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Chemistry of Life

Atom: electron, protons, neutrons

63% Hydrogen, 24% Oxygen, 10% Carbon, 1.4% Nitrogen, } Maj Elements
Phosphorous, Sulphur.
0.2% 0.1%

Ca, Cl, K, Na, Mg, Fe, Se, I etc. } Trace Element

The molecular composition of life: 80% water & 20% contains
50% proteins
15% Carbohydrates
10% lipids & fats
15% nucleic acid [DNA & RNA]

Carbon: 1. Highly versatile capability to form large complex, varied diversity of organism
2. Essential component for various biomolecules (DNA, proteins, Carbohydrates etc)
3. Variation in carbon skeleton is one important source of molecular complexity & diversity that characterize living matter.
4. Catenation.

Bonds in a living organisms: 1. Covalent
2. Ionic
3. Hydrogen
4. Van der Waal's interactions
5. Hydrophobic interactions

Bond Stability: $8e^-$ in valence shell.

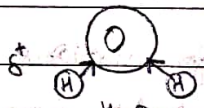
Covalent Bonds: Strongest
Stable
Sharing of valence e^-

- Polar: Unequally shared pair of e^-
- Non-Polar: equally shared pair of e^-

Electronegativity: tendency to pull ↓ e^- towards it.

Shared pair of

δ^- Partial -ve



δ^+ δ^+ Partial +ve

H_2O

Electronegativity trend in Periodic table: → Increase

Why
Same no. of orbitals
∴ +ve Charge more
So more attraction

↑ Increase

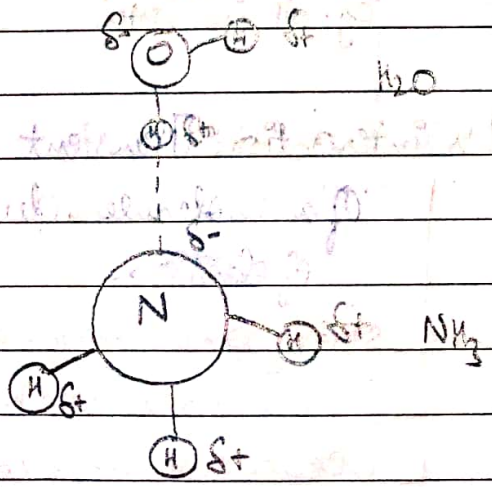
Why: No of Orbitals are less So less force on outermost e^- therefore high in lower Orbital elements

Ionic Bond: bonds between ions. * Salts dissolve because of attraction of δ^+ by δ^- & δ^- by δ^+ of $O^{\delta-}$ & $H^{\delta+}$ respectively
Stable in normal form disturbed when mixed.

Bond Nature	Non polar Covalent Bond	Polar Covalent Bond	Ionic Bond
Electron Pair	Shared Equally	Shared unequally	Taken completely
	0.5		1.7

Electronegativity difference

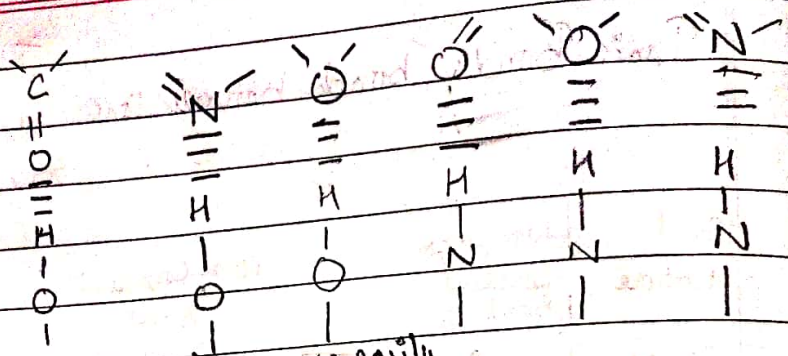
Hydrogen Bonds: Bond energy: 5kcal/mole



Salt, Sugar etc. dissolves in water due to formation of hydrogen bonds.

Bonds b/w two water molecules : Hydrogen bond.

Hydrogen acceptor :



Hydrogen Donor.

Advantage: they can come together & separate easily.

In biological systems: the common acceptor is O, N & donor is another electronegative atom.

Hydrophobic interactions: Incapability of forming bonds in water; non-polar ring / straight chain
Eg: oil in water

Van der Waal's interaction: Transient +ve & -ve Charges of a molecule due to chance accumulation of electrons.

- strong when many in no.
- Individually weak
- Occur only on close contact
- Bond energy = 1 kcal/mol

* $\bar{e}$ are not always symmetrically distributed in such a molecule

Eg:

Covalent > Ionic > Hydrogen > Hydrophobic > Van der Waals
50-110 3-7 3-7 1-2 1

Gecko Adhesive system →
Scansors → Setae → Spatula
gill-like, on bottom of foot; Hair like; Δ structure, flat

→ Same Group : Substitution

Important: Substitution of Elements & Toxicity

* Strontium can be substituted with calcium [Concern in nuclear accidents]
* Pb can substitute Carbon in various life processes.
* Arsenic for Phosphorous (As poisoning : Karnataka)
* Selenium for Sulphur

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(2)

Carbohydrates — monosaccharides
— disaccharides
— Oligosaccharides
— polysaccharides (x)

[C & OH group compulsory; C arbonyl]

C=O group at terminal so aldo
C=O group in chain so keto

	Aldo	Keto
Triose:	Glyceraldehyde	Dihydroxy Acetone
Pentose:	Ribose	Ribulose
Hexose:	Glucose, Galactose	Fructose

Sugars exist in 2 forms: ring & Chain
↳ favoured because Stable

Two sugar units are joined by glycosidic bonds.
↓
formed by dehydration.

Maltose: 2 sugar units [1,4 - glycosidic bond]

Sucrose: Glucose & Fructose [1,2 - glycosidic bond]

Lactose: Glucose & Galactose

(1)

Polysaccharides:
- Storage: Starch & Glycogen (only in animals)
- Structural: Cellulose; Chitin (exoskeleton of arthropods) (fungi)

(only glucose bonded in Syllabus)

Cellulose: polymer of glucose but glycosidic linkage are different.

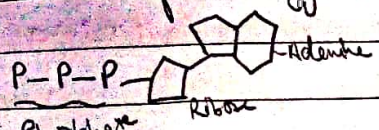
Starch (plants (1,4: glycosidic)) — formed of glucose monomers.
- Amylose: Simple & unbranched
- Amylopectin: Complex & branched (1,4: at glucose) (1,6: at the branches)

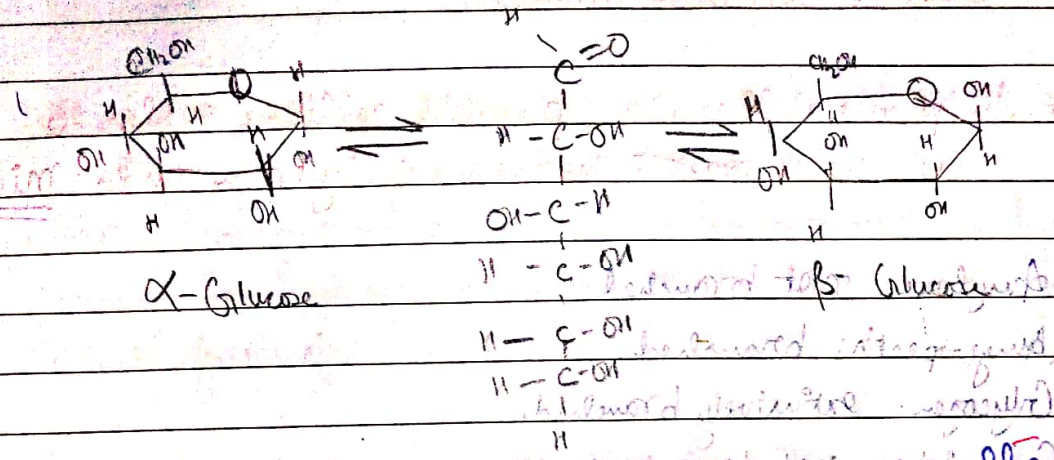
Animals
↓
Glycogen: extensively branched
↓
branched helps in release of energy and hydrolysis

ATP: Adenosine triphosphate

Production of energy: ATP → ADP + Inorganic phosphate

7.3 kcal/mol





α-Glucose

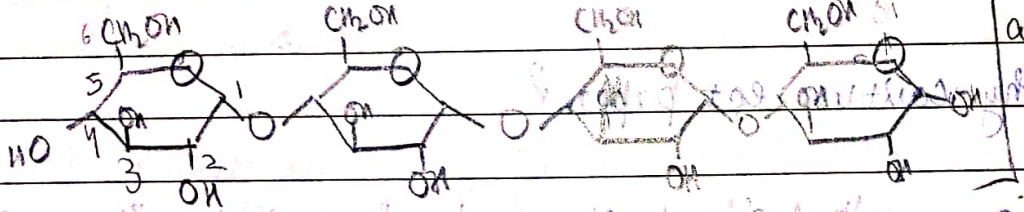
β- Glucose

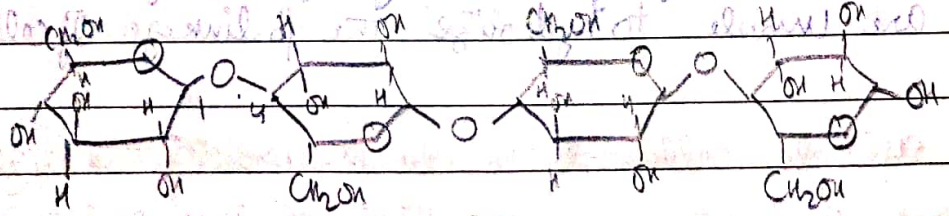
Starch : α-glucose #

Cellulose: β- glucose #

Starch: 1,4-α glucose monomers

all monomers are in same orientation

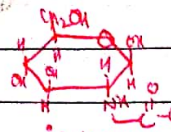




Cellulose : 1,4 - β glucose monomers

every β glucose is upside down wrt its neighbor

* Starch molecules are largely helical. Cellulose molecule is straight.

* Chitin 

* Cellulose is never branched

* In plant cell walls, parallel cellulose molecules are held together by means of hydrogen bonds: microfibrils

Amylose: not branched
Amylopectin: branched
Glycogen: extensively branched.
Cellulose: not branched

* Cellulose is major constituent in paper & only component in cotton.

Q. Why can't we eat paper?

→ Enzymes that digest starch by hydrolyzing its α-linkages are unable to hydrolize the β linkage of cellulose.

* In animals cellulose abrades the wall of the digestive tract and stimulates the lining to secrete mucus.
* Not a nutrient for humans, but an important part of healthful diet.
* Some microorganisms can digest cellulose, breaking it down

into glucose monomers

* A cow harbours cellulose digesting prokaryotes and protists in its stomach. Similarly, a termite has prokaryotes or protists in its gut.

③ Water and Phospholipids:

- Polar covalent bond in water molecules results in hydrogen bonding. The hydrogen bonds formed, break and re-form with great frequency.
- Each last only a few trillionth of a second, but molecules are constantly forming new hydrogen bonds with sucession of partners.
- Therfore at any instant, all water molecules are hydrogen bonded to their neighbors.
- Water molecules stay close to each other as a result of hydrogen bonding. These linkages make water more structured than most other liquids.

* The hydrogen bond holds the substance together, a phenomenon called cohesion.

* Adhesion is the force of clinging one substance to another.

- Adhesion of water to cellwalls by hydrogen bonds helps counter the downward pull of gravity.

Moderation of Temperature by water:

→ Water moderates air temperature by absorbing heat from air that is warmer and releases the heat to air that is cooler.

Q. Why is water an effective heat bank?

→ Water is effective as a heat bank because it can absorb or release a relatively large amount of heat with only a slight change in its own temperature (due to high specific heat of water)

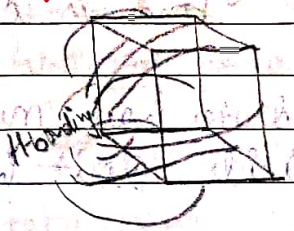
Specific heat: amt of heat that must be gained or lost by one gram of water to change by one °C.

Note: Any property of water is caused due to hydrogen bonding.

* Ice floats on water because when solid ice, Vol↑

∴ density ↓ ∵ $d = \frac{m}{V}$

⊙ Ice has higher volume because the hydrogen bonding is regular whereas in liquid water is having irregular hydrogen bonding.



* floating of ice on water helps in existence of aquatic life underwater in polar regions.

(4) Lipids:

- hydrophobic molecules.
- made of fatty acids.
- for living organisms two types are important: fats & phospholipids.

Fatty acids: • long carbon chain
• carbon at one end of the skeleton is a part of carbonyl group.
• The diff in electronegativity of C and H is 0.4 (C: 2.5, H = 2.1), ~~therefore they~~ are polar ~~therefore~~ hydrophobic.

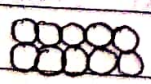
Q. Prev yrs: A molecule is hydrophilic or hydrophobic?
→ If C-H skeleton then hydrophobic.
C-H ring hydrophobic.

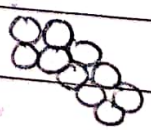
* Three fatty acid chains make up fat.
(3 fatty acids linked to a glycerol molecule via ester bond is called Triacylglycerol or Triglyceride

Carbohydrates have multiple -OH groups but Fatty acids don't have -OH groups.

Carbohydrates and Fatty acids both have -CHO group.

Saturated Fats	Unsaturated Fats
1. Solid form	1. Liquid form
2. all 3 chains of fatty acids are single bonded.	2. One or more chains are double or triple bonded. (slight bend)
3. Eg: Butter.	3. Eg: Oil





Imp wrt Exams !!

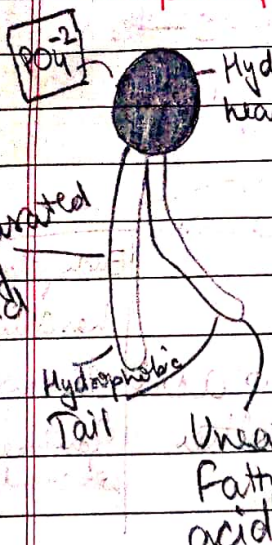
Phospholipids: → components of cell membrane

→ similar to fats but two fatty acid chains are attached instead of 3.

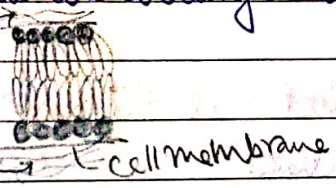
→ The 3rd hydroxyl group is joined to a phosphate group, which has (-ve) electrical charge in the cell

→ Among two fatty acid chains in phospholipids, one is saturated and other is unsaturated (double bond only)

→ In the cell membrane phospholipids are arranged in bi-layer.



A phospholipid example



Q. If both fatty acids are saturated?

→ Then cell membrane will be impermeable because then both will be stick together.

Q. If both fatty acids are unsaturated?

→ Then cell membrane ~~is~~ will be freely permeable and unstable.

Func. of cell membrane:

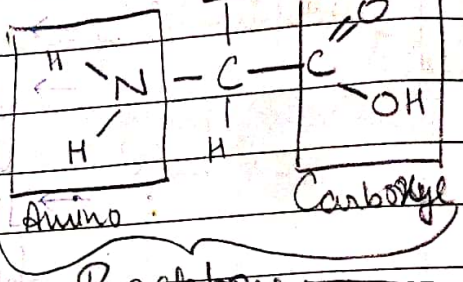
→ Separate two cells

→ restricted entry of elements. (Semi-permeable)

Whenever monomers make polymers it is always dehydration reaction.

⑤ Proteins:

function: Speed up chemical reaction, defense, storage, transport, cellular communication or structural support



⊙ most abundant biological macromolecules.

