right]\left[OH^-\right] = 10^{-16}$ at 25^oC

(7). $pH = -\log [H^+]$

(8). $pK_w = pH + pOH = 14$ at 25^oC

(9). $K_p = K_c(RT)^{\Delta n}$

(10). Hydrolysis of salts

(i) For a salt of strong acid and weak base

$$pH = \frac{1}{2}[pK_w - pK_b - \log\ c]$$

(ii) for a salt of weak acid and strong base

$$pH = \frac{1}{2}[pK_w + pK_a + \log\ c]$$

(iii) For salts of weak acid and weak base

$$pH = \frac{1}{2}[pK_w + pK_a - pK_b]$$

(11). Equilibrium constant, $K_{eq} = \frac{K_a}{K_b}$

(12). K_a or $K_b = c\alpha^2$

(13). Concentration quotient, $Q = \frac{[C]^c[D]^d}{[A]^a[B]^b}$

6. SOLID STATE

(1). Density of Cubic Crystal System

$$\rho \text{ (or } d) = \frac{Z \times M}{a^3 \times N_A} g.cm^{-3}$$

Where, Z = number of atoms per unit cell

N_A = Avogadro's Number

M = Gram atomic weight of element (g. mol^{-1})

a = edge − length

(2). Radius-ratio in ionic solids

Voids	**Triangular**	**Tetrahedral**	**Octahedral**	**Cubical**
Radius-ratio	$0.155 \le \frac{r^+}{r^-} < 0.225$	$0.255 \le \frac{r^+}{r^-} < 0.414$	$0.414 \le \frac{r^+}{r^-} < 0.732$	$0.732 \le \frac{r^+}{r^-} < 0.999$

(3).

Crystal	**Radius of atom (r)**	**No. of atoms per unit cell**	**p.f.**
Simple cubic	$\frac{a}{2}$	1	52.4 %
F.C.C.	$\frac{a}{2\sqrt{2}}$	2	74 %
B.C.C	$\frac{\sqrt{3}}{4}a$	2	68 %

(4). Packing Fraction (p.f.) = $\frac{\text{Volume occupied by particles (per unit cell)}}{\text{Volume of unit cell}}$

Contribution of each atom present on the corner = $\frac{1}{8}$

Contribution of each atom present on the centre of face = $\frac{1}{2}$

Contribution of each atom present on the body centre = 1

Contribution of each atom present on the edge centre = $\frac{1}{4}$

(5). Seven crystal system with dimensions :

(a) Cubic : $\alpha = \beta = \gamma = 90^o$, $a = b = c$

(b) Tetragonal : $\alpha = \beta = \gamma = 90^o$, $a = b \neq c$

(c) Orthorhombic : $\alpha = \beta = \gamma = 90^o$; $a \neq b \neq c$

(d) Monoclinic : $\alpha = \gamma = 90^o$; $\beta \neq 90^o$; $a \neq b \neq c$

(e) Hexagonal : $\alpha = \beta = 90^o$; $\gamma = 90^o$; $a = b \neq c$

(f) Rhombohedral or trigonal : $\alpha = \beta = \gamma \neq 90^o$; $a = b = c$

(g) Triclinic : $\alpha \neq \beta \neq \gamma \neq 90^o$; $a \neq b \neq c$

7. SOLUTIONS

(1). **Depression in freezing point**

$\Delta T_f = K_f \times m$

$K_f = \frac{RT_0^2}{1000\, l_{fusion}} = \frac{M_A RT_0^2}{1000\, \Delta H_{fusion}}$

(2) **Dissociation of solute**

$(A)_n \rightarrow nA$

$i = \frac{1 + (n-1)\alpha}{1}$ {α = degree of dissociation}

(3). $P_{sol} = \left.\begin{matrix} P_A^o X_A + P_B^0 X_B \\ (P_B^0 - P_A^0)X_B + P_A^0 \end{matrix}\right\}$ Raoult's law

(4). **Osmotic pressure**

$\pi = CRT$

For isotonic solution, $\pi_1 = \pi_2$

(5) $\frac{1}{P_{sol}} = \frac{Y_A}{P_A^o} + \frac{Y_B}{P_B^o}$

(6). **Relative lowering of vapour pressure**

$\frac{P_A^o - P}{P_A^o} = \chi_B$ $\{\chi_B$ = mole fraction of solute$\}$

(7) $Y_A = \frac{P_A}{P_T}$; $Y_B = \frac{P_B}{P_T}$

Where Y_A and Y_B are mole fractions in vapour phase and $P_A = P_A^o X_A$: $P_B = P_B^o X_B$

(8). **Elevation of boiling point**

$\Delta T_b = K_b \times m$

$K_b = \frac{RT_0^2}{100\ l_{vapour}} = \frac{M_A RT_0^2}{1000\ \Delta H_{vapour}}$

Where, m = molality

M_A = molecular mass of solvent

(9).

Molality (m) = $\frac{\text{Number of moles of solute}}{\text{Weight of solvent (kg)}}$ mole / kg

Molarity (M) = $\frac{\text{Number of moles of solute}}{\text{Volume of solution (L)}}$ mole / L

$$\text{Normality (N)} = \frac{\text{Number of gram equivalent of solute}}{\text{Volume of solution (L)}} \text{ g equiv / L}$$

$$\text{Formality (F)} = \frac{\text{Number of gram formula mass}}{\text{Volume of solution (L)}}$$

(10). **Van't Hoff factor**

$$i = \frac{\text{Experimental colligative property (observed)}}{\text{Calculated (normal) colligative property}}$$

$$\frac{P_A^B - P}{P_A^B} = \frac{(i \times n_B)}{(i \times n_B) + n_A}$$

$$\Delta T_b = i \times K_b \times m$$

$$\Delta T_f = i \times K_f \times m$$

$$\pi = iCRT$$

(11). **Association of Solute**

$$nA \rightarrow (A)_n$$

$$i = \frac{(1 - \alpha) + \frac{\alpha}{n}}{1} \qquad \{\alpha = \text{degree of association}\}$$

(12). **Henry's Law**

$$\rho = K_H.X \begin{cases} p = \text{partial pressure of gas in vapour phase} \\ K_H = \text{Henry's law constant} \\ X = \text{Mole fraction of gas} \end{cases}$$

8. ELECTROCHEMISTRY

(1). **Ohm's law** $\Rightarrow$ $V = RI$

$$R = \rho \frac{\ell}{a}$$

V = Potential difference

R = Resistance

I = Current

ρ = Specific resistance (resistivity)

ℓ = length of conductor

a = cross-section area of conductor

(2). Conductance $G = \frac{1}{R}$

Specific conductance (conductivity) $\kappa = \frac{1}{\rho}$

(3). **Cell constant** $\sigma = \frac{\ell}{a}$

$\kappa = G.\sigma$

(4). **Molar conductance** Λ_M (or ϕ_C) $= \frac{1000 \times \kappa}{C \text{ (or } M)}$ {C = concentration of electrolyte in terms of molarity}

(5). **Equivalent conductance** Λ_M (or A_C) $= \frac{1000 \times \kappa}{C \text{ (or } N)}$ {C = concentration (normality)}

$\Lambda_M = \Lambda_N \times (n - \text{factor})$

$\Lambda_0 = \lim_{C \to 0} \Lambda_C$ {Λ_0 = equivalent conductance at infinite dilution (or zero concentration)}

(6) For weak electrolyte, $\Lambda_C \propto \frac{1}{\sqrt{C}}$

For strong electrolyte, $\Lambda_C = \Lambda_0 - B(C)^{1/2}$ {B = constant}

(7). At infinite dilution, for an electrolyte A_xB_y

$A_xB_y \rightleftharpoons xA^{y+} + yB^{x-}$

$\Lambda^o_{A_xB_y} = x\lambda^o_A + y\lambda^o_B$ {λ^o_A, λ^o_B = equivalent conductance at infinite dilution of cation and anion}

$= x\lambda^o_+ + \lambda^o_-$

$\lambda^o_C = k\mu^o_c$ {μ = ionic mobility, K = 96500 coulomb}

$\mu = \frac{\text{Ionic velocity}}{\text{Potential gradient}}$

(8). For a weak electrolyte, $(CH_3COOH \rightleftharpoons CH_3COO^- + H^+)$

Degree of dissociation, $\alpha = \frac{\Lambda_M}{\Lambda_0}$, $K_{eq} = \frac{C(\Lambda_M / \Lambda_0)^2}{1 - (\Lambda_M / \Lambda_0)}$

(9). For solubility of salt $(AgCl \rightleftharpoons Ag^+ + Cl^-)$

$K_{sp} = \left(\frac{1000\ K}{\Lambda_0}\right)^2$

(10). For a cell reaction in an electrochemical cell,

$Zn + CuSO_4 \rightleftharpoons Cu + ZnSO_4$

Cell representation $\Rightarrow$ $\underset{\text{Anode}(-)}{Zn \mid Zn^{2+}(aq.)} \,||\, \underset{\text{Cathode}(+)}{Cu^{2+}(aq.) \mid Cu}$

(11). For half cell reaction $M \rightarrow M^{n+}(aq.) + ne^-$; $E_{ox} = E_{M/M^-}$

$M^{n+}(aq) + ne^- \rightarrow M$; $E_{red} = E_{M^-/M}$

emf of cell, $E^o_{cell} = E^o_{right} - E^o_{left}$

$= \underset{\text{(R.P.)}}{E^o_{cathode}} - \underset{\text{(R.P)}}{E^o_{anode}}$ {R.P. = Reduction potential}

(12). $\Delta G = -nFE_{cell}$

= - W

$= -\Delta G^{o} + 2.303\ RT\ \log\ Q$

$\Delta G^{o} = -nFE^{o}_{cell}$

$E_{cell} = E^{o}_{cell} - \frac{2.303\ RT}{nF}\ \log\ Q$

$\left[\begin{array}{l} \Delta G = \text{Change in free energy} \\ W = \text{Useful work done} \\ n = \text{Number of electrons exchanged} \\ F = \text{Faraday constant (96500 coulomb)} \\ Q = \text{Reaction quotient} \end{array}\right]$

At room temperature (25°C)

$\Rightarrow$ Nernst's equation $\Rightarrow E_{cell} = E^{o}_{cell} - \frac{0.0591}{n}\ \log\ Q$

(13). For electrode concentration cell, $(Pt,\ \underset{\text{anode}}{H_2(P_1)} \mid H^{+} \mid\mid \underset{\text{cathode}}{H_2(P_2)}, Pt)$

$E_{cell} = \frac{0.0591}{2} \log \frac{P_1}{P_2}$ (P = Pressure)

For electrolyte concentration cell $(Cu \mid \underset{\text{anode}(-)}{Cu^{2+}(C_1)} \mid\mid \underset{\text{cathode}(+)}{Cu^{2+}(C_2)} \mid Cu)$

$E_{cell} = \frac{0.0591}{2} \log \frac{C_2}{C_1}$

For concentration cells, $E^{o}_{cell} = 0$

(14). At equilibrium, $E_{cell} = 0$ (as $\Delta G = 0$)

(15). Temperature coefficient (T.C.) = $\left(\frac{\partial}{\partial T} E_{cell}\right)_P$

Change in entropy, $\Delta S = +nF \times (T.C.)$ {ΔH = heat of cell-reaction}

$E_{cell} = \left(\frac{-\Delta H}{nF}\right) + T.(T.C.)$

$T.C. > 0 \Rightarrow$ Cell-reaction is endothermic and vice-versa.

(16). Faraday's 1st law of electrolysis

m = Zit

m = mass of substance deposited

Z = electrochemical equivalent

i = current

t = time

$$Z = \frac{\text{Atomic mass}}{n \times F}$$

Faraday's 2nd law of electrolysis

$$\frac{m_1}{m_2} = \frac{E_1}{E_2}$$ (E = equivalent weight)

(17). Oxidation potential for half-cell reaction : $M \rightarrow M^{+n} + ne^-$

$$E_{ox} = E^o_{ox} - \frac{2.303}{nF} \log [M^{n+}]$$

Reduction potential for half-cell reaction : $M^{n+} + ne^- \rightarrow M$

$$E_{red} = E^o_{red} + \frac{2.303\ RT}{nF} \log[M^{n+}]$$

9. CHEMICAL KINETICS AND NUCLEAR CHEMISTRY

(1). For a general chemical transformation

$nA + mB \rightarrow pC + qD$

$$\text{Rate} = \frac{-1}{n}\frac{d[A]}{dt} = \frac{-1}{m}\frac{d[B]}{dt} = +\frac{1}{p}\frac{d[C]}{dt} = \frac{1}{q}\frac{d[D]}{dt}$$

(2). For elementary chemical reaction

$mA + nB \longrightarrow products$

Theoretical rate $= \frac{dx}{dt} = k[A]^{rm} \times [B]^{n}$

(3). For a general reaction ; $aA + bB \longrightarrow Products$

$\text{Rate} = \frac{dx}{dt} = k[A]^{m} \times [B]^{n}$

Order of reaction w.r.t. A = m overall order of reaction = (m + n)

Order of reaction w.r.t. B = n

(4). Unit of rate constant = $(\text{mole})^{1-n}\ (\text{litre})^{n-1}\ \text{time}^{-1}$

Where, n = order of reaction

(5) For a zero order reaction ; $A \longrightarrow B$

$\text{Rate} = \frac{-d[A]}{dt} = k[A]^{B} = k\ (constant)$

$$\boxed{K = \frac{[A_0] - [A]}{K}}$$

(6). For a first order reaction ; $A \longrightarrow B$

$\text{Rate} = \frac{-d[A]}{dt} = k[A]$

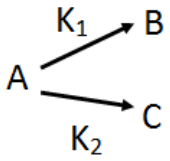
$k = \frac{2.303}{t} \log_{10} \frac{[A]_0}{[A]_1} = \frac{2.303}{t} \log_{10} \left(\frac{a}{a-x} \right)$

(7). For a zero order reaction, $t_{1/2} = \frac{[A]_0}{2k}$

For a first order reaction, $t_{1/2} = \frac{0.693}{k}$

For an n^{th} order reaction, $t_{1/2} \propto \frac{1}{[A]_0^{n-1}}$ (for $n \geq 2$)

(8). For a parallel reaction



$$\frac{-d[A]}{dt} = (k_1 + k_2)[A]$$

(9). For a first order reaction : $A \longrightarrow B + C$, a reagent reacts with all A, B and C

$$k = \frac{2.303}{t}\log_{10}\left(\frac{V_\infty - V_0}{V_\infty - V_t}\right)$$ {V = vol. of reagent}

(10). Temperature coefficient = $\frac{k_{T+10^oC}}{k_T}$

Arrhenius equation, $k = Ae^{-E_a/RT}$

$$\log_{10}\frac{k_2}{k_1} = \frac{E_a}{(2.303\ R)}\left(\frac{T_2 - T_1}{T_2 T_1}\right)$$

$$\log_{10} k = \log_{10} A - \frac{E_0}{2.303RT}$$

$\begin{cases} A = \text{Arrhenius's constant} \\ E_a = \text{Activation energy} \end{cases}$

$$\log_{10}\ k = \log_{10} A - \frac{E_0}{2.303\ RT}$$

(12). Binding energy, $B.E. = \Delta m \times 931.5$ MeV

Δm = mass defect = calculated At. Mass – observed At. Mass

B.E. per nucleon $= \frac{\text{B.E. (total)}}{\text{mass number}}$

$1\ \text{MeV} = 9.6 \times 10^{10}$ Joule mol^{-1}

(13). Packing fraction. P.F. $= \frac{\text{Isotopic atomic mass-mass no.}}{\text{mass numer}} \times 10^6$

(14). In a radioactive decay, $N_t = N_0 e^{-\lambda t}$

Amount of radioactive substance after 'n' half-life periods

$$N = \left(\frac{1}{2}\right)^n N_0$$

(15). Activity, $A_t = A_0 e^{-\lambda t}$, $A = \lambda N$

10. SURFACE CHEMISTRY

(1). **Freundlich Adsorption isotherm**

$$\left(\frac{x}{m}\right) = Kp^{\left(\frac{1}{m}\right)} \; ; \; n \geq 1$$

(2). **Langmuir Adsorption isotherm**

$$\theta = \frac{K'P_A}{1 + KP_A}$$

Or, $\frac{x}{m} = \frac{aP}{1+bP}$ or $\frac{m}{x} = \frac{1}{aP} + \frac{b}{a}$

(3) $\frac{x}{m} = KC^{\left(\frac{1}{n}\right)}$; C = Concentration of solute in solution.

(4). Zeta potential, $Z = \frac{4\pi\eta\mu}{D}$

11. HYDROGEN

(1) At. Wt. of $H = \frac{\% \ {}^{1}_{1}H \times 1 + \% \ {}^{2}_{1}H \times 2 + \% \ {}^{3}_{1}H \times 3}{100}$

(2) Vapour density of a gas = $\frac{\text{molar mass of gas}}{\text{molar mass of } H_2}$

LHS and RHS both are unitless

(3). Molecular wt. = $2 \times (\text{V.D.})$

(4). Vol. Strength of H_2O_2 = Molarity $\times$ 11.2

= Normality $\times$ 5.6

12. S-BLOCK ELEMENTS

(1) General Electronic Configuration ns^{1-2}.

(2) Atomic Radii increases down the group.

(3) Hydration enthalpy decreases down the group.

(4). Ionization enthalpy decreases down the group.

(5). On reaction with oxygen give oxide, peroxide and superoxides.

(6) On reaction with water produces hydroxide and hydrogen.

(7). Some important compounds and their general names.

Name	Chemical Formula	Prepared by
Caustic Soda	NaOH	Electrolysis in costner kellner cell
Washing Soda	Na_2CO_3, $10H_2O$	Solvay's process
Baking Soda	$NaHCO_3$	Solvay's process
Glauber's Salt	Na_2SO_4, $10H_2O$	$NaCl + H_2SO_4$
Microcosmic salt	$Na(NH_4)HPO_4$	$NH_4Cl + Na_2HPO_4$

Potash or Pearl Ash	K_2CO_3	Leblanc Process
Caustic potash	KOH	Electrolysis of KCl
Quick lime	CaO	Decomposition of $CaCO_3$
Slaked lime	$Ca(OH)_2$	Hydrolysis of CaO
Gypsum	$CaSO_4$, $2H_2O$	$CaCl_2 + H_2SO_4$
Plaster of Paris	$CaSO_4$, ½ H_2O	By heating gypsum

13. P-BLOCK ELEMENTS

(1). In general metallic character, electropositive character, atomic radii, basic character, reducing character decreases on moving left to right in a period and increases down the group.

(2). Some important compound of p-block elements

i.	Borax (Tincal)	$Na_2B_4O_7, 10H_2O$
ii.	Colomonite	$Ca_2B_6O_{11}, 5H_2O$
iii.	Kemite	$Na_2B_4O_7, 4H_2O$
iv.	Sassolite or boric acid	H_3BO_3
v.	Diborane	B_2H_6
vi.	Borazole	$B_3N_3H_6$
vii.	Alumina	Al_2O_3
viii.	Lithium aluminium hydride	$LiAlH_4$
ix.	Potash Alum	$K_2SO_4, Al_2(SO_4)_3, 24\ H_2O$

14. COORDINATION COMPOUND

(1). Magnetic moment, $\mu = \sqrt{n(n+2)}\,B.M$

(2) $\Delta_0(CFSE) = \left[\left(-4 \times n_{\substack{e^- \\ (t_{2g})}}\right) + \left(+6 \times n_{\substack{e^- \\ (e_g)}}\right)\right] Dq$

(3). $\Delta_t(CFSE) = \left[\left(+4 \times n_{\substack{e^- \\ (t_{2g})}}\right) + \left(-6 \times n_{\substack{e^- \\ (e_g)}}\right)\right] Dq$

(4). $\Delta_t = \frac{4}{9}\Delta_0$

(5). For the reaction : $M + 4L \rightleftharpoons ML_4$, overall stability constant of complex (ML_4) is $\beta_4 = \frac{[ML_4]}{[M][L]^4}$

(6). $\underset{\text{(of metal atom/ion)}}{\text{EAN}} = Z - O.N. + 2(C.N.)$

15. ORGANIC CHEMISTRY

Relations for the estimation of elements in organic compounds.

$$\%\ \text{of C} = \frac{12}{44} \times \frac{\text{Mass of } CO_2 \text{ formed}}{\text{Mass of the compound}} \times 100$$

$$\%\ \text{of H} = \frac{2}{18} \times \frac{\text{Mass of } H_2O \text{ formed}}{\text{Mass of the compound}} \times 100$$

$$\underset{\text{(Dumas's method)}}{\%\ \text{of N}} = \frac{28}{22400} \times \frac{\text{Volume of } N_2 \text{ at NTP}}{\text{Mass of compound}} \times 100$$

$$\underset{\text{(kjeldahl's method)}}{\%\ \text{of N}} = \frac{1.4 \times \text{Normality of acid used} \times \text{Volume of acid used}}{\text{Mass of the compound}}$$

$$\% \text{ of } X(\text{Halogens}) = \frac{\text{At. mass of } X}{(108 + \text{At. mass of } X)} \times \frac{\text{Mass of AgX formed}}{\text{Mass of the compound}} \times 100$$

$$\% \text{ of } S = \frac{32}{233} \times \frac{\text{Mass of } BaSO_4 \text{ formed}}{\text{Mass of the compound}} \times 100$$

$$\% \text{ of } P = \frac{62}{222} \times \frac{\text{Mass of } Mg_2P_2O_2 \text{ formed}}{\text{Mass of the compound}} \times 100$$

(1). Inductive effect

(+I effect) $CH_3 < C_2H_5 < C_3H_7 < R_2CH < R_3C < -\dot{O}-R$

(-I effect) $R_4N > NO_2 > -CN > SO_3H > COOH > -F > Cl > 1 > -OR > -OH > -NH_2 > -C_6H_5$

(2). Relative basic strength in aqueous medium.

$R = CH_3$	$2^o > 1^o > 3^o > NH_3$
$R = C_2H_5$	$2^o > 3^o > 1^o > NH_3$
Me_2CH^-	$1^o > NH_3 > 2^o > 3^o$
M_2C	$NH_3 > 1^o > 2^o > 3^o$

(3). Stability of free radical

$$\underset{3^o}{Me_3\dot{C}} > \underset{2^o}{Me_2\dot{C}H} > \underset{1^o}{Me\dot{C}H_2} > \underset{1^o}{\dot{M}e}$$

(4) Heat of hydrogenation of alkenes

1-butene > cis-2-butene > trans-2-butene

(5). Leaving nature in Nucleophilic substitution reaction

$$ArSO_3^- > ROSO_2^- > CH_3COO^- > CN^- > O^-H > MeO^- > H^- > R^-$$

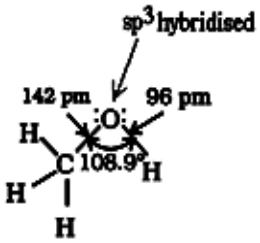
(6). Number of product formed during crossed aldol condensation

S. No.	Carbonyl compound (I)	Carbonyl compound (II)	Self Condensation Product	Cross Condensation Product	Total Product
1.	One type of similar α H-atom	One type of similar α H-atoms	2	2	4

	$CH_3 - \underset{\|}{\overset{O}{C}} - H$	$CH_3 - CH_2 - CHO$			
2.	Two different types of dissimilar α H-atoms $CH_3 - COCH_2CH_3$	One type of similar α H-atoms $CH_3 - CH_2 - CHO$	3	3	6
3	Two different types of dissimilar α H-atoms $CH_3CO - CH_2 - CH_3$	Two different types of dissimilar α H-atoms $PhCH_2 - CO - CH_2 - CH_3$	4	4	8

16. ALCOHOLS, PHENOLS AND ETHERS

Structure of Alcohols :

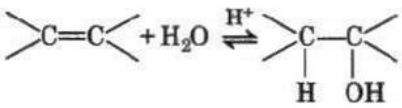


Methanol
(Alcohol)

Preparation of Alcohols

(i) From alkenes

(a) By acid catalysed hydration in accordance with Markownikoff's rule.



(b) By hydroboration-oxidation

$$CH_3 - CH = CH_2 + (H - BH_2)_2 \xrightarrow{B_2H_6, H_2O_2/OH^-} CH_3CH_2CH_2OH + B(OH)_3$$

(ii) From carbonyl compounds

(a) By reduction of aldehydes and ketones

$$R - CHO + H_2 \xrightarrow{Pd} RCH_2 - OH$$

$$RCOR' \xrightarrow{NaBH_4} R - \underset{\underset{OH}{|}}{CH} - R'$$

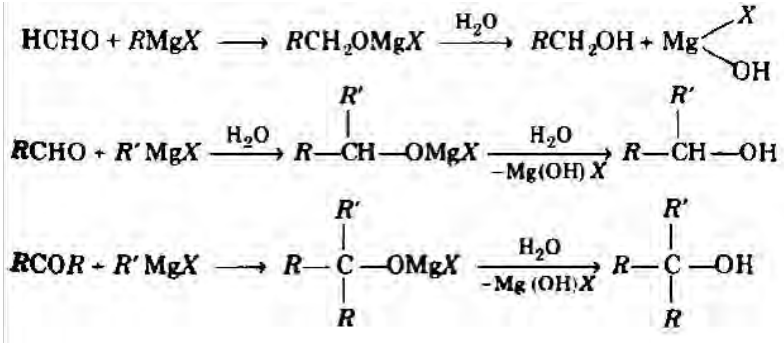
(b) By reduction of carboxylic acids and ester

$$RCOOH \xrightarrow[(ii)\ H_2O]{(i)\ LiAlH_4} RCH_2OH$$

$$RCOOR' \xrightarrow[Catalyst]{H_2} RCH_2OH + R'OH$$

Reduction of aldehyde, ketones and esters with No alcohol is called Bouveault-blanc reduction.

Reaction of carbonyl compound with Grignard Reagent.



(iv) Hydrolysis of alkyl halides

$$R - X + KOH_{(aq)} \rightarrow ROH + KX$$

Ease of hydrolysis of alkyl halides RI > RBr > RCl > and $3^o > 2^o > 1^o$ alkyl halides.

(v) Hydrolysis of ethers

$$R - \ddot{O} - R + H_2O \xrightarrow{H_2SO_4} 2ROH$$

(vi) From primary amines by treatment with nitrous acid

$$RNH_2 + HONO \xrightarrow{(NaNO_2 + HCl)} ROH + N_2 + H_2O$$

Methylamine does not give methyl alcohol when treated with HNO_2. It gives CH_3OCH_3 and CH_3ONO.

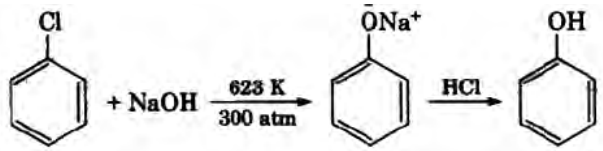
(vii) By alcoholic fermentation

$$\underset{\text{sucrose}}{C_{12}H_{22}O_{11}} + H_2O \xrightarrow{\text{Invertase}} \underset{\text{glucose}}{C_6H_{12}O_6} + \underset{\text{fructose}}{C_6H_{12}O_6}$$

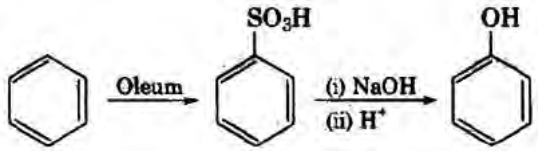
$$\underset{\text{glucose and fructose}}{C_6H_{12}O_6} \xrightarrow{\text{Zymase}} \underset{\text{ethyl alcohol}}{2C_2H_5OH} + 2CO_{2(g)}$$

Preparation of Phenols

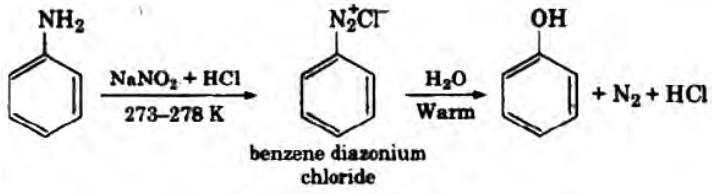
(i) From haloarenes



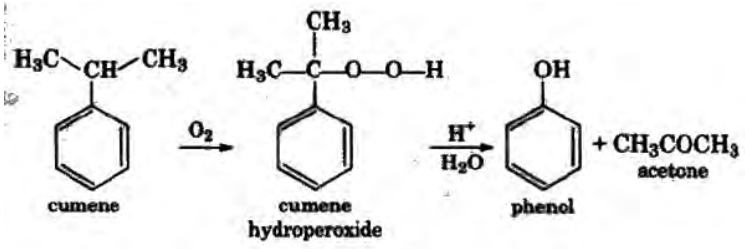
(ii) From benzene sulphonic acid



(iii) From diazonium salts



(iv) From cumene



Chemical properties of alcohols :

1. Reaction involving cleavage of O-H bond :

Alcohols react as nucleophiles :

(a) Reaction with metals

$$2R-O-H+2Na \rightarrow \underset{\text{Sodium alkoxide}}{2R-O-Na}+H_2$$

(b) Esterification reaction

$$\underset{\text{Alcohol}}{RO-H}+R'-COOH \overset{H^+}{\Leftrightarrow} ROCOR'+H_2O$$

$$\underset{\text{Alcohol}}{RO-H}+(R'CO_2)O \overset{H^+}{\Leftrightarrow} ROCOR'+R'COOH$$

$$\underset{\text{Alcohol}}{RO-H}+R'COCl \xrightarrow{\text{Pyridine}} R-OCOR'+HCl$$

(b) Reaction with phosphorus halides

$$ROH+PCl_5 \longrightarrow RCl+POCl_3+HCl$$

$$3ROH+PBr_3 \xrightarrow{P/Br_2} 3RBr+H_3PO_3$$

$$3ROH+PI_3 \xrightarrow{P/I_2} 3RI+H_3PO_3$$

(c) Reaction with thionyl chloride

$$ROH+SOCl_2 \longrightarrow RCl+SO_2\uparrow+HCl\uparrow$$

(c) Dehydration reaction

$$\text{Alcohol} \xrightarrow[\text{Or}\\\text{Catalysis (anhyd. } ZnCl_2 \text{ or alumina)}]{\text{Protic acids (conc. } H_2SO_4 \text{ or } H_3PO_4)} C=C+H_2O$$

(d) Oxidation reaction

$$\text{Alcohol} \xrightarrow{\text{Acidified potassium permanganate}} \text{Carboxylic acid}$$

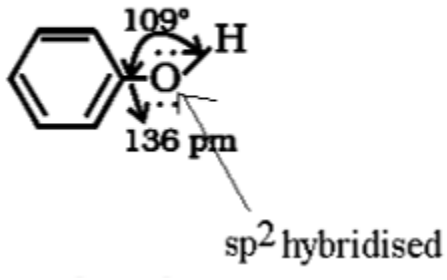
(i) Primary Alchol $\xrightarrow[\text{Or}\\CrO_3\\\text{Or}\\\text{PCC}]{\text{Cu, 573k}}$ Aldehyde

(ii) Secondary Alcohol $\xrightarrow[\text{Or}\\CrO_3]{\text{Cu, 573k}}$ Ketone

(iii) Tertiary Alcohol $\xrightarrow[\text{Or}\\KMnO_4]{\text{Cu, 573k}}$ Alkene

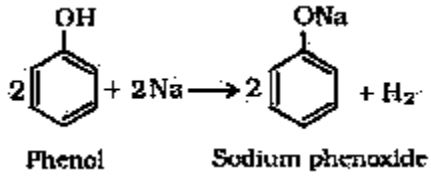
Phenols

Structure of Phenols :



Chemical properties of phenols :

(a) Reaction with metals



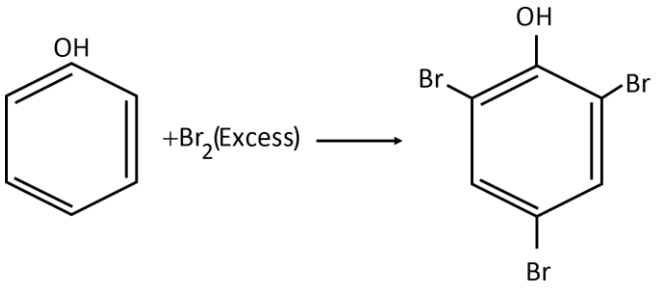
(b) Esterification reaction

$$\underset{\text{Phenol}}{Ar-OH} + R'-COOH \overset{H^+}{\Leftrightarrow} Ar-OCOR' + H_2O$$

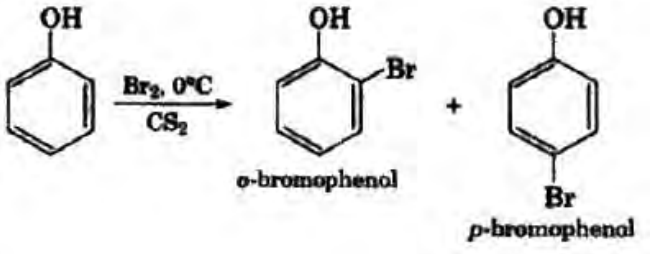
$$\underset{\text{Phenol}}{Ar-OH} + (R'CO)_2O \overset{H^+}{\Leftrightarrow} Ar-OCOR' + R'COOH$$

$$\underset{\text{Phenol}}{Ar-OH} + R'COCl \xrightarrow{\text{Pyridine}} ArOCOR' + HCl$$

(a) Halogenation



2,4,6–tribromophenol



o-bromophenol

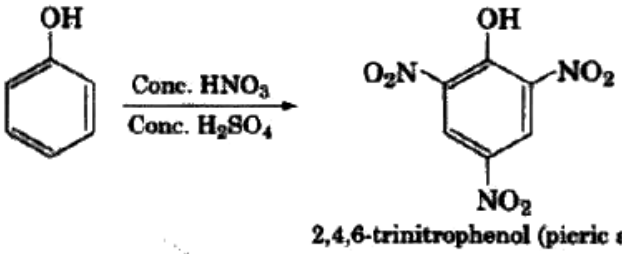
p-bromophenol

(b) Sulphonation

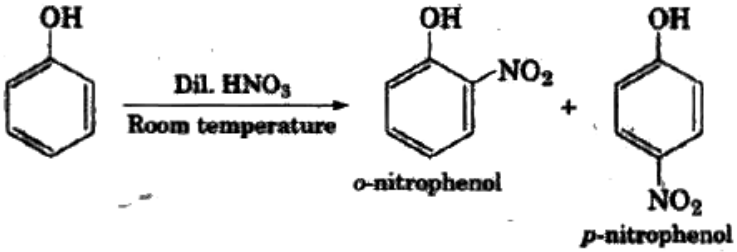
o-hydroxybenzene sulphonic acid

p-hydroxybenzene sulphonic acid

(c) Nitration



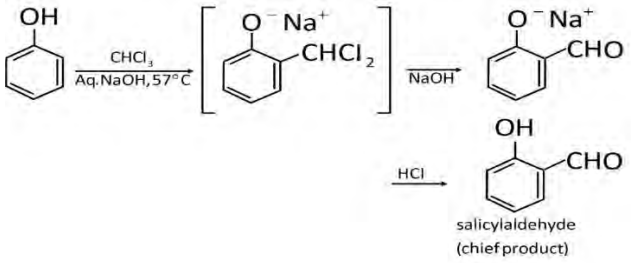
2,4,6-trinitrophenol (picric acid)

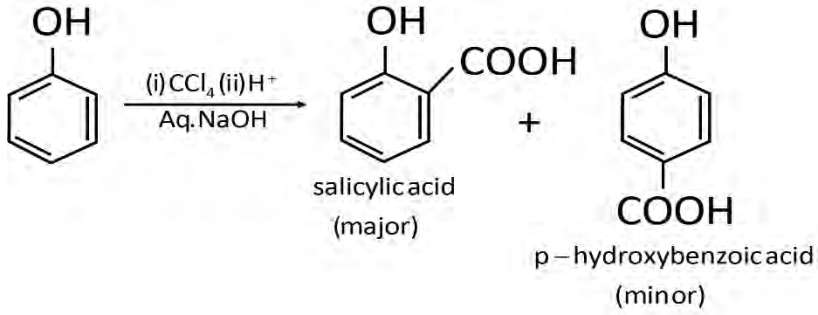


o-nitrophenol

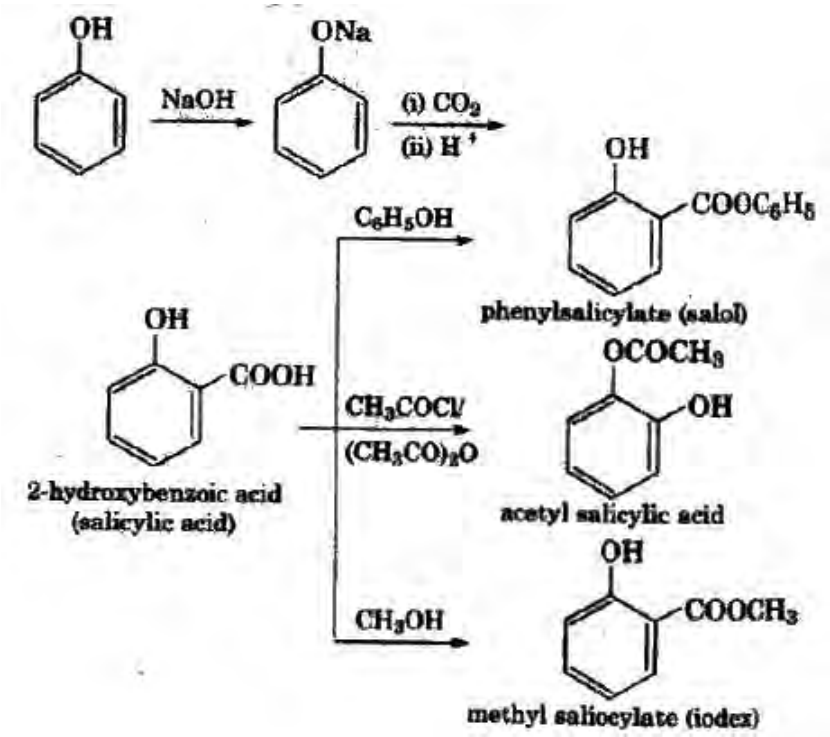
p-nitrophenol

(d) Reimer-Tiemann reaction

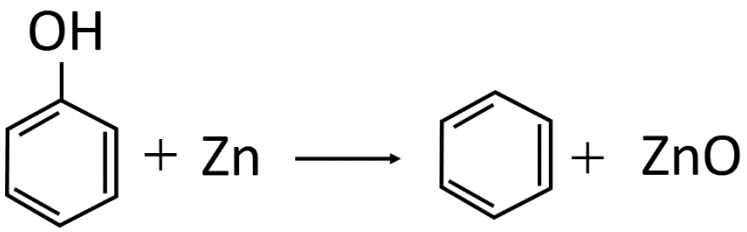




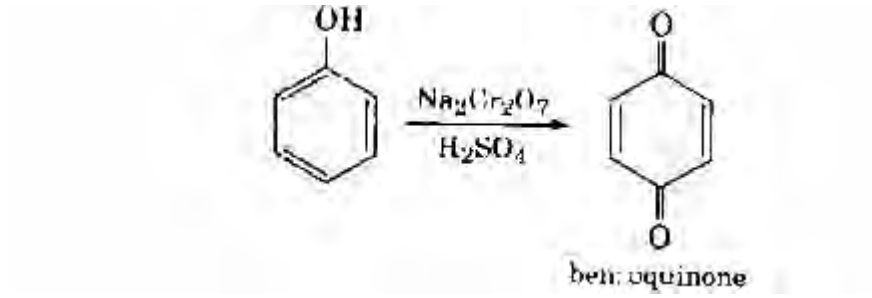
(ii) Kolbe's reaction



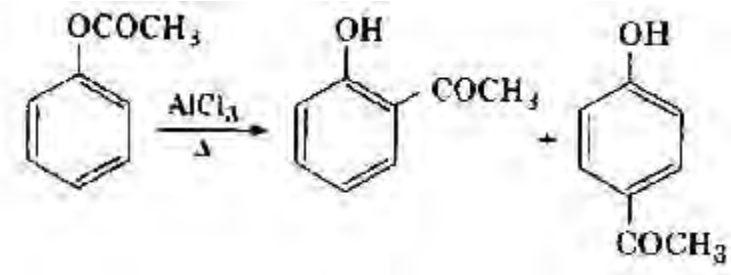
iii) Reaction with zinc dust



(iv) Oxidation

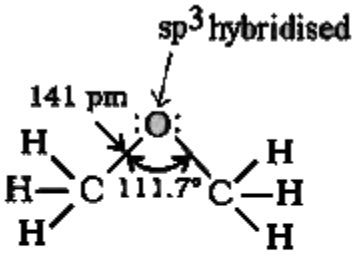


(v) Fries rearrangement



Ethers

Structure of Ethers



Methoxymethane
(Ether)

Preparation of Ethers

(i) By dehydration of alcohols

$$\underset{\text{excess}}{2CH_3CH_2-OH} \xrightarrow[418K]{H_2SO_4\,(conc.)} CH_3-CH_2-\ddot{O}-CH_2-CH_3 + H_2O$$

Williamson's Synthesis Only primary alkyl halides when react with sodium alkoxide give ether while tertiary alkyl halides give alkene due to steric hindrance.

$$CH_3CH_2Br + CH_3CH_2ONa \longrightarrow CH_3CH_2OCH_2CH_3 + NaBr$$

Chemical Reactions of Ether

$$R-O-R' + HX \longrightarrow RX + R'OR$$

The order of reactivity of hydrogen halides is as follows

HI > HBr > HCl

(ii) Halogenation

$$CH_3CH_2OCH_2CH_3 \xrightarrow[Dark]{Cl_2} \underset{(\alpha-\text{monochloro diethyl ether})}{CH_3CHClOCH_2CH_3}$$

$$\underset{(excess)}{C_2H_5OC_2H_5} + 10Cl_2 \xrightarrow[(light)]{h\nu} \underset{(perchlorodiethyl\ ether)}{C_2Cl_5OC_2Cl_5} + 10HCl$$

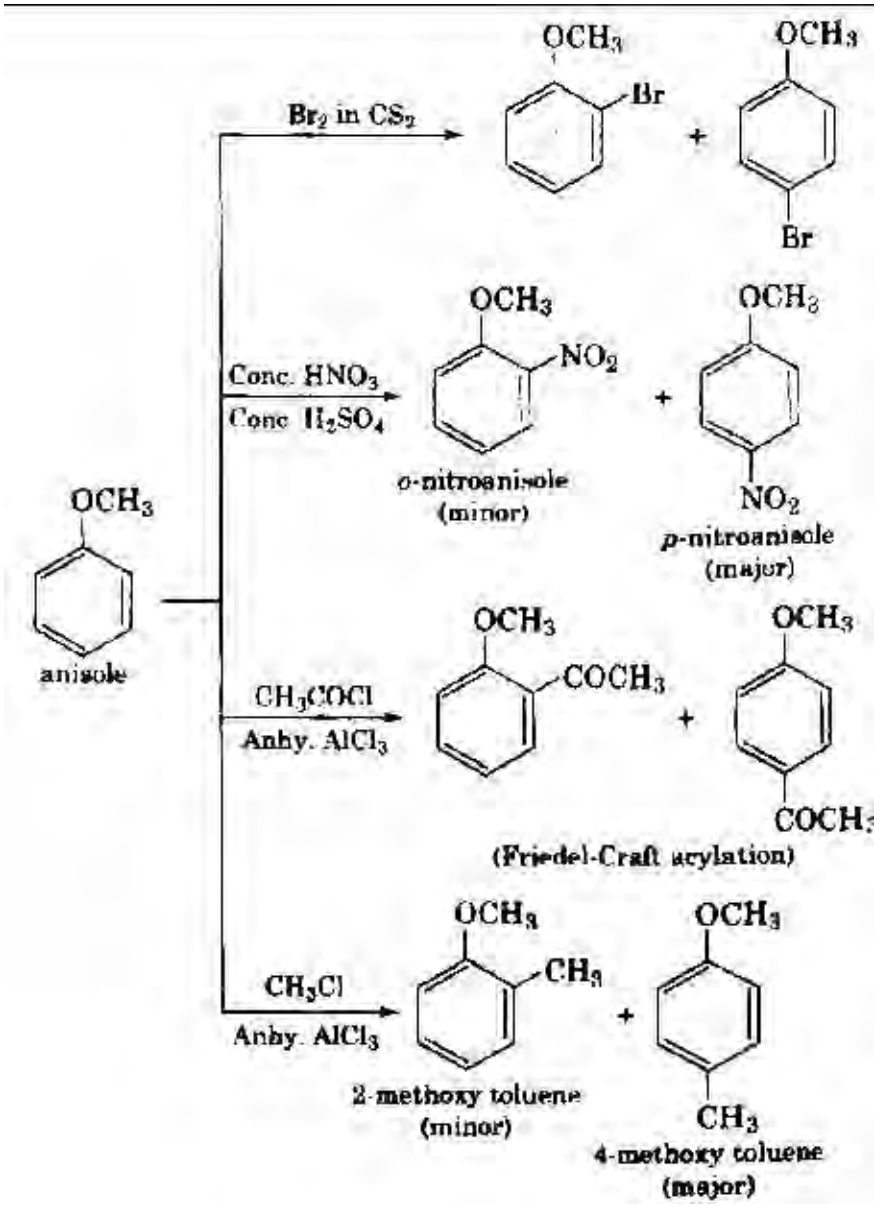
(iii) Reaction with PCl_5

$$R-O-R + PCl_5 \xrightarrow{\Delta} 2RCl + POCl_3$$

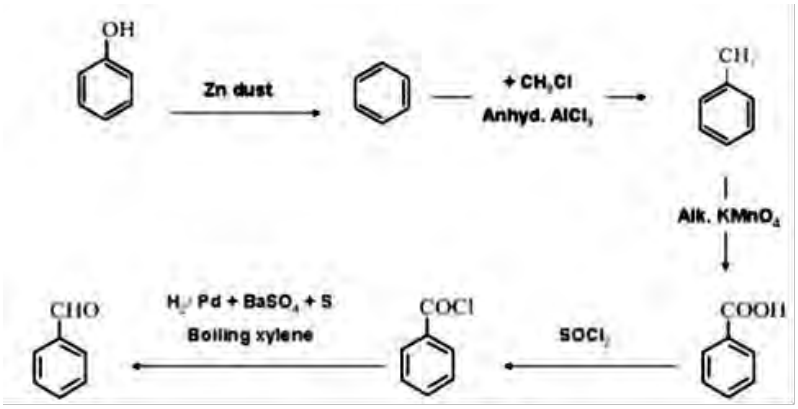
(iv) Reaction with CO

$$ROR + CO \xrightarrow[500\ atm]{BF_3/150^oC} RCOOR$$

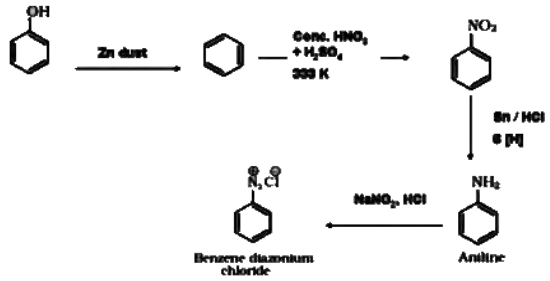
Electrophilic Substitution reactions



- Other conversion reactions :
  (a) Phenol to salicylaldehyde



(b) Phenol to benzene diazonium chloride



Differentiate between organic compounds :

(a) Alcohols and phenols

Phenol on reaction with neutral $FeCl_3$ gives purple colour whereas alcohols do not give purple colour.

$$6C_6H_5OH + Fe^{3+} \longrightarrow \underset{\text{Purple colour}}{[Fe(OC_6H_5)_6]^{3-}} + 6H^+$$

(b) Primary, secondary and tertiary alcohols

Lucas reagent test :

$$ROH + HCl \xrightarrow{\text{conc. } HCl + ZnCl_2 \text{ /lucas reagent}} RCl + H_2O$$

If it is a primary alcohol, no turbidity appears at room temperature. Turbidity appears only on heating. If it is a secondary alcohol, turbidity appears in 5 minutes. If it is a tertiary alcohol, turbidity appears immediately.

(c) Methanol and ethanol

Iodoform test : Ethanol when reacted with (I_2 and NaOH) or NaOI gives yellow ppt of iodoform since it has the presence of CH_3-CH (OH)-group.

$$C_2H_5OH + 4I_2 + 6NaOH \rightarrow \underset{\text{Yellow ppt}}{CHI_3} + 5NaI + 5H_2O + HCOONa$$

$$CH_3OH + I_2 + NaOH \rightarrow \text{No yellow ppt}$$

17. ALDEHYDES, KETONES AND CARBOXYLIC ACIDS

Preparation of Aldehydes and Ketones

(i) By oxidation of alcohols

Aldehydes and ketones are generally prepared by oxidation of primary and secondary alcohols, respectively.

$$RCH_2OH \xrightarrow{CrO_3} RCHO$$

$$R-\underset{\underset{OH}{|}}{CH}-R' \xrightarrow{CrO_3} R-\underset{\underset{O}{||}}{C}-R'$$

By dehydrogenation of alcohols

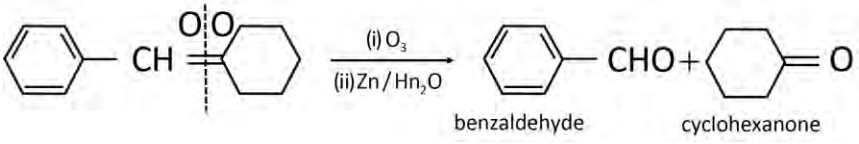
Primary and secondary alcohols give aldehydes and ketones, respectively.

$$R-CH_2-OH \xrightarrow[573\ K]{Cu} RCHO$$

$$R-\underset{\underset{OH}{|}}{CH}-R' \xrightarrow[573\ K]{Cu} R-\underset{\underset{O}{||}}{C}-R'$$

(iii) By ozonolysis of alkenes

$$R-CH=CH-R \xrightarrow[(ii)Zn/Hn_2O]{(i)O_3} 2RCHO$$



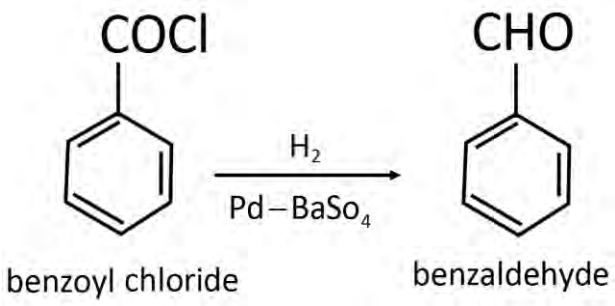
(iv) By hydration of alkynes

$$\underset{\text{acetylene}}{CH\equiv CH} + H_2O \xrightarrow[H_2SO_4]{HgSO_4} \underset{\text{acetaldehyde}}{CH_3-CHO}$$

$$R-C\equiv CH + H_2O \xrightarrow[H_2SO_4]{HgSO_4} \underset{\text{ketone}}{R-CO-CH_3}$$

Preparation of Aldehydes

(i) Rosenmund reduction



Formaldehyde cannot be prepared by this method as HCOCl is highly unstable.

(ii) From nitriles

$$RCN + SnCl_2 + HCl \longrightarrow RCH = NH \xrightarrow{H_3O^+} RCHO$$

This reaction is called **Stephen reaction.**

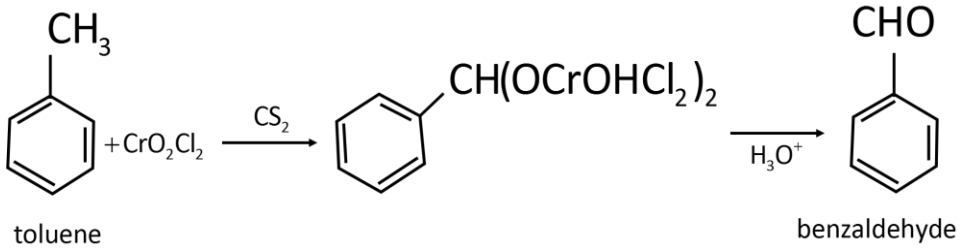
Alternatively, nitriles are selectively reduced by diisobutylaluminium hydride, [DiBAL-H] to imines which on hydrolysis give aldehydes.

$$RCN \xrightarrow[(ii)\ H_2O]{(i)\ AlH(iBu)_2} RCHO$$

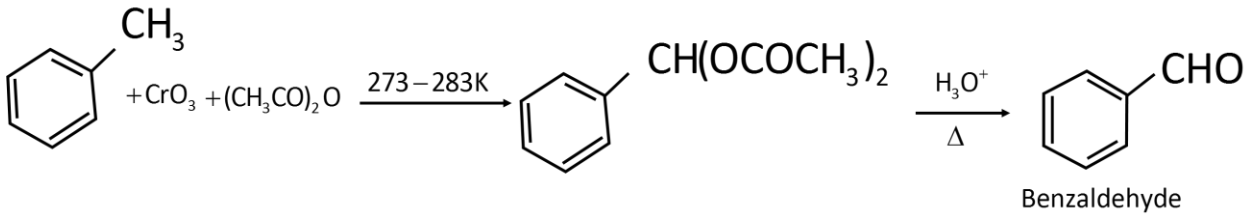
Similarly, esters can also be reduced to aldehydes with DiBAL-H.

$$CH_3(CH_2)_3 - COOC_2H_5 \xrightarrow[(ii)\ H_2O]{(i)\ DiBAL-H} CH_3(CH_2)_3 - CHO$$

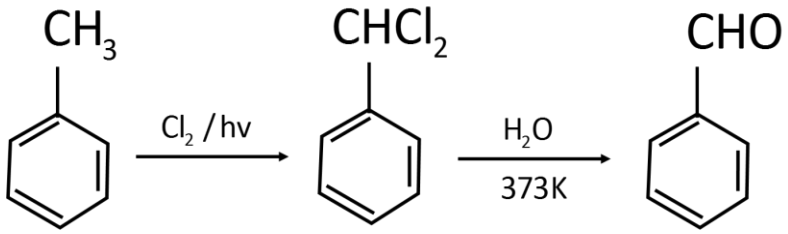
(iii) Etard reaction



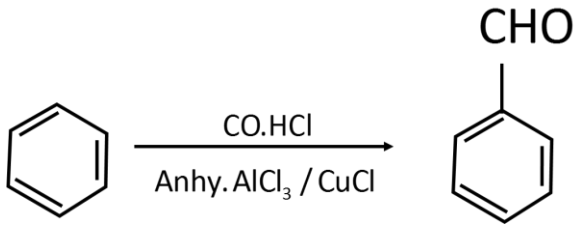
Using chromium oxide (CrO_3) : Toluene or substituted toluene is converted to benzaldehyde in presence of chromic oxide in acetic anhydride.



