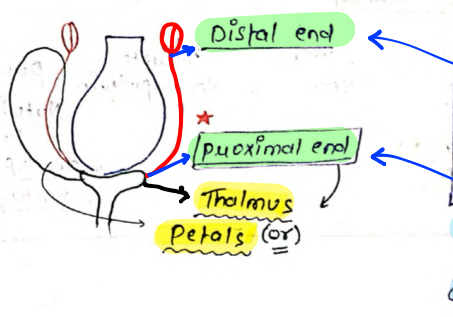
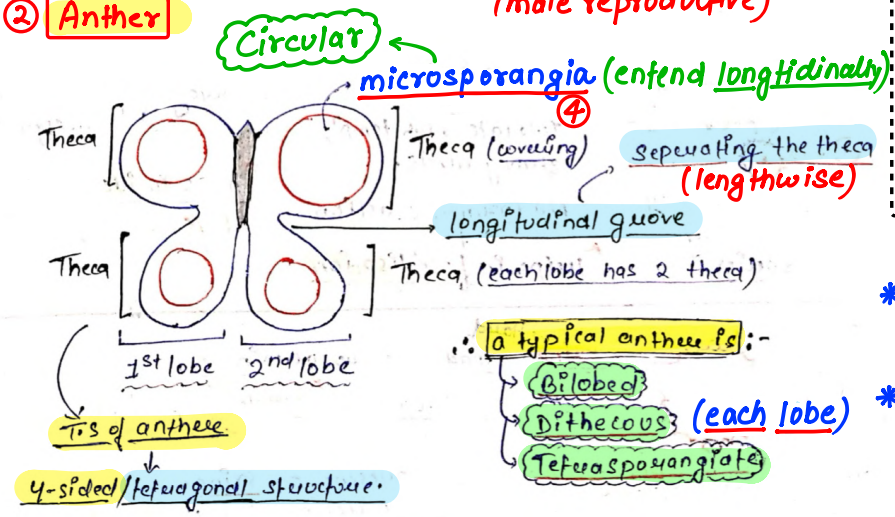
SEXUAL REPRODUCTION IN FLOWERING PLANTS

① Stamen



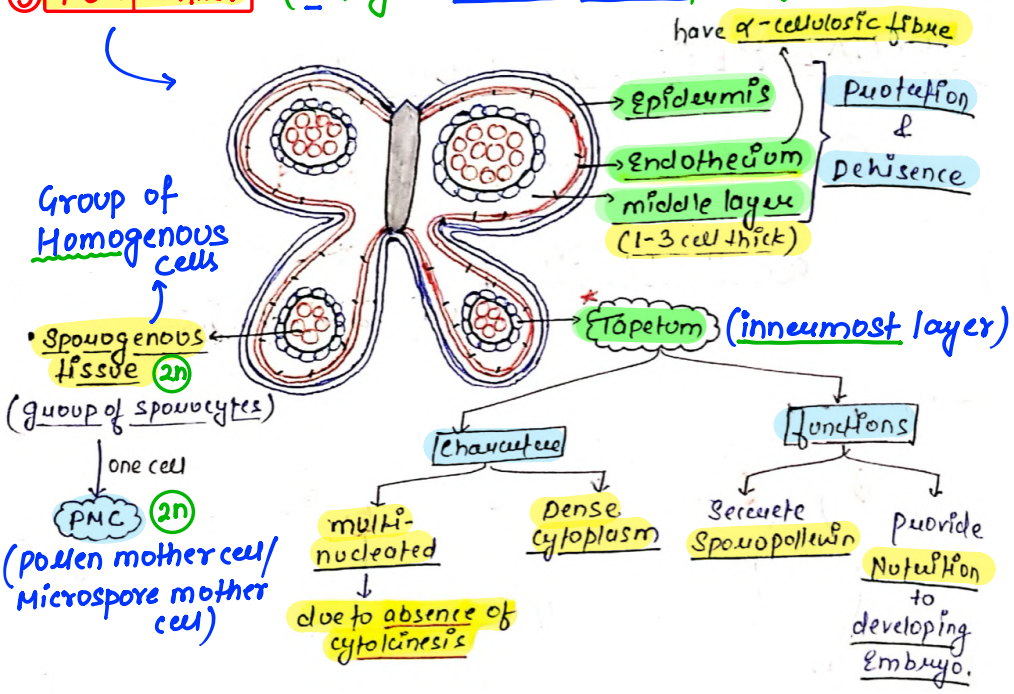
* Flowers are object of aesthetic, ornamental, social, religious & cultural value.
* Flowers are morphological & embryological marvels & site of sexual Reproduction
* several hormonal & structural changes initiated → which lead to differentiation & further development of floral primordium

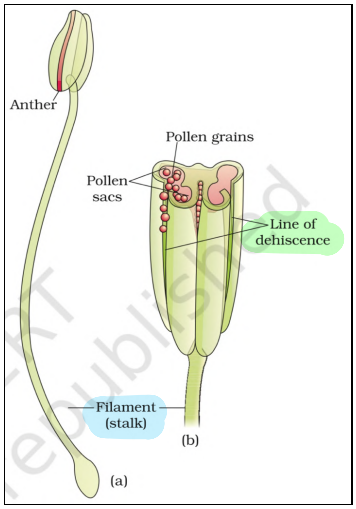
② Anther

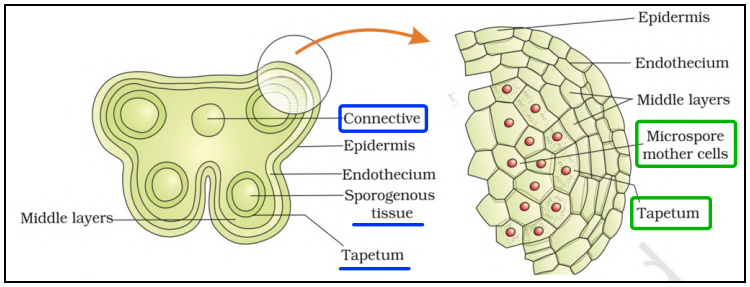


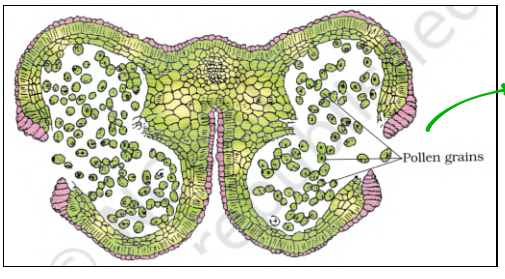
* Number & length of stamens are variable in flowers of diff species
* microsporangia → pollen sac (pollen grain)

③ T.S of anther (4-layers around microsporangia)



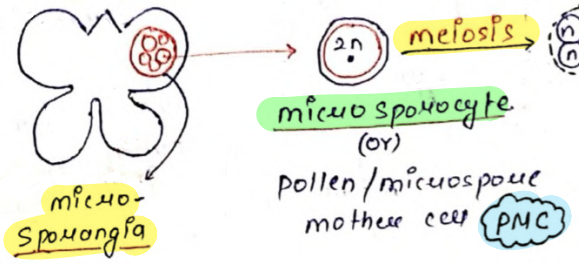






dehiscence of anther

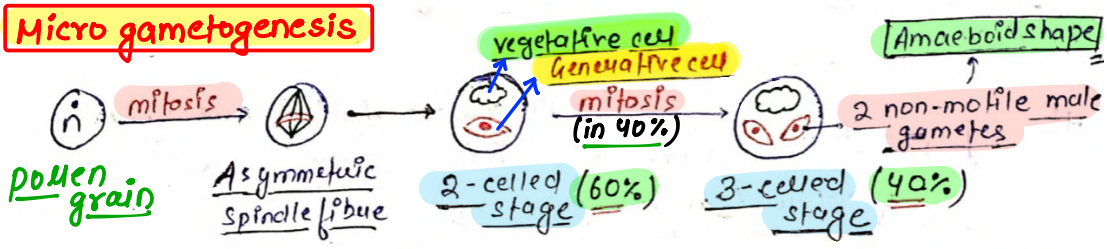
④ Micro sporogenesis (PMC meiosis → microspore)

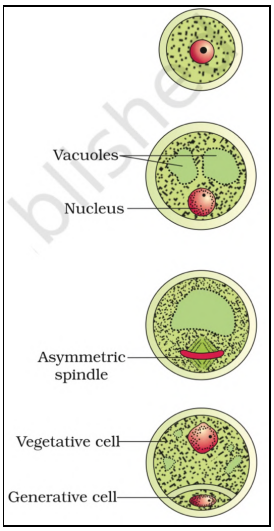


- Each cell of sporogenous tissue is capable to form microspore tetrad, ∴ each one is potential PMC

→ as anther mature & dehydrate microspore dissociate & develop into pollen grain.

⑤ Micro gametogenesis





mature pollen grain

- Vegetative cell (Tube cell) → Big cell → Abundant food reserve (Nutrition) → Irregular Nucleus (large)
- Generative cell (small) → Spindle shape → Dense cytoplasm → floates in cytoplasm of vegetative cell.

⑥ pollen grain (male gametophyte)

- exine: Hard, made of sporopollenin
- inline: Thin, contineous, cellulose & pectin
- Germ pore (prominent apertures) → pore present on exine where sporopollenin is absent. → pollen tube arise
- Size: 25-50 µm in diameter (spherical)

* pollen grains of different species have variety of architecture in → size, shapes, colours, design

⑦ Sporopollenin

- Secreated by Tapetum
  - Ubisch body
  - * its deposition very specific in every species.
- most inert/resistant organic material
  - Tolerate high temp°, strong acids.
  - No enzymatic action
  - * Helps in fossilisation
- * It form exine
  - exhibits fascinating array of pattern & design
  - * helps in identification (Taxonomy)

⑧

Pollen Allergy	Pollen Tablet	Pollen viability	Pollen bank
• airborn pollen grain. ↓ • allergies & bronchial affection ↓ chronic Respiratory disorder → asthma, bronchitis • Parthenium (carrot grass) ↓ Imported with wheat.	• pollen rich in nutrients ↓ used as tablet & syrup to increase efficiency of Race horse & Athletes • Bee pollen • Pollen jelly (in western countries mostly)	• period upto which pollen can germinate ↓ → variable, → Depend on temp & moisture. ↓ • Wheat, Rice → 30 min (poaceae) • Leguminosae, Rosaceae, Solanaceae → months	• Storage of pollen in liquid nitrogen ↓ at −196°C ↓ used in • Crop breeding programme (called Cryopreservation

★ Imp points

Sporophyte → sporocyte (2n) —meiosis→ Spore (n) —mitosis→ Gametophyte (n)

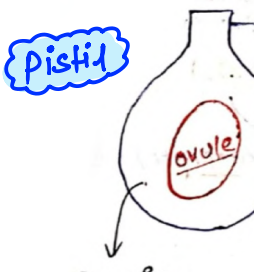
- mega sporocyte = MMC
- micro sporocyte = PMC

Spore (n):
- mega spore
- micro spore (Tetrad)

Gametophyte (n):
- male gamete = pollen grain
- female gamete = Embryo sac

Sporophyte → phyllleaf, Sporangia → Sporophyll
- megasporophyll = ovary
- microsporophyll = anther

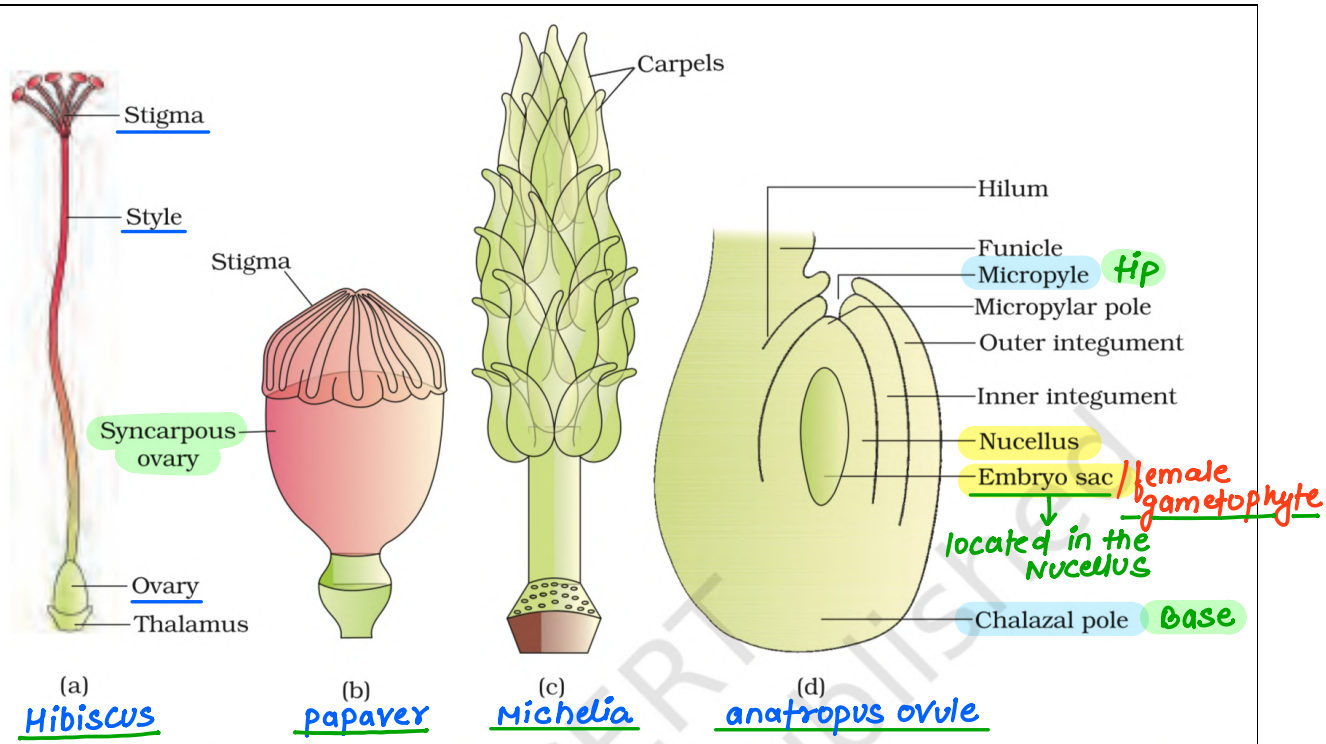
⑨ Gynoecium (female reproductive part, it is group of pistils)



* placenta located inside ovarian cavity

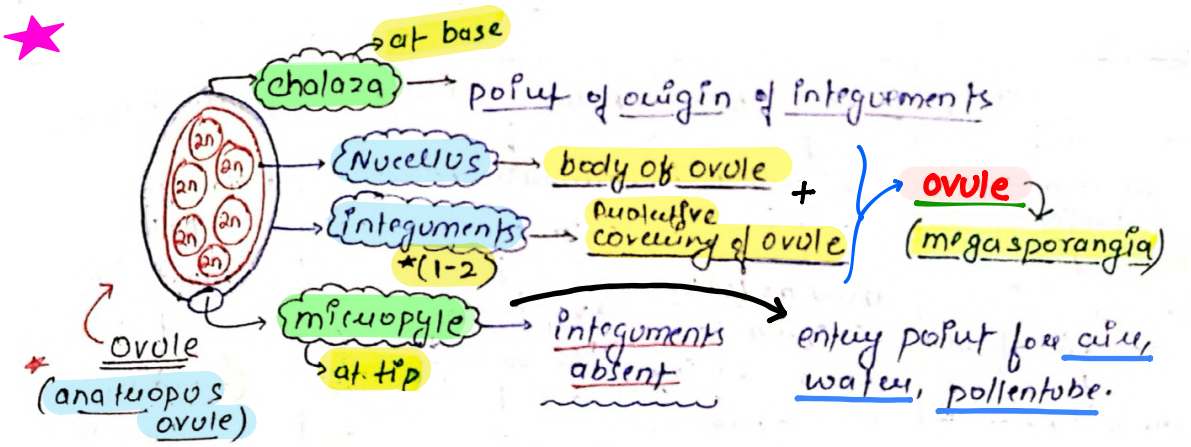
* carpel & pistil are generally non-convertable terms.

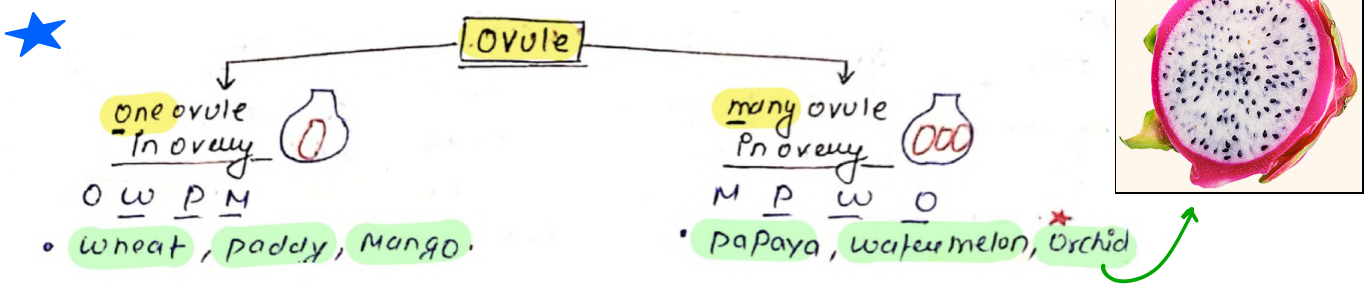
- monocarpellary
  - Hibiscus
- multi-carpellary
  - Syncarpous (fused)
    - papaver
    - Lady finger
  - Apocarpous (free)
    - Michelia
    - Rose, lotus

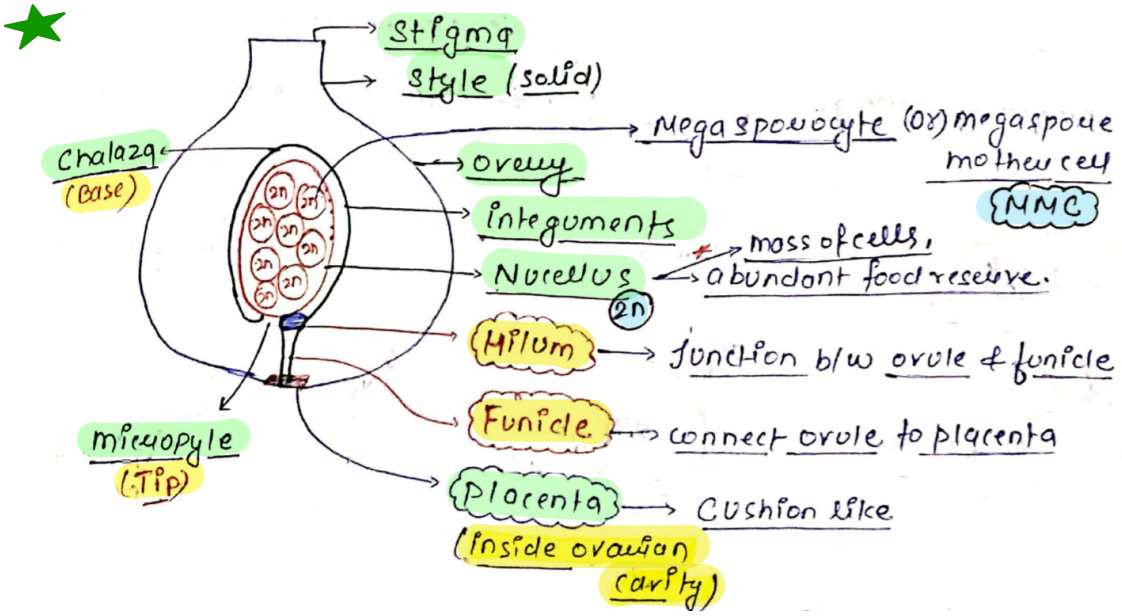


(a) A dissected flower of *Hibiscus* showing pistil (other floral parts have been removed); (b) Multicarpellary, syncarpous pistil of *Papaver*; (c) A multicarpellary, apocarpous gynoecium of *Michelia*; (d) A diagrammatic view of a typical anatropous ovule

(10) Megasporangia / ovule

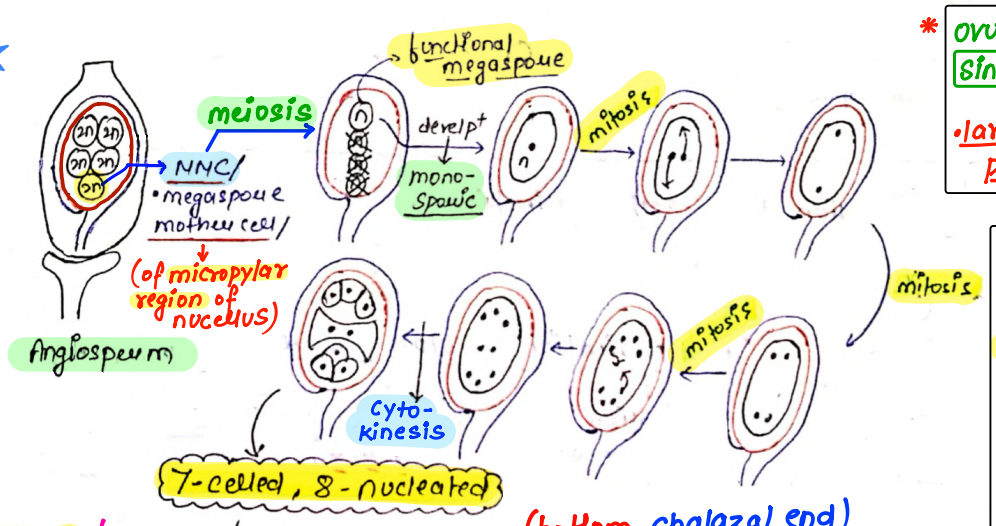






The ovule is a small structure attached to the placenta by means of a stalk called **funicle**. The body of the ovule fuses with funicle in the region called **hilum.** Thus, hilum represents the junction between ovule and funicle. Each ovule has one or two protective envelopes called **integuments.** Integuments encircle the nucellus except at the tip where a small opening called the **micropyle** is organised. Opposite the micropylar end, is the **chalaza**, representing the basal part of the ovule.