✱ amino acids bond by peptide bond

peptide bond: carbonyl of one amino acid to amino group of another (dehydration reaction)

Each polypeptide has a unique linear sequence of amino acids, with C-end & N-end

Structural hierarchy: 1. Primary
2. Secondary
3. Tertiary
4. Quaternary

If side chain:
1. polar: hydrophilic
2. non-polar: hydrophobic
3. Charged group: hydrophilic

✱ 20 amino acids are capable of protein formation.

polypeptide: polymers built from same set of 20 amino acids

protein: biologically functional molecules with one or more polypeptides

1. Primary: Simple chain joined by peptide bonds. determined by inherited genetic information

2. Secondary: H-bond is formed in the backbone of amino acids. (H in amino bonds with O in carbonyl)
2 types: α-helix (formed in the same chain)
β- sheet. (formed in the diff. chains)

IMMUNE SYSTEM: Antibody should be of exact same shape to attack/destroy antigen (foreign substance)

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[formed by amino acids only]

Turns: Structures which connect α-helix to β- sheets

→ allow large proteins to fold into highly compact form
→ consist of 3 or 4 residues
→ form sharp bends that redirect the polypeptide backbone.
→ stablized by hydrogen bond b/w their end residues

commonly found in: • Glycine: due to lack of large side chain
• Prolines: due to presence of built-in bend

3- Tertiary Structure: Overall shape of a polypeptide resulting from interaction b/w the side chains (R groups) of the various amino acids.

4. Quaternary Structure: Overall protein structure that results from the aggregation of these polypeptide subunits

• 3 identical helical polypeptides intertwined into a larger triple helix, giving the long fibre great strength.

• Function as the girders of connective tissue in skin, bone, tendons, ligaments and other body parts.

STRUCTURE OF PROTEIN
→ 1-D Structure
→ Sequence of amino acid determines 3-D Structure

⑥ Enzymes:

Substrate: reactant enzyme acts on
Transition State: An unstable state of reactants following absorption energy

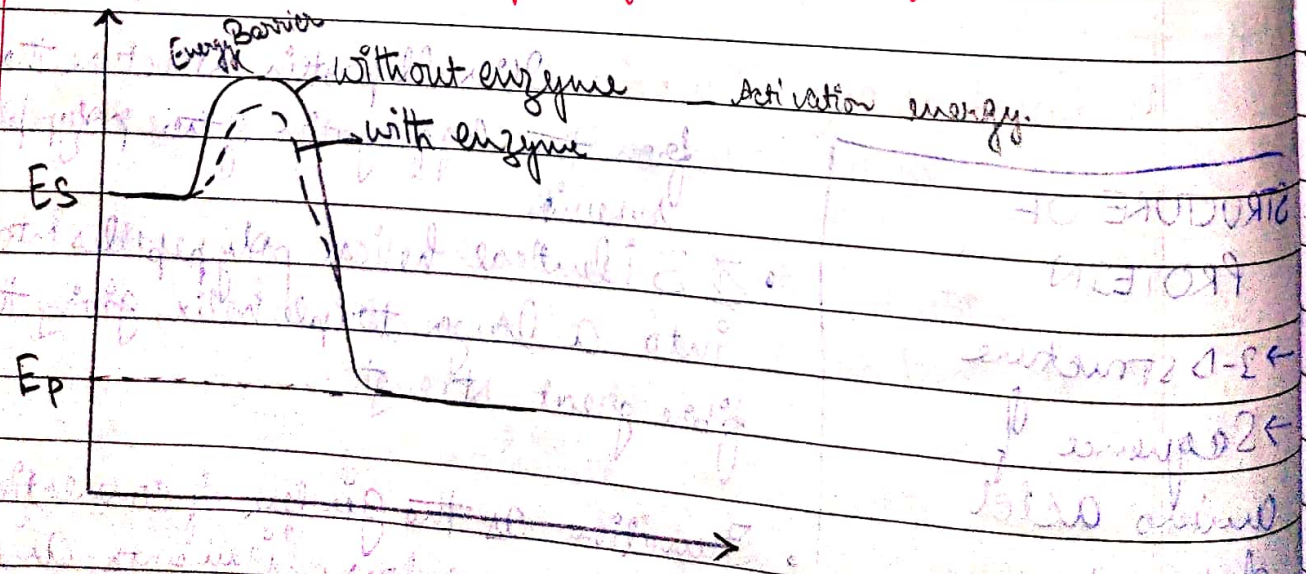
- Made up of only proteins.
- Catalytic property
- Highly specific for substrate.
- Function in aqueous solution.
- Does not effect the extent of the reaction.
- Catalyzes reaction that are energetically favourable. (✗) Pump

Substrate → Product.

$\Delta G = E_p - E_s$

If: ΔG = -ve (Energetically favourable reaction)

- Increases the rate of reaction by decreasing activation energy.
- Activation energy: required for initiation of reaction.



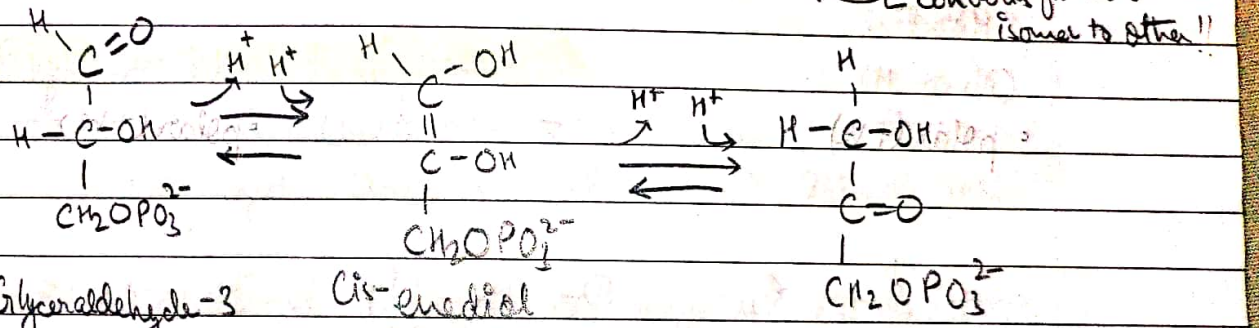
→ does not change energetic favourability (E_p & E_s does not change)
→ does change activation barrier
→ stabilizes the transition state
→ prevents side reaction from occuring
→ speeds up the reaction.

unstable

$S \rightarrow$ Intermediate $\rightarrow P$

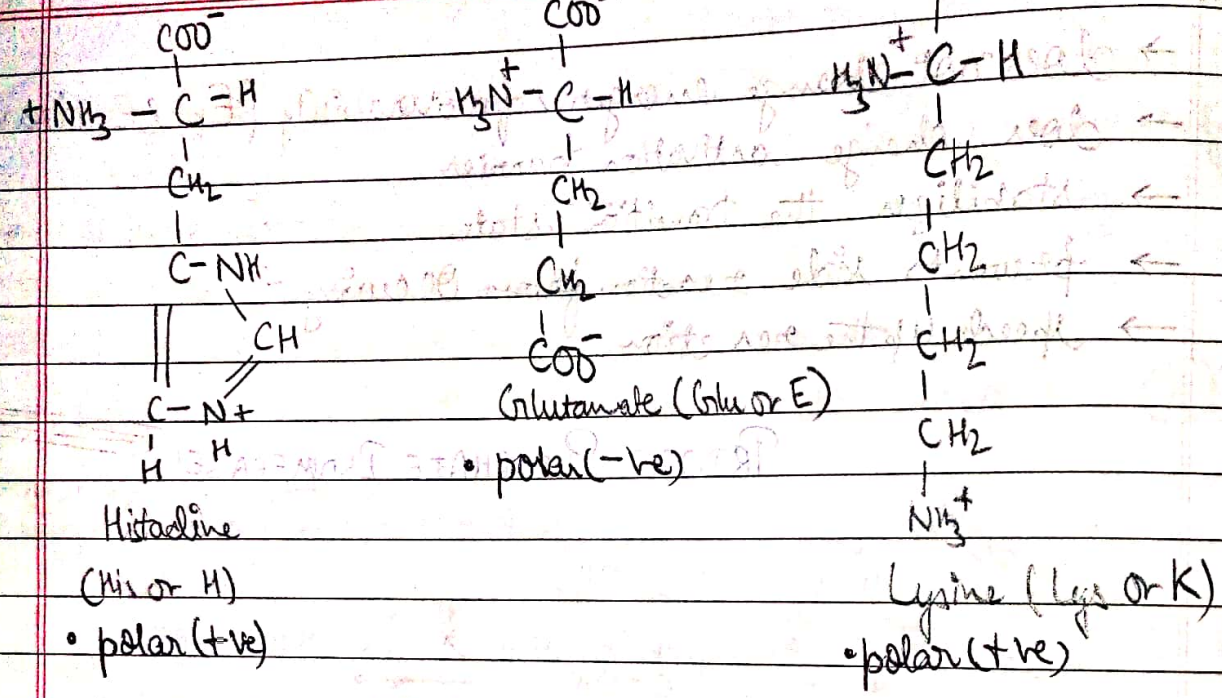
TRIOSE PHOSPHATE ISOMERASE:

↳ converts from one isomer to other !!



- High energy intermediate "cis-enediol" is an energetically unfavourable molecule (∵ ΔG > 0)
- Formation of product in normal condition is impossible.
- Here! Enzyme helps to stablize the transition state and formation of product.

Our enzyme: → 250 amino acid polypeptide
→ Dimeric protein
→ His 95, Glu 165 & Lys 12 present at active site.
Histadine Glutamate Lysine — Inside the enzyme.

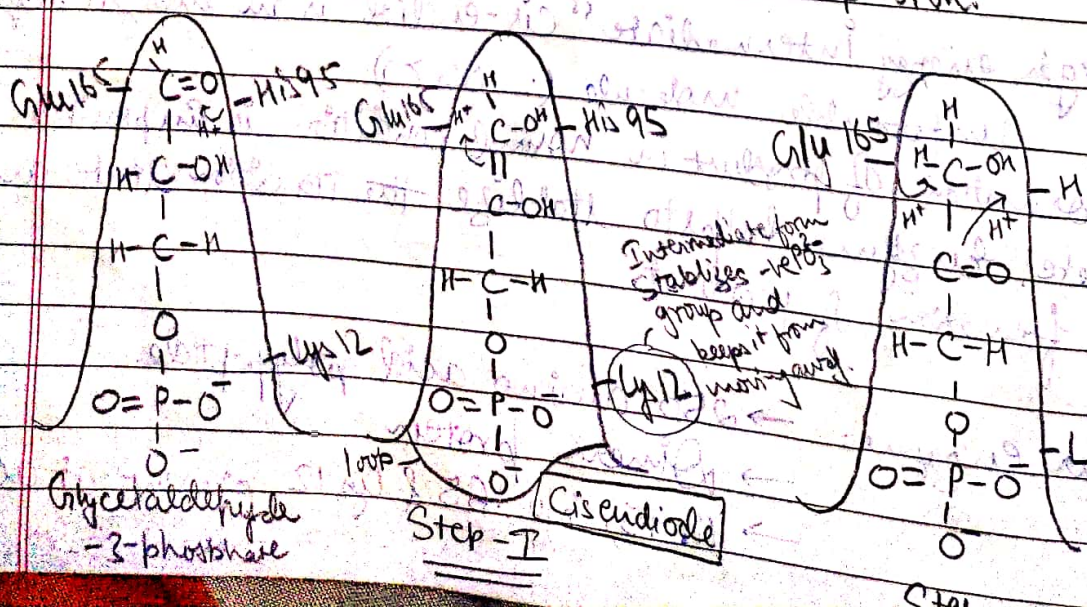


Action of the Enzyme Procedure!!: 1. First carbon acts as the proton, so accept the proton

2. Second carbon donate proton.

3. +vely charged amino acid will give a proton.

4. -vely charged amino acid will always accept a proton



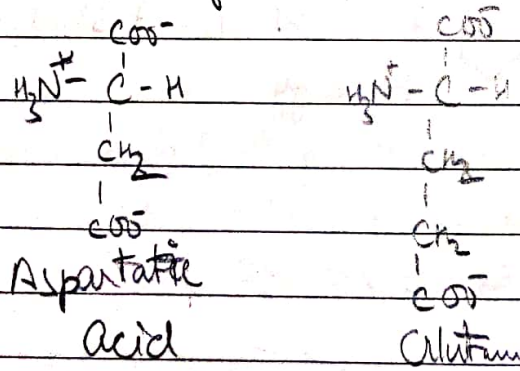
- If a turn is long then it is called a loop.
- Loop is formed by the enzyme which does not let the intermediate form to escape & also does not let water to enter.

- Numbers associated with the amino acid tells its position in the protein.

* Substitution at active site:

→ glutamic acid was replaced by another negatively charged amino acid like aspartic acid??

→ 10000 times worse working in terms of rate of reaction.



Aspartate acid — Glutamic acid

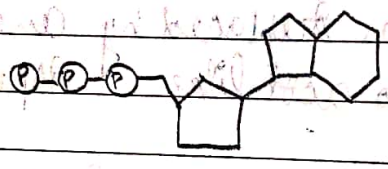
→ Lysine with arginine (X) +ve charge not at ideal pos^{n}.

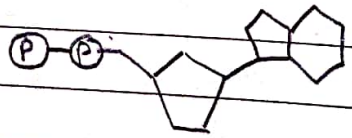
⑦ Biochemical Pathways:

Autotrophs - Anabolism (constructive mechanism)
Heterotrophs - catabolism (destructive mechanism)
Plants
Multicellular organisms and most microorganisms.

Metabolism: (Combination of anabolism & catabolism)

- Reation
- Pathway. (series of reaction)





$G = -7.3$ kcal/mol.

Chemical reaction energy:

Reactants ↔ Products

- The change in free energy is given by (ΔG):

$\Delta G = \Delta G_{free\ products} - \Delta G_{free\ reactants}$

ΔG (-ve): fwd reaction

ΔG (+ve): bwd reaction

ΔG (0): both reaction occur simultaneously at eqlb. ($\Delta G = 0$)

* Std. free energy change ($\Delta G^{\circ\prime}$):

→ Std condition: 298K (25°C)
1 atm pressure
7.0 pH
1M conc. for all reactants & products initially.

Actual change in free energy of the cell:

$$\Delta G = \Delta G^{\circ\prime} + RT \ln [Q]$$
$$= \Delta G^{\circ\prime} + RT \ln [\text{products}]/[\text{reactions}]$$

R is gas constant (1.987 cal/°mol)
T is temp.
Q is ratio of conc. of products to reactants

$C_6H_{12}O_6 + 6O_2 \rightarrow 6CO_2 + 6H_2O$
$\Delta G = -686$ kcal/mol
(-2,870 kJ/mol)

- ΔG of the reaction is independent of rate of reaction.
- Cellular processes use two tricks in energetics to make energetically unfavourable reaction into a favourable one.

$$\Delta G = \Delta G^{\circ\prime} + RT \ln \frac{[\text{Prod}]}{[\text{Reac}]}$$

R: 1.987 cal/mol

Trick(1)- An unfavourable chemical reaction can proceed if it is with an Energetically favourable reaction

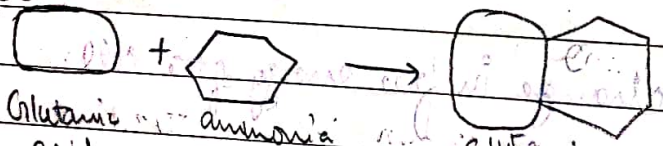
$A \leftrightarrow B : \Delta G_1 > 0 \quad (rk = 1)$

$C \leftrightarrow D : \Delta G_2 < 0 \quad (rk = 2)$

$A + C \leftrightarrow B + D, \ \Delta G < 0$ (overall reaction)

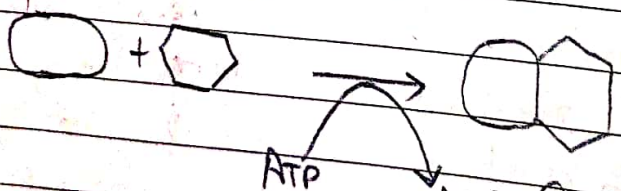
~~Trick(2)~~

Uncoupled:



$\Delta G = +3.4$ kcal/mol (Unfavourable)

Coupled:



Glu + NH_3 → Glutamine $\quad \Delta G = +3.4$ kcal/mol

ATP → ADP + Pi $\quad \Delta G = -7.3$ kcal/mol

$\Delta G = -3.9$ kcal/mol.