(iv) Side chain halogenation is followed by hydrolysis of toluene

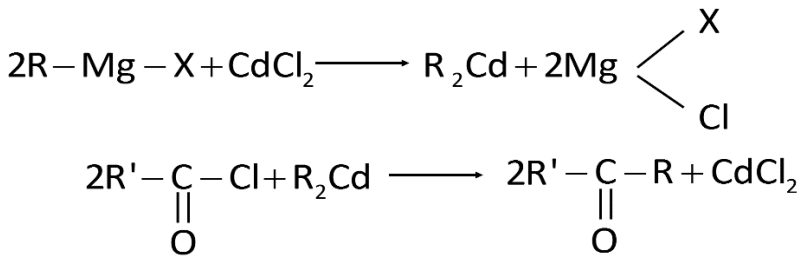


(v) Gattermann-Koch synthesis

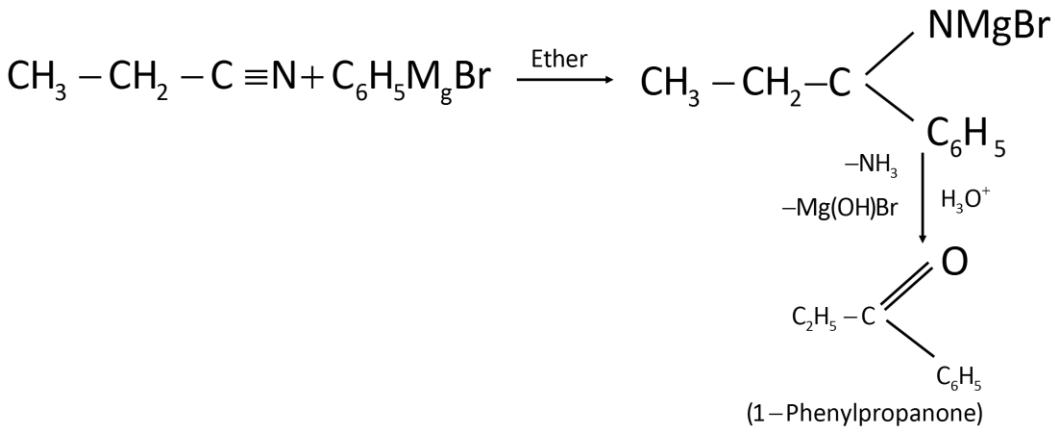


Preparation of Ketones

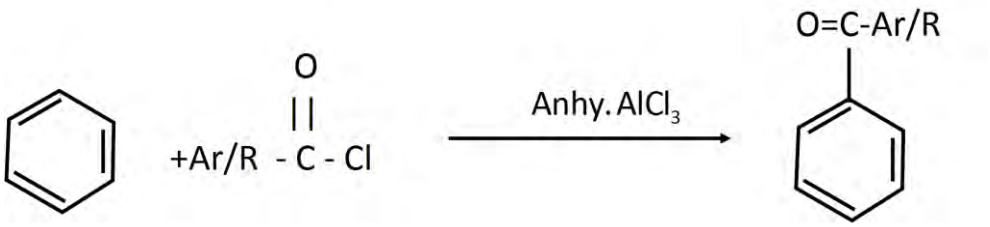
(i) From acyl chlorides



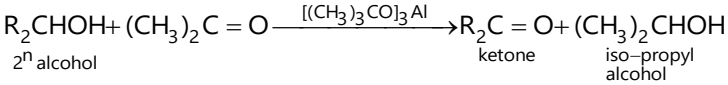
(ii) From nitriles



(iii) Friedel-Crafts acylation

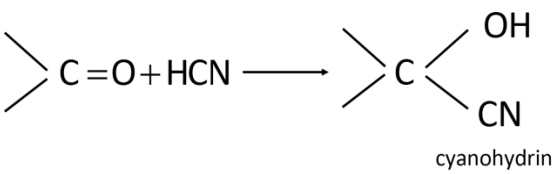


(iv) Oppenauer oxidation

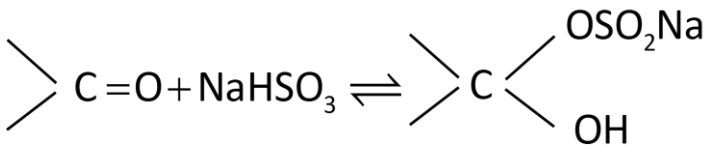


Chemical Reactions of Aldehydes and Ketones

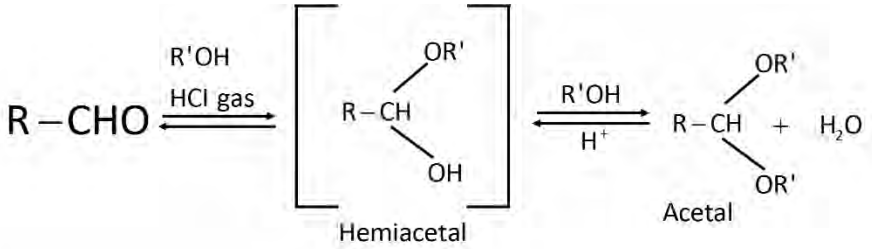
(i) Addition of hydrogen cyanide

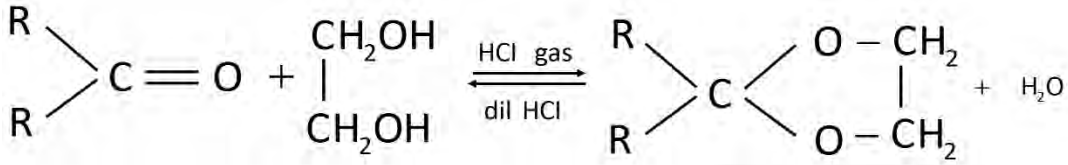


(ii) Addition of sodium hydrogen sulphite



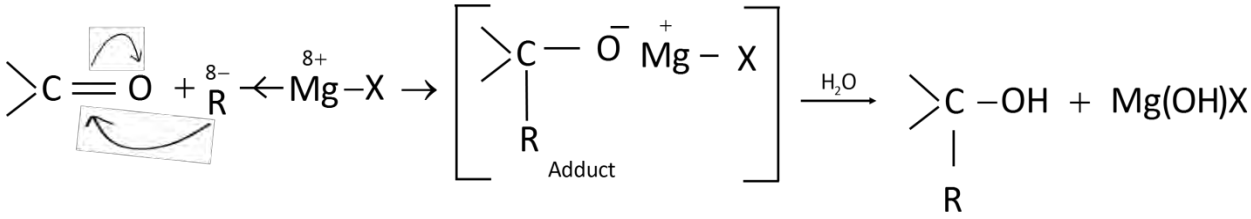
white crystalline solid



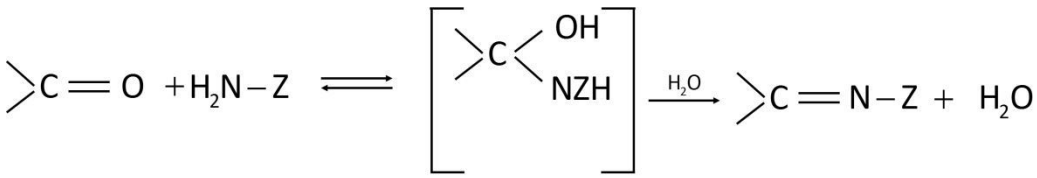


Ethylene glycol ketal

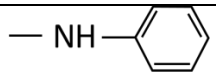
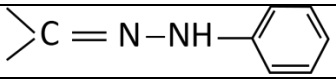
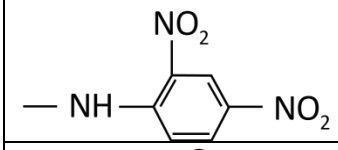
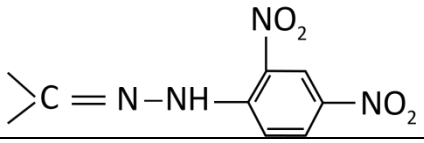
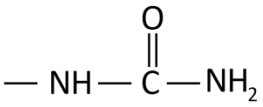
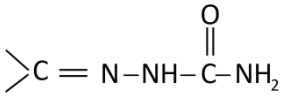
(iii) Addition of Grignard reagent (RMgX) to form alcohol



(iv) Addition of ammonia and its derivatives

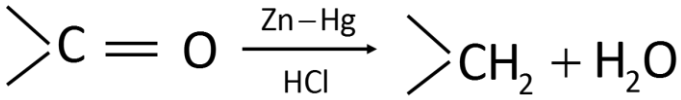


Z = Alkyl, aryl, OH, NH_2, C_6H_5NH, $NHCONH_2$, etc

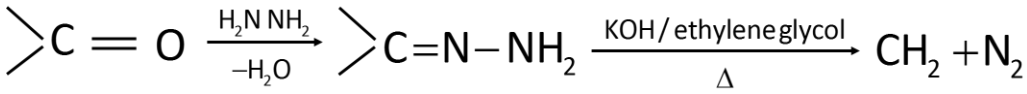
Z	Reagent name	Carbonyl derivative	Product Name
-R	Amine	$-C=NR$ |	Substituted imine (Schiff's base)
-OH	Hydroxyl amine	$-C=N-OH$ |	Oxime
$-NH_2$	Hydrazine	$-C=N-NH_2$ |	Hydrazone
	Phenyl-hydrazine		Phenylhydrazone
	**2, 4-** dinitrophenyl hydrazine		2, 4-dinitrophenyl hydrazone
	Semi-carbazide		Semi-carbazone

Reduction

(1). Clemmensen reduction

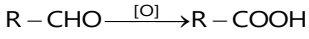


(2). Wolff-Kishner reduction

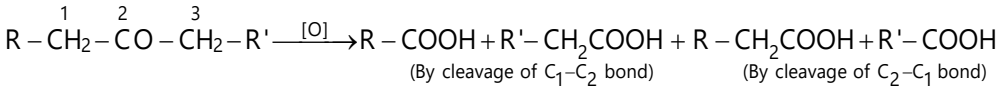


(3). Oxidation

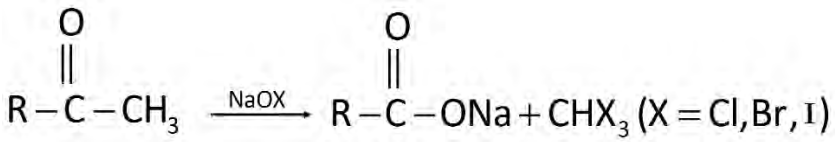
(i) Aldehydes are oxidized to acids in presence of mild oxidizing agents HNO_3, $K_2Cr_2O_7$, $KMnO_4$



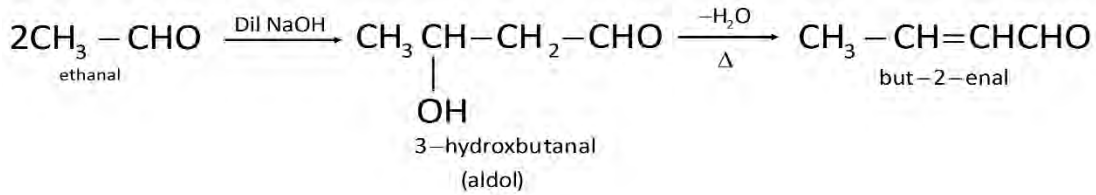
(ii) Ketones are oxidized under drastic conditions i.e. with powerful oxidizing agents like HNO_3, $K_2Cr_2O_7 / H_2SO_4$, $KMnO_4 / H_2SO_4$ at higher temperature.

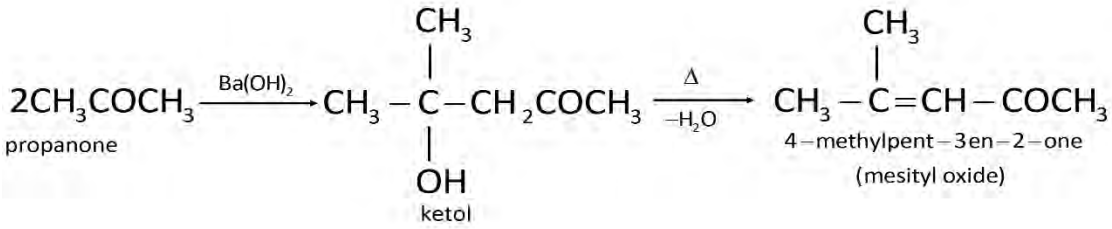


(iii) Haloform reaction :



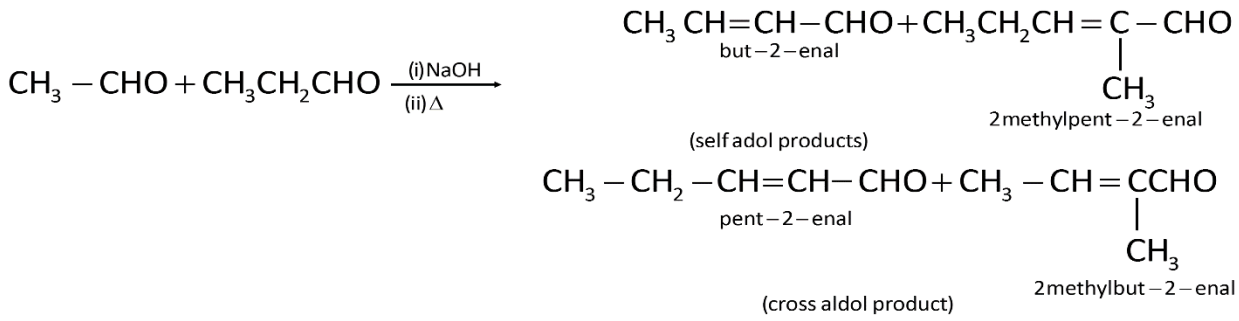
(v) Aldol condensation



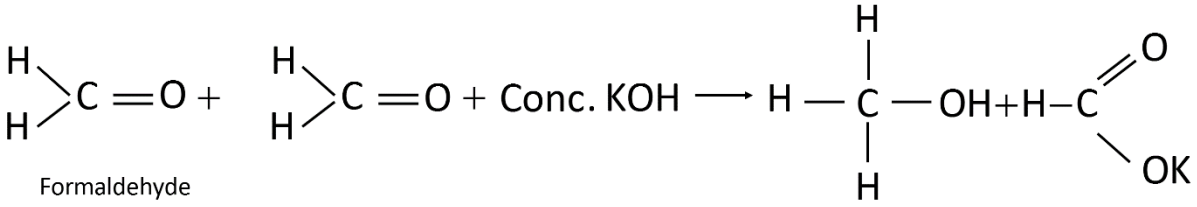


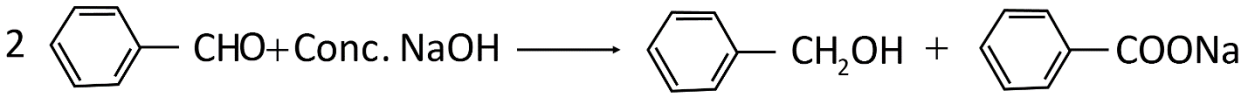
Cross aldol condensation

Base catalysed crossed aldol condensation between an aromatic aldehyde and an aliphatic aldehyde or ketone is called **Claisen-Schmidt condensation or Claisen reaction**.



Cannizzaro reaction





Test to distinguish aldehydes and ketones :

(1) Tollen's test : When an aldehyde is heated with Tollen's reagent it forms silver mirror.

Tollen's reagent is ammoniacal solution of $AgNO_3$

$$RCHO + 2[Ag(NH_3)_2]^+ + 3OH^- \longrightarrow RCOO^- + 2Ag + 2H_2O + 4NH_3$$

Ketones do not form silver mirror and hence do not give this test.

(2) Fehling's test : When an aldehyde is heated with Fehling's reagent it forms reddish brown precipitates of cuprous oxide.

Fehling's reagent : Fehling solution A (aqueous solution of $CuSO_4$) + Fehling solution B (alkaline solution of sodium potassium tartarate)

$$R-CHO + 2Cu^{2+} + 5OH^- \rightarrow RCOO^- + \underset{\text{Red–Brown ppt}}{Cu_2O} + 3H_2O$$

Ketones do not give this test.

Carboxylic Acids

Methods of Preparation of carboxylic Acids

From primary alcohols and aldehydes

(a) $RCH_2OH \xrightarrow{\text{alkaline } KMnO_4/H_3O^+} RCOOH$

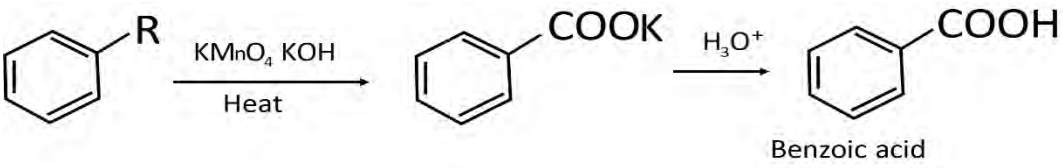
(b) $RCH_2OH \xrightarrow{CrO_3-H_2SO_4} RCOOH$

From aldehydes

(a) $RCHOH + 2[Ag(NH_3)_2]^+ + 3OH^- \rightarrow RCOO^- + 2Ag + 2H_2O + 4N$

(b) $R - CHO + 2Cu^{2+} + 5OH^- \rightarrow RCOO^- + Cu_2O + 3H_2O$

From alkyl benzenes



From acid derivatives

All acid derivatives like amides ($RCONH_2$), acid halides (RCOCl), esters (RCOOR'), acid anhydrides (RCO-O-COR) on hydrolysis give carboxylic acids. All acid derivatives break from RCO^+.

$$RCOZ \xrightarrow[\text{or dil. NaOH}]{\text{Dil. HCl}} RCOOH$$

$Z = -NH_2, -X(X = Cl, Br, I), OR', RCOO - etc.$

Ease of hydrolysis : $RCOCl > (RCO)_2O > RCOOR' > RCONH_2$

From nitriles and amides

$$R - CN \xrightarrow{H^+ \text{ or } OH^-/H_2O} R - \underset{\underset{O}{\|}}{C} - NH_2 \xrightarrow{H^+ \text{ or } OH^-/\Delta} RCOOH$$

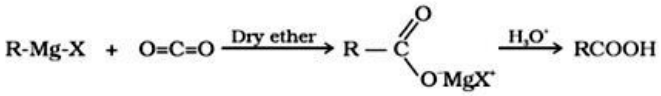
From alkenes

Suitably substituted alkenes are oxidized to carboxylic acids on oxidation with acidic potassium permanganate or acidic potassium dichromate.

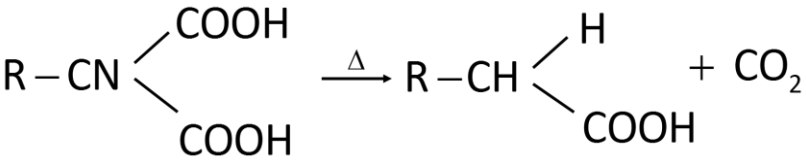
(a) $R - CH = CH - R \xrightarrow{KMnO_4/H^+} 2R - COOH$

(b) $R - CH = CH - R_1 \xrightarrow{KMnO_4/H^+} R - COOH + R_1 - COOH$

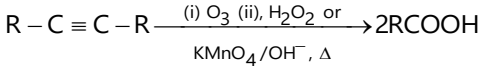
From Grignard reagents



By heating germinal dicarboxylic acids

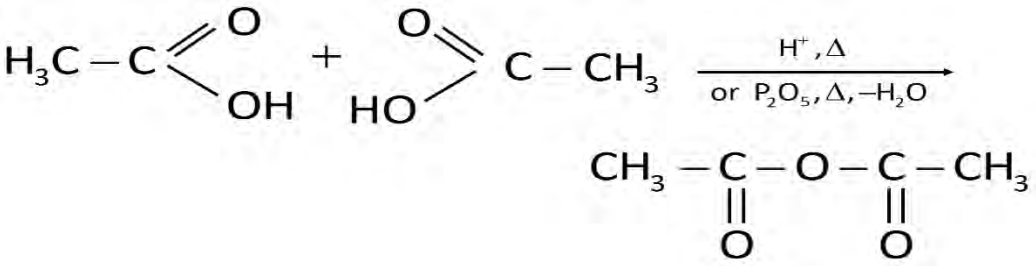


From alkynes

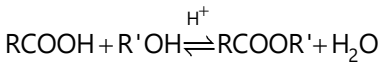


Reactions of Carboxylic acids

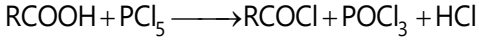
Formation of anhydride

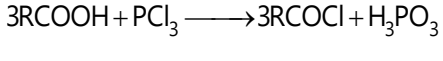


Esterification



Reactions with PCl_5, PCl_3 **and** $SOCl_2$





Reaction with ammonia (NH_3)

Carboxylic acids react with ammonia to give ammonium salt which on further heating at high temperature gives amides.

(a) $CH_3COOH + NH_3 \Leftrightarrow \underset{\text{Ammonium acetate}}{CH_3COO^-NH_4^+} \xrightarrow{\Delta/-H_2O} \underset{\text{Acetamide}}{CH_3CONH_2}$

(b)

Chemical reactions involving – COOH group

(a) Reduction

$$RCOOH \xrightarrow[\text{or } B_2H_6 \text{ (ii) } H_3O^+]{\text{(i) } LiAlH_4 \text{ /ether}} R - CH_2 - OH$$

(b) Decarboxylation

$$RCOONa \xrightarrow[\Delta]{NaOH,\ CaO\ (Ratio\ 3:1)} R - H + Na_2CO_3$$

Substitution reactions in the hydrocarbon part

Hell-Volhard-Zelinsky reaction

$$R - CH_2 - COOH \xrightarrow{X_2/Red\ Phosphorus/H_2O} \underset{\substack{| \\ X \\ X = Cl,\ Br \\ \alpha\text{–Halocarboxylic acid}}}{R - CH - COOH}$$

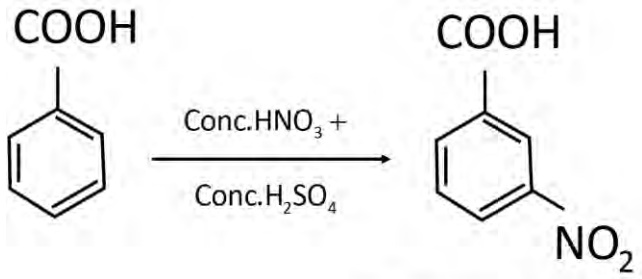
Arndt-Eistert reaction

$$RCOOH \xrightarrow{PCl_5} RCOCl \xrightarrow{CH_2N_2} \underset{\text{diazo ketone}}{RCOCHN_2} \xrightarrow{HOH} RCH_2COOH$$

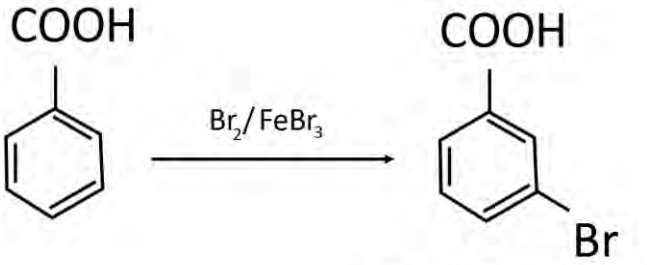
Reducing property

$$HCOOH + HgCl_2 \rightarrow Hg + 2HCl + CO_2$$

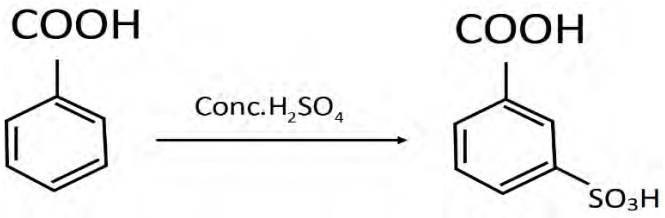
Electrophilic substitution reactions of aromatic acids



m – Nitrobenzoic acid



m – Bromobenzoic acid



3-sulphonic benzoic acid

18. AMINES

Methods of Preparation of Amines

(i) By reduction of nitro compounds :

Nitro compounds can be catalytically reduced by passing hydrogen gas in presence of Raney Ni, finely divided Pt or Pd as catalyst at room temperature.

(a) $R-NO_2 + 3H_2 \xrightarrow{\text{Ni, Pt or pd}} R-NH_2 + 2H_2O$

(b) $Ar-NO_2+3H_2 \xrightarrow{\text{Ni, Pt or pd}} Ar-NH_2+2H_2O$

Nitro compounds can also be reduced with active metals such as Fe, Sn, Zn etc. with conc. HCl.

(a) $R-NO_2+3H_2 \xrightarrow{\text{Sn/HCl or Fe/HCl}} R-NH_2+2H_2O$

(b) $Ar-NO_2+3H_2 \xrightarrow{\text{Sn/HCl or Fe/HCl}} Ar-NH_2+2H_2O$

(ii) By Hoffmann's method (Ammonolysis of alkyl halides):

$$\underset{(1^O)}{RNH_2} \xrightarrow{RX} \underset{(2^O)}{R_2NH} \xrightarrow{RX} \underset{(3^O)}{R_3N} \xrightarrow{RX} \underset{\text{Quaternary ammonium salt}}{R_4\overset{+}{N}X^-}$$

- The free amine can be obtained from the ammonium salt by treatment with a strong base :

(a) $NH_3+RX \rightarrow RNH_3^+X^- \xrightarrow{NaOH} \underset{(1^O \text{ amine})}{RNH_2}+H_2O+Na^+X^-$

(b) $RNH_2+RX \rightarrow R_2NH_2^+X^- \xrightarrow{NaOH} \underset{(2^O \text{ amine})}{R_2NH}+H_2O+Na^+X^-$

(c) $R_2NH+RX \rightarrow R_3NH^+X^- \xrightarrow{NaOH} \underset{(3^O \text{ amine})}{R_3N}+H_2O+Na^+X^-$

- Order of reactivity of halides is : RI > RBr > RCl

(iii) By reduction of nitriles :

Nitriles can be reduced to amines using H_2/Ni, $LiAlH_4$ or Na(Hg)/C_2H_5OH

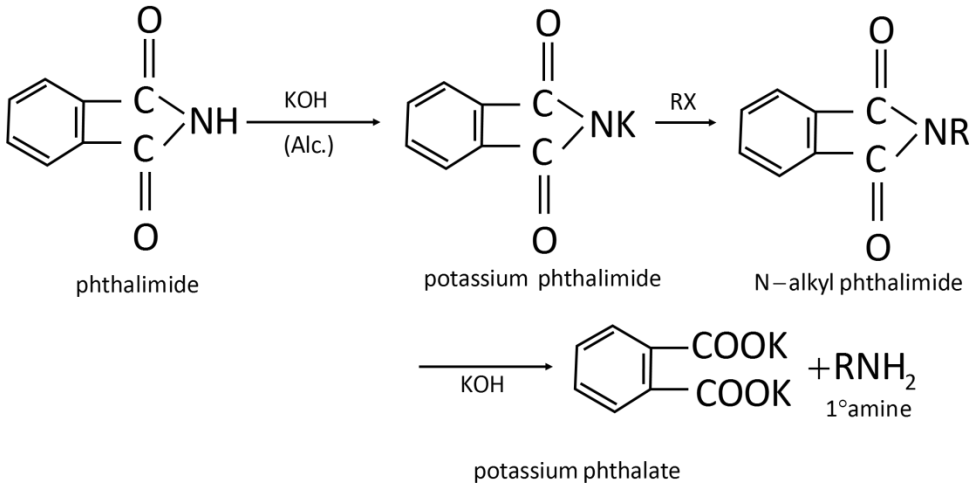
$$R-C\equiv N \xrightarrow[\text{Or Na(Hg)/}C_2H_5OH \text{ Or } LiAlH_4]{H_2/Ni} R-CH_2-NH_2$$

(iv) By reduction of amides :

Amides are reduced to corresponding amines by $LiAlH_4$

$$R-\underset{\|}{\overset{O}{C}}-NH_2 \xrightarrow{LiAlH_4/H_2O} R-CH_2-NH_2$$

(v) Gabriel's phthalimide reaction

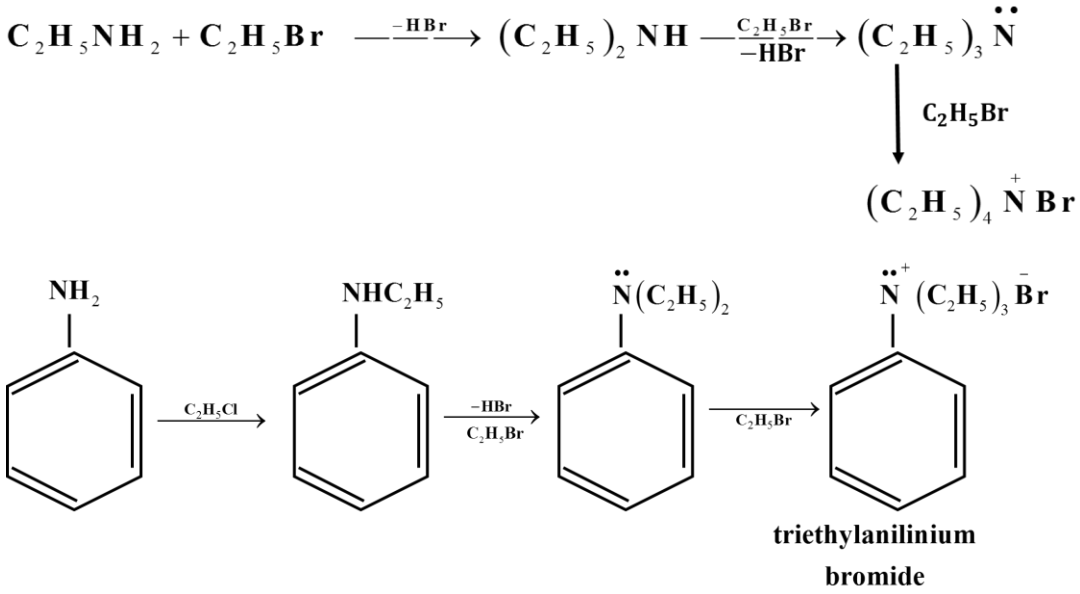


(vi) Hofmann bromamide degradation reaction

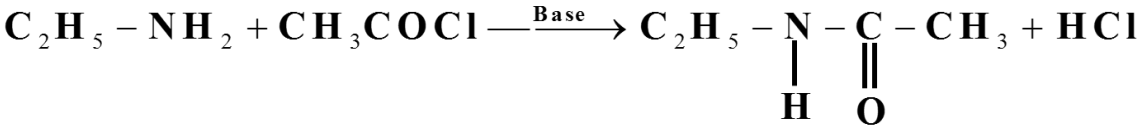
$$R-CO-NH_2+Br_2+4NaOH\longrightarrow RNH_2+Na_2CO_3+2NaBr+2H_2O$$

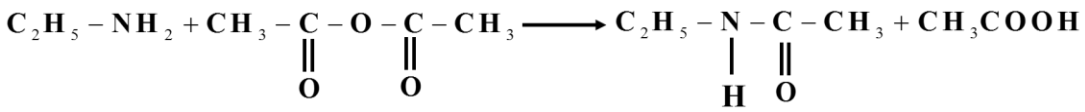
Reactions of Amines

(i) Alkylation



(ii) Acylation





(iii) Benzoylation

$$CH_3NH_2 + C_6H_5COCl \xrightarrow{\text{Pyridine}} CH_3NHCOC_6H_5 + HCl$$

Benzoylation of aniline is known as Schotten Baumann reaction.

(iv) Carbylamine reaction [only by 1° amines]

$$R-NH_2 + CHCl_3 + 3KOH \xrightarrow{\text{Heat}} \underset{\substack{\text{isocyanide}\\(\text{a bad smalling compound})}}{R-N\equiv C} + 3KCl + 3H_2O$$

Methyl isocyanate gas $(CH_3-N=C=O)$ was responsible for Bhopal gas tragedy in December 1984.

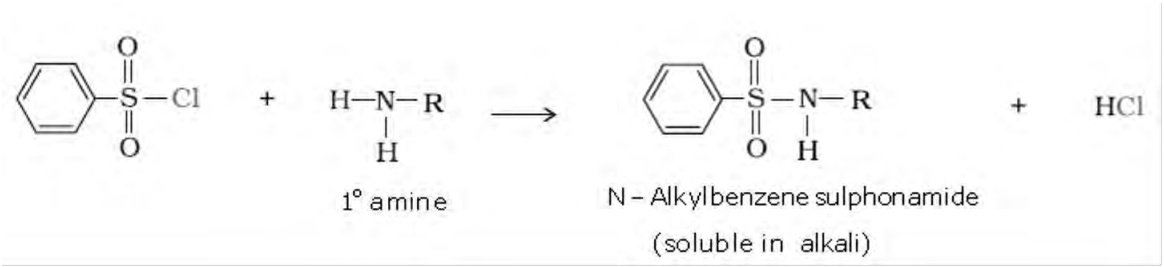
(v) Reaction with nitrous acid

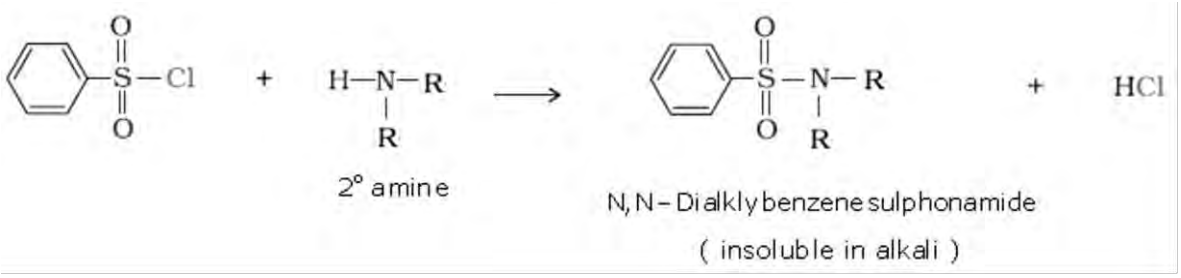
$$RNH_2 + HNO_2 \xrightarrow{NaNO_2+HCl} [RN_2^+Cl] \xrightarrow{H_2O} ROH + N_2 + HCl$$

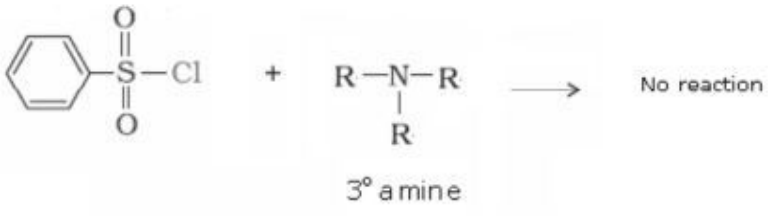
Quantitative evolution of nitrogen is used in estimation of amino acids and proteins.

$$C_6H_6-NH_2 \xrightarrow[273-278\ K]{NaNO_2+2HCl} C_6H_5N_2^+Cl^- + NaCl + 2H_2O$$

Reaction with aryl sulphonyl chloride [Hinsberg reagent]





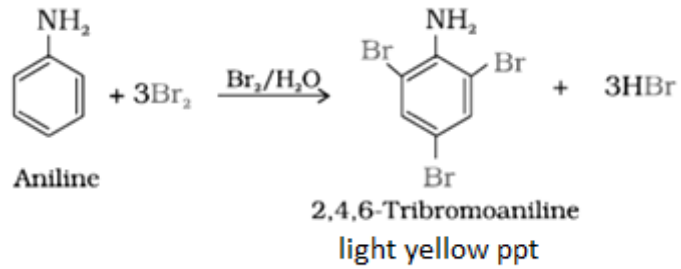


Reaction with aldehydes

Schiff base is obtained.

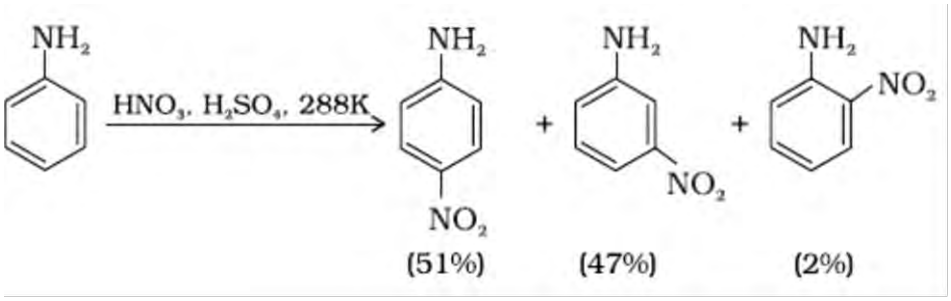
$$C_6H_5NH_2 + \underset{\text{benzaldehyde}}{OHCC_6H_5} \xrightarrow[-H_2O]{ZnCl_2,\ \Delta} \underset{\substack{\text{benzylidene aniline}\\ \text{(Schiff base)}}}{C_6H_5N=CHC_6H_5}$$

Electrophilic substitution reactions



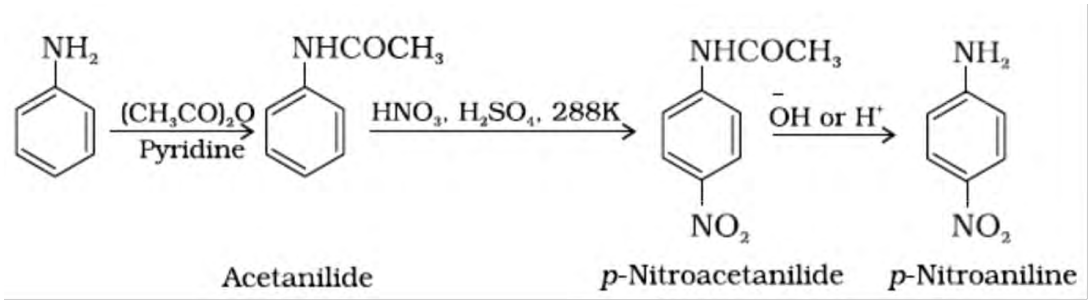
Nitration

(a) Under strongly acidic medium aniline gets protonated to form anilinium ion, which is deactivating group and is meta directing. Hence m-nitroaniline is also formed in 47 % along with ortho and para products.

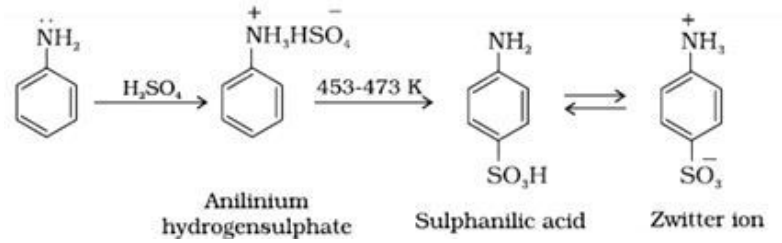


Aromatic amines cannot be nitrated directly because HNO_3 being a strong oxidizing agent oxidizes it forming black mass.

(b) Nitration by protecting the $-NH_2$ group by acetylation reaction with acetic anhydride :



(c) Sulphonation On sulphonation, aniline gives sulphanilic acid, as the major product.



Oxidation

Oxidising agent	**Product**
Acidified $KMnO_4$ (or $Na_2Cr_2O_7 + CuSO_4 +$ dill acid)	Aniline back (a dye)
Chromic acid $(Na_2Cr_2O_7 + \text{Conc } H_2SO_4)$	p-benzaquinone
Caro's acid (H_2SO_5)	Nitrobenzene and nitrosobenzene
Conc. Nitric acid	decomposes

Benzene Diazonium Chloride $(C_6H_5N_2^+ ; Cl^-)$

Preparation (Diazotisation reaction)

$$C_6H_5NH_2 + NaNO_2 + 2HCl \xrightarrow{273-278\ K} C_6H_5N = N - Cl + NaCl + 2H_2O$$

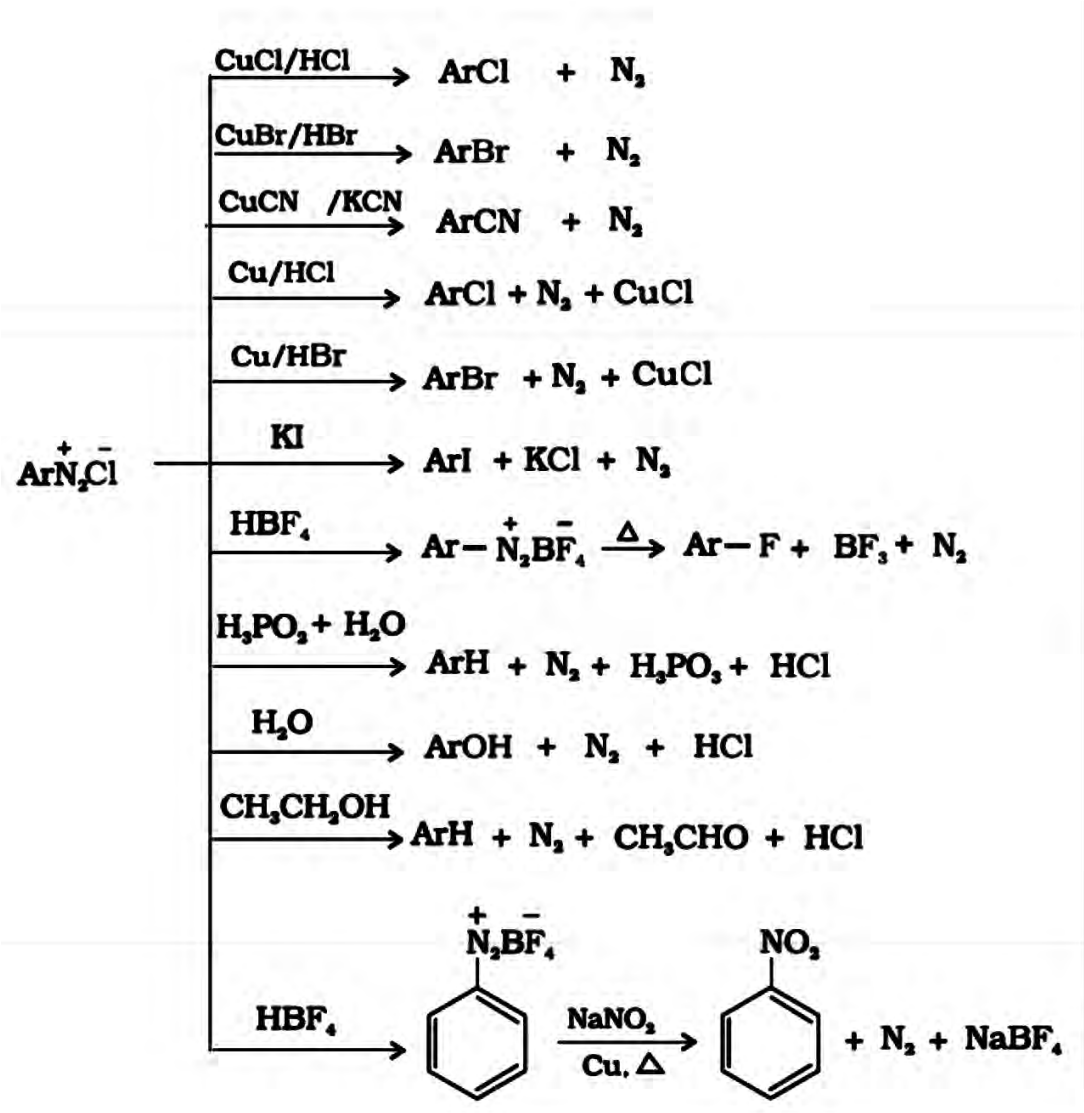
Chemical reactions

$$C_6H_5N_2^+Cl^- \xrightarrow{Cu^+,\,H_3PO_2/H_2O} C_6H_6 + N_2\uparrow + H_3PO_3 + HCl$$

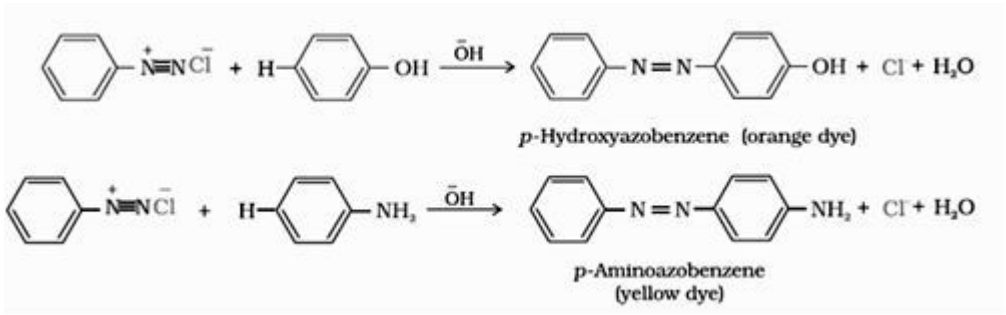
$$C_6H_5N_2^+Cl^- \xrightarrow{CH_3CH_2OH} C_6H_6 + N_2 + HCl + CH_3CHO \quad (\text{Deamination})$$

$$C_6H_5N_2^+Cl^- \xrightarrow{CuBr/HBr} C_6H_6Br + N_2 \quad (\text{bromobenzene})$$

(a) Reactions involving displacement of nitrogen :



Azo coupling reactions



Alkyl Cyanides

Methods of Preparation

(i) From alkyl halides

$$RX + KCN_{(alc)} \xrightarrow{100^{o}C} \underset{(major)}{RCN} + RNC$$

(ii) From acid amides

$$RCONH_2 \xrightarrow[-H_2O]{P_2O_5\,\Delta} RC \equiv N$$

Reactions of Alkyl Cyanides

(i) Hydrolysis

$$RCN \xrightarrow[\substack{\text{Alk } H_2O_2\\ \text{(partiial hydrolysis)}}]{H_2O} \underset{\text{amide}}{RCONH_2} \xrightarrow[H^+]{H_2O} \underset{\text{carboxylic acid}}{RCOOH} + NH_3$$

(ii) Reduction

$$RCN + 4[H] \xrightarrow{Na+C_2H_5OH} RCH_2NH_2$$

$$RCN + 4[H] \xrightarrow{LiAlH_4} RCH_2NH_2$$ **(Mendius reduction)**

$$RCN \xrightarrow{SnCl_2/HCl} \underset{\text{imine hydrochloride}}{RCH=NH\cdot HCl} \xrightarrow{H_2O} \underset{\text{aldehyde}}{RCHO} + NH_4Cl$$

(iii) Reaction with Grignard reagent

$$RCN + R'MgX \xrightarrow{Ether} \underset{\substack{|\\ MgX}}{\overset{\overset{R'}{|}}{R-C=N}} \xrightarrow{2H_2O} \underset{O}{\overset{\overset{R'}{|}}{R-C=}}$$

Alkyl isocyanides

Methods of Preparation

(a) From alkyl halides

$$R-X+AgCN\xrightarrow[\Delta]{C_2H_5OH}\underset{\text{(major)}}{RNC}+RCN$$

(b) Carbylamine reaction

$$RNH_2+CHCl_3+3KOH_{(alc)}\xrightarrow{\Delta}RNC+3KCl+3H_2O$$

(c) From N-alkyl formamide

$$R-NH-\underset{\text{Pyridine}}{CHO}\xrightarrow{POCl_3}R-N\equiv C+H_2O$$

Reactions of Alkyl isocyanides

Hydrolysis

$$R-N\equiv C+2H_2O\xrightarrow{H^+}RNH_2+HCOOH$$

(ii) Reduction

$$RN\equiv C+4[H]\xrightarrow[\text{or Ni or Pt}]{Na/C_2H_5OH}\underset{2^O\text{ amine}}{RNHCH_3}$$

(iii) Addition reaction

Due to the presence of unshared pair of electrons on C atom, alkyl isocyanides give addition reaction.

$$RNC+S\longrightarrow RNCS$$

$$RNC+HgO\longrightarrow RNCO+Hg$$

$$RNC+O_3\longrightarrow RNCO$$

(iv) Isomerisation At 250°C, it isomerizes to nitrile.

$$RNC\xrightarrow{\Delta}RCN$$

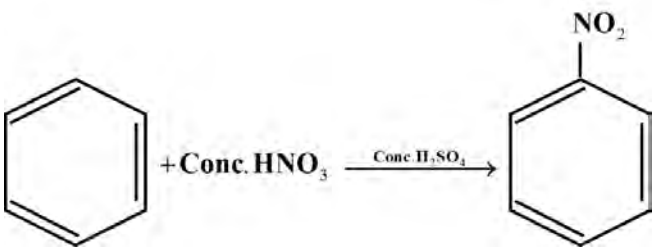
Nitro Compounds

Methods of Preparation

(i) From alkyl halides

$$RX + AgNO_2 \xrightarrow{\Delta} RNO_2 + AgX$$

(ii) Nitration: Nitrating mixture is conc HNO_3 + conc H_2SO_4



Reactions of Nitro Compounds

Reduction

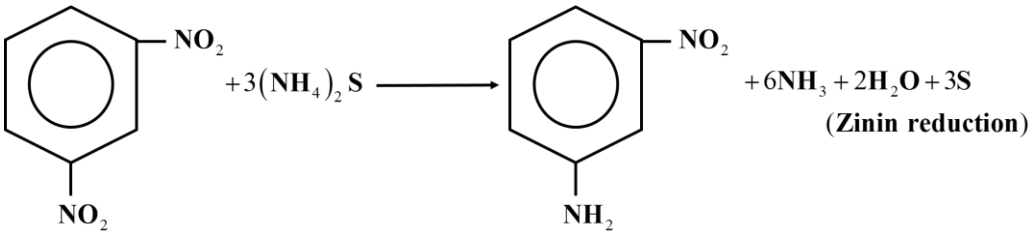
With Sn/HCl or catalytic hydrogenation, nitroalkanes are reduced to amines.

$$RNO_2 + 6[H] \xrightarrow{Sn/HCl} R - NH_2 + 2H_2O$$

If neutral reducing agent like Zn dust + NH_4Cl is used, hydroxylamines are obtained as major product.

$$RNO_2 + 4[H] \xrightarrow{Zn+NH_4Cl} \underset{\text{N–alkylhydroxylamine}}{R - NHOH} + H_2O$$

In the presence of $(NH_4)_2S$ or Na_2S, selective reduction takes place.



Nitrobenzene gives different products with different reagents and in different mediums.

Medium	Reagent	Product
Acid	Sn/HCl	Aniline
Neutral	Zn/NH_4Cl	N-phenyl hydroxylamine
	$Na_3AsO_3/NaOH$	Azoxbenzene $(C_6H_5N=\overset{\overset{O}{\uparrow}}{N}C_6H_5)$

Alkaline	Zn/NaOH, CH_3OH Zn/NaOH, C_2H_5OH	Azobenzene hydrazobenzene
Metallic hydride	$LiAlH_4$	aniline
Electrolytic	dil H_2SO_4	p-aminophenol

Action of HNO_2

1° nitroalkane gives nitrolic acid which gives red colour with NaOH.

$$RCH_2NH_2 \xrightarrow[-H_2O]{HNO_2} \underset{\text{nitrolic acid}}{RC(NO_2)=NOH} \xrightarrow{NaOH} \underset{\text{(red)}}{RC(NO_2)=NONa}$$

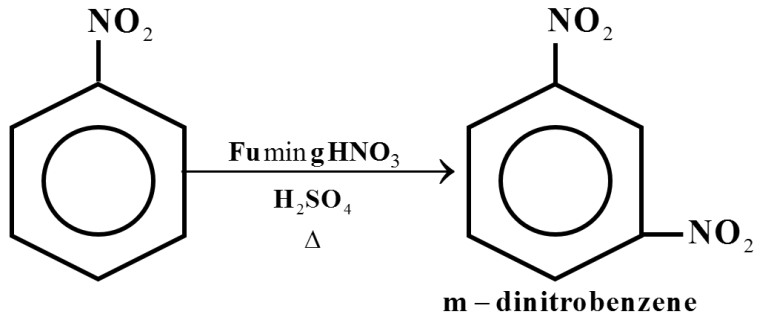
2° nitrolkanes give pseudonitrol with HNO_2

$$R_2CH(NO_2) \xrightarrow[-H_2O]{HNO_2} \underset{\begin{array}{c}|\\ NO_2\\ \text{Pseudonitrol}\end{array}}{R_2C-NO} \xrightarrow{NaOH} \text{Blue}$$

Nef carbonyl synthesis

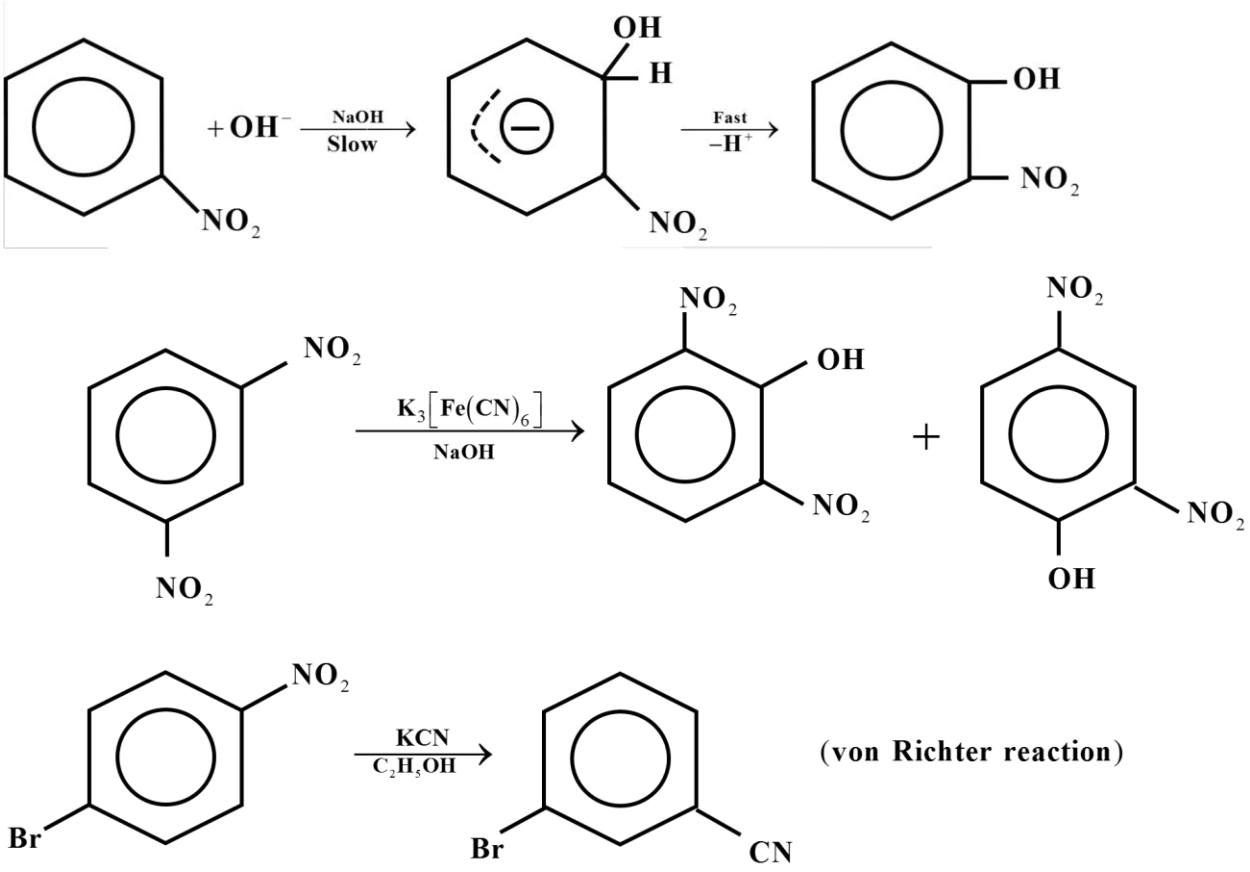
$$R-CH_2NO_2 \xrightarrow{NaOH} \underset{\begin{array}{c}|\\ O^-\end{array}}{R-CH=\overset{+}{N}-O^-Na^+} \xrightarrow{50\%\ H_2SO_4} \underset{\text{aldehyde}}{R-CH=O}$$

Electrophilic substitution On nitration



m – dinitrobenzene

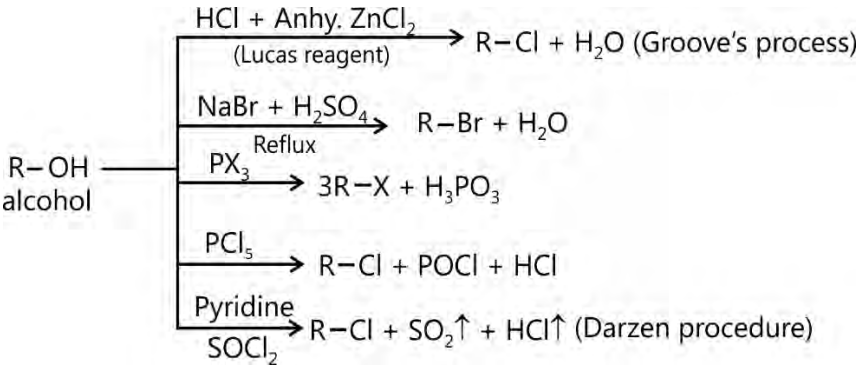
Nucleophilic substitution reaction -NO_2 group activates the ring towards nucleophilic substitution.