(1) Megasporogenesis (MMC (2n) —meiosis→ megaspore (n))



* ovule generally differentiate single MMC in Micropylar region.
  - large, dense cytoplasm, prominent nucleus

Functional megaspore
3-mitosis | monosporic development
Embryo sac / female gametophyte
(7-celled, 8-nucleated)

- Embryo sac / female gameto-phyde

(bottom, chalazal end)
- antipodal cells → degenerate after pollination
- central cells (middle)
- polar nucleus (n+n) → fuse prior to fertilization
- 1 egg cells, 2 Synergids → egg apparatus (top) → micropylar end
- filiform apparatus → secrete chemicals to attract pollen tube
- cellular thickenings of synergids

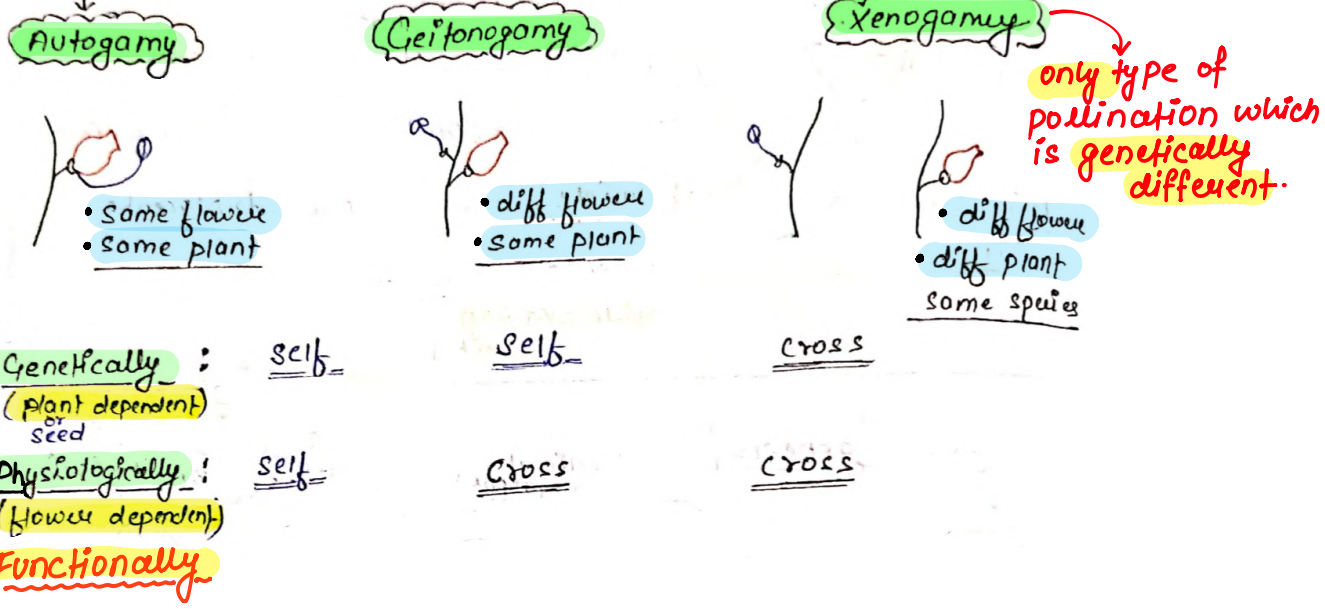
* Mitotic divisions are strictly free nuclear
  ↓
  i.e, nuclear division are not followed immediately by cell wall formation

(12) Pollination

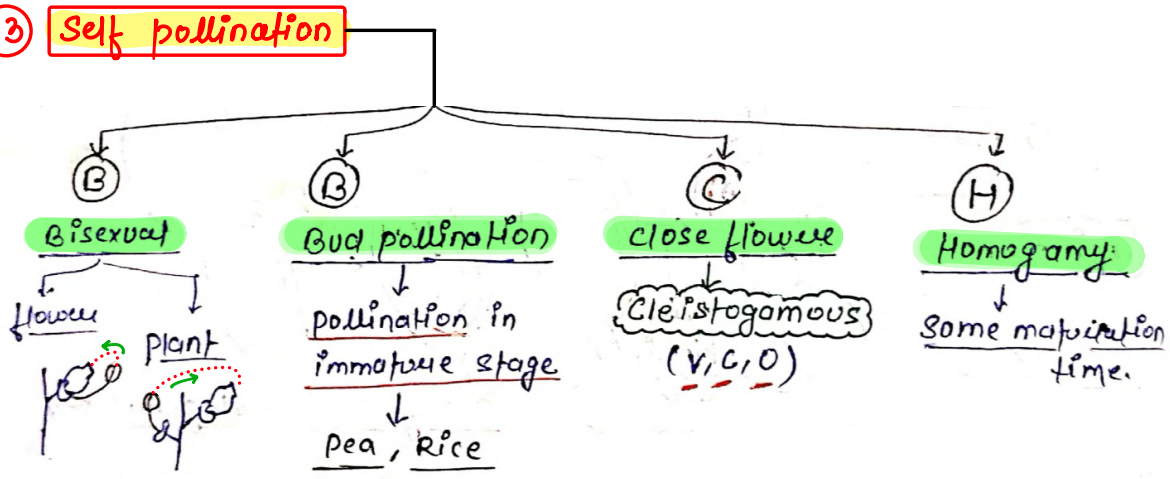
→ Transfer of pollen grain from anther to stigma of same species

→ pollination is required, b/c both male & female gamete are non-motile

Types of pollination (depend on source of pollen)



(13) Self pollination



★ IMP

- Viola
- Commelina
- Oxalis

common pansy

Close flower [Cleistogamous]
- Cross ⊗
- 100% self pollination ∴ No need of pollinators.
- invariably autogamous
- No variation.

No chances of cross pollination

Open flower [Chasmogamous] → Cross ✓

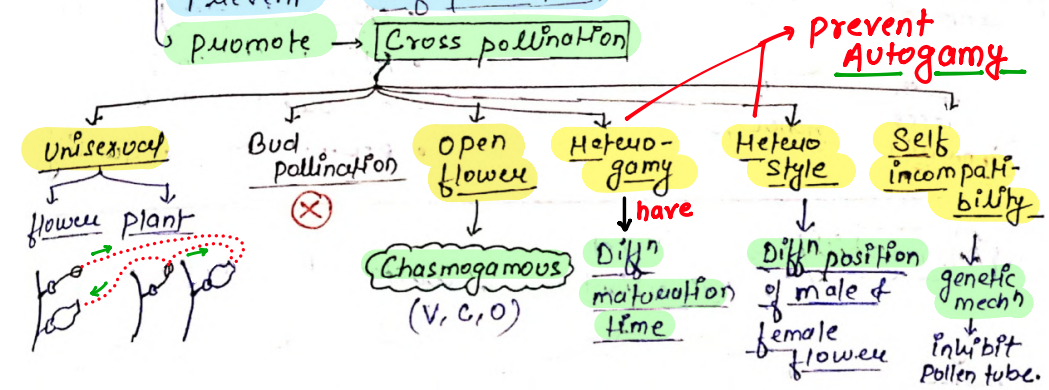
→ autogamy rare if req synchrony in pollen release & stigma receptivity

(14) Self pollination

- **advantage**
  - Economical
  - no need of fragence, nectous.
  - Assure seed foemation
  - Produce pure line / Homozygous
- **disadvantage**
  - lack of variation
  - Inbreeding depression → (accumulation of lethal gene)

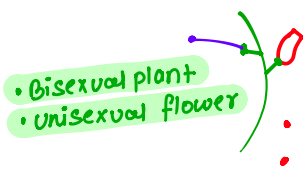
(15) Outbreeding device

- Prevent → self pollination
- promote → Cross pollination



(16) Saxuality

Monocious / Bisexual



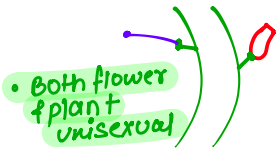
- Maize
- Castor

- A: ✗
- G: ✓
- X: ✓

- diff flower
- same plant

• prevent Autogamy, but not geitonogamy.

Diocious / unisexual



- papaya

- A: ✗
- G: ✗
- X: ✓

- diff flower
- diff plant

• prevent both Autogamy & geitonogamy

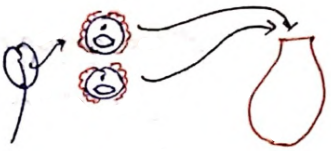
NCERT

Out breeding devices

Flowering plants have developed many devices to discourage self-pollination and to encourage cross-pollination. In some species, pollen release and stigma receptivity are not synchronised. Either the pollen is released before the stigma becomes receptive or stigma becomes receptive much before the release of pollen. In some other species, the anther and stigma are placed at different positions so that the pollen cannot come in contact with the stigma of the same flower. Both these devices prevent autogamy. The third device to prevent inbreeding is self-incompatibility. This is a genetic mechanism and prevents self-pollen (from the same flower or other flowers of the same plant) from fertilising the ovules by inhibiting pollen germination or pollen tube growth in the pistil. Another device to prevent self-pollination is the production of unisexual flowers. If both male and female flowers are present on the same plant such as castor and maize (monoecious), it prevents autogamy but not geitonogamy. In several species such as papaya, male and female flowers are present on different plants, that is each plant is either male or female (dioecy). This condition prevents both autogamy and geitonogamy.

→ diff Maturation time
→ diff position
→ Self incompatibility
→ sexuality

(17) pollinating agent



pollen grains are non-motile
they need pollinating agent

- Abiotic (non-living) (small proportion)
  - Wind / Air [more common] → common in grasses
  - Water [Rare] → limited to ★ 30 genus → monocots
- Biotic (living) (majority)
  - ★ Insects (most common) → Honey bee
  - Birds
  - Bats
  - Lizard (reptile)
  - Primates (lemurs)
  - arboreal rodents (tree dwelling)

(a) Anemophilly → Air/wind

→ directionless → wastage of pollen grain

pollen grain	male flower	female flower	ovule
• large no.	• well exposed stamens	• large & feathery stigma	single ovule
• light wt.	• ⊕ in group	• sticky stigma	
• non sticky	• inflorescence ✓	• Inflo ✓	
• non wettable		• colour, Nectar, fragrance ⊗	
• winged pollen grain → Pinus			

- Stigma and style are feathery
- Tessels (corn cob) help to trap pollen grain

example:
- B → Bamboo
- M → Maize
- W → wheat
- S → Sugarcane
- C → coconut, cashew
- G → grasses

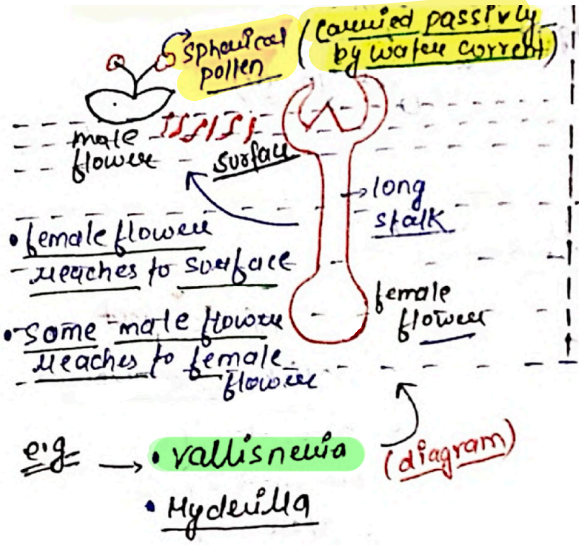
⑥ Hydrophilly → water

- pollen grain
  - light wt
  - large no
  - sticky
    - naked pollen
    - mucilage covering (sticky) → protect from wetting (non wettable)
- male flower
  - large no.
  - Boat shaped
- female flower
  - sticky stigma → twisted
  - long style
- ovule
  - any type
- example
  - EH: Hydrilla, Vallisneria
  - HH: Zostera (marine grass)

water is a regular mode of transport for the male gametes among the lower plant groups such as algae, bryophytes and pteridophytes. It is believed, particularly for some bryophytes and pteridophytes, that their distribution is limited because of the need for water for the transport of male gametes and fertilisation.

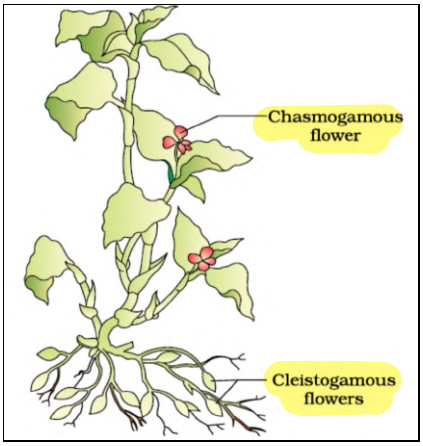
★ Hydrophilly types:

Epihydrophilly

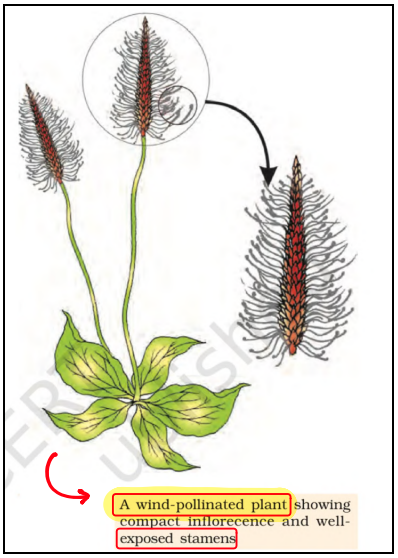


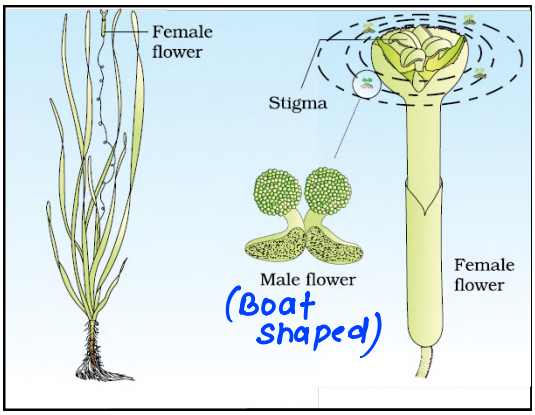
Hypohydrophilly

* Most of aquatic plants pollinated by wind / insects
  - those flower emerge above the level of water
  - water hyacinth, water lily



Commelina





Valisneria

EH

★ In *Vallisneria*, the female flower reach the surface of water by the long stalk and the male flowers or pollen grains are released on to the surface of water. They are carried passively by water currents some of them eventually reach the female flowers and the stigma.

HH

In another group of water pollinated plants such as seagrasses, female flowers remain submerged in water and the pollen grains are released inside the water. Pollen grains in many such species are long, ribbon like and they are carried passively inside the water; some of them reach the stigma and achieve pollination. In most of the water-pollinated species, pollen grains are protected from wetting by a mucilaginous covering.

© Entomophilly → insects (Honey bee most common)

- pollen grain
  - Heavy
  - Sticky
- male flowers
  - large
  - well exposed
  - (+) in group
- female flowers
  - sticky stigma
  - large & well exposed
  - Inflorescence ✓
    - colourful ✓
    - fragrance ✓
    - Nectar ✓
- ovule
  - any type
- example
  - Water Hyacinth
  - water lily
  - Many

(18) Some important points

★ Plants pollinated by flies & beetles → secrete foul smell.

★ Plants provide floral reward (Nectar & pollen grain)

- Figs & wasp
  - safe place for laying egg
  - pollinating agent.
- Yucca & moth
  - provide safe place for laying egg
  - pollinating agent
- Amorphophallous & insects
  - tallest tree
  - safe place to lay egg
  - pollinating agent

★ (6 feet flower)

↓ Mutualism

★ Plants → requirement for agent:

Abiotic agent
- Pollen grain in large amt.
- colour, fragnance, nectar ⊗

Biotic agent
- Sticky, well exposed
- colour, fragnance, nectar ✓

(19) Pollen pistil intraction → Dynamic process, involve pollen recognition, then promotion/inhibition

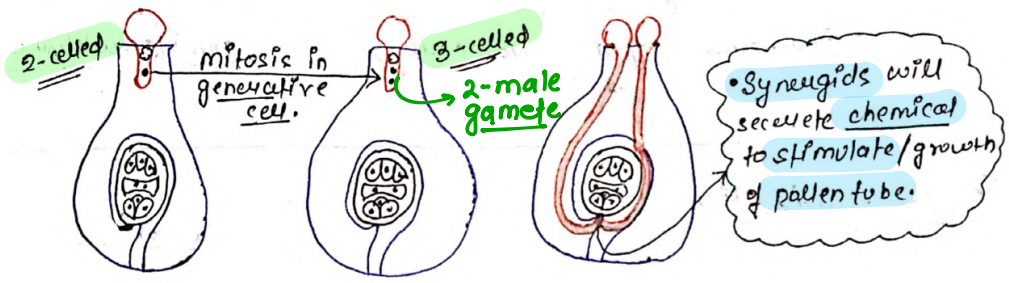
- pollination does not guarantee transfer of correct pollen grain.
- pistil chemically evaluate pollen grain (chemical mediation)

Correct type PG (compatible) (pollen grain of same spp.) → Germination of pollen grain

Incorrect type PG (incompatable) → Germination → prevent by stigma / prevent by style

- post-fertilization event ✓

inhibit pollen tube formn.



(20) Pollen tube

Growth of pollen tube

- Apical
- Chemotropic (in response to chemical secrete by synergids)

Entry of pollen tube

- enter into embryo sac via micropylar end, b/c synergids & egg are present.