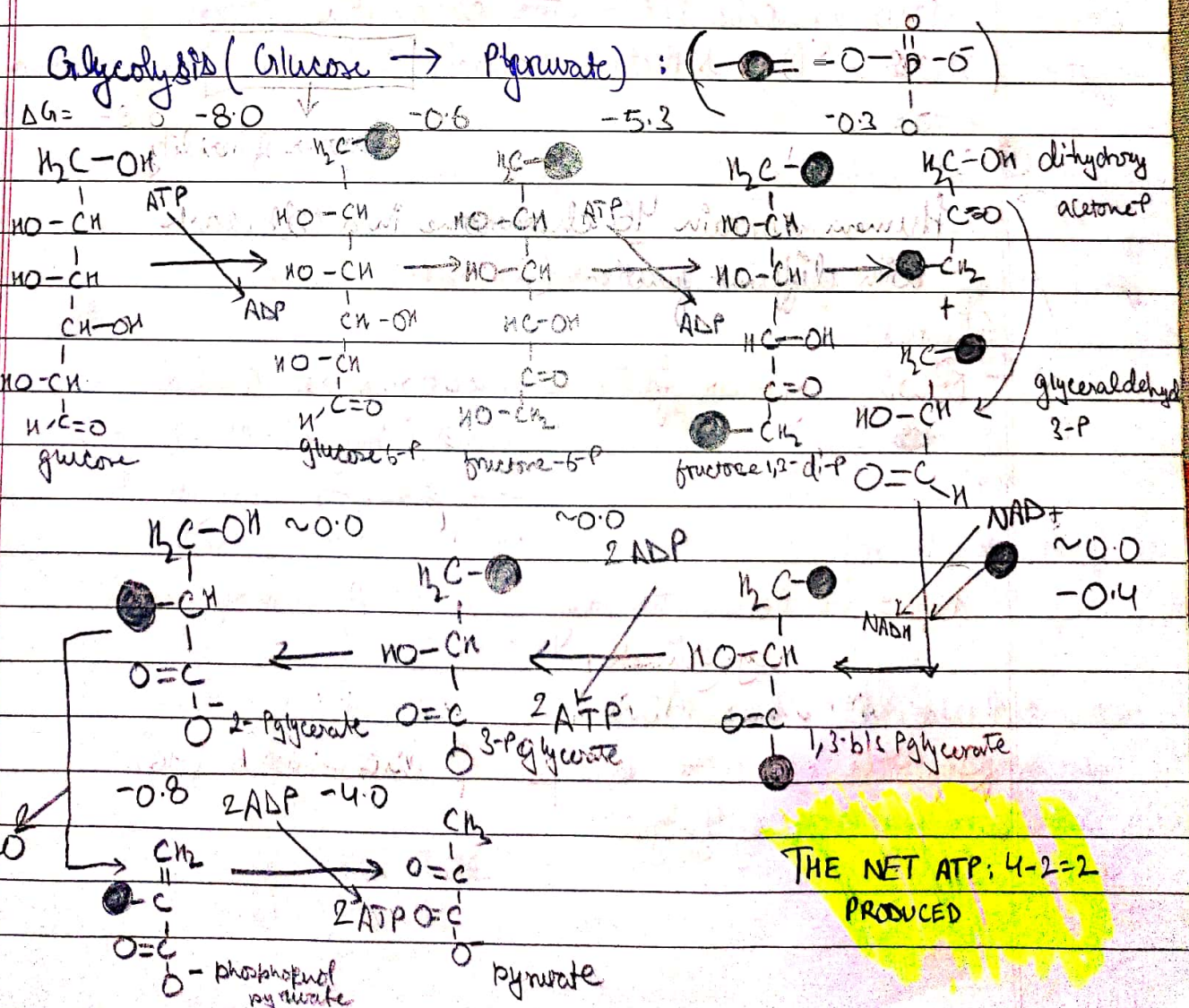
BUFFER: Weak acid conjugate base, weak base conjugate acid. One can soak excess proton other can soak excess hydroxide

Trick ② – An unfavourable chemical reaction can proceed if it is indirectly coupled with Energetically favourable reaction.

In a series of reaction like: $V \leftrightarrow W \leftrightarrow X \leftrightarrow Y \leftrightarrow Z$

$X \leftrightarrow Y \quad \Delta G_3 > 0 \ (rk = 3)$
$Y \leftrightarrow Z \quad \Delta G < 0 \ (rk = 4)$
} one after another indirect coupling

Glycolysis (Glucose → Pyruvate) : (–O–P(=O)(–O⁻)–O⁻)



THE NET ATP: 4-2=2 PRODUCED

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⑧ Monohybrid Cross & Law of Seggregation

Functional part of DNA is **gene** ~ responsible for a character.

DNA is coiled in a cell around/attached to **Histone** protein.
The bundle is called **chromatin.**

During cell division, the chromatin becomes rod-like structure called **chromosomes** ← Chromosome
↓
Carrier of heridity

Humans contain 46 chromosome in a cell, each with different function. (23 pair)

During gamete formation : 23 pairs are divided.
and only 23 chromosomes are present in each gamete

Haploid: cell with only one set of chromosomes (23)
(eg. gamete)

Diploid: cell with both pair of chromosome (46)
(eg. zygote)

Locus: A fixed location on a strand of DNA where one of its alleles is located

Allele: genes from a pair of homologous chromosomes are called allele.

Dominant: gene which is expressed among the allele is called dominant genes

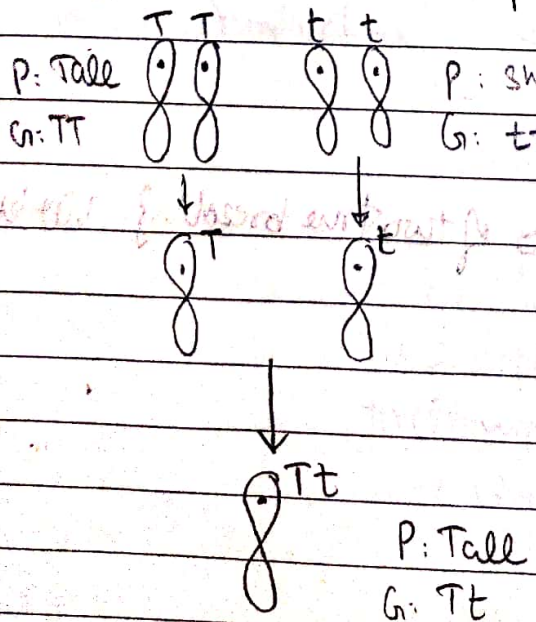
Recessive: gene which is not expressed among the allele is called recessive gene.

Homozygous: if alleles are same then zygote is called homozygous

Heterozygous: If alleles are different then zygote is called heterozygous.

Phenotype: external characteristics; visible. (height, colour)

Genotype: characteristic responsible (TT, Tt, tt)



Gamete: Haploid cell formed by male/female

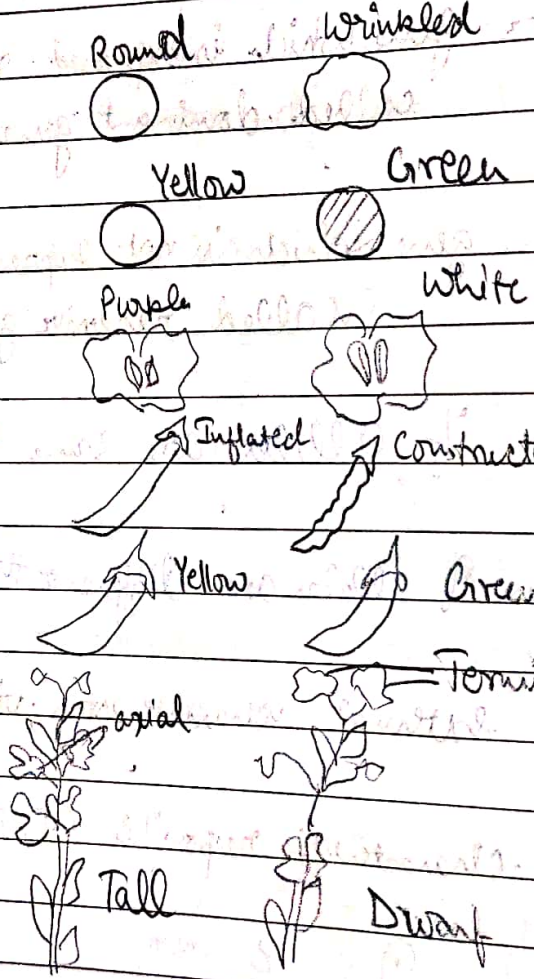
Character: heritable feature that varies - flower color

Trait: variant of character - purple/white.

MENDELE: FATHER OF GENETICS

Seven variations:

1. Seed Shape: Round, Wrinkled
2. Seed Color: Yellow, Green
3. Flower Color: Purple, White
4. Pod Shape: Inflated, Constricted
5. Pod color: Yellow, Green
6. Flower Position: axial, Terminal
7. Stem Height: Tall, Dwarf



Hybridization: Mating or crossing of two true breeding varieties

F1: First filial generation

⑨ Test Cross & Dihybrid Cross.

Spherical Wrinkled
SS x ss
↓
(S) (s)
↓ F1
Ss x Ss F1
Spherical
(Dominant)
↓ F2
(SS) (ss)
Spherical Wrinkled
3 : 1

	S	s	
S	SS	Ss	3:1
s	Ss	ss	Tall Dwarf

phenotypic ratio: 3:1
genotypic ratio: 1:2:1
SS Ss ss

"Whenever a pair of characters is brought together in a hybrid, they segregate during the formation of gametes and each gamete is pure with reference to its character."

Law of Segregation: The units of inheritance are never blended but segregated independently during reproduction caused by separation of homologous chromosome during meiosis

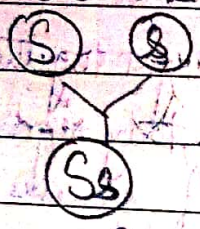
Law of Dominance: The Characters which appear in the F_1 is having the higher percentage in F_2. This it the **Dominant Character**

The other or alternative character which is disapearing in F_1 is also less in no. compared to dominant character in F_2 is called **Recessive Character**

* Test Cross: take a dominant plant and cross it with a recessive plant. (homozygous)

* Test Cross method:

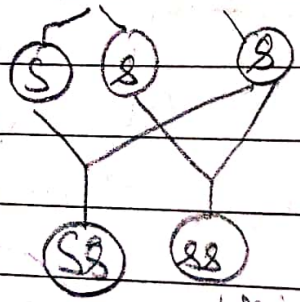
SS × ss



Spherical

If genotype of dominant plant is homozygous: F1 will have all dominant

Ss × ss

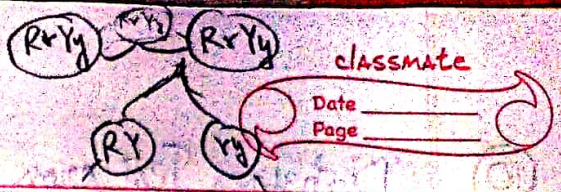


Spherical

Wrinkled

If genotype of dominant plant is heterozygous: F1 will have 1:1 dominant & recessive

* Dyhybrid Cross: Study of Characters & Its ative to check association



RRYY rr yy

	RY	Ry	rY	ry
RY	RRYY	RRYy	RrYY	RrYy
Ry	RRYy	RRyy	RrYy	Rryy
rY	RrYY	RrYy	rrYY	rrYy
ry	RrYy	Rryy	rrYy	rryy

SS YY × ssyy

SY sy

F1 SsYy × SsYy F1

SSYy SSYY SsYy SsYY Ssyy SSyy ssYy ssYy ssyy

Punnet Square

	SY	Sy	sY	sy
SY	SSYY	SSYy	SsYY	SsYy
Sy	SSYy	SSyy	SsYy	Ssyy
sY	SsYY	SsYy	ssYY	ssYy
sy	SsYy	Ssyy	ssYy	ssyy

SY Sy sY sy

P: 9:3:3:1

G:

Law of Independent Assortment: two genes are assorted independently and are not affected by each other.

In case of factors for two or more pairs of contrasting character, each pair of alleles segregates independently of each other pair of alleles during gamete formation.

(10) Dihybrid Test cross and Probability Calculation

SS × ss

S s

P=1 P=1

↓

F1 Ss × Ss

P= ½ ½ ½ ½

S s S s

F2 SS Ss ss ss

P= ½×½=¼ ½×½=¼ + ½×½=¼ ½×½=¼

½

YY Yy yY yy

¼ ½ ¼

SS = ¼ YY = ¼ SY = ¾×¾ = 9/16

Ss = ½ Yy = ½ Sy = ¾ × ½ = 3/16

ss = ¼ yy = ¼ sY = ¼×¾ = 3/16

sy = ¼×¼ = 1/16

9:3:3:1

Dihybrid Test Cross :

$SsYy \times ssyy$

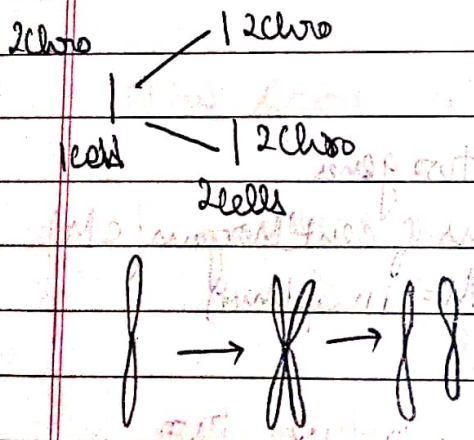
Gametes: SY, Sy, sY, sy $\times$ sy

$ssYy$: $Ssyy$: $SsYy$: $Ssyy$

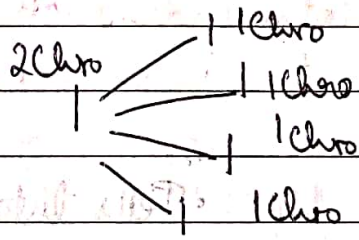
1 : 1 : 1 : 1

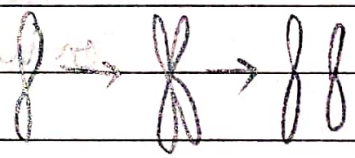
Rule:
In a monohybrid test cross if dominant plant is heterozygous, F1 will be 1:1 ratio.
In a dihybrid test cross if dominant plant is heterozygous, F1 will be 1:1:1:1

Mitosis

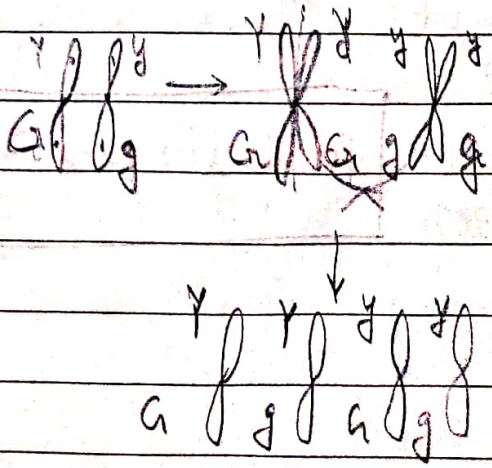


Meiosis





Crossing over



⑪ Genetic Map & X-Linked Inheritence

Morgan: modern father of genetics — Body color, Wing Size > Fruit Fly

* Reason for more no. of parental char. in F1 than recombinants: (i) Cross-over (exchange of part of chromosome in homologous chromosomes) doesn't happen at 100%
(ii) Genes present in the same chromosome

* Recombination frequency:

$$\left(\frac{\text{Recombinant Type}}{\text{Total individuals}}\right)$$

[Always represent in % when % is asked]

GENETIC - MAP: • Tells distance b/w two genes
• measured in terms of centiMorgans (cM) or map units (1 cM = 1 map unit)

* the probability of recombination between two loci (genes) increases with distance.

Map distance = (100 × recombinant frequency) cM

Eg:

TBTB tbtb 1:1
TtBb ttbb Ttbb ttBb

classmate Date Page

g: Take an Organism with gene a, b, c on one chromosome and do genetic mapping like know, at F_1 we get AaBb for 1st genetic map

Crossing

performing a test cross AaBb x aabb

result were:

parental types: 450 + 450 (AaBb; aabb)

recombinant types: 50 + 50 (Aabb; aaBb)

§

$$\text{Map distance} = \left(\frac{100}{1000} \times 100\right) \text{cM}$$

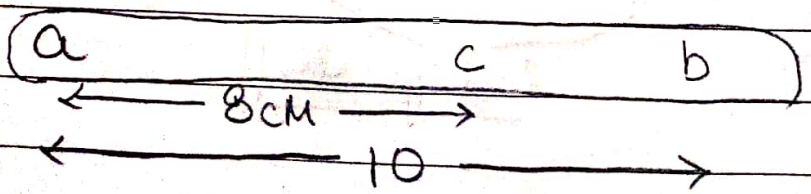
$$= 10 \text{ cM}$$

Now cross AaCc x aacc

460 AaCc, 460 aaCC, 40 Aacc, 40 aaCc

Parental Recombinant

$$\text{Map distance} = \left(\frac{80}{1000} \times 100\right) \text{cM} = 8 \text{cM}$$



For B&C,
490 BbCc, 490 bbcc
10 Bbcc, 10 bbCc
∴ Map dist = 2cM

Chromosomal theory: Chromosomes are responsible for transmission of trait from one generation to next.