19. HALOALKANES AND HALOARENES

General Methods of Preparation of Haloalkanes

From Alcohols



Free Radical Halogenation of Alkanes

$$CH_3CH_2CH_2CH_3 \xrightarrow[\text{UV light or Heat}]{Cl_2} CH_3CH_2CH_2CH_2Cl + CH_3CH_2\underset{\displaystyle Cl}{\underset{|}{C}}HCH_3$$

Addition of hydrogen Halides on Alkenes

$$-\overset{|}{C}-C=C-+HBr \longrightarrow -\overset{|}{C}-\overset{|}{C}-\underset{\displaystyle Br}{\underset{|}{C}}-$$

2–bromopropane

$$-\overset{|}{C}-C=C-+HBr \xrightarrow{\text{Organic peroxide}} -\overset{|}{C}-\overset{|}{C}-\overset{|}{C}-Br$$

(i) Halogen Exchange method :

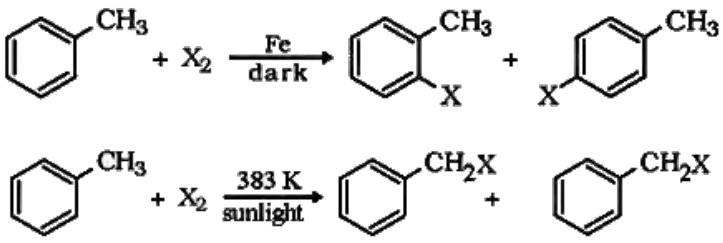
$R-X+NaI \rightarrow R-I+NaX$ **(Finkelstein reaction)**

$R-Br+AgF \rightarrow R-F+AgBr$ **(Swarts reaction)**

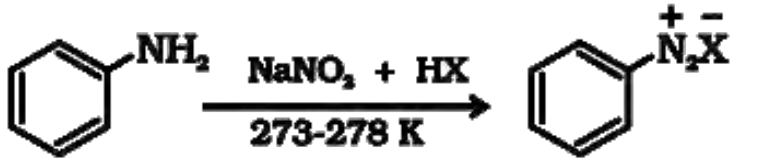
Hunsdiecker Reaction

$$CH_3COOAg + Br_2 \xrightarrow[CCl_4]{} CH_3Br + AgBr + CO_2$$

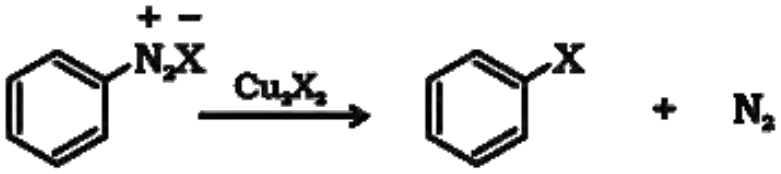
- **Preparation of haloarenes :**
  (a) By electrophilic substitution reaction :



(b) Sandmeyer's reaction :



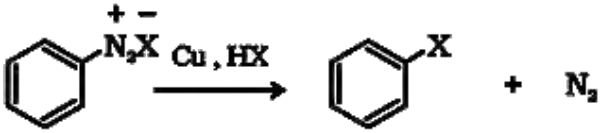
Benzene diazonium halide



Aryl halide

X = Cl, Br

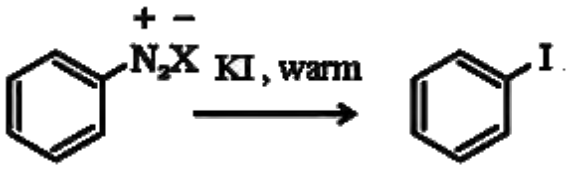
(c) Gattermann reaction :



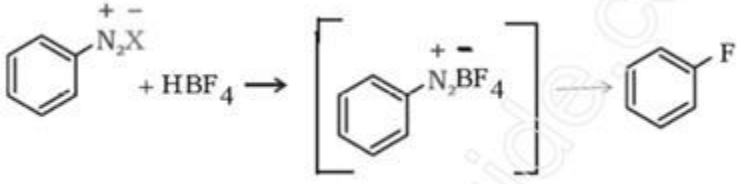
Aryl halide

X = Cl, Br

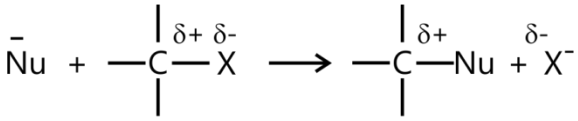
(d) From Diazonium Chloride :

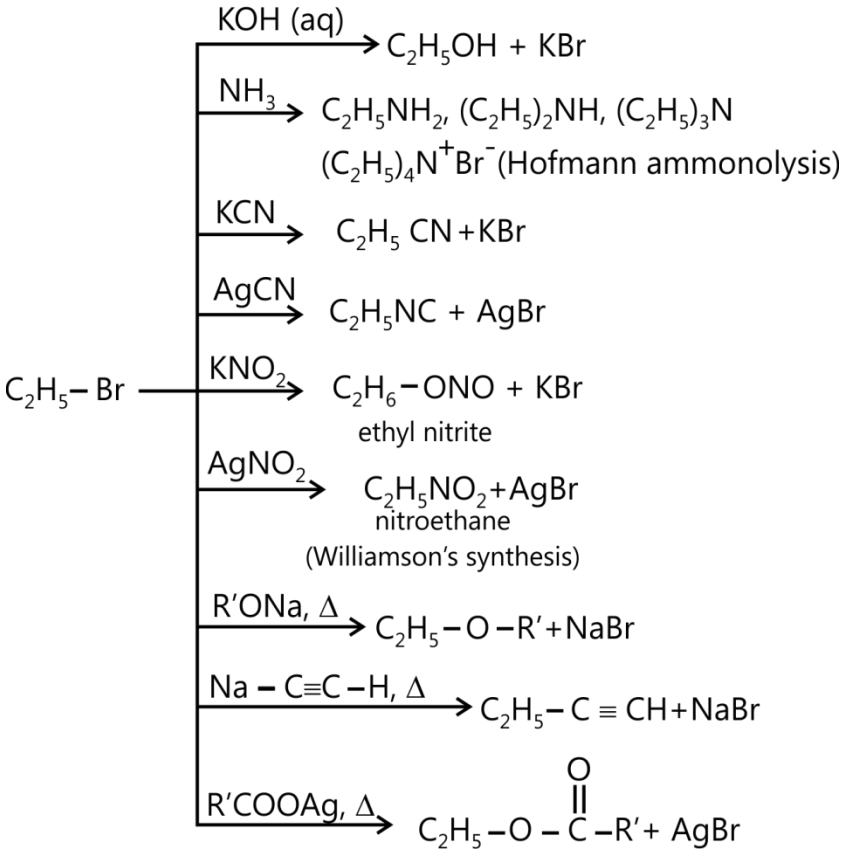


(e) Balz-Schiemann reaction :



Nucleophilic Substitution Reactions





2. Elimination Reactions

Dehydrohalogenation is a β-elimination reaction in which halogen is from α-carbon atom and the hydrogen from the α-carbon according to Saytzeff rule, e.g.

$$CH_3-CH_2-\underset{\displaystyle Br}{\underset{|}{CH}}-CH_3 \xrightarrow[-KBr,\,-H_2O]{\text{Alc. KOH}} \underset{\text{but-2-ene (major)}}{CH_3-CH=CH-CH_3} + \underset{\text{butene-1 (minor)}}{CH_3CH_2CH=CH_2}$$

Reduction

$$C_2H_5-Br + H_2 \xrightarrow{\text{Ni, 575 K}} C_2H_6 + HBr$$

$$C_2H_5I + HI \xrightarrow{\text{Red P, 420 K}} C_2H_6 + I_2$$

Reaction with Metals

(i) Wurtz reaction

$$RX + 2Na + XR \xrightarrow{\text{Dry ether}} R - R(\text{alkane}) + 2NaX$$

(ii) Wurtz-Fitting reaction

$$C_6H_5\text{-}Cl + 2Na + Cl\text{-}CH_3 \xrightarrow{\text{Dry ether}} C_6H_5 - CH_3 + 2NaCl$$

(iii) Reaction with Mg

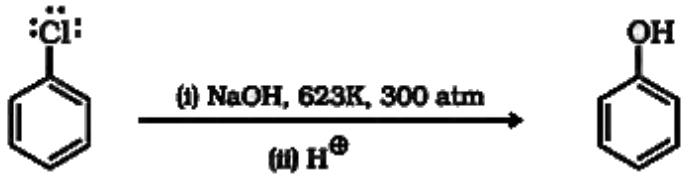
$$C_2H_5Br + Mg \xrightarrow{\text{Dry ether}} \underset{\text{Grignard's reagent)}}{C_2H_5 - Mg - Br}$$

Isomerisation

$$CH_3CH_2CH_2 - Cl \xrightarrow[\text{or anhy. } AlCl_5]{573\ K} CH_3 - \underset{\displaystyle Cl}{\underset{|}{CH}} - CH_3$$

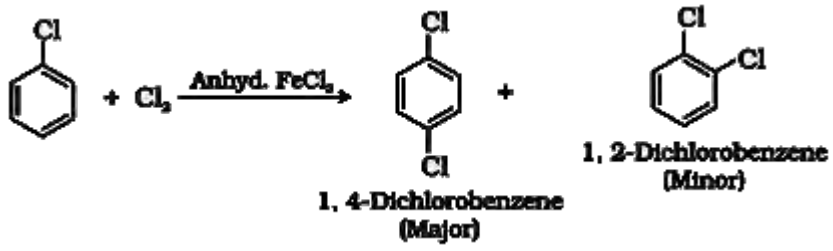
Chemical properties of haloarenes :

(a) Dow's Process

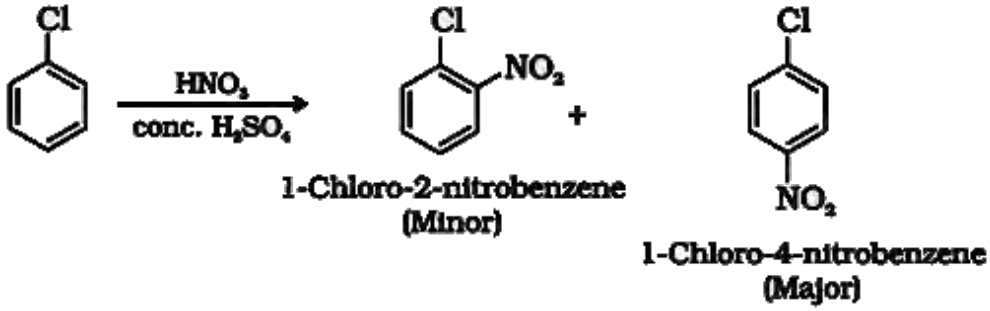


Electrophilic substitution Reactions

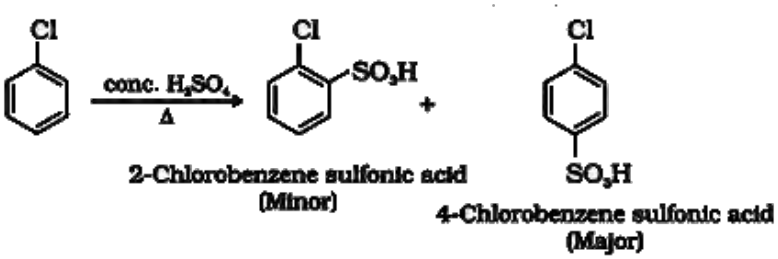
(b) With halogens



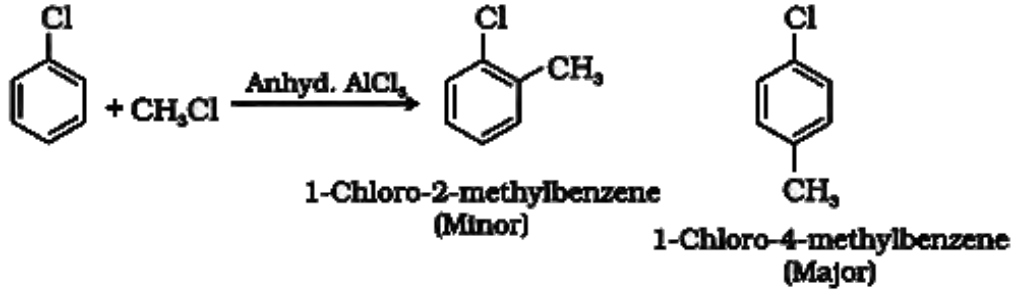
(c) With conc. sulphuric acid and nitric acid



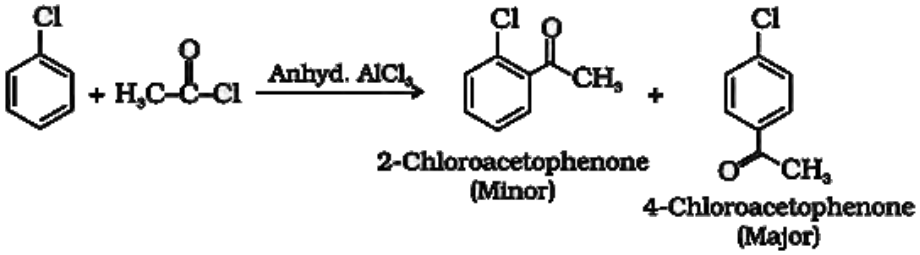
(d) On heating with conc. sulphuric acid



(e) With methyl chloride



(f) With acetyl chloride



(i) Other conversions :

$R-X+KCN \rightarrow R-CN+KX$

$R-CN \xrightarrow{Na, C_2H_5OH \text{ or } LiAH_4 \text{ or } Ni/H_2} R-CH_2NH_2 \xrightarrow{HONO} RCH_2OH$

$R-CN \xrightarrow{H_3O^+} R-COOH \xrightarrow{NH_3} R-CONH_2$

$R-COOH \xrightarrow{LiAlH_4} RCH_2OH$

$R-COOH \xrightarrow{PCl_5 \text{ or } PCl_3 \text{ or } SOCl_2} R-COCl$

$R-X+Mg \xrightarrow{\text{Dry ether}} RMgX$

$RMgX+CO_2 \rightarrow RCOOH$

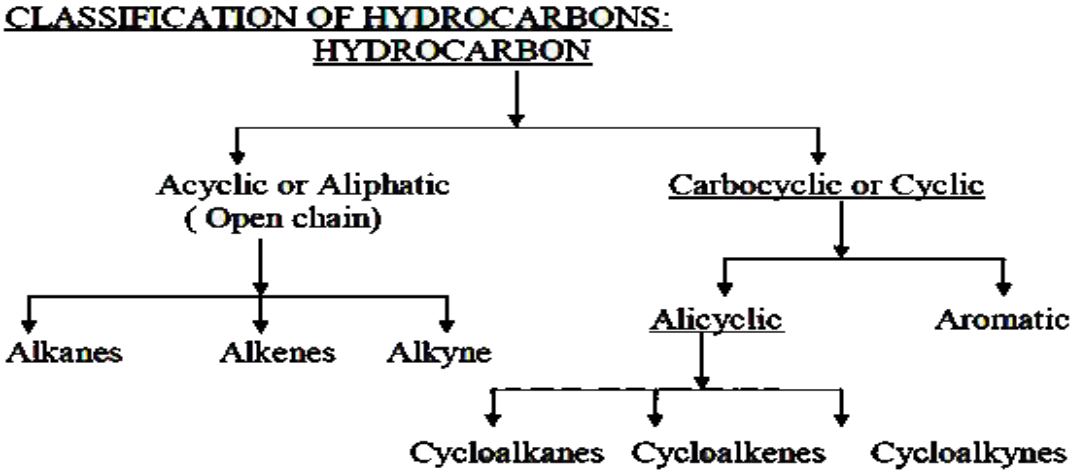
$RMgX+HCHO \rightarrow \text{Primary alcohol}$

$RMgX+RCHO \rightarrow \text{Secondary alcohol}$

$RMgx+R-CO-R \rightarrow \text{Tertiary alcohol}$

20. HYDROCARBONS

CLASSIFICATION OF HYDROCARBONS:



Alkanes

Preparation of Alkanes

(1) Wurtz reaction :

$$2CH_3CH_2Br + 2Na \xrightarrow[\text{ether}]{\text{Dry}} CH_3CH_2CH_2CH_3 + 2NaBr$$

Frankland reaction

$$RX + Zn + Rx \longrightarrow R - R + ZnX_2$$

(2) From Grignard reagent (RMgX)

$$RMgX + HOH \rightarrow RH + Mg(OH)X$$

$$RMgX + R'OH \rightarrow RH + Mg(OR')X$$

$$RMgX + R'NH_2 \rightarrow RH + Mg(NHR')X$$

(3) From unsaturated hydrocarbons :-

Sabatier-Senderens reduction

$$R - CH = CH_2 + H_2 \xrightarrow{Ni/\Delta} R - CH_2 - CH_3$$

$$R - C \equiv CH + H_2 \xrightarrow{Ni/\Delta} R - CH_2 - CH_3$$

4. From carboxylic acids-

Decarboxylation –

$$\underset{\text{Sodium ethanoate}}{CH_3COO^-Na^+} + NaOH \xrightarrow[\Delta]{CaO} CH_4 + Na_2CO_3$$

Kolbe's electrolytic method –

$$\underset{\text{Sodium acetate}}{2CH_3COO^-Na^+} + 2H_2O \xrightarrow{\text{Electrolysis}} CH_3 - CH_3 + 2CO_2 + H_2 + 2NaOH$$

Reactions

Combustion :-

$$CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O, \qquad \Delta H = -217.0 \text{ K cal / mole}$$

Oxidation :-

$$CH_4 + O_2 \xrightarrow[573\ K]{Cu} 2CH_3OH$$

$$CH_4 + O_2 \xrightarrow{Mo_2O_3} \underset{\text{Methanal}}{HCHO} + H_2O$$

Substitution :-

Halogenation :-

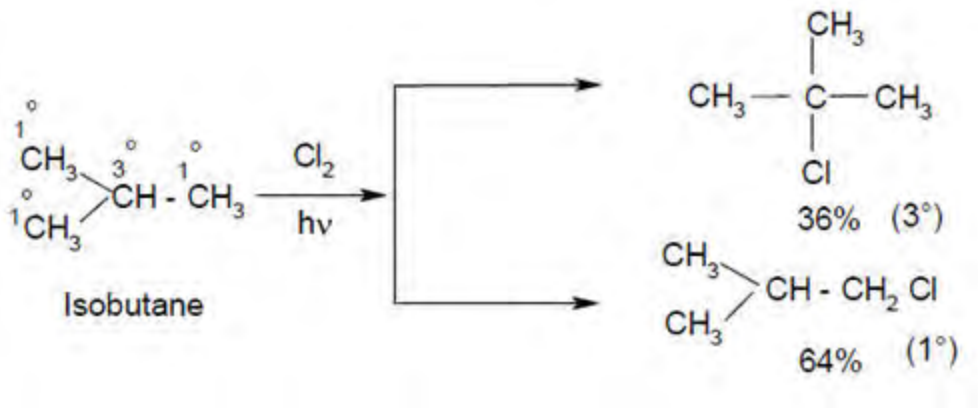
$$CH_4 + Cl_2 \xrightarrow{UV} CH_3Cl + HCl$$

$$CH_3Cl \xrightarrow{UV} CH_2Cl_2 \xrightarrow{UV} CHCl_3 \xrightarrow{UV} CCl_4$$

(i) The reactivity of Halogens : $F_2 > Cl_2 > Br_2 > I_2$

(ii) The rate of replacement of Hydrogens of alkanes is : $3^o > 2^o > 1^o$

$$\underset{\text{n–Butane}}{CH_3CH_2CH_2CH_3} \xrightarrow[h\nu]{Cl_2} CH_3CH_2CH_2CH_2Cl + CH_3CH_2ClCHCH_3$$

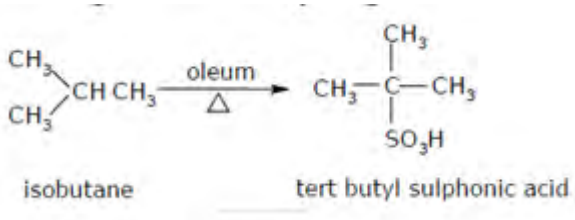


Nitration

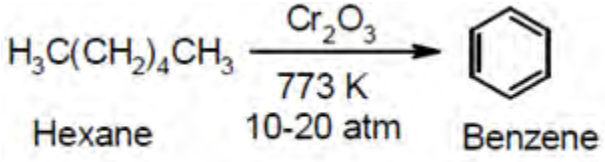
$$CH_3CH_2CH_3 \xrightarrow[\text{Conc. } HNO_3]{450^oC} CH_3CH_2CH_2NO_2 + CH_3CHNO_2CH_3 + CH_3CH_2NO_2 + CH_3NO_2$$

25 % 40 % 10 % 25 %

Sulphonation : - replacement of hydrogen atom of alkane by – SO_3H group.



Aromatization :-



(6) Thermal decomposition or Pyrolysis or cracking or Fragmentation : - when higher alkanes are heated at high temp (about 700 – 800 K) in the presence of alumina or silica catalysts, the alkanes break down to lower alkenes and alkanes.

$$CH_3-CH_2-CH_3 \longrightarrow CH_3-CH-CH_2+CH_3-CH_3+C_2H_4+CH_4$$

(7) Action of steam : - Catalyst : nickel, alumina Al_2O_3

$$CH_4+H_2O(Steam) \xrightarrow{1000^oC} CO+3H_2$$

Isomerization

$$\underset{\text{n–Hexane}}{CH_3(CH_2)_4CH_3} \xrightarrow{\text{Anhy. } AlCl_3/HCl} \underset{\text{2–Methylpentane}}{CH_3CH-(CH_2)_2-CH_3} + \underset{\text{3–Methylpentane}}{CH_3CH_2-CH-CH_2-CH_3}$$

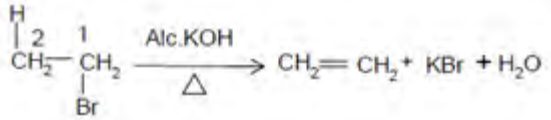
Alkenes

Preparation :

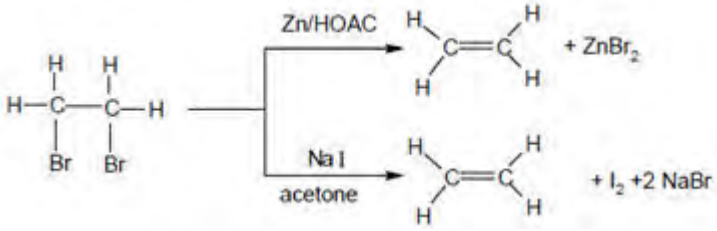
1. From Alkynes : - Alkynes on partial reduction with partially deactivated palladised charcoal known as Lindlar's catalyst give alkynes.

$$\underset{\text{Ethyne}}{CH\equiv CH}+H_2 \xrightarrow{Pd/C} \underset{\text{Ethene}}{CH_2=CH_2}$$

2. From Haloalkanes :- dehydrohalogenation (E_2 or 1, 2-elimination or Beta-elimination)



3. From Dihaloalkanes :- Dehalogenation



4. From Alcohols :- Dehydration (E1 – elimination)

$$CH_3CH_2CH_2OH \xrightarrow[160^{O}]{\text{Conc. } H_2SO_4} CH_3CH=CH_2 + H_2O$$

$$CH_3CH_2CH_2CH_2OH \xrightarrow[300^{O}C]{Al_2O_3} CH_3CH_2CH=CH_2$$

Reactions of Alkenes

(1) Addition Reaction :- Alkene show electrophilic addition reaction.

1. Addition of Hydrogen :-

$$RCH=CH_2 \xrightarrow{H_2/Ni} RCH_2CH_3$$

2. Addition of Halogens :-

$$CH_2=CH_2 + Br_2 \xrightarrow[\text{Solvent}]{CCl_4} BrCH_2-CH_2Br$$

$$\underset{\text{(Brown colour)}}{CH_2=CH_2 + Br_2} \xrightarrow[\text{Solvent}]{H_2O} Br-CH_2-\underset{\text{(Colourless)}}{CH_2-OH} + HBr$$

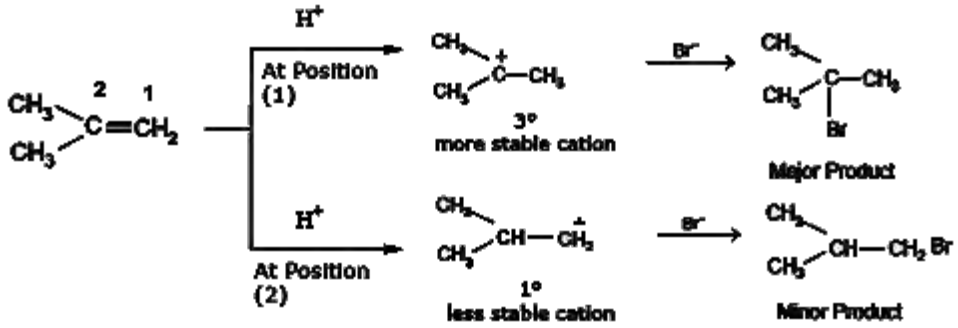
3. Addition of hydrogen halides –

Addition reaction of HBr to symmetrical alkenes

$$CH_2=CH_2 + H-Br \longrightarrow CH_3-CH_2-Br$$

Addition reaction of HBr to unsymmetrical alkenes takes place according to Markovnikov Rule

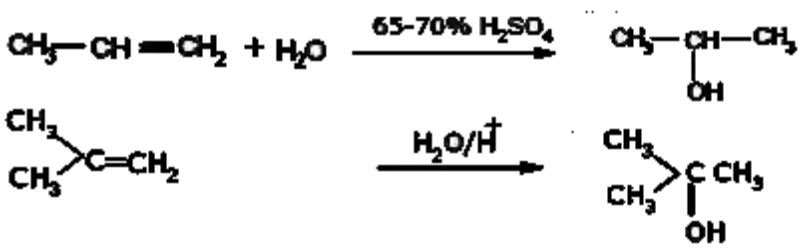
Markownikov rule :- negative part of the addendum (adding molecule) gets attached to that carbon atom which possesses lesser number of hydrogen atoms. E.g.



Peroxide effect or Kharasch (Anti Markownikoff's addition) :- In 1933 Kharasch and Mayo observed that when HBr is added to an unsymmetrical double bond in the presence of organic peroxide, the reaction take places opposite to the markovnikov rule.

$$CH_3 - CH = CH_2 \xrightarrow[\text{Peroxide}]{HBr} \underset{\text{Propyl bromide}}{CH_3 - CH_2 - CH_2Br}$$

4. Addition of water (Hydration):- Acid catalyzed addition of water



2. Oxidation :-

1. Combustion : $CO_2 + H_2O$

2. Hydrocarboration-oxidation:- Alkenes react with diborane to form trialkyl boranes which on oxidation with alkaline H_2O_2 give alcohols.

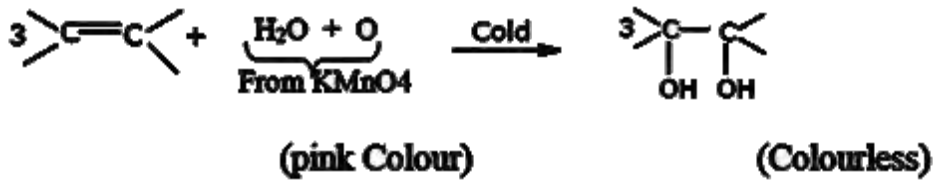
$$3CH_2 = CH_2 \xrightarrow{BH_3} \underset{\text{Triethylborane}}{CH_3CH_2} \; B \xrightarrow{H_2O_2/OH^-} \underset{\text{Ethyl alcohol}}{3CH_3CH_2OH}$$

3. Oxymercuration-demercuration :-

$$H_2C = CH_2 \xrightarrow[THF,\ H_2O]{Hg(OAC)_2} OH - CH_2 - CH_2 - Hg\ OAc \xrightarrow[OH^-]{NaBH_4} CH_3CH_2OH + Hg$$

4. Oxidation with potassium permanganate :-

$$2KMnO_4 + H_2O \longrightarrow 2KOH + 2MnO_2 + 3[O]$$

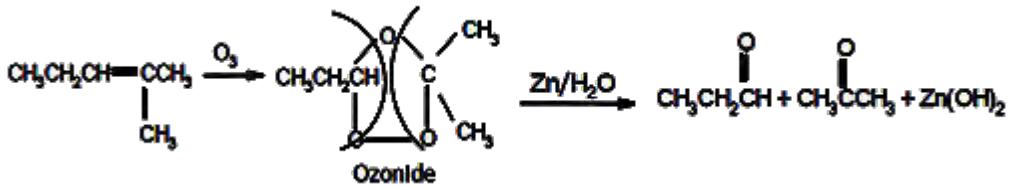


(pink Colour) (Colourless)

Bayer's Test

$$CH_3 - CH = CH_2 \xrightarrow[(ii)\ H^+\Delta]{(i)\ Alk.\ KMnO_4} CH_3COOH + CO_2 + H_2O$$

Oxidation with Ozone :- Ozonolysis-give carbonyls compounds



Alkynes

Preparation :-

From vicinal dihalides :- dehalogenation

$$CH_3 - BrCH - CH_2 - Br \xrightarrow[\Delta]{2KOH\ (alc)} CH_3 - C \equiv CH + 2KBr + 2H_2O$$

By the action of water on calcium carbide :-

$$CaC_2 + H_2O \rightarrow HC \equiv CH + Ca(OH)_2$$

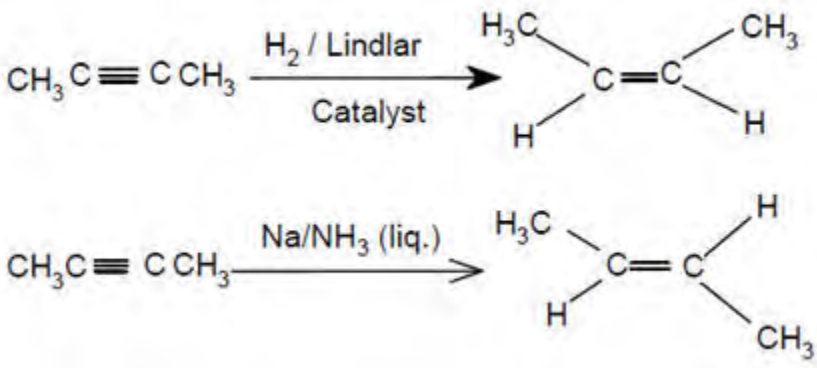
Reactions

(1) Addition Reaction : Alkyne show electrophilic addition reaction.

1. Addition of Hydrogen – Hydrogenation.

$$\underset{Propyne}{CH_3C \equiv CH} + 2H_2 \xrightarrow{Ni} CH_3CH_2CH_3$$

Birch Reduction



2. Addition of Halogens :-

$$HC \equiv CH \xrightarrow{2Br_2} Br_2HC - CHBr_2$$

3. Addition of hydrogen halides :-

$$HC \equiv CH + 2HBr \longrightarrow CH_3CH\,Br_2$$

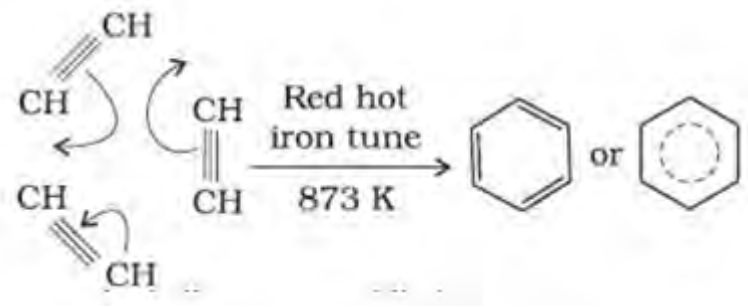
4. Addition of water (Hydration):- Acid catalyzed addition of water

$$HC \equiv CH + H_2O \xrightarrow[H_2SO_4]{HgSO_4} \underset{\text{Unstable}}{[CH_2 = CHOH]} \rightleftharpoons CH_3CHO$$

5. Polymerisation –

(a) Linear polymerization : of ethyne gives polyacetylene or polyethyne which is a high molecular weight polyene containing repeating units of (CH = CH – CH = CH) and can be represented as – (CH = CH – CH= CH)n-

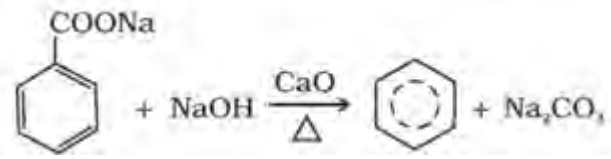
(b) Cyclic polymerization-results in the formation of aromatic compound.



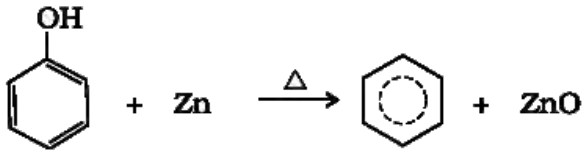
Aromatic Hydrocarbon

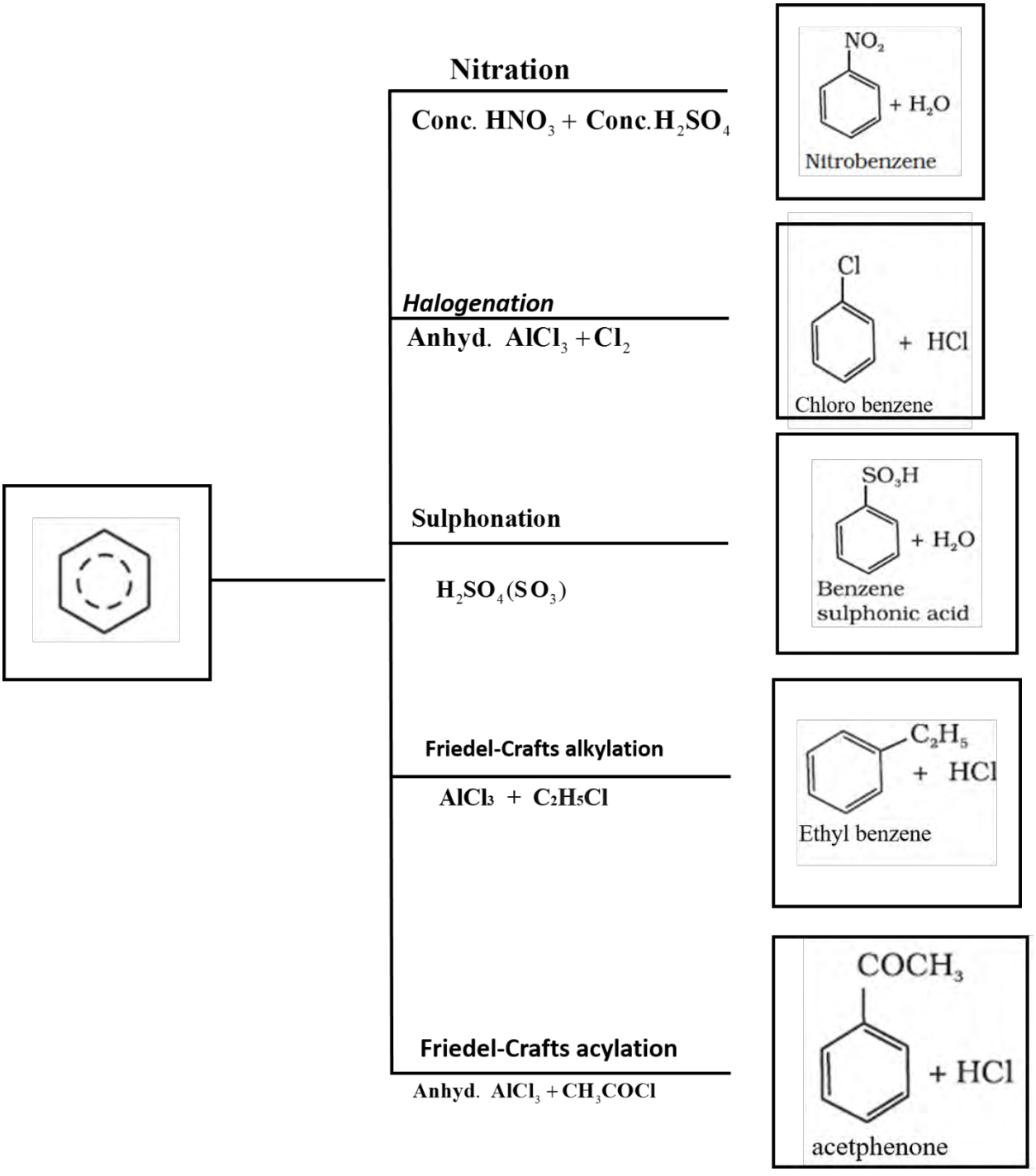
Preparation of Benzene

(i) Decarboxylation of aromatic acids.

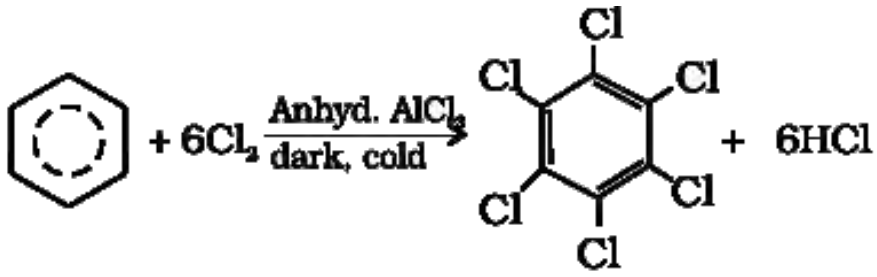


(ii) Reduction of phenol: Phenol is reduced to benzene by passing its vapours over heated zinc dust





Benzene on treatment with excess of chlorine in the presence of anhydrous $AlCl_3$ in dark yields hexachlorobenzene (C_6Cl_6)



Hexachlorobenzene
(C_6Cl_6)

Directive influence of a functional group in monosubstituted benzene :-

1. Ortho and para directing groups and activating

$-OH, -NH_2, -NHR, -NHCOCH_3, -OCH_3, -CH_3, -C_2H_5$ etc.

2. Meta directing group and deactivating :- $-NO_2, -CN, -CHO, -COR, -COOH, -COOR, -SO_3H$,

3. Ortho and para directing groups and deactivating – Halogens because of their strong – I effect, overall electron density on benzene ring decreases. However due to resonance the electron density on o- and p- position is greater than that at the m-position. Hence, they are also o- and p- directing groups.

21. POLYMERS

Important Addition Polymers

Polyolefins

1. Polythene

Polymer of ethylene or ethene.

(a) Low density polythene (LDP)

$$\underset{\text{Ethene}}{nCH_2 = CH_2} \xrightarrow{350-750k/1000 \text{ to } 2000 \text{ atm traces of } O_2} \underset{\text{Polythene}}{(CH_2 - CH_2)_n}$$

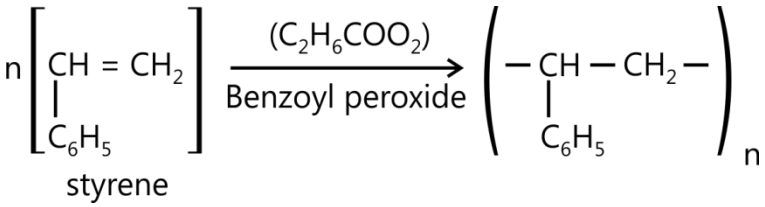
(b) High density polythene (HDP)

$$\underset{\text{Ethene}}{nCH_2 = CH_2} \xrightarrow{333-343k/6-7\ atm\ zieglar\ Natta\ catalyst} \underset{\text{Polythene}}{(CH_2 - CH_2)_n}$$

(d) Polyacrylonitrile

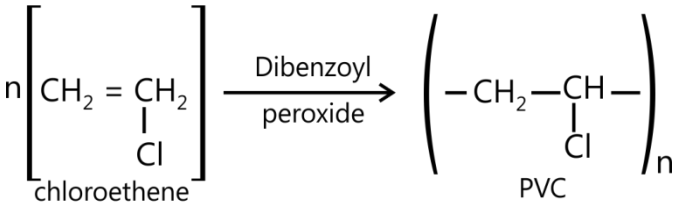
$$\underset{\text{Acrylonitrile}}{nCH_2 = CHCN} \xrightarrow{\text{Polymerisation/Peroxide catalyst}} \underset{\text{Polyacrylonitrile}}{(CH_2 - CN - CN)_n}$$

2. Polystyrene (Styrone)



styrene

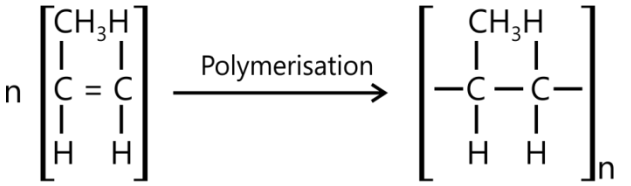
3. Polyvinylchloride (PVC)



chloroethene
(vinyl chloride)

PVC

4. Polypropylene (PP)



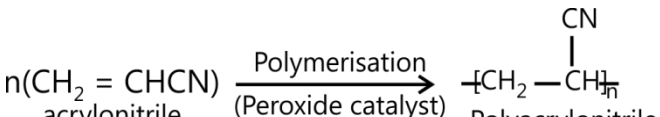
Propylene

Polypropylene (PP)

5. Polytetrafluoroethene (Teflon)

$$\underset{\text{Tetrafluorethene}}{nCF_2 = CF_2} \xrightarrow{\text{catalyst/High pressure}} \underset{\text{Teflon}}{(CF_2 - CF_2)_n}$$

6. Polyacrylonitrile

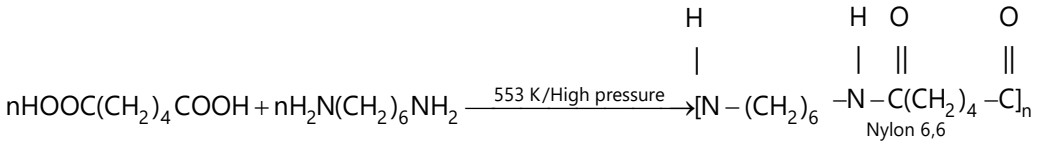


Polyacrylonitrile
or
orlon

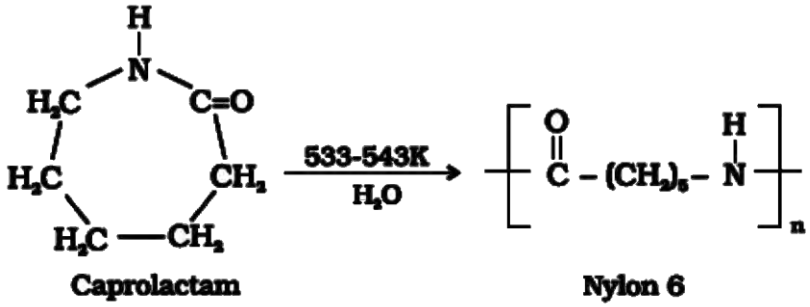
Condensation polymers

Polyamides

(a) Nylon 6, 6 : It is prepared by the condensation polymerization of hexamethylenediamine with adipic acid under high pressure and at high temperature.

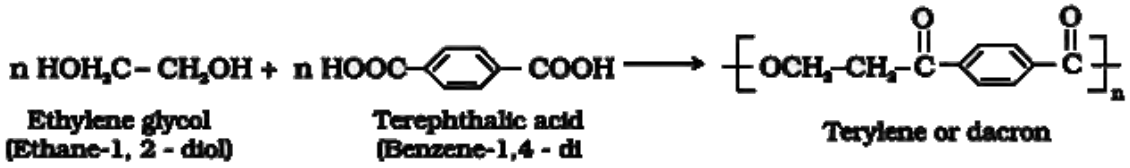


(b) Nylon 6 : It is obtained by heating caprolactum with water at a high temperature

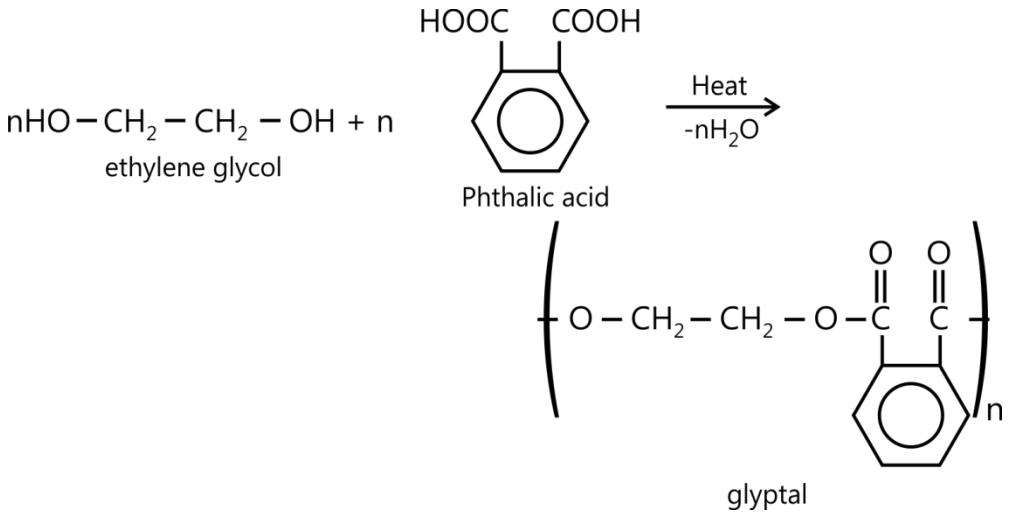


Polyesters

(a) Terylene or Dacron : It is manufactured by heating a mixture of ethylene glycol and terephtalic acid at 420 to 460 K in the presence of zinc acetate-antimony trioxide catalyst.



2. Glyptal



glyptal

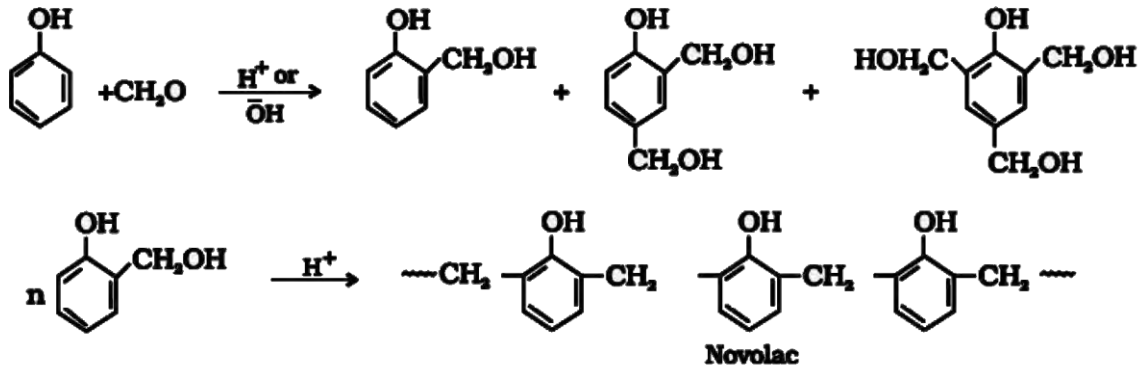
Polymethylmethacrylate (PMMA)

The polymer is known by several commercial names such as lucite, acrylite, plexiglass and perspex.

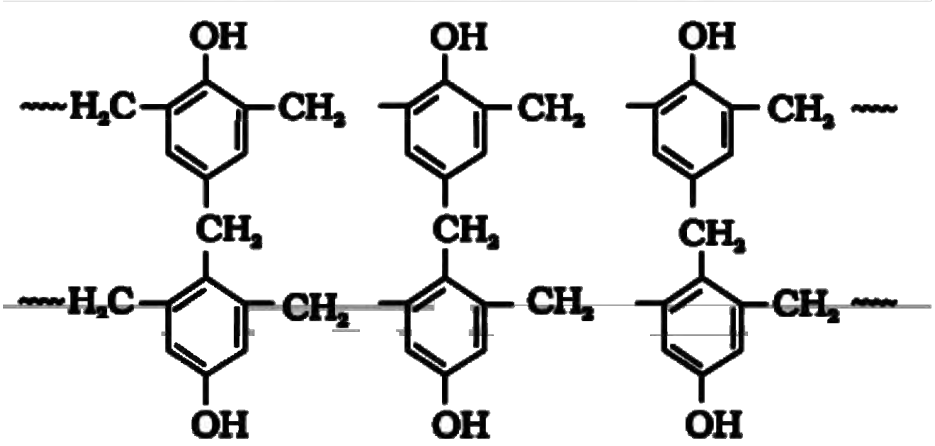
Resins

1. Phenol-Formaldehyde Polymer

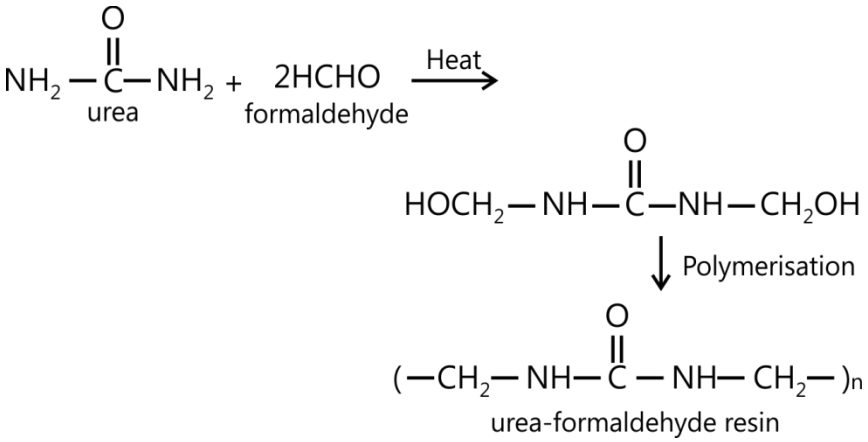
These polymers are obtained by the condensation reaction of phenol with formaldehyde in the presence of either acid or a base catalyst. The reaction involves the formation of methylene bridge at ortho, para or both ortho and para positions. A linear or cross linked material is obtained depending upon the condition of reaction.



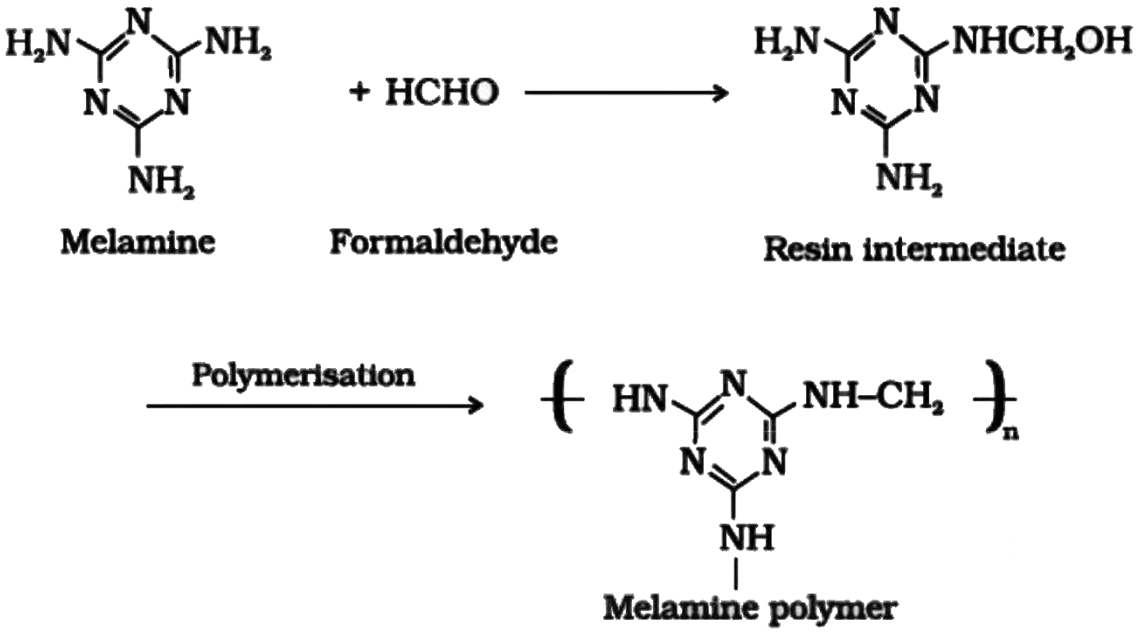
(b) Novolac on heating with formaldehyde forms Bakelite



2. Urea-Formaldehyde Resin



4. Melamine – formaldehyde polymer : Melamine formaldehyde polymer is formed by the condensation polymerization of melamine and formaldehyde

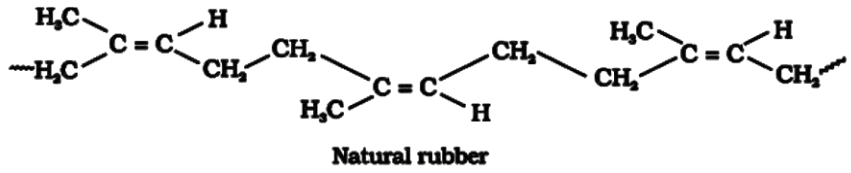


4. Natural Rubber

Natural rubber is a coiled linear 1, 4-polymer of isoprene.

$$CH_2 = \underset{\text{isoprene}}{\overset{\overset{CH_3}{|}}{C} - CH = CH_2}$$

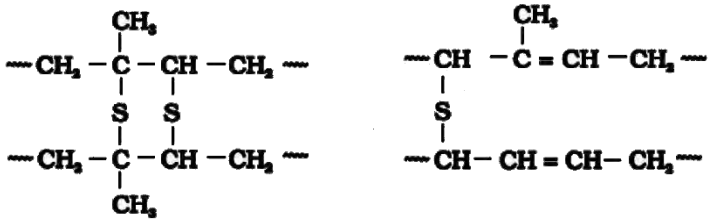
(a) Natural rubber : Natural rubber is a linear polymer of isoprene (2-methyl-1, 3-butadiene) and is also called as cis-1, 4-polyisoprene.