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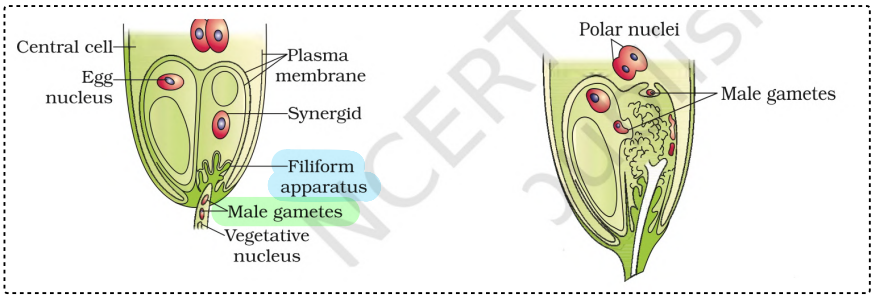
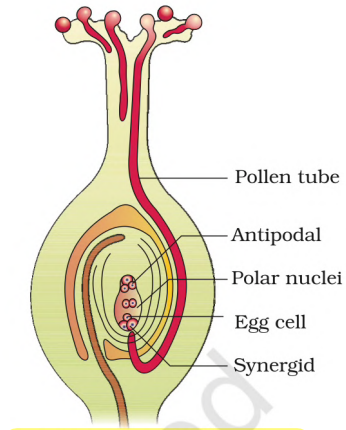
some plants, pollen grains are shed at two-celled condition (a vegetative cell and a generative cell). In such plants, the generative cell divides and forms the two male gametes during the growth of pollen tube in the stigma. In plants which shed pollen in the three-celled condition, pollen tubes carry the two male gametes from the beginning. Pollen tube, after reaching the ovary, enters the ovule through the micropyle and then enters one of the synergids through the filiform apparatus





Longitudinal section of a flower showing growth of pollen tube

(21) Artificial Hybridisation

- For same species / diff species
- Transfer of desired pollen grain on stigma
- used in crop improvement programme

Steps:

① Emasculation — Anther Removal
- Removal of immature anther from flower bud using forceps (To prevent self pollination / Autogamy)

② Bagging — butter paper
- covering of female flower with butter paper (To prevent unwanted cross pollination / xenogamy)

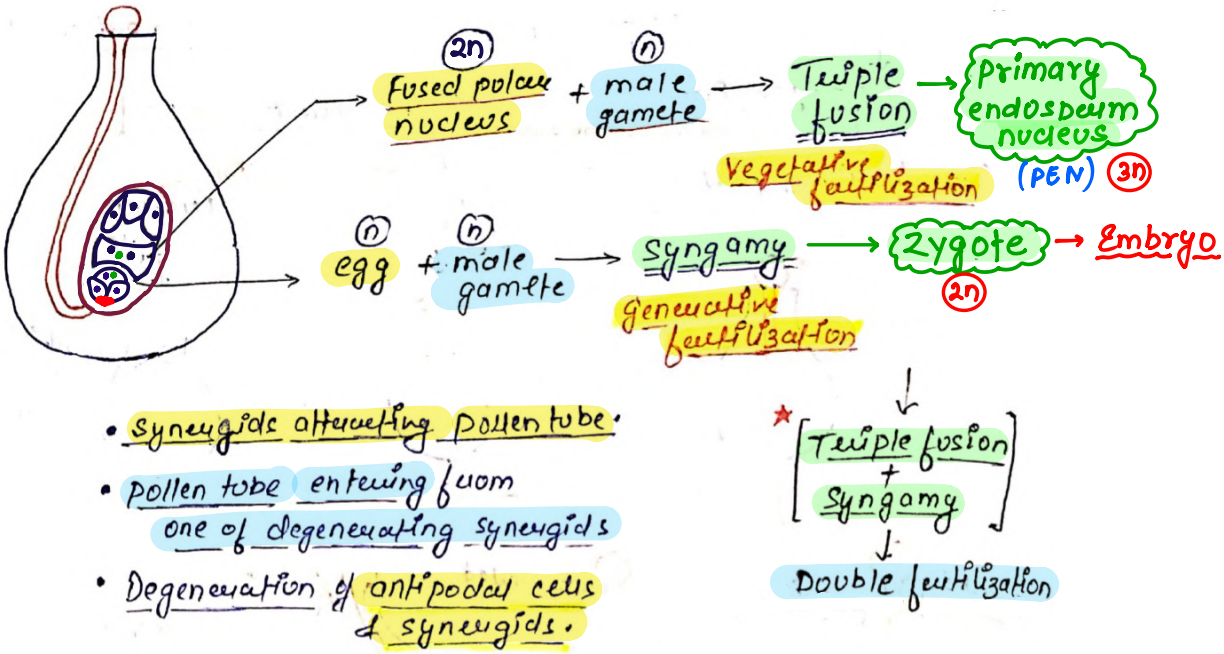
③ Dusting
- when stigma become receptive, then mature/desired pollen dusted on stigma

④ Re-bagging
- To prevent contamination (unwanted pollen)

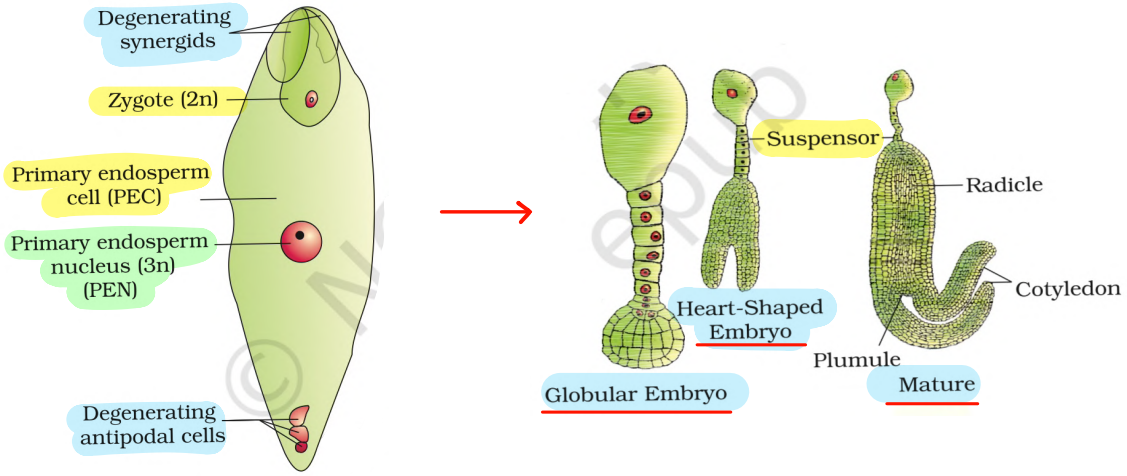
★ Bisexual flower: (1st step) Emasculation → Bagging → Dusting → Re-bagging

Unisexual flower: ~~Emasculation~~ → Bagging (1st step) → Dusting → Re-bagging

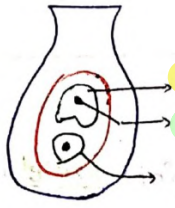
(22) Double fertilization (characteristics of angiosperm)



After entering one of the synergids, the pollen tube releases the two male gametes into the cytoplasm of the synergid. One of the male gametes moves towards the egg cell and fuses with its nucleus thus completing the **syngamy**. This results in the formation of a diploid cell, the **zygote.** The other male gamete moves towards the two polar nuclei located in the central cell and fuses with them to produce a triploid **primary endosperm nucleus** (PEN) As this involves the fusion of three haploid nuclei it is termed **triple fusion.** Since two types of fusions, syngamy and triple fusion take place in an embryo sac the phenomenon is termed **double fertilisation**, an event unique to flowering plants. The central cell after triple fusion becomes the **primary endosperm cell** (PEC) and develops into the **endosperm** while the zygote develops into an **embryo.**



(23) Post fertilization event



- primary endosperm cell (PEC)
- primary endosperm nucleus (PEN) (3n)
- Zygote (2n)

PEC → endosperm

PEN → Endosperm development → provide Nutrition

Precede embryo development

Endosperm development

- 3n

1. free nuclear endosperm (most common)
   - coconut water (liquid)
   - cotton
   - ↓ syncitum condition (karyokinesis not followed by cytokinesis)
   - ↳ multinucleated condn
2. cellular endosperm
   - white kernel of coconut.

Post fertilization event

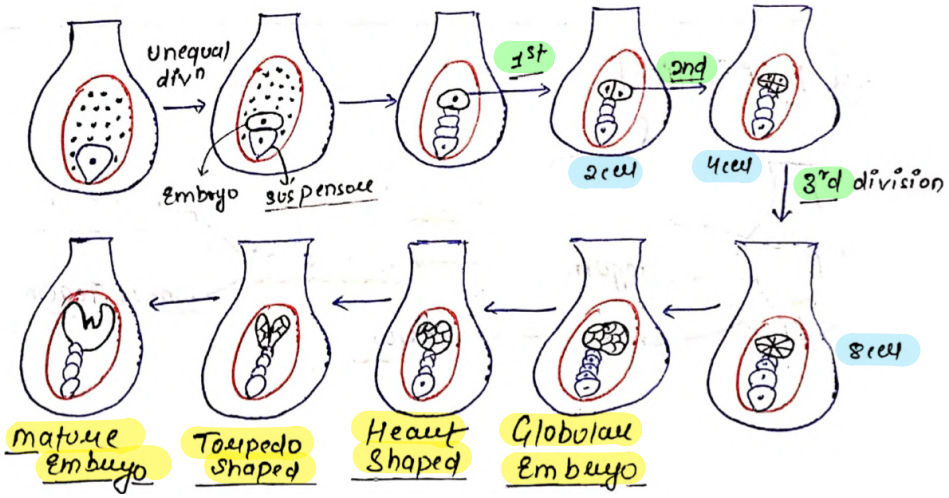
- Endosperm event
- Embryo devp.
- ovule → seed
- ovary → fruit

(24) Embryo development

During megasporogenesis

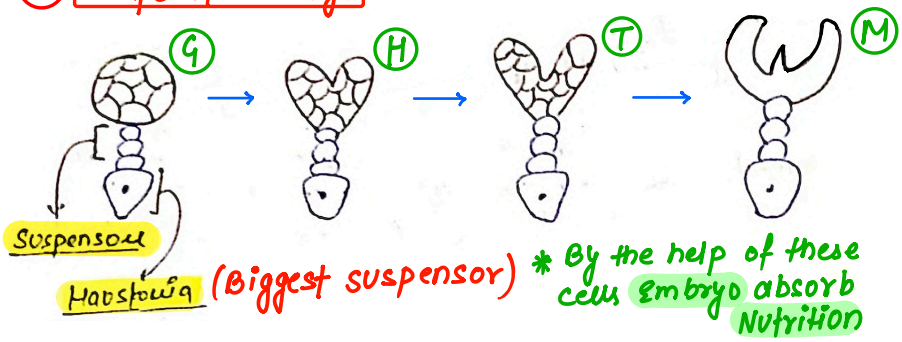
Endosperm completely consumed	Some amt of Endosperm remains (persistant Endosperm)	nucellus remains (persistant nucellus) (2n)	Nucellus completely consumed
↓	↓	↓	↓
Non-endospermic seed	Endospermic seed	perispermic seed (2n)	non-perispermic seed
↓	↓	↓	
ex/non-albuminous seed	albuminous seed	• Black pepper • Beet	
↓	↓		
• B → Bean • G → Ground nut, Gram • P → Pea	B → Barley M → maize W → wheat S → sunflower C → castor, coconut R → rice		

25 Embryogenesis



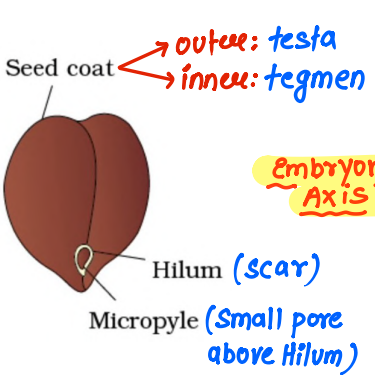
- Embryo develop at micropylar end.
- most zygote diride only after certain amt of endosperm formed to provide assured nutrition to the developing embryo.
- Early stage of embryo development similar in both monocot & Dicot.

26 Shape of Embryo

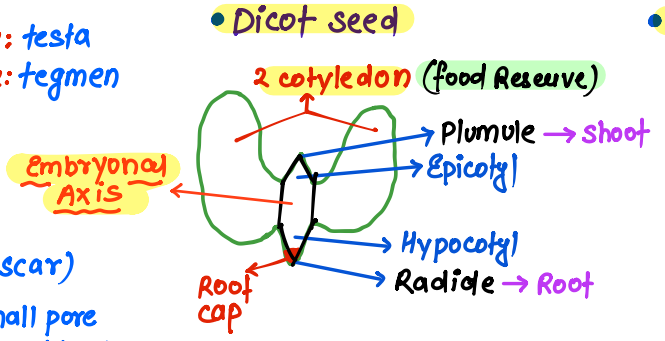


(Biggest suspensor) * By the help of these cells embryo absorb Nutrition

27 Seed

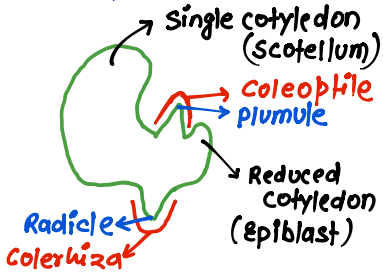


- Dicot seed



→ Bean, castor

- Monocot seed



→ maize, Grass, onion

- Coleoptile : Hollow foliar str
- Coleorhiza : Undifferentiated Sheath.

NCERT

Integuments of ovules harden as tough protective seed coats. The micropyle remains as a small pore in the seed coat. This facilitates entry of oxygen and water into the seed during germination. As the seed matures, its water content is reduced and seeds become relatively dry (10-15 per cent moisture by mass). The general metabolic activity of the embryo slows down. The embryo may enter a state of inactivity called **dormancy**, or if favourable conditions are available (adequate moisture, oxygen and suitable temperature), they germinate.

* Dehydration & dormancy is crucial for storage of seed & can be used as food and raise crop in next season.

(28) **Fruit** (fruit wall: pericarp)

- **True fruit** → develop from fertilised ovary → • Mango
- **false fruit** → develop from other than ovary → • Apple, Strawberry • cashew (edible thalmus)
- **parthenocarpic fruit** → develop without fertilization (seedless) → • Banana
  - can induced via → Growth hormone

★

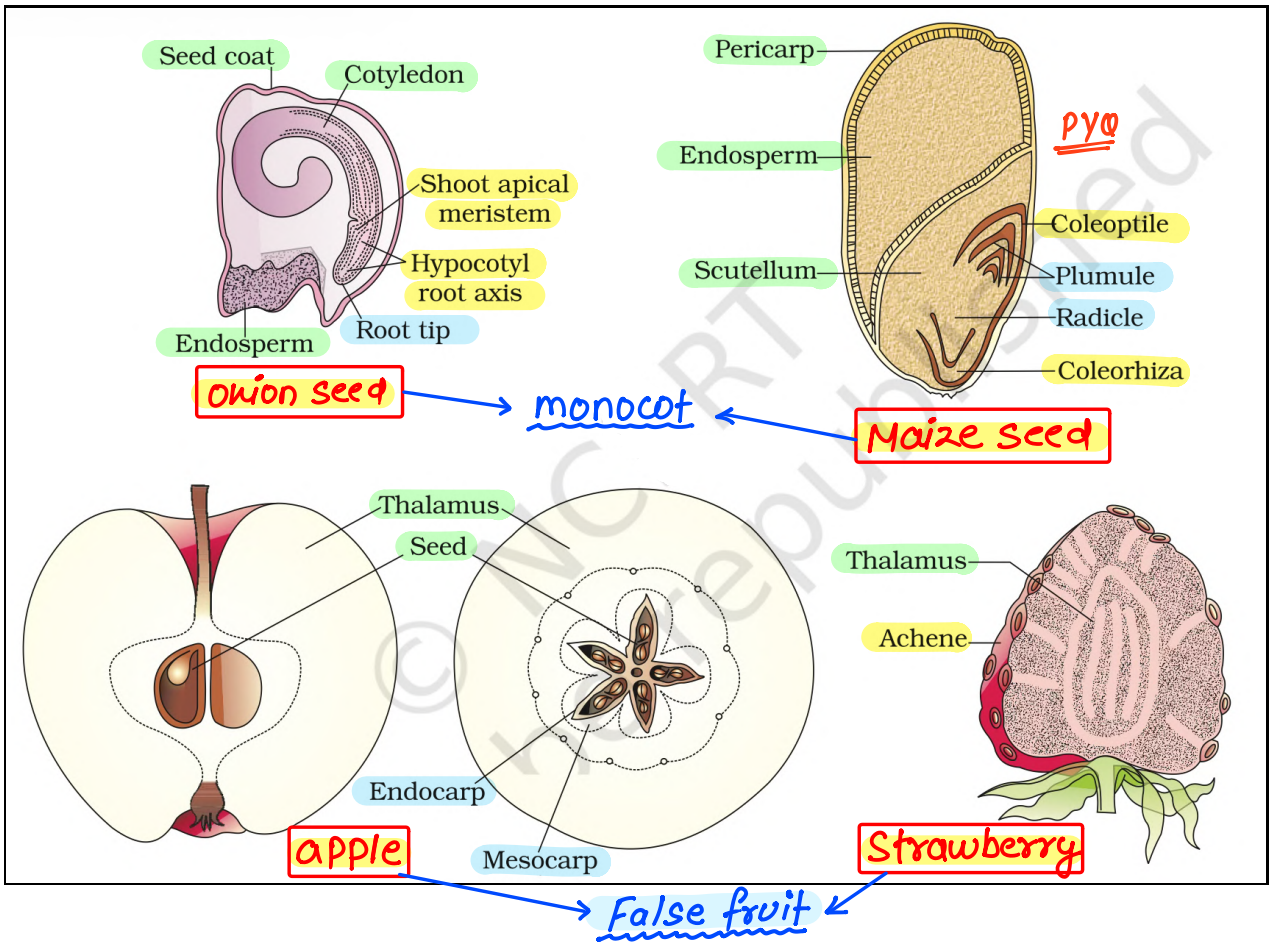
fleshy fruit	Dry fruit
• Guava, orange, mango	• Groundnut, mustard

(29) **Seed viability**

→ period upto which seed have power of germination

→ varies from species to species

eg:
- In few species (oxalis) → few month
- In large species → several years
- Date palm (phoenix dactylifera) → 2000 yrs (discovered at King Herod's palace near Dead sea)
- Lupine (lupinus arcticus) → 10,000 yrs (from arctic tundra)
  - → oldest



(30) **Apomixis** (away fusion) (asexual) V/S **Amphimixis** (involve fusion)

- formation of seed without fertilization
- formation of seed with fert.ⁿ (sexual)

eg:- → Asteraceae family & some grasses

* Apomixis is a form asexual reproduction that mimics sexual reproduction.

(31) **Polyembryony** (ovule contain many embryo)

- no. of embryo >> no. of seeds

→ diploid egg formed without Reduction division & develops into embryo without fertilization

eg:
- Citrus
- Mango
- Lemon
- orange

* fruits contain large no. of seeds.
  - orchids
  - orobanche
  - Striga

  → parasitic species

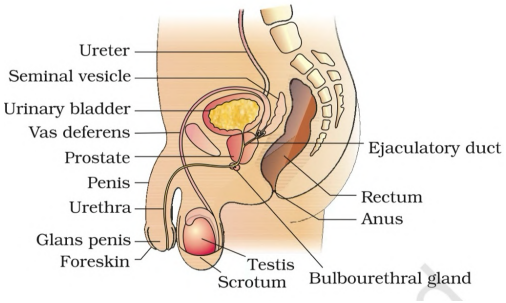
(32) **Hybrid seed**

Hybrid varieties of several of our food and vegetable crops are being extensively cultivated. Cultivation of hybrids has tremendously increased productivity. One of the problems of hybrids is that hybrid seeds have to be produced every year. If the seeds collected from hybrids are sown, the plants in the progeny will segregate and do not maintain hybrid characters. Production of hybrid seeds is costly and hence the cost of hybrid seeds become too expensive for the farmers. If these hybrids are made into apomicts, there is no segregation of characters in the hybrid progeny. Then the farmers can keep on using the hybrid seeds to raise new crop year after year and he does not have to buy hybrid seeds every year. Because of the importance of apomixis in hybrid seed industry, active research is going on in many laboratories around the world to understand the genetics of apomixis and to transfer apomictic genes into hybrid varieties.

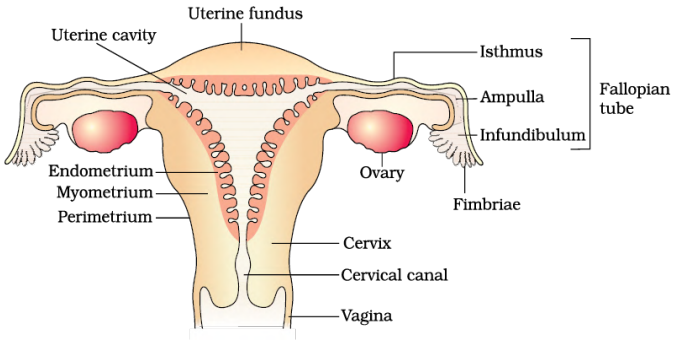
HUMAN REPRODUCTION

① Male reproductive system → spermatogenesis → sperm

Female reproductive system → oogenesis → ova



fertilization → zygote (2n) → Blastocyst → Implantation → Cleavage → Gastation period (9-month) → parturation (Birth) → Lactation (breast feeding)



② Types of sex organ

Primary sex organ
- gamete formation
- sex Hormone secretion

→ male: Testis
→ Female: ovary

Secondary sex organ
- Gamete maturation
- Gamete Transportation

→ male: epididymis, vas deferens etc.
→ female: fallopian tube, uterus, cervix etc.