23 pair — 22 autosomes, 1 allosomes

♂ XY ♀ XX

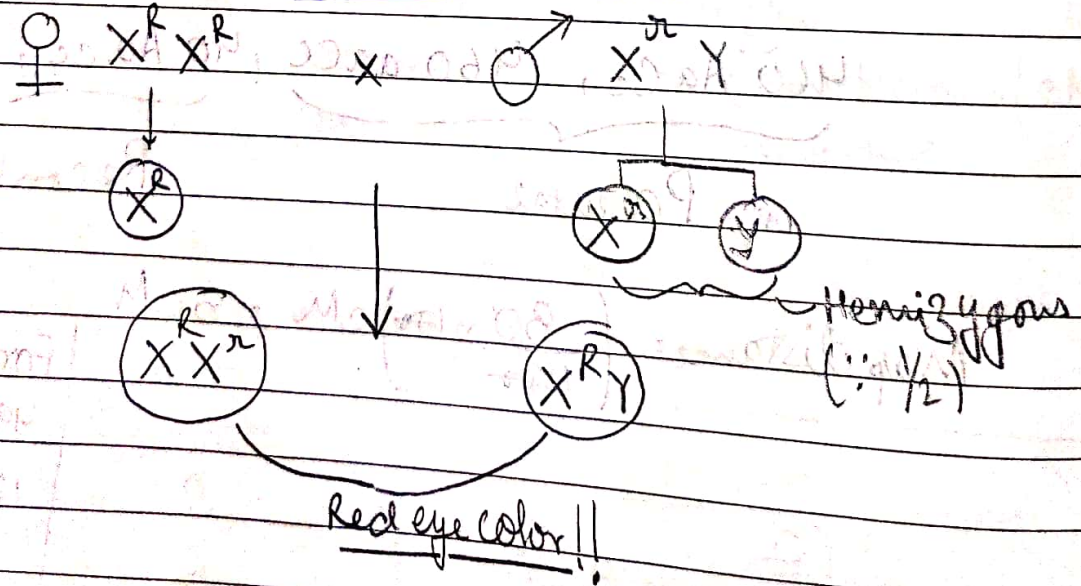
X-Linked Inheritence

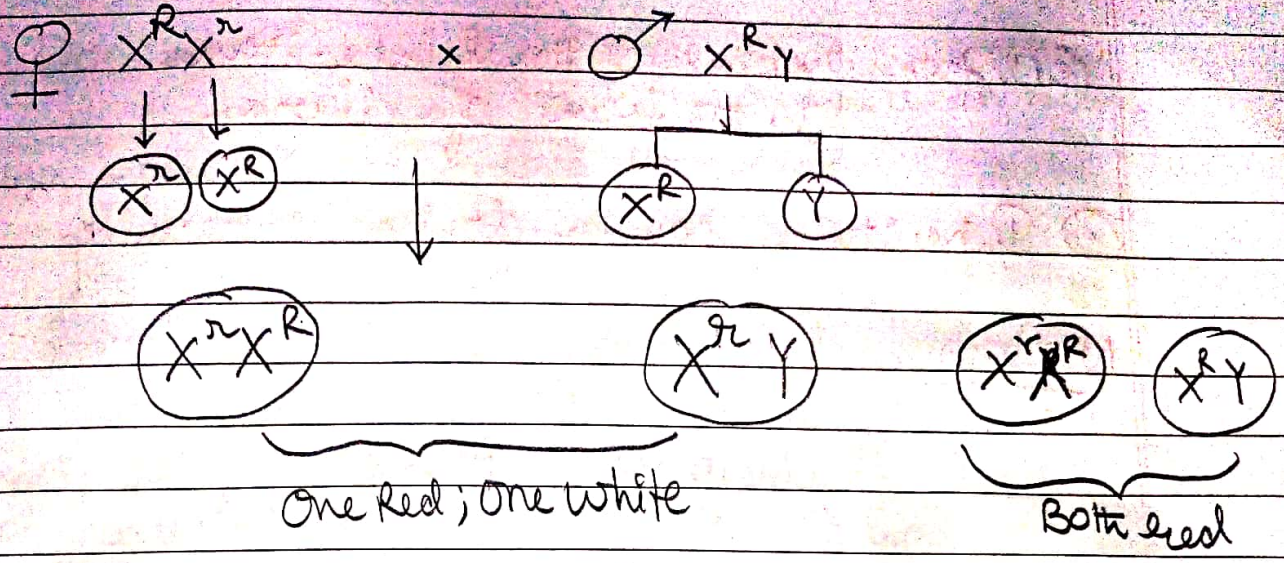
Two genes are said to be linked when they are very close to each other.

Why X- chromosome?

→ it is not in same no. in male & female.

DROSOPHILA (fly) Test





∵ dominance is expressed only because of X chromosome thus X-linked inheritence

* A gene located on either sex chromosome is sex linked gene.

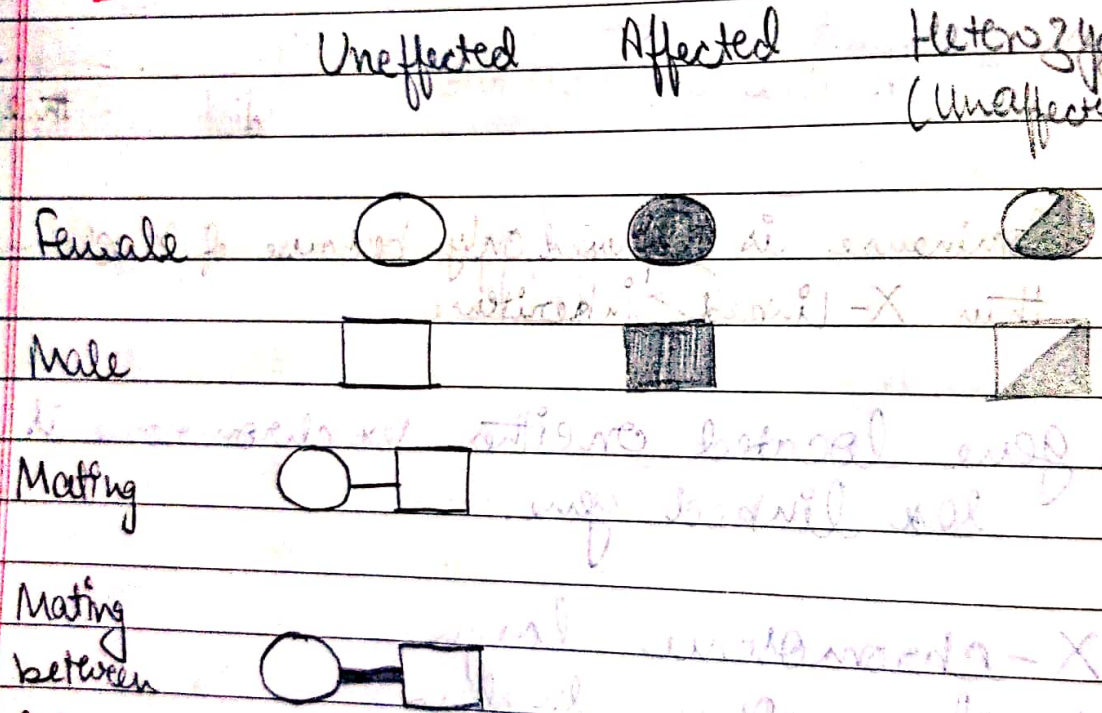
* X-chromosome larger
Y-chromosome smaller

(12) Inheritence & Pedigree

Pedigree: representation of inheritence in the form of a diagram.

⊙ Inheritance can be dominant or recessive.

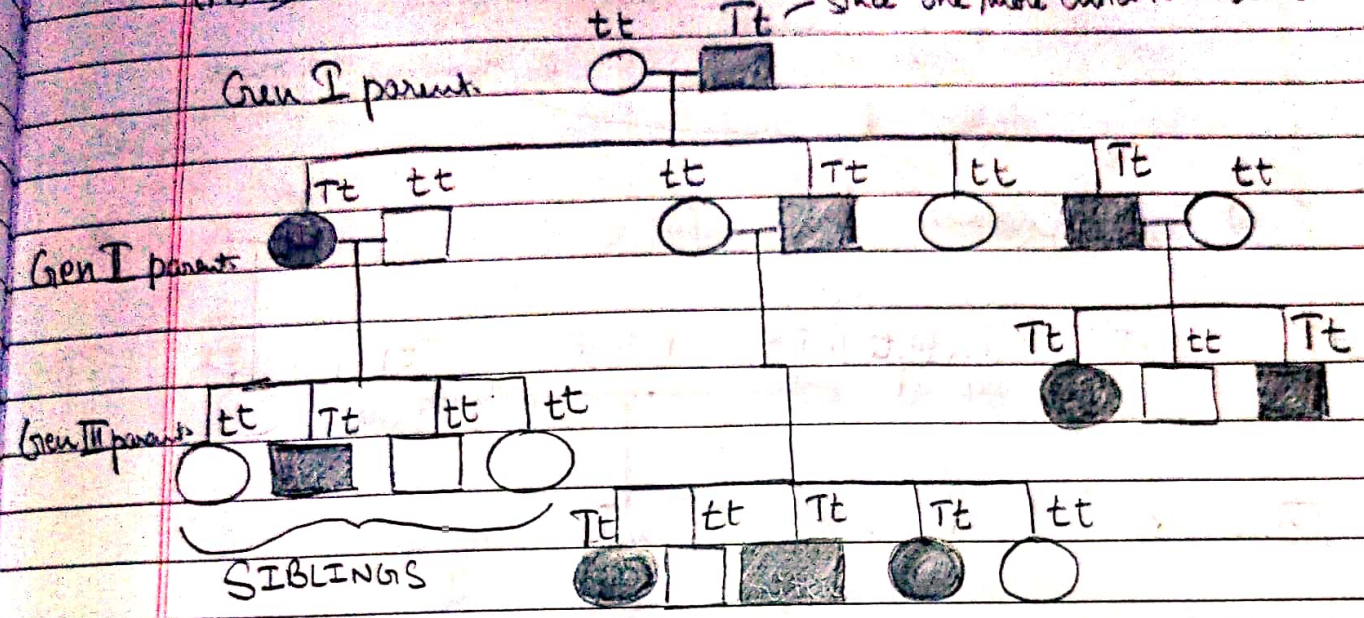
Notations:



Gen I

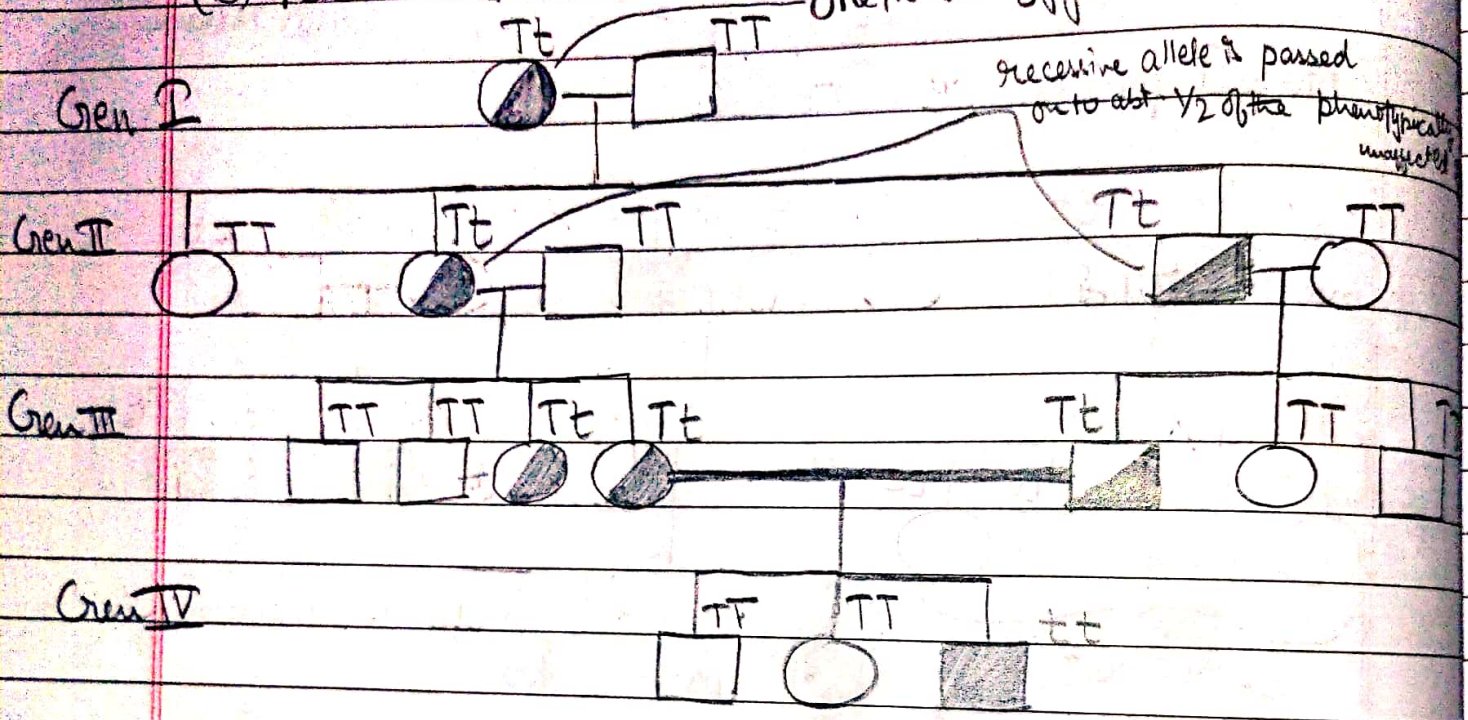
Gen II

(A) Dominant Inheritance



- The male can be homozygous dominant or heterozygous.
- If he is homozygous dominant, the probability of unaffected child is 0.
- The probability is 50% if he is heterozygous in each child birth

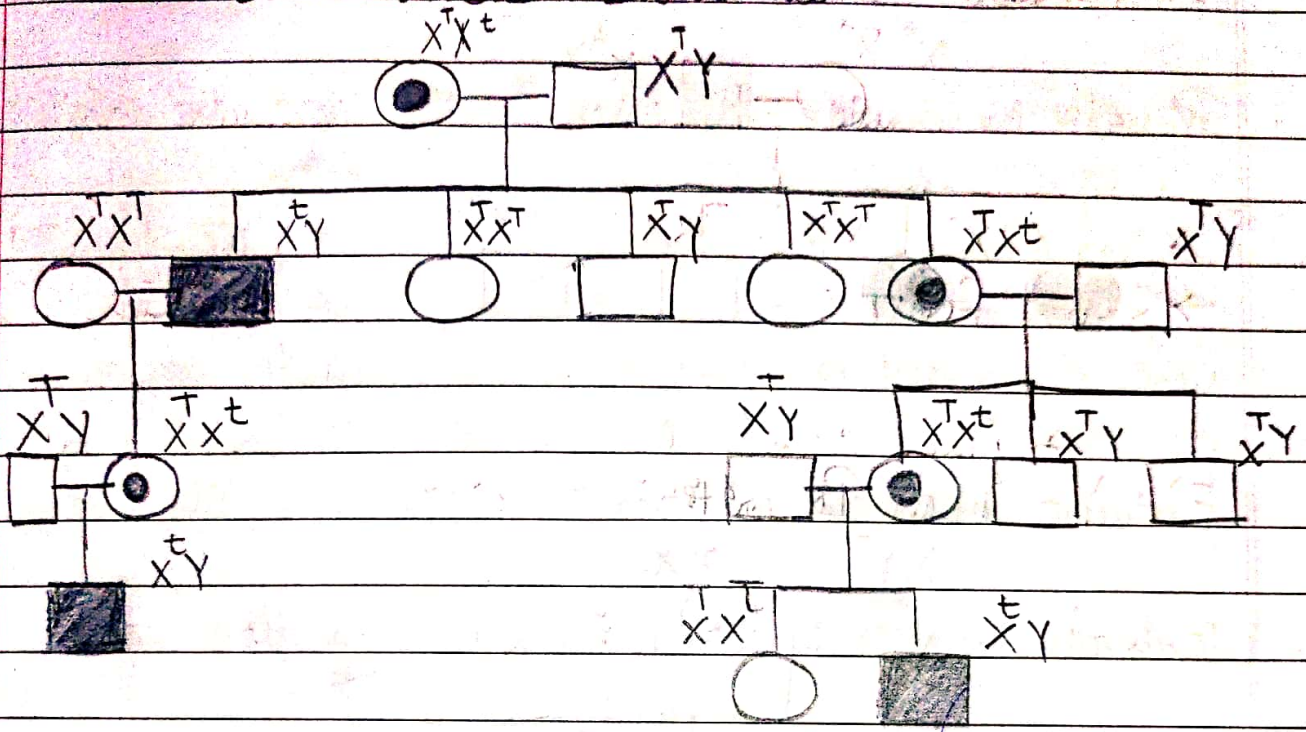
(B) Recessive Puberitence:



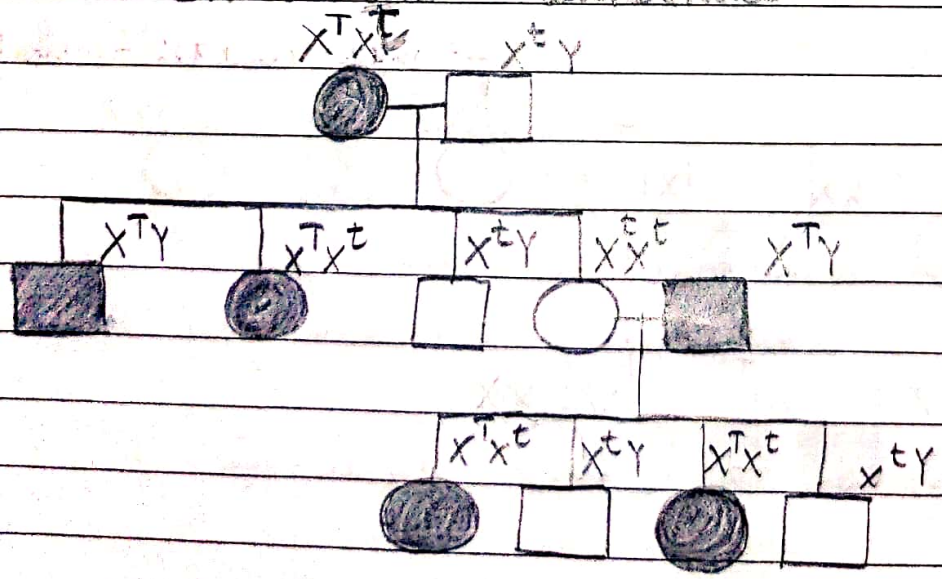
Mating of heterozygous recessive parents may produce homozygous recessive offspring

- The above types of inheritence appears on both sexes
- Hence the factor or the gene is resided on the autosomes
- An autosomal inheritance can be autosomal dominant or autosomal recessive.

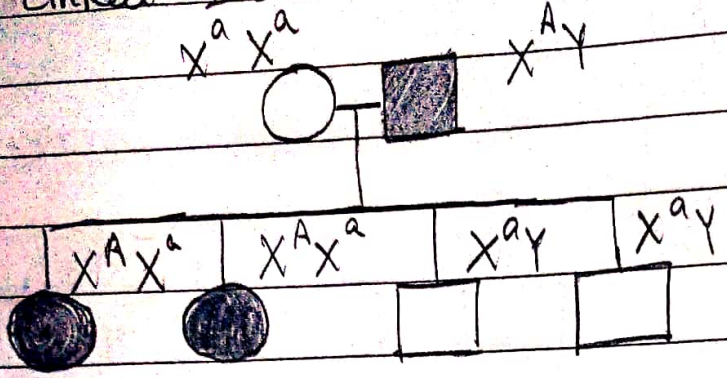
(C) X-Linked recessive Inheritance



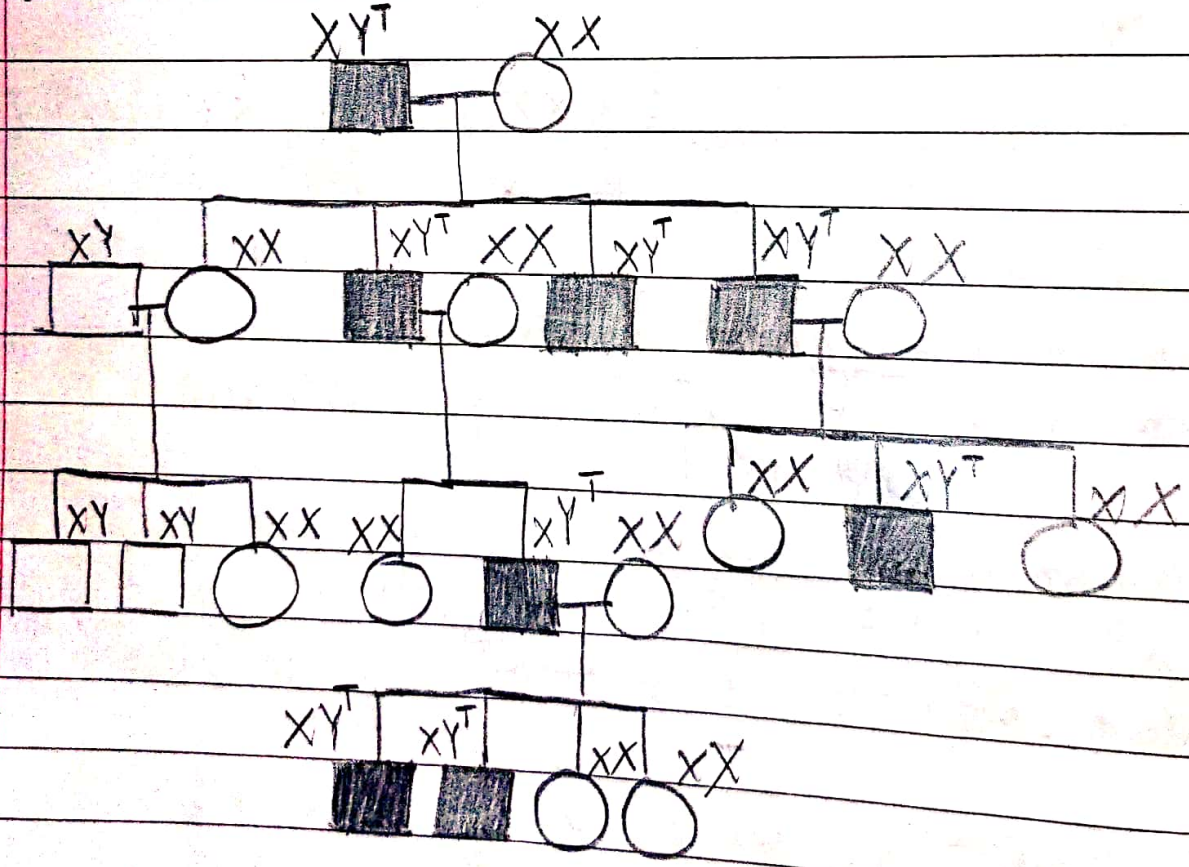
(D) X-Linked Dominant Inheritance



X-Linked Dominant Disorders



(E) Y-Linked Inheritance



Trait / Disease	Type of Inheritance
Color Blindness	X-linked recessive
Hemophilia	X-linked recessive
Huntington disease	Autosomal dominant
Sickle Cell Anaemia	Autosomal recessive
Bigue rolling	Autosomal dominant
Alport Syndrome	X-linked dominant
ADP/ATP translocase	Y-linked.

(13) DNA - Introduction.

Chromosome → Condensed Chromatin → DNA + Histone Protein

1. The Circumstantial evidence & logic to Assume DNA as a genetic material.

→ Robert Feulgen - developed a red dye which binds to DNA (Feulgen stain).

* The intensity of red color is an Approx. estimate of the DNA it contains.

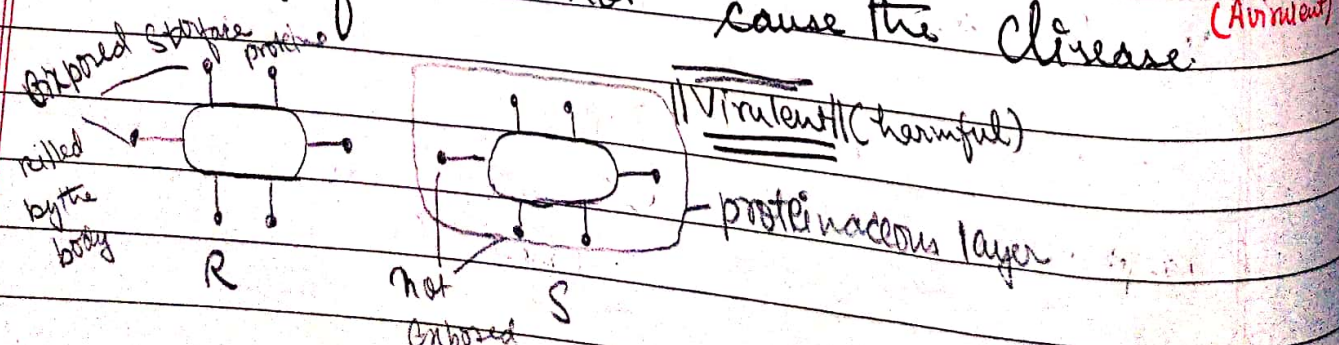
2. The Cause And Effect evidence:

→ Fredrick Griffith

* Streptococcus pneumonia - exist in two forms (strains) (S) smooth and (R) rough form

* Smooth form - hidden inside a proteinaceous cover (Virulent form) - cause the disease

* Rough form - do not cause the disease. (Avirulent)



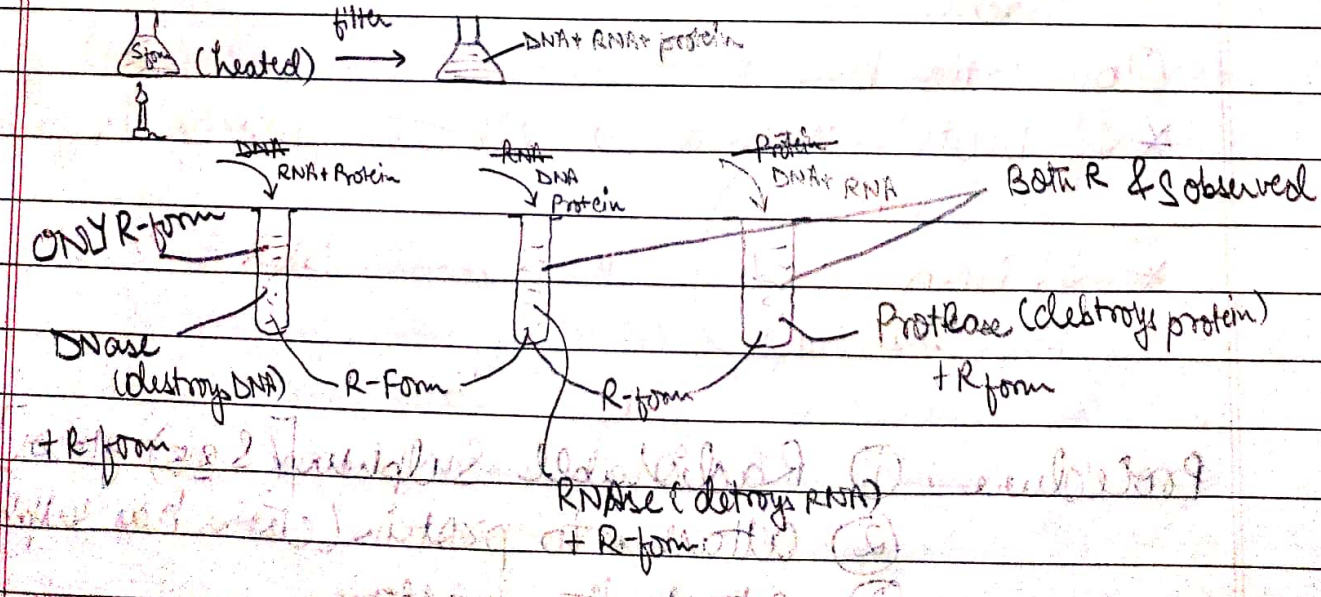
* DNA transformation experiment

Exp-1	Exp-2	Exp-3	Exp-4
Living S-form injected	Living R-form injected	Dead S-form (heated) injected	Dead S-form (heated) + Living R-form injected
Result: Died	Result: Lived (Bacteria killed)	Result: Lived (Dead Bacteria)	Result: Died (R-form transformed to S)

3. The Transforming Substance experiment:

* Oswald Avery group (~~Oswald~~, Avery, MacLeod & McCarty)

* Discovered. DNA from the "S" strain of pneumococcus was responsible for transformation.

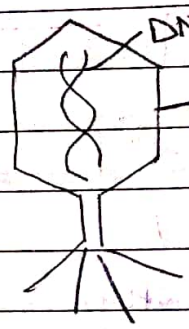


4. DNA contains genetic material

* Alfred Hershey & Martha Chase (Hershey & Chase)

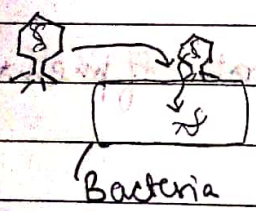
* Using a "Bacteriophage"

* "Phage": Virus
* "Bacteriophage": Virus killing bacteria



Bacteriophage

Used because it only contains DNA & protein



① Virus attaches to Bacterial Wall
② Virus released DNA into Bacteria

Observation basis:

* If protein moved to cell then protein is genetic material
* If DNA " " " " DNA " "

Procedure: ① Radiolabel Sulphur [(S 35) glows]
② attaches to protein (Cistine has sulphur)
③ attack the bacteria
④ agitated so bacteria & virus are separated

⑤ Centrifuged
⑥ Collected in test tube &

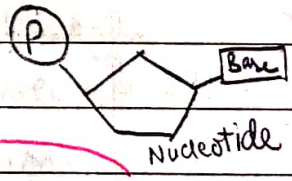
Result: ① Liquid after centrifuge (Protein capsid) showed radioactivity
② Solid after centrifuge (DNA in Bacteria) showed no activity

Similarly, radioactive phosphorous used i.e. P will be in DNA and after centrifuge solid will show radio activity

(14)

DNA - Chemical Composition and Replication.