Vulcanisation of Rubber

The properties of natural rubber can be modified by introducing -S-S- polysulphide crosslinks in its structure.

The process of heating a mixture of raw rubber with sulphur and an appropriate addictive in a temperature range between 373 K to 415 K to improve upon physical properties like elasticity, strength etc.



Sulphur cross links in vulcanised rubber

Synthetic rubber

(A) Neoprene or polychloroprene

$$\underset{\text{2–chloro–1,3–butadiene}}{nCH_2=\overset{Cl}{\overset{|}{C}}-CH=CH_2} \xrightarrow{\text{Polymerisation}} \underset{\text{Neoprene}}{[CH_2-\overset{Cl}{\overset{|}{C}}=CH-CH_2]_n}$$

(B) Buna – N

$$\underset{\text{1,3–butaline}}{nCH_2=CH-CH=CH_2} + \underset{\text{Acrylanitrile}}{nCH_2=\overset{CN}{\overset{|}{C}}H} \xrightarrow{\text{Copolymerisation}} \underset{\text{Buna–N}}{[CH_2-CH=CH-CH_2-CH_2-\overset{CN}{\overset{|}{C}}H]_n}$$

(C) Buna – S

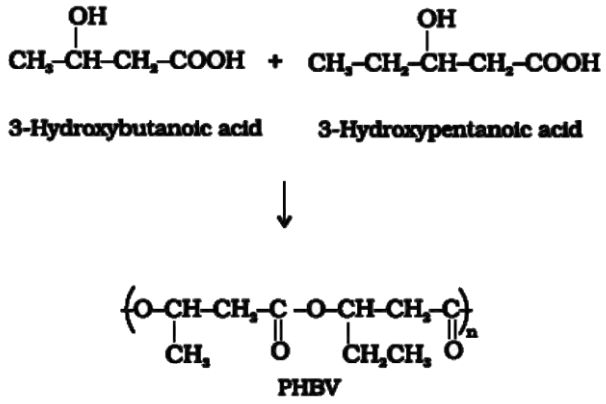
$$\underset{\text{1,3–butadine}}{nCH_2=CH-CH=CH_2} + \underset{\text{Styreme}}{nC_6H_5CH=CH_2} \longrightarrow \underset{\substack{\text{Butadine–styreme copolymer}\\ \text{(Buna–S)}}}{[CH_2-CH=CH-CH_2-CH_2-\overset{C_6H_5}{\overset{|}{C}}H]_n}$$

Biopolymers and Biodegradable Polymers

Aliphatic polyesters are the common examples of biodegradable Polymers.

(a) Poly-β-hydroxybutyrate-co-β-hydroxy valerate (PHBV):

It is obtained by the copolymerization of 3-hydroxybutanoic acid and 3-hydroxypentanoic acid



(b) Nylon 2-nylon 6 : It is an alternating polyamide copolymer of glycine (H_2N-CH_2-COOH) and amino caproic acid $(H_2N(CH_2)_5COOH)$

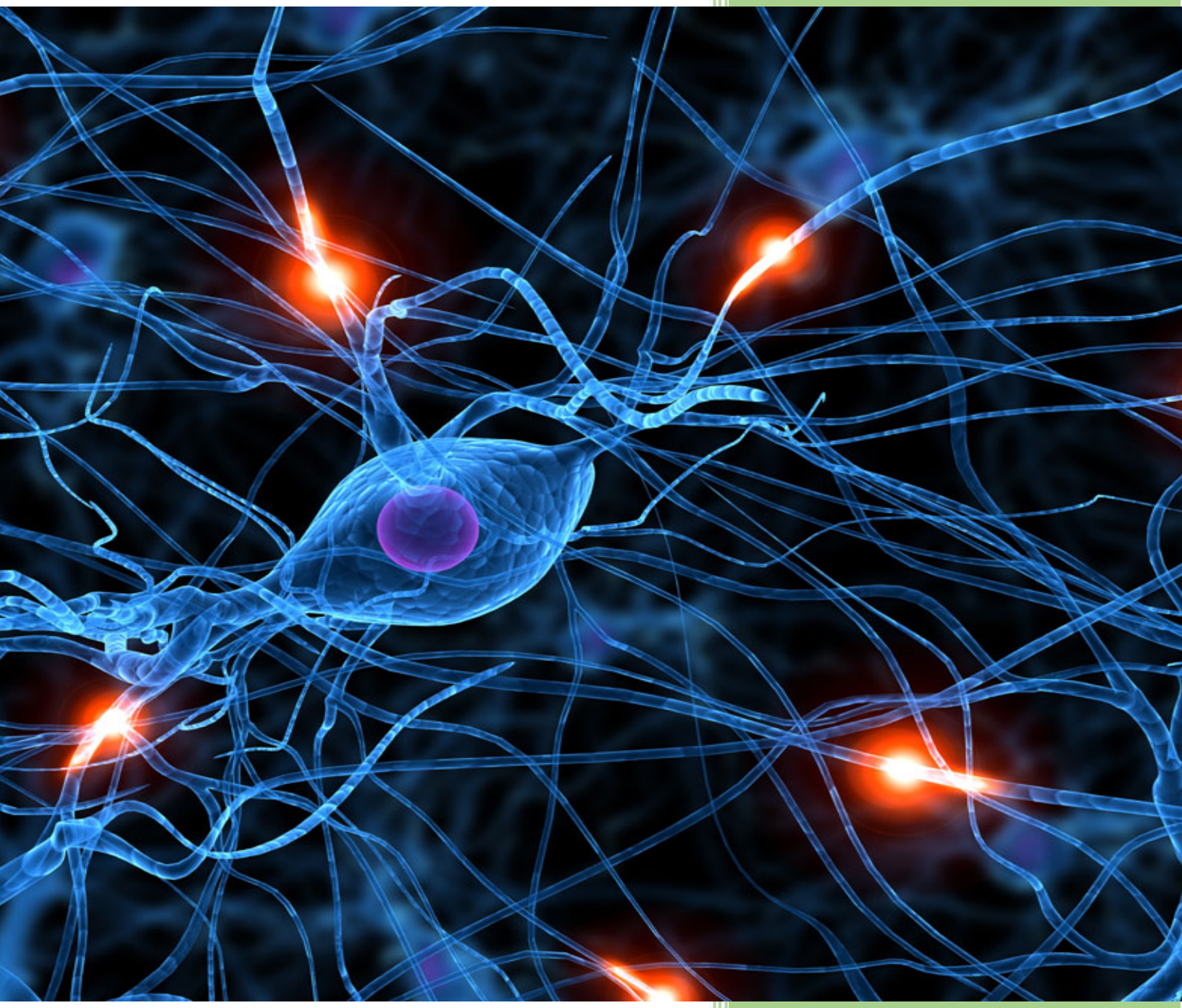
$$\underset{\text{Glycine}}{nH_2N-CH_2-COOH} + \underset{\text{Amino expronic acid}}{nH_2N-(CH_2)_5-COOH} \rightarrow (HN-CH_2-\overset{O}{\overset{\|}{C}}-HN-(CH_2)_5-\overset{O}{\overset{\|}{C}})_n$$

Some polymers:

S.N	Name of polymer	Class of polymer	Name/s of monomer/s	Uses
1.	Dynel	Copolymer	Vinyl chloride and acrylonitrile	Human hair wigs
2.	Glyptal	Copolymer	Ethylene glycol and phthalic acid	In paints
3.	Thiokol	Condensation	Ethylene chloride and sodium (Polysulphide rubber)	Rubber tetra sulphide
4.	Superglue	Homopolymer	Methyl α-cyanoacrylate	Glue
5.	Kevlar	Polyamide condensation	Terephthalic acid chloride and p-phenylene diamine	Bullet proof vests and helmets
6.	Nomex	Polyamide condensation	m-phthalic acid and m-dinitrobenzene	Protective clothes for race car drives and fire fighters.
7.	Lexan	Polycarbonate	Diethylcarbonate and bisphenol Ester condensation	Bullet proof windows and helmets
viii)	Polyurethane or Thermocole	Copolymer glycol	Toluene diisocyanate and ethylene	For padding and building insulation
ix)	Saran	Copolymer chloride	Vinyl chloride and vinylidene	Bumpers

BIOLOGY

FORMULA HAND BOOK



அம்மா கல்வியகம்

Contents

1. THE LIVING WORLD

Unique Features of Living organism:-

- Growth
- Reproduction
- Metabolism
- Consciousness
- Life span

All processes of life occur in protoplasm and hence Huxley Wrightly called protoplasm as the physical basis of life. It is known as living matter because it shows all properties of life.

BIODIVERSITY

Currently there are some 1.7 – 1.8 million living organisms known to science.
Out of which 1.25 are animals and about 0.5 millions are plants.
Use of Systematics

1) Identification
2) Nomenclature
3) Classification

Biological nomenclature : For providing scientific name to known organisms.
Each name has two components- generic name (genus) and specific epithet (species).
This system of nomenclature was provided by Carolus Linnaeus.
Taxonomic categories : A taxonomic category is a rank or level in the hierarchical classification of organisms. There are seven obligate categories and some intermediate categories.

Taxonomic hierarchy is given below :

Kingdom ⟶ Division ⟶ Class ⟶ Order ⟶ Family ⟶ Genus ⟶ Species

Taxonomic Aids : Techniques, procedures and stored information that are useful in identification and classification of organisms are called taxonomic aids. Like:

1. Herbarium
2. Museums
3. Zoological park
4. Botanical Garden
5. Key

- Key stone species determine the biotic structure of an entire commonly.
- Taxonomy is divided into three types by Turil (1938).
  (1) α **(alpha) taxonomy –** It deals with collection and identification of organisms on the basis of gross morphology, field and herbarium studies that helps to comile monographs and flora and to identify plants. It is classical taxonomy.

(2) β **(beta) taxonomy –** It deals with collection and identification on the basis of morphology and evidences from genetics, cytology, anatomy, physiology, etc.

(3) ω **(omega) taxonomy –** It consider all microscopic observations and biochemical evidences and is equivalent to neosystematics (modern taxonomy) and based on phonetic classification.

- Father H. Santapau – Father of Indian Taxonomy.
- William Roxburgh – Father of Indian Botany and Indian Herbaria.
- The term taxonomy was coined and used by French botanist A.P. de Candolle (1813) in his book Theorie Elementaire de La Botanique.
- Term systematic was used by Swedish botanist and doctor Linnaeus (father of Taxonomy for his book System Nature (1735).
- **Famous Books**

The origin of Life	Oparin
Principles of Systematic Zoology	Emst Mayr
Phillosophic Zoologique	Lamarck
Systema Naturae (1735, 1758)	Linnaeus
Species Plantarum (1753)	Linnaeus
Genera Plantarum (1737)	Linnaeus
Philosophia Botanica	Linnaeus

- **Correlated** characters are groups of common features present in different members of a group which are used delimitation of various taxa e.g. common features in different species from a genus. This shows common ancestry.
- **Revision of Group.** It is the grouping of species into distinct taxa of higher category on the basis of their hormology and evolutionary relationship.
- **Vegetation** of an area is described but flora/fauna is listed.
- **FAA** (Formalin aceto-alcohol) is a liquid preservative, most commonly used for preserving anatomy materials.
- **Botanical survey** of India (BSI) was established in 1890. Its head office is at Calcutta.

Species with two or more varieties/subspecies is known as polytypic species while the one which has no race/variety/subspecies is called monotypic species.

Cohort A group of individuals of the same age within a population.

Sympatric species (Sym = Similar). These are genetically unrelated (different) individuals of species having same or overlapping area of geographical distribution.

Allopatric species (Allo = different). These are genetically related species having different area of geographical distribution.

Lamarck gave dyanamic concept stating that species is mutable and dynamic.

Biological concept of species was given by Dobzansky (1937) and Mayr (1942).

2. BILOGICAL CLASSIFICATION

Biological classification is the scientific procedure of arranging organisms into groups and subgroups on the basis of their similarities and dissimilarities and placing the group in a hierarchy of categories.

Kingdom System of Classification

Two Kingdom	Three Kingdom	Five Kingdom
Plantae	Plantae	Monera
Animalia	Protista	Protista
	Animalia	Fungi
		Plantae
		Animalia

- Eichler and Engler and Prantl phylogenetic systems are transitional (partly) phylogenetic.
- Phylogeny is developmental history of entire race. Haeckel proposed concept of phylogeny.
- Term monera was used by Dogherty and Allen.
  Phyletic Classification. It is a type of *phylogenetic classification* based on the relationship to a particular line of descent. There are two components of phyletic relationships.

(i) *Patristic* (a term used for similarities between two plants due to a known common ancestry)

(ii) *Cledistic* (L Cledos = branch, term used for closeness of relationship in terms of phyletic lines).

Cladistlcs (phylogenetic systematics) is a method of classification (given by wiilii henning) (also called hennigian classification)

- **Green Data Book (GDB).** It gives information about rare plants growing in botanical gardens/protected areas.
- **Blue Book.** United Nations environment Programme (UNEP) has compiled endangered species of the world under the title Blue Book.
- **Traffic.** Trade record analysis of flora and fauna in commerce
- **UNESCO –** United Nations Educational Scientific and Cultural Organisation.
- **IUCNNR (IUCN) –** International Union for Conservation of Nature and Natural Resources or IUCN.
- **GEF –** Global Environmental Facility.
- **BHNS –** Bombay Natural History Society, Mumbai (its logo is Hombill)
- **WWF-N –** World wide Fund for Nature (Old name was WWF – World wild life fund). Since 1986, it is WWF-N. Its logo is giant panda *Ailusopoda melanoleuca*..
- **IBWL –** Indian Board for Wild life (1952)
- **WPSI –** Wild life Preservation Society of India. Dehradun.
- **UNEP –** United Nations Environments Programme.
- **NBPGR –** National Bureau of Plant Genetic Resources, New Delhi.
- **NBAGR –** National Bureau of Animal Genetic Resources, Karnal.
- **Mixotrophy.** This nutrition is found in eugienoids which show photosynthetic mode of nutrition in light and become hotozoic in the absence of light.
- *Albizzia falcate* is world's fastest growing tree.

- *Lornatia tasmanica* is longest living plant (43000 years old).
- *Butea monosperma* is called flame of the forest.

1. Monera –

The kingdom includes all prokaryotes – mycoplasma, bacteria, actinomycetes, and cyanobacteria.

(a) Unicellular, prokaryotes and containing the most primitive of living forms.
(b) The cells are microscopic and cell wall is generally present.
(c) Genetic materials are not organized into nucleus and contain naked DNA.
(d) Membrane bounded organelles are absent.
(e) Reproduction is asexual except gene recombination.
(f) Flagella may be present and are of single stranded.

Example – Blue-green algae, Bacteria etc.

Bacteria:
Shapes:
Coccus: spherical shaped
Spirillum: spiral or coiled shaped
Bacillus: rod shaped
Vibrio: comma shaped

Archaeobacteria –
They are group of most primitive prokaryotes which live under most hostile conditions like extreme-salty area (halophiles), hot springs (thermoacidiophiles) and marshy area (methanogens). The call wall structure shows absence of peptidoglycan. Methanogens are responsible for production of biogas (methane).

Eubacteria – They are called as true bacteria contain rigid cell wall, if motile contain flagellum. Cyanobacteria or blue-green algae are gram positive photosynthetic bacteria. They contain chlorophyll a and carotenoids. They may be unicellular, colonial or filamentous, fresh water, marine or terrestrial. Some of them have specialized heterocyst cells to perform nitrogen fixation (Nostoc and Anabaena).

Chemosynthetic bacteria oxidize inorganic substances like nitriate, nitrite, ammonia etc. to produce energy and help in recycling of nitrogen, phosphorous, sulphur etc.

Heterotrophic bacteria are helpful in production of curd, antibiotic and fixing nitrogen in leguminous plants.

Mycoplasma –
They are the simplest free living prokaryotes. They are also known as PPLO (Pleuropneumonia like organism). They lack cell wall and can survive without oxygen.

2. Protista –

Kingdom Protista includes Chrysophytes, Dinoflagellates, Eugleoids, Slime mould and Protozoans.

(a) It includes all unicellular and coloniel eukaryotes.
(b) Most of them are aquatic forming plankton.
(c) Mode of nutrition may be photosynthetic, saprobic, parasitic or holozoic.
(d) Flagella if present are 11 stranded with 9 + 2 arrangement of microtubules composed of tubulin.
(e) Genetic material consists of 2 or more DNA molecules.

Chrysophytes

- They includes diatoms and golden algae (desmids) found in fresh water as well as marine water.
- In diatoms cell wall forms two thin overlapping cells which fit together as in soap box.
- The siliceous indestructible cell wall pile up at the bottom of water reservoirs and form big heaps called diatomaceous earth.

Dinoflagellates

- They are basically unicellular motile, biflagellate and photosynthetic protists.
- Predominate colour is golden brown but yellow, green, red and even blue.
- Some Dinoflagellates like *Gymnodinium* and *Gonyaulax* grow in large number in the sea and make the water look red and cause the so called **''red tide''.**

Eugleoids

- They are Euglena like unicellular flagellates which possess pellicle instead of cell wall which make their body flexible.
- They have two flagella, one short and other long.
- They are photosynthetic in presence of sunlight and act as predators in absence of sunlight.
- Example – *Euglena, Peranema.*

Slime Moulds

- They are saprophytic protists and feeds on decaying twinges and leaves.
- Under favorable condition, they form an aggregation called plasmodium which produce fruiting bodies bearing spores.
- The cell wall of spores bears cellulose.
- Example – *Physarum, Fuligo.*

Protozoans

- All protozoans are heterotrophs and live as predators of parasites.

Classified as:

- Amoeboids: Amoeba, Entamoeba
- Flagellated protozoans: Trypanosoma
- Ciliated protozoans: Paramoecium
- Sporozoans: Plasmodium

3. Fungi –

- They are achlorophyllous, heterotrophic, spore forming, non-vesicular eukaryotic organisms.
- Cell wall is made up of chitin or fungal cellulose.

- Reserved food is glycogen.
- Mode of nutrition is saprophytic, parasitic or symbiotic.
- Reproduction may be vegetative (Fragmentation, fission or budding), asexual (conidia, sporangiospores or zoospores) or sexual reproduction by oospores, ascospore and basidiospores.
- Sexual cycles involves the following steps –

a) Plasmogamy, fusion of male and female gametes.
b) Karyogamy, fusion of two nuclei.
c) Meiosis in zygote to produce haploid spores.

Phycomycetes-

- They are found in aquatic habitat and on decaying wood in moist and damp places.
- The mycelium is aseptate and coenocytic.
- Asexual reproduction by zoospores (motile) or aplanospores (non-motile).
- Example-Mucus, Rhizopus, Albugo etc.

(b) Ascomycetes (The sac fungi)

- They are saprophytic, decomposers, parasitic or coprophilous (growing on dung).
- Mycelium and branched and septate and asexual spores are conidia.
- Sexual spores are called ascospores produced inside the fruiting body called ascocarps.
  Example- *Neurospora, Asperigillus, Claviceps etc.*

(c) Basidiomycetes (The club fungi)

- The mycelium is branched and septate.
- Vegetative reproduction is by fragmentation. Asexual spores are not found. Sexual reproduction is by two vegetative or somatic cells forming basidium.
- Basidiospores are produced in basidium by developing a fruiting body called basidiocarps.
- Example – *Agaricus, Ustilage, Puccinia*

(d) Deuteromycetes (The fungi imperfect)

- Only vegetative and asexual phase is known.
- Mycelium is septate and branched. Some members are saprophytes or parasites.
- Example – *Alternaria, Trichoderma, Colletotrichu*

4. Plantae

- Kingdom plantae includes Algae, Bryophytes, Pteridophytes, Gymnosperms and Angiosperms.

5. Animalia

Heterotrophic, eukaryotic organisms that are multicellular and cell wall is absent in the cell.

Virus, Viroids and Lichens

Five kingdom system of classification does not includes Virus, Viroids and Lichens

- Viruses are non-cellular organisms having inert crystalline structure outside the living.
- In addition to proteins, viruses also contain genetic material that could be DNA or RNA. In general, virus that infect plants have single stranded RNA and virus that infect animals have double stranded DNA.
- Bacteria feeding virus are called bacteriophage.
- Viroids are discovered by T.O. Diener as new infectious agent smaller than virus causing potato spindle tuber disease. They are free RNA without protein coat.
- Lichens are symbiotic association between algae and fungi. The algal part is called Phycobiont and fungal parts are called Mycobiont.
- The term protozoa was given by Goldfuess.
- Protozoans were observed for the first time by leeuwanhoek.
- Unicellular nature of the protozoans was recognized by von selbold.
- Dobel described protozoans as acellular animals.
- Food vacuoles in protozoans are also known as gastrioias. The term gastriole was given by volkovsky.
- Contents of food vacuoles in *Amoeba* are first acidic in nature and later alkaline.
- Hyman (1917) first proposed sol – gel theory.
- Pinocytosis in *Amoeba* was first studied by Mast and Doyle (1934).
- Giant amoeba is *Pelomyxa* or *Choas chaos.*
- Protarospongia. A colonial protozoan, a connecting link between protozoa/Protista and Porifera/Meta-zoa.
- Hydramoeba. Ectoparasitic protozoan which feeds on epidermal cells of *Hydra.*.
- If a *Amoeba* is placed in distilled water its contractile vacuole works faster.
- If an *Amoeba* is placed in salt water, its contractile vacuole disappears.
- Study of viruses is called virology. Father of virology is *Stanley* STNV is parasite on another virus.
- Pseudo virion. A pseudo virion contains host cell DNA instead of the viral genome.
- Small pox eradication programs was started by WHO in 1967.
- Viruses can be cultured on living cells by (i) host tissue culture method. (ii) Chick embryo method. Chorioallantoic membrane is widely used tissue to culture animal viruses.
- Hepatitis A virus (HAV) is most stable virus infecting humans. It can withstand heating at 56^{o}C for 30 minutes and treatment with diethyl ether.
- Most mutable virus is HIV. Second most mutable is influenza virus. TMV is most resistance virus.

3. PLANT KINGDOM

Plant Kingdom is subdivided as follows:

(A) Cryptogamae (Plants without seeds)

a. Thallophyta

b. Bryophyta

c. Pteridophyta

(B) Phanerogamae (Plants with seeds)

a. Gymnosperm

b. Angiosperm

Thallophyta – Comprises the simplest plants which possess undifferentiated or thallus like forms, reproductive organs single called gametangia. It includes only algae.

Characteristic of algae

- Plant body is thallus, which may be unicellular, colonial, filamentous or parenchymatous.
- Vascular tissues and mechanical tissue are absent.
- Reproduction is vegetative by fragmentation, asexual by spore formation (zoospores) and sexual reproduction by fusion of two gametes which may be Isogamous (*Spirogyra*) Anisogamous (*Chlamydomonous*) or Oogamous (*Volvox*).
- Life cycle is various-haplontic or diplohaplontic.
- Algae is subdivided as: Chlorophyceae, Phaecophyceae, Rhodophyceae.

Green Algae	Brown Algae	Red Algae
Mostly fresh water and sub aerial	Mostly marine	Mostly marine
Chlorophyll a and b type	Chlorophyll a and c type	Chlorophyll a and b type
Reserve food is starch	Reserve food is laminarin	Reserve food is floridean starch
Cell wall is of cellulose	Cell wall contains cellulose and algin	Cell wall contains cellulose and poly-sulphate esters
Zoospores present.	Zoospores present.	Zoospores absent
Chlamydomonas, Ulothrix, Spirogyra	*Focus, Sorgassum, ectocarpus*	*Polysiphonia, Gelidium, Porphyra etc*

Economic importance –

(i) A number of brown algae (*Laminaria, Sargassum*) are used as food in some countries.
(ii) Fungus and Laminaria are rich source of iodine.
(iii) Laminaria and Ascophyllum have antibiotic properties.
(iv) Alginic acid is obtained from fungus and liverworts that grow in moist shady region.

Bryophytes – They are non-vascular mosses and liverworts that grow in moist shady region. They are called amphibians of plants kingdom because these plants live on soil but dependent on water for sexual reproduction.

Characteristic features –

- Roots are absent but contain rhizoids
- Vegetative reproduction is by fragmentation, tubers, gemmae, buds etc. Sex organs are multicellular and jacketed. Antheridium and archegonium produce male and female gametes called antherozoids and egg or oospore.
- Sporophyte is parasite on gametophyte.
- Bryophytes divided as: Hepaticopsida(Liverworts), Bryopsida (Mosses)

Liverworts

- The thallus is dorsiventral flattened, dichotomously branched with or without leaf-like appendage.
- Unicellular rhizoids, multicellular scales and completely parasitic sporophyte or sporangium.
- Asexual reproduction takes place by fragmentation thallus or formation of specialized structure called gammae. Gemmae are given, multicellular, asexual buds, which develops in small receptacles called gemmae cups. The gemmae becomes detached from the parent body and germinate to form new individuals.
- During sexual reproduction male and female sex organs are produced on same thallus or different.
- The sporophyte is differentiated into foot, seta and capsule.

Mosses –

- The gametophyte of mosses consists of two stages the first stage is protonema stage. The second stage is the leafy stage.
- Vegatative reproduction by the fragmentation and budding in secondary protonema. A sex organ develops on leafy shoots.
- Common examples are *funaria, Polytrichum, Sphagnum* etc.

Pteridophytes –

- They are seedless vascular plants that have sporophytic plant body and inconspicuous gametophyte.
- Vascular tissue are present but vessels are absent from xylem and companion cells and sieve tube are absent.
- In some plants (*Selaginella*) compact structure called strobili or cone is formed.
- Sporangia produce spores by meiosis in spore mother cells. Spores germinate to produce multicellular thalloid, prothallus.
- Gametophyte bears male and female sex organ called antheridia and archegonia. Water is required for fertilization of male and female gametes.
- Most of Pteridophytes produce spores are of similar kind (homosporous) but in *Selginella* and *Salvinia,* spores are of two kinds (heterosporous) larger called megaspore that produce female gematophyte and smaller microspore that produce male gametes.
- Pteridophtyes Classes:
  Psilopsida (psilotum), Lycopsida (Lycopodium, Selaginella), Sphenopsida (Equisetum), Filicopsida (Pteris, Adiantum).

Gymnosperms

- Gymnosperms are those plants in which the ovules are not enclosed inside the ovary wall and remain exposed before and after fertilization.
- Stem may be unbranched (Cycas) or branched (Pinus). Root is tap. Leaves may be simple or compound.
- They are heterosporous, produce haploid microspore and megaspore in male and female Strobili respectively.
- Example-Pines, Cycas, Cedrus, Ginkgo etc.

Angiosperms

- Pollen grain and ovules are developed in specialized structure. Flower seeds enclosed inside the fruits.
- Size varies from almost microscopic Wolfia (0.1 cm) to tall tree Eucalyptus (more than 100m).
- Angiosperms divided into two classes: Dicotyledons and Monocotyleons

Monocotyledons	Dicotyledons
a. Single cotyledons.	a. Two cotyledons.
b. Parallel venation.	b. Reticulate venation.
c. Fibrous root system.	c. Tap root system.
d. Closed vascular bundle.	d. Open vascular bundle.
e. More number of vascular bundles.	e. Less number of vascular bundles.
f. Banana, wheat, rice.	f. Gram, mango, apple.

- Double fertilization- Each pollen grain produce two male gametes. One gamete fuses with egg to form embryo, Syngamy and other gametes fuse with two polar nuclei to form endosperm, triple fission. Since fertilization takes place twice so, it is called double fertilization.

Alternation of generation

Different plant groups complete their life cycles in different patterns. Angiosperms complete their life cycle in two phases- a diploid sporophytes and haploid gametophyte. The two follows each other. This phenomenon is called alternation of generation.

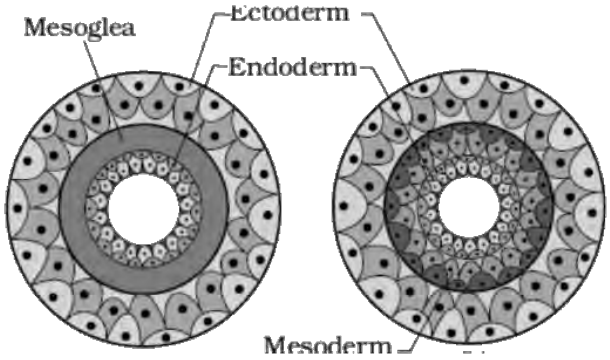
(a) Haplontic- Saprophytic generation is represented by only the one-celled zygote. Meiosis in zygote results into haploid spores to form gametophytes, which is the dominant vegetative phase. Example- Volvox, Spirogyra etc.

(b) Diplontic- Diploid sporophytes is dominant, independent, photosynthetic plants. The gametophyte is represented by single to few celled. All seed bearing plants fall under this category.

(c) Haplo-diplontic- Both phases are multicellular and intermediate condition is present. It is present in Bryophytes and Pteridophytes.

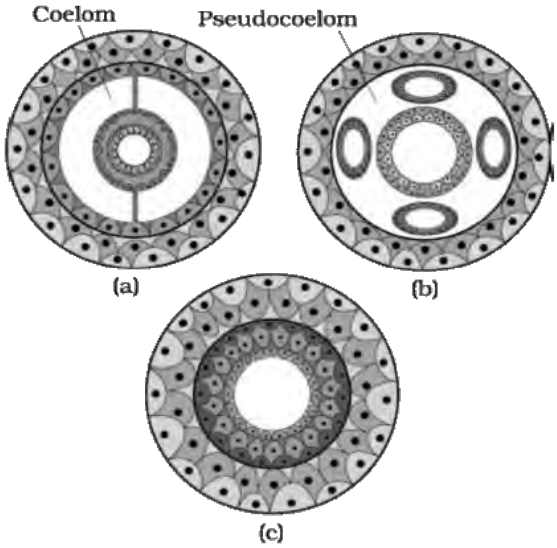
4. ANIMAL KINGDOM

- Animals are classified on the basis of arrangement of cells, body symmetry, nature of coelom, pattern of digestive, circulatory and reproductive system.
- Open circulatory system- blood is pumped out of heart and cells and tissue are directly bathed in it.
- Closed circulatory system- blood is circulated through arteries, veins and capillaries.
- The animals in which cells are arranged in two embryonic layer, external ectoderm and internal endoderm are called **diploblastic**. Eg. Porifera and Cnidaria.



- The animals in which developing embryo has a third germinal layer, mesoderm besides ectoderm and endoderm are called triploblastic. Eg. Platyhelminthes, Chordates.

The body cavity which is lined by mesoderm is called coelom. Animals possessing coelom are called **coelomate** (Annelida, Chordates, Mollusca). In some animals cavity is not lined by mesoderm but scattered as pouches in between ectoderm and endoderm, are called **pseudo-coelomates** (Aschelminthes). The animals in which body cavity is absent are called **acoelomate** (Platyhelminthes).



In some animals, body is externally and internally divided into segments with serial repetition as in earthworm, called metameric segmentation.

CLASSIFICATION OF ANIMALS

1. Phylum Porifera-

- Members of this phylum are commonly known as sponges. Mostly marine, asymmetrical and have cellular level of organization.
- They have water transport or canal system. Water enters through minute pores, **Ostia** into central cavity **Spongocoel,** from where it goes out through **Osculum.**
- Nutrition, respiration and excretion is performed by pathway of water transport system.
- Skeleton made up of spicules or spongin fibres.

- Egg and sperms are produced by same organism (hermaphrodite). Asexual reproduction by fragmentation and sexual reproduction by gametes formation.
- Example- *Sycon, Spongilla.*

2. Phylum Cnidaria (Coelenterate)-

- They are aquatic, mostly marine, sessile, free swimming, radially symmetrical animals.
- They exhibit tissue level of organization, diploblastic, coelomate with single opening.
- They show two types of body called polyp and medusa.
- Polyp is sessile, fixed, and cylindrical, without gonads such as *Hydra, Adamsia* and Medusa is free swimming, umbrella like having four gonads like *Aurelia* and *Jelly fish.*
- Some cnidarians exhibits both forms (*Obelia),* polyp produce medusa asexually and medusa produce polyp sexually.

3. **Phylum Ctenophora-**

- Commonly known as the Comb Jellies or Sea Walnuts.
- Exclusively marine, diploblastic, radially symmetrical, with tissue level of organization.
- Body bears eight ciliated comb plates which help in locomotion.
- Bioluminescence (to emit light) is present in Ctenophores.
- Hermaphrodite, fertilization external, development indirect,
- Example- *Ctenoplana, Pleurobranchia.*

4. Phylum Platyhelminthes (The Flat worms)

- Dorso-ventrally flattened body, bilaterally symmetrical, triploblastic, acoelomate with organs levels of organization.
- Hooks and sucker are present in parasitic forms. Flame cells help in osmoregulation and excretion.
- Fertilization is internal, development is indirect, hermaphrodite.
- Example- *Taenia, Planaria, Fasciola.*

5. Phylum Aschelminthes (The Round Worm)

- They may be free-living, aquatic, terrestrial or parasitic in plants or animals.
- Bilaterally symmetrical, triploblastic, pseudo coelomate.
- Alimentary canal is complete with well-developed muscular pharynx.
- Dioecious, females are longer than male.
- Example- *Ascaris* (round worm), *Wuchereria (*filarial worm), *Ancyclostoma.*

6. Phylum Annelida

- Aquatic or terrestrial, bilaterally symmetrical, segmented with organ system level of organization.
- Aquatic Annelids like *Nereis* possesses lateral appendages parapodia, for swimming. Nephridia help in osmoregulation and excretion. Neural system consists of paired ganglia.

- Dioecious (Nereis) or monocious (earthworm, leech)
- Example- Pheretima (earthworm), Hirunidaria (Blood sucking leech).

7. Phylum Arthropoda

- Largest phylum of animals which includes insects. Organ system of organization, triploblastic, coelomate, bilaterally symmetrical with chitinous exoskeleton.
- Body consists of head, thorax and abdomen, jointed appendages (jointed feet). Respiratory organs are gills, book lungs or tracheal system with open circulatory system.
- Excretion through malpighian tubules, sense organs antenna or eyes. Fertilization internal, mostly oviparous.
- Example- Economically important- *Apis* (honey bee), *Bombyx* (silk worm).
  Vectors- Anopheles, Ades, Culex (mosquito).
  Living fossils- Limulus (king crab)

8. Phylum Mollusca

- Terrestrial or aquatic, organ level of organization, bilaterally symmetrical, triploblastic and coelomate.
- Body divided into head, muscular foot and visceral hump. Unregimented and covered with calcareous shell.
- Feather like gills are present between hump and mantle.
- Mouth contains file like rasping organ for feeding called radula.
- Example- *Pila, Octopus.*

9. Phylum Echinodermata (The Spiny Skinned Animals)

- Endoskeleton of calcareous ossicles, marine with organ system of organization.
- Triploblastic, coelomate, presence of water vascular system help in locomotion, capture of food and respiration.
- Sexes are separate, fertilization is external and development is indirect.
- Example- Asterias (Star fish), Cucumaria (Sea cucumber), Antedon (Sea lily).

10.Phylum Hemichordata

- Worm-like marine animals with organ system of organization, bilaterally symmetrical, triploblastic and coelomate animals.
- Body is cylindrical, composed of anterior proboscis, a collar and a long trunk.
- Open circulatory system, respiration by gills, excretory organ is proboscis glands.
- Sex separate, fertilization is external, indirect development.
- Example- *Balanoglossus, Saccoglossus.*

11.Phylum Chordates

- Presence of notochord, a dorsal hollow nerve chord and paired pharyngeal gill slits.
- Bilaterally symmetrical, triploblastic, coelomate with organs system levels of organization.
- Closed circulatory system, ventral heart, post-anal tail is present.
- Subphylums are Urochordata, Cephalochordata, Vertebrata.
- In **Urochordata,** notochord is present only in larval tail.
- In **Cephalochordate** it extends from head to tail and persists throughout the life.
- **Vertebrata** possesses notochord in embryonic period which is replaced by vertebral column in the adults.
- **Sub-phylum Vertebrata is** further divided into two division **Agnatha** (lacks jaw) and **Gnathostomata** (bears jaw).
- **Gnathostomata** is further divided into two super class- **Pisces** (bears fins) and **Tetrapoda** (bears limbs).

Class Cyclostomata (Circular mouthed fishes)-

- They are ectoparasites on some fishes. Having sucking and circular mouth without jaws.
- Body devoid of scales, gill slits for respiration, cranium and vertebral column is cartilaginous.
- Circulation is closed type. They are marine but migrate to fresh water for spawning and die after few days. Larva return to seas after metamorphosis.
- Example- Petromyzon (Lamprey), Maxine (Hag fish).

Class Chondrichithyes (The Cartilaginous Fish)

- They are marine, streamlined body, bears cartilaginous endoskeleton, cold blooded, tough skin with minute placoid scales.
- Gill slits are separate with operculum, powerful jaw and predator.
- Air bladder is absent, to avoid sinking swims constantly. Heart is two chambered, cold blooded (Poikilothermus).
- Sexes separate, in males pelvic fins bears claspers. Internal fertilization, many are viviparous.
- **Electric organ** is present in *Torpedo* and **Poison sting** in *Trygon*
  Example- *Scoliodon* (Dog fish), *Carcharodron* (great white shark).

Class Ostechthyes (The body fish)

- Marine and fresh water both with bony endoskeleton. Streamlined body with four pair of gills covered by operculum.
- Skin is covered with scales, air bladder is present, and heart is two chambered, cold blooded.
- Sexes are separate, fertilization is external, oviparous and development direct.
  Example: Marine- *Hippocampus* (Sea horse), *Exocoetus* (Flying fish).
  Fresh water- *Labeo* (Rohu), *Catla , Clarias* (Magur).

Class Tetrapoda:
Subdivided as: Amphibia, Reptilia, Aves, Mammals.

Amphibia	Reptilia	Aves	Mammals

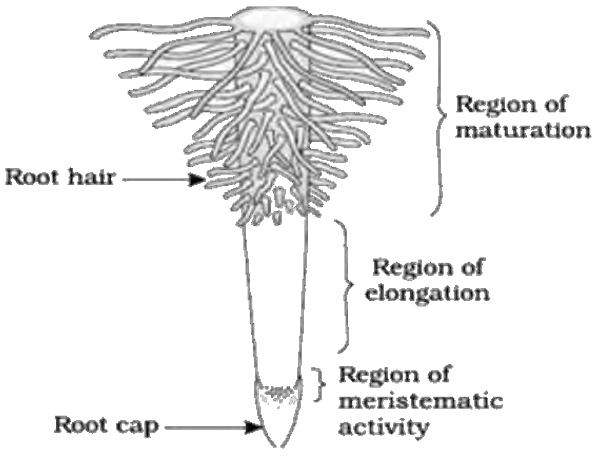
Lives in aquatic as well as terrestrial habitat.	Mostly terrestrial animals.	Presence of feathers for flying.	Mostly terrestrial, a few can fly and live in water.
Two pairs of limbs.	Limbs two pair if present.	Forelimb is modified into wings.	Two pair of limbs.
Moist skin without scales.	Dry and cornified skin having scale or scute.	Skin is dry without glands. Long bones are hollow with air cavities.	Mammary gland is present to produce milk. Skin possesses hairs.
Respiration by gills, lungs or skin.	Respiration by lungs.	Respiration by lungs.	Respiration by lungs.
Heart three chambered, cold blooded.	Heart three chambered, Crocodile 4-chambered.	Heart is four chambered, warm blooded.	Heart is four chambered.
Oviparous.	Oviparous.	Oviparous.	Viviparous or Oviparous.
Rana (frog), Salamander.	*Chamelion, Crocodilus, Naja*	*Columba, Pavo,* Ostrich.	Platypus(oviparous), Camel, Dog, Blue whale.

5. MORPHOLOGY OF FLOWERING PLANTS

The Root

- In Dicotyledons, elongation of radicle forms the primary roots which bears lateral roots of several orders called secondary roots, tertiary roots etc.
- Primary roots along with lateral roots forms the **Tap root system.** Mustard, Gram etc.
- In monocotyledons, primary root is replaced by large number of roots at its base of stem to constitute the **Fibrous root system.** Wheat, rice etc.
- The roots that arise from other parts of plant beside radicle are called **adventitious roots.** Example- Grass, Banyan tree, Maize etc.

Regions of Roots-



Modification of roots- Roots are modified for storage, nitrogen fixation, aeration and support.

- Tap root of carrot (conical tap root), radish (fusiform tap root), turnip (napiform tap root) and adventitious root of sweet potato get swollen to store food.
- Prop root of Banyan and Stilt root of maize and sugarcane have supporting root coming out from lower node of stems.
- In Rhizophora, Pneumatophores help to get oxygen for respiration as it grows in swampy areas.

The Stem

- It develops from Plumule of the embryo.
- Stem bears nodes and internodes. The region of stem where leaves are born called nodes and portion between two nodes are called internodes.

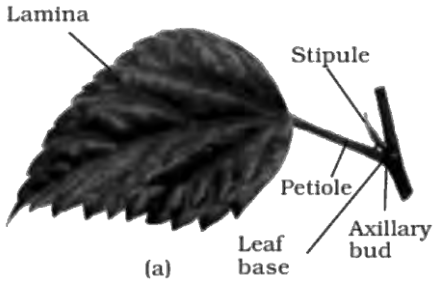
Modification of stems-

- Underground stem modifications act as organ of perennation in unfavorable conditions.

Types are as follows:
Sucker: Mint, Chrysanthemum
Rhizome: Ginger
Corm: Colocasia
Tuber: Potato
Bulb: Onions, Garlic

- Stem tendril help plants to climb as in cucumber, pumpkins, and grapes.
- Axillary buds of stem may modify into woody, straight and pointed thorns as in Citrus and Bougainvillea.

The Leaf –



- Leaf is a green, dissimilar exogenous lateral flattened outgrowth which is borne on the node of a stem or its branches.
- Leaves originate from shoot apical meristem and are arranged in an acropetal order.
- A typical leaf consists of three parts- Leaf base, Petiole, Lamina.
- Leaf is attached with stem by Leaf Base which may bear two small leaf like structure called stipule.

- Middle prominent vein is called mid vein.
- The arrangement of vein and veinlets in the lamina is called venation.

Reticulate venation	Parallel venation
a. Veinlets form a near network.	a. A network is absent.
b. Veins are irregularly distributed.	b. Veins are parallel to one another.
c. It is present in all Dicotyledons like Gram, Pea, Beans, and Mango etc.	c. It is present in Monocotyledons like Grass, Banana, Rice etc.

Types of Leaves

(a) Simple Leaves
(b) Compound leaves: Pinnately compound leaves and Palmately compound leaves

- The pattern of arrangement of leaves on the stem or branch is called **Phyllotaxy.**
- In **alternate type of phyllotaxy** single leaf arise at each node as in China rose.
- In **opposite type of phyllotaxy** a pair of leaves arise from each node opposite to each other as in Guava.
- If more than two leaves arise at a node and form a whorl is called **whorled type** of phyllotaxy as in Alastonia.

Inflorescence

The arrangement of flowers on the floral axis is termed as inflorescence. Two main types of inflorescence are racemose and cymose.

The flower

- A typical flower has four whorls arranged on a swollen end of stalk or pedicel called **thalamus.** They are **Calyx, Corolla, Androecium and Gynoecium.**
- When flower can be divided into two equal radial halves in any radii passing through center the symmetry of flower is called actinomorphic
- When flower can be divided into two similar parts only in one vertical plane it is **zygomorphic**
- Floral appendages are in multiple of 3,4 or 5 they are called **trimerous, tetramerous** and **pentamerous** respectively. Flower with reduced small leaf at the base of pedicel are called **bracteates** and without it **ebracteate.**
- Based on the position of ovary with respect to other floral part on thalamus flowers are of following types:
  (a). Hypogynous flower
  (b). Perigynous flowers
  (c). Epigynous flowers

Calyx is the outermost whorls of the flower ; its members are called sepals.
It may be gamosepalous (sepals united) or polysepalous (sepals free).

Corolla consists of petals, they may be gamopetalous or polypetalous.

- The mode of arrangement of sepals or petals in floral bud with respect to the other members of same whorl is called aestivation.

- Types are: Valvate, Twisted, Imbricate, and Vaxillary aestivation.

The Androecium

- Androecium represent the male reproductive parts of flower, consists of stamens. Each stamen consists of filament and anther. Sterile stamen is called **Stemenode.**
- When stamens are attached with petals it is called epipetalous (Brinjal).
- Stamen may be free (polyandrous) or may be united in one bundle (monoadelphous), two bundles (diadelphous), more than two (polyadelphous).

The Gynoecium

- Female reproductive part of flower consists of one or more carpels. Each carpel is made up of stigma style and ovary.
- When more than one carpel is present, it may be free (**apocarpous**) as in lotus and rose or fused together (**syncarpous**) as in mustard and tomato.

Placentation

- The arrangement of ovules within the ovary is called placentation.
- Types are:

a) Marginal (pea)
b) Axle (china rose)
c) Parietal (mustard)
d) Free central (dianthes)
e) Basal (sunflower)

The fruit

- Mature and ripened ovary developed after fertilization is fruit. If a fruit is formed without fertilization of ovary it is called **parthenocarpic fruit.**
- Fruit consists of seeds and pericarp. Thick and fleshy pericarp is three layered called epicarp, mesocarp and endocarp.

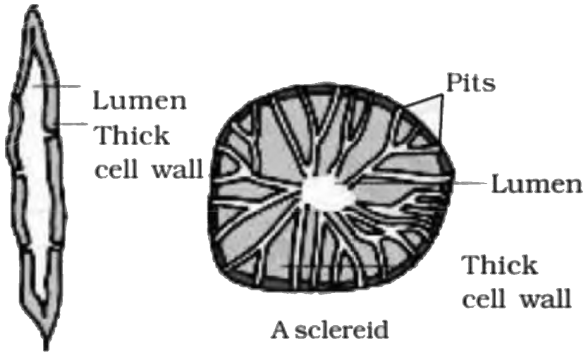
The Seed

- Dicotyledonous Seed is made up of a seed coat and an embryo. Embryo is made up of embryonal axis, radicle and cotyledons.
- Seed coat has two layers outer **testa** and inner **tegmen**. Hilum is scar through which seed is attached to the ovary. Small pore above the hilum is called micropyle.
- In monocotyledonous seed, outer covering of endosperm separate the embryo by a protienous layer called **aleurone layer.**
- Single cotyledon is called as scutellum having a short axis bearing Plumule and radicle.
- Plumule and radicle are closed inside sheaths called as coleoptile and coleorhizae respectively.

6. ANATOMY OF FLOWERING PLANTS

The tissue

- A group of cells having a common origin and usually performing common function are called tissues.
- Plant tissues divided as:
- Meristematic Tissue: a). Apical Meristem
  b). Intercalary Meristem
  c). Lateral Meristem
- Permanent Tissue:
  1. Simple Permanent Tissue: a). Parenchyma
     b). Collenchyma
     c). Sclerenchyma
  2. Complex Permanent Tissue: a). Xylem
     b). Phloem
- **Parenchyma** is a simple permanent living tissue
- **Collenchyma** Consists of cells which are much thickened at corner due to cellulose, hemicelluloses and pectin. They provide mechanical support to the growing parts of the plant like young stem.
- **Sclerenchymas** are supportive tissue having highly thick walled cells with little or no protoplasm due to deposition of cellulose or lignin. They are of two types fibres and sclereids.



Complex Tissues – Xylem and phloem constitute the complex tissues in plants and work together as a unit.

Xylem	Phloem
(a). It conducts water or sap.	(a). Phloem conducts organic food.
(b) Xylem is made up of vessels, tracheid, xylem fibre and xylem parenchyma.	(b). Phloem is made up of sieve tube, companion cells, phloem parenchyma and phloem fibres.

- Primary xylem is of two types – Protoxylem and mataxylem.
- In gymnosperms, albuminous cells and sieve cells, they lack sieve tube and companion cells.

Epidermal Tissue System

- It forms the outermost covering of whole plant body, which consists of epidermal cells, stomata, epidermal appendages (trichomes and hairs).
- In dicots, stomata are bean-shaped having two guard cells closing the stomatal pore. In monocots, stoma is dumbbell-shaped. Guard cells contain chloroplasts that help in opening and closing of stomata.
- Trichomes are present on stems, which are multicellular, branched or unbranched preventing water loss due to transpiration.

The ground Tissue System

- All the tissue between epidermis and vascular bundle forms the ground tissues.
- Leaves the mesophyll, chloroplast containing cell forms the ground tissues.

The Vascular Tissue System

- The vascular system consists of complex tissue, xylem and phloem that together form vascular bundles.
- Open vascular bundle (cambium between xylem and phloem) found in dicot stem.
- Closed vascular bundle (cambium absent between xylem and phloem) found in moncot stem.

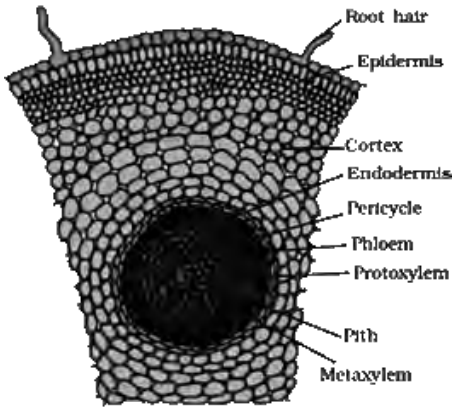
- When xylem and phloem within a vascular bundle are arranged in alternate manner on different radii, the arrangement are called radial as in roots.
- When xylem and phloem are situated at the same radius of vascular bundle, it is called conjoint as in stem and leaves.

Dicotyledonous Root

- The outermost layer of dicot root is epidermis containing unicellular root hairs.
- The innermost layer of cortex is called endodermis having waxy material suberin as casparian strips.
- Pericycle is present below endodermis.
- Two to four xylem and phloem patches are present.

Monocotyledonous Roots

- Anatomically monocots roots epidermis cortex, endodermis, pith are similar to dicots except having more than 6 vascular bundles with larger pith.



Dicotyledonous Stem

- Epidermis is the outermost layer of dicot stems having thin layer of cuticle, may contain trichomes and hairs.
- Cortex is divided into three sub layers- outer hypodermis (collenchymatous), middle cortical layer (parenchymatous) and inner endodermis, which is rich in starch grains so, also known as starch sheath.
- Vascular bundles are conjoint, open, endarch with protoxylem. Pith is the parenchymatous with intercellular spaces.

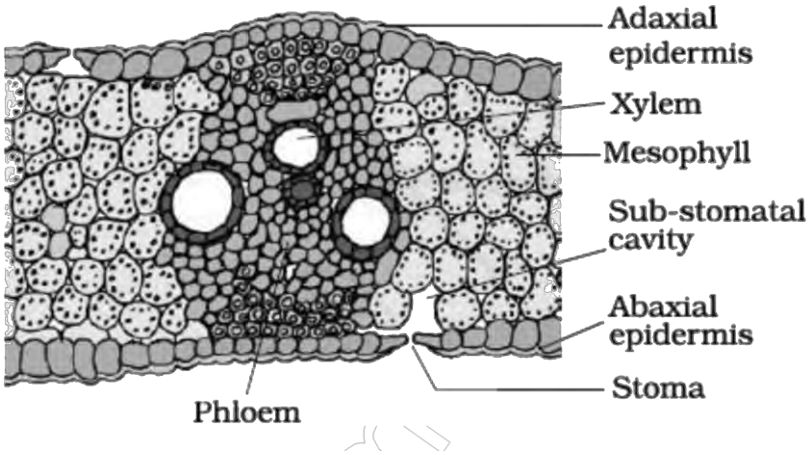
Monocotyledonous Stem

- They have sclerenchymatous hypodermis, large number of scattered vascular bundles surrounded by sclerenchymatous bundle sheath. Vascular bundles closed and conjoint. Phloem parenchyma is absent.

Dicotyledonous Leaf (Dorsi-ventral)

- Epidermis covers both upper (adaxial) and lower (abaxial) surface. Abaxial surface have more stomata.
- Mesophyll bears chlorophyll to carryout photosynthesis, are made up of parenchyma. Spongy parenchyma are spherical and loosely arranged but palisade parenchyma are elongated.
- Vascular system includes vascular bundles, which are seen as veins and midribs.

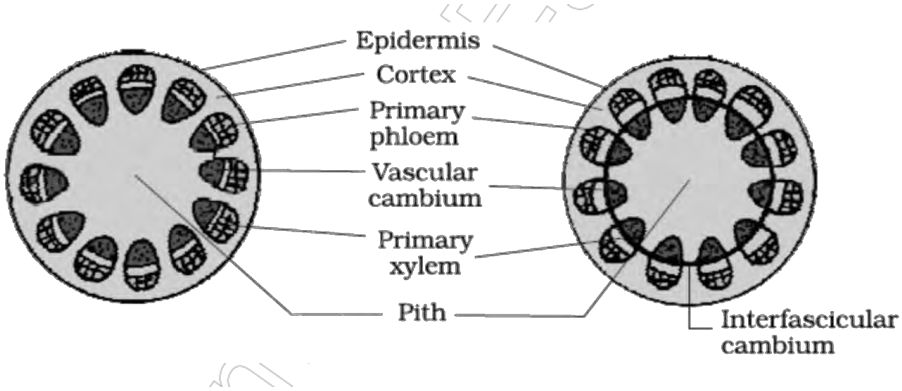
Monocotyledonous leaf (Isobilateral)



- Stomata are present on both surfaces of epidermis and mesophyll cells are not differentiated as spongy and palisade cells.
- In grasses, some adaxial epidermal cell with veins modify into large, empty, colourless cells called bulliform cells.