③ Male Reproductive system (pelvis region)

- pair of testis : pri. sex organ
- Accessory duct : Rete testis, vasa efferentia, epididymis, vas deferens
- External genitalia: Penis & scrotum

★ Semen → sperms + seminal plasma

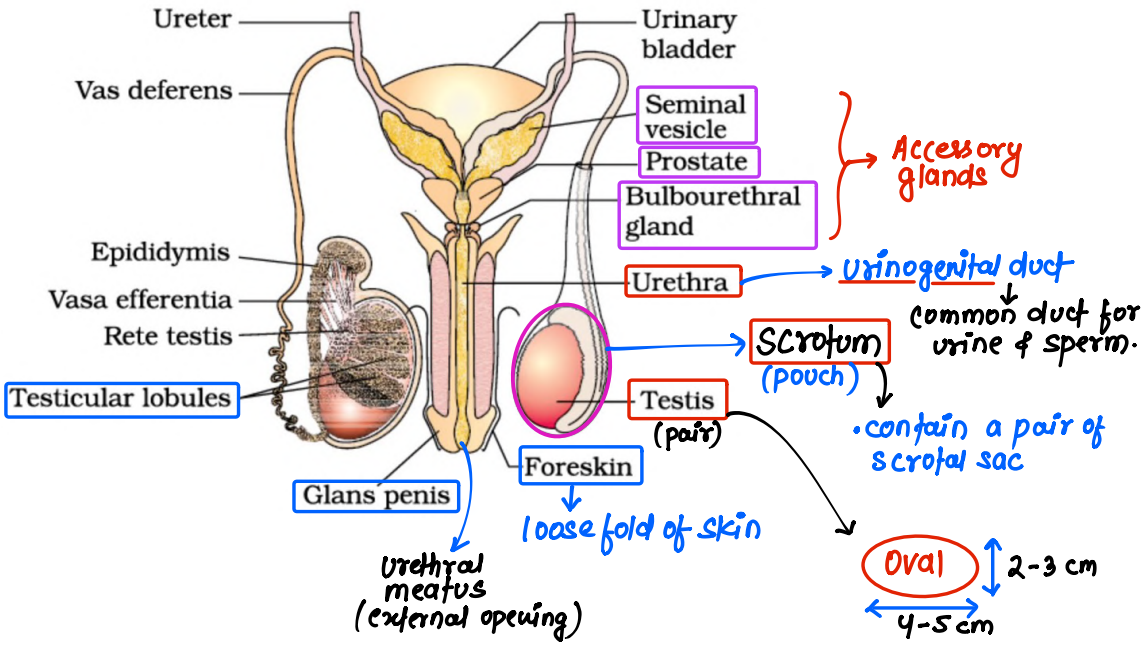
* Male accessory gland : Seminal plasma

Seminal vesicles (pair)
- 60-70% semen
- Alkaline
- Fructose
- Clotting enzymes

prostate (single)
- 20-25% semen
- Acidic
- calcium

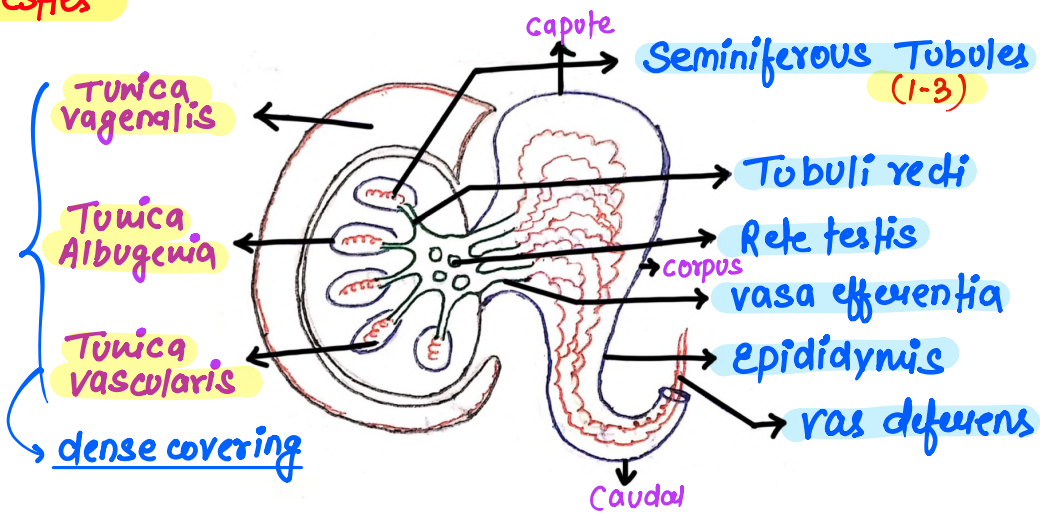
Bulbourethral (pair)
- Alkaline
- lubrecation of penis

④



* Testis are outside abdominal cavity within scrotum
* Scrotum help in maintaining low Temp by 2-2.5 which required for spermatogenesis
* Ejaculatory duct: Seminal vesicle + vas deferens
  → Store & transport sperm

⑤ Testes

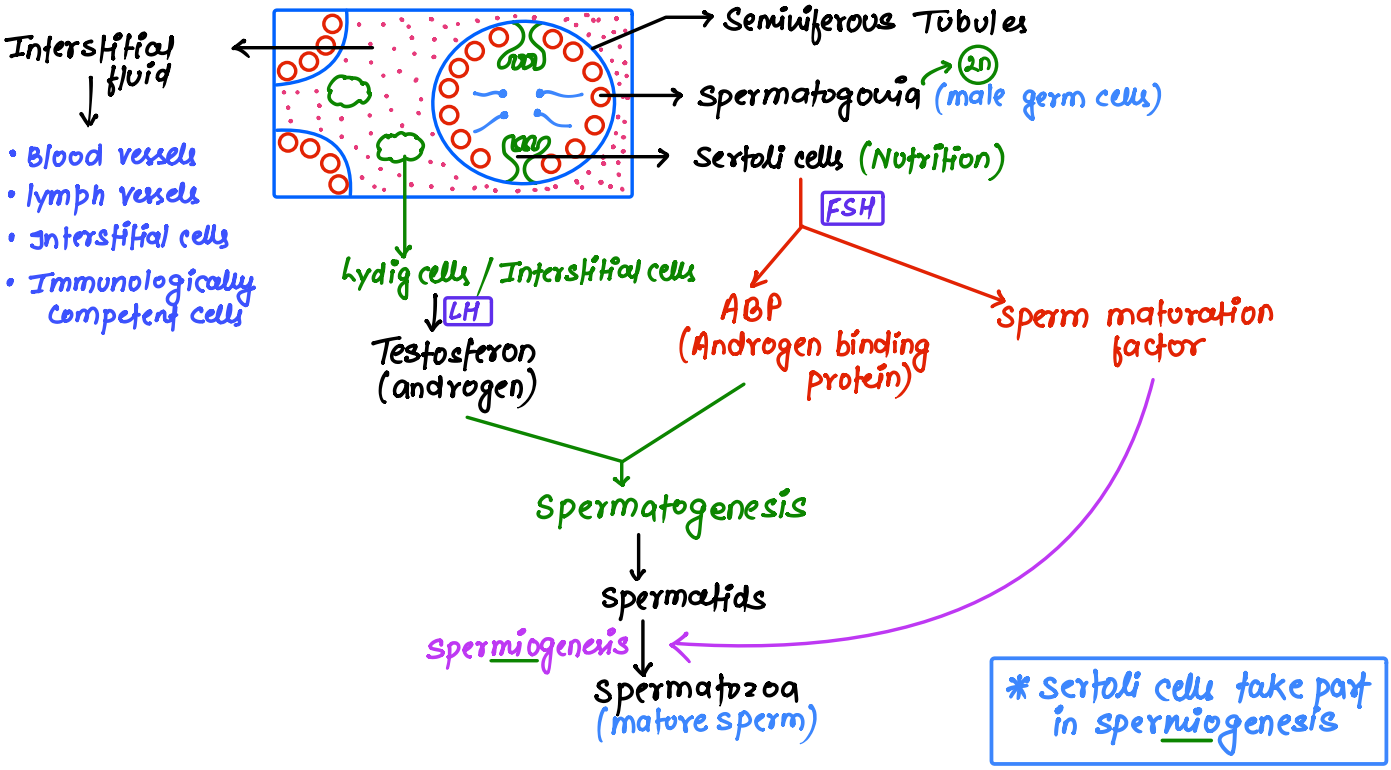


* Pathway of sperm: Seminiferous Tubules → Tubuli recti → Rete Testis → vasa efferentia → Epididymis → vas deferens → Ejaculatory duct → urethera

* Each testis: 250 compartments called Testicular lobules

* Each lobules: 1-3 highly coiled → seminiferous tubules (sperms produced)

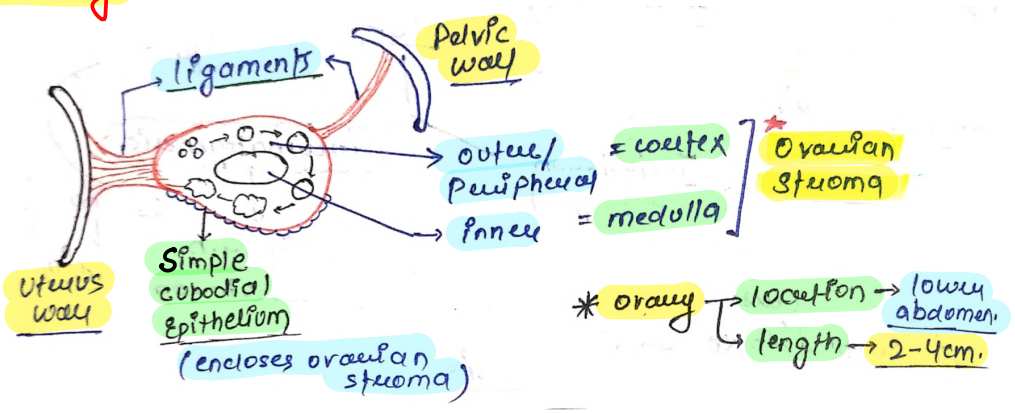
⑥ Transverse section of Testis:



⑦ Female Reproductive System

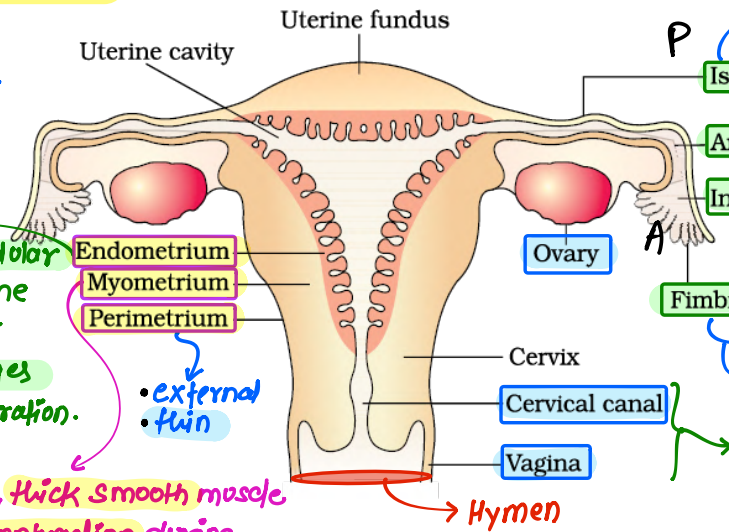
- pair of ovaries : primary sex organ
- Accessory duct (Ductus system) → Fallopian tube/oviduct , uterus/womb , cervix , vagina (Birth canal)
- External Genitalia (vulva) → mons pubis , labia majora , labia minora , hymen , clitoris
- Mammary gland → Sec sexual characters

⑧ Ovary



(9) Uterus / womb

↓ inverted-pear shape



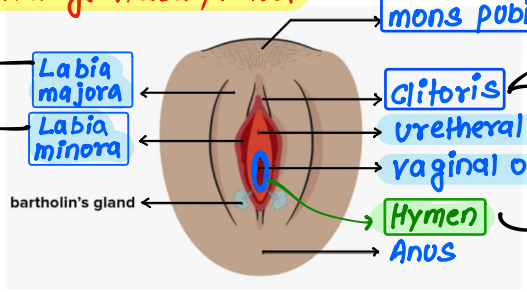
- posterior & last part of oviduct
- narrow lumen
- wider part
- site of fertilization
- 10-12 cm
- funnel shaped
- anterior & close to ovary
- Finger like projection
- help in ova collection
- Birth canal

- Inner, glandular
- lines uterine cavity
- cyclic changes during mesturation.

- external
- thin

- middle, thick smooth muscle
- strong contraction during delivery

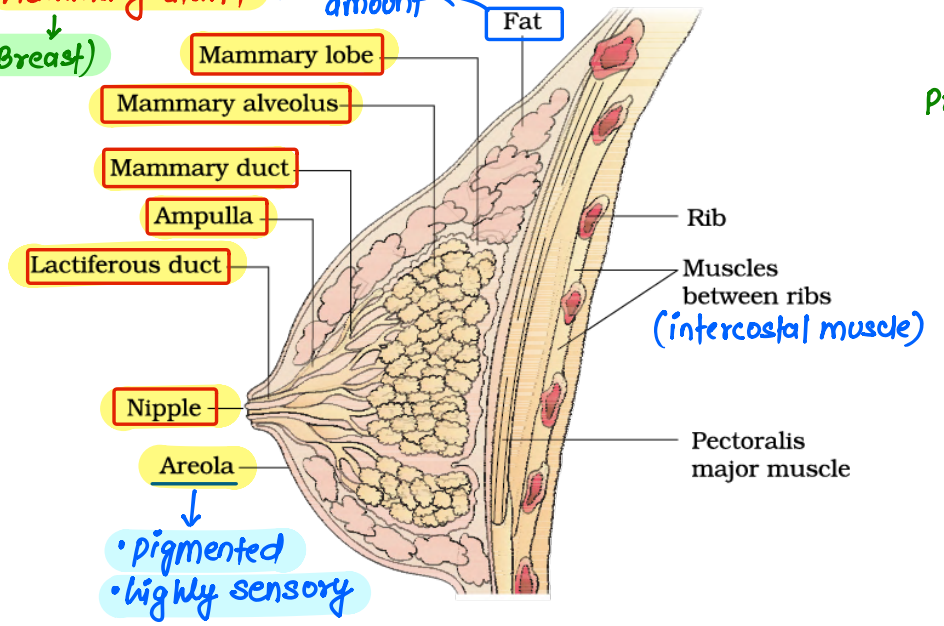
(10) Female external genitalia / valva



- cushion of fatty tissue
- skin, pubic hair
- fleshy folds
- paired folds
- tiny finger-like
- upper to labia minora & above urethral opening
- partially cover vaginal opening
- Generally torn during 1st coitus.

* But it is not a reliable indicator of sexual intercourse.

(11) Mammary Gland (Breast)



- pigmented
- highly sensory

Glandular tissue
↓ divides

Proximal
- Mammary lobe (15-20)
- ↓ mammary alveoli
- ↓ mammary tubules
- ↓ mammary duct
- ↓ mammary Ampulla
- ↓ Lactiferous duct
- ↓ Nipple

Distal

* Mammary alveoli: Secrete & store milk

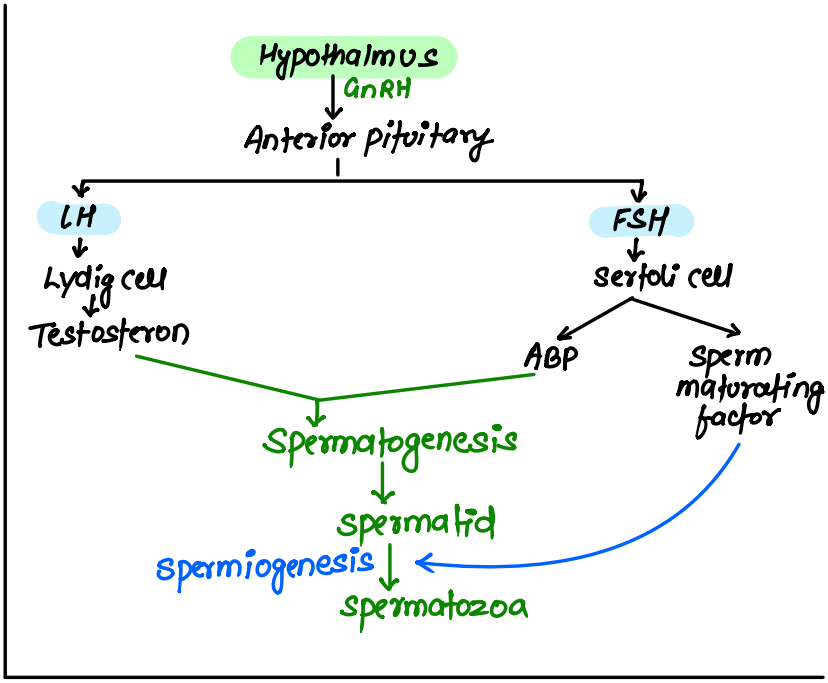
(12) Gametogenesis

(a) Spermatogenesis : (male)

Start at the age of puberty

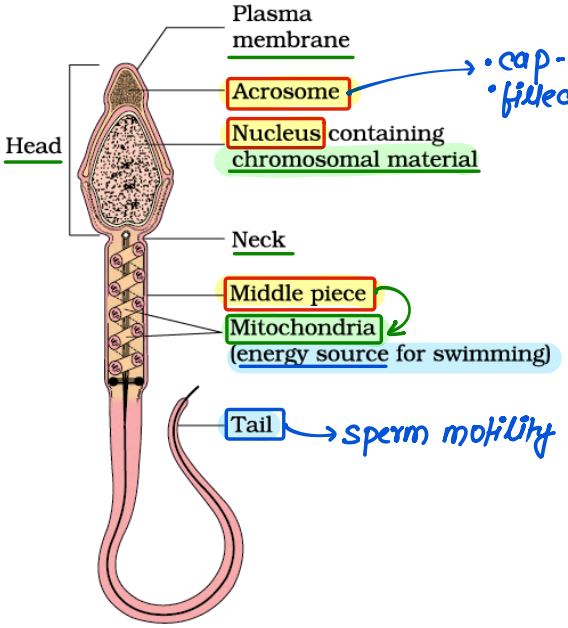
- (2n) Spermatogonia (Immature male germ cells)
  - mitosis
- (2n) primary spermatocytes
  - meiosis (I)
- (n) (n) Sec. spermatocytes
  - meiosis (II)
- (n) (n) (n) (n) Spermatids
  - Spermiogenesis (Differentiation)
- Spermatozoa (mature sperm)

* 2n: 46 chromosomes
  n: 23 chromosomes



* Spermatogenesis: Spermatogonia —(full process)→ sperm
* Spermiogenesis: spermatids —(last process)→ sperm
* Spermiation: Release of sperm into seminiferous tubules after spermiogenesis