Deoxy riboNucleic Acid



Nucleoside

Composition: 1. Nucleotide → Nitrogen + Deoxyribose + P

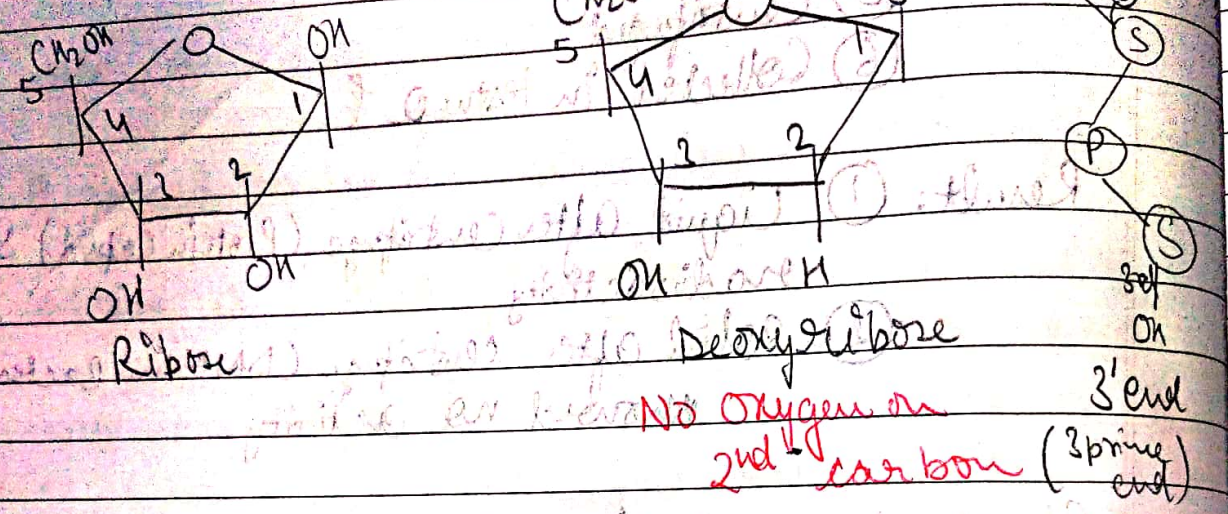
Base Sugar

Nucleotide

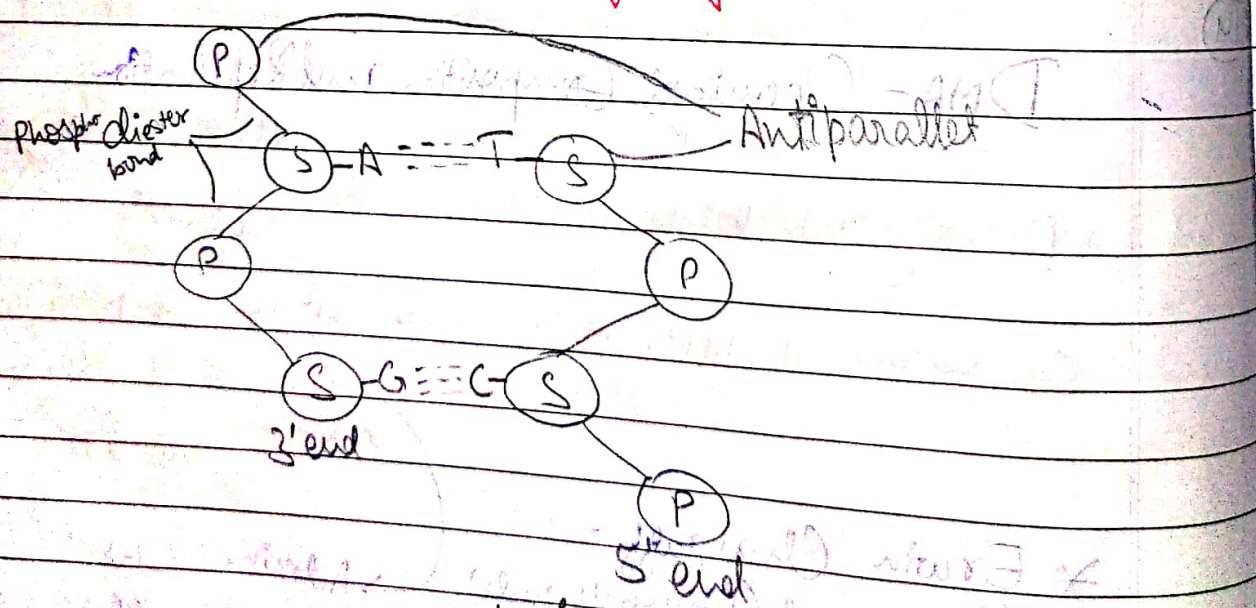
* Erwin Chargaff discovered (Chargaff rule)
A = T (amt. wise)
G = C (amt. wise)

A ═ T
G ≡ C
H-bond

→ Adenine (A)
→ Guanine (G)
→ Cytosine (C)
→ Thymine (T)



Imp points: 1. OH at 3rd carbon
2. Phosphate is attached to 5th carbon of sugar



Nitrogenous bases — pyrimidines (C, T, U) - single ⬡ ring
— purines (A, G) = ⬡ fused with ⬠

DNA Structure:

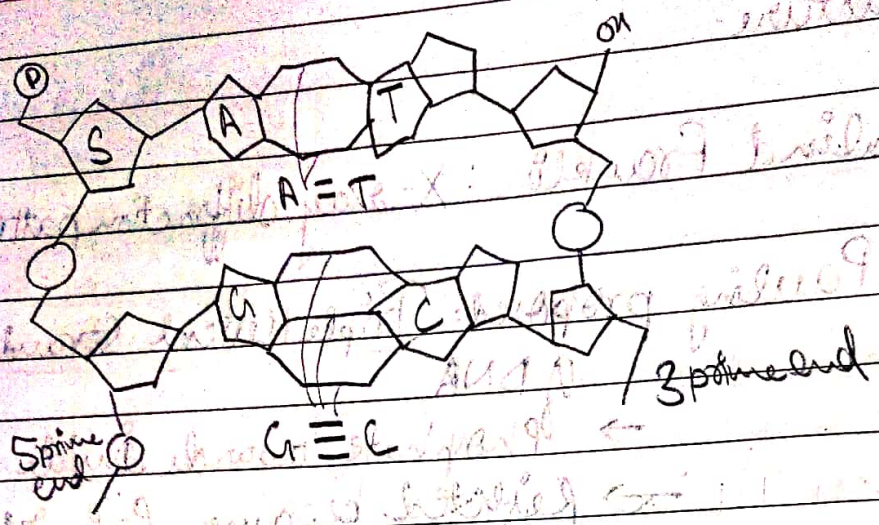
1. Rosalind Franklin: X-ray diffraction pattern

2. Linus Pauling proposed: Triple Helical Strands of DNA
   → Phosphate towards inside
   → Rejected because P-P repulsion due to -ve equal charge.

3. Watson & Crick: Anti-parallel double helical structure
   → phosphate on the inside.
   → double helix has uniform diameter.
   → Bonds b/w Phosphate and sugar is called Phospho-di-ester bond.
   → Strong due to phosphate-sugar back bone.
   → If one is 3-prime other will be 5-prime.
   → One DNA molecule includes many genes.

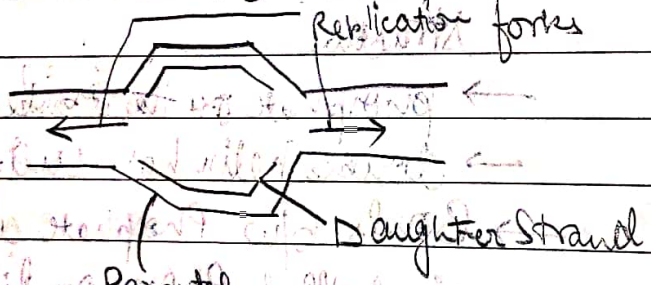
(*) 3-H bond in G-C make it strong, can come back together easily.

(15) DNA Replication



PROCESS OF REPLICATION of DNA:

1. Replication Bubble:



* A=T rich region is more prone to act as replication bubble.

2. Enzymes Involved:

1. DNA Helicase:
2. Single strand Binding Proteins
3. Primase → (RNA Primer) [Short stretch of RNA formed for giving OH to previous daughter cell terminal]
4. DNA Polymerase III (forming polymer of DNA)
   - Leading strand
   - Lagging strand
   - Okazaki Fragments

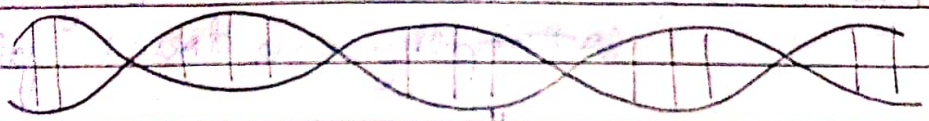
HELICASE

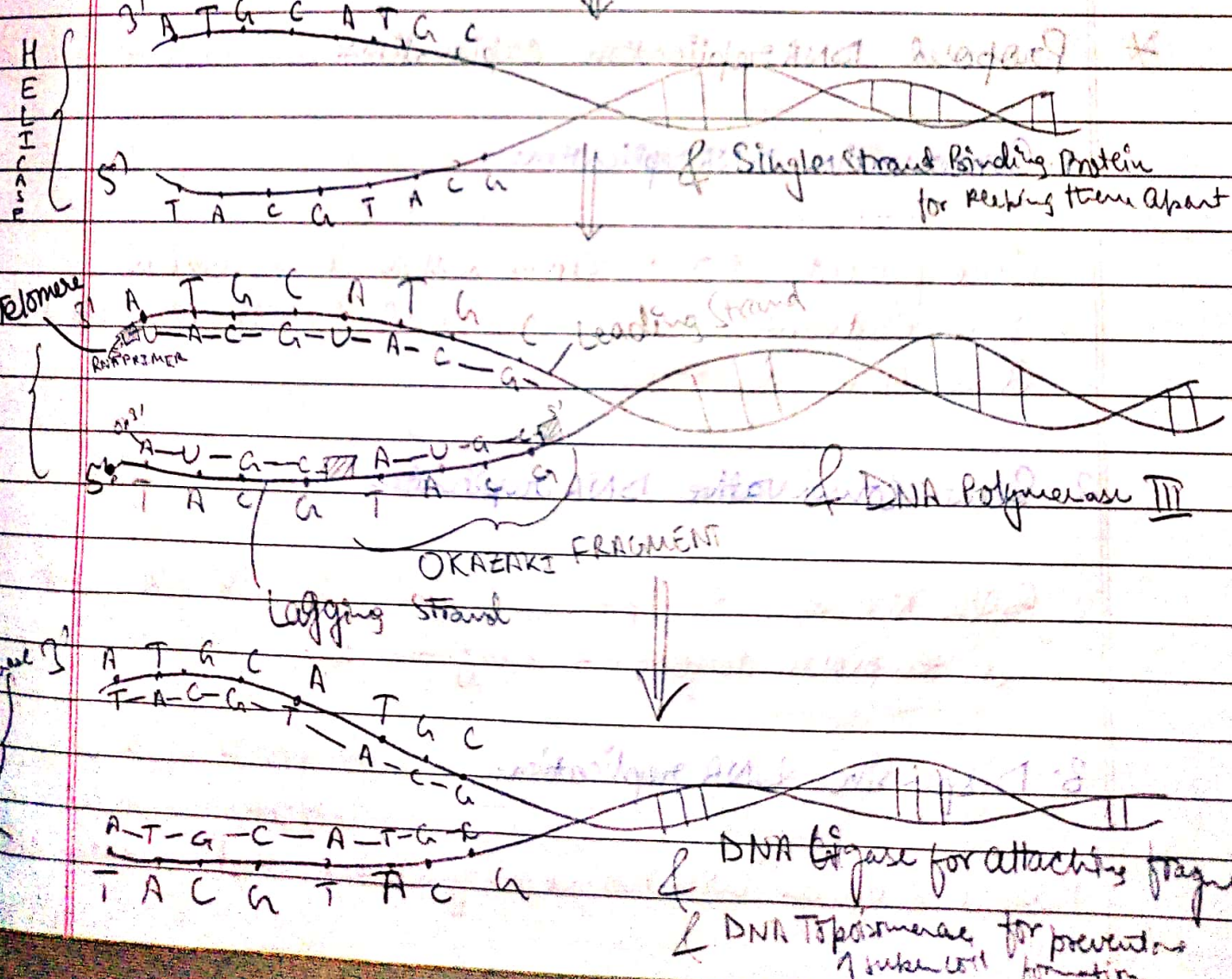
PRIMASE

DNA POLY III

5. DNA Polymerase I (Replacement of RNA primer with DNA molecule)
6. DNA Ligase (Attaches different Okazaki Fragments)
7. DNA Topoisomerase (removing supercoils formed during replication by single strand nick)
8. DNA Polymerase II (Associates & dissociates DNA strand to catalytic subunit)

Replication:





(16) DNA Replication - II

At telomere (terminals of DNA) replacing RNA primer with DNA is difficult (because of free phosphate group type of on using which new nucleotides can't come and attach). So the enzyme Telomerase synthesizes DNA at Telomere region.

Sliding DNA clamp: binds with DNA and polymerase so that polymerase doesn't fall off.

(17)

* Proposed DNA replication explanations:

1. Conservative DNA replication:

One parent strand forms 2 strands in which one daughter cell has total Parents characteristics and other was totally new.

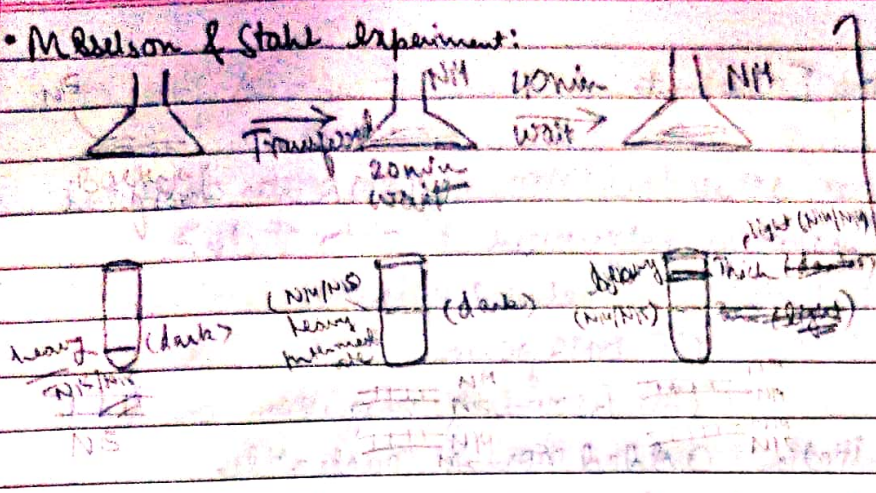
2. Semi-Conservative DNA replication:

Both strands will separate each strand will act as template to form 2 daughter cell.

3. Dispersive DNA replication:

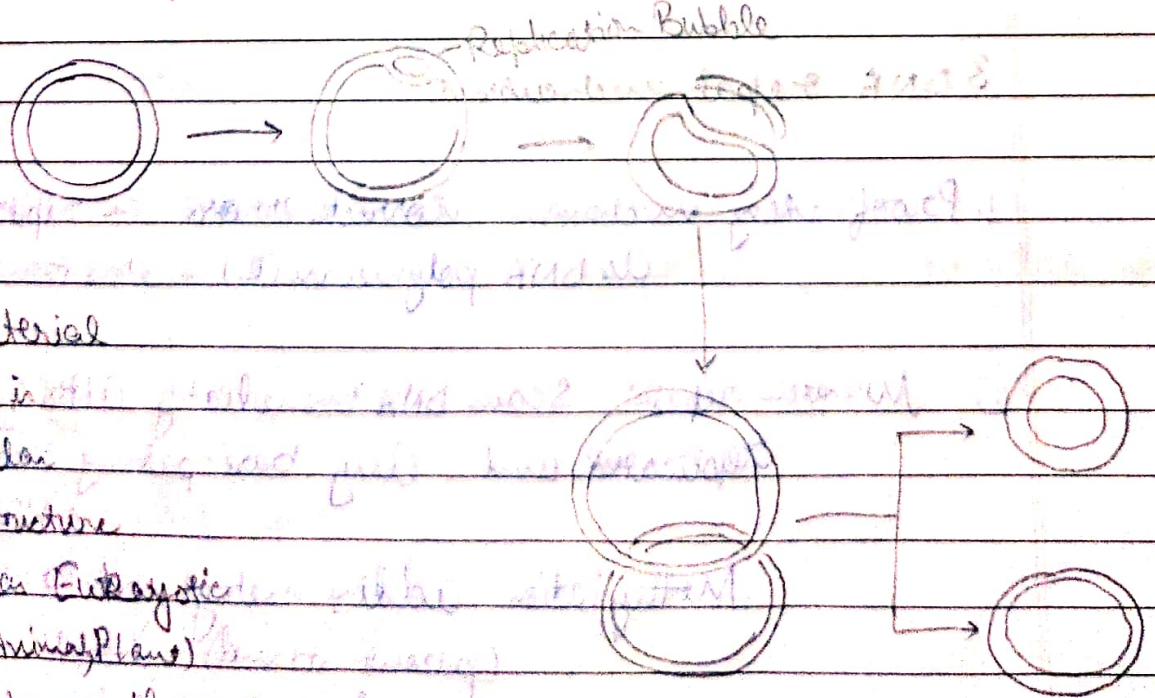
Parent strands will randomly (disperse) cleave to give daughter cell.

• Meselson & Stahl Experiment:



(17) Experiments and DNA Repair:

⊙ Bacteria requires only one origin of replication (i.e. One replication bubble).