Secondary Growth

- It is the growth in girth (thickness) due to the formation of secondary tissues by lateral meristems (vesicular cambium and cork cambium).
- In dicot stem, cambium present between xylem and phloem is called **intrafascicular cambium.** The cells of medullary rays become meristematic to form **interfascicular cambium**, which together form the complete ring of cambium.



- Cork cambium or phellogen is formed in the outer cortex of stem.
- Cork is impervious to water due to deposition of suberin in cell wall. Phellogen, phellem and phelloderm are collectively called periderm.
- Secondary growth also occurs in stem and root of Gymnosperms but not in monocotyledons.

7. STRUCTURAL ORGANIZATION IN ANIMALS

Epithelial Tissue

This tissue provides covering or lining for some part of the body. Types of tissues are:

- **Simple epithelium**
- **The compound epithelium**
- **The squamous epithelium**
- **Cuboidal epithelium**
- **Columnar epitheliums**
- **Columnar ciliated epithelium**
- Columnar and cuboidal epithelium specialized for secretion are known as glandular epithelium, which may be unicellular as in goblet cells of alimentary canal or multicellular as in salivary gland.

Connective Tissues

They are most abundant and widely distributed tissues which link and support the other tissues. All connective tissue except blood, cell secretes fibres of structural protein called collagen or elastin to provide elasticity and flexibility.

- **Loose Connective Tissues** contain cells and fibres loosely arranged in semi-fluid ground substance. It includes areolar tissue and adipose tissue.

Areolar Connective Tissue	Adipose Connective Tissue
It contains fibroblast, macrophages and mast cells	Fibroblast, macrophages and mast cells are absent.

- **Dense connective Tissue** contains fibres and fibroblast compactly packed. The orientation of fibres may be regular or irregular pattern.

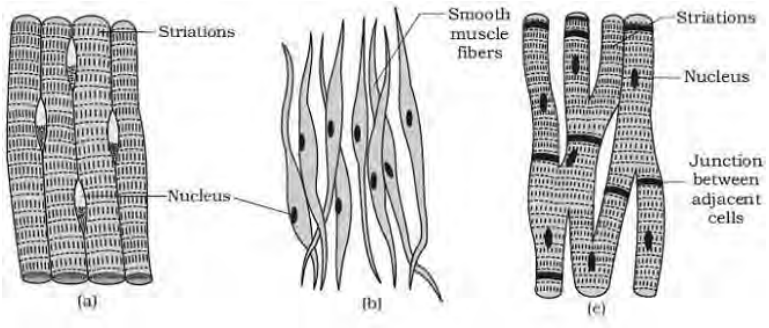
Cartilage	Bone
They are soft skeletal tissue	Bones are hard skeletal tissue
Chondriocyctes are enclosed in small cavities with matrix	They are rich in Calcium salt and collagen fibres
They are present in tips of nose, outer ear, between vertebral bones	They form the skeletal framework of vertebrates like limbs, legs etc.

- Blood is fluid connective tissue containing plasma, red blood cells, white blood cells and platelets.

Muscle Tissue

Each muscle is made up of long cylindrical fibres arranged parallel to each other. Fibres are composed

of fine fibrils called myofibrils. Muscle fibres contract and relax in response to stimulation.



Skeletal	Smooth	Cardiac
They are also known as striated, voluntary muscles.	They are known as unstriated or involuntary muscles.	They are known as heart muscles and involuntary in nature.
Multinucleated with light and dark bands.	They are uninucleate without bands.	Uninucleate with faint light and dark bands.
They are attached with bones	Present in vessels, esophagus.	Present in wall of heart.
Fibrous and un-branched, cylindrical in shape	Fibrous and un-branched, spindle shaped	Fibrous and branched, cylindrical in shape.

Neural Tissue

The unit of neural system is neuron. Neuroglial cell protect and supports the neuron.

Earthworm

- The common Indian earthworms are *Pheretima* and *Lumbricus.*
- Earthworms have long cylindrical body divided into segments called metameres. The ventral surface contain genital pore and dorsal surface contain mid dorsal line.
- First body segment is called **peristomium** which contain mouth. 14-16 segments are covered by dark band called **clitellum**.
- Single genital pore is present on mid ventral line of 14^{th} segments. A pair of male genital pore is present on 18^{th} segment on ventro-lateral side.
- All the segment except 1^{st}, last and clitellum contain S-shaped setae for locomotion.
- Alimentary canal is straight tube from 1^{st} to last segment having, buccal cavity, muscular pharynx, oesophagus that leads to gizzards, which help in grinding the soil particles and decaying leaves. Stomach and small intestine leads to anus.
- Closed vascular system consists of heart, blood vessels and capillaries. Earthworms lack respiratory organs and respire through moist skin.
- Excretory organs is coiled segmental tubules called nephridia. There are three types of nephridia. Septal nephridia, integumentary nephridia and pharyngeal nephridia.
- Earthworm is hermaphrodite. Two pairs of testis is present 10th and 11th segment. Prostrate and spematic duct open to surface as male genital pore on 18th segment.
- One pair of ovaries is attached to the intersegmental septum of 12th and 13th segments. Female genital pore open on ventral side of 14th segment. Mutual exchange of sperms takes place during mating.
- Mature sperms and egg cells along with nutritive materials are deposited in cocoon in the soil where fertilization takes place.

Cockroach (Periplaneta Americana)

- Cockroaches are nocturnal omnivorous organism that lives in damp places everywhere. The body of cockroach is segmented and divisible into **head, thorax and abdomen**. The body is covered by hard chitinous exoskeleton.
- Head is triangular in shape formed by fusion of six segments to show flexibility. Head bears compound eyes. Antenna attached on head help in monitoring the environment.
- Thorax consists of three parts- prothorax, mesothorax and metathorax. Forewings and hind wings are attached with thorax. Abdomen consists of 10 segments.

Digestive System of Cockroach-

- Alimentary canal is divided into foregut, midgut and hindgut. Food is stored in crop used for storing the food. Gizzard help in grinding the food particles.
- At the junction of midgut and hindgut yellow coloured filamentous Malpighian tubules are present which help in excretion.
- Blood vascular system is open type having poorly developed blood vessels. The haemolymph contains colourless plasma and haemocycts.
- Respiratory system consists of network of trachea which open through 10 pairs of spiracles on lateral side.

- Cockroaches are dioecious. Male reproductive system consists of a pair of testes one lying on each lateral side in 4^{th} – 6^{th} abdominal segments. The female reproductive system consists of two large ovaries situated on 2^{nd} – 6^{th} abdominal segments.
- The fertilized eggs are encased in capsule called ootheacea. 9 to 10 ootheace are produced by each female.

Frog (Rana tigrina)

Frogs are cold-blooded organism having ability to change colours to hide from enemies. Body is divisible into head and trunk, bulged eyes covered by nictating membrane. Male frog is different from female having vocal sacs and copulatory pad on first digit of forelimb.

- Digestive system consists of alimentary canal and digestive glands.
- Skin acts as aquatic respiratory organs. On land skin, buccal cavity and lungs acts as respiratory organs.
- Heart is 3-chambered. Blood consist of plasma and blood cells. RBC is absent.

8. CELL: STRUCTURE AND FUNCTIONS

- Study of form, structure, and composition of cell is called **cytology**.
- Cell is the structural and functional unit of life.
- Melthias Schleiden and Theodore Schwann(1938) proposed the cell theory.
  (a). All living organisms are composed of cells and products of cells.
  (b). All cells arise from pre-existing cells.

Prokaryotic cells	Eukaryotic cells
(i) Membrane bound nucleus is absent.	(i) Membrane bound nucleus is present.
(ii) Single chromosome is present.	(ii) More than one chromosome is present.
(iii) Membrane bound organelles are absent.	(iii) Membrane bound organelles are present.

Mycoplasma is the smallest cell and largest isolated cell is the ostrich egg.

Prokaryotic Cells

- Prokaryotic cells are represented by Bacteria, Blue green algae, Mycoplasma and PPLO. They multiply rapidly and vary in size greatly.
  All prokaryotic cells have cell wall surrounding the cell membrane except in Mycoplasma.
  Genetic material is naked.
- Cell organelles like Mitochondria, Golgi bodies etc. are absent in prokaryotes. A specialized differentiated cell membrane called Mesosome is the characteristic of prokaryotes.
- In bacterial cell a chemically complex cell envelope is present, which consist of three layers. The outermost is Glycocalyx, middle one cell wall and inner innermost is the cell membrane.
- Glycocalyax may be as loose sheath in some bacteria called **slime layer**. In some other bacteria Glycocalyx may be thick and tough called **capsule**.

- Plasma membrane is semi-permeable having mesosome in form of vesicles, tubules and lamellae. They help in cell wall formation, DNA replication and distribution to daughter cells.
- Motile bacterial cell contain flagella, which is composed of filament, hook and basal body. Pili and fimbriae are the other surface structure that help the bacteria in attach with host and other substance.
- In prokaryotes, ribosome are attached with cell membrane having two sub-units – 50S and 30S to form together 70S prokaryotic ribosomes.
- Ribosomes are site of protein synthesis. Ribosomes attached with mRNA to form a chain called polyribosomes.
- Reserved materials in prokaryotic cells are present in cytoplasm as cell inclusion bodies, which may contain phosphate, granules, glycogen granules etc.
- Gas vacuoles are found in blue green algae and purple and green photosynthetic bacteria.

Eukaryotic Cell

- Eukaryotic cells are present in Protista, plants, Animals and Fungi.
- Plants cells differ in having cell wall, plastids and large central vacuole as compared to animal cells. Animal cells have centrioles, which are absent in plant cells.
- **Cell membrane** is composed of lipids and that are arranged in bilayer. A lipid component is mainly composed on phosphoglycerides. Later it was found that protein is also present in cell membrane. Ratio of protein and lipids varies in different cells.
- Membrane protein may be integral or peripheral. Integral protein remains buried in membrane but peripheral protein lies of surface.
- Singer and Nicholson (1972) proposed **fluid mosaic model.** According to this model the quasi-fluid nature of lipid enables lateral movement of within the bilayer of lipids.

- The main function of plasma membrane is the transport of molecules across it.

Active Transport	**Passive Transport**
(a). The transport involves an expenditure of energy by the cells	(a). The cells do not spend energy in passive transport.
(b). It occurs against the concentration gradient.	(b). It always occurs along the concentration gradient.
(c). It is rapid process	(c). It is comparatively slow process.

- The movement of water from higher concentration to lower concentration by diffusion is called **osmosis.**
- Cell wall is present in plant cells and fungi. Algae have cell wall made up of cellulose, galactans and minerals like calcium carbonate.
- Plasmodesmata connect the cytoplasm of neighboring cells.
- Endomembrane system of cell includes endoplasmic reticulum, golgi complex, lysosomes and vacuoles.

Endoplasmic Reticulum

Are the tubular scattered structure scattered in the cytoplasm.
(i) Rough endoplasmic reticulum bears ribosomes on its surface. RER is involved in protein synthesis and secretion.
(ii) Smooth endoplasmic reticulum does not bear ribosomes on its surface. SER is involved in lipid synthesis and steroidal hormones.

Golgi apparatus was first observed by Camillo Golgi in 1898 near nucleus. Golgi apparatus is the site for synthesis of Glycoprotiens and glycolipids.

Lysosomes are membrane bound vesicular structure formed by process of packaging in the Golgi apparatus. They are rich in hydrolytic enzyme- lipase, protease, carbohydrases active at acidic pH. These enzymes are capable of digesting carbohydrates, proteins, lipids and nucleic acids.

Vacuoles are membrane bound space found in cytoplasm water, sap and excretory product bounded by single membrane. They form contractile vacuole and food vacuole in many organisms.

Mitochondria double membrane bound structure with the outer membrane and inner membrane dividing its lumen in two compartments. The inner membrane forms a number of infoldings called cristae towards the matrix. Mitochondria are sites for aerobic respiration.

Plastids are found only in plant cells and Eugleoids having specific pigments to provide colours to plants parts.

- **Chloroplast** contains chlorophyll that traps solar energy for photosynthesis. Chromoplast provides yellow, orange and red colours to different parts of plants.
- **Leucoplasts** are colourless plastids that store food, amyloplasts (carbohydrates), elaioplasts (oils) and aleuroplasts (proteins).

Chloroplasts are double membrane structure. The space limited by inner membrane is called stroma. Thylakoids are present in stroma as stacks like the piles of coins called grana.
Stroma contain enzyme for synthesis of protein and carbohydrates. Double strand circular DNA and ribosomes are also present in stroma.
Ribosomes are granular structure of 80S.

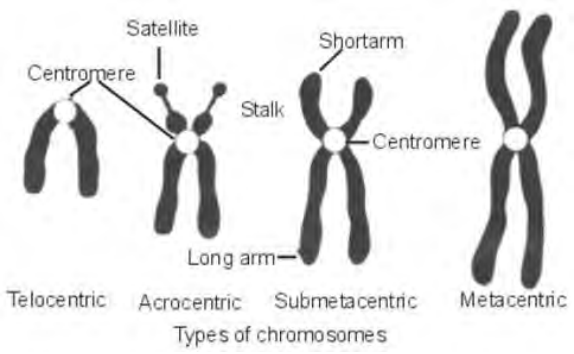
Centrosomes is an organelles containing two cylindrical structures called centrioles. Each centrioles is made up of 9 fibrils of tubulin protein. Central parts of centriole is called hub and peripheral fibrils are called spokes .

Nucleus has highly extended, elaborate nucleoprotein fibres called chromatin, nuclear matrix and nucleoli. The outer membrane is continuous with endoplasmic reticulum and bears ribosomes.

The chromatin materials change into chromosome during active cell division consists of DNA and histone proteins.

Every chromosome has a primary constriction or the centromere, on the sides of which disc shaped kinetochores are present.

On the basis of position of centromere chromosomes are of following types-

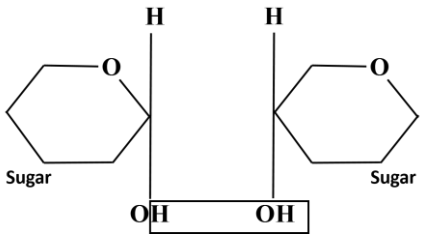


Types of chromosomes

- Some chromosomes have non-staining secondary contraction at certain location. This give a small fragment called satellite.

9. BIOMOLECULES

- Chemicals or molecules present in the living organism are known as biomolecules. Biomolecules are divided into two types- inorganic and organic.
- Inorganic biomolecules includes minerals, gases and water and organic biomolecules includes carbohydrates, fats, proteins, nucleic acids, vitamins etc.
- Proteins are polymers of amino acids.
- In nucleic acids, the phosphate molecules links 3' C of sugar of one nucleoside to the 5' C of sugar of next nucleosides releasing two water molecules to form 3'-5' phosphodiester bond.
- In polysaccharides, the mono-saccharides are linked by glycosidic bonds formed by dehydration between two carbon atoms of two adjacent monosaccharaides.



Carbohydrates (Polysaccharides)

- Polysaccharides are long chain of sugar containing different monosaccharaides as a building block.
- Starch is present in plants as store house of energy in plants. It forms helical secondary structure to hold the I_2 molecules.
- Cellulose molecules contain glucose molecules joined together by 1-4 β linkage. It is the most abundant organic molecules on earth.
- Glycogen is called animal starch as it is the reserve food materials for animals, bacteria and fungi. Glucose molecules are arranged in highly branched bush like chain having two types of linkage 1-4 α in straight chain and 1-6 linkage in branching.

Proteins

These are polypeptide chains made up of amino acids. There are 20 types of amino acids joined together by peptide bond between amino and carboxylic group. There are two kinds of amino acids.
(a). Essential amino acids are obtained by living organism along with food.
(b). Non-essential amino acids can be prepared by our body from raw materials.

Collagen is the most abundant protein in animal world.
Primary structure of protein is the basic structure of protein in which a number of polypeptides are involved having sequence of amino acids.
Secondary structure protein threads forms helix. There are three types of secondary structure- α helix, β pleated and collagen.
In Tertiary structure long protein chain is folded upon itself like a hollow woolen ball to give three dimensional view of proteins.
In Quaternary structure each polypeptide develops its own tertiary structure and function as subunit of protein. Eg. Hemoglobin.
Nucleic Acid

Nucleic acids are polynucleotides. A nucleic acid has three chemically distinct components- heterocyclic compound (nitrogenous base), polysaccharides (ribose/ deoxy-ribose sugar) and phosphate or phosphoric acid. There are two kinds of nitrogenous bases - purines and pyrimidines.
Purines: Adenine and Guanine
Pyrimidines: Cytosine,Thymine and Uracil.
The sugar found in nucleic acid is either ribose or deoxyribose.
Nucleic acid containing deoxyribose sugar is called DNA (Deoxyribonucleic Acid) and those containing ribose sugars are called RNA (Ribonucleic acid).

Metabolic Basis for living organism: The metabolic pathways that lead to more complex structure from simpler structure are called biosynthetic or anabolic pathways and those pathways that lead to simpler structure from complex structure are called catabolic pathways.

Enzymes

- Enzymes are commonly proteinaceous substances which are capable of catalyzing chemical reactions of biological origin without themselves undergoing any change, commonly called as biocatalysts.
  The nucleic acids that behave like enzymes are called ribozymes.
- The major difference between inorganic and organic catalyst is inorganic catalyst works effectively at high temperature and pressure but enzyme get damaged at high temperature.
- The external energy required to start a chemical reaction is called activation energy.

Factors influencing Enzyme Activity
(a). **Temperature**
(b)**. pH**
(c) Concentration of Substrate

Competitive Inhibitor- When the molecular structure of inhibitor resembles the substrate that inhibits the function of enzymes.

- Enzymes are classified as
  - **Oxidoreductases/Dehydrogenases -**
  - **Transferases**
  - **Hydrolases**
  - **Lyases**
  - **Isomerases**
  - **LIgases**

Co-factors are the non-protein constituent of an enzyme to make the enzyme catalytically more active. The protein portions of enzyme are called apoenzymes.
There are two types of cofactors: Coenzymes Prosthetic groups.
The essential chemical components of any coenzymes are vitamins. As NAD and NADP contains vitamins niacin.

10. CELL CYCLE AND CELL DIVISION

Phases of Cell cycle

Human cell divides once in approximately 24 hours, which may vary in different organisms. In yeasts it takes about 90 minutes to complete the cell division process.

(a). Interphase- It is the phase between two successive M phases. Interphase lasts for 95% of a cell cycle. This phase is called as resting phase but during this period the cells prepare its self for nuclear division by cell growth.

(b). M Phase- When the actual cell division or mitosis occurs. It starts with karyokinesis (nuclear division) or duplication of chromosome and end with cytokinesis or division of cell matrix (cytoplasm division).

- G_1 phase represents the interval between mitosis and initiation of DNA replication.
- During S phase, replication or synthesis of DNA takes place and amount of DNA get doubles per cell.
- During G_2 phase protein is synthesized in preparation for mitosis.
- In adult animals, some cells do not divide or may divide occasionally. These cells do not divide further and exits the G_1 phase to enter an inactive stage called **Quiescent Stage** (G_0) of cell cycle.
- Mitosis cell division is also known as **equational division.**

Prophase is the first phase of mitosis followed by G2 phase. It involves following events-

(a) Initiation of condensation of chromosomal materials.
(b) Movement of centrioles towards opposite poles of the cell.
(c) At the end of prophase, endoplasmic reticulum, nuclear membrane, Golgi complex disappears.

Metaphase starts with complete disappearance of nuclear membrane. The most suitable stage for study of morphology of chromosomes. It involves

(a) Condensation of chromosomal materials in to compact and distinct chromosomes made up of two sister chromatids attached with spindle fibres with kinetochores.
(b) Chromosomes arrange at centre of cell called metaphase plate.

Anaphase involves the

(a) Splitting of each chromosome at centromere into two sister chromatids.

(b) Two chromatids start moving towards opposite poles.

Telophase is the last stage of mitosis which involves

(a) Chromosomes reach at opposite poles and loose its identity as discrete unit.
(b) Nuclear membrane reassembles around the chromosome clusters.
(c) Nucleolus, Golgi complex and ER reappear.

Cytokinesis is the division of cytoplasm of a cell after karyokinesis (division of chromosome) into two daughter cells.

Meiosis

The cell division that reduce the number of chromosome half and results in the production of haploid daughter cells. It helps in production of haploid phase of life cycle of sexually reproducing organism. It involves following events.

(a) Two sequential cycles of nuclear and cell division called meiosis I and meiosis II but single cycle of DNA replication.
(b) It involves pairing of homologous chromosome and recombination of them.
(c) Four haploid cells are formed at the end of meiosis II.

Meiosis I	Meiosis II
Prophase I	Prophase II
Metaphase I	Metaphase II
Anaphase I	Anaphase II
Telophase I	Telophase II

Meiosis I

Prophase I of Meiosis is the first stage of meiosis and is defined by five different phases; Leptotene, Zygotene, Pachytene, Diplotene and Diakinesis.
In metaphase I, the bivalent chromosome align at equatorial plate and microtubules from the opposite poles of the spindle attached to the pair of homologous chromosomes.
In Anaphase I, homologous chromosome separate but sister chromatids remain attached at centromere.
During Telophase I, nuclear membrane and nucleolus reappears and cytokinesis follows. This is called as dyad of the cells.
The stage between two meiotic divisions is called **interkinesis** and it is short lived that follows Prophase II.

Meiosis II

It is initiated immediately after cytokinesis before chromosome gets elongated.

In prophase II, nuclear membrane disappears and chromosome becomes compact.
At metaphase II stage, the chromosomes align at equator and microtubules attach with kinetochores of sister chromatids.
Anaphase II start with splitting of centromere of each chromosome to move towards opposite poles.
Meiosis ends with Telophase II in which two groups of chromosomes get enclosed by nuclear membrane followed by cytokinesis to form tetrad of cells (four daughter cells).

11 TRANSPORT IN PLANTS

Long distance transport occurs through vascular system, xylem and phloem phloem called **translocation** through mass flow.
The direction of translocation may be unidirectional as in case of water and multidirectional as in minerals and organic solutes.

Simple Diffusion-
• Movement by diffusion is passive and flows along the concentration gradient through permeable membrane.
• No energy expenditure takes place. It occurs in liquid and gases.
• Rate of diffusion are affected by gradient of concentration, permeability of membrane, temperature and pressure.

Facilitated Diffusion-
• Lipid soluble particles easily pass through cell membrane but the hydrophilic solutes movement is facilitated.
• For facilitated diffusion, membrane possesses aquaporins or water channels. Aquaporins are membrane proteins for passive transport of water soluble substances without utilization of energy.
• The porins are proteins that forms huge pores in the outer membrane of the plastids, mitochondria etc.

Symport, Antiport and Uniport-
• In **Symport**, both molecules cross the membrane in the same direction.
• In **Antiport**, both molecules moves in opposite direction.
• When a molecule moves across a membrane independent of other molecules, the process is called **uniport**.

Active Transport
• Uses energy to pump molecules against the concentration gradient. It is carried out by membrane proteins.
• In active transport, movable carrier proteins are called pumps.
• The pumps can transport substance from low concentration to high concentration. The carrier proteins are very specific in what it carries across the membrane.

Plant Water Relationship

Terrestrial plants take lot of water and release most of it in form of water vapour by the process of transpiration.

Water Potential (Ψw)- Water potential is determined by solute potential (**Ψs**) and pressure potential (**Ψp).**

- Water molecules possess kinetic energy. The greater the concentration of water in the system, the greater is its kinetic energy or water potential. So pure water has greatest water potential.
- Water potential is denoted by Greek symbol Psi (**Ψ)** and is expressed in pressure unit Pascal (Pa).
- Water pressure of pure water is taken as zero at standard temperature and pressure. A solution has less water potential due to less water concentration.
- The magnitude of lowering of water potential due to dissolution of solute is called solute potential (**Ψs**). Solute potential is always negative. More the solute molecules in the solution lesser the solute potential.
- If a pressure greater than atmospheric pressure is applied to pure water or solution, its water potential increases. Pressure potential is usually positive. Pressure potential is denoted by (**Ψp).**
- Water potential of a cell is affected by both solute and pressure potential. The relationship is as follows.

- $\Psi w = \Psi s + \Psi p$

Osmosis is the diffusion of water across a semipermeable membrane. The net direction and rate of osmosis depends upon the pressure gradient and concentration gradient. Water will move from its region of higher concentration to region of lower concentration until equilibrium is reached.

Osmotic potential is the pressure required to prevent water from diffusing. More the solute concentration greater will be the pressure required to prevent water from diffusing it.
Numerically osmotic pressure is equal to osmotic potential but sign is opposite. Osmotic pressure is the positive pressure while osmotic potential is negative.
If the surrounding solution balances the osmotic pressure of cytoplasm, the solution is called **isotonic**.
If the external solution is more dilute than cytoplasm, it is **hypotonic**. The cells swell up when placed in hypotonic solution.
If the external solution is more concentrated than cytoplasm, it is **hypertonic**. Cell will shrink in hypertonic solution.

Plasmolysis is the shrinkage of the cytoplasm of the cell from its cell wall under the influence of hypertonic solution. The pressure of plasmolysis is usually reversible when the cell is placed in hypotonic solution.
The pressure build up against the wall due to movement of water inside is called **turgor pressure**. It is responsible for enlargement and extension growth of cells.

Imbibition is a special type of diffusion when water is absorbed by solid colloids causing them to increase in volume. For example absorption of water by seeds and dry woods. Imbibition is also a kind of diffusion because movement of water is from higher concentration to lower concentration.
• Water potential gradient between the absorbent and liquid imbibed is essential for imbibition.

- Long distance transport of water in plants takes place by **mass or bulk flow system**. It is the movement of substance in bulk from one point to another as a result of pressure difference between two points.
- The bulk movement of substances through the conducting or vascular tissue of plants is called **Translocation**. Xylem is associated with translocation of water and mineral salts, some organic nitrogen and hormone from roots to aerial parts of plants.
- Phloem transport organic and inorganic solutes from leaves to other part of plants.

Absorption of water by plants

• Water is absorbed along with mineral solutes by roots hairs by diffusion. The absorbed water passes to deeper layer of by two pathways.
Apoplast pathway and Symplast pathway
Apoplast pathway consists of nonliving parts of plants body such as cell wall and intercellular spaces whereas Symplast pathway consists of living parts of plant body such as protoplast connected to plasmodesmata.

• Most of the water flows in roots via apoplast pathway because cortical cells are loosely packed and offers no resistance to water movement.
• The inner boundary of cortex, endodermis is impervious to water due to suberized matrix called **Casperian strip**. Water molecules are directed through wall regions that are not suberized.
• Water flows through the different layers of roots to reach the xylem tissues as follows-
• A **mycorrhiza** is the symbiotic association between a fungus and angiosperic roots. The fungal filaments forms a network around the young root to have large surface area that mineral ions and water from the soil. The fungus provide minerals and waters and roots in turn provide organic and nitrogen containing compounds.

Ascent of sap (Translocation of water)

The upward movement of water from roots towards the tips of stem branches and their leaves is called ascent of sap.

Theories of Ascent of Sap

- **Vital force theory** was forwarded by J.C.Bose in 1923. This theory believes that the innermost cortical cells of the root absorb water from the outer side and pump the same into xylem channels.
- **Root pressure theory** was forwarded by Priestley in 1916. Root pressure is positive pressure that develops in the xylem sap of the root of plants. It can be responsible for pushing up water to small heights in plants. Loss of water in liquid phase by herbaceous plants from the tips of leaf blades is known as **guttation**.
- Water rises in tubes of small diameters, kept in vessels having water due to force of surface tension. Similarly water rises up in the walls of xylem channels due to adhesion and cohesion. This theory is called **Theory of Capillarity**.
- **Cohesion Tension theory** was put forwarded by Dixon and Joly in 1894. According to this theory water is mostly pulled due to driving force of transpiration from the leaves. The water molecules remain attached with one another by cohesion force. The water molecule does not breaks in vessels and tracheid due to adhesive force between their walls and water molecules. On account of tension crated by transpiration, the water column of plant is pulled up passively from roots to great heights.

  Transpiration is the loss of water in form of water vapour from aerial parts of plants.

Phloem transport: Flow from Source to Sink

- Food (sucrose) is transported by phloem form source to sink. The part of plant that synthesize the food is called source and part where food is used or stored.
- The source and sink can be reversed by the plants depending upon the season or plant's need. So, the direction of movement in the phloem is bi-directional.
- Phloem sap is mainly water and sucrose but other sugars, hormones and amino acids are also translocated through it.

Pressure flow or Mass flow hypothesis

- It is the most accepted theory for the translocation of sugar from source to sink. Glucose is prepared at source by photosynthesis which is converted into disaccharides (sucrose). Sucrose moves into companion cells and then into sieve tube cells by active transport.
- Loading of phloem at source creates a water potential gradient that facilitate the mass movement in the phloem.
- Sieve tube cells of phloem forms a long column with holes in their wall called sieve plates. Cytoplasmic strands pass through the whole in the sieve plates to form continuous filament. Hydrostatic pressure developed in sieve tube cells moves the sap in the phloem.

At sink incoming sugar is actively moved out of the phloem as complex carbohydrates. The loss of solute produces a high water potential in the phloem and water passes out and returning into xylem.

12 MINERAL NUTRITION

Mineral nutrition is the study of source, mode of absorption, distribution and metabolism of various inorganic substances (minerals) by plants for their growth, development, structure, physiology and reproduction.

Methods to study the Mineral Requirement of Plants

• **Hydroponics** is the technique of growing plants in nutrient solution in complete absence of soil. This method is used to determine the nutrients essential for plants.
• Essential elements are identified and their deficiency symptoms are discovered by hydroponics methods.

Various forms and function of essential nutrients-.

a) **Nitrogen-** required by plants in greatest amount, it is absorbed by plants as NO_2, NO_3 and NH_4^+ **.** It is one of the major constituent of proteins, nucleic acids and vitamins.
b) **Phosphorus-** Absorbed by plants from soil in form of phosphate ions. It is the constituent of cell membrane, all nucleic acids and nucleotides require phosphorus.
c) **Potassium –** absorbed as potassium ions (K^+). Help to maintain cation-anion balance in cells. It is involved in protein synthesis, opening and closing of stomata.
d) **Calcium –** absorbed by plants from soil in form of Calcium ions (Ca^{2+}). Used in synthesis of cell wall. It activates certain enzymes.
e) **Magnesium-** absorbed by plants in form of Mg^{2+} ions. It activates the enzymes for respiration, photosynthesis, and involved in DNA and RNA. Constituent of chlorophyll.
f) **Sulphur-** plants obtain sulphur in form of sulphate (SO_4^{2-}). Present in amino acids (cysteine, methionine) and is main constituent of coenzymes and vitamins.
g) **Iron-** obtains in form of ferric iron (Fe^{3+}). It is important constituents of protein involved in transport system.
h) **Manganese-** absorbed in form of Mn^{2+} ions. Main function is splitting of water to liberate Hydrogen and Oxygen during photosynthesis.
i) **Zinc-** obtained as Zn^{2+} ions. Activate enzymes like carboxylases. Needed in formation of Auxin.
j) **Copper –** absorbed as cupric ions (Cu^{2+}). Involved in various metabolic activities and redox reactions.
k) **Boron-** absorbed as BO_3^{3-} or B_4O_7 ions. Required for uptake of calcium, cell elongation and pollen germination.
l) **Chlorine –** it is absorbed in form of Cl^- ions. Determine the solute concentration and splitting of water during photosynthesis.

Deficiency Symptoms of Essential elements

- The concentration of essential elements below which plant growth is retarded is called **critical concentration.**
- In absence of any particular element shows certain morphological changes. These morphological changes are called **deficiency symptoms**.
- The parts of plant that show deficiency symptoms depend upon mobility of elements in the plants. Elements that are actively mobilized (N,Mg,K) shows deficiency in older regions. On the other hand, symptoms appear first in young region if the elements are relatively immobile (Ca) and not transported out of mature tissues.

Kinds of deficiency syndrome are as follows-

Deficiency Disease	Symptoms	Deficient elements
Chlorosis	Yellowing of leaves due to loss of chlorophyll	N, K, Mg, S, Fe, MN, Zn, Mo
Necrosis	Death of tissue (leaf)	Ca, Mg, Cu, K
Stunted plant growth	Less height of plant	Fe, K
Premature fall of leaves and buds	Falling of leaves and buds	P, Mg, Cu
Inhibition of cell division	Less elongation in stem	Low level of N, K, S, Mo

- **Mechanism of absorption of elements** takes place in two phases. In first phase, rapid intake of ions occurs in free space or outer space of the cells, apoplast. In second phase, ions are taken slowly into inner space, the symplast of the cells.
- Passive movement of ions in apoplast occurs through ion channels and trans-membrane protein. On the other hand, movement of ions into symplast occurs by expenditure of energy by active process.
- The movement of ion is called **flux**. The inward movement is called **influx** and outward movement is called **efflux**.

Metabolism of Nitrogen

• Nitrogen is the most prevalent elements in living world along with C, H and O. It is the main constituent of proteins, nucleic acids, fats, hormones, enzymes etc.

• The process of conversion of nitrogen to ammonia is called **nitrogen fixation**. In nature lightening and ultraviolet radiation provide energy to convert atmospheric nitrogen into nitrogen oxide $(NO, NO_2$ and $N_2O)$.

• The decomposition of organic nitrogen of dead plants and animals into ammonia is called **ammonification**.

• Ammonia is first oxidized to nitrite by bacteria *Nitrosomonas* or *Nitrococcus*. Which is further oxidized to nitrate with help of bacteria *Nitrobactor*. These process are called nitrification.

$$2NH_3 + 3O_2 \rightarrow 2NO_2^- + 2H^+ + 2H_2O$$

$$2NO_2^- + O_2 \rightarrow 2NO_3^-$$

• Nitrates formed is absorbed by plants and transported to leaves. Nitrates is converted into free nitrogen by the process called **denitrificaion** by bacteria *Pseudomonas* and *Thiobacilus*.

• Reduction of nitrogen to ammonia by living organism is called **Biological Nitrogen Fixation**. The enzyme nitrogenase, present in prokaryotic organism called nitrogen fixer.

$$N \equiv N \xrightarrow{\text{Nitrogenase}} NH_3$$

• Nitrogen fixing microbes may be symbiotic (Rhizobium) or free living (Nostoc, Azotobactor, Anabaena).

• Symbiotic biological nitrogen fixation includes legume-bacteria relationship in which rod shaped Rhizobium lives with symbiotic relation with nodules of Leguminous plants.

• Central portion of nodule is pink or red due to presence of leguminous haemoglobin or leghaemoglobin.

Nodule contain all necessary biochemical components like enzyme nitrogenase and leghaemoglobin

Enzyme nitrogense is a Mo-Fe protein and catalyzes the conversion of atmospheric nitrogen into ammonia.

The reaction is as follows-

$$N_2 + 8e^- + 8H^+ + 16ATP \rightarrow 2NH_3 + H_2 + 16ADP + 16P_1$$

- The enzyme nitrogenase is highly sensitive to molecular oxygen and needs anaerobic condition. To protect this enzyme from oxygen, the nodules contain an oxygen scavenger called leg-haemoglobin.
- The ammonia synthesized by nitrogenase enzyme require large amount of energy (18ATP) for each NH_3 produced.

Fat of ammonia- at physiological pH, ammonia is converted into ammonium ions (NH_4^+). It is toxic for plants in larger concentration and ammonium ion is converted into amino acids by two methodsa.

Reductive animation- in this process ammonia reacts with α-ketoglutaric acid to form glutamic acid.

$$\alpha - \text{ketoglutaric acid} + NH_4^+ + NADPS \xrightarrow[\text{Dehydrogenase}]{\text{Glutamate}} \text{glutamate} + H_2O + NADP$$

Transamination involves the transfer of amino group from amino acids to keto group of keto acid. Glutamic acid is the main amino acid from which transfer of NH_3 takes place and another amino acid is formed by transamination. Two important amides asparagine and glutamine found in plants in proteins. They are formed from aspartic acid and glutamic acid by addition of another amino groups to it.

13 PHOTOSYNTHESIS IN HIGHER PLANTS

Photosynthesis is an enzyme regulated anabolic process of manufacture of organic compounds inside the chlorophyll containing cells from carbon dioxide and water with the help of sunlight as source of energy.

$$6CO_2 + 12H_2O \xrightarrow{\text{Light}} C_6H_{12}O_6 + 6H_2O + 6O_2$$

- Chlorophyll, light and CO_2 is required for photosynthesis. It occurs only in green part of leaves in presence of light.

Early Experiments

- Joseph Priestley in 1770, concluded that foul air produced by animal is converted into pure air by plants. Priestley discovered Oxygen gas in 1774.
- Julius Van Sachs in 1854 shows that green plant in plants produces glucose which is stored as starch. Starch is the first visible product of photosynthesis.
- T.W.Engelmann (1843-1909) discovered the effect of different wavelength of light on photosynthesis (action spectrum).
- Cornelius Van Neil (1897-1985) on the basis of studies with purple and green Sulphur bacteria shows that photosynthesis is a light dependent reaction in which hydrogen from an oxidisable compound reduces CO_2 to form sugar.

$$2H_2A + CO_2 \xrightarrow{\text{Light}} 2A + CH_2O + H_2O$$

In green sulphur bacteria, when H_2S, instead of H_2O was used as hydrogen donor, no O_2 was evolved. He inferred that O_2 evolved by green plants comes from H_2O but not from CO_2 as thought earlier.

Where Does Photosynthesis Takes Place?

• Chloroplasts are green plastids which function as the site of photosynthesis in eukaryotic photoautotrophs

• Within the chloroplast there is a membranous system consisting of grana, the stroma lamellae and the fluid stroma.

• The reaction in which light energy is absorbed by grana to synthesis ATP and NADPH is called **light reaction**. The later part of photosynthesis in which CO2 is reduced to sugar, in which light is not necessary is called **dark reaction**.

Pigments involved in Photosynthesis – The plant pigments are found in chloroplasts on the thylakoids.

The 4 Plant Pigments are-

- Chlorophyll a: Light to medium green. Main photosynthetic pigment.
- Chlorophyll b: Blue-green. Accessory Pigment.
- Carotene: Yellow- Orange . Accessory Pigment.
- Xanthophyll: Yellow. Accessory Pigment.

• Maximum absorption by chlorophyll a occurs in blue and red regions having higher rate of photosynthesis. So, chlorophyll a is the chief pigment.

Light reaction

• Light reaction (photochemical phase) includes

a. Light absorption
b. Water splitting
c. Oxygen release
d. Formation of high energy chemical intermediates (ATP and NADPH).

• The pigments are organized into two discrete LHC(light harvesting complex) within photosystem I and photosystem II.
• LHC are made up of hundreds of hundreds of pigments molecules containing all pigments except single chlorophyll a molecules in each PS.
• The pigments in photosystem I and photosystem II absorbs the lights of different wavelength. Single chlorophyll molecules make the reaction centre. In PS I reaction centre has highest peak 700nm, hence called P700. And PS II reaction centre has highest peak at 680 nm, so called P680.

The Electron Transport System

- Reaction centre of photosystem II absorbs light of 680 nm in red region and causing electron to becomes excited. These electrons are picked by electron an electron acceptor which passes to electron transport system consisting of cytochrome.
- Electrons passed through electron transport chain and passed on to the pigment of PS I. electron in the PSI also get excited due to light of wavelength 700nm and transferred to higher potential.
- When electron passes in downhill direction, energy is released that reduce the ADP to ATP and NADP+ to NADPH. The whole scheme of transfer of electron is called Z-scheme due to its shape.
- Photolysis of water release electrons that provide electron to PS II. Oxygen is released during photosynthesis due to this also.

$$2H_2O \rightarrow 4H^- + O_2 + 4e^-$$

- **Difference between cyclic and non-cyclic photophosphorylation**

Cyclic photophosphorylation	Non-cyclic photophosphorylation
a. It is performed by photosystem I independently.	a. It is performed by collaboration of both PS I and PS II.
b. An external source of electron is not required.	b. The process requires an external electron donar.
c. It synthesizes only ATP.	c. It synthesizes ATP and NADH both.
d. It occurs only in stromal or intergranal thylakoids.	d. It occurs in the granal thylakoids only.

Chemiosmotic Hypothesis of ATP formation was proposed by Mitchell in 1961.
The product of light reaction is used to drive the process leading to synthesis of sugar are called **biosynthetic phase** of photosynthesis.

Calvin Cycle/C_3 cycle/Reductive Pentose Sugar Phosphate Pathway

- Malvin Calvin, Benson and their colleagues used radioactive 14C and Chlorealla and Scenedesmus algae to discover that first CO_2 fixation product is 3-carbon organic compound (3-phosphoglyceric acid) or PGA. Later on a new compound was discovered which contain 4- carbon called Oxaloacetic Acid (AAO). On the basis of number of carbon atoms in first stable product they are named C_3 and C_4 pathway.

• **Carboxylation** is the fixation of CO_2 into 3-phosphoglyceric acid (3-PGA). Carboxylation of RuBP occurs in presence of enzyme **RuBP carboxylase (RuBisCO)** which results in the formation of two molecules of 3-PGA.
• **Reduction** is series of reaction that leads to formation of glucose. Two molecules of ATP and two molecules of NADPH are required for reduction of one molecules of CO_2. Six turn of this cycle are required for removal of one molecule of Glucose molecules from pathway.
• **Regeneration** is the generation of RuBP molecules for the continuation of cycle. This process require one molecules of ATP.

Fig-Calvin Cycle/ C_3 Cycle

• For every molecules of CO_2 entering the Calvin Cycle, 3 molecules of ATP and 2 molecules of NADPH is required.

C_4 pathway/Hatch Slack Pathway

- This pathway was worked out by Hatch and Slack (1965, 1967), mainly operational in plants growing in dry tropical region like Maize, Sugarcane, Sorghum etc.
- In this pathway first stable product is a 4-carbon compound Oxaloacetic acid (AAO) so called as C_4 pathway. C_4 plants have Kranz Anatomy (vascular bundles are surrounded by bundle sheath cells arranged in wreath like manner), characterized by large no of chloroplast, thick wall impervious to gases and absence of intercellular spaces.
- The primary CO_2 acceptor is a 3-carbon molecule Phosphoenol Pyruvate present in mesophyll cells and enzyme involved is PEP carboxylase.
- OAA formed in mesophyll cell forms 4-carbon compound like malic acid or aspartic acid which is transported to bundle sheath cells.
- In bundle sheath cell, it is broken into CO_2 and a 3- carbon molecule. The 3-carbon molecule is returned back to mesophyll cells to form PEP.
- The CO_2 molecules released in bundle sheath cells enters the Calvin cycle, where enzyme RuBisCO is present that forms sugar.

Photorespiration

It is a light dependent process of oxygenation of RuBP and release of carbon dioxide by photosynthetic organs of plants.

Photorespiration decrease the rate of photosynthesis when oxygen concentration is increased from 2-3% to 21%.

This pathway involves **Chloroplast, Peroxisome and Mitochondria**. Photorespiration do not occurs in C_4 plants.

Factors affecting photosynthesis

a. **Light**

b. **Carbon dioxide concentration**

c. **Temperature-** it does not influence the rate of photosynthesis directly but at higher temperature enzyme activity is inhibited due to denaturation to affect the dark reaction.

d. **Water**

14 RESPIRATION IN PLANTS

Respiration is an energy releasing enzymatically controlled catabolic process which involves a step-wise oxidative breakdown of food substance inside living cells.

$$C_6H_{12}O_6 + 6O_2 \rightarrow 6CO_2 + 6H_2O + \text{Energy}$$

• **Cellular respiration** is the mechanism of breaking down of food materials within the cell to release energy for synthesis of ATP.

• Energy released during oxidation is not used directly but utilized in synthesis of ATP, which is broken down when energy is required. Therefore, **ATP is called energy currency** of cells.

• The process of respiration requires oxygen. In plants oxygen is taken in by stomata, lenticels and root hairs.

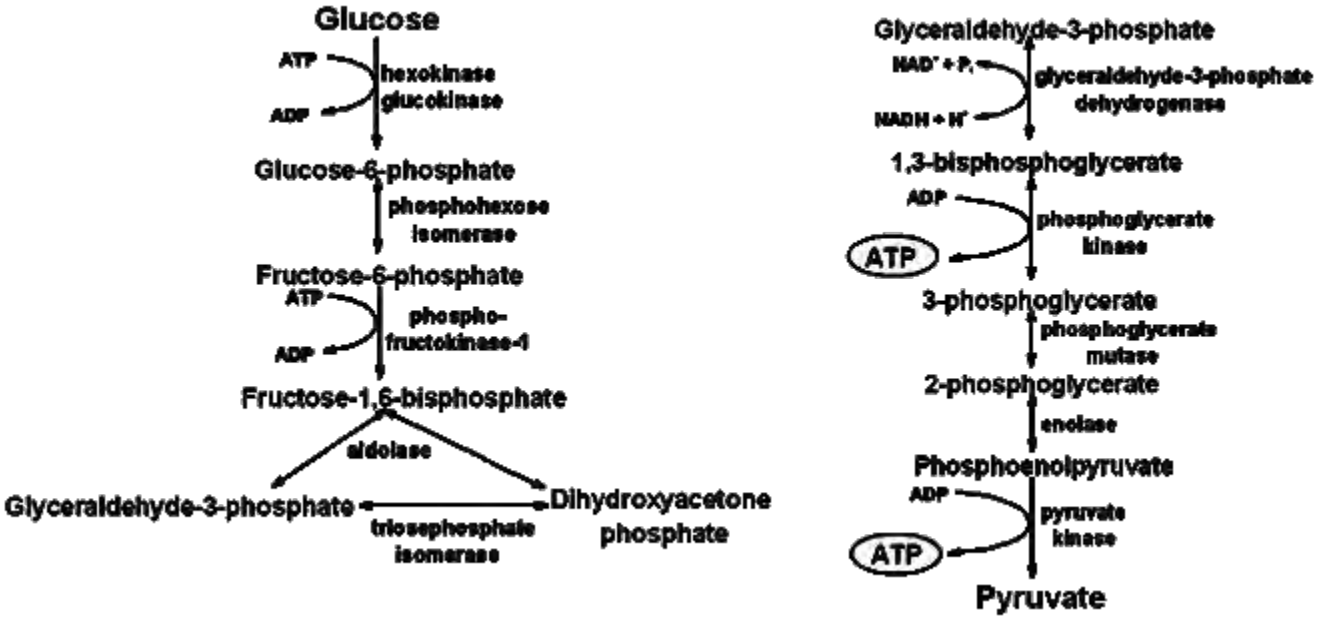
• **Respiratory Quotient** is the ratio of the volume of carbon dioxide produced to the volume of oxygen consumed in respiration over a period of time. RQ is equal to one for carbohydrate and less than one for protein and peptones.

Aerobic Respiration is an enzymatically controlled release of energy in a stepwise catabolic process of complete oxidation of organic food into carbon dioxide and water with oxygen acting as terminal oxidant.

Glycolysis

• The scheme of glycolysis is given by Gustav Embden, Otto Meyerhof, and J. Parnas. It is also called as EMP pathway.

• Glycolysis is the partial oxidation of glucose or similar hexose sugar into two molecules of pyruvic acid through a series of enzyme mediated reaction releasing some ATP and $NADH_2$. It occurs in cytoplasm.



• In fermentation by yeast, pyruvic acid is converted to ethanol and CO_2. The enzyme involved is pyruvic acid decarboxylase and alcohol dehydrogenase catalyze this reaction.

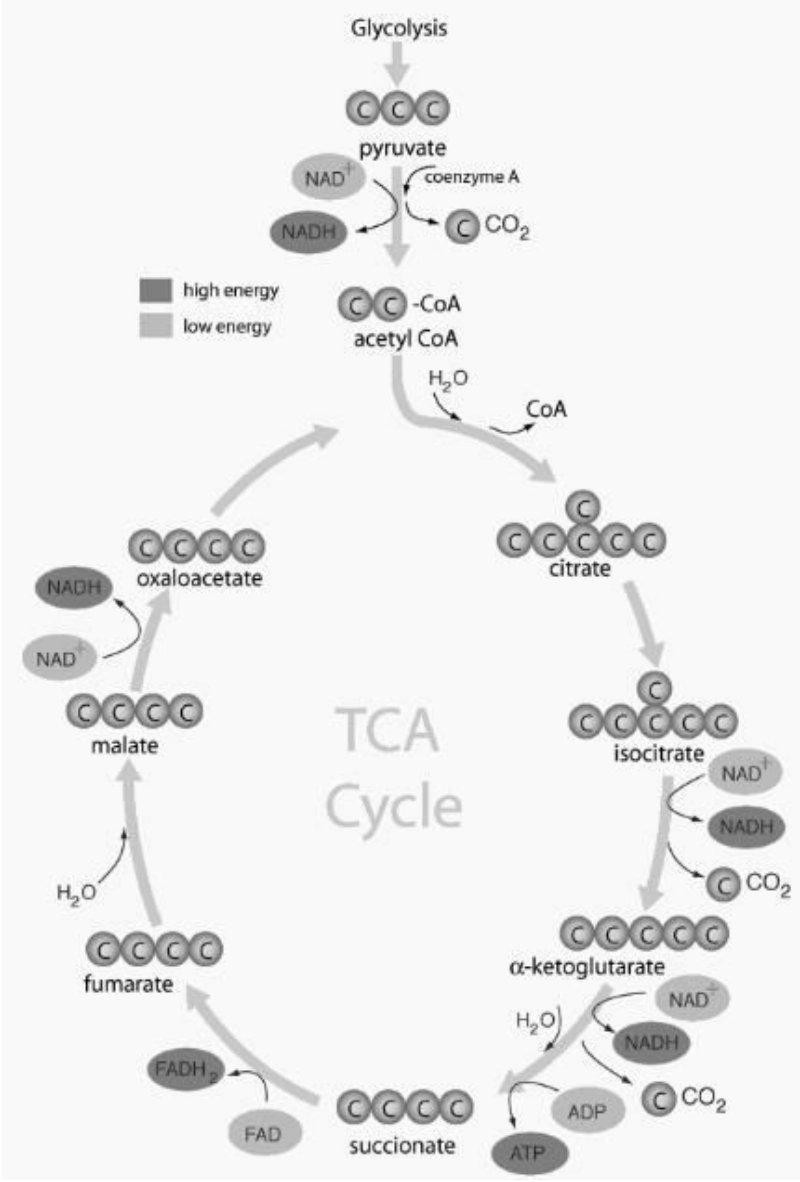
• In both lactic acid fermentation and alcohol fermentation very less amount of energy is released.

• Yeasts poison themselves to death if concentration of alcohol reaches above 13%.

Oxidation of Pyruvate to Acetyl-CoA is done to produce CO_2 and NADH. The reaction catalyzed by pyruvic dehydrogenase requires the participation of several Coenzymes including . NAD^+

$$\text{Pyruvic} + \text{CoA} + \text{NAD} \xrightarrow[\text{Pyruvale dehy drogenase}]{Mg^{2+}} \text{Acetyl CoA} + CO_2 + \text{NADH} + H^+$$

❖ The Acetyl CoA enters a cyclic pathway called TCA cycle or Kreb's cycle.



Tricarboxylic Acid Cycle/Krebs Cycle

- TCA cycle was discovered by Hans Krebs in 1940. This cycle is called TCA cycle because initial product is citric acid.
- The two molecules of pyruvate are completely degraded in Krebs cycle to form two molecules of ATP, $8NADH_2$ and $2FADH_2$.

$$Pyruvic\,acid + 4NAD^+ + FAD^+ + 2H_2O + ADP + Pl \xrightarrow{\text{Mitochondrial Matrix}} 3CO_2 + 4NADH + 4H^+FADH_2\ ATP$$

Terminal Oxidation is the name of oxidation found in aerobic respiration that occurs towards end of catabolic process and involves the passage of both electrons and protons of reduced coenzyme to oxygen to produce water.

Electron Transport Chain

• The metabolic pathway through which the electron passes from one carrier to another inside the inner mitochondrial membrane is called ETC or mitochondrial respiratory chain.

• Electrons from NADH produced during citric acid cycle are oxidized by NADH dehydrogenase and electrons are transferred to ubiquinone located within the inner membrane. Ubiquinone also receives electrons from $FADH_2$ which is transferred to cytochrome c via cytochrome bc_1 complex.

• When the electrons pass from one carrier to another via electron transport chain, they produce ATP form ADP and inorganic phosphate. The number of ATP molecules synthesized depends upon electron donor.
• Oxidation of one molecule of NADH give rise 3 molecules of ATP, while oxidation of one molecule of $FADH_2$ produce two molecules of ATP.

Oxidative phosphorylation	Photophosphorylation
a) It occurs in respiration process.	a) It occurs in photosynthesis.
b) Energy of oxidation reduction is used for production of protein gradient required for phosphorylation.	b) Light energy is utilized for production of proton gradient for phosphorylation.

Amphibolic Pathway

- ❖ Glucose is the favored substrate for respiration. All carbohydrates are usually converted into glucose before used for respiration.
- ❖ Fats needs to be broken down into glycerol and fatty acid, which is further broken converted into Acetyl CoA and enter the respiratory pathway.
- ❖ Proteins are broken into amino acids and further enter into Krebs cycle.
- ❖ Breaking down process within living organism is called catabolism and synthesis process is called anabolism process. So, respiration is an Amphibolic pathway.

15 PLANT GROWTH AND DEVELOPMENT

• Development is the sum of two processes **growth** and **differentiation**.
Growth is a permanent or irreversible increase in dry weight, size, mass or volume of cell, organ or organism. It is internal or intrinsic in living beings.
• In plants growth is accomplished by cell division, increase in cell number and cell enlargement. So, growth is a quantitative phenomenon which can be measured in relation to time.
• **Plant growth is generally indeterminate** due to capacity of unlimited growth throughout the life. Meristem tissues present at the certain locality of plant body.
• The plant growth in which new cells are always being added to plant body is due to meristem is called **open form of growth**.
• **Root apical meristem and shoot apical** meristem are responsible for primary growth and elongation of plant body along the axis.
• **Intercalary meristem** located at nodes produce buds and new branches in plants.
• Secondary growth in plants is the function of lateral meristem that is vascular cambium and cork cambium.