(13) Spermatozoa / mature sperm

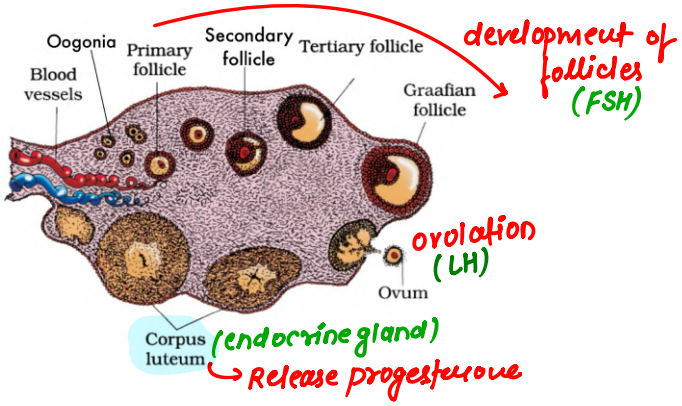


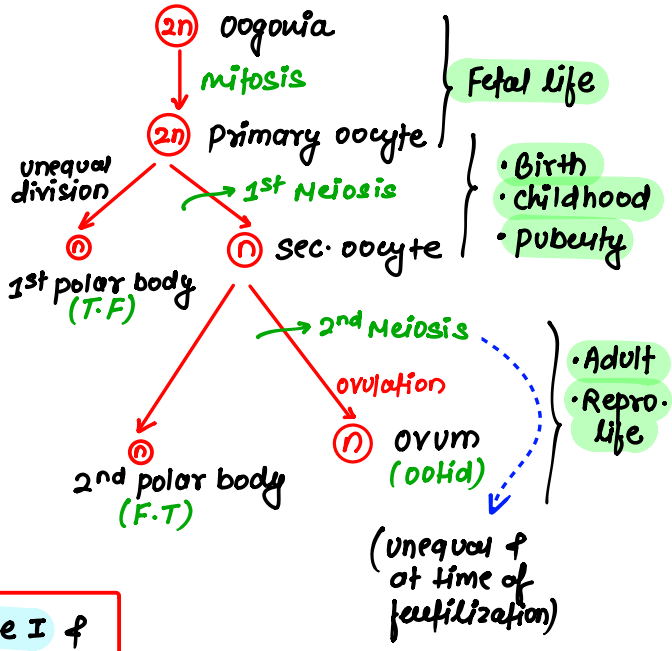
- cap-like
- filled with enzyme → help in fertilization
- Tail → sperm motility

* Male ejaculates 200-300 million sperms during coitus
* For normal fertility
  - 60% sperms must have normal shape & size
  - 40% sperms must vigorous motality

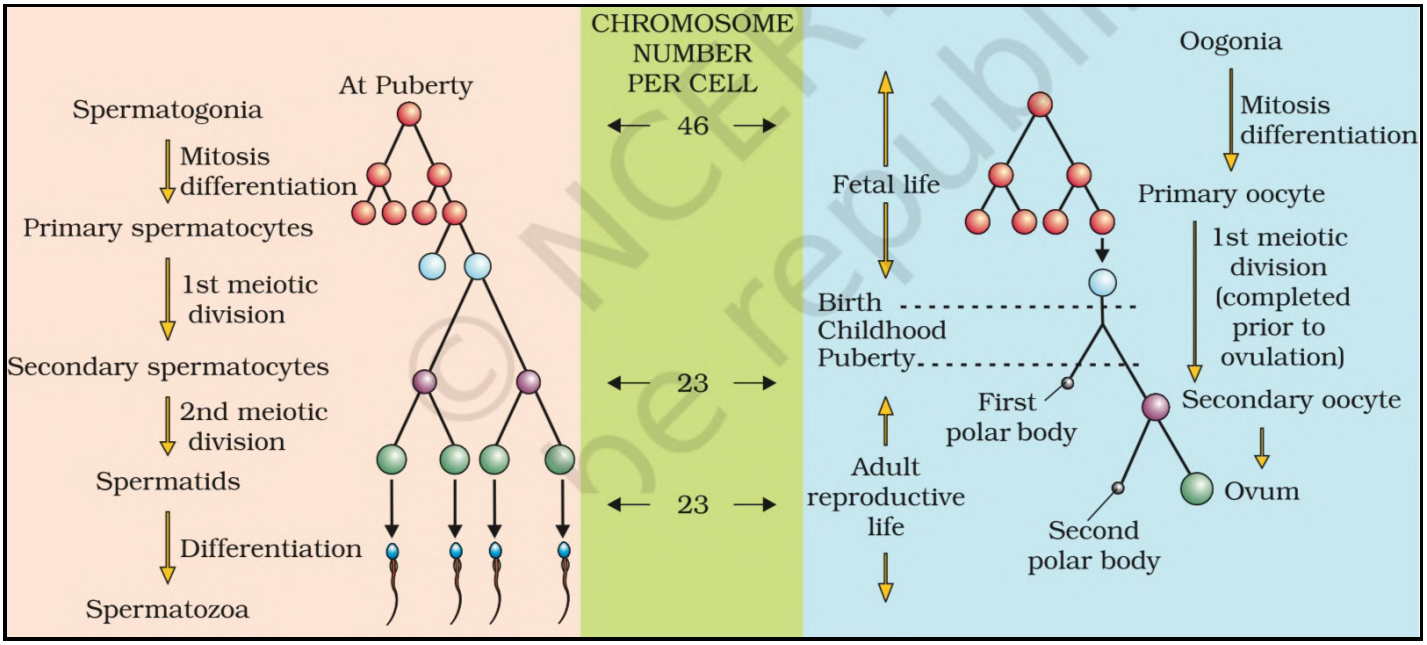
(14) Oogenesis (female)

- Initated during Embryonic stage (4 Million oogonia formed)
- No more oogonia formed after birth





* Division on sec oocyte arrested in prophase I & at fertilization Meiosis-II continue & ovum & 2nd PB formed



(15)

Primary follicle
- pri·oocyte (2n) + single layer of Granulosa cells
- Meiosis arrest in prophase-I
- At puberty: 60,000 - 80,000 pri·follicle left in each ovary

Sec·follicle
- pri·oocyte (2n) + multilayer layer Granulosa cells + New theca

Ter·follicle
- sec·oocyte (n) + Theca interna Theca externa
- * + Antrum (fluid filled cavity)
- * pri·oocyte (2n) → (unequal division (Meiosis-I)) → n (1st PB) + n (sec·oocyte)

Graafian/Mature follicle
- sec·oocyte form new theca layer: zona pellucida

* Graafian follicle → Rupture → Release sec·oocyte (ovulation)

(16) **Menstural cycle**
- In Female primates → Monkeys, apes, Humans.
- Start at puberty: Menarche
- Ends at 50 yr: Menopause
- Menstruation repeated in interval of 28/29 days
- Ovulation occur during Middle of cycle. (14th day)
- Lack of Menstruation → Indicative of pregnancy (or) * Stress, poor Health etc

* During pregnancy all event of menstural cycle stop
* Mensuration only occur if released ovum is not fertilised
(if fertilised, then pregnancy ✓ → ∴ No menstruation)

(17)

Menstural phase (1st - 5th day)
∴ 3-4 day interval

Uterine event: Breakdown of endometrium lining

Ovarian Hormone: P ↓, E ↓

Ovarian event: Regression/degeneration of corpus Leutum

Pituitary hormone: LH/FSH ↓

Follicular phase/ Proliferative phase (6 st-13th day)
∴ 7 day interval

Uterine event: Thickning & Regeneration of endometrium

Ovarian Hormone: E ↑ (Secretion)

Ovarian event: follicular development (pri. follicle → Mature follicle)

Pituitary hormone: LH & FSH ↑

Ovulatory phase (14th day)

Uterine event: endometrium developing

Ovarian Hormone: E: peak

Ovarian event: Ovulation

Pituitary hormone: Both LH & FSH: peak (middle of cycle) → 14th day

* LH surge (peak)

Luteal phase/secretory phase (15th - 29th day)
∴ 14 day interval

Uterine event: endometrium fully developed

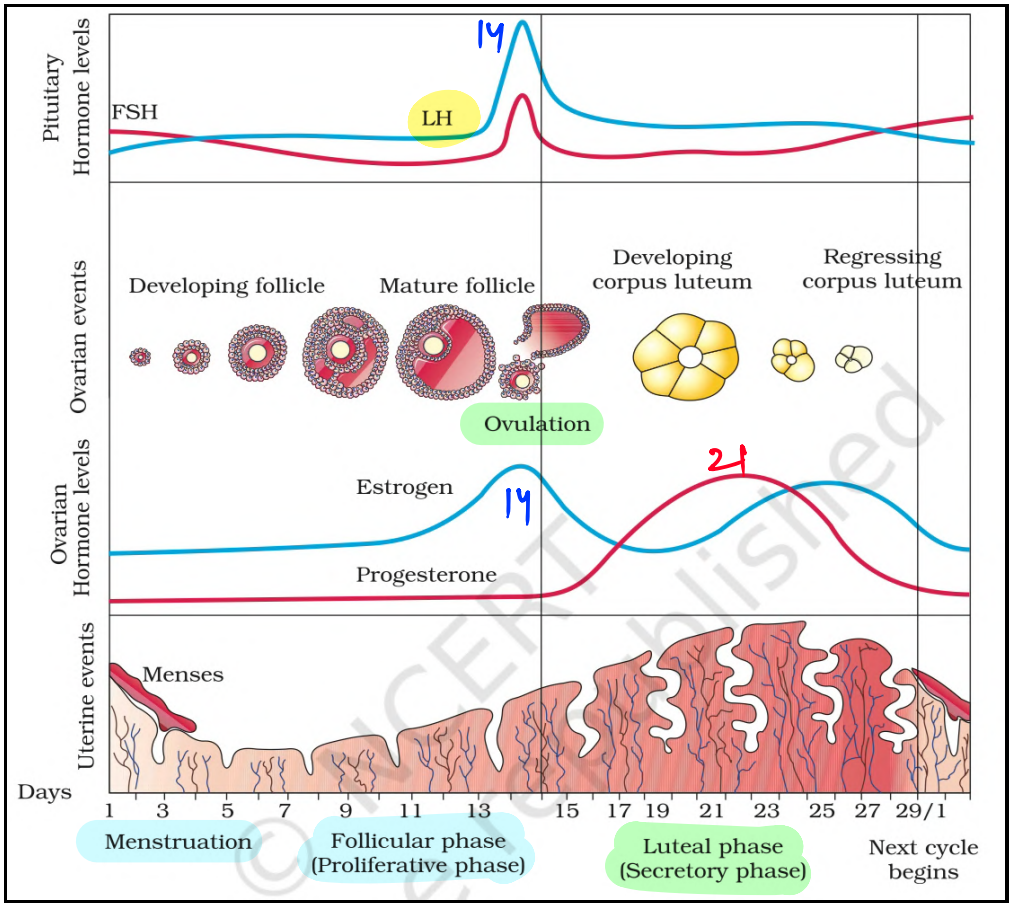
Ovarian Hormone: P ↑ (Released by corpus leutum)

Ovarian event: development of corpus Leutum

* P: peak (21th day)

→ corpus leutum → progesterone → maintain endometrium (For implantation)

• Fx ∴ CL ✗ → P ↓ → End ✗ (Mens)



Menstrual Hygiene

Maintenance of hygiene and sanitation during menstruation is very important. Take bath and clean yourself regulary. Use sanitary napkins or clean homemade pads. Change sanitary napkins or homemade pads after every 4–5 hrs as per the requirement. Dispose of the used sanitary napkins properly wrapping it with a used paper. Do not throw the used napkins in the drainpipe of toilets or in the open area. After handling the napkin wash hands with soap.

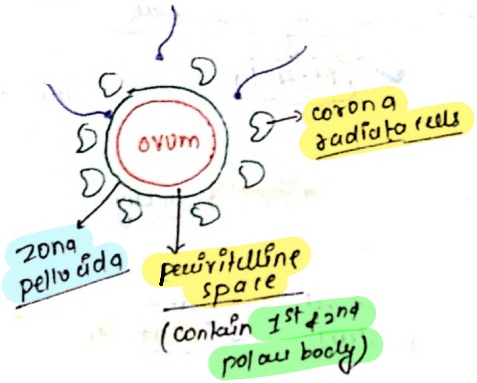
(18) Fertilization (Sperm + ova)

ampullary region → Fertilization junction

Insemination (release of sperm into vagina)

(A) Not all copulation lead to fertilization & pregnancy.

(R) Fertilization occurs only if ovum & sperm transported to ampula simultaneously



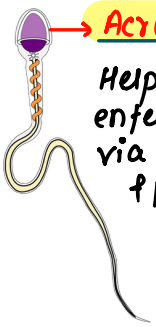
Now
* Sperm contact with zona pellucida
↓
induce changes in membrane
↓
∴ Block entry of additional sperm
↓
∴ only one can enter to fertilize

* During fertilization

Sec. oocyte

meiotic division complete | (Meiosis-II) unequal division

- Ovum (ootid) +
- 2nd polar body



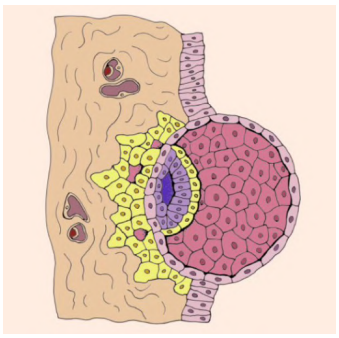
Acrosome
↓
Help sperm to enter into ovum via zona pellucida & plasma membn

(19) Implantation

* Isthmus of oviduct → zygote → Cleavage (Mitotic division) → Uterus
* 2 → 4 → 8 → 16 (Blastomeres) } Daughter cells of zygote

* Cleavage (mitosis)

- 2 cell (Blastomere) → 4 cell (Blastomere) → 8 cell (Blastomere, Blastomere) → 16 cell → Morula → Blastocyst → Blastocyst implantation



Blastocyst

- Inner cell mass (Inner) → differentiate → Embryo
- Tropoblast (outer) → attach to Endometrium → after attachment → Uterine cell divide & cover Blastocyst → ∴ Blastocyst embedded into Endometrium → * Implantation → Pregnancy

* **After Implantation:** Inner cell mass → diff^{t} →
  - Ectoderm (outer)
  - Mesoderm (middle)
  - Endoderm (inner)

NB Inner cell mass give rise to all tissue & organ B/c it have stem cells

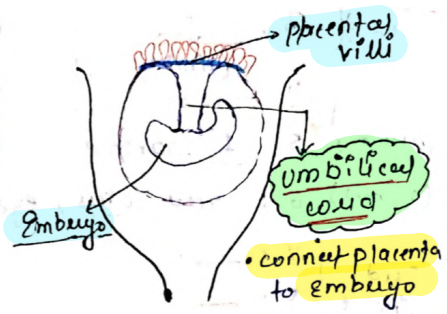
(20) Pregnancy

* After implantation

- Finger like projection on Tropoblast → Chorionic villi
  - Surrounded by
    - Uterine tissue
    - Maternal blood
- * Chorionic villi + uterine tissue → Structural & functional unit → b/w foetus & mother → c/a placenta

(21) Placenta

- Str & functional unit
- Supply oxygen & Nutrient
- Remove CO_2 & waste
- It is Endocrine tissue ∴ produce Hormone



- connect placenta to embryo
- Transportation of Nutrient

★ Placental Hormone: Estrogen, Progestron, HCG, HPL, "Relaxin" (also secreted by Ovary) — * only during Pregnancy

(estrogen, progestrone, cortisol, prolactin, thyroxin)

Ⓐ During pregnancy level of Hormone increased in maternal blood

Ⓡ These hormone essential for
- → foetal growth
- → metabolic changes
- → pregnancy maintenance

(22) Gestation period (9-month)

- 1st trimester
  - 1 : Heart formed (1st sign of growing foetus by listening Heart sound)
  - 2 : limbs & digits
  - (12 week) ← 3 : major organ formed (end of 1st trimester) (limbs, genital organ)
- 2nd trimester
  - 4
  - 5 : 1st movement, Hairs
  - (24 week) ← 6 : Body Hairs, eye-lids, eye-lashes (end of 2nd trimester)
- 3rd trimester
  - 7
  - 8
  - (36 week) ← 9 : Fully developed

(23) parturation

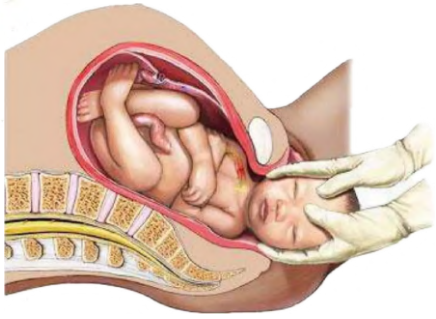
→ Delivery of foetus / childbirth

→ complex neuroendocrine mechanism.

★ Signal from foetus → Placenta induce mild uterine contraction

(Placenta + foetus) * → foetal ejection Reflex → stimulate pituitary → Release oxytoxin → Stronger Uterine contraction → again stimulate pituitary → Release oxytoxin → more Strongers contraction

∴ Stimultory Reflex + continous oxytoxin secretion → Vigorous uterine contraction → parturation of infant



(24) Lactation

* mammary gland start producing milk
* Initial milk : Colostrum (IgA) → IgA antibody essential for Healthy baby

∴ Doctors suggest brest feeding during initial period

REPRODUCTIVE HEALTH

① Defination

* According to WHO Reproductive Health means well-being of physical, Emotional, behavioural, social

* India was 1st country → initate Reproductive Health as social goal
  ↓
  family planning progroms (1951)

* Currenty this operated under RCH {Reproductive child Health care}

★ RCH Objective

- Awareness about reproduction by audio-visual printmedia, NGO's, govt.
- Major role : parent, teacher etc
- Introduction of sex education

★ population

- According to 2011 census popⁿ growth was less than 2%.
- * Increased population due to
- Rapid decline in death Rate ↓
- MNR ↓, IMR ↓
- inc. ↑ in Reproductive age people
- inc. in Health facilities

② Amniocentesis

- Test based on chromosomal pattern & Genetic disorder
- Ban on Amniocentesis for sex determination to prevent (check on) female foeticides

③ Contreceptive methods

ⓐ Natural / Traditional methods (No side effect, but high risk)

↳ avoid chance of ovum & Sperm meeting.

- Periodic abstinence ; avoid coitus from day 10 to 17 of menstural cycle. (B/c it is fertile period)
- withdrawl / coitus interruptus
- Lactational Amenorrhea :→ Based on ovulation & cycle do not occur during the period intense lactation following parturation.
  (absence of menstruation)
  ↳ Hormone Based.
  Effective upto 6 month
  - side effect : Nil
  - failure Rate : High

(b) Barrier method

→ prevent fertilization. (prevent conception by blocking the entry of sperm through cervix)

eg:-
- condoms (both for male & female)
  - → Nirodh (male condom)
- Diaphragm
- Cervical caps
- Vaults

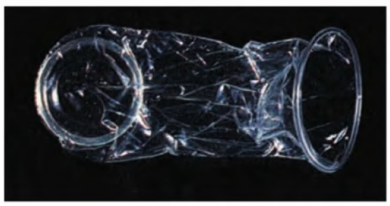
For females only → (cover cervix during coitus)

→ Reusable

* spermicidal creams (creams, jellies & foams) + along with barrier → increase contraceptive efficiency

* condoms prevents from STDs & AIDS

Condom for male



Condom for female

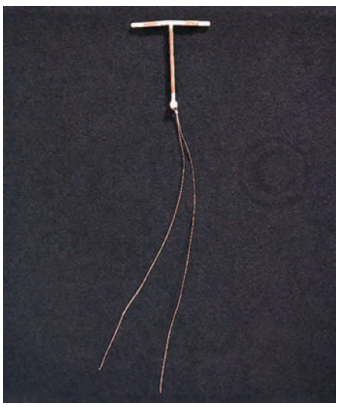
Diaphragm

vaults

(c) Intra uterine Device (IUDs) : females (To delay pregnency)

→ • Inserted by expert Doctors & Nurses in uterus
- IUDs increase phagocytosis of sperms in uterus.
- Most widely accepted methods

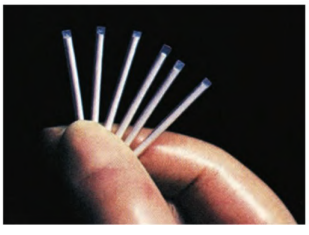
- Non-medicated IUDs : Lippes loop
- copper releasing IUDs → CUT, CU 7, Multiload 375
  - → Cu ions supress → sperm motility ↓, fertilising capacity of sperm ↓
- Hormone Releasing IUDs → progestasert, LNG-20
  - → makes uterus unsuitable for implantation & cervix Hostile for sperms



Copper-T

(d) Implants

- Progestogens (or) progestogens + estrogens { used by female as injection (or) implants under skin
- mode similar to oral pills
- long period effective



ⓔ **Oral pills**

- progestogens
- progestogen-estrogen

→ consumed in the form of tablets. (by females)

★ inhibit ovulation, implantation.
★ Alter quality of cervical mucus to prevent entry of sperm

- very effective & lesser side-effect

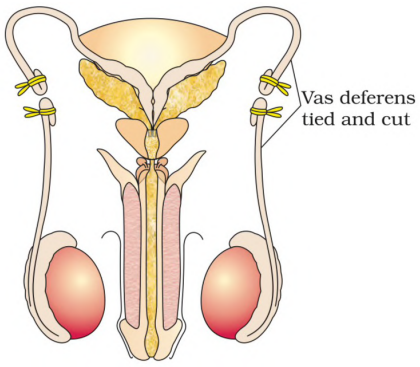
★ **Timing**
- pills have to taken daily for 21 days period.
- Start within first five days of Menstrual cycle
- After Gap of 7 days → repeted again in same pattern
  (menstruation occur)

VVIP
*Emergency contraceptions
↓
use of oral pills/ IUDs within 72 hours of coitus (very effective)

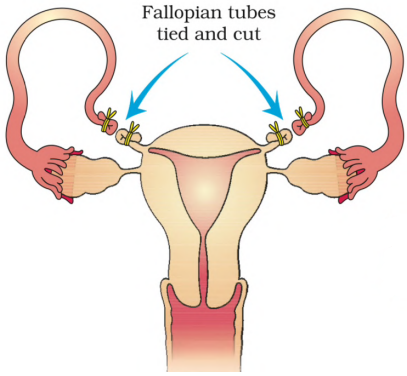
★ **Saheli** (few side effect & high contraceptive valve)
- new oral contraceptive
- Developed at CDRI, Lucknow → central drug Research institute
- Non-Steroidal
- once/week

④ **Surgical Method / Sterilisation**
- permanent method (irreversible) → no effect on sexual desire
- blocks gamete transfer & prevent conception

Vasectomy
- In male, small part of Vas deference removed & tied up (seman without sperm)



Tubectomy
- In female, small part of fallopean tube removed & tied up



★ **Ill effect of contraception:** nausea, abdominal pain, bleeding, irregular menstrual, breast cancer

⑤ Medical termination of pregnancy (MTP) → legal: 1971

↳ Termination of pregnancy by voluntary means abortion

* Safe during 1st trimester (upto 12 weeks)
* Second Trimester → abortions are much more risky.