Bacterial DNA is Circular in structure whereas Eukaryotic DNA (Animal, Plant) is straight / linear chain

→ Kornberg Experiments

- Cell free setup / in vitro DNA was developed
- DNA is always polymerized in 5' to 3' dirⁿ.
- Rkⁿ included: (i) Labelled nucleotide
  (ii) DNA primer
  (iii) A source of magnesium ion, & ATP.
- For initiation added normal nucleotide
- Added radioactive (^{32}P) nucleotide for brief period and then quickly stopped the rkⁿ
- At completion, observed that ^{32}P attached only to 3'-OH end of growing strand.

* DNA Replication - Proofreading

3 DNA repair mechanisms:

1. Proofreading mechanism: Corrects errors in replication as DNA polymerase (III) makes them.
2. Mismatch repair: Scans DNA immediately after it has been replicated and any base-pairing mismatches ~~mistakes~~.
   (Polymerase I)
   Methylation: adding methyl grp to DNA molecule (parent strand) which tells polymerase which strand to correct during repair.

3. Excision repair: this mechanism removes abnormal bases that have formed because of chemical damage and replaces them with functional bases.

- A DNA molecule is chemically modified some time after replication.
- In prokaryotes, methyl groups ($-CH_3$) are added some adenines
- In eukaryotes, cytosine bases are methylated.

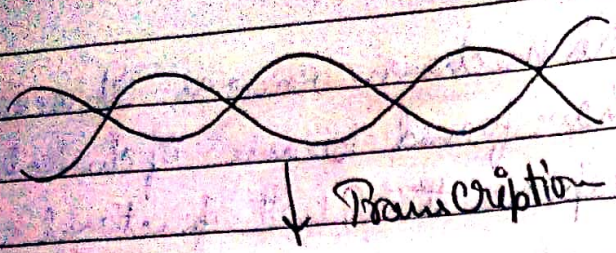
* Xeroderma pigmentosum (caused by UV radiation) - lack an excision repair mechanism. They can develop skin cancer after even a brief exposure to sunlight.

(18) Transcription:

- Life exists in reducing environment.
- First molecule that formed was protein (b/w, DNA, RNA, protein)

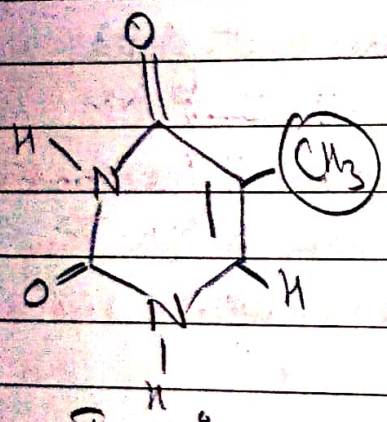
Protein → RNA → DNA

RNA: Single Stranded (prone to enzymatic degradation); Ribose Sugar; Uracil (nitrogen based exposed)

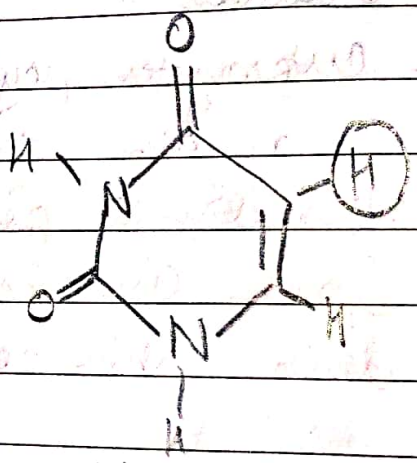


↓ Transcription

↓ Translation



Thymine



Uracil.

* DNA is in nucleus *

DNA → Pre-mRNA → m-RNA → Polypeptide

↓ Transcription

Processing

Translation

In Nucleus

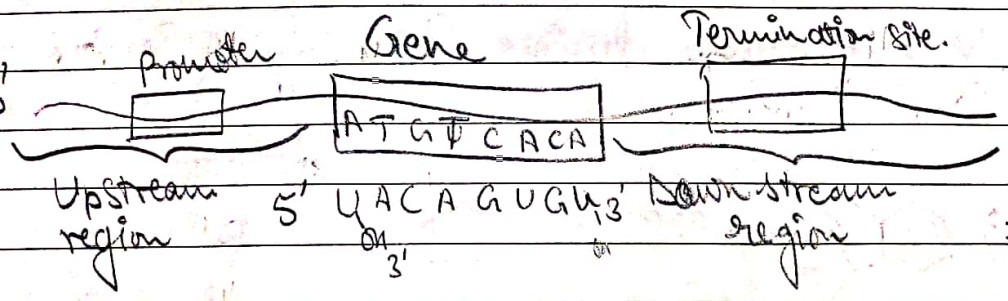
In Cytoplasm

15 — 12 — 16

Transcription: 1. Initiation
2. Elongation
3. Termination

RNA polymerase: polymerises RNA molecule by attatching RNA nucleotides.

Gene: functional part of DNA as it forms RNA



RNA polymerase for transcription requires no primer.

Promoter: Binding site & Start site / Initiation
→ Eukaryotes: One gene - one promoter
→ Prokaryotes: Many genes - one promoter (Operon) & Viruses.

Elongation: When the other pair of nucleotides are formed.

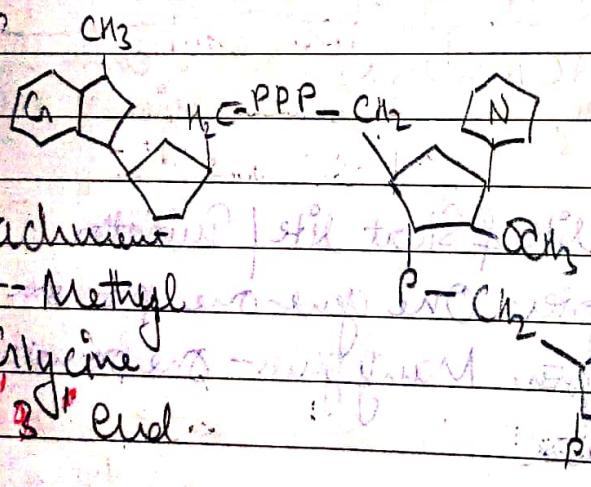
In prokaryotes Sigma protein directs RNA polymerase to promoter. (RNA polymerase + Sigma protein : holoenzyme)

In eukaryotes, transcription factor (protein) directs RNA polymerase to promoter.

Processing: 1. I modification 7-Methyle guanine attaches to 5' end. (to indicate beginning of RNA)
2. II modification at the cleavage site near 3' end, breaking happens and a poly-A-tail is attached to it.
3. III modification the non-functional part of RNA (introns) are spliced and ale exons are joined together

3 Modification during Processing of Pre-mRNA to m-RNA

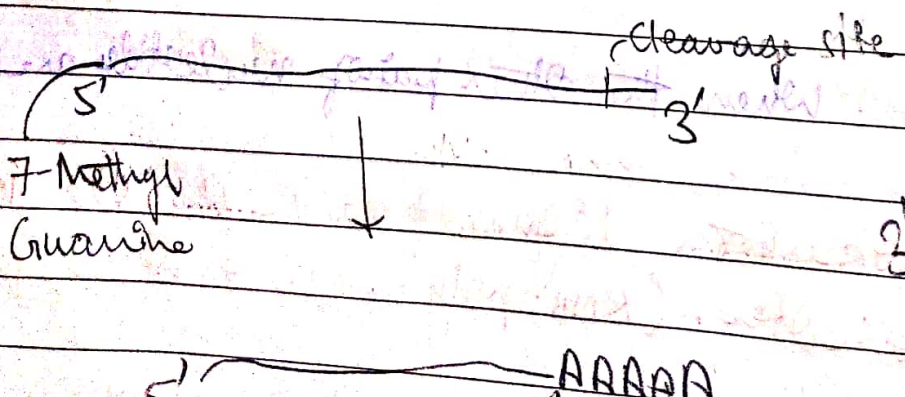
I.



attachment of 7-Methyl Glycine to 5' 3' end.

5' cap protects from degradation by nucleases

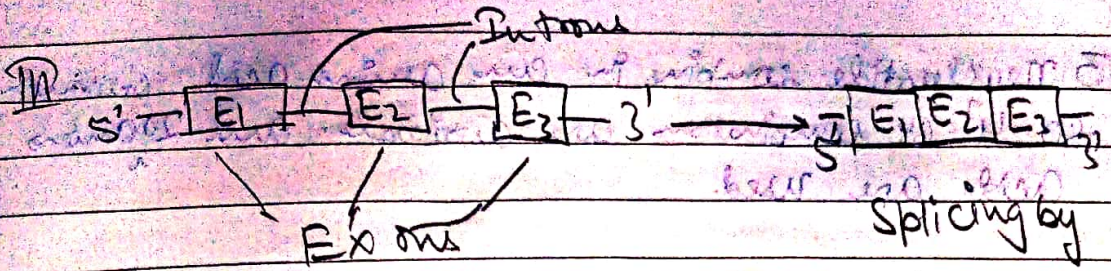
II.



3' poly A tail provides stability and prevents from nucleases

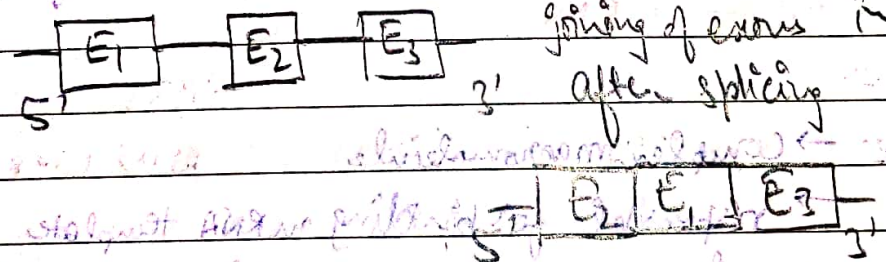
from cytoplasm

Consensus sequence : AAUAAA after 11-20 nucleotide cleavage & poly A tail added



Alternative splicing (only in Eukaryotes):

Case I:



Case II:

Same gene can form diff types of protein either by changing the sequence of exons or by joining only certain exons.

Translation

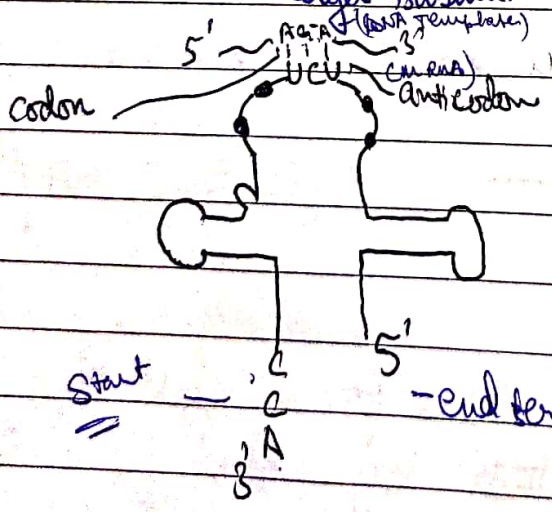
3 nucleotide combine in an amino acid combination of so $4^3 = 64$ combinations are available and 20 amino acids are used.

also: 3 nucleotide sequence: codon

* The genetic code is redundant; an amino acid may be represented by more than one codon

tRNA: acts as adapter (transfer RNA): from nucleus to cytoplasm
rRNA: ribosomal RNA

Ribosome: → Complex macromolecule
→ responsible for binding mRNA template
→ larger subunit sequentially binds to tRNA



Start Codon: Methionine
Stop Codon: UAA, UAG, UGA

Left: NH_2 Right: COOH

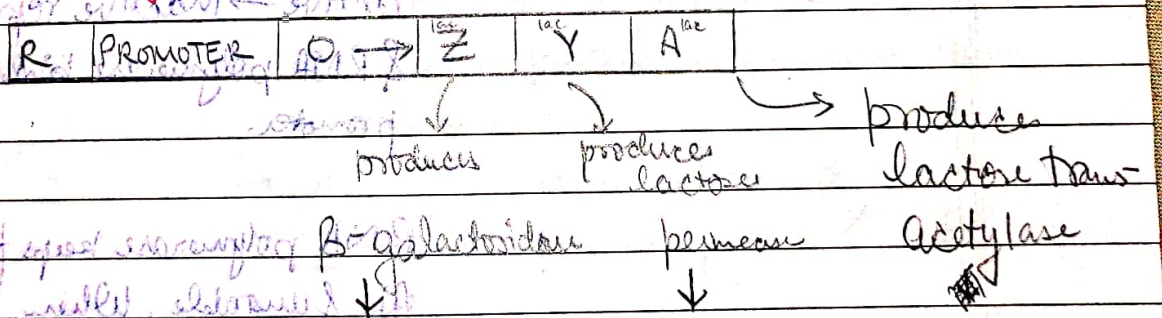
(20) LAC Operon:

Operon: series of genes with single promoter (transcribed at same time)
Only prokaryotes.

Lactose → Glucose + Galactose

Bacteria requires Glucose; when Glucose not avail use Lactose
When both present Bacteria utilizes Glucose.

Operon → promoter, operator, regulator



⊙ When glucose is present & lactose is absent E. coli does not produce β-galactosidase

⊙ When glucose is present & lactose is present E. coli does not produce β-galactosidase.

① When both are absent E. coli doesn't produce β-galactosidase
① When glucose is absent factor to present E. coli " " "

Glucose	Lactose	Consequence
1) ✓	✓	production of active repressor which binds to operator, RNA polymerase doesn't bind to promoter.
2)		
2) X	✓	Lactose converted to allolactose, converts active → inactive repressor & RNA polymerase bind to promoter.
3) X	X	RNA polymerase keeps falling off & unstable. When ~~lactose absent~~ glucose is absent (activator protein forms & works to keep RNA polymerase stable.

(21)

EVOLUTION

Evolution: Change over a period of time; it is a process by which modern organisms have descended from ancient organisms.

MAJOR THEORIES FOR EVOLUTION:

1) Special creation: → supported by most religion, civilizations
→ created by a supernatural power at particular time
→ no intellectual conflict b/w scientific & theological theories

2) Spontaneous Creation: → life arose from non-living matter.
→ life did not arise from pre-existing parent but also from spontaneous generation due to natural forces.
→ fell when science advanced.
→ finally disapproved.

3) Cosmozoan: → does not suggest a mechanism for origin of life.
→ idea that life has extraterrestrial origin.

4) Biochemical evolution: → life arose as per chemical & physical laws
→ accumulation of simple compounds in the ocean resulted in the production of primeval soup.
→ Miller's experiment led to discovery of 15 amino acids, organic acid, ribose sugar & purine, adenine.

Lamarck's Theory of Evolution:

Based on inheritence of acquired characteristics of offspring that adapt further, advance evolution of species.

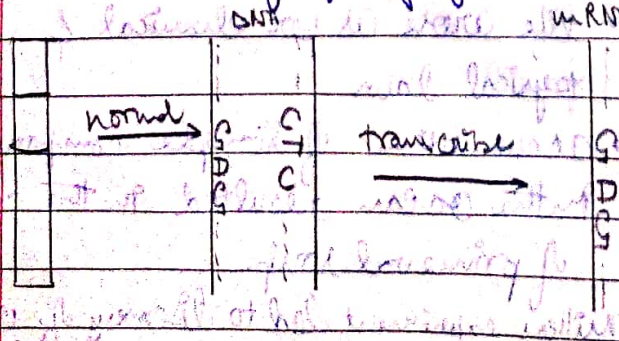
DISCREDITED: Use or disuse of all the abilities does not cause transfer of ability to next generation (healthy parents need not have healthy children)

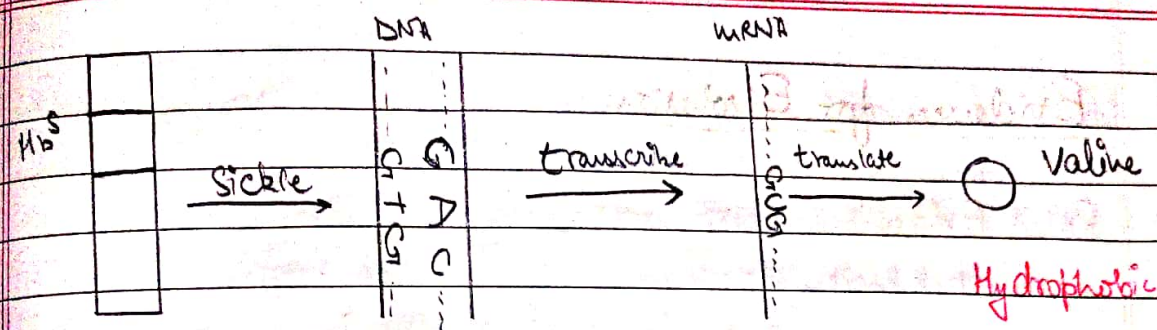
Theory of Natural Selection:

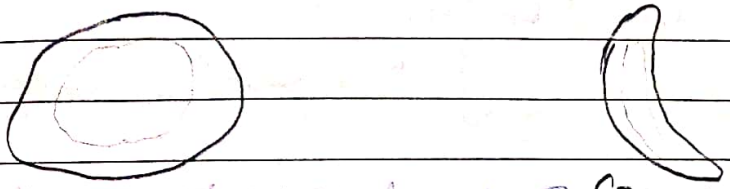
"WHEN THERE ARE DIFFERENCES IN ORGANISMS ABILITIES TO SURVIVE AND REPRODUCE BASED UPON INHERITABLE TRAITS NATURAL SELECTION TAKES PLACE."