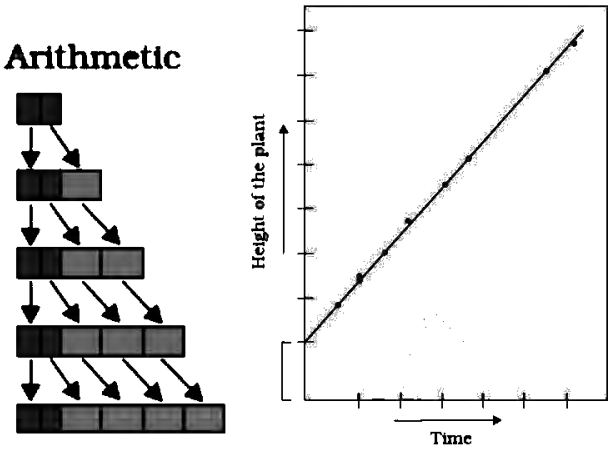
Phases Of Growth

- ➢ **Formative phase** is also called as the phase of cell formation or cell division. It occurs at root apex, shot apex and other region having meristematic tissue. The rate of respiration is very high in the cells undergoing mitosis division in formative phase.
- ➢ **Phase of Enlargement-** newly formed cells produced in formative phase undergo enlargement. Enlarging cells also develops vacuoles that further increase the volume of cell. Cell enlargement occurs in all direction with maximum elongation in conducting tissues and fibres.
- ➢ **Phase of maturation-** the enlarged cells develops into special or particular type of cells by undergoing structural and physiological differentiation.

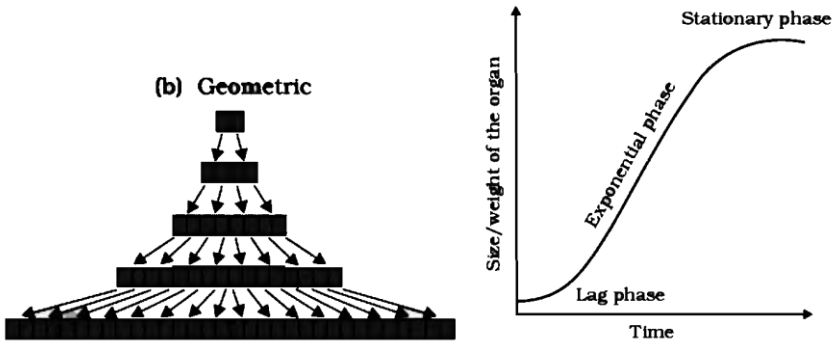
Growth Rate- increase in growth per unit time is called growth rate. Growth rate may be arithmetic or geometrical.
Arithmetic Growth- the rate of growth is constant and increase in growth occurs in arithmetic progression- 2,4,6,8 ……. It is found in root and shot elongation.

$L_t = L_0 + rt$

Length after time = length at beginning + growth rate x time.



- **Geometric Growth-** here initial growth is slow and increase rapidly thereafter. Every cell divides. The daughter cells grow and divide and the granddaughter cells that result into exponential growth. Geometrical growth is common in unicellular oranisms when grows in nutrient rich medium.



- Sigmoid growth curve consists of fast dividing exponential phase and stationary phase. It is typical of most living organisms in their natural environment.

Exponential growth can be represented as follows-

$W_1 = W_0 e^{rt}$, W1 = final size, W0 = initial size, r = growth rate, t = time of growth and e is the base of natural logarithms (2.71828).

• Cells produced by apical meristem become specialized to perform specific function. This act of maturation is called **differentiation**.

• The living differentiated cells that have lost ability of division can regain the capacity of division. This phenomenon is called **dedifferentiation**. For example interfascicular cambium and cork cambium.

• Dedifferentiated cells mature and lose the capacity of cell division again to perform specific functions. This process is called **redifferentiation**.

Sequence of development process in plant cell

• Different structures develop in different phases of growth as well as in response to environment. The ability to change under the influence of internal or external stimuli is called **plasticity**. Heterophylly is the example of plasticity.

Plant Growth Regulators are simple molecules of diverse chemical composition which may be indole compounds, adenine derivatives or derivatives of carotenoids.
• Auxin was isolated by F.W. Went from tips of coleoptiles of oat seedlings.
• The 'bakane disease' of rice seedlings is caused by fungal pathogen *Gibberella fujikuroi*. E. Kurosawa found that this disease is caused due to presence of Gibberellin.
• Skoog and Miller identified and crystallized the cytokinins, promoting active substance called kinetin.
Auxin- It is commonly called indole-3-acetic acid (IAA). It is generally produced at stem and root apex.
Functions-

a) Cell enlargement and cell division
b) Apical dominance
c) Inhibition of abscission
d) Induce Parthenocarpy

Gibberellins- The most common one is GA_3 (Gibberellic Acid).

Functions-

a) Cell elongation
b) Breaking of dormancy
c) Early maturity
d) Seed germination

Cytokinins- Most common forms includes kinetin, zeatin etc. They are mainly synthesized in roots.
Functions-

a) Cell division and cell differentiation
b) Overcome apical dominance
c) Promote nutrient metabolism

Ethylene – It is a gaseous hormone which stimulates transverse or isodiametric growth but retards the longitudinal one.
Functions-

a) Inhibition of longitudinal growth
b) Fruit ripening
c) Senescence
d) Promote apical dominance

Abscisic Acid – It is also called stress hormone or dormin. It is mainly produced in chloroplast of leaves.
Functions-

a) Bud dormancy
b) Leaf senescence
c) Induce Parthenocarpy
d) Seed development and maturation

Photoperiodism- is the effect of photoperiods or day duration of light hours on the growth and development of plant, especially flowering is called Photoperiodism. On the basis of photoperiodic response to flowering plants have been divided into the following categoriesa.

a) Short Day Plants
b) Long Day Plants

c) **Day Neutral Plants**

Vernalisation- is the process of shortening of the juvenile or vegetative phase and hastening flowering by a previous cold treatment.

16 DIGESTION AND ABSORPTION

The process of conversion of complex food into simpler absorbable form is called digestion

Digestive System- Human digestive system consists of alimentary canal and associated glands.

• Alimentary canal comprises of following parts

Mouth- Each teeth is embedded in socket of jaw bone (**thecodont**). Milk teeth is replaced by permanent or adult teeth, this type of dentation is called **diphyodont**. Four different types of teeth are incisors (I), canine (C), premolar (PM) and molar (M).

$$\text{Dental formula} = \frac{2123}{2124}$$

Upper surface of tongue has small projections called **papillae**, some of which contain taste buds.

Pharynx passage for food and air. Cartilaginous flaps called epiglottis prevents the entry of food into wind pipe (glottis) during swallowing.

Stomach- Oesophagus leads to stomach. The opening of stomach is guarded by a sphincter (gastro-esophageal). Stomach is divided into three parts- **cardiac, fundic** and **pyloric**.

Small intestine- is the longest part of alimentary canal divided into **duodenum**, **jejunum** and **ileum**. Pyloric sphincter is present between stomach and duodenum.

Large intestine- ileum opens into large intestine, which is divided into caecum, colon and rectum. Caecum is a blind sac which host microbes. Vermiform appendix arises from caecum. Rectum opens through anus.

Histology of Alimentary canal-

The wall of alimentary canal from Oesophagus to rectum consists of four layers.

a) Serosa-
b) Muscularis-
c) Submucosa-
d) Mucosa-

Digestive Glands

Salivary Glands- secrete their release in oral cavity. In human beings salivary glands are three pairs- parotid, sublingual, and submandibular.

Liver- it is the largest gland in human body lies in upper right side of the abdominal cavity just below the diaphragm. Hepatic lobules, covered by Glisson's capsule, are structural and functional unit of liver made up of hepatic cells. The secretion is stored and concentrated in gall bladder. Bile duct and pancreatic duct open together in duodenum by common duct guarded by sphincter of Oddi.

Pancreas- consists of exocrine and endocrine portion. The exocrine portion secretes alkaline pancreatic juice and endocrine secretes hormones insulin and glucagon.

Digestion of food

• Chemical digestion of food starts in oral cavity by the action of enzyme salivary amylase and lysozyme. Lysozyme acts as antibacterial agent in mouth to prevent infection.
• Mucosa of stomach have gastric glands having three types of cells- mucus neck cells that secrete mucus, peptic of chief cells that secretes proenzyme pepsinogen and pariental or oxyntic cells that secretes HCl. HCl activates the pepsinogen to pepsin to digest protein.

$$\text{Protein} \xrightarrow[\text{HCl}]{\text{pepsin}} \text{peptones} + \text{proteoses}$$

• Mucus and bicarbonates present in gastric juice play important role in lubrication and protecting inner wall of stomach form the action of HCl. Renin is a protolytic enzyme found in gastric juice of infants to digest milk protein.
• The Bile, pancreatic juice and intestinal juice are released in small intestine. Pancreatic juice contain inactive trypsinogen, chymotrypsinogen, procarboxypeptidases, amylases, lipases and nucleases.
• Trypsinogen is activated by enzyme enterokinase in to trypsin, which further activates the other enzyme of intestinal juice.
• Bile contains bile pigments (bilirubin and bil-verdin), bile salts, cholesterol and phospholipids which help in emulsification of fats.

$$\text{Dipeptides} \xrightarrow{\text{Dipeptidases}} \text{Amino acids}$$
$$\text{Maltose} \xrightarrow{\text{Maltase}} \text{Glucose + Glucose}$$
$$\text{Lactose} \xrightarrow{\text{Lactase}} \text{Glucose + Calactose}$$
$$\text{Sucrose} \xrightarrow{\text{Sucrase}} \text{Glucose + Fructose}$$
$$\text{Nucleotides} \xrightarrow{\text{Nucleotidases}} \text{Nucleosides} \xrightarrow{\text{Nucleosidases}} \text{Sugars + Bases}$$
$$\text{Diand Monoglycerides} \xrightarrow{\text{Lipases}} \text{Fatty acids + Glycerol}$$

Disorder of Digestive System

a. **Jaundice**- It is a disease of liver. In jaundice the skin and the eyes turn yellow due to large quantities of bilirubin pigments in the extra cellular fluid.
b. **Vomiting** – It is the ejection of stomach content through the mouth. This reflex action is controlled by the vomit Centre in the medulla.
c. **Diarrhoea-** Frequent defecation of liquid faeces is known as Diarrhoea. It reduces the absorption of food.
d. **Constipation**- In constipation the faeces are retained within the rectum as the bowel movements occur irregularly.
e. **Indigestion**- Incomplete digestion is usually accompanied by one or more of the following symptoms- pain, nausea, vomiting, heartburn, acid regurgitation, accumulation of gas.

17 BREATHING AND EXCHANGE OF GASES

Human Respiratory System

- Human respiratory system consists of a pair of nostrils, pharynx, larynx, bronchi and bronchioles that finally terminates into alveoli.

- Nasal chamber open into pharynx that leads to larynx. Larynx contains voice box (sound box) that help in sound production.
- The trachea, primary, secondary and tertiary bronchi and initial bronchioles are supported by incomplete cartilaginous rings to prevent collapsing in absence of air.
- Each bronchiole terminates into a irregular walled, vascularized bag like structure called alveoli.
- Two lungs are covered with double layered pleura having pleural fluid between them to reduce the friction on lung surface.

Steps of Respiration

a. Breathing in which Oxygen rich atmospheric air is diffused in and CO_2 rich alveolar air is diffused out.
b. Diffusion of gases across alveolar membrane.
c. Transport of gases by blood.
d. Diffusion of 0_2 and CO_2 between blood and tissues.
e. Utilization of 0_2 by cells to obtain energy and release of CO_2 (cellular respiration).

Mechanism of Breathing

- Breathing involves inspiration and expiration.
- Movement of air in and out takes place due to difference in pressure gradient
- The diaphragm and external and internal intercostal muscles between the ribs help in developing pressure gradient due to change in volume.
- The contraction of intercostal muscles lifts the ribs and sternum causing an increase in volume of thoracic cavity that results the decrease in pressure than the atmospheric pressure to cause inspiration.
- Relaxation of the diaphragm and intercostal muscles reduce the thoracic volume and increase the pressure to cause expiration.
- The volume of air involved in breathing movements is estimated by using spirometer to clinical assessment of pulmonary functions.

Respiratory Volume and Capacities

Tidal volume (TV) - volume of air inspired or expired during a normal respiration. It is about 500mL in healthy man.
Inspiratory Reserve Volume (IRV) – additional volume of air a person can inspire by forceful inspiration. It is about 2500 mL o 3000mL.
Expiatory Reserve Volume (ERV) – additional volume of air a person can expire by forceful expiration. It is about 1000 mL to 1100mL.
Residual Volume (RV) - volume of air remains in lungs even after a forcible expiration. It is about 1100mL to 1200mL.
Inspiratory Capacity (IC) - TV + IRV
Expiratory Capacity (EC) – TV + ERV
Functional Residual Capacity (FRC) - ERV + RV
Vital Capacity (VC) - maximum volume of air a person can breathe in after a forceful expiration. ERV+ TV+ IRV
Total Lung Capacity (TLC) - total volume of air accommodated in lung at the end of forced inspiration. RV+ ERV+ TV+ IRV= Vital capacity + Residual Volume.

Exchange of Gases

• Exchange of gases takes place at two sites
a. Alveoli to blood
b. Between blood and tissues.
• Pressure contributed by individual gas in a mixture of gas is called partial pressure represented by pCO_2 and pO_2.

Transport of Oxygen

- Haemoglobin in RBC combines with 0_2 to form **Oxyhaemoglobin**. Each haemoglobin combine with four oxygen molecules.

- In the alveoli, pO2 is more and pCO2 is less

Transport of Carbon dioxide

- Carbon dioxide is transported by haemoglobin as **carbamino-haemoglobin**. In tissues pCO_2 is high and pO_2 is less that favour the binding of carbon dioxide with haemoglobin. Opposite condition help in dissociation of carbamino- haemoglobin in alveoli.
- Enzyme carbonic anhydrase help in formation of carbonate ions to transport carbon dioxide.

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

Regulation of Respiration

• Respiratory rhythm centre is located in medulla region of hind brain. Pneumtaxic centre in pons moderate the function of respiratory rhythm centre.

Mountain Sickness is the condition characterised by the ill effect of hypoxia (shortage of oxygen) in the tissues at high altitude commonly to person going to high altitude for the first time.

Disorder of Respiratory System

a) Asthma- it is due to allergic reaction to foreign particles that affect the respiratory tract. The symptoms include coughing, wheezing and difficulty in breathing. This is due to excess of mucus in wall of respiratory tract.
b) Emphysema- is the inflation or abnormal distension of the bronchioles or alveolar sacs of lungs. This occurs due to destroying of septa between alveoli because of smoking and inhalation of other smokes.
c) Occupational Respiratory Disorders- occurs due to occupation of individual. This is caused by inhalation of gas, fumes or dust present in surrounding of work place. This includes Silicosis, Asbestoses due to expose of silica and asbestos. The symptom includes proliferation of fibrous connective tissue of upper part of lung causing inflammation.
d) Pneumonia- it is acute infection or inflammation of the alveoli of the lungs due to bacterium *Streptococcus pneumoniae.* Alveoli become acutely inflamed and most of air space of the alveoli is filled with fluid and dead white blood corpuscles limiting gaseous exchange.

18 BODY FLUIDS AND CIRCULATION

Blood

Blood is a mobile connective tissue composed of a fluid, plasma and the cells, the blood corpuscles. It forms about 30-35% of the extracellular fluid. It is slightly alkaline fluid having pH7.4.

- **Plasma** is straw coloured viscous fluid that constitutes 55% of blood volume. It consists of 90-92% water, 6-8% protein (fibrinogens, albumins and globulins), glucose, amino acids and small amount of minerals like Na+, Ca++, Cl- etc.
- Erythrocytes, leucocytes and platelets are collectively called **formed elements**.
- **Erythrocytes**- Total blood count of RBCs is 5-5.5 million, which is slightly less in females due to menstruation. It is formed in bone marrow. Nucleus is absent in mammalian RBCs having biconcave in shape.
- Every 100 ml of blood contain 12-16 gm. of haemoglobin. They have life span of 120 days. They are destroyed in spleen(graveyard of RBCs).
- **Leucocytes** or WBCs are colourless due to absence of haemoglobin. 6000-8000 WBCs are present in each ml. of blood.
- The different types of white blood cells (leukocytes) include neutrophils, basophils, eosinophils, lymphocytes, monocytes, and macrophages.

- Neutrophils are most abundant and basophils are least abundant WBCs. Monocytes and neutrophils are phagocytic cells which destroy foreign organisms.
- Basophils secrete histamine, serotonin and heparin that involve in inflammatory reactions.
- Eosinophils resist infection and allergic reactions. B and T lymphocytes are responsible for immune response of the body.

Thrombocytes or platelets are cell fragments produced from megakaryocytes in bone marrow. 150000-350000 platelets are present in each ml of blood. Platelets are involved in clotting or coagulation of blood in case of injuries.

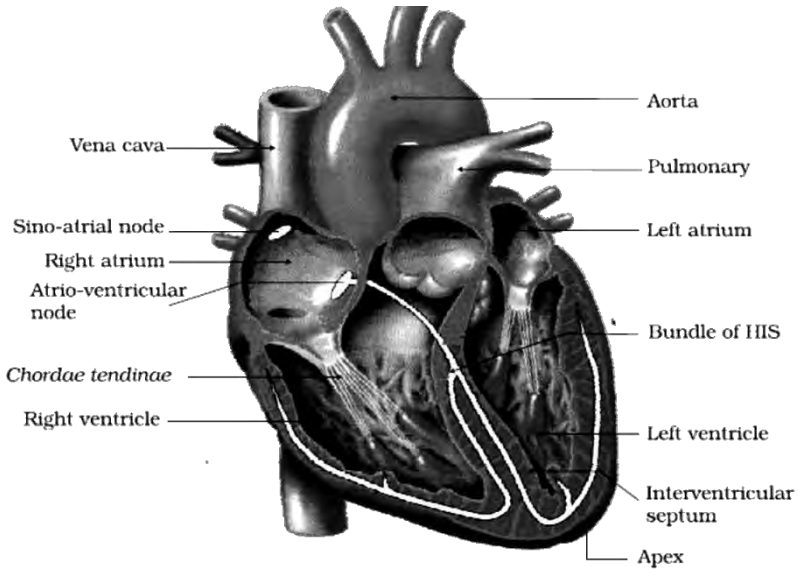
Blood Groups – blood of human beings differ in certain aspects although it appear same in all individuals.
Two main types of grouping are ABO and Rh.
ABO grouping is based on presence or absence of two surface antigens RBC, antigen A and antigen B. The plasma of an individual also contains two antibodies produced in response of antigens.

Blood Group	Antigens on RBCs	Antibodies in Plasma	Donor's Group
A	A	Anti-B	A,O
B	B	Anti-A	B,O
AB	A,B	Nil	AB,A,B,O
O	Ntl	Anti-A,B	O

• Group 'O' blood can be donated to any individual with any blood group, so it is called **universal donor**.
• Person with 'AB' blood group can receive blood from any person of any group, so it is called **universal recipient**.
Rh grouping – Rh antigen (similar to Rhesus monkey) are observed on surface of RBCs of majority of individuals (about 80%). Such people are called Rh positive (Rh+) and whom in which this antigen is absent are called Rh negative (Rh-).

- **Erythroblastosis foetalis**- If father's blood is Rh+ and mother blood is Rh-, the foetus blood is Rh+. During the delivery of first child there is a possibility of exposure of mother blood with foetus blood to develop antibodies in mother blood. In subsequent pregnancy the mother blood can leak into foetus blood that destroys the foetus RBC. This case is called erythroblastosis foetalis.

Circulatory Pathways
Human Circulatory System – consists of 4 chambered muscular heart, closed branching blood vessels and circulatory fluid blood.
Heart is the mesodermally derived muscular organ, present in thoracic cavity between the two lungs protected by double membrane of pericardium.



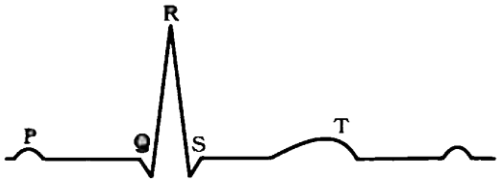
- The opening between right atrium and right ventricle is guarded by a three muscular flaps or cusps called **tricuspid valve**. **Bicuspid or mitral valve** guards the left atrium and ventricle.
- The opening of right and left ventricle to pulmonary artery and aorta respectively is controlled by semilunar valve.
- The nodal tissue present on upper right corner of right atrium is called SAN (sino-atrial node) and those on lower left corner of right atrium is called AVN (atrio-ventricular node).
- The purkinje fibres along with right and left bundles form the bundle of HIS. The nodal musculature has ability to generate action potential.
- SAN generate maximum number of action potential and is responsible for rhythmic contraction of heart. Therefore it is called **pace maker**.

Cardiac Cycle

• To begin with, all four chambers are in relaxed state called **joint disystole**.

• SA node generates action potential that contracts the both atria (atrial systole). The action potential is passes to AV node and bundle of HIS transmit it to ventricular musculature to cause ventricular systole. At the same time atria undergoes relaxation disystole to close the bicuspid and tricuspid valve.

• During each cardiac cycle two sounds are produced. The first sound (lub) is due to closure of bicuspid and tricuspid valve and 2nd heart sound (dub) is due to closure of semilunar valve. **ECG (Electrocardiograph)** is a graphical representation of electrical activity of heart during cardiac cycle.



• The P-wave represents the electrical excitation of atria (depolarization) which leads to contraction of atria.

• The PRS-wave represents the depolarization of ventricles, which initiates the ventricular contraction.

• The T-wave represents the return of ventricle from exited to normal state (repolarization). At the end of T-wave marks the end of systole. Counting the number of QRS complex in given period of time determine the heartbeat rate.

Double Circulation

Flow of same blood twice through the heart once in oxygenated form and other in deoxygenated form is called double circulation. It includes systematic and pulmonary circulation.

Systematic circulation includes flow of oxygenated blood for the left ventricle to all parts of body and deoxygenated blood from various body parts to the right atrium. All systematic circulation starts form aorta and ends at superior vena cava, inferior vena cava or coronary sinus to right atrium.

Pulmonary Circulation

The flow of deoxygenated blood from the right ventricle to the lungs and the return of oxygenated blood form the lung to the left atrium is called pulmonary circulation.

Regulation of Cardiac Activity

Normal activities of heart are regulated by nodal tissue (SA and AV node), so the heart is myogenic. A special neural centre in medulla oblongata moderates the cardiac function by ANS. Sympathetic nerve controls the can increase the rate of heart beat and parasympathetic nerve of ANS decrease the rate of heart beat. Adrenal medullar hormone also increases the cardiac output.

Disorder of Circulatory System

a) **Hypertension (high blood pressure)** – Blood pressure higher than (120/80). 120 mm Hg is the systolic that is pumping pressure and 80 mm Hg is the diastolic, resting pressure. It leads to heart disease and affect vital organs like brain and kidney.

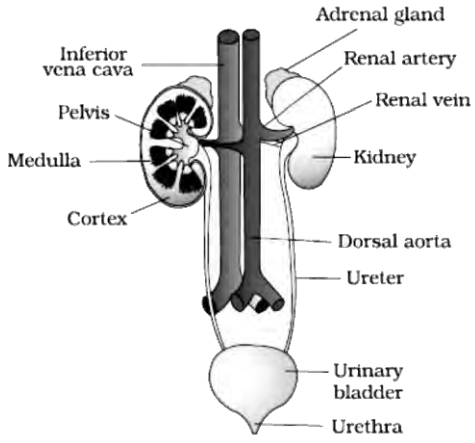
b) **Coronary Artery Disease (CAD)**- commonly called atherosclerosis that affects the blood vessels that supply blood to heart muscles due to deposition of fat, calcium, cholesterol that makes the arteries lumen narrower.
c) **Angina**- also called angina pectoris, acute chest pain due to less supply of oxygen to heart muscles. It may occur in elderly male and female. It occurs due to restricted blood flow.
d) **Heart failure**- heart not pumps enough blood to meet the requirement of body. It is also known as congestive heart failure because congestion of lung is one of its causes. Heart failure is different from heart attack (heart muscle is damaged by inadequate blood supply) and cardiac arrest (when heart stops beating).
e) **Coronary Thrombosis**- formation of clot in the coronary artery is coronary thrombosis. It occurs most frequently in the left anterior descending coronary artery.

19 EXCRETORY PRODUCTS AND THEIR ELIMINATION

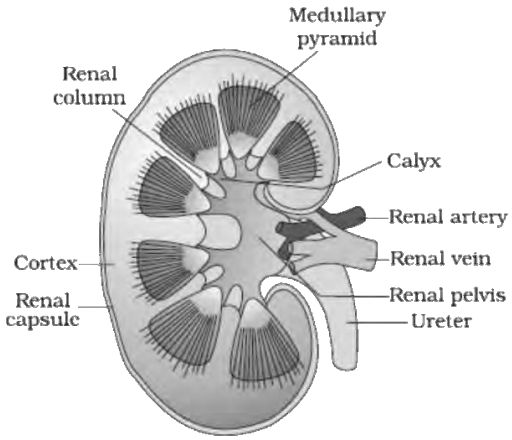
• Ammonia is the most toxic and uric acid is the least toxic. The process of removing ammonia is called **ammonotelism** and organisms that excrete ammonia are called **ammonotelic** (bony fishes, aquatic amphibians and insects).
• The organism that release urea as nitrogenous wastes are called **ureotelic** (mammals, terrestrial amphibians). The organism that excretes uric acids are called **urecotelic** (reptiles, birds and land snails).

Animals	Excretory organs
Flat worms, some annelids and cephalochordates	Protonephridia or flame cells
Earthworms and annelids	Nephridia
Insects including cockroaches	Malpighian tubules
Mammals	Kidney

Human Excretory System
Human excretory system consists of
i. A pair of kidneys
ii. A pair of ureters
iii. A urinary bladder
iv. A urethra

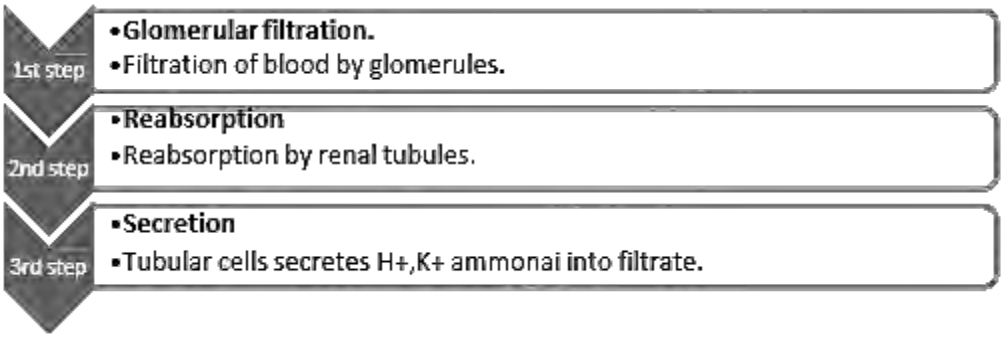


- **Kidneys**



- The functional unit of kidney is nephron. Each kidney contains about one million nephrons.
- Each nephron had two parts- **the glomerulus and renal tubules**.
- The malpighian tubules, PCT and DCT of nephron are situated in cortical region where as loops of Hanle's into medulla.

Urine formation



• The amount of filtrate formed by kidneys per minute is called **glomerular filtration rate (GFR)** which is 125 ml/minute.
• **Glomerular Filtration rate** is controlled by carried out by Juxta glomerular apparatus (JGA).
• 99% of filtrate has been reabsorbed by renal tubules called reabsorption.

Function of Tubules
I. **Proximal Convoluted Tubules (PCT)** - all the important nutrients, 70-80% electrolytes and water are reabsorbed.
II. **Henle's Loop**- maintains high osmolarity of medullary institutional fluid.
III. **Distal Convoluted Tubules (DCT)** – conditional reabsorption of Na+ and water. Maintain pH and sodium-potassium balance.
IV. **Collecting Duct**- large amount of water is reabsorbed to produce concentrated urine.

- The transport of substance facilitated by special arrangement of Henle's loop and vasa recta is called **counter current mechanism.**

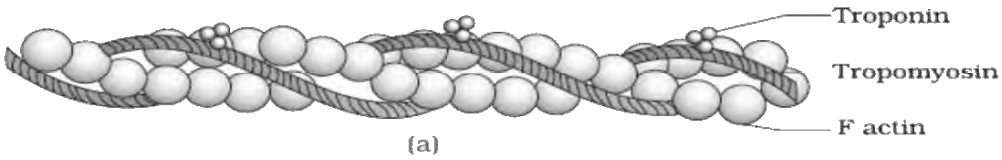
Disorders of Excretory System
• **Uremia**- there is high concentration of non-protein nitrogen (urea, uric acid, creatinine). Urea can be removed by hemodialysis.

• **Renal failure**- also known as kidney failure which glomerular filtration is ceased and both kidney stops working. Kidney transplant is the ultimate method in correction of acute kidney failure.
• **Renal Calculi**- formation of stone or insoluble mass of crystalized salts formed within the kidney.
• **Glomerulonephritis (Bright's Disease)-** inflammation of glomeruli of kidney due to entry of protein or red blood corpuscles in to filtrate due to injury.

20 LOCOMOTION AND MOVEMENT

Muscles are specialized tissues of mesodermal origin. They have property like excitability, contractility, extensibility and elasticity.

- **Skeletal Muscles** is made up of muscles bundles (fascicles), held together by collagenous connective tissue called fascia.
- Light bands contain actin and is called I-band (isotropic band) and dark band contain myosin, called A-band (anisotropic band). Both bands are present parallel to each other in longitudinal fashion.
- In centre of each I-band is elastic fibre called 'Z' line. In the middle of A-band is thin fibrous 'M' line. The protein of myofibrils between two successive 'Z' lines is the functional unit of contraction called a **sarcomere**.
- At resting stage thin filament overlaps the thick filament. The part of thick filament not overlapped is called 'H' zone.



(a)

- The mechanism of muscle contraction is explained by sliding mechanism theory in which thin filament slide over thick filament.
- Red fibres (aerobic muscles) contain myoglobin that has plenty of mitochondria to produce large amount of oxygen stored in them. The muscle fibres containing less number or myoglobin are called white fibres.

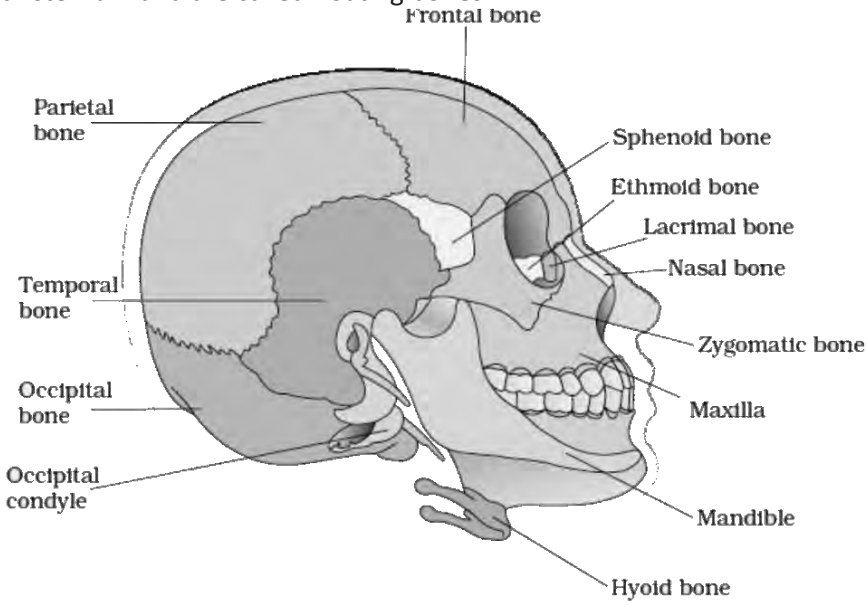
Skeletal System

Framework of bones and cartilage forms the skeletal system. In human beings, it consists of 206 bones and some cartilage. The two principle division of skeletal system are

a. Axial Skeleton (80 bones)- includes skull, vertebral column, sternum and ribs constitute axial system.

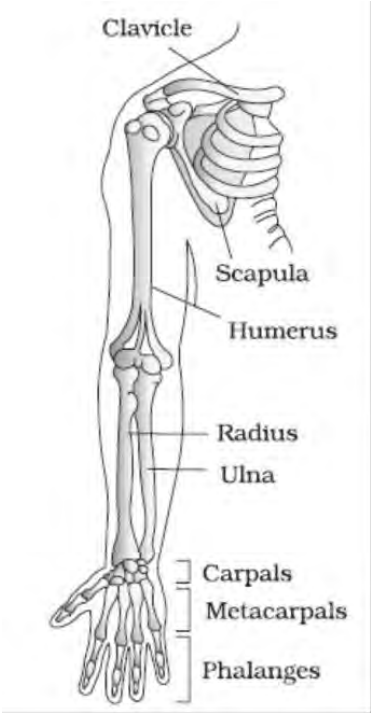
- The skull (22 bones) is composed of cranial and facial bones. Cranial (8 bones) forms protective covering for brain (cranium). The facial region consists of 14 skeletal systems that form front part of skull. Hyoid bone (U-shaped) forms the base of buccal cavity.
- The middle ear bone (Malleus, Incus and Stapes) collectively called Ear Ossicles. Skull joins with vertebral column with two occipital condyle.
- Vertebral column consists of 26 serially arranged vertebrae. First vertebra is atlas that combines with occipital condyle other include Cervical-7, thoracic -12, lumbar -5, sacral – 1 coccoygeal -1.

- 12 pairs of ribs connected dorsally to vertebral column and ventrally to sternum. 11th and 12th rib bones are not connected with sternum and are called floating bones.



Appendicular Skeleton- of bones of limbs and girdles. Each limb contains 30 bones.

Upper Arm	Lower Limb
Humerous, radius and ulna, 8- carpels, 5-metacarpels, 14- phalanges,	Femur, tibia and fibula, 7-tarsal, 5-metataral, 14-phalanges, cup shaped patella cover the knee.



Joints – are points of contact between bones, or between bones and cartilage.

I. **Fibrous joints**- do not allow any movements. Present in flat skull bones to form cranium.

II. **Cartilaginous joints**- bones are held together with the help of cartilage present in vertebrae. Permits limited movements.

III. **Synovial joints**- fluid field synovial cavity, provide considerable movements. Ball and socket joint, hinge joints, pivot joints, gliding joints etc.

Disorders of Muscular and Skeletal System

• **Myasthenia gravis-** auto immune disorder affecting neuromuscular junction causing fatigue, weakening and paralysis of skeletal system.

• **Muscular Dystrophy-** degeneration of skeletal muscles due to genetic disorder.

• **Osteoporosis –** decreased bone mass in old age leading to chance of fracture due to decreased estrogen.

• **Arthritis-** inflammation of joints.

• **Gout-** inflammation of joints due to accumulation of uric acid crystals.

21 NEURAL CONTROL AND COORDINATION

Human neural system consists of two main parts, the central nervous system (CNS) and the peripheral nervous system (PNS).

Afferent fibres- transmit impulses from tissue/organ to CNS.

• Efferent fibres- transmit regulatory impulses from CNS to concerned peripheral organs.

The peripheral nervous system is subdivided into the

- Sensory-somatic nervous system
- Autonomic nervous system

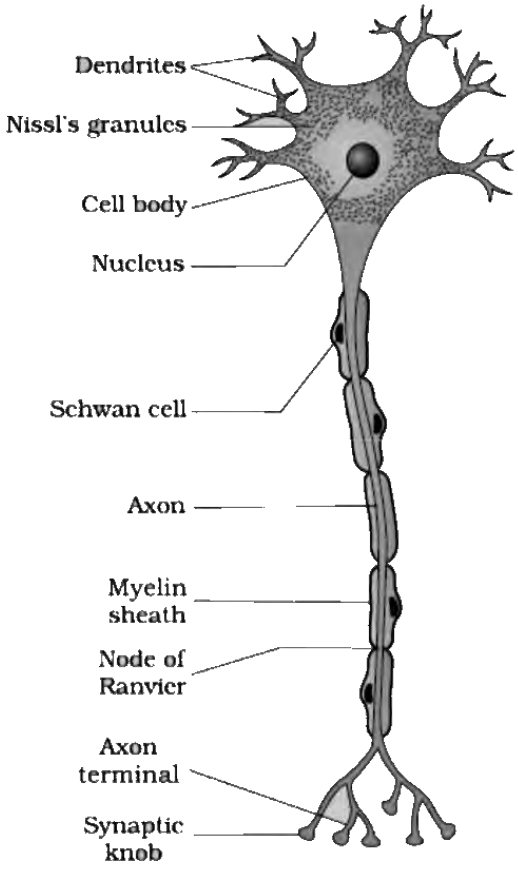
Somatic neural systems relay impulses from CNS to skeletal muscles.

Autonomic neural system transmits impulses from CNS to involuntary system and smooth muscles.

Neuron as Structural and Functional Unit of Neural System

Neuron is made up of three major parts- **cell body**, **dendrite** and **axon**.

• Cell body contains cytoplasm, cell organelles and Nissel's granules. Short fibres projecting out from cell body is called dendrites. The axon is long fibre having branched structure at the end that terminates into knob like structure called **synaptic knob**.

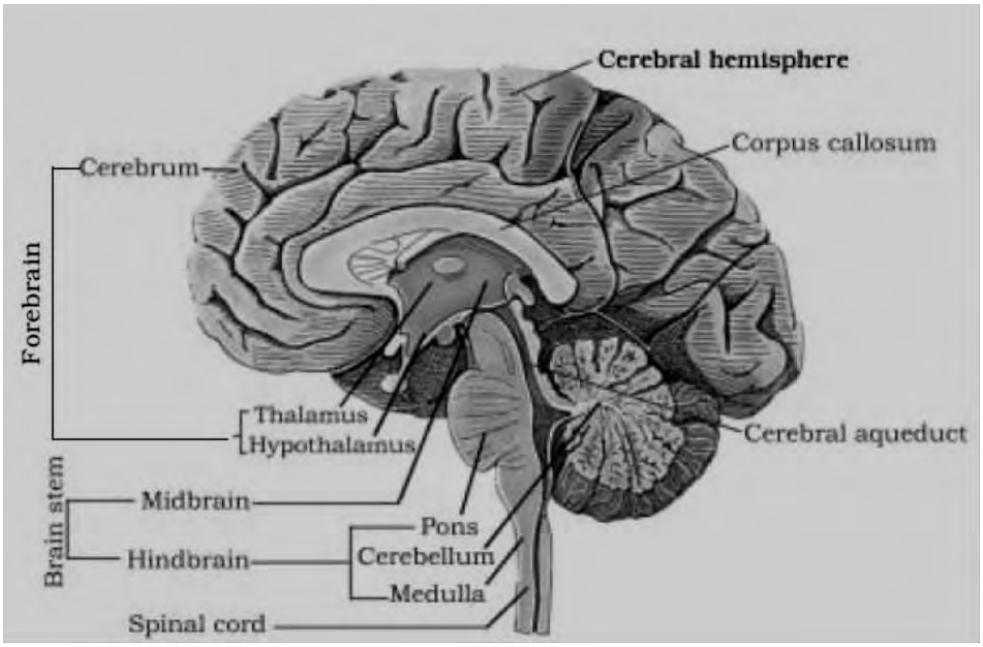


• Based on number of axon and dendrites neuron are of three types-
  - **Multipolar**- one axon and two or more dendrite found in cerebral cortex.
  - **Bipolar** – one axon and one dendrite found in retina of eyes.
  - **Unipolar**- cell body with one axon only found in embryonic.

There are two types of axon-
o **Myelinated neuron**- fibres are enveloped with **Schwann cells** to form myelin sheath around the axon. The gap between two myelin sheaths is called **nodes of Ranvier.** Found in spinal and cranial nerves.
o **Unmylinated nerve** fibre is enclosed by Schwann cells that do not form myelin sheath around the axon. Found in autonomes and somatic neural system.
• The electrical potential difference across the resting membrane is called **resting potential**.

There are two types of synapses.
a. **Electrical synapse-**
b. **Chemical synapse**

Human brain is protected by skull (cranium) and cranial meninges, three layered membrane, outer **dura meter**, middle **arachnoid** and inner **pia meter**.
Brain can be divided 3 parts- **forebrain, midbrain and hindbrain**. **Forebrain**- consists of **cerebrum, thalamus and hypothalamus**. Cerebrum is divided into left and right cerebral hemispheres which are covered by cerebral cortex (grey matter). Cerebral cortex contains sensory neuron, motor neuron and association area. Association area controls the memory and communication like complex process.



Hypothalamus controls the urge for eating, drinking and body temperature. They also release hypothalamic hormones. Limbic system is involved in controlling sexual behavior and expression of emotional reactions.
Midbrain is located between hypothalamus and pons of hindbrain. Dorsal portion consists of four round lobes called corpora quadrigemina. They are involved in relay of impulses back and forth between cerebrum, cerebellum, pons and medulla.
Hind brain consists of pons, medulla oblongata and cerebellum. Pneumatic centre is present in hindbrain that control inspiration. They also relay impulses between the medulla and superior part of brain. Cerebellum controls balance and posture.
The path followed by reflex action is called reflex arc.

Human Eye – spherical structure consists of three layers, external layer is **sclera** whose inner most layers is called **cornea**, middle layer **choroid** and innermost layer is called **retina**.
Human Ears
Divided into three regions outer ear, middle ear and inner ear.

22 CHEMICAL COORDINATION AND INTEGRATION

- Hormones are non-nutrient chemicals which act as intercellular messengers and are produced in trace amount.

Pituitary Gland is located in a body cavity called sella turcica and is attached to the hypothalamus by a stalk.

- The pituitary gland (hypophysis) is composed of the adenohypophysis (anterior lobe) and the neurohypophysis (posterior lobe).
- In Anterior lobe, the pars distalis secretes Growth Hormone (GH), Thyroid-stimulating hormone (TSH), Adrenocorticotrophic hormone (ACTH), Follicle-stimulating hormone(FSH), Lutenizing hormone (LH),and Prolactin. The pars intermedia secretes Melanocyte-stimulating hormone (MSH).

- The posterior pituitary stores and secretes (but does not synthesize) the following important endocrine hormones vasopressin and oxytocin.

- Over secretion of GH (growth hormone) causes over growth of the body leading to gigantism and low secretion causes stunted growth called dwarfism.
- Prolactin stimulates growth of mammary gland secretion of milk. TSH stimulates and regulates thyroid hormone.
- LH ans FSH stimulates gonadal activity. In male, LH stimulates synthesis and secretion of androgen hormone from testis. In female, LH induce ovulation of fully mature ovum from ovary.
- Oxytocin helps in contraction of uterus during child birth and milk ejection from mammary glands. Vasopressin stimulates absorption of water and electrolyte in kidney.

The pineal Gland- located on dorsal side of forebrain and release melatonin hormone that help in 24 hour rhythm of body like sleeps wake cycle and body temperature.

Thyroid Gland- composed of two lobes on either side of trachea connected by isthmus.

- The 2 main thyroid hormones are T3 (triiodothyronine) and T4 (thyroxine).
- Iodine is essential for synthesis of thyroid hormones. Deficiency of iodine leads to hyperthyroidism (Goitre). During pregnancy, hyperthyroidism may cause stunted growth of baby and mental retardation.

Parathyroid Gland- located on the back side of thyroid gland, secretes peptide hormone called parathyroid hormone (PTH). PTH regulates the circulating level of calcium ions. It also helps in reabsorption of calcium from renal tubules and digestive tracts.

Thymus- located on the dorsal side of heart and the aorta. This gland release peptide hormone thymosins that help in differentiation of T-Lymphocytes. It also promotes production of antibodies to provide humeral immunity.

Adrenal Gland – located on anterior part of each kidney, composed of two types of tissues central adrenal medulla and outside adrenal cortex. Adrenal medulla secretes adrenaline and noradrenaline hormone together called emergency hormone. Adrenal cortex secretes many hormones together called corticoids which are involved in metabolism of carbohydrates and maintaining water and electrolyte balance.

Pancreas – acts as both endocrine and exocrine gland. Endocrine pancreas consists of “Islets of Langerhans” which contain α-cells and β-cells. The α-cells secrete hormone glucagon and β- cells secrete insulin. Both hormones are involved in maintenance of blood sugar levels.
• Glycogen is a peptide hormone that stimulates glycogenolysis resulting increased blood sugar (hyperglycemia).
• Insulin is a peptide hormone that play major role in regulation of glucose hemostasis. The rapid movement of glucose from glucose to hepatocytes and adipocytes resulting in decreased blood glucose levels (hypoglycemia).

Testis – perform dual functions as a primary sex organ as well as endocrine glands. Lyding cells or interstitial cells produce androgen mainly testosterone which regulate regulation and maturation of primary sex organs.

Ovary – produce two groups of steroid hormones called estrogen and progesterone. Estrogen is synthesized and secreted by growing ovarian follicles. After ovulation, raptured ovum called corpus luteum, which secretes progesterone. Estrogen produces wide range actions like growth of female secondary sex organs. Progesterone regulates pregnancy.

Atrial wall of heart secretes peptide hormone called atrial natriuretic factor (ANF) that cause blood dilution. The juxtaglomerular cells of kidney produce erythropoietin hormone which stimulate erythropoiesis.

23 REPRODUCTION IN ORGANISMS

Reproduction is the means of perpetuation of race as older individuals undergo senescence and die.
• When the offspring is produced by single parents with or without the involvement of gamete formation, the reproduction is called **asexual reproduction**.
• When two parents (opposite sex) participates in reproduction process and also involves the fusion of male and female gametes, it is called **sexual reproduction**.

Asexual Reproduction

Single individual is capable of producing offspring which are identical and exact copy of their parent. The morphological and genetically individuals of same parents are called **clone**.

- Asexual reproduction is common among single celled organisms, plants and animals with simple organization.
- In Protista and Monera, the parent cells divides into two to give rise to new individuals. Thus, in these organisms **cell division** is the mode of reproduction itself.
- **Binary fission**- in this method of asexual reproduction, a cell divides into two halves and rapidly grows into an adult. Ex- amoeba, paramecium.
- **Budding**- small buds are produced that remain attached initially with parents and get separated on maturation. Ex. Yeast.
- Fungi and simple plants like algae reproduce through special reproductive structures like zoospores (motile structure), conidia (penicillium), buds (hydra) and gemmules (sponges).
- In plants, vegetative reproduction occurs by vegetative propagules like runner, rhizome, sucker, tuber, offset and bulb.
- **Water hyacinth** is called 'terror of Bengal' because it one of the most invasive weeds found growing wherever there is standing water. It drains oxygen from the water which leads to death of fishes.
- The ability of plants like potato, zinger, sugarcane, banana etc. has ability to produce roots from their nodes when come in contact of soil. This ability is used by gardeners and cultivators for commercial propagation.
- Bryophyllum develops adventitious buds from notches present at margin of leaves.
- Asexual reproduction is the most common method of reproduction in organisms having simpler body like in algae and fungi but during unfavorable condition they shift to sexual reproduction.

Sexual Reproduction involves formation of male and female gametes, either by the same individual or different individuals of opposite sex. These gametes fuse to form zygote which develops to form the new organisms.

- In sexual reproduction, fusion of male and female gametes results in offspring that are not identical to parents.
- Some plants show flowering in particular season and some other flowers in all seasons. Some other plants like bamboo species flowers once in life time (after 50-100 years), *Strobilanthus kunthiana* flowers once in 12 years.
- The female placental animals exhibit cyclic change in activities ovaries and accessary glands as well as hormone during the reproductive phase.
- In non-primate animals (cow, sheep, rat, deer, dog, tiger etc.) cyclic change in females is called oestrus cycles and where as in primates (monkey, apes, human beings) it is called menstrual cycle.

Pre-fertilization- all the events prior to fusion of gametes are included in it. It includes gametogenesis and gamete transfer.

a. **Gametogenesis** is the process of formation of male and female gametes.

- Gametes are haploid cells which may be similar or dissimilar in structure. In algae, both gametes are similar in structure called **isogametes**. In higher organism that reproduces sexually, two morphologically distinct gametes are formed called **heterogametes**, male gametes are called antherozoid or sperm and female gametes are called ovum or egg.
- In animals, species which possess both male and female reproductive organs in same individual are called bisexual or hermaphrodites (earthworm, sponges, tapeworm etc.) and both having either male or female reproductive organs are called unisexual (cockroach, human).
- Gametes are always haploid, although organisms may be haploid and diploid. Diploid organisms form gametes by meiotic division. The organisms belonging to algae, fungi, and bryophytes have haploid plant body and pteridophytes, gymnosperms, angiosperms and most of animals are diploid.
- In diploid organisms, gamete mother cell (meiocyte) undergoes meiosis in which one set of chromosome is present in gametes.

b. **Gamete Transfer –** in majority of organisms, male gametes are motile and females gametes are non-motile, except in fungi and algae in which both gametes are motile.

- In simple plants like algae, fungi, bryophytes and pteridophytes water is the medium through which male and female gametes moves.
- In higher plants pollen grains are carrier of male gametes and ovule has eggs. Pollen grains must be transferred from anther to stigma to facilitate fertilization. The transfer of pollen grains from anther to stigma is called pollination. Pollination may be self (anther to stigma of flower) or cross (anther to stigma of different flower).
- Pollen grains germinate on stigma to produce pollen tube that delivers the male gametes near the ovule.

Fertilization – the fusion of male and female gametes is called syngamy that results in the formation of zygote, the process is called fertilization.

- The process of development of new organisms without fertilization of female gametes is called **parthenogenesis**.
- In aquatic organism, fertilization occurs in water; outside the body of organism is called external fertilization.
- In terrestrial organisms, syngamy occurs inside the body of organisms, so called internal fertilization.

Post Fertilization Events- events in the sexual reproduction after formation of zygote.

- In the organisms, having external fertilization, zygote is formed in external medium (water) and those having internal fertilization zygote is formed inside the body of female.
- In algae and fungi, zygote develops a thick wall resistant to desiccation and damage. This germinates after a period of rest.
- In the organisms having haplontic life cycle, zygote divides to form haploid spores that germinate to form haploid individual.

Embryogenesis –is the process of development of embryo from the zygote. During this, zygote undergoes mitotic division and cell differentiation. Cell division increase the number and cell differentiation help in formation of new group of cells and organs.

- In flowering plants, zygote is formed inside the ovule. After fertilization, sepals, petals and stamens of flower fall off. The zygote develops into embryo and ovules into seeds. The ovary develops into fruits which develop a thick wall called pericarp, protective in function.
- After dispersal, seeds germinate under favorable condition to produce new plants.

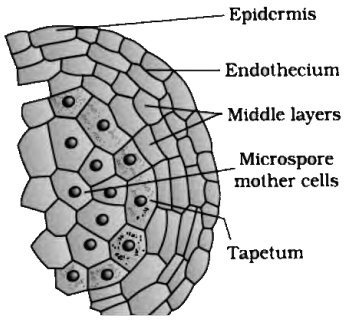
24. SEXUAL REPRODUCTION IN FLOWERING PLANTS

Reproduction is the means of perpetuation of race as the older individuals undergo senescence and die. Flowering plants shows sexual mode of reproduction and bears complex reproductive units as male and female reproductive units along with accessary structures.

Pre-fertilization: Structures and Events

• Several structural and hormonal changes lead to formation and development of the floral primordium. Inflorescence is formed that bears floral buds and then flower.
• In flowers, male (androecium) and female (gynoecium) differentiate and develops in which male and female gametes are produced.
• Stamen consists of long and slender stalk called filament and generally bilobed anthers. Each lobe contains two theca (dithecious).
• The anther is four-sided structure consisting of four microsporangia, two in each lobes.
• Microsporangia develop further and become pollen sacs which contain pollen grains.
• Microsporangium is generally surrounded by four layered walls- the epidermis, endothecium, middle layer and tepetum. Innermost layer tepetum nourishes the developing pollen grains.
• Sporogenous tissues are present in the middle of microsporangium.

Microsporogenesis- is the process of formation of microspores from a pollen mother cell through meiotic division
• The cells of sporogenous tissues undergo meiotic division to form microspore tetrad. As the anther mature and dehydrate, the microspore dissociate and develops into pollen grains.



• The pollen grain represents the male gametophytes. Each pollen grains have two layered wall, the outer **exine** made up of sporopollenin and inner wall is called **intine** made up of cellulose and pectin.
• Pollen grain exine has prominent aperture called germ pores. Pollen grain contain 2 cells the vegetative cell and generative cell.
• In most of the angiosperms, pollen grains are shed in 2-celled stage.

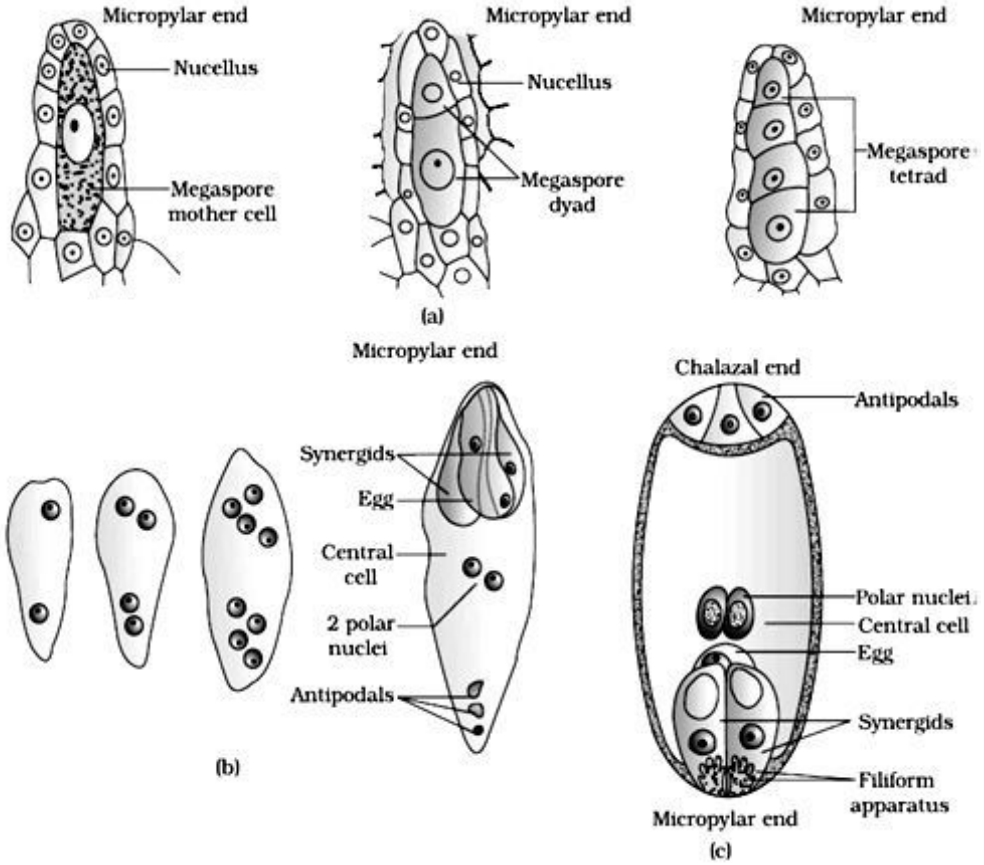
The Pistil, Megasporangium (Ovule) and Embryo sac

- Gynoecium may consists of single pistil (monocarpellary) or more than one pistil (polycarpellary) which may be fused (syncarpous) or free (apocarpous).
- Each pistil has three parts the **stigma, style and ovary**. Inside the ovary is ovarian cavity (locule). The placenta is located inside the ovarian cavity. Megasporangia (ovules) arise from placenta.