The Medical Termination of Pregnancy (Amendment) Act, 2017 was enacted by the government of India with the intension of reducing the incidence of illegal abortion and consequent maternal mortality and morbidity. According to this Act, a pregnancy may be terminated on certain considered grounds within the first 12 weeks of pregnancy on the opinion of one registered medical practitioner. If the pregnancy has lasted more than 12 weeks, but fewer than 24 weeks, two registered medical practitioners must be of the opinion, formed in good faith, that the required ground exist.

⑥ STDs

⇒ Sexually transmitted diseases (STDs) / venereal diseases (VD) / Reproductive tract infection (RTI)

* Also Transmitted through → • Sharing infection, • Surgical instrument, • transfusion of Blood, • from infected mother to foetus.

eg:
- Gonorrhoea
- Syphilis
- Chlamydiasis
- Genital warts
- Trichomoniasis

→ Curable (If detected at early stage)

- Hepatitis-B
- Genital Herpes
- AIDS (HIV infection) → most dangerous

→ non-curable

VIPS

* Early symptoms of STDs → itching, fluid discharge, slight pain, swellings (in genital part)

* If not treated/detected early →
- Pelvic inflammatory diseases
- abortions, still births
- ectopic pregnancies
- infertility, cancers in RT

* Precautions

(i) Avoid sex with unknown partners/multiple partners.
(ii) Always try to use condoms during coitus.
(iii) In case of doubt, one should go to a qualified doctor for early detection and get complete treatment if diagnosed with infection.

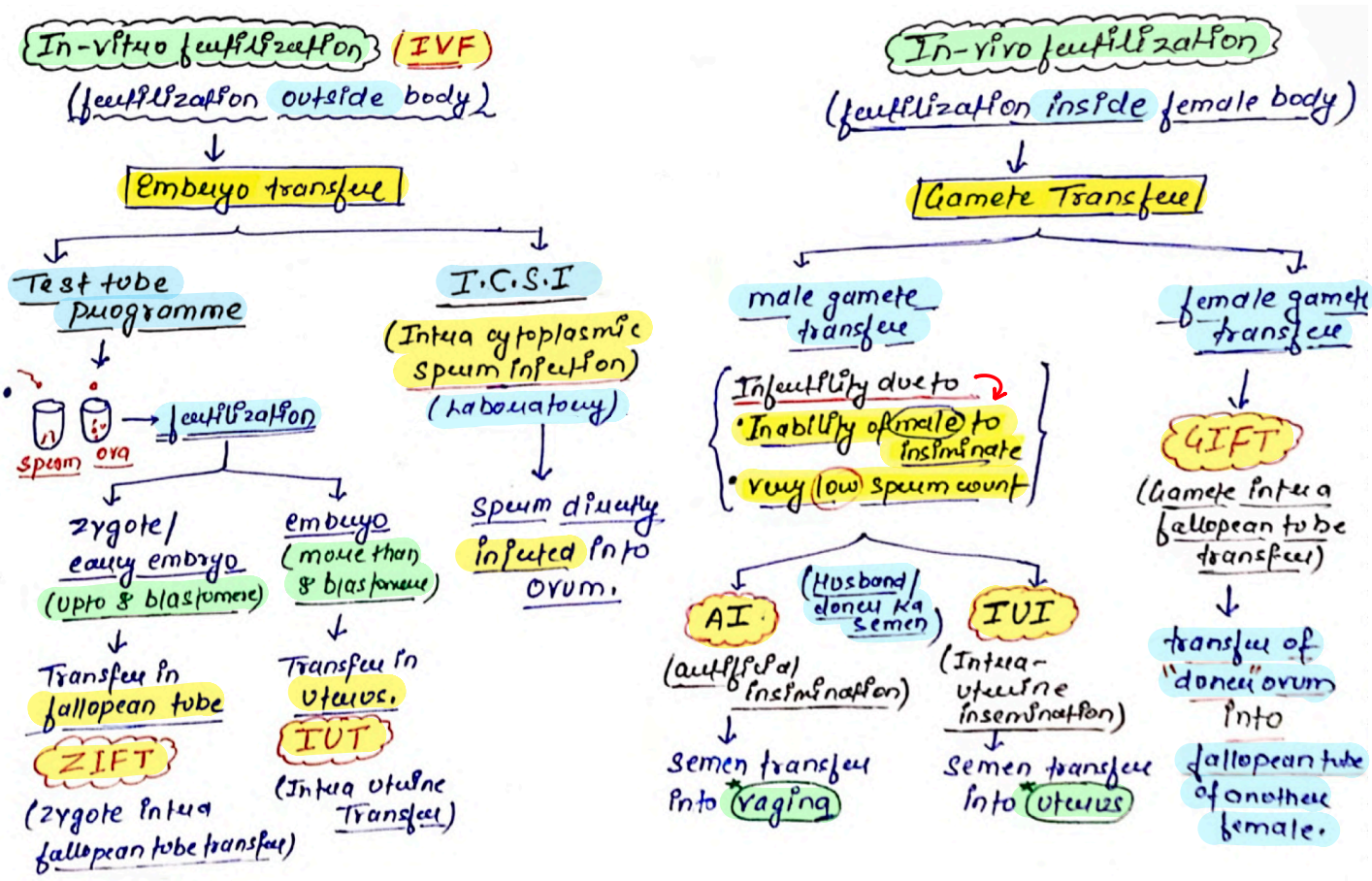
⑦ Infertility

- Inability to concive children even after 2-years of unprotected sex

* To correct Infertility → Techniques (where clinical dignosis not possible) → ART (Assisted Reproductive technique)

ART
- in-vitro (embryo transfer) • ZIFT, IUT, ICSI
- in-vivo (gamete transfer) • AI, IUI, GIFT

⑧ ART (Assisted Reproductive technique)



PRINCIPLES OF INHERITANCE AND VARIATION

① Gregor John Mendal

- 7 years (1856-1863)
- 7 characters of garden pea (pisum sativum)

Character	Dominant trait	Recessive trait
Seed shape	Round R	Wrinkled r
Seed colour	Yellow Y	Green y
Flower colour	Purple/ voilet V	White v
Flower position	Axial A	Terminal a
Plant height	Tall T	Short t
Pod shape	Inflated P	Constricted p
Pod colour	Green G	Yellow g

- Small plant, easily grow in small area
- Short life cycle (3-4 month)
- clear variation in character
- easily self pollinated & cross pollinated
- easily obtain pure line / true breeding
- single cross produce large no. of seed

② Imp points:

Gene → Segment of DNA which synthesise RNA

v/s

Allele → Varients of gene

Gene ↗ T/R ↘ t/r

Homozygous → Same gametes (TT), (tt)

v/s

Heterozygous → different Gametes (Tt)

Locus

T T → Locus : if locus have same allele (Homozygous)

R r → Locus : if locus have diff allele of same gene (Heterozygous)

Homologous chromosome

Dominant → in Heterozygous condⁿ, Factor which expres it self → Dominant (Tt) = Tall

v/s

Recessive → in Heterozygous condⁿ, Factor that not expresses → Recessive (it expres itself in Homozygous condⁿ)

- tt = dwarf

Genotype → Genetic makup

v/s

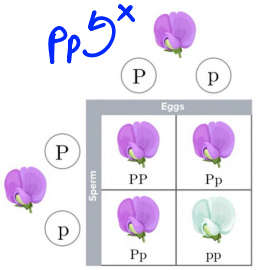
Phenotype → physical appearence (depend: • Genotype • environment factors)

- TT → Tall
- Tt → Tall
- tt → dwarf

Punnet square

Reginold C. punnet (British scientist)

* it tells about possible gametic combination



Pure plant / True breeding / Homozygous

→ They on continous self pollination show stable trait inheritance (one phenotype)

→ Recessive character are always pure line

* Mendal select 14 true breeding pea plant varieties (7-pairs)

③ Law of Dominance

- Characters are controlled by factors (discrete unit)
- Factors occur in pair
- In dissimilar pair of factors → one dominates (expressing chr)
  → other recessive (non-expressing chr)
- In monohybrid cross → F_1: only one parental character expresses
  → F_2: both the parental character expresses

monohybrid cross

parental: TT x tt

T t

F_1: Tt

selfing

Tt x Tt

F_2:

	T	t
T	TT	Tt
t	Tt	tt

- Phenotypic Ratio: 3 : 1 (tall : dwarf)
- Genotypic Ratio: 1 : 2 : 1 (TT : Tt : tt)

④ Law of segregation

- Based on: factors/allele do not show blending (Both parental chr recovered in F_2 gen.)
- Factors segregate at time of gamete formⁿ.

→ Homozygous: produce similar type gametes

→ Heterozygous: produce two kinds of gametes (each having one allele with equal proportion)

TT x tt

F_1: Tt

F_2: TT, Tt, Tt, tt

∴ Factors do not show blending

B/C Reappearence of dwarf chr in F_2, which was not seen in F_1.

⑤ Test cross

Unknown Tall × Recessive parent

TT Tt × tt

Tt

100% tall

Tt, tt

50% tall, 50% dwarf

∴ To identify unknown genotype, mendal cross it with Recessive parent

- If 1 type of phenotype observed ∴ unknown → TT (1 gamete)
- If 2 type of phenotype observed ∴ unknown → Tt (2 gamete)

Test cross: • PR = GR = 1 : 1

⑥ Incomplete dominance

→ F_1 offspring / phenotype does not resemble any of parent

eg: Dog flower / Snapdragon / Antirrhinum species

parent: Red (RR) × white (rr)

R, r

F_1: pink (Rr)

F_2: Red (RR), pink (Rr), pink (Rr), white (rr)

do not show blending

* In incomplete dominance
- law of segregation ✓
- law of dominance ✗

- PR: Red : pink : white = 1 : 2 : 1
- GR: RR : Rr : rr = 1 : 2 : 1

∴ PR = GR

⑦ Normal Allele → (Mutation) → Modified Allele

Normal Allele → Form → Normal enzyme → Normal phenotype → Dominant trait

Modified Allele → Form →
- less Functional enzyme (less efficient) → equivalent to unmodified allele → Dominant trait
- Non-Functional enzyme
- No enzyme

→ Reduced / effected phenotype → Recessive trait

⑧ Co-dominance

→ F_1 gen. resembles both the parent

→ In Hetrozygous condn → Both allele expresses (Both capital letter)

eg: AB Blood group, cattle hair colour, Gene of sickle cell anemia

Red bull (RR) × white cow (WW)

R, W

RW Roan

RR, RW, RW, WW

(Red bull) (Roan) (Roan) (white cow)

- PR: Red : Roan : white = 1 : 2 : 1
- GR: RR : RW : WW = 1 : 2 : 1

∴ PR = GR

PR = GR → Test cross = 1 : 1
→ co-dominance = 1 : 2 : 1
→ Incomplete dominance = 1 : 2 : 1

⑨ Multiple allele

- if gene have more than two allele / varients

eg: ABO Blood group (I gene) → 3 allele → I^A, I^B, i
- I^A, I^B → Dominant allele → produce slightly different suger.
- i → Recessive allele → do not produce suger.

Genotype	Phenotype
I^AI^B	AB (co-dominance)
I^AI^A	A
I^Ai	A
I^BI^B	B
I^Bi	B
ii	O

∴ Total Genotype: 6

• Total phenotype: 4

* For max^m posibilities → select Heterozygous parent

Allele from Parent 1	Allele from Parent 2	Genotype of offspring	Blood types of offspring
I^A	I^A	I^AI^A	A
I^A	I^B	I^AI^B	AB
I^A	i	I^Ai	A
I^B	I^A	I^AI^B	AB
I^B	I^B	I^BI^B	B
I^B	i	I^Bi	B
i	i	ii	O

eg: F (AB, I^AI^B) × M (O, ii)

	A	B
O	AO	BO
O	AO	BO

∴ Child : I^Ai = A

I^Bi = B

F (A, I^Ai) × M (?)

Child (B, I^Bi)

- I^BI^B : B
- I^Bi : B
- I^AI^B : AB

eg: As per ABO blood grouping system, the blood group of father is B^+, mother is A^+ and child is O^+. Their respective genotype can be

A. $I^Bi/I^Ai/ii$ ✓

B. $I^BI^B/I^AI^A/ii$

C. $I^AI^B/iI^A/I^Bi$

D. $I^Ai/I^Bi/I^Ai$

E. $iI^B/iI^A/I^AI^B$

Choose the most appropriate answer from the options given below:

1. B only
2. C & B only
3. D & E only
4. A only ✓

I^BI^B / I^AI^A / ii

I^Bi I^Ai

ii

Neet-2024

(10) Dihybrid cross (Two character)

Parental: Round & yellow RR YY × wrinkled & green rryy

F1 gen: (RrYy) (Round & yellow) ✗

F2 gen:

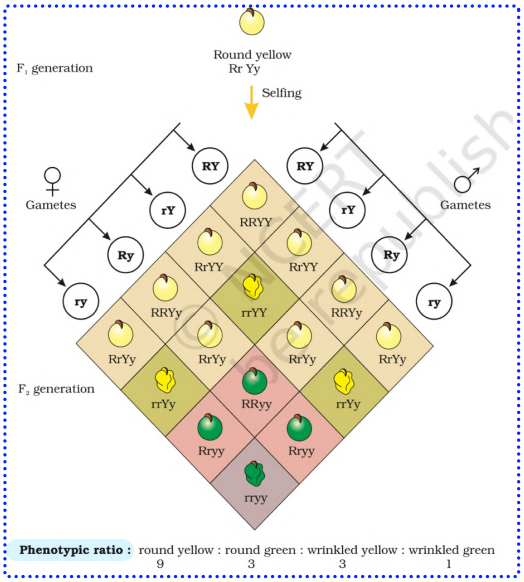
	RY	Ry	rY	ry
RY	RRYY	RRYy	RrYY	RrYy
Ry	RRYy	RRyy	RrYy	Rryy
rY	RrYY	RrYy	rrYY	rrYy
ry	RrYy	Rryy	rrYy	rryy

(3:1)(3:1)

Phenotypic ratio: Round & yellow (3×3) 9 : Round & Green (3×1) 3 : wrinkled yellow (1×3) 3 : wrinkled Green (1×1) 1

Genotypic ratio: (1:2:1)(1:2:1) = 1:2:1:2:4:2:1:2:1

(RrYy)



P → 9:3:3:1

G → 1:2:1:2:4:2:1:2:1 (Dihybrid cross)

* Parental type: 10
* Non parental: 6 (Recombinant)

(11) Law of independent assortment

- Based on dihybrid cross observation.
- When two pairs of traits are combined in hybrid then segregation of one pair of trait is (independent) of other pair trait

★ Round & yellow (RRYY) × wrinkled & green (rryy)

(RrYy)

Round & Yellow | wrinkled Green | Round Green | wrinkled yellow

Round & Yellow, wrinkled Green → parental type

Round Green, wrinkled yellow → Non-parental type

Suggest independent assortment.

* Duplicative → 15:1
* Additive → 9:6:1
* collaborative → 9:3:3:1
* Dominent epistasis → 12:3:1
* Recessive epistasis → 9:3:4

(12) Mendal work

- Mendal → 7 years (1856-1863)
- Mendal published his work → 1865 *
  - Inheritance of character
- Mendal unrecognised till → 1900
  - Reason for unrecognisation
    1. communication was not easy
    2. His concept of genes/factors as stable & discrete unit
       ∴ characters are controlled by factor
       - pair of alleles which did not blend, not accepted by his contemporary,
    3. Using Mathematics in biology.
    4. Mendal suggested factors/gene were discrete unit but he failed to provide physical proof.

1900
↓
3 scientist
↓
de-vries, correns & von tschermark
↓
they independently rediscovered Mendal's work

1902
↓
Chromosome discovered (colour bodies)

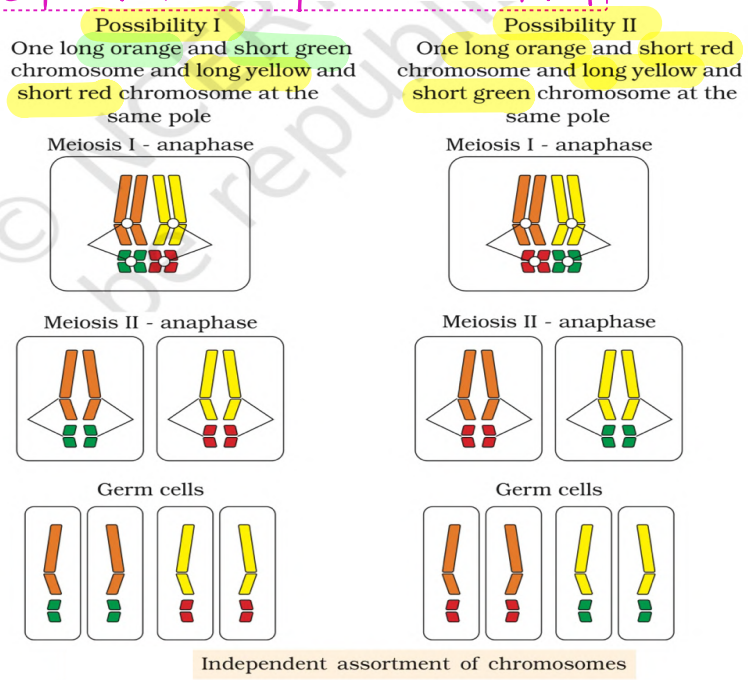
(13) Sutton & Boveri

↓

★ observe chromosome movement during cell devision
↓
Behaviour of chromosomes parallel to behaviours of gene

* They used chromosome movement to explain Mendal's law

★ Experiment on independent assortment



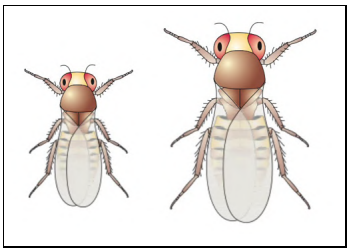
Independent assortment of chromosomes

Mendal expt
- Behaviour of gene/factor
- Factors occur in pair (TT, Tt, tt)
- Factors segerate at time of gamete formation
- one pair segerate independently

Sutton & Boveri's expt
- Behaviour of chromosome
- Chromosome occur in pair (88)
- Chrm. segerate at time of gamete formation (meiosis)
- Independent pair segerate independently