Observed cases of natural selection:

→ Insects resistant to insecticides
→ Bacterial resistance to antibiotics
→ Increased frequency of Sickle cell anaemia in Africans







Normal Hemoglobin SICKLE CELL Hemoglobin

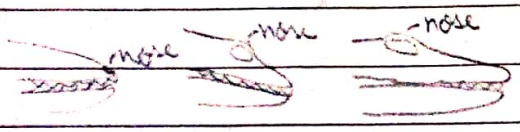
Sickle Cell is resistive to malaria: Early stage of malaria pathogen requires oxygen to complete its life cycle. Since heterozygous RBCs have low O_2 carrying capacity, so the pathogen cannot survive.

Loophole in Darwin's Theory: Could not explain the inheritence of traits from one generation to next.

Existence of vestigial organs could not be explained using natural selection. Over specilization of some structures like Antlers, tusks of elephants becomes hinderance. This fact that these structures that were hinderance to the organism being inherited could not be explained.

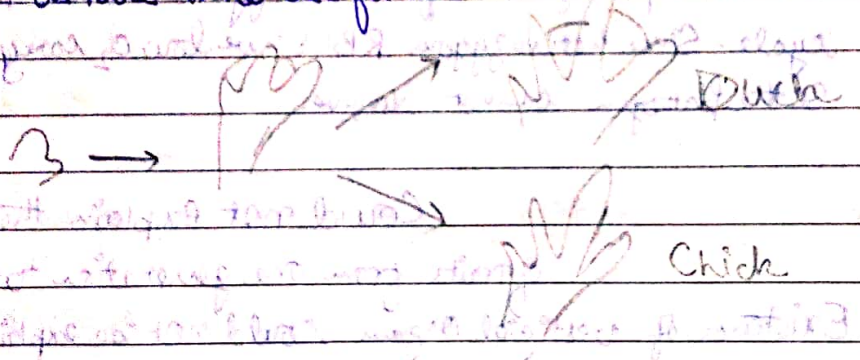
Evidences for Evolution:

1) Fossil Evidence:



Change in posⁿ of nose in Whale Family.

2) Embryonic Evidence: Duck and chick both embryo's have presence of webbed feet. Later stages in chick embryo causes death of layer in the interdigital zone as there is no use for it.



3) Hemoglobin & Chlorophyll: Both of them are porphyrin ring but the central atom is Fe in hemoglobin but Mg in chlorophyll.

Existence of hemocyanin: As in Centre..

4) Form & function evidence: function of a certain part of body is due to certain shape. Vestigial organs are remains of a structure that was functional in some ancestor but is no longer functional in the organism in question.

✱ The Mechanism Responsible for Evolution are:

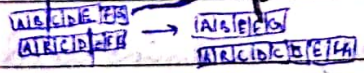
1) Mutation: Most rare in occurence of errors are during DNA replication. But these lead to severe changes because these are heritable. Mutations are heritable changes in genetic information which may spontaneously occur or may be induced.

→ point mutation: Change in certain nucleotide (gain, loss, substitution) [one nucleotide]

→ chromosomal mutation: more extensive than point mutations.

4 types: 1. deletions
2. duplications
3. inversions
4. Translocations: non homologous chromosomes exchange segment.

[Segment of DNA duplicated or lost]



Effects: ① Scope for evolution.
② germ line and somatic mutation can be harmful.

2) Gene flow may change allele frequency: frequency of appearance of allele. Also depends on the migration of individuals & movements of gametes b/w population. Which is called gene flow.

3) Genetic drift: In small population, random change in allele freq. from one generation to the next may produce large change in allele frequency over time. This is called genetic drift.

4) Non-random mating can change genotype freq.: mating patterns may alter genotype frequencies if individuals in a population do not choose mates at random.

Constraints in Evolution:

→ Development process constraints evolution.
→ Trade-offs constraints evolution
→ Short term & long term evolutionary outcomes sometimes differ.

* Silent mutation: no change in amino acid sequence even with change in nucleotide.
* Missense mutation: new amino acid introduced on change in nucleotide.
* Nonsense mutation: introduces a stop codon and so no protein made.
* Frame-shift mutation: nucleotide inserted so as to change all the following amino acid sequence.

(22) Virus Replication Strategy.

- Simplest form of life which exist on borderline b/w living & inanimate world.
- They are DNA/RNA in a coating called 'Capsid'.
- They are Obligate parasites, i.e, they can only replicate after they have invaded & parasitized host cell.

Difference b/w Virus & Other beings:

→ produced from the assembly of preformed components, whereas others grow from increase in components & reproduce by division.

→ does not grow / undergo division.

→ lacks genetic info. that encodes apparatus necessary for generation of metabolic energy / protein synthesis

Life Cycle Of Virus:

(1) Attachment to host → (2) Taking in virus, Endocytosis.

↓

(3) Viral envelope fuse with endosomal membrane releasing nucleo-capsids

↓

(4) Nucleic acid of virus covered by capsid protein.

→ ⑤ Viral nucleic acid enters Cytoplasm

↓

⑥ Viral nucleic acid serves as template for new viral nucleic acid

↓

⑦ Nucleocapsid enters the nucleus & begins morphogenesis.

↓

⑧ Envelope proteins pass through the ER & golgi body.

↓

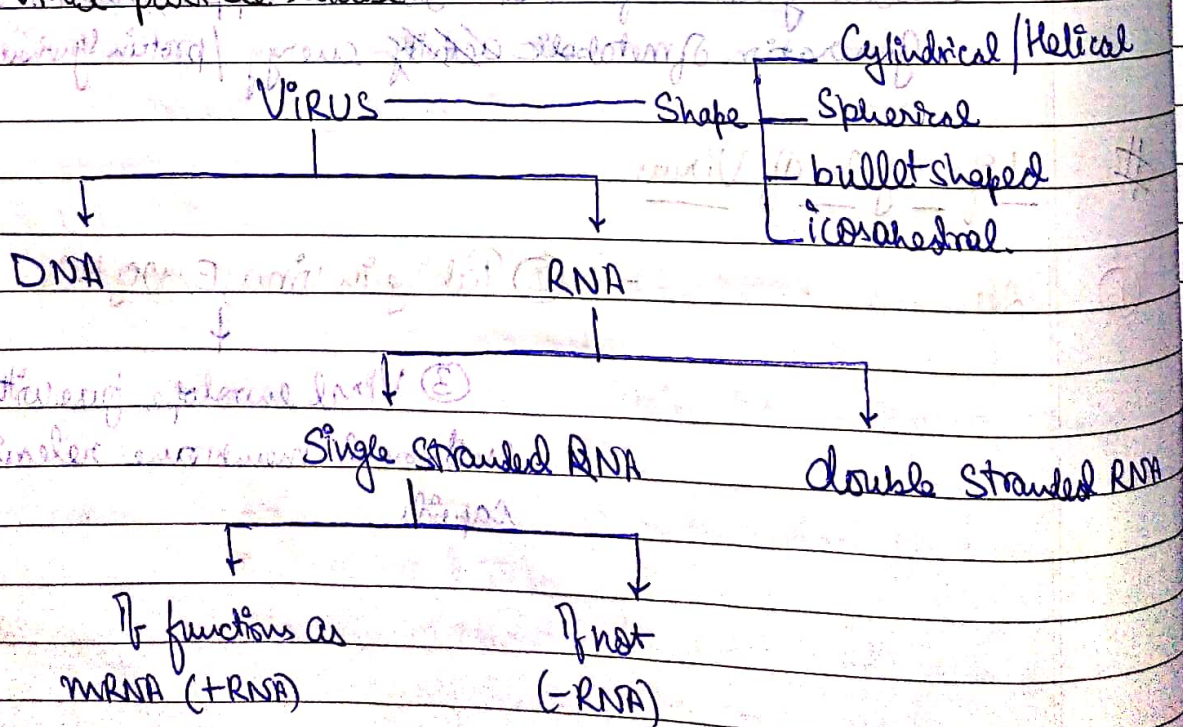
⑨ Nucleocapsid moves to membrane

↓

⑩ Budding process

↓

⑪ Viral particle release.



REPLICATION STRATEGIES:

1) +SSRNA Virus genome replication:

they are directly translated (eg- picornavirus & togavirus); RNA polymerase is produced early stage & catalyzes the transcription of intermediate complementary -RNA. -RNA serves as template for +RNA

2) RT directed +SS RNA Virus genome replication: Retrovirus Are +RNA group of viruses that synthesizes new +RNA using DNA template, Reverse transcriptase sequentially synthesizes a DNA strand complementary to the first & resulting in dsDNA which further creates +SSRNA using dsDNA as template.

3) -SS RNA Virus genome replication: -RNA can not be translated, it serves a mRNA for replication of + SS RNA, viral protein helps in synthesis of full length +RNA which serves as template for creation of -RNA genome strand.

4) dsRNA virus: (Eg. reovirus) produce copies of +RNA, which further produce -RNA complimentary strand.

5) dsDNA: follows basic life cycle of virus.

(23) Vaccines

Historical Evidences:

1. Chinese & Turks in 15th Century to prevent small pox by inserting dried pustules into cuts
2. Lady Mary Wortley Montagu performed same techniques to her own children
3. Edward Jenner inoculated an 8 yr old with fluid of cow pox pustule. It prevented small pox but was unethical approach.
4. Louis Pasteur succeded in growing bacterium which causes fowl cholera. In 1885 he injected a boy with weakened rabies virus and boy got cured.

Vaccine: biological preparation that improves immunity to a particular disease.

Working: Weakened disease causing germ (~~virus~~ microorganism) is inserted
↓
Immune system recognise it as foreign substance, destroy it and keeps record of it
↓
If ever happens / encountered later can be destroyed again.

* Antigen: from outside
* Antibody: present inside

Immunization: process of eliciting a long-lived state of protective immunity against a disease causing pathogen.

Doubt: "Vaccination does not ensure immunity, and a state of immune protection can be achieved by vaccination"

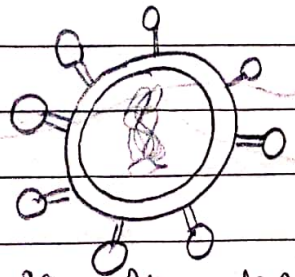
Vaccination: exposure to live pathogen followed by recovery.

A state of immunity can be induced by:

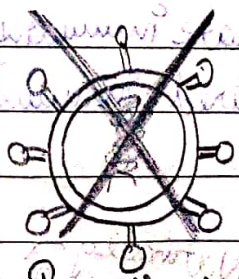
active immunization
→ natural infection (or vaccination)
→ long-term immunity.

passive immunization
→ transfer of preformed antibodies
→ short-term.

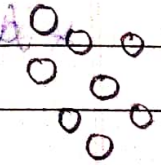
Types of vaccine:



Live Attenuated Vaccine

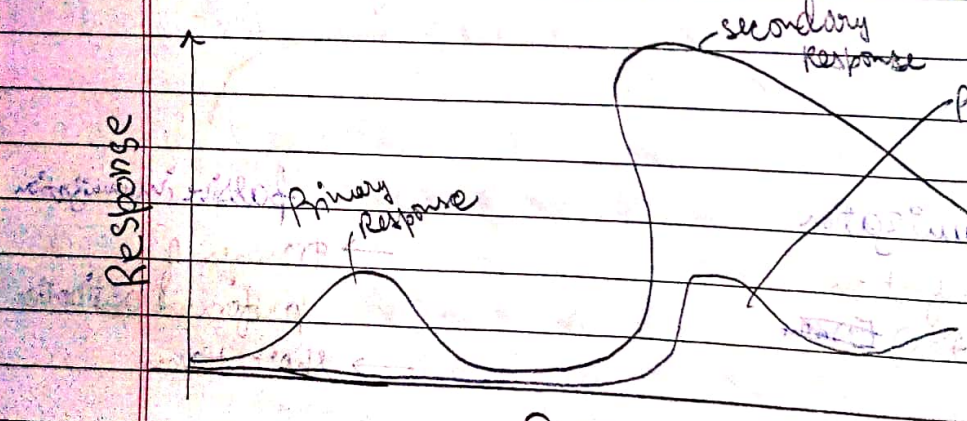


Inactivated Vaccine



Subunit vaccine

Live Attenuated	Inactivated	Subunits
→ both humoral & cell mediated immunity	→ killed using chemical, heat, radiation	→ used when toxic effect are due to discrete protein product.
→ most effective immunity	→ stable & safer	→ Polysaccharides & other less immunogenic vaccines may be conjugated to more immunogenic proteins to maximize immune response
→ risk of reversion	→ no reversion	
	→ don't require refrigeration	
	→ easily accessible & transported.	



* Innate immunity
* Aquired immunity

- Naturally
  - Active — Infection contact
  - Passive — Antibodies passed by mother to foetus, milk
- Artificially
  - Active — Vaccine
  - Passive — Injection of immune ser

Influenza: 1) producing a series of spontaneous point mutations that occur gradually, minor change in HA & NA
2) (H0N1, H1N1 etc.) producing subtype of HA & NA also.

HA: Hemagglutinin
NA: neuraminidase

* Vaccine cannot be designed for such an organism that can only raise innate response.

(24) Ascent of Sap.

Root map of WATER TRANSPORT in plants

Root Hair → Cortex cells → Xylem vessels of root → Xylem vessels of stem → Xylem vessels of leaf → Stomata (Transpiration)

Water absorption:
Root hair - like epidermal cell is responsible for water absorption.
This adaptation is to increase absorption area.
The root hair architecture is to maintain contact with the soil by bending into soil and penetrating into the crevices.
Functions of root: (i) To absorb water & mineral ions
(ii) To support the plant.

* Cell wall is hydrophylic
* water reaches cell sap through osmosis
* It travels to xylem cell by osmosis
* It enters xylem cells by transpiration pull.
* Water need to move radially to reach xylem.
  - Apoplastic (through non-living cell wall)
  - Symplastic (through living part i.e. cytoplasm)
  - transcellular (crosses cell)

Xylem advantages: (i) continuous system
(ii) Chilling does not stop water movement
(iii) It can transport toxic substances too.

Motive forces of Water movement:

[a] Capillary Force: [b] Transpirational pull [c] Root pressure

* IN PLANTS ALL CELLS ARE NOT LIVING. It is a system or combination of both dead & living cells emerged as an efficient mechanism of water transport

* Mechanisms Enhancing efficiency of water absorption:

1) Mycorhizae: symbiotic relationship b/w root cells and fungus. fungal filament are more fine and to reach areas where root hair cannot. In return plant provides food & shelter.

2) Velamen tissue: Velamen tissue is like dead xylem, it directly absorbs moisture from atmosphere by imbibition.

3) Water absorption in hydrophytes: roots in these plants are just for anchorage. Xylem is poorly developed, water absorption takes place all over the body. Stomata is inactive.

* Mechanism of phloem transport:

Phloem unlike xylem is living tissue, it has cross walls and sap transport is possible in both directions.

Phloem sap can be transported in any direction needed aslong as there is a source of sugar and a sink able to use.

The accepted mechanism needed for the translocation of sugars from source to sink is called PRESSURE FLOW HYPOTHESIS.

Q. Can xylem and phloem get blocked? Whether air bubbles are formed there?

→ Xylem & phloem can be blocked with secondary metabolites such as phenolics. Blockage are also possible with viral particles or phytoplasma.
If air bubbles are formed water fails to move.