The Megasporangium (ovule) is small structure attached to the placenta by means of stalk called funicle.

Embryogenesis- is the process of formation of megaspores from the megaspore mother cell.
• Ovule differentiates a single megaspore mother cell (MMC) in the micropylar region of nucellus. MMC undergoes meiotic division that results into the production of four megaspores.

• In most of the flowering plants three megaspores degenerate. 1 megaspore develops into female gametophyte (embryo sac).
• The nucleus of functional megaspore divides mitotically to form two nuclei which move to opposite poles to form 2- nucleate embryo sac. Two more sequential mitotic division results into 8-nucleate embryo sac.
• Six of the eight nuclei surrounded by cell wall and remaining two nuclei (polar nuclei) are situated below the egg apparatus.
• Three cells are grouped at micropylar end to constitute egg apparatus and three cells at chalazal end forms antipodal cells. At maturity embryo sac is 8-nucleate and 7 celled.



Pollination –is transfer of pollen grains from anther to stigma.
a) **Autogamy**- transfer of pollen grain from anther to stigma of same flower. Types are as follows:
i. **Cleistogamous** – flower which do not open.
ii. **Chasmogamous**- exposed anther and stigma.
b) **Geitonogamy** – transfer of pollen grains from anther to stigma of different flower of same plant.
c) **Xenogamy**- transfer of pollen grain from anther to stigma of different plant's flower of same species.

Agents of pollination includes abiotic (water, wind) and biotic (insects, butterfly, honey bee etc.
Outbreeding Devices- the various mechanisms that discourage self-pollination and encourage cross pollination as continued self-pollination leads to inbreeding depression. It includes
• Pollen release and stigma receptivity not synchronized.
• Anther and stigma are placed at different position.
• Inhibiting pollen germination in pistil.
• Production of unisexual flowers.

Pollen pistil interaction – the pistil has ability to recognize the compatible pollen to initiate post pollination events that leads to fertilization. Pollen grain produce pollen tube through germ pores to facilitate transfer of male gametes to embryo sac.
Double Fertilization- after entering the egg synergids, each pollen grain releases two male gametes. One male gametes fuse with egg (**syngamy**) and other male gametes fuse with two polar nuclei (**triple fusion**) to produce triploid primary endosperm nucleus (PEN).
Since two types of fusion takes place in an embryo sac the phenomenon is called double fertilization. The PEN develops into the endosperm and zygote develops into embryo.

Post fertilization events include endosperm and embryo development, maturation of ovules into seeds and ovary into fruits.
Endosperm- the primary endosperm cell divides many time to forms triploid endosperm tissue having reserve food materials. In coconut, water is free nuclear endosperm and white kernel is the cellular endosperm.
• The wall of ovary develops into wall of fruit called pericarp. In true fruits only ovary contributes in fruit formation by in false fruit thalamus also contributes in fruit formation.
• **Apomixis** – formation of seeds without fertilization.
• **Polyembryony**- occurrence of more than one embryo in a seed.

25. HUMAN REPRODUCTION

Humans are sexually reproducing and viviparous. The reproductive events in humans include formation of gametes, sperms in male and ovum in females, transfer of sperms into female genital tract and fusion of male and female gametes. The reproductive event occurs after puberty.

The Male Reproductive System
The male reproductive system includes a pair of testes, along with accessory ducts, glands and external genitalia.
• The testes are situated outside the abdominal cavity in a pouch called scrotum, which help in maintaining the low temperature of testes necessary for spermatogenesis.
• Each testes has about 250 testicular lobules and each lobule contain highly coiled seminiferous tubules in which sperms are produced. Each seminiferous tubules is lined by two types of cells, spermatogonia (male germ cell) and Sertoli cells.
• Leydig cells present around the seminiferous tubules synthesize and secrete androgen hormone.
• Ejaculatory duct store and transport the sperm from testes to outside through urethra which originate from urinary bladder and extend through penis to its external opening urethral meatus.
• The penis is male external genitalia. The enlarged end of penis is called the glans penis is covered by a loose fold of skin called **foreskin**.
• Male accessary glands include paired seminal vesicles, prostrate and paired bulbourethral glands. Secretion of these glands forms the seminal plasma which contains fructose, calcium and number enzymes. The secretion of bulbourethral glands also helps in lubrication of the penis.

The Female Reproductive System

- Female reproductive system consists of a pair of ovaries, a pair of oviduct, uterus, cervix, vagina and external genitalia located in pelvic region. A pair of mammary gland also supports the process of reproduction.
- Ovaries are primary female sex organ that produce the female gamete and several steroid hormones. Each ovary is covered by thin epithelium which encloses the ovarian stroma, which is divided into a peripheral cortex and an inner medulla.

- Fallopian tube extends from periphery of ovary to the uterus. The part closer to ovary is a funnel shaped structure called infundibulum having finger like projection called fimbriae.
- Infundibulum leads to ampulla and join with uterus with isthmus. Uterus is pear shaped structure also called womb.
- Uterus open vagina through a narrow cervix. The cavity of cervix (cervical canal) along with vagina forms the **birth canal**.
- The wall of uterus has three layers of tissue

I. Perimetrium- external membrane.
II. Myometrium – middle thick layer of smooth muscles which exhibit strong contraction during delivery of baby.
III. Endometrium - line the uterine wall and undergo cyclic changes during menstrual cycle.

- Female external genitalia includes: Mons pubis, Labia majora and Labia minora,
- The opening of vagina is often partially covered by a membrane called **hymen**. The tiny finger like projection present at the upper junction of two labia minora above the urethral opening is called **clitoris**.
- Mammary glands are paired structures that contain glandular tissues and variable fats. Each glandular tissue contains 15-20 mammary lobes containing alveoli that secrete milk. Mammary ducts join to form mammary ampulla.

Gametogenesis

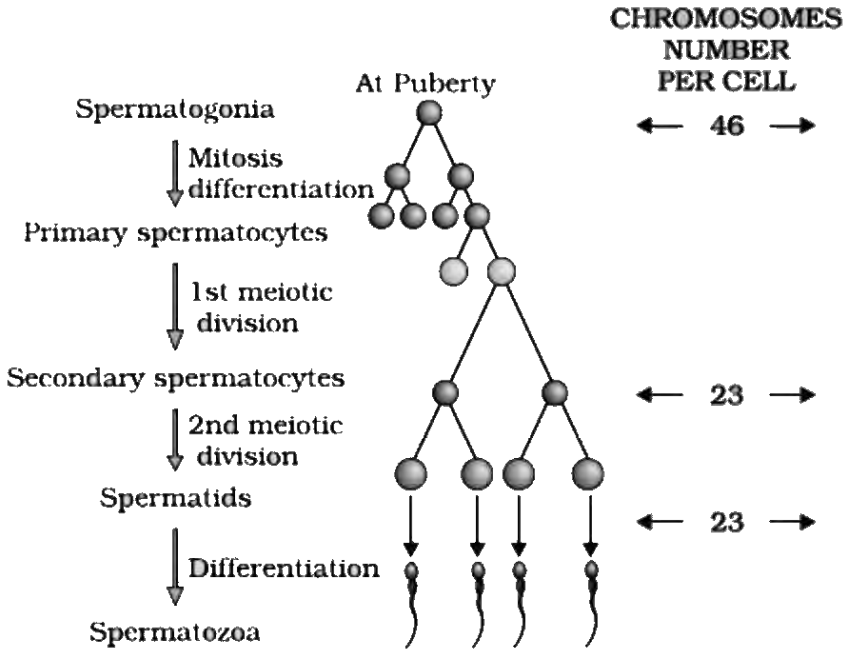
The process of formation of male and female gametes in testes and ovary respectively is called gametogenesis.

Spermatogenesis- in testes immature, male germ cells (spermatogonia) produce sperm by spermatogenesis that begin at puberty.

• The spermatogonia present at the inner side of seminiferous tubules multiply by mitotic division and increase in number. Each spematogonium contain 46 chromosomes.

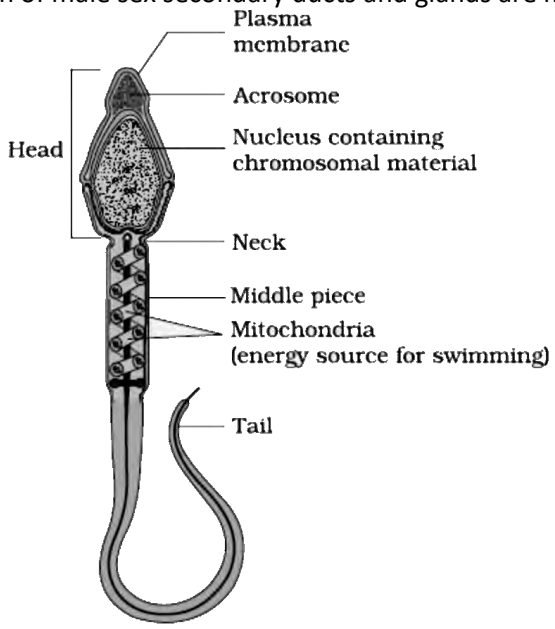
• Spermatogonia forms spermatocyte that undergo meiotic division to reproduce secondary spermatocytes having 23 chromosomes.

• The spermatids are transformed into spermatozoa by the process called spermiogenesis. The sperm heads remain embedded in sertoli cells and are released from seminiferous tubules by the process of spermiation.



Structure of sperm- sperm is a microscopic structure composed of a head, neck, a middle piece and a tail. The sperm head contain elongated haploid nucleus, anterior portion of which is covered by cap like structure **acrosome**.

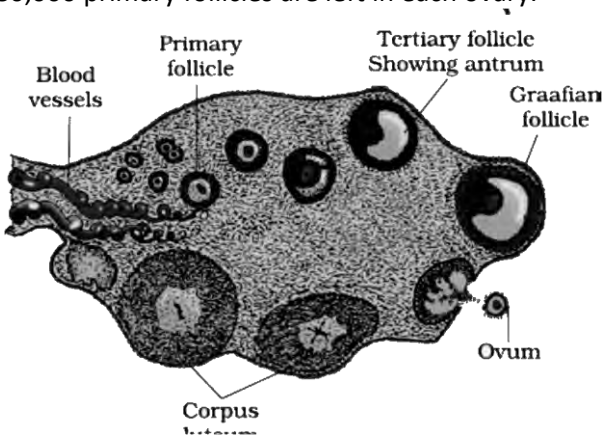
• Human male ejaculates about 200-300 million sperms during a coitus. The seminal plasma along with the sperms constitutes the semen. The function of male sex secondary ducts and glands are maintained by androgen hormones.



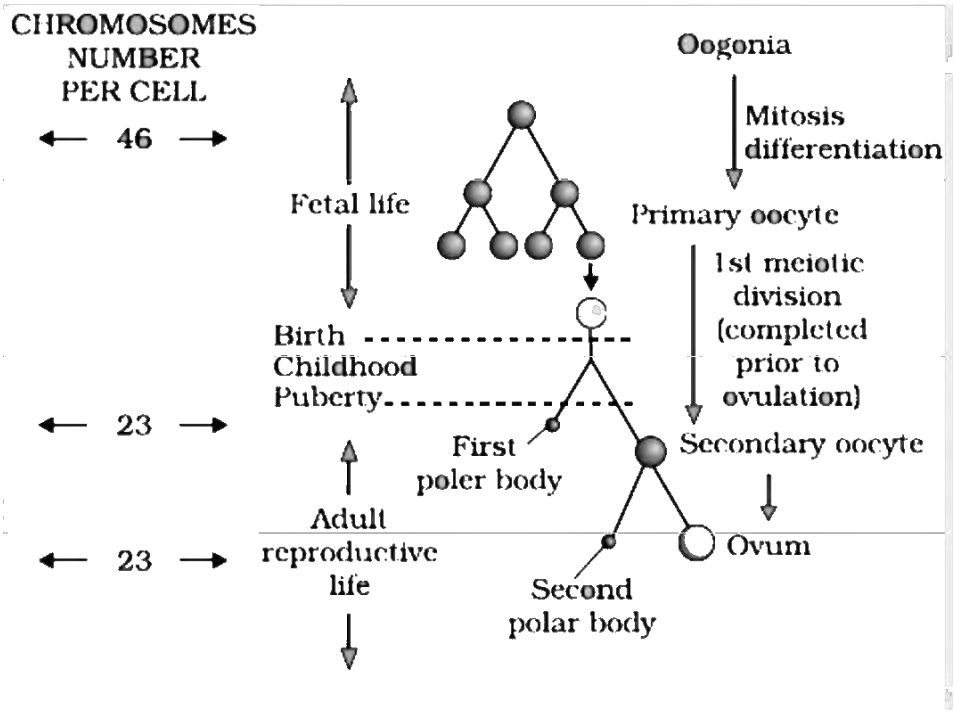
Oogenesis

The process of formation of mature female gametes is called oogenesis. It started during embryonic development stage when millions of oogonia (gamete mother cells) are formed in each fetal ovary.

- The gamete mother cells start division and enter into prophase-I of meiotic division and get temporarily arrested at that stage called **primary oocytes**.
- Each primary oocyte get surrounded by a layer of granulosa cell then it is called the **primary follicle**.
- At puberty, about 60,000- 80,000 primary follicles are left in each ovary.



- Primary follicle gets surrounded by more layers of granulosa cells called secondary follicle that transform into tertiary follicle that contain fluid filled cavity called antrum.
- The tertiary follicles further changes into the mature follicle called Graafian follicle, which rapture to release secondary oocytes (ovum) from the ovary by the process of ovulation.



Menstrual cycle

The reproductive cycles in female primates is called menstrual cycle. It start at puberty and is called menarche. The cycle of events starting from one menstruation till the next one is called the menstrual cycle. One ovum is released (ovulation) at the middle of this cycle.

- The cycle starts with menstrual phase, in which menstrual flow occurs for 3-5days due to breakdown of endometrial lining of the uterus.
- The pituitary and ovarian hormones brings about changes in ovary and uterus. The LH and FSH hormone causes rapture of Graafian follicle to cause ovulation.
- In human females menstrual cycle seized at around 50 years of age that is called menopause.

Fertilization and Implantation

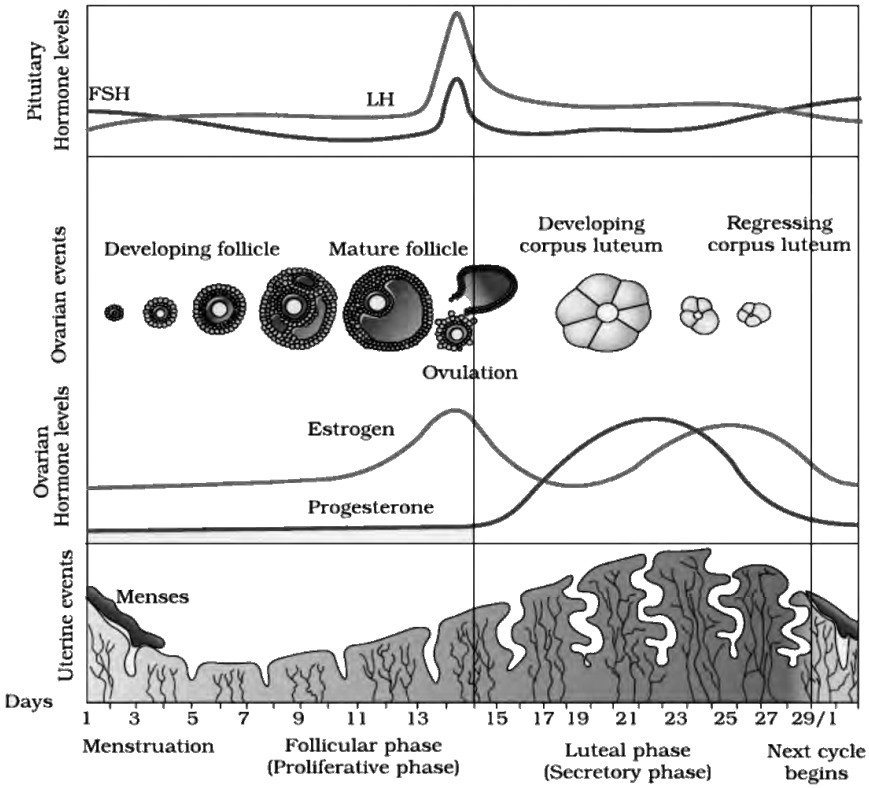
The process of fusion of sperm with ovum is called fertilization.

• During coitus (copulation) semen is released into vagina. The motile sperms swim rapidly to reach the junction of isthmus and ampulla of fallopian tube. The ovum also reaches there and fusion of gametes takes place in at ampullary isthmic junction.

• During fertilization, a sperm come in contact of zona pellucida layer of ovum to change the membrane to prevent entry of other sperms.

• The haploid gametes fuse together to form diploid zygote. As the zygote moves towards the uterus, the mitotic division starts and form cleavage to change into 2, 4, 8, 16- celled blastomeres.

• The blastomeres with 8 to 16 cells are called morula. Morula divide to change into blastocysts. The outer layer of blastocyst is called trophoblast that attach with endometrium of uterus, called implantation that leads to pregnancy.



Pregnancy and embryonic development

The finger-like projections on trophoblaste after implantation called is called **chronic villi** that along with uterine wall forms functional unit between developing embryo and maternal body called **placenta**. Placenta is attached with fetus with an umbilical cord that transport food and oxygen to embryo.

• Hormones hCG (human chorionic gonadotropin), hPL (human placental lactogen) and relaxin are produced in woman only during pregnancy by placenta.

• The inner cell mass (embryo) contain certain cells called stem cells that have potency to give rise all tissues and organs.

• In human, after one month of pregnancy the embryo's heart is formed. By the end of 2nd month limbs and digits are formed. By the end of 12 months, major organs and external genital organs are well developed. The first movement of foetus is observed in 5 months. By the end of 24 weeks body is covered with fine hair, eye lids and eyeless are formed. At the end of 9 months fetus is fully developed.

Parturition- the process of delivery of fully developed foetus is called parturition. It occurs due to **foetal ejection reflex**.

The mammary glands of female, start producing milk, to the end of pregnancy by the process of lactation. The milk produced during the initial few days of lactation is called colostrum, which contain several antibodies.

26. REPRODUCTIVE HEALTH

According to WHO, reproductive health means total well-being in all aspects of reproduction i.e. physical, emotional, social and behavioral.

Reproductive Health: Problem and Strategies

- To attain total reproductive health as social goal, action plans and programs at a national level are initiated at national level. These programs are called family planning initiated in 1951.
- Proper information about reproductive organs, adolescence and related changes, safe and hygienic sexual practice, STD and AIDS would help people to lead a reproductively healthy life.
- **Amniocentesis** is a foetal sex determination test based on chromosomal pattern in amniotic fluid is surrounding the developing embryo.
- Better awareness about the sex related matters, increased number of medically assisted deliveries and better post-natal care leading to decreased maternal and infant mortality rate, increased number of couples with smaller families, better detection and cure of STDs.

Population Explosion and Birth Control

- Rapid decline in death rate, MMR (maternal mortality rate) and IMR (infant mortality rate) along with increase in population of reproductive age is the main for population explosion.
- Steps to overcome population explosion-
  - Using various contraceptive methods.
  - Educating people about the demerits of large family.
  - Increasing the marriageable age of female and male
  - Providing incentive to parents having 1or 2 children
- **Contraceptive methods** are used to prevent the unwanted pregnancy and modifying the menstrual cycle. An ideal contraceptive should be-
  - ✓ User friendly
  - ✓ Easily available
  - ✓ Effective
  - ✓ Reversible
  - ✓ No side effects
  - ✓ No way interferes with sexual desire and sexual act

Contraceptive methods could be divided into following categories-

a) Natural or traditional methods
b) Barrier methods
c) IUDs
d) Oral contraceptive methods
e) Injectable
f) Implants
g) Surgical methods.

❖ **Natural methods** works on the principle of avoiding chances of ovum and sperm meeting. It includes-

- **Periodic absentee** - the couples avoid coitus from day 10 to 17 of menstrual cycle.

- **Withdrawal or coitus intercepts –** male partner withdraws penis from vagina just before ejaculation.
- **Lactational Amenorrhea –** absence of menstruation after parturition and intense milk feeding **and** no ovulation in this period.

❖ In **Barrier methods**, ovum and sperms are prevented from physical meeting with help of barrier. **Diaphragms, cervical cap and vaults** are barrier made of rubber that is inserted into the female reproductive tract during coitus.

❖ **Intra uterine Devices**- inserted by doctor or trained nurse into the female uterus through vagina. IUCDs may be non-medicated (lippes loop), Cu-T, LNG-20 etc. IUCDs increase the phagocytosis of sperm in uterus and copper reduce the motility and fertility capacity of sperms. It is ideal for female that wants to delay pregnancy and spacing between two children.

❖ **Oral Pills** are progesterone or progesterone-estrogen combination used by females in form of tablets. They inhibit ovulation and implantation as well as prevent entry of sperms into cervix. Administration of progesterone or progesterone-estrogen combination within 72 hours of coitus is found to be very effective as emergency contraceptive.

❖ **Surgical method** is used as terminal method of contraception in male and female to prevent any more pregnancy.

❖ **Vasectomy** is the surgical method in male; a small portion of vas deference is removed or tied through a small incision in scrotum to prevent release of sperms.

❖ **Tubectomy** is the surgical method in females in which small part of fallopian tube is removed surgically.

Medical Termination of Pregnancy

- Voluntary termination of pregnancy before full term is called MTP (medical termination of pregnancy) or induced abortion. It plays important role in decreasing population by aborting unwanted pregnancy.
- In India, MTP is legalized in 1971 with some restriction to prevent its misuse such as indiscriminate and illegal female foeticides.
- MTP is used to get rid of unwanted pregnancy due to unprotected intercourse or failure of contraceptives used during coitus or rapes or when pregnancy continuation could be harmful or even fetal to mother or foetus.
- MTPs are considered relatively safe during first trimester or up to 12 months of pregnancy. Second trimester MTPs are much more riskier.

Sexually Transmitted Disease (STDs)

Diseases or infections which are transmitted through sexual intercourse are collectively called sexually transmitted disease or venereal disease (VD) or reproductive tract infection (RTI).

➢ Some common STDs are Gonorrhea, syphilis, genital herpes, chlamydiasis, genital warts, trichomoniasis, hepatitis-Ba and AIDS.

➢ Hepatitis-B and HIV is also transmitted by sharing of injection needles, surgical instruments with infected person, transfusion of blood, or from infected mother to foetus.

➢ Except genital herpes, HIV and hepatitis-B are completely curable if detected earlier and treated properly.

➢ Infections of STDs can be prevented by-

a) Avoid sex with unknown partners/multiple partners.
b) Always use condoms during coitus.

c) Go to a qualified doctor in case of doubt for early detection and get complete treatment if diagnosed.

Infertility

Infertility may be due to physical, congenital, diseases, drugs, immunological or even physiological.

- Infertile couples can be assisted to have children through certain special techniques commonly called **assisted reproductive technologies (ART)**. Which includes-

  - **In vitro fertilization (IVF)** - fertilization outside the body followed by embryo transfer, which is commonly called test tube baby program. The ovum from wife/donor and sperms from husband/ donor are collected and induced to fertilize in laboratory conditions. The zygote or early embryo (8 blastomeres) could be transferred into fallopian tube called **ZIFT** (zygote intra fallopian transfer) and embryo with more than 8 blastomeres **IUT** (intra uterine transfer) into the uterus to complete the further development.
  - **GIFT (gamete intra fallopian transfer) –** transfer of gametes collected from a donor into fallopian tube of another female who do not produce ovum.
  - **Intra cytoplasmic sperm injection (ICSI) -** specialized procedure to form an embryo in laboratory in which sperm is directly injected into ovum.
  - **Artificial insemination-** infertility cases in which male partner is unable to produce healthy sperms are treated by this technique in which semen collected from donor is artificially introduced into vagina or into uterus, IUI (intra uterine insemination) of the female.

All these techniques require extremely high precision handling by specialized professional and expensive instruments. There for their benefits are limited to certain countries and people.
Emotional, religious and social factors also prevent the adaptation of these methods.

27. PRINCIPLES OF INHERITANCE AND VARIATION

Genetics is the study of principles and mechanism of heredity and variation. Gregor Johann Mendel is known as 'father of Genetics'.

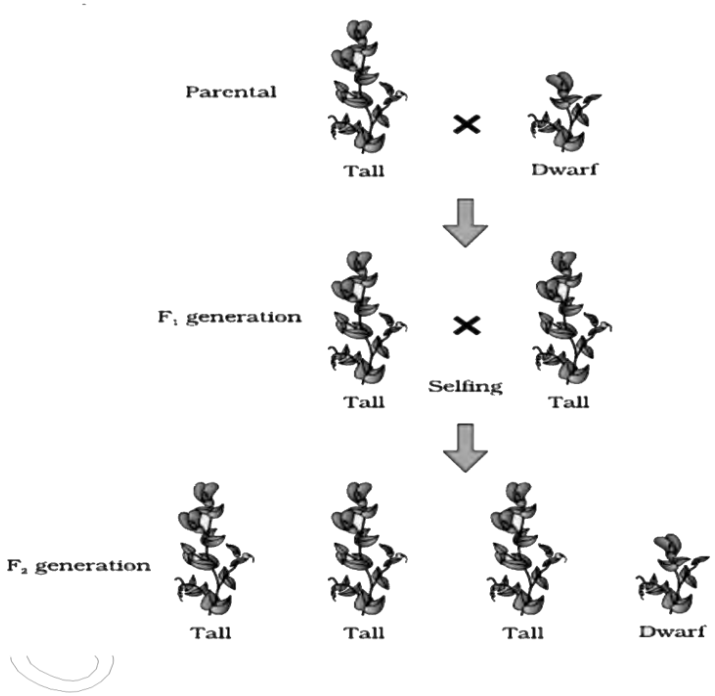
- Inheritance is the process by which characters are passed from one parent to progeny. It is the basis of heredity.
- Variation is the degree by which progeny differ from their parents. Variation may be in terms of morphology, physiology, cytology and behavioristic traits of individual belonging to same species.
- Variation occurs due to Reshuffling of gene/chromosomes, Crossing over, Mutation and effect of environment.

Mendel's Law of Inheritance

Mendel selected 7 contrasting characters of garden pea for his hybridization experiments.

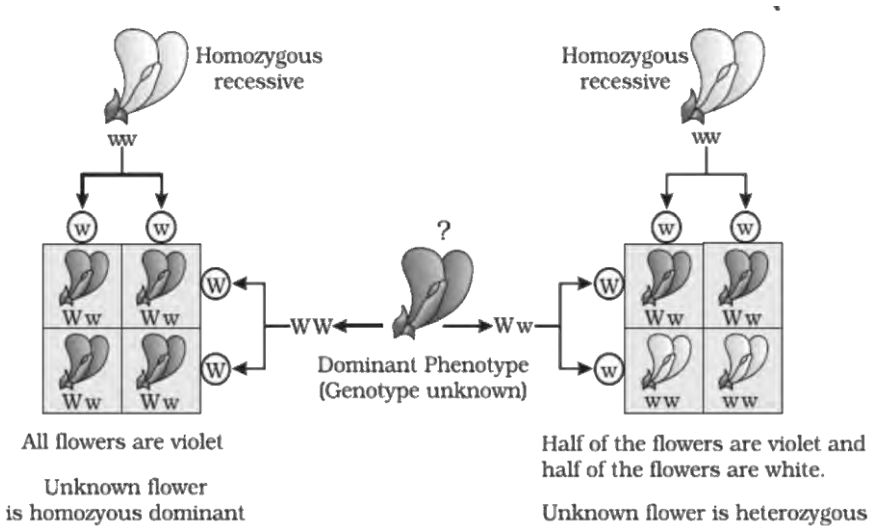
Characters	Dominant traits	Recessive traits
Plant height	Tall	dwarf
Flower/pod position	Axillary	Terminal
Fruit/pod colour	Green	Yellow
Seed shape	Round	Wrinkled
Seed colour	Yellow	Green
Flower colour	Violet	White
Pod shape	Inflated	Constricted

Inheritance of one gene (Monohybrid cross)



- Mendel called the '**factors**' that passes through gametes from one generation to next generation. Now a day it is called as genes (unit of inheritance).
- Genes that code for a pair of contrasting traits are known as **alleles**.
- Alphabetical symbols are used to represent each gene, capital letter (TT) for gene expressed in F1 generation and small letter (tt) for other gene.
- Mendel also proposed that in true breeding tall and dwarf variety allelic pair of genes for height is **homozygous** (TT or tt). TT, Tt or tt are called **genotype** and tall and dwarf are called **phenotype**.
- The hybrids which contain alleles which express contrasting traits are called **heterozygous** (Tt).
- The monohybrid ratio of F_2 hybrid is 3:1(phenotypic) and 1:2:1(genotypic).

Test cross is the cross between an individual with dominant trait and a recessive organism in order to know whether the dominant trait is homozygous or heterozygous.



Principle or Law of Inheritance

Based on observations of monohybrid cross, Mendel proposed two law of inheritance-

Law of dominance states that –
Characters are controlled by discrete units called factors.
Factors always occur in pair.
In a dissimilar pair of factors one member of pair dominate the other.

Law of Segregation- alleles do not blend and both the characters are recovered during gametes formation as in F_2 generation. During gamete formation traits segregate (separate) from each other and passes to different gametes. Homozygous produce similar kinds of gametes but heterozygous produce to different kinds of gametes with different traits.

Incomplete dominance

- It is a post Mendelian discovery. Incomplete dominance is the phenomenon of neither of the two alleles being dominant so that expression in the hybrid is a fine mixture or intermediate between the expressions of two alleles.
- In snapdragon (*Mirabilis jalapa*), there are two types of pure breeding plants, red flowered and white flowered. On crossing the two, F_1 plants possess pink flowers. On selfing them, F_2 generation has 1red: 2 pink: 1white. The pink flower is due to incomplete dominance.

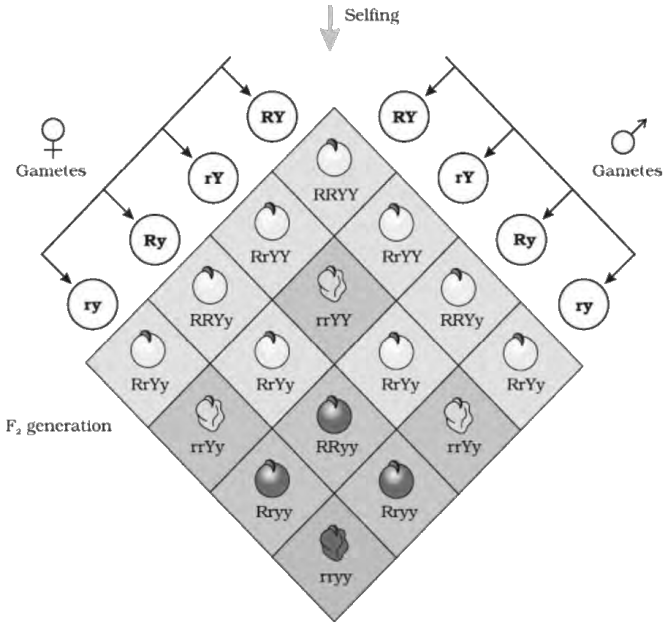
Co-dominance

- It is the phenomenon of two alleles lacking dominance-recessive relationship and both expressing themselves in the organism.
- Human beings, ABO blood grouping are controlled by gene *I*. The gene has three alleles I_A, I_B, *i i.* Any person contains any two of three genes. I_A, I_B, are dominant over *i.*

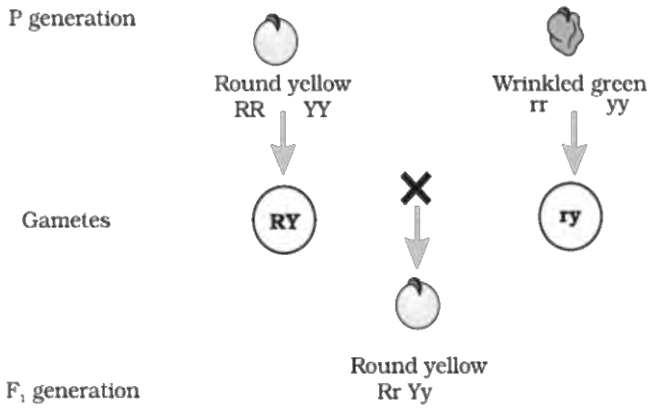
Multiple Alleles

They are multiple forms of a mendelian factor or gene which occur on the same gene locus distributed in different organisms in the gene pool with an organism carrying only two alleles and a gamete only one allele.

Inheritance of Two genes (Dihybrid Cross)



Phenotypic ratio : round yellow : round green : wrinkled yellow : wrinkled green
9 3 3 1



A cross made to study simultaneous inheritance of two pairs of mendelian factors of genes.

Law of independent Assortment – when two pairs of traits are combined in a hybrid, segregation of one pair of character is independent of other pair of characters. In Dihybrid cross two new combinations, round and yellow and wrinkled and green are formed due to independent assortment of four traits, round, wrinkled, yellow and green.

Chromosomal Theory of Inheritance

- Chromosome as well as gene both occurs in pair. The two alleles of a gene pair are located on homologous sites on homologous chromosomes.
- Sutton and Boveri argued that the pairing and separation of a pair of chromosomes would lead to segregation of a pair of factors (gene) they carried.
- Sutton united the knowledge of chromosomal segregation with mendelian principles and called it the chromosomal theory of inheritance.

Linkage and Recombination

- ❖ When two genes in a Dihybrid cross were situated on same chromosome, the proportion of parental gene combination was much higher than the non-parental type. Morgan attributed this due to the physical association or the linkage of the two genes and coined the **linkage** to describe the physical association of genes on same chromosome.
- ❖ The generation of non-parental gene combination during Dihybrid cross is called recombination. When genes are located on same chromosome, they are tightly linked and show very low recombination.

Sex Determination

- ➢ Latter it was observed that the ovum that receive the sperms with x body become female and those not becomes males, so this x body was called as **sex chromosome** and other chromosomes are called **autosomes.**
- ➢ In humans and other organisms XY types of sex determination is seen but in some insects like Drosophila, XO type of sex determination is present.
- ➢ In both types of sex determination, male produce two different types of gametes either with or without X chromosome or some with X chromosome and some with Y chromosomes. Such types of sex determination are called **male heterogamety**.
- ➢ **In birds,** two different types of gametes are produced by females in terms of sex chromosomes; this type of sex determination is called **female heterogamety**.

Mutation is a phenomenon which results in alternation of DNA sequence and consequently results in the change in the genotype and phenotype of an organism. The mutations that arise due to due to change in single base pair of DNA are called **point mutation**.

Genetic Disorder

The analysis of traits in several of generation of a family is called the **pedigree analysis**. The inheritance of a particular trait is represented in family tree over several generations. It is used to trace the inheritance of particular trait, abnormality and disease.

Mendelian disorder includes-

a. **Hemophilia-** sex linked recessive disease in which, in an infected individual, a minor cuts leads to non-stop bleeding. Heterozygous female (carrier) can transmit the disease to their son.
b. **Sickle cell anemia-** an autosome linked recessive trait in which mutant hemoglobin molecules

undergo polymerization under low oxygen tension causing change in shape of the RBC from biconvex disc to elongated sickle like structure.

c. **Phenylketonuria-** inborn error of metabolism inherited as autosomal recessive trait. The affected individual lacks an enzyme that converts the amino acids phenylalanine to tyrosine that results into mental retardation.

Chromosomal Disorders-Failure of segregation of chromatids during cell division results in loss or gain of chromosome called **aneuploidy**. The failure of cytokinesis leads to two sets of chromosome called **polyploidy**.

a. **Down's Syndrome**- is due to presence of additional copy of the chromosome number 21. The affected individual is short statured with small rounded head, furrowed tongue and partially opened mouth. Mental development is retarded.

b. **Klinefleter's Syndrome**- due to presence of an additional copy of X-chromosome (XXY). Such persons have overall masculine development. They are sterile.

c. **Turner's Syndrome** – caused due to the absence of one of the X chromosome. 45 with XO, such females are sterile as ovaries are rudimentary. They lack secondary sexual characters.

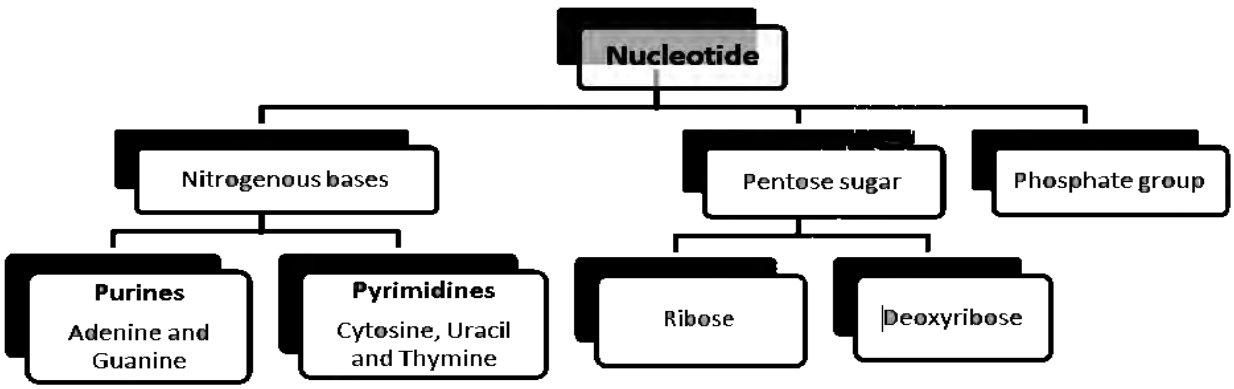
28. MOLECULAR BASIS OF INHERITANCE

DNA (Deoxyribonucleic Acid) and RNA (Ribonucleic Acid) are two types of nucleic acid found in living organisms.

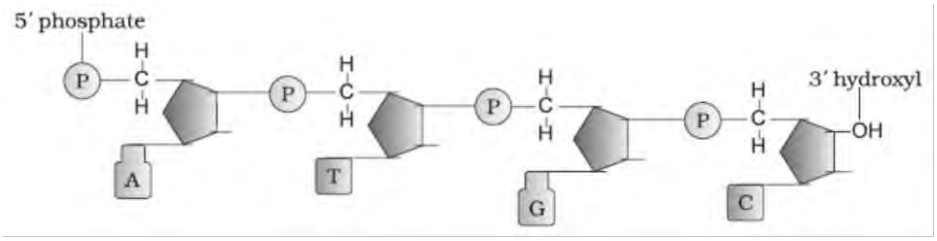
The DNA

DNA is a long polymer of deoxyribonucleotides. A pair of nucleotide is also known as base pairs. Length of DNA is usually defined as number nucleotides present in it. Escherichia coli have 4.6 x 106 bp.

Structure of Polynucleotide Chain



Cytosine is common for both DNA and RNA and Thymine is present in DNA. Uracil is present in RNA at the place of Thymine.



A nitrogenous base is linked to pentose sugar with N-glycosidic linkage to form to form a nucleoside. When phosphate group is linked 5'-OH of a nucleoside through phosphoester linkage nucleotide is formed. Two nucleotides are linked through 3'-5' phosphodiester linkage to form dinucleotide. More nucleotide joins together to form polynucleotide.

In RNA, nucleotide residue has additional –OH group present at 2'-position in ribose and uracil is found at the place of Thymine.

Double Helix Model for Structure of DNA- James Watson and Francis Crick, based on X-ray diffraction data produced by Wilkin and Rosalind proposed this model of DNA.

The sailent features of this model are-

- DNA is made of two polynucleotide chains in which backbone is made up of sugar- phosphate and bases projected inside it.
- Two chains have anti-parallel polarity.
- The bases in two strands are paired through H-bonds. Adenine and Thymine forms double hydrogen bond and Guanine and Cytosine forms triple hydrogen bonds.
- The bases in two strands are paired through H-bonds. Adenine and Thymine forms double hydrogen bond and Guanine and Cytosine forms triple hydrogen bonds.
- Two chains are coiled in right handed fashion. The pitch of helix is 3.4 nm and roughly 10 bp in each turn.
- The plane of one base pair stacks over the other in double helix to confer stability.

Packing of DNA helix-

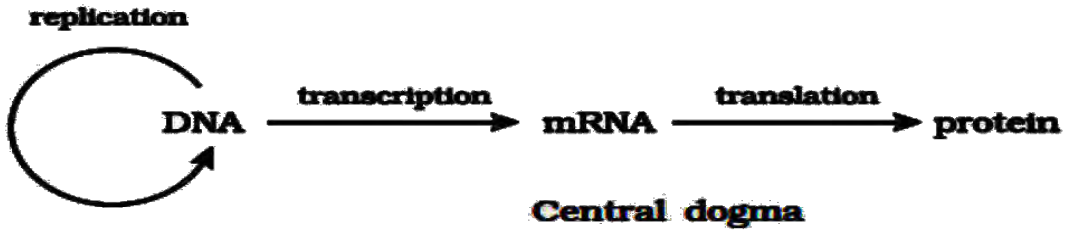
- In prokaryotes, well defined nucleus is absent and negatively charged DNA is combined with some positively charged proteins called nucleoids.
- In eukaryotes, histones, positively charged protein organized to form 8 molecules unit called histone octomer. Negatively charged DNA is wrapped around the histone octomer to form nucleosome. Single nucleosome contains about 200 base pairs. Chromatin is the repeating unit of nucleosome.

Replication of DNA

Watson and Crick suggested that two strands of DNA separate from each other and act as template for synthesis of new complementary strands. After the completion of replication each DNA molecule would have one parental and one newly synthesised strand, this method is called **semiconservative replication**.

Messelson and stahl's shows experimental evidence of semiconservative replication. Using radioactive Nitrogen (N-15).

Replication of DNA require Enzyme DNA polymerase that catalyse the polymerisation in one strand 5'→3' only. So, replication in one stand is continuous and other strand it is discontinuous due to the synthesized fragments that are joined together by enzyme DNA ligase.



Central dogma

Transcription is the process of copying genetic information from one strand of DNA into RNA. In transcription only one segment of DNA and only one strand is copied in RNA. The Adenosine forms base pair with Uracil instead of Thymine.

Transcription of DNA includes a promoter, the structural gene and a terminator. The strands that has polarity 3'→5' act as template and called template strand and other strand is called coding strand.

- Promoter is located at 5' end and that bind the enzyme RNA polymerase to start transcription. The terminator is located at 3'end of coding strand and usually defines the end of transcription.
- Exons are those sequences that appear in mature and processed RNA. Exons are interrupted by introns. Introns do not appear in mature and processed RNA.
- In bacteria there are three types of RNA's- mRNA, t-RNA and r-RNA. All these are needed for synthesis of protein in the cells.
- The m-RNA provide the template, t-RNA brings the amino acids and read the genetic code, the r-RNA play structural and catalytic role during translation.
- The primary transcript contains both exon and intron and is non-functional. It undergoes the process of **splicing** in which introns are removed and exons are joined in a defined order.
- The hnRNA (heterogeneous nuclear RNA) undergo additional processing called as capping and tailing. In **capping** in unusual nucleotide (methyl guanosine triphosphate) to the 5'end of hnRNA. In **tailing** adenylatelate is added at 3'end in a template at independent manner.

Genetic Code is the relationship of amino acids sequence in a polypeptide and nucleotide/base sequence in mRNA. It directs the sequence of amino acids during synthesis of proteins.

Salient features of Genetic Code are-

i. The code is triplet. 61 codons code for amino acids and 3 codons do not code for any amino acids called stop codons.
ii. Codon is unambiguous and specific, code for one amino acid.
iii. The code is degenerate. Some amino acids are coded by more than one codon.
iv. The codon is read in mRNA in a contiguous fashion without any punctuation.
v. The codon is nearly universal. AUG has dual functions. It codes for methionine and also act as initiator codon.

Mutations and Genetic code

- A change of single base pair (point mutation) in the chain of Beta globin chain that results in the change of amino acid residue glutamate to valine. These results into diseased condition called sickle cell anaemia.
- Insertion and deletion of three or its multiple bases insert or delete one or multiple codons hence one or more amino acids and reading frame remain unaltered from that point onwards. Such mutations are called frame-shift insertion or deletion mutations.

The t-RNA called as adaptor molecules. It has an anticodon loop that has bases complementary to code and also has an amino acid acceptor to which amino acid binds. t-RNA is specific for each amino acids.
It also contain another specific t-RNA referred as initiator t-RNA. The secondary structure of t-RNA is depicted as clover-leaf. In actual structure, the t-RNA is a compact molecule which look like inverted L.

Translation process

- **Translation** is the process of polymerisation of amino acids to form a polypeptide. The order and sequence of amino acids are defined by the sequence of bases in the mRNA. Amino acids are joined by peptide bonds. It involved following steps-
    - Charging of t-RNA.
    - Formation of peptide bonds between two charged tRNA.
- The start codon is AUG. An mRNA has some additional sequence that are not translated called untranslated region (UTR).
- For initiation ribosome binds to mRNA at the start codon. Ribosomes moves from codon to codon along mRNA for elongation of protein chain. At the end release factors binds to the stop codon, terminating the translation and release of polypeptide form ribosome.

The Lac Operon

- Lac operon consists of one regulatory gene (*i*) and three structural genes (y,z and a). Gene i code for the repressor of the lac operon. The z gene code for beta-galactodase, that is responsible for hydrolysis of disaccharide, lactose into monomeric units, galactose and glucose. Gene y code for permease, which increases permeability of the cell. Gene a encode for transacetylase.
- Lactose is the substrate for enzyme beta-galactosidase and it regulates switching on and off of the operon, so it is called inducer.
- Regulation of Lac operon is done by repressor referred as **negative regulation**. Operation of Lac operon is also under the control of positive regulation.

Human Genome Project was launched in 1990 to find out the complete DNA sequence of human genome using genetic engineering technique to isolate and clone the DNA segment for determining DNA sequence.

DNA fingerprinting is a very quick way to compare the DNA sequence of any two individual. It includes identifying differences in some specific region in DNA sequence called as **repetitive DNA** because in this region, a small stretch of DNA is repeated many times.

- Depending upon the base composition, length of segment and number of repetitive units satellite DNA is classified into many categories.
- Polymorphism in DNA sequence is the basis for genetic mapping of human genome as well as fingerprinting.
- The technique of fingerprinting was initially developed by Alec Jeffrey. He used a satellite DNA as probe to so high polymorphism was called Variable Number of Tendon Repeats (VNTR).

29. EVOLUTION

Evolutionary biology is the study of history of life forms on earth, the evolution of life on earth, different changes in flora and fauna around earth that co-exist along with human beings also forms parts of evolution.

Origin of Life

- **Big Bang Theory** attempts to explain the origin of universe. According to this theory, a huge explosion occurs that forms the different galaxies.
- In solar system of Milky Way galaxies, earth has been supposed to be formed about 4.5 billion years ago. There was no atmosphere in early earth. Water vapour, methane, carbon dioxide and ammonia released from molten covered the earth surface.
- UV rays from sun splits the water into hydrogen and oxygen. Life appeared 500 million years after the formation of earth.
- There are different theories regarding the origin of life on earth-
  - Some scientist believes that life comes from other planets. Early Greek thinker thoughts that unit of life is called spores transferred from other planets.
  - According to other theory, life comes out of dead and decaying matters like straw and mud. This theory is called **theory of spontaneous origin**.
  - Louis Pasteur experimentally proved that life arises only from pre-existing life.
  - Oparin and Haldane proposed that the first form of life could have come from pre-existing non-living organic molecules like RNA and protein etc. The formation of life preceded by chemical evolution. At that time condition on earth were- high temperature, volcanic eruption, reducing atmosphere containing CH_4 and NH_3.

Miller experiment of Origin of Life- S.L. Miller in 1953, conducted an experiment to show the origin of life on earth in the physical environment similar to condition prevails at that time.

Miller created electric discharge in a flask containing CH_4, H_2 and NH_3 and water vapour at 800^oC. He observed formation of amino acids after 15 days in the flask.

The theory that first form of life arose slowly through evolutionary forces from non-living molecules is called **biogenesis**.

Evolution of Life forms

- Many theory were proposed by different thinkers, scientist and religious literatures about the origin of different forms of life on earth. The main theories include-
- Religious literatures tell us about **special creation theories**.
-

Evidence of Evolution

Evidence that evolution of life forms has taken place on earth have many proofs as mentioned below-

1. **Paleontological evidence**- different aged rock sediments contain fossils of different life forms that probably died during the formation of particular sediment.
2. **Homologous organs**- those organs that perform different function but have similar origin and structure are called homologous organs.

In these animal similar structure developed along different directions due to adaptation of different needs. This is called **divergent evolution**.

3. **Analogous structures**- they are not anatomically similar organs but perform similar function. This is due to similar habitat that resulted in similar adaptive features in different groups of organisms. This that of evolution is called **convergent evolution**.
4. **Evolution by natural selection.**

Adaptive Radiation- the process of evolution of different species in given geographical area starting from a point and radiating to other areas of geography (habitat) is called adaptive radiation. Darwin's finches represent one of the best examples of adaptive radiation.

Biological Evolution – the nature select for fittest and fitness is based on characteristics which are inherited. Some organisms are better adapted to survive in otherwise hostile environment. Fitness is the end result of the ability to adapt and get selected by nature.

- Lamarck had said that evolution of life form had occurred but driven by use and disuse of organs. He gave the example of giraffe to evolve their neck.
- Darwin theory of natural selection was based on certain observations like-
    - Limited natural resources.
    - Over population
    - Struggle for existence
    - Survival of the fittest.
    -

Mechanism of Evolution

- Hugo de Vries based on his work on evening primrose brought forth the idea of **mutation**.
- Mutations are random and directionless while Darwin variations are small and directional.
  Hugo de Vries believed that mutation causes speciation and hence called **saltation**.

Hardy-Weinberg Principle-

- This principle states that allele frequencies in a population are stable and is constant from generation to generation. The gene pool remains constant. This is called genetic equilibrium and sum total of all the allelic frequencies is 1.
- Binomial expansion of $(p + q)^2 = p^2 + 2pq + q^2 = 1$. Where p and q are the frequency of different alleles.
- When frequency is measured, the actual value varies that indicates the extent of evolutionary changes. Change of frequency in a alleles (Hardy-Weinberg equilibrium) in a population resulted due to evolution.
- The factors that affect Hardy-Weinberg equilibrium are-
    - Gene migration or gene flow
    - Genetic drift
    - Mutation
    - Genetic recombination
    - Natural selection

Sometimes change in alleles frequency is so different in a sample of population that they become a different species. The original drifted population becomes founder and that effect is called **founder effect**.

Origin and Evolution of Man

- About 15 maya, primates called Dryopithecus and Ramapithecus, exists. They are hairy and walked like gorilla and chimpanzees. Ramapithecus are more man like and Dryopithecus are more like apes.
- The first creatures that was human like being the hominid and was called *Homo habilis* having brain capacities 650-800 cc.
- The fossils discovered in java in 1891 revealed the *Home erectus* having brain about 900cc. *Homo sapiens* arose is Africa and moved across the continents and developed into distinct races.
- During ice age between 75,000 to 10000 years ago modern Homo sapiens arose. Pre-historic cave art developed about 18,000 years ago and agriculture comes around 10,000 years back to start human settlement.

30. HUMAN HEALTH AND DISEASE

The state of complete physical, mental and social well beings is called health. Health simply does not simply means disease free condition or physical fitness. Health is affected by-

I. Genetic disorders
II. Infection from microbes or other organisms.
III. Life style

Good health can be maintained by- Balanced diet, Personal hygiene, Regular exercise, Awareness about the disease and their effect, Immunization against the infectious disease, Proper disposal of wastage, Control of vectors, and Maintenance of hygienic food and water.

- The diseases which are easily transmitted from infected person to healthy persons are called infectious disease and diseases which cannot be transmitted from one person to other are called non-infectious disease.
-

Common Diseases in Humans

- The disease causing microorganisms like bacteria, virus, fungus, protozoa, helminthes are called **pathogen**.
- The pathogen can enter the body by various means and multiply and interfere with normal vital activities resulting in morphological and functional damage.