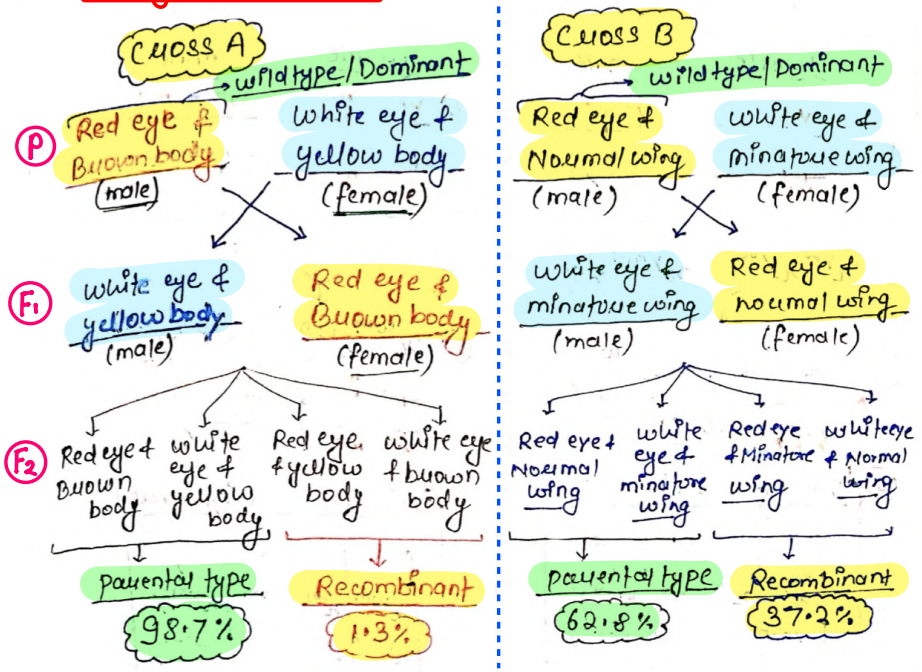
(14) Chromosomal theory of inheritance

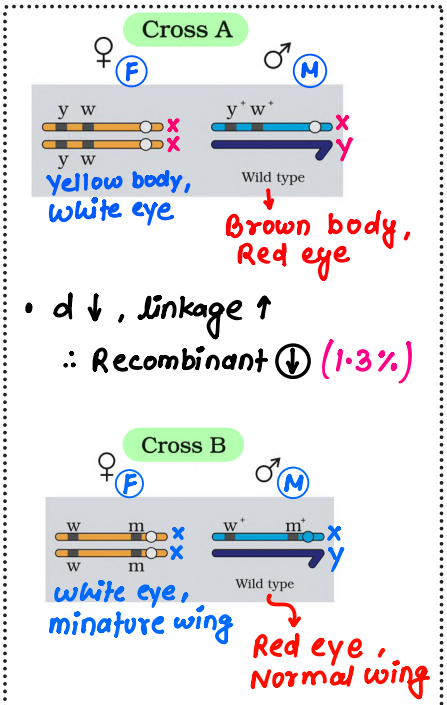
- Sutton & Boveri → pairing & seperation of chromosome lead to pairing & seperation of pair of factors. (they carried)
- Sutton → united knowledge of chromosome & factor behaviour → give → Chromosal theory of inheritance (Gene/factors present on chromosome)
- Experimental verification ⇒ Thomas Hunt Morgan (He used Drosophilla Melanogaster (fruit fly))



- Grown on simple synthetic medium
- Short life cycle (2 weeks : 14 days)
- Single mating can produce large number of progeny
- clear differentation in saxes (male & female)
- Many types of Hereditary variations

(15) Morgan's Cross





- d ↓, linkage ↑ ∴ Recombinant ↓ (1.3%)
- d ↑, linkage ↓ ∴ Recombinant ↑ (37.2%)

* parental type always greater than Recombinants

★ Distance b/w gene ∝ crossing over ∝ Recombinant ∝ $\frac{1}{\text{Linkage}}$

(16) Some important points

- Recombinants are the result of crossing over.
- parental type > Recombinants
- (+) → dominant type
- crossing over only possible in XX chromosome.
  - ★ B/C: Homologous chromosome
- ★ Morgan coined term linkage → physical association of Gene on chromosome
  - term Recombination → Generation of non-parental combination (Recombinant)
- Morgan → father of experimental Genetics
- Recombination frequency → $R = \frac{\text{No. of Recombinants}}{\text{Total offspring}} \times 100$
  - Total offspring = parental + Non parental (Recombinant)

(17) Genetic map

- ★ Alfred Sturtevent (student of Morgan)
  - ★ He used Recombination frequency to measure distance b/w genes & mapped their position of chromosome.
    - Genetic map
    - Distance b/w Gene ∝ Rf
- ★ Unit of dist^n b/w gene
  - In Eukaryotes
    - Rf = 30%
    - distance = 30 b/w gene
      - ★ centimorgan
  - prokaryote
    - Rf = 20%
    - dist^n b/w = 20 gene
      - Map unit

Q.

Assertion (A) : Mendel's law of independent assortment does not hold good for the genes that are located closely on the same chromosome.

Reason (R) : Closely located genes assort independently.

In the light of the above statements, choose the correct answer from the options given below : 2022

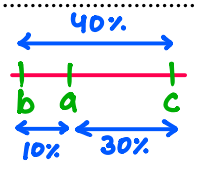
A. Both (A) and (R) are correct and (R) is the correct explanation of (A)

B. Both (A) and (R) are correct but (R) is not the correct explanation of (A)

C. (A) is correct but (R) is not correct

D. (A) is not correct but (R) is correct

Q: Rf: • a—c : 30%
• a—b : 10%
• b—c : 40% ✓



(18) Polygenic inheritance

many Gene → 1 effect

eg:
- Range of Human Height
- Human skin colour

* Phenotype reflect contrib of each allele
  - effect of allele is additive
  - eg A, B, C → dark colour
    a, b, c → light colour
  - ∴ AABBCC : darkest skin
    aabbcc : lightest skin
    AaBbCc : intermediate skin colour.

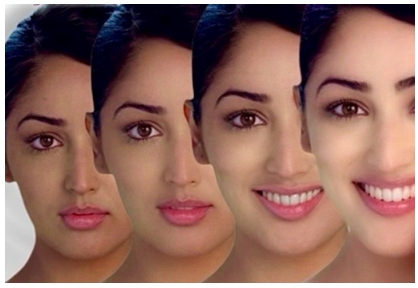
* polygenic inheritance influence by environment.

Pleiotropy

Single Gene → many effect

eg:
- Gene on metabolic pathway
- Phenylketonuria (PKU)
  - caused by single gene mutation
  - its phenotypic expression
    - → mental retardation,
    - → Hair loss,
    - → Skin pigmentation
- Starch grain size.
  - BB → large size.
  - Bb → intermediate size.
  - bb → smaller size.

incomplete dominance

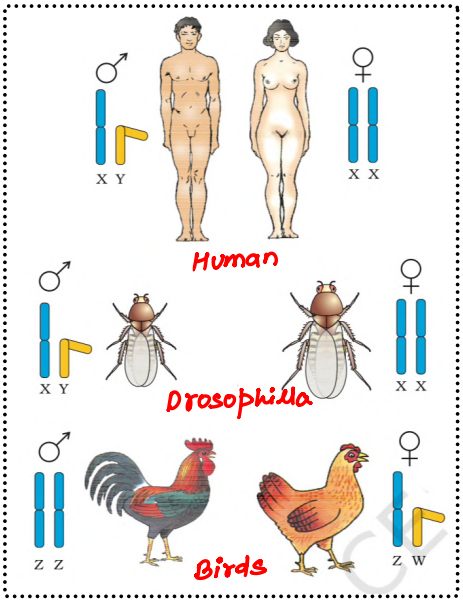


PHENYLKETONURIA

(19) Sex determination

male Heterogamety
- XY & XX (male)
  - Humans
  - Drosophila
- XO & XX (male)
  - Grasshopper

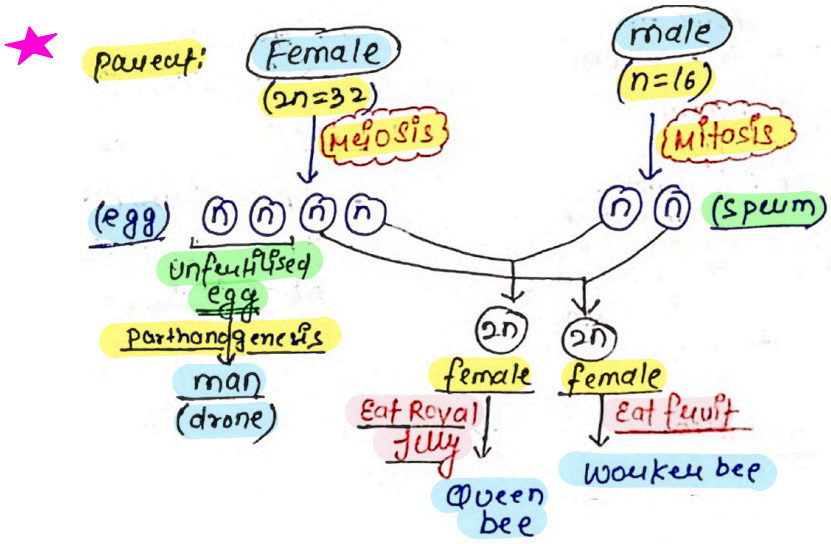
Female Heterogamety
- ZW & ZZ (female)
  - Bird
- ZO & ZZ (female)
  - Butterfly
  - moth

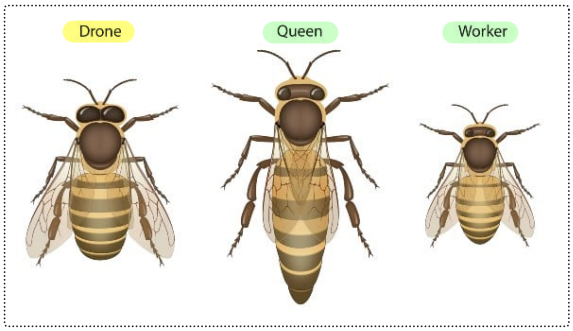


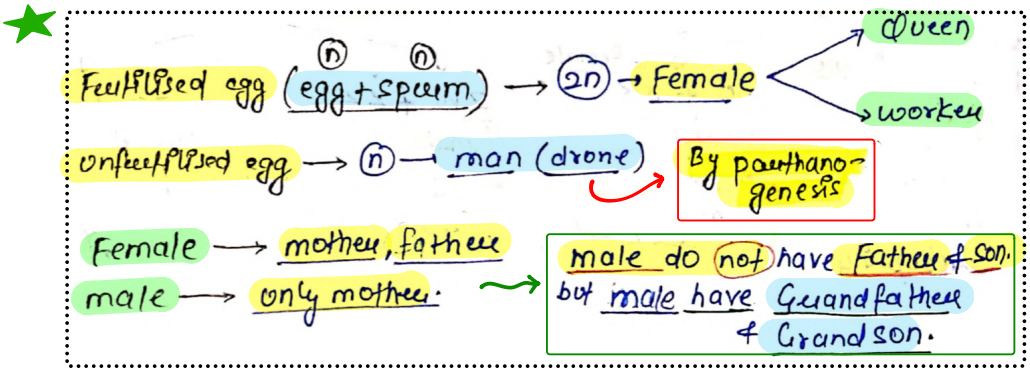
* Sex determination in Humans
  - XY type, 23 pair of chromosomes
    - 22 pair: Autosomes
    - 1 pair: sex chromosome (XX/XY)

(In each pregnancy there is always 50% probability of either male/female child)

* Sex determination in Honey bee
  - * Haplo-diploidic sex determination
  - → males: n (16) : Haploid
  - → Females: 2n (32) : Diploid
  - ⇒ Based on number of sets of chromosomes an individual receives







(20) Mendelian Disorders

By Mutation / alteration in single gene (inheritable from parent to offspring)

- **Sex linked / X-linked recessive**
  - Haemophilia, colour blindness
- **Autosome linked recessive**
  - Cystic fibrosis, PKU, Albinism, Sickle cell anamia, Thalesemia
- **Autosome linked dominant**
  - Myotonic dystrophy

(a) HAEMOPHILIA

→ X-linked Recessive (hh)

→ Affected Clotting of Blood → (cascade of proteins)

∴ a simple cause Non-stop bleeding

→ eg: Family pedigree of Queen victoria (Haemophilic carrier)

- X^hX^h → Diseased female
- XX → Normal female
- X^hX → Normal but carrier female
- X^hY → Diseased male
- XY → Normal male

(Death at later stage / Adolescence)

- X^hX^h → Diseased female → Extremely Rare

B/c it need X^hX (carrier mother) XX^hY (Diseased father)

Diseased male died in later stage

(b) COLOUR BLINDNESS

→ X-linked Recessive (c.c)

→ Defect in (Red / green) cone of eye

∴ Fail to differentiate b/w Red & green colour

* males → 8%
  females → 0.4%
  → B/C Genes that lead colour-blindness present on X-chromosome.
  ∴ Male have only 1 'X' chromosome
  ∴ disorder percentage is high.

* • $X^C X^C$ → colourblind female
  • X X → Normal female
  • $X^C X$ → carrier female
  • $X^C Y$ → colourblind male
  • X Y → Normal male

eg $(X^C X) \times (X^C Y)$

	X^C	Y
X^C	$X^C X^C$	$X^C Y$
X	$X^C X$	X Y

→ 50% child disease (3/4)
→ 50% female child disease (1/2)
→ 50% male child disease (1/2)

(c) SICKLE CELL ANAEMIA

→ Autosomal recessive

→ change in shape of RBC (Biconcave → Sickle shape)

* $Hb^A Hb^A$ → Normal
  $Hb^A Hb^S$ → Carrier (Heterozygous)
  $Hb^S Hb^S$ → Diseased (SCA)

* Hb^A → A
  Hb^S → a
  (Autosomal)
  • AA → Normal person
  • Aa → Normal person
  • aa → diseased person

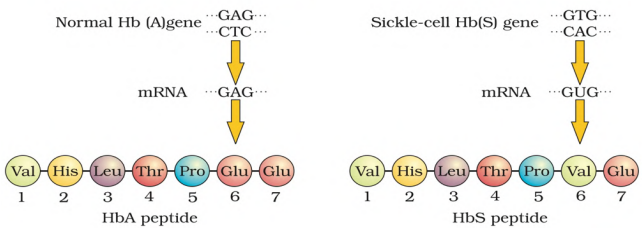
* Normal allele → GAG → Glutamic acid (Glu)
  Mutated / SCA allele → GUG → Valine (Val)

* Due to single base subst at 6th codon of β-Globin Gene (GAG → GUG)
  ↓
  Subst of Glutamic acid to valine at 6th position of β-chain of Haemoglobin

★ Normal person

SCA person

RBC (Biconcave Disc shape) → polymerisation in low O_2 → elongated (Sickle shape)



(point mutation)

(d) PHENYLKETOUREA

→ Autosomal recessive

→ Inborn error in metabolism. (due to single gene mutation)

* Phenyl-alanine → (Enzyme ✓ : Phenyl-alanine hydroxylase) → Tyrosine

* Mutation in Gene that code for enzyme ∴ Enzyme (X)

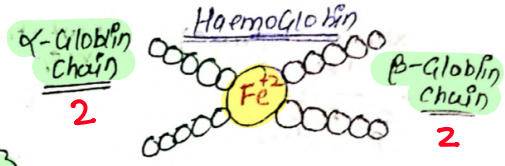
∴ Phenyl-alanine (Accumulation) → (Enzyme (X)) → Phenyl-Pyruvic acid

* Accumulation of phenyl alanine in brain results
→ mental retardation, hair loss, skin pigmentation,

* These are excreted through urine
B/C of its poor absorption by kidney.

PHENYLKETONURIA

(c) THALASSEMIA



→ Autosomal - Recessive

→ Blood Disease / Anaemia

due to mutation/deletion in Globin Chain (α & β Chain)

↓

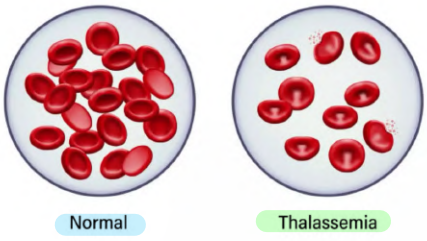
Rate of synthesis of one of globin (↓)

↓

Form^n of Abnormal Haemoglobin

↓

Anaemia



α - Thalassemia

↓

- α-globin affected
- controlled by Two closely linked Gene HBA1 & HBA2

↓

present on (CN=16)

- observed due to Mutation of one / more than 4 gene.

V/S

β - Thalassemia

↓

- β-globin affected
- controlled by single gene HBB

↓

present on (CN=11)

- due to mutation in one / both genes.

Blood related disorders

* Thalassemia
↓
Quantative problem
(synthesising very few globin molecule)

* Sickle cell anaemia
↓
Qualitative problem
(synthesising incorrect functioning globin)

(21) Chromosomal disorders

↳ due to absence/excess/abnormal arrangement of one or more chromosomes

Aneuploidy → DS, TS, KS

- Failure of Anaphase II
  ↓
  failure of segregation of Chromatids during cell division
  ↓ results
  Gain/loss in chromosomes

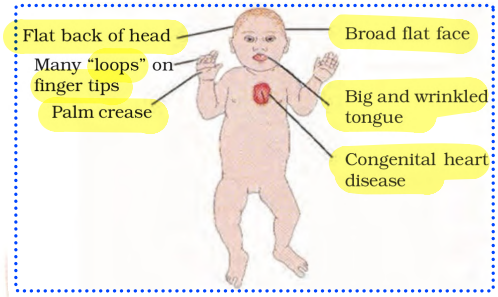
polyploidy (usually in plants)

failure of cytokinesis after telophase stage of cell division
↓ Results
↑ inc. in whole set of chromosomes

(a) Down's syndrome

→ Gain of extra chromosome -21 (Autosome)
→ Trisomy of 21
→ Discovered by London Dolon in (1866)
→ Effect:
- Short Statured person
- physical/mental/psychomotor
  ↳ devpt: Retarded

⇒
- Head: Small-Round, flat in back
- Face: Broad-flat
- mouth: partially open
- tongue: Big wrinkled-furrowed
- Heart: congenital disease
- palm: Broad-Crease
- finger: many loops.



(b) Klinefelter's syndrome

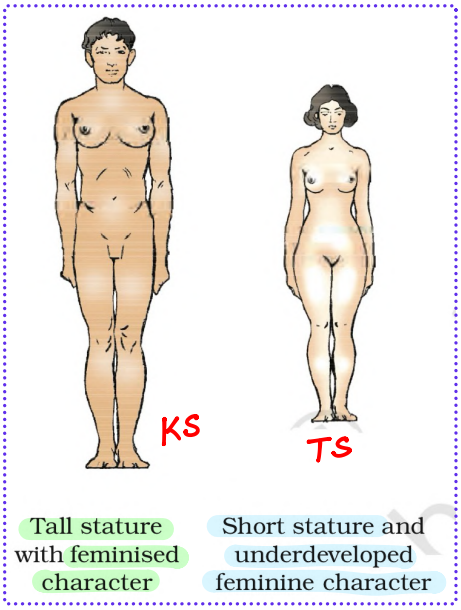
* Gain of extra X-chromosome
↓
XXY {trisomy}
↓
47 chromosome

* Effect
* overall masculine but
* feminine character develop.
* Gynaecomastia (development of Breast)
∴ Sterile male

(c) Turner's syndrome

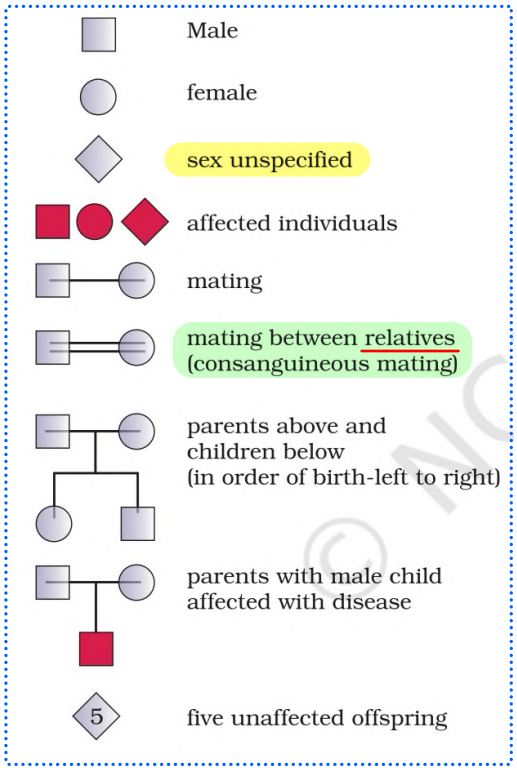
* loss of X-chromosome in female
↓
XO {monosomy}
↓
45 chromosome

* Effect
- Rudimentary ovaries
- lack of Sec-sexual character.
∴ Sterile female



(22) Pedigree Analysis

* Analysis of trait in several generation & study of family history about inheritance
* Analysis of trait whether it is → dominant / Recessive & sex-link / Autosomal



① Dominant v/s Recessive

Dominant → when disease present in every generation

Recessive → Disease Not present in each generation

② Autosomal v/s sex-linked

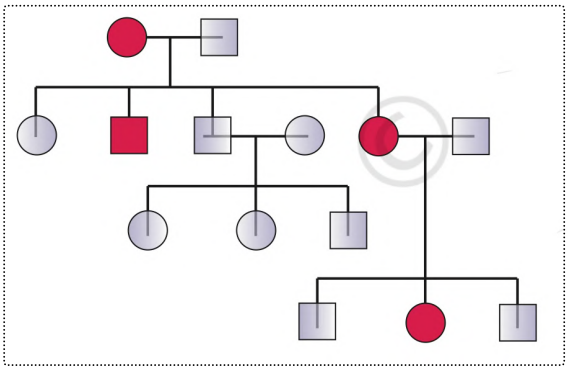
Autosomal → Disease present randomely in both sex.