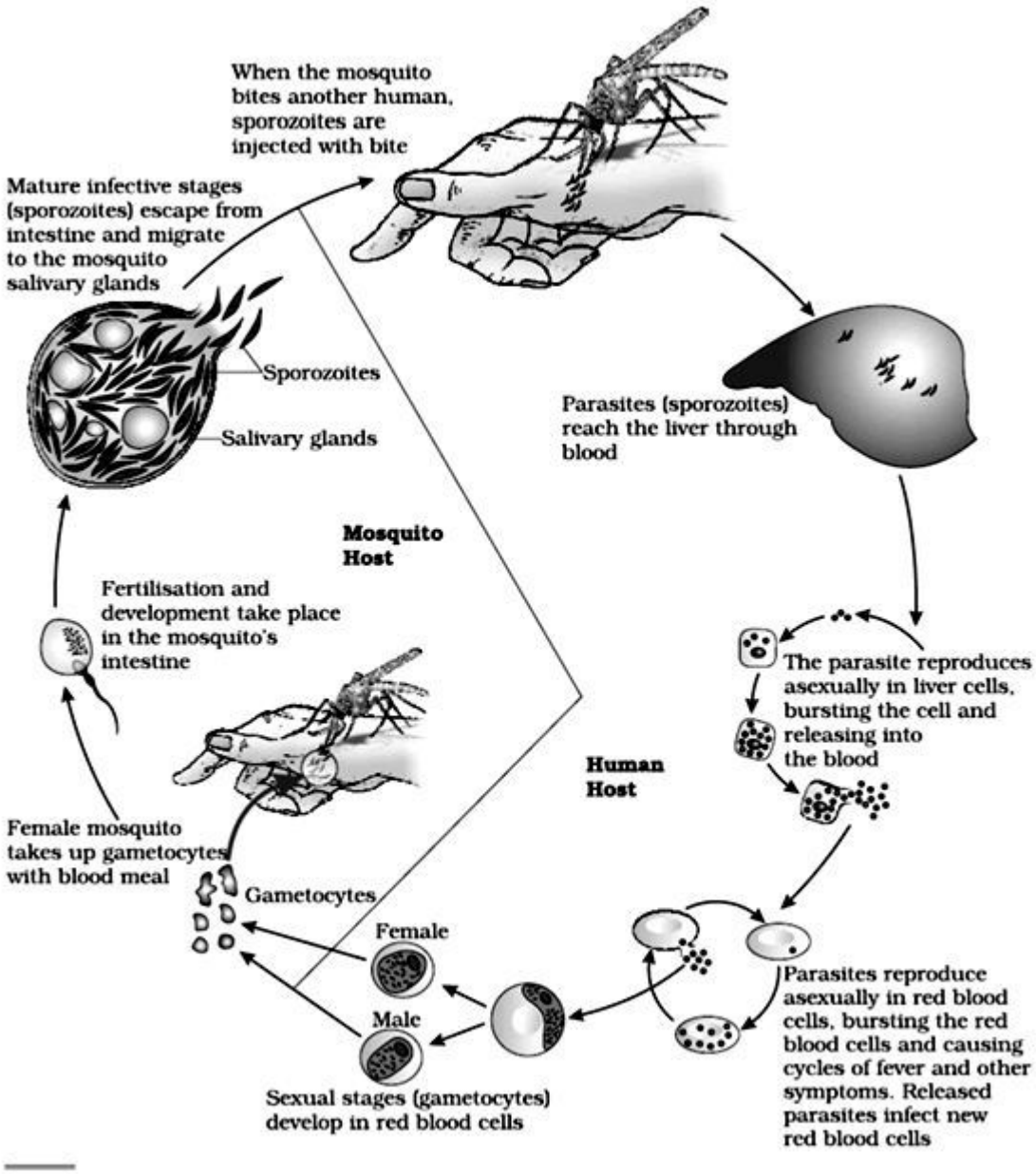
Name of disease /test	Causal organisms	Symptoms	Effects
Typhoid / Widal test	*Salmonella typhi*	Sustained high fever, weakness, stomach pain, constipation.	Intestinal perforation and death may occur in severe cases.
Pneumonia	*Streptococcus pneumoniae* and *Haemophilus influenzae*	Fever, chills, cough and headache.	Alveoli get filled with fluid leading to severe problems in respiration.

Common cold	Rhino viruses	Nasal congestion and discharge, sore throat, cough and headache.	Infect the nose and respiratory passage.
Malaria	*Plasmodium(P. vivax*, *P. malaria* and *P. falciparum*)	Chill and high fever recurring 3 to 4 days.	Parasite multiply within liver cells and then attack the RBCs.
Amoebiasis or Amoebic dysentery	*Entamoeba histolytica*	Constipation, abdominal pain, cramps, stool with mucous and blood clot.	Infect the large intestine.
Ascariasis	Ascaris (Helminthes)	Internal bleeding, muscular pain, fever, anemia etc.	Healthy person get infected through water, vegetable etc.
Elephantiasis or **filariasis**	*Wuchereria (W. bancrofti* and *W. malayi)*	Inflammation in the lower limb and genital organs.	Lymphatic vessels of lower limbs get blocked.
Ring worms	*Microsporum*, *Trichophyton* and *Epidermophyton*	Appearance of dry, scaly lesions on various part of body.	Infects the skin, nail and scalp.

Life cycle of plasmodium

Plasmodium enters the human body as small sporozoites through the bite of infected female anopheles mosquito and multiplies within the lever cells. Later attacks the RBCs resulting the rapture with release of toxic substance, haemozoin, which is responsible for high fever and chill recurring every three to four days.

Malarial parasite requires two parasites, human and anopheles mosquito to complete their life cycle. Female anopheles is vector of this disease to human beings.



Immunity – the ability of host cells to fight the disease causing microorganism due to immune system is called immunity. There are two types of immunity.

- **Innate immunity**- non-specific types of defence presents at the time of birth and provide different kinds of barriers to the entry of foreign agents into the body. it consists of four types of barrier-

1. Physical barrier- skin, mucus coating of epithelium lining the respiratory, gastrointestinal and urogenital tract.
2. Physiological barrier- acid in stomach and saliva in mouth.
3. Cellular barrier- leucocytes, neutrophils, monocytes.
4. Cytokine barriers- virus infected cells secretes protein called **interferon**.

- **Acquired Immunity**- pathogen specific defence characterised by memory. When our body encounters a

pathogen first time produces a response called **primary response** of low intensity. Subsequent encounter by same pathogen produce highly intensified response called **secondary response or** an amnestic response due to memory of first encounter.

- ❖ Primary and secondary responses are carried out with the help of B-lymphocytes and T- lymphocytes. B-lymphocytes produce army of protein called antibodies each having two light and two heavy chains.
- ❖ Different types of antibodies produce in blood include IgA, IgM, IgE etc. They are called humoral immune response due to presence in blood.

Active immunity	Passive immunity
1. Antibodies are produced in the host body. 2. It is slow and takes time to gives it full effective response.	1. Ready-made antibodies are directly given to protect the body. 2. It is fast and act quickly in response to pathogen.

Allergies –

The exaggerated response of immune system to certain antigens present in the environment is called allergy. The substance to which such immune response is produced is called allergens. The antibodies produced to these are IgE types. Allergy is due to secretion of chemicals like histamine and serotonin from the mast cells.

Human immune system can distinguish between self and foreign molecules or foreign bodies. Sometimes, due to genetic or unknown reasons, the body attack self-cells. This results in damage to the body and called **auto-immune disease**. Rheumatoid arthritis is due to this effect.

Immune system in the body- the human immune system includes lymphoid organs, tissue, cells and soluble molecules like antibodies.

- **Lymphoid organs** are the organs where origin and maturation and proliferation of lymphocytes occur. Primary lymphoid organs include **bone marrow** and **thymus**.
- After maturation lymphocytes migrate to **secondary lymphoid** organ like spleen, lymph nodes, tonsils, peyer's patches of small intestine and appendix. They provide the sites for interaction lymphocyte with antigens.
- There is lymphoid tissue also located within the lining of respiratory, digestive and urogenital tract called mucosal associated lymphoid tissue (MALT). It constitute 50% of lymphoid tissues in human body.

AIDS (Acquired Immuno Deficiency Syndrome) was first reported in 1981. It is caused by HIV (human Immuno deficiency virus), a retrovirus. Transmission of HIV virus occurs by-

1. Sexual contact with infected person
2. Transfusion of contaminated blood and blood products
3. Sharing infected needles as in intravenous drug abusers
4. Infected mother to her child through placenta.

Diagnostic test for AIDS is ELISA (enzyme-linked Immuno-sorbent assay).

NACO (national AIDS control organisation) and other NGOs are doing a lot to educate people about AIDS.

Cancer is one of the most dreaded diseases of human beings and is a major cause of death all over the world. Normal cells show a property called contact inhibition by virtue of which contact with other cells inhibit their uncontrolled growth. Cancer cells lost this property.

Cancerous cells continue to divide giving rise to masses of cells called tumors. There are two kind so tumors-

- **Benign tumors**- remain confined to original location and do not spread to other parts of the body.
- **Malignant tumors**- cells grows rapidly, invading and damaging the surrounding normal tissues. Metastasis is the most dangerous property of these tumors.
  - **Causes of cancer** – cancerous neoplastic cell may be induced by physical, chemical and biological agents called carcinogens. Cancer causing viruses called oncogenic virus have gene called viral oncogenes.
  - **Cancer detection and diagnosis**- Cancer detection is based on biopsy and histopathological study of the tissues, blood and bone marrow test for increased cell counts. Radiography, CT (computed tomography), MRI (magnetic resonance imaging) are very useful to cancers of internal organs.
  - **Treatment of Cancer-** the common method for treatment of cancer includes surgery, radiation therapy and immunotherapy. Several chemotherapeutic drugs are used to kill cancerous cells. They have side effects like loss of hair, anaemia. Biological response modifiers such as interferon which activate their immune system.

Drugs and Alcohol Abuse

Commonly abused drugs include opioids, cannabinoids and coca alkaloids obtained from flowering plants and a few from fungi.

- Opioids are the drugs which bind to specific opioids receptors present in our central nervous system and gastrointestinal tract. Heroin commonly called smack is chemically diacetylmorphine which is a white, odourless, bitter crystalline compound. It is extracted from the latex of poppy plant (*Papaver somniferum*).
- Cannabinoids are a group of chemicals which interact with cannabinoid receptors present in the brain. Natural cannabinoids are obtained from the inflorescence of the plant cannabis sativa. They include marijuana, hashish, charas and gangja.
- Dependence is the tendency of the body to manifest a characteristic and unpleasant withdrawal syndrome if regular dose of drug/alcohol is abruptly discontinued that includes anxiety, shakiness, nausea and sweating.

31. STRATEGIES FOR ENHANCEMENT IN FOOD PRODUCTION

Animal husbandry- is the agricultural practice of breeding and raising livestock. Animal husbandry deals with the care and breeding of livestock like buffaloes, cows, pigs, horses, cattle, sheep, camel goat etc. it also includes poultry farming and fisheries. More than 70% of livestock population of the livestock live in India and China.

Management of Farm and Farm Animals

Some of the management procedures applied in various livestock are as follows-

Dairy farm management

Dairying is the management of animals for its milk and its product for human consumption. Milk production mainly depends upon the quality of breeds in the farm. Selection of good breeds having high yielding potential combined with resistance to disease is very important.

Poultry Farm Management

Poultry is the class of domesticated birds used for food or for their eggs. It mainly includes chicken and ducks and with turkey and geese. Important components of poultry farm management includes- Selection of disease free and suitable breeds, Proper and safe farm condition, Proper feed and water, and Hygiene and health care.

Animal Breeding – aims at increasing yields of animals and improving the desirable qualities of the produce. A breed is a group of animals related by descent and similar in most of characters like general appearance, features, size, configuration etc. there are two kinds of breeding

- Inbreeding – breeding between animals of same breeds.
- Outbreeding- crosses between different breeds.
- Mating of more closely related individuals within the same breed for 4-6 generation is done in inbreeding. It includes- Identification and mating of superior males and females of same breeds and Evaluation of progeny and identification of superior male and female form them.
- Inbreeding increases homozygosity. Close inbreeding usually reduce fertility and even productivity. This is called breeding depression.
- **Out-breeding** is the breeding of unrelated animals, which may be between individuals of same breed but, having no common ancestors or between different breeds (cross breeding) or different species (interspecific hybridization).
- **Out-crossing-** this is the practice of mating of animals within the same breed but having no common ancestors on either side of their pedigree up to 4-6 generation. The offspring are called out-cross.
- **Cross breeding-** superior male of one breed are mated with superior female of another females of another breed. Cross breeding allows the desirable qualities of two breeds to be combined.
- **Interspecific hybridization-** male and female animals of two different species are mated. The progeny may combine desirable features of both and parents. Ex- mule.

- **Controlled breeding experiments** are carried out using **artificial insemination.** The semen is collected from the male that is chosen as a parent and injected into the reproductive tract of the selected female by the breeder.
- **Multiple Ovulation Embryo Transfer Technology (MOET)** is used to increase the success rate of artificial insemination. In this method, a cow is administrated hormones (FSH) to induce follicular maturation and super ovulation, instead of one egg; they produce 6-8 eggs. The fertilised eggs 8-32 cells stages, are recovered non-surgically and transferred to surrogate mothers.

Bee-keeping

Bee-keeping or apiculture is the maintenance of hives of honeybees for the production of honey. Honey is a food of high nutritive value and also finds use in the indigenous systems of medicine. It also produces beeswax. The most common species of honey bee is *Apis indica.*

Fisheries

Fishery is an industry devoted to catching, processing or selling of fish, shellfish or other aquatic animals.

- Fresh water fishes which are very common include catla, rohu and common carp. Common marine fishes are Hilsa, sardines, mackerel and pomfrets.
- Different techniques have been applied to increase production like aquaculture and pisciculture. Blue Revolution is implemented to increase fish production.

Plant Breeding is the purposeful manipulation of plant species in order to create desired plant species in order to create desired plant types that are better suited for cultivation, give better yields and are disease resistant.

The main steps in plant breeding are

a) **Collection of variability is the collection** and preservation of all the different wild varieties, species and relatives of the cultivated species. The entire collection having all the diverse alleles for all genes in a given crop is called **germplasm collection.**

b) **Evaluation and selection of parents** is the identification of plants with desirable combination of characters. The selected plants are multiplied and used in the process of hybridization.

c) **Cross hybridization among the selected parents** to obtained desired crop characters.

d) **Selection and testing of superior recombinants**

e) **Testing, releasing and commercialization of new cultivars.**

Wheat and Rice

Production of wheat and rice increased tremendously between 1960-2000 due to introduction of semi-dwarf varieties of rice and wheat. Several varieties such as Sonalika and Kalyan Sona, which were high yielding and disease resistant were introduced all over the rice and wheat growing field of India. Semi dwarf rice varities were derived from IR-8 and Taichung Native. Two new varieties are, better yielding and semi-dwarf, Jaya and Ratana were developed in India.

Sugar cane

Sugar cane *(Saccharum barberi)* was grown in north India and *Saccharum officinarum* in south India. Two species are successfully crossed to get sugar cane varieties combining the desirable qualities of high yield, thick stems, high sugar and ability to grow in sugar cane areas of north India.

Millets

Hybrid maize, jowar and bajra are developed in India. These varieties are high yielding and resistant to water stress.

Plant Breeding for Disease Resistance

Some crop varieties bred by hybridization and selection for disease resistance to fungi, bacterial and viral disease are released

Crop	Variety	Resistance to diseases
Wheat	Himgiri	Leaf and stripe rust, hill bunt
Brassica	Pusa swarnim (Karan rai)	White rust
Cauliflower	Pusa Shubhra, Pusa Snowball K-1	Black rot and Curi blight black rot
Cowpea	Pusa komal	Bacterial blight
Chilli	Pusa Sadabahar	Chilly mosaic virus, Tobacco mosaic virus and Leaf curl

Mutation is the process by which genetic variations are created through changes in the base sequence within genes resulting in the creation of a new character or trait not found in the parental types. It is done by using mutants like chemicals or radiations. This process is called mutation breeding. Mung bean resistance to yellow mosaic virus and powdery mildew were induced by mutation.

Plant breeding for Developing Resistance to Insect Pests

- Crop plant and crop products are destructed by insects and pests on large scale. To prevent this loss new varieties resistance to them are developed. Breeding is similar to other breeding programme and resistance gene is obtained from cultivated varieties, germplasm collection of crop or wild relatives.

Crop	Variety	Insect Pests
Brassica (rapeseed mustard)	Pusa Gaurav	Aphids
Flat bean	Pusa sem 2, Pusa sem 3	Jassids, aphids and fruit borer
Okra (Bhindi)	Pusa Sawani Pusa A-4	Shoot and Fruit borer

Bio-fortification -Breeding crops with higher levels of vitamins and minerals, or higher protein and healthier fats. Breeding for improved nutritional qualities have following objectives of improving

- Protein content and quality.
- Oil content and quality
- Vitamin content
- Micronutrient and mineral content

IARI, New Delhi have released many varieties of vegetables crops rich in vitamins and minerals like vitamin A enriched carrot, spinach and pumpkin and vitamin C enriched bitter gourd, bathua, mustard etc.

Single Cell Protein (SCP)– alternate source of protein for animal and human nutrition. Microbes are grown on industrial scale as a source of good protein. Microbes like spirullina can be grown easily on materials like waste water from potato processing plants having starch, molasses, animal manure and even sewage to produce large quantities and can serve as food rich in protein, minerals, fats, carbohydrates and vitamins.

Tissue Culture

The capacity to generate whole plants form any cell/explant is called totipotency. Thousands of plants can be produced from expalnts in short interval of time using suitable nutrient medium, aseptic condition and use of phytohormones. This method of producing thousands of plant is called micropropagation.

Somatic Hybridization

Isolation of single cells from their plants and after digesting their cell wall fusing the cytoplasms of two different varieties is called somatic hybridization. The hybrid obtained is called somatic hybrid.

32. MICROBES IN HUMAN WELFARE

Microbes are diverse-protozoa, bacteria, fungi and microscopic plants viruses, viroid and also prions that are proteinaceous infectious agents. Bacteria and fungi can be grown on nutritive media to form colonies, which can be seen by necked eyes and very useful in study of microorganisms.

Microbes in household products

a. Microorganisms like Lactobacillus and other commonly called lactic acid bacteria (LAB) grow in milk and convert it to curd. A small amount of curd added to fresh milk as inoculum or starter contain millions of LAB which multiply at suitable temperature and convert milk into curd.

b. The dough is used for making foods such as dosa and idli is fermented by bacteria. The puffed-up appearance of dough is due to the production of CO_2 gas. The dough used for making bread is fermented using baker's yeast (*Saccharomyces cervisiae*). Microbes are also used to ferment fish, Soyabeans and bamboo shoots to make foods.

Microbes in industrial production

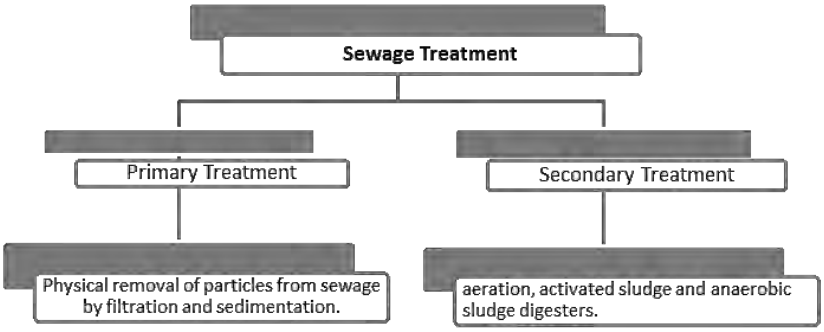
A number of products like beverages and antibiotics involve uses of microbes. Production on large scale requires growing microbes in very large vessels called fermenters.

(a) Fermented Beverages- yeast (*Saccharomyces cerevisiae*) is used for production of beverages like wine, bear, whisky and rum. Wine and bear are produced without distillation whereas whisky, brandy and rum are produced by distillation of the fermented broth.

(b) Antibiotics- they are chemical substances produced by some microbes and can kill or retard the growth of other microbes. Penicillin was first antibiotic to be discovered. Antibiotics have great improved our capacity to treat deadly diseases such as plague, whooping cough, diphtheria and leprosy.

(c) Chemical, Enzymes and other Bioactive Molecules are commercially produced by microbes. *Apergillus niger* (fungus) produce citric acid, *Acetobacter aceti* (bacteria) produce acetic acid and Lactobacillus (bacterium) produce lactic acid etc. Bioactive molecules l i k e cyclosporine A , that is used as an immunosuppressive agent in organ-transplant patients is produced by fungus *Trichoderma polysporium*.

Microbes in sewage Treatment Municipal waste water (sewage) contains large amount of organic matter and microbes which are pathogenic and cannot be discharged into natural water bodies like rivers and streams. Sewage is treated in sewage treatment plant to make it less polluting by using heterotrophic microbes naturally present in sewage. Sewage treatment is done in two stages-



- In primary treatment, floating debris is removed by sequential filtration. Grit (soil and small pebbles) are removed by sedimentation.
- Secondary treatment or biological treatment involves passing of primary effluents in large aeration tank to help the growth of aerobic microbes into flocs. These microbes increase the consumption of organic wastes and decrease the **BOD (biological oxygen demand)** of the effluents.
- BOD is the amount of oxygen that would be consumed if all the organic matter in one litre of water were oxidised by bacteria. It measures the amount of organic matter present in the water. Greater the BOD of water more it is polluted.
- Sludge is passed into large tanks called anaerobic sludge digesters in which anaerobic bacteria digest the bacteria and fungi in the sludge and produce mixture of gas called biogas, which is a mixture of methane, hydrogen sulphide and carbon dioxide.
- The effluents from the secondary treatment plant are released into water bodies.

Microbes in Production of Biogas

Biogas is a mixture of gases produced by the microbial activity that can be used as fuel. Certain bacteria that grows anaerobically on cellulosic material produce large amount of methane along with CO_2 and H_2. These bacteria are collectively called methanogens (*Methanobacterium*).

Biogas Plant – the excreta of cattle (gobar) is rich in methanogens bacteria and is used for generation of biogas also called as gobar gas.

- Biogas plant consists of a concrete tank in which bio-wastes are collected and slurry of dung is fed.
- A floating cover is placed over digester that moves upward when gas is produced. The gas produced is removed and supplied through an outlet pipe for consumption.
- The spent slurry is removed through another outlet and used as fertilizers. Biogas plant is more often build in rural areas as large amount of cattle dug is available easily.

Microbes as Biocontrol agent

Biocontrol means use of biochemical method for controlling plant disease and pests. The chemical used as pesticides and insecticides are harmful to human beings and animals.

- **Biological control of pests and disease** is a method of controlling pest on natural prediction rather than chemicals. The organic farmer creates a system where the pests are not eradicated but kept at manageable level by complex system of check and balance within the living and vibrant ecosystem. For example, the Ladybird and Dragonflies are used to get rid of aphids and mosquitoes respectively. On brassicas and fruit tree, to control butterfly caterpillars bacteria *Bacillus thuringiensis* is used.
- Biological control developed for used in the treatment of plant disease is the fungus Trichodema. Trichoderma are free-living fungi that are very common in the root systems that control several plant pathogens.

Microbes as Bio fertilizers

Bio fertilizers are organisms that enrich the nutrient quality of the soil. The main sources includes bacteria, fungi and cyanobacteria.

- The root nodule formed by Rhizobium bacteria on root of leguminous plants increase the nitrogen level of soil, necessary for various metabolic processes. Azotobacter and Azospirillum are free living bacteria that live in soil and fix atmospheric nitrogen into organic forms.
- Symbiotic association of fungi with angiosperm plants (mycorrhiza) also increase the fertility of soil. *Glomu* form mycorrhiza that absorbs phosphorus from the soil and passes it to the plant. These microbes also provide benefits like resistance to root-borne pathogens, tolerance to salinity and drought.

Cyanobacteria (*Nostoc, Anabaena*), an autotrophic microbes found in aquatic and terrestrial environment fix atmospheric nitrogen. In paddy field this acts as important bio-fertiliser. Blue green algae also add organic matter to the soil and increase its fertility.

33. BIOTECHNOLOGY: PRINCIPLES AND PROCESSES

The European Federation of Biotechnology (EFB) definition of biotechnology is as follow- "the integration of natural science and organisms, cells, parts thereof, and molecular analogous for products and services".

- **Genetic Engineering**- it is the technique of altering the chemistry of genetic material (DNA and RNA) to introduce these into host organisms and thus changes the phenotype of the host organism.
- In chromosome there is a specific DNA sequence called the origin of replication, which is responsible for initiating replication. In genetic engineering the foreign DNA is linked with the origin of replication, so the foreign DNA can replicate and multiply itself in the host organism, which is also known as **cloning** or making multiple identical copies of any template DNA.
- Stanley Cohen and Herbert Boyer in 1972 isolated the antibiotic resistance gene by cutting out a piece of DNA from a plasmid which was making multiple identical copies of any template DNA. The cutting of DNA at specific locations became possible with the discovery of the so-called molecular scissors'– **restriction enzymes**.

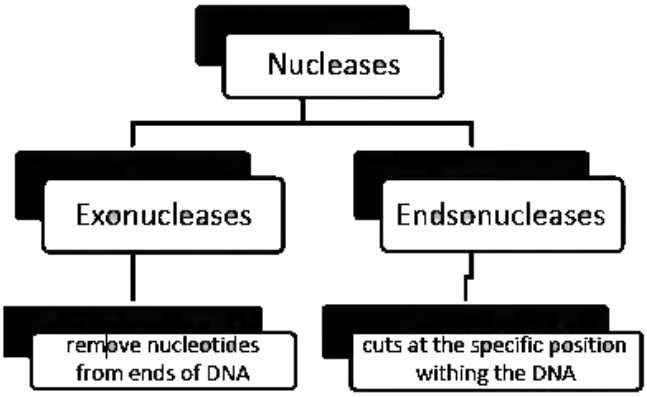
Steps of Genetically Modifying an organism-

I. Identification of DNA with desirable genes.
II. Introduction of the identified DNA into the host.
III. Maintenance of introduced DNA in the host and transfer of the DNA to its progeny.

Tools of Recombinant DNA Technology includes

- Restriction Enzymes
- Polymerase enzymes
- Ligases
- Vectors host organisms

❖ Restriction enzymes are responsible for restricting the growth of bacteriophage in E.coli was called as **restriction endonuclease**. The first restriction endonuclease- Hind II always cut DNA molecule at a particular point by recognizing a specific sequence of six base pairs, called recognition sequence. Restriction enzymes belong to group of enzymes called nucleases.



- Each restriction endonuclease recognises a specific palindromic nucleotide sequence in the DNA. Palindromes are group of letters that form the same words when read both forward and backward for example “MALYALAM”.
- Restriction enzymes cut the strand of DNA a little away from the centre of the palindrome site between the same two bases on the opposite strands having sticky strand. The stickiness of the strands facilities the action of the enzyme DNA ligase.

Separation and isolation of DNA fragments

The fragment of DNA obtained by cutting DNA using restriction enzyme is separated by technique called **gel electrophoresis**. Negatively charged DNA fragments can be separated by forcing them to move towards the anode under an electric field through medium. DNA fragments separate according to their size through sieving effect provided by agarose gel.

The separated DNA fragment can be visualized after staining the DNA with ethodium bromide followed by exposure to UV light. Separated bands of DNA are separated from agarose gel and extracted from gel, called **elution**. The DNA fragment purified this way is used for recombination.

Cloning Vector

Plasmids and Bacteriophages is commonly used vector for cloning. They have ability to replicate within bacterial cells independent of the control of chromosomal DNA.

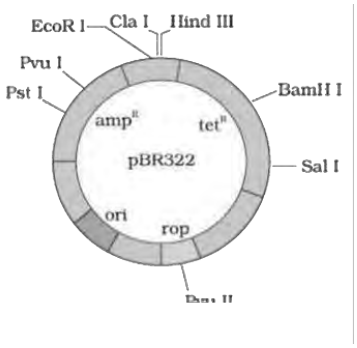
Following features are required to facilitate cloning into a vector-

(a) Origin of replication (ori)

(b) Selectable marker

(c) Cloning sites

(d) Vector for cloning genes in plants and animals



Agrobacterium tumefactions (pathogen of dicot plant) is able to deliver a piece of DNA known as 'T-DNA" to transform normal plant cells into a tumor and direct these tumor cells to produce the chemicals required by the pathogen.

Competent host

- Now a day, DNA is directly introduced into host cell by microinjection in which DNA is directly injected into the nucleus of an animal cell. Biolistic or gene gun is also used to inject DNA in to target host.

Processed of Recombinant DNA Technology

Recombinant DNA technology involves several steps in specific sequence-

1. Isolation of DNA
2. Fragmentation of DNA by restriction endonucleases
3. Isolation of a desired DNA fragment
4. Ligation of the DNA fragment into vector
5. Transforming the recombinant DNA into the host
6. Culturing the host cells in a medium at large scale
7. Extraction of the desired product.

- **Downstream Processing** involves processes that make the product obtain ready for marketing. This process includes separation and purification called as downstream processing. Suitable preservatives are added to it and send for clinical trial in case of drugs before releasing to market for public use.

34. BIOTECHNOLOGY AND ITS APPLICATIONS

The main three critical research areas of biotechnology includes –

I. Providing the best catalyst in the form of improved organism usually a microbes or pure enzyme.

II. Creating optimal conditions through engineering for a catalyst to act.
III. Downstream processing technologies to purify the protein or organic compounds.

Biotechnological Applications in Agriculture- food production can be increased by

a) Agro-chemical based agriculture
b) Organic agriculture
c) Genetically engineered crop-based agriculture.

- Plants, bacteria, fungi and animals whose genes have been altered by manipulation are called **Genetically Modified Organisms (GMO).** GM plants have many applications-
- More tolerant to abiotic stress likes cold, drought, salt, heat etc.
- Reduced reliance of chemical pesticides (pest resistant crops)
- Reduced post-harvest losses.
- Increased efficiency of mineral usage by plants
- Enhanced nutritional value of food like Vitamin A enriched rice.
- Create tailor-made plants to supply alternative resources to industries as starch, fuels and pharmaceuticals etc.

Application of Biotechnology in production of pest resistant plants-

Pest resistant plants decrease the amount of pesticides used. Bt toxin is produced by a bacterium called *Bacillus thuringiensis*.

Bt cotton- Bacterium *Bacillus thuringiensis* produce proteins that kill certain insects like lepidopterens, colepterans (beetels) and dipterans (flies, mosquitoes).

- The gene from B. thuringiensis has been incorporated into several crop plants like cotton, maize, rice etc. The toxin is coded by a gene named **cry.** The protein coded by the genes crylAb and cryIIAb control the cotton bollworms, cryIAb controls com borer.

Pest Resistant Plants

Nematodes like *Meloidegyne incognitia* infects the roots of tobacco plants and causes reduction in yield. The infestation of these nematodes can be prevented by the process of RNA interference (RNAi). RNAi is present in all eukaryotic organisms as cellular defence by silencing of specific mRNA due to complementary dsRNA molecules that bind to and prevents translation of the mRNA.

Biotechnological Applications in Medicine

Genetically Engineered Insulin

- Insulin consists of two short polypeptide chains- chain A and chain B, that are linked together by disulphide bridges.

- An American company, Eli Lilly in 1983 prepared two DNA sequence corresponding to A and B chain of human insulin and introduced them in plasmids of E.coli to produce insulin chain. Chain A and Chain B were produced separately, extracted and combined by creating disulphide bonds to form human insulin.

Gene Therapy

It is a collection of methods that allows correction of a gene defect that has been diagnosed in a child or embryo. This method is applied in a person with a hereditary disease. In this method, genes are inserted into a person's cells and tissues to treat a disease.

- The correction of gene defect involves delivery of a normal gene into the individual or embryo to take over the function of and compensate for non-functional gene.
- The first clinical gene therapy was done in 1990 to a 4 year old girl with adenosine deaminase (ADA) deficiency.

Molecular Diagnosis

Conventional method of diagnosis such as serum or urine analysis is not able to early detection of disease causing pathogens or virus. Following methods can be used to diagnosed earlier-

I. Recombinant DNA technology
II. Polymerase Chain Reaction (PCR)
III. Enzyme Linked Immuno-sorbent Assay (ELISA).

ELISA is based on the principle of antigen-antibody interaction.

Transgenic Animals

Animals that have had their DNA manipulated to possess and express a foreign gene are known as transgenic animals. Transgenic mice, rats, rabbits, pigs, sheep, cows and fish have been produced. Common reasons for development of transgenic animals-

The first transgenic cow Rosie (in 1997) produced human protein-enriched milk. The milk contain the human alpha-lactalbuim, which is nutritionally more balanced than cow milk.

Ethical Issues

- The Indian government has set up organisations like GEAC (Genetic Engineering Approval Committee) which make decision regarding the validity or GM research and safety of introducing GM-organisms for public services.

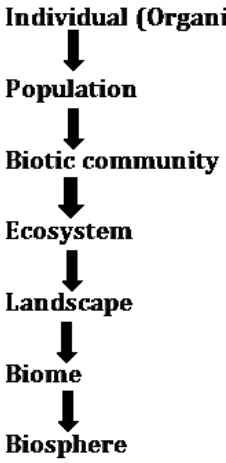
Biopiracy

Use of bio-resources by multinational companies and other organizations without proper authorization from the countries and people concerned without compensatory payment. There has been growing realization of injustice, inadequate compensation and benefit sharing between developed and developing countries.

35. ORGANISMS AND POPULATIONS

Ecology is the branch of biology that deals with the inter-relationship amongst the organisms and their environment.

- **Applied ecology** is the study of specialized field of ecology which are concerned with conservation and economic exploitation of organisms. Example- agronomy, wild life management etc.
- **System ecology** deals with interpretation of ecological concepts and processes in terms of mathematical models of formulae.
- **Genecology** is the study of genetic composition and changes in relation to the origin of ecades, ecotypes, new species etc.



Organism and Its Environment

- The variation in the intensity and duration of temperature along with annual variations in precipitation results in formation of major biomes like desert, rain forest and tundra.
- Regional and local variations within each biome lead to the formation of different kinds of habitats like tropical rain forest, deciduous forest, desert, sea coast etc.

Major Abiotic Factors

a) **Temperature -** The organisms that can tolerate wide range of temperature are called **eurythermal** and those organism restricted to a narrow range of temperatures are called **stenothermal**.
b) **Water-** Some organisms are tolerant to wide range of salinities are called **euryhaline** and others are restricted to a narrow range are called **stenohaline**.
c) **Light-** Flowering in some plants occurs only in presence of critical day light called Photoperiodism.
d) **Soil-** Soil composition, grain size and aggregation determine the percolation and water holding capacity of the soils along with pH, mineral, composition and topography determine the vegetation in any area.

Responses of Abiotic Factor

Regulate- All birds and animals are capable of maintaining homeostasis by physiological means which ensures constant body temperature, constant osmotic concentration etc.

Conform- Most of animals and plants, their body temperature change with ambient temperature. In aquatic animals osmotic concentration of the body fluid change with that of the ambient water osmotic concentration. These animals are called conformer.

Migrate- The organism move away for time being from the stressful unfavorable habitat to more suitable habitat and return back when stressful period is over. Siberia birds migrate to Keolado National Park, Bharatpur, India.

Suspend- In microorganisms like bacteria, fungi and lower plants a thick wall is formed which help them to survive unfavorable conditions.

Adaptation is the attribute of organism morphological, physiological and behavioral changes that enables the organism to survive and reproduce in its habitat.
Mammals from colder climates have shorter ears and limbs to minimize heat loss. This is called **Allen's Rule**. In polar seas aquatic mammals like seals have a thick layer of fat called **blubber**, below their skin that acts as an insulator and reduces loss of body heat.

Populations

Individuals of any species live in groups in well-defined geographical area, share or compete for similar resources, potentially interbreed and constitute a population.

Population Attributes

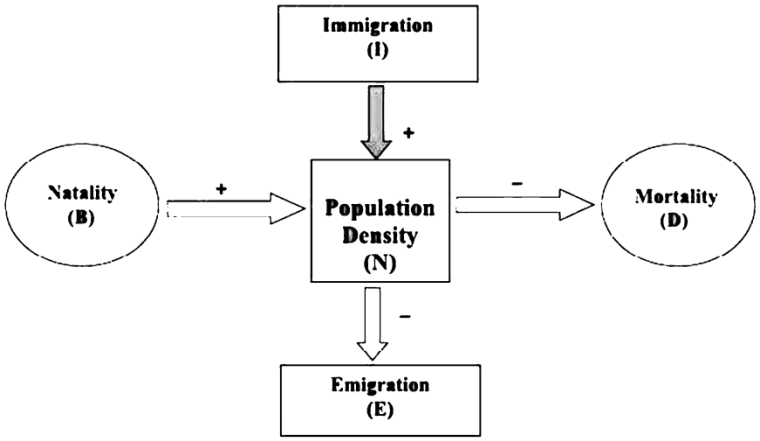
- **The birth and death rates**
- **Sex Ratio**

- A population at given time composed of different individual of different ages. If the age distribution is plotted for the population, the resulting structure is called age pyramids.
- The shape of pyramids reflects the shape of growth status of population. Which may be
  - Expending
  - Stable
  - Declining

Population Growth

The main factors that determine the population growth are-

- Natality (number of birth)
- Mortality (number of death)
- Immigration (individual come into habitat)
- Emigration (individual leaves the habitat)



If 'N' is the population density at a time't', then its density at t+1 is

Growth model

Growth of population takes place according to availability of food, habit condition and presence of other biotic and abiotic factors. There are two main types of models-

I. Exponential Growth- in this kinds of growth occurs when food and space is available in sufficient amount. The population grows in an exponential or geometric fashion. If in a population of size N, the birth rates as represented as 'b' and death rate as 'd'. Then increase and decrease in N during unit period time 't' will be

$dN/dt = (b-d) \times N$

Let $(b-d) = r$, then

$dN/dt = rN$

Then, the r in this equation is called 'intrinsic rate of natural increase'.

I. Logistic Growth- there is a completion between the individuals of a population for food and space. The fittest organism survives and reproduces. In this types of growth initially shows a leg phase followed by phases of acceleration and de-acceleration.

$$dN/dt = rN\left(\frac{K-N}{K}\right)$$

Where N = Population density at time t

r = Intrinsic rate of natural increase

K = carrying capacity

Population interaction

Following types of interaction are seen-

a. Predation
b. Competition
c. Parasitism
d. Commensalism
e. Mutualism

Species A	Species B	Name of Interaction
+	+	Mutalism
-	-	Competition
+	-	Predation
+	-	Parasitism
+	0	Commensalism
-	0	Amensalism

36. ECOSYSTEM

Ecosystem is the functional unit of nature where living organisms interact among themselves and also with the surroundings physical environment.

Ecosystem- Structure and Functions The biotic and abiotic factors of ecosystem work in integrated manner for flow of energy within the components of ecosystem. Interaction of biotic and abiotic components results in a physical structure that is characteristic for each type of ecosystem. The vertical distribution of different species occupying different levels is called **stratification**.

Productivity- Primary production is defined as the amount of biomass or organic matter produced per unit area over a time period by plants during photosynthesis. The rate of biomass production is called productivity. It can be divided into gross primary productivity (GPP) and net primary productivity (NPP). GPP of an ecosystem is the rate of production of organic matter during photosynthesis and NPP is the remaining biomass after respiration (R).

$$GPP - R = NPP$$

NPP is the available biomass for consumption to heterotrophs. Secondary productivity is defined as the rate of formation of new organic matter by consumers.

- **Decomposition-** Breakdown of complex organic matter into inorganic substances like carbon dioxide, water and nutrients is called decomposition. Decomposition involves following steps- fragmentation, leaching, catabolism, humification and mineralization. The detritivores break down detritus into smaller particles called fragmentation. Humification leads to accumulation of dark coloured amorphous substance called humus.
- **Energy Flow-** All living organisms are dependent for their food on producers, directly or indirectly. There is a unidirectional flow of energy from the sun to producers and then to consumers. Photosynthetically active radiation (PAR) is responsible for synthesis of food by plants. The process of eating and being eaten is called **food chain** in which energy flow from producers to consumers. In Grazing food chain (GFC)-

Grass ⟶ Goat ⟶ Man ⟶

(Producer) (Primary Consumer) (Secondary Consumer)

The detritus food chain begins (DFC) begins with dead organic matter. It is made up of decomposers which are heterotrophic organisms (fungi and bacteria). Natural interconnection of food chain forms the **food web**.

Based on source of food, organism occupies a specific place in food chain that is known as **trophic level**.

Each tropic level has a certain mass of living material at particular time called as **standing crop**. It is measured as mass of living organism or number in unit area.

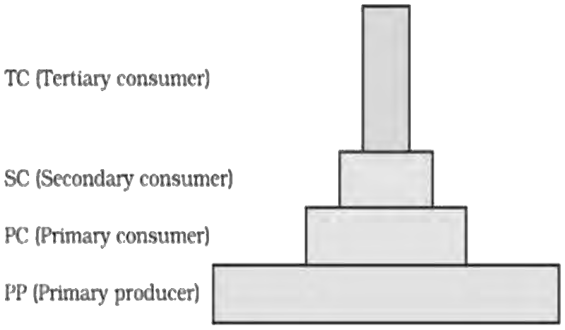
The number of trophic levels in the grazing food chain is limited as the transfer of energy follows 10 percent law that is only 10 percent of the energy is transferred to each trophic level from the lower

trophic level. In GFC, following trophic levels are possible- producer, herbivore, primary carnivore, secondary carnivore.

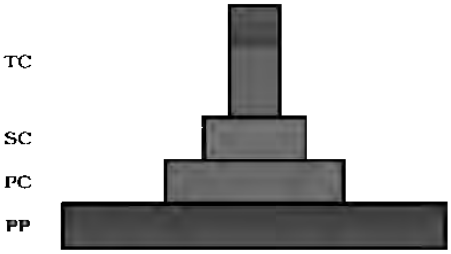
Ecological Pyramids

Ecological pyramid is the graphical representation of an ecological parameter (number, biomass, energy) sequence wise in various trophic levels of a food chain with producers at the base and herbivores in the middle and carnivores at the top tiers. It can be upright, inverted, or spindle shaped.

a) **Pyramids of number**- Employs the number of individuals per unit area at various trophic levels with producer at base and various consumers at successively higher levels. It is generally **upright**.

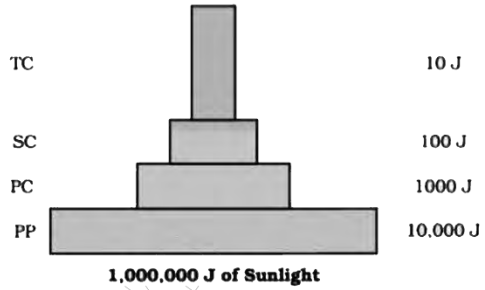


b) Pyramids of biomass- represent the biomass in various trophic levels. A pyramid of mass is upright except in aquatic food chain involving short lived plankton.



A pyramid of biomass in sea is generally invert because biomass of fishes generally exceeds phytoplankton.

(c) **Pyramids of energy**- It gives graphic representation of amount of energy trapped by different trophic levels per unit area. It is always upright because during transfer of energy from one trophic levels to next lot of wastage occurs in feeding, digestion, assimilation and respiration.



Ecological Succession

The gradual and fairly predictable change in species composition of a given area is called ecological succession. During succession some species colonise an area and their population becomes more numerous whereas population of other species decline and even disappear.

- Orderly and sequential change that leads to a community that is near equilibrium is called **climax community**.
- The entire sequence of communities that successively changes in a given area is called **sere** and individual transitional communities are termed seral stage or seral communities.
- Primary succession starts where no organism are there. For example bare rocks, cooled volcano etc.
- Secondary succession occurs in the area where the living organisms have lost due to certain regions like forest fire, Earthquake etc.

Succession of Plants

On the basis of nature of habitat, succession of plants can be grouped as-

- Hydrach succession takes place in wetter area and the successional series progress from hydric to the mesic conditions.
- Xerarch succession takes place in dry areas and series progress from xeric to mesic conditions.
- The species that invade a bare area are called pioneer species. In primary succession on rocks lichens are pioneer species that secrete acids to dissolve the rock for weathering to form soil.
- In primary succession in water, the pioneer species are the small phytoplanktons that are replaced by free floating angiosperms.

Nutrient Cycling

The movement of nutrients elements through the various components of an ecosystem is called nutrient cycling. It is also called as biogeochemical cycle. There are two types of nutrient cycles-

- Gaseous – exist in atmosphere.
- Sedimentary- exists in earth crust.

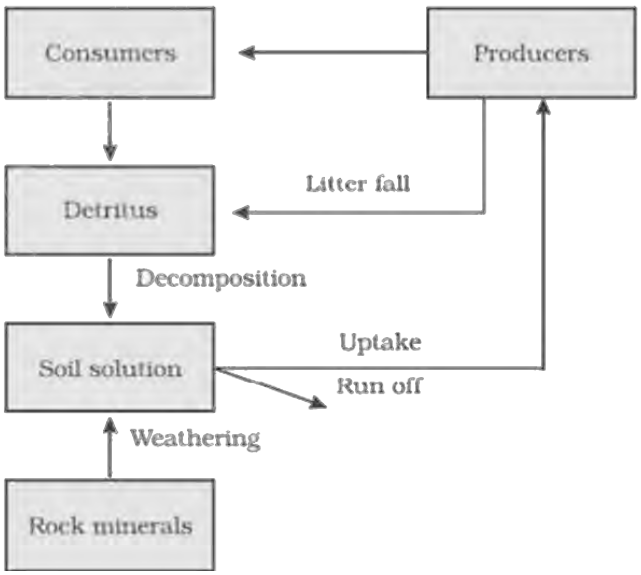
Environmental factors like soil, moisture, pH, temperature regulate the rate of release of nutrients into the atmosphere.

Carbon Cycle

Carbon cycling occurs through atmosphere, ocean and through living and dead organisms. Most of carbon is fixed by plants during the process of photosynthesis and returns to atmosphere in form of CO_2 during respiration. Burning of wood, forest fire and combustion of organic matter, fossil fuel, and volcanic activity are other sources of releasing CO_2 in the atmosphere.

Phosphorus Cycle

The natural reservoir of phosphorus is rock which contains phosphorus in the form of phosphates. On weathering, minute amount of phosphates dissolve in soil solution and absorbed by the roots of the plants. The waste products of dead organisms are decomposed by bacteria to release phosphorus. Gaseous exchange between organism and environment is negligible as compared to carbon.



Ecosystem Services

The products of ecosystem processes are called ecosystem services. It includes-

- The healthy forest ecosystem purify air and water
- Mitigates floods and droughts
- Cycle nutrients

- Generate fertile soil
- Provide wildlife habitat
- Maintain biodiversity etc.

These fundamental ecosystem services are taken granted because they are free although its value is twice the total global gross national product (GNP). Soil formation accounts for about 50% of total ecosystem services.

37. BIODIVERSITY AND CONSERVATION

The important diversity at the levels of biological organization are-

I. Genetic Diversity- a single species might show high diversity at the genetic level over its distributional range. India has more than 50,000 genetically different strains of rice and 1000 varieties of mango.
II. Species Diversity- diversity at species level for example, the Western Ghats have more amphibian species diversity than the Eastern Ghats.
III. Ecological Diversity- deserts, rain forests, mangroves, coral reefs, wetlands, estuaries and alpine meadows are types of ecological diversity.

- India has only 2.4% of land area of world but share 8.1% of global species diversity. Our country is one of the 12 mega diversity countries of the world.

Species-Area relationships

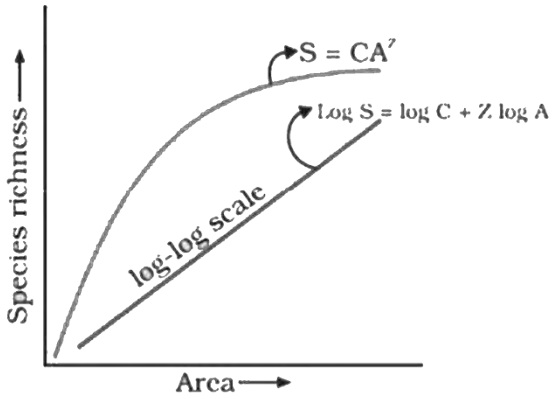
Alexander von Humboldt observed that species richness increases with increasing explored area. The relation between species richness and area for a wide variety of texa turns out to be a rectangular hyperbola.

On logarithmic scale, the relationship is a straight line described by the equation

$\log S = \log C + Z \log A$.

Where, S= species, A= Area, Z= slope of the line, C =Y- intercept.

Ecologists have discovered that the value of Z lies in range of 0.1 to 0.2 regardless of taxonomic group of the region.



Loss of Biodiversity

In general, loss of biodiversity in a region may lead to

a. Decline in plant production

b. Lowered resistance to environmental perturbations, drought, and flood.

c. Increased variability in ecosystem processes such as productivity, water use, and pest and disease cycles.

Causes of biodiversity losses

Faster rates of species extinctions are largely due to human activities. The four major causes are called 'The Evil Quartet'.

1) **Habitat loss and fragmentation**-
2) **Over-exploitation**
3) **Alien species invasions**
4) **Co-extinction**

How do we conserve Biodiversity ?

There are two ways of conservation of biodiversity –

In situ (on site) conservation- Conservationists have identified for maximum protection certain 'biodiversity hotspots' regions with very high levels of species richness and high degree of endemism, species found in that region and not found anywhere else. There are 34 biodiversity hot spots in the world. These hotspots are also regions of accelerated habitat loss. India has 14 biosphere reserves, 90 national parks and 448 wildlife sanctuaries.

Ex situ (off site) conservation- In this method, threatened animals and plants are taken out from their natural habitat and placed in special setting when they be protected and given special care . Zoological parks, Botanical Gardens and wildlife safari parks are used for this purpose.

The historic convention on Biological Diversity (The Earth Summit) held in Rio de Janeiro in 1992,called upon all nations to take appropriate measures for conservation of biodiversity and sustainable development held in 2002 in Johannesburg, South Africa.

38. ENVIROMENTAL ISSUES

Pollution is undesirable change in physical, chemical or biological properties of air, land, water or soil. The substances that cause undesirable change are called pollutants.

Air Pollution and its Control

Thermal power plants, smelters and other industries release particulate and gaseous air pollutants along with harmless gases such as nitrogen, oxygen etc.

Electrostatic Precipitator- can remove over 99% of particulate matter present in the exhaust from thermal power plant.

A scrubber can remove gases like sulphur dioxide.

- According to CPCB (Central Pollution Control Board) particulate size less than 2.5 micrometers cause greatest harm to human health.
- Automobiles are main cause of atmospheric pollution in metro cities. Proper maintenance of automobiles.

Catalytic converters contain platinum-palladium and rhodium as the catalyst, are fitted into automobiles for reducing emission of poisonous gases. As the exhaust passes through the catalytic converter, unburnt hydrocarbons are converted into carbon dioxide and water. The vehicles fitted with catalytic converter should use unleaded petrol because lead in the petrol inactivates the catalyst.

In India, the Air (Prevention and Control of Pollution) Act came into force in 1981 and was amended in 1987 to include noise as an air pollutant.

Water Pollution and it control

The Government of India has passed the water (Prevention and Control of Pollution) Act, 1974 to protect the water resources.

Domestic Sewage and Industrial Effluents-

The sewage that comes out from house and office makes the domestic sewage. A more 0.1% impurities make domestic sewage unfit for human use.

Biological Oxygen Demand (BOD)

The microbes that decompose organic wastes in water bodies consume a lot of oxygen that result into sharp decline in dissolved oxygen downstream from the point of sewage discharge. This decrease in dissolved oxygen in water bodies is called BOD. The main effects include mortality of fish and other aquatic creatures.

Algal Bloom

Presence of large amount of organic nutrients in water causes excessive growth of planktonic or free floating algae called algal bloom. Due to this colour of water bodies get changed. This may cause deterioration of the water quality and fish mortality. Water hyacinth (*Eichhornia crassipes*) is the world's most problematic aquatic weed.

This weed is called as 'Terror of Bengal'.

Biomagnification or Biological Magnification

The increase in concentration of toxicant at each successive trophic levels is called biological magnification. The most common toxicant that get accumulated at successive trophic levels includes DDT and Mercury.

Eutrophication

It is the natural aging of a lake by biological enrichment of its water. Due to addition of nutrients such as nitrogen and phosphorus that encourage the growth of aquatic organism the accumulation of organic remains in course of time leads to shall lowing of lake.

The pollutants from man's activities such as effluents from the industries and homes radically accelerate the aging of lake. This phenomenon is called **Cultural or Accelerated Eutrophication.** Main contaminants include nitrates, phosphates that act as plant nutrients.

Solid Wastes

Agro-chemicals and other effects

Use of inorganic fertilizers and pesticides has been increased many fold due to green revolution for enhancing crop production. They are biomagnified in the terrestrial ecosystem.

Organic Farming

Integrated organic farming is a cyclic, zero-waste procedure in which waste products from one process are cycled in as nutrients for other processes to allow the maximum utilization of resource and increase the efficiency of production. It includes bee-keeping, dairy management, water harvesting, composting and agriculture

Radioactive Wastes

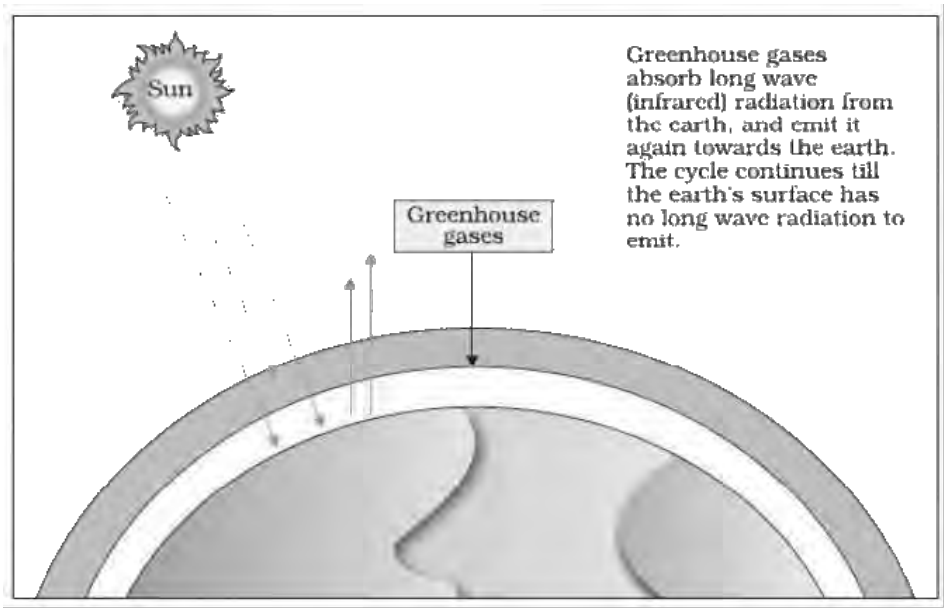
Nuclear energy has two very serious problems –

- Accidental leakage
- Safe disposal of radioactive wastes

The radiation released from nuclear wastes is extremely damaging to biological organisms as it causes mutations to occur at very high rate.

Green House Effect and Global Warming.

The greenhouse effect is a naturally occurring phenomenon that is responsible for heating of Earth's surface and atmosphere due to increase in concentration of carbon dioxide and methane gas.



Global warming is caused due to greenhouse effect.

Global warming can be controlled by

- Cutting down use of fossil fuel
- Improving efficiency of energy usage
- Reducing deforestation
- Planting trees
- Slowing down the growth of human population.

Ozone Depletion in the Stratosphere

The thickness of the ozone in a column of air from the ground to the top of the atmosphere is measured in terms of Dobson units (DU).

Due to increase of ozone degradation by chlorofluorocarbons (CFCs) used in refrigerants ozone in stratosphere is increased. Ozone depletion is marked over the Antarctic region called as **ozone hole.** High dose of UV-B causes inflammation of cornea, called snow blindness cataract.

Deforestation

It is the conversion of forested areas to non-forested ones due to human activities like slash and burn agriculture also called **Jhum cultivation**, use of fertilizers and cutting of trees for industries and residential use. Main consequence of deforestation includes-

- Enhanced carbon dioxide concentration
- Loss of biodiversity
- Disturbed hydrologic cycles
- Soil erosion
- Desertification etc.

“எல்லோரும் எல்லாமும் பெற வேண்டும் ...
இங்கு இல்லாமை இல்லாத நிலை வேண்டும்”

- மாண்புமிகு புரட்சித்தலைவி அம்மா

அம்மா கல்வியகம்

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