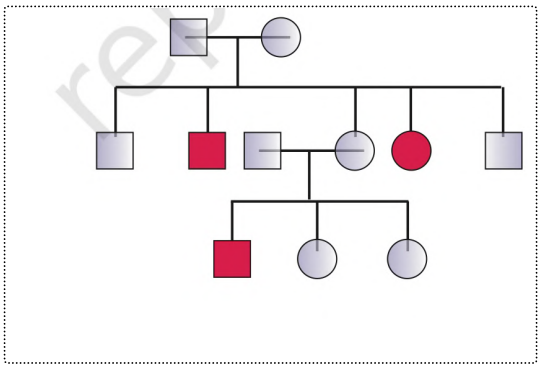
sex-linked → Y-linked → Disease only present in male

sex-linked → X-linked recessive
- Disease present in few males.
- females are carriers

* Transmission from carrier female → male progeny

Q.





- Autosomal Dominant (Myotonic dystrophy)

Autosomal Recessive (Sickle cell anaemia)

(23) Mutation

→ caused by UV Radiation

- factor that cause mutation c/a: Mutagen
- Alteration of DNA sequence / chromosome → change in genotype & phenotype

Gene mutation

Insertion, Deletion, Substitution

AAAAA → AAUAAA (insertion)

AATGC → AAGC (deletion)

GAG (Glu) → GUG (Val) (substitution)

Chromosomal mutation

- loss / gain of segment of DNA
- commonly observed in cancer cells

Point Mutation

- change in single base pair of DNA

eg: Sickle cell animia (GAG → GUG)

Frameshift Mutation

(Frameshift insertion / deletion Mutation)

- Insertion / deletion of base pairs of DNA

AUG GGG CCC UUU — Mutation ✓

→ insert 1: AUG UGG GCC CUU U } change in Reading Frame

→ insert 2: AUG UUG GGC CCU UU } change in Reading Frame

→ insert 3: AUG UUU GGG CCC UUU } NO change in Reading Frame

(multiple of three)

Mutation ✗

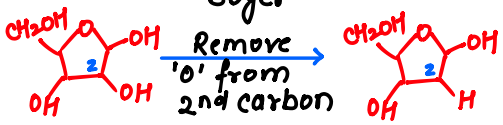
MOLECULAR BASIS OF INHERITANCE

① DNA

Deoxyribonucleotide → Three

Phosphate → ions of phosphoric acid (H_3PO_4)

Suger → Deoxy Ribose Suger



Ribose Suger (RNA) — Deoxy Ribose Suger (DNA)

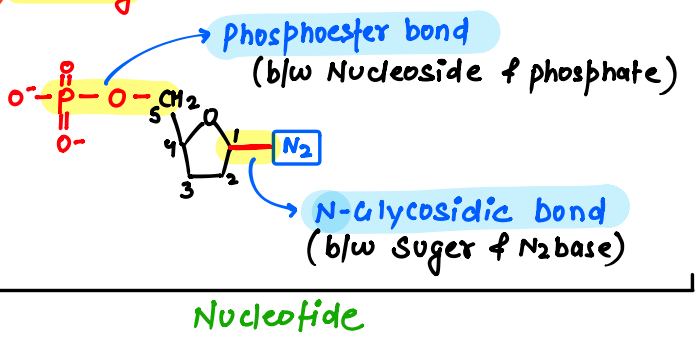
N_2-Base

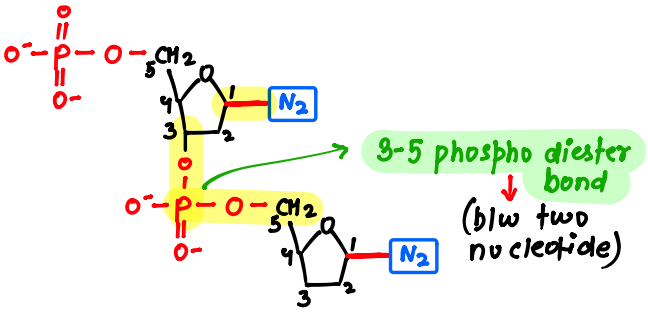
- **Pyrimidine**
  - Cytosine
  - Thymine (DNA)
  - Uracil (RNA)
  - 5 methyl uracil
- **Purine**
  - Adenine
  - Guanine

* Suger + N-Base → Ribonucleoside {Adenosine, Guanosine, Cytidine, Uridine}

Deoxysuger + N-Base → Deoxyribonucleoside {Deoxy Adenosine, Deoxy Guanosine, Deoxycytidine, Deoxy-thymidine}

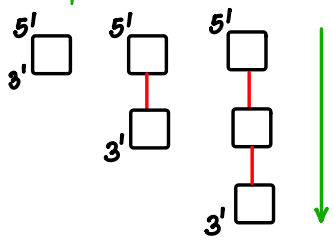
② Bonding





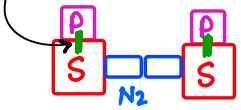
★ polymerisation

- polymerisation always takes place from 5 → 3



Ⓡ: B/c new nucleotide always adds on 3'-end of previous nucleotide

* Back bone → Suger + Phosphate



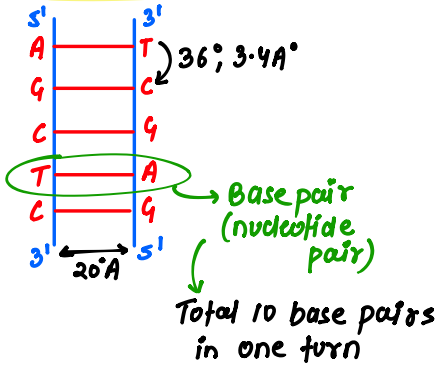
→ project inward from backbone

③ DNA characteristics

- 1st discovered by Friedrich Meichere (1869)
  - He discovered Acidic substance inside Nucleus
    - Named Nuclein

* Double Helix Model : watson & crick
  - Based on
    - X-ray diffraction data : Rosalind Franklin & Mourice wilkins
    - Chargaff's Rule

* Dimensions



- Dist^n b/w 2 nucleotide or a base pair = 3·4A° = 0·34 nm
- Pitch of helix = 34°A = 3·4nm
- Diameter of DNA = 20°A = 2nm
- turn b/w each BP = 36°
- One turn = 360° of DNA

④ Salient features of DNA

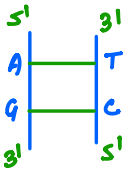
The salient features of the Double-helix structure of DNA are as follows:

(i) It is made of two polynucleotide chains, where the backbone is constituted by sugar-phosphate, and the bases project inside.

(ii) The two chains have anti-parallel polarity. It means, if one chain has the polarity 5′→3′, the other has 3′→5′.

(iii) The bases in two strands are paired through hydrogen bond (H-bonds) forming base pairs (bp). Adenine forms two hydrogen bonds with Thymine from opposite strand and vice-versa. Similarly, Guanine is bonded with Cytosine with three H-bonds. As a result, always a purine comes opposite to a pyrimidine. This generates approximately uniform distance between the two strands of the helix

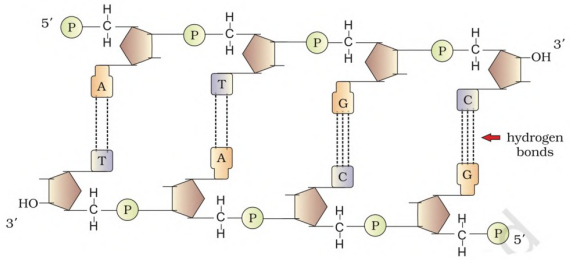
(iv) The two chains are coiled in a right-handed fashion. The pitch of the helix is 3.4 nm (a nanometre is one billionth of a metre, that is 10^{-9} m) and there are roughly 10 bp in each turn



A = T (2 H-bond)
G ≡ C (3H-bond)
Purine Pyrimidine

(v) Stability of DNA → • H-bond : purine always binds with pyrm^d

• 36° turn b/w BP : One base pair Stacks over another Basepair



⑤ Chargaff's rule

→ only for Double Helix

→ Amt of purine = Amt of pyrimidine

$A+G = C+T$

$\frac{A+G}{C+T} = 1$

- $A = T$
- $G = C$
- $A+T+G+C = 100\%$
- $A/T + G/C = 50\%$

eg: • A=30%

∴ T=30%
• G=20%
• C=20%

Imp Base pair

- ϕx174 Bacteriophage → 5386 nucleotide (SS DNA)
- Lambda Bacteriophage → 48502 base pair (DS DNA)
- E.coli → 4.6×10^6 Base pair (DS DNA)
- Human → Haploid → 3.3×10^9 BP (DS DNA)
  → Diploid → 6.6×10^9 Bp

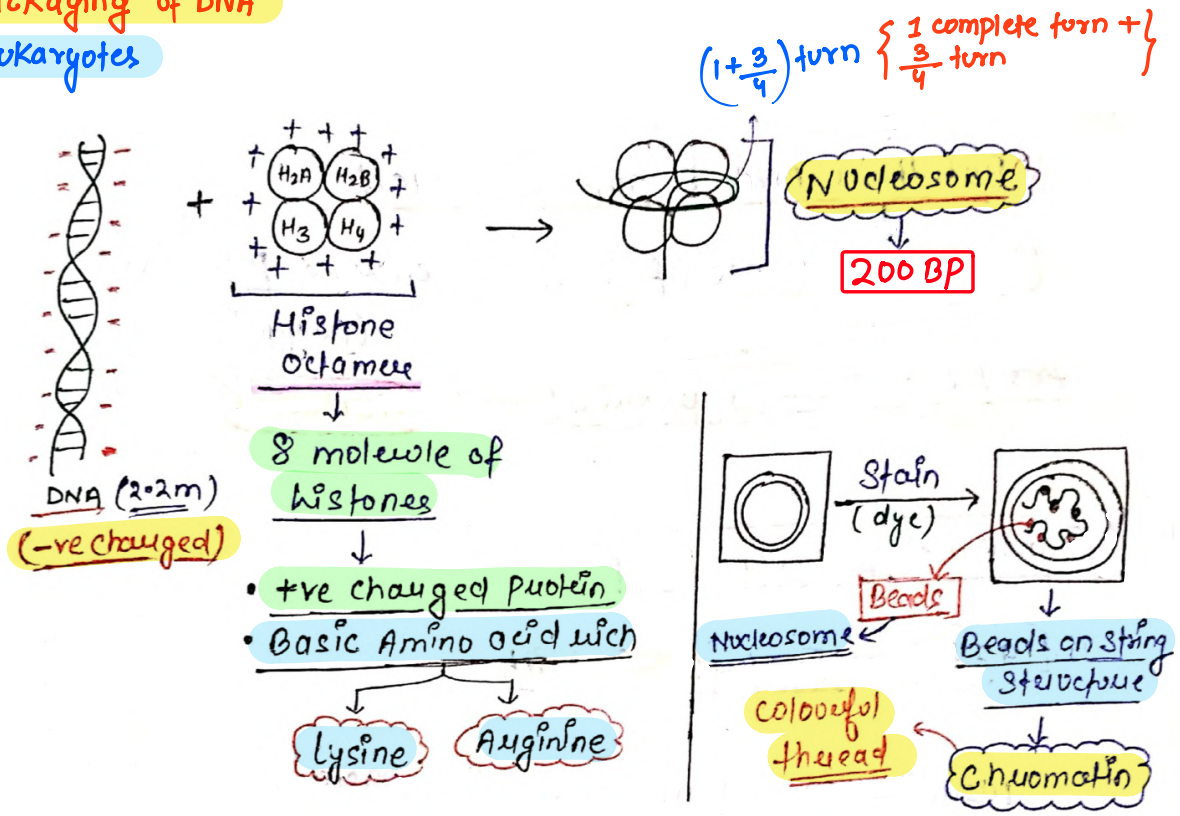
* Total length of DNA = total no. of base pair × $\frac{\text{distn b/w adj b.p}}{(3.4A^\circ)}$

$L = n \times d$

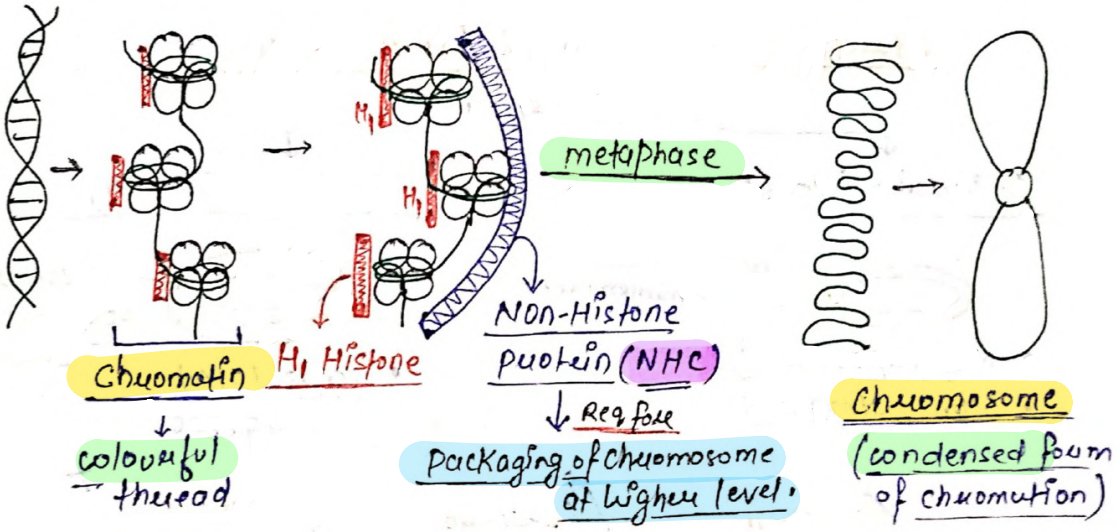
Q. *If the length of E. coli DNA is 1.36 mm, can you calculate the number of base pairs in E.coli?*

⑥ Packaging of DNA

ⓐ Eukaryotes



Packing



★ **Heterochromatin**

- Densely packed chromatin
  - Dark stained
- Transcriptionally inactive
  - (DNA —X→ RNA)

Euchromatin

- Loosely packed chromatin
  - Light stained
- Transcriptionally active
  - (DNA —✓→ RNA)

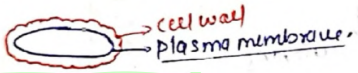
(b) Prokaryotes

Histones are absent & do not have well defined nucleus
↓
but their DNA is not scattered
Due to presence of some +ve charged proteins (polyamines)
↓
∴ DNA (-ve) in large loops held by protein (+ve) in Nucleoid.

(7) Transforming principle

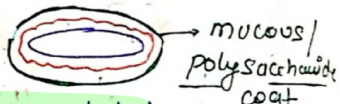
In 1928 → Fredrick Griffith
↓
working on pneumonia causing bacteria
↓
Streptococcus pneumonia / pneumoeccos
has two strain

R-strain (Rough)



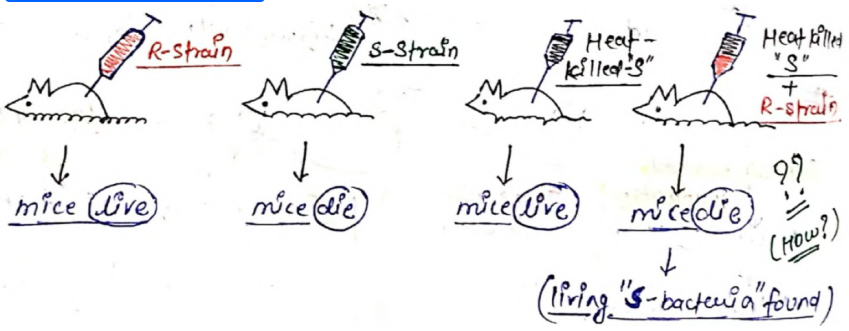
- Non capsulated
- Non pathogenic

S-strain (Smooth)

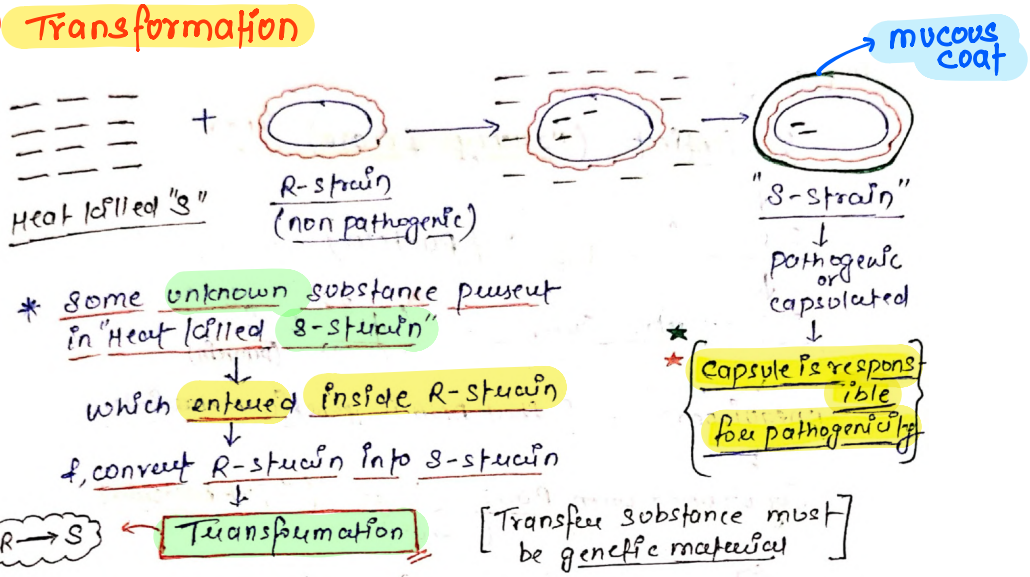


- capsulated
- pathogenic

Mice + Strain



⑧ Transformation



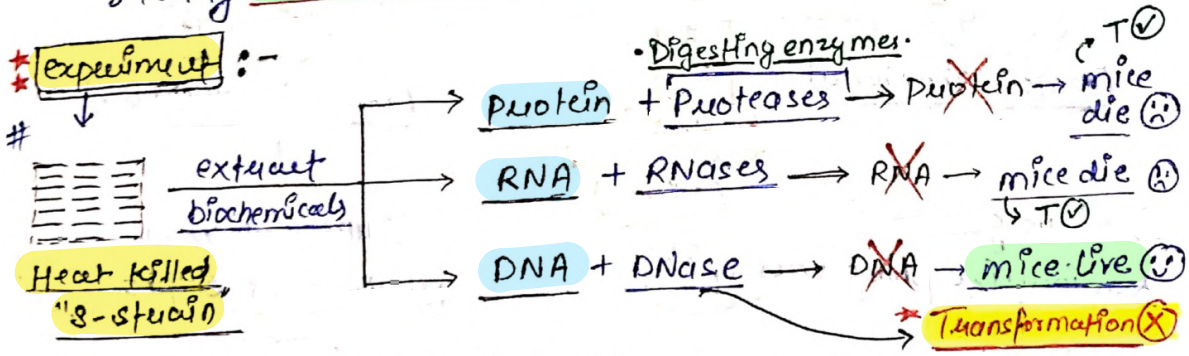
⑨ Biochemical characterisation

In 1933-44

3 scientist (Avery, Macleod & Mc Carty) ANM

3 Material (DNA / RNA / Protein)

Identify biochemical nature of transforming material.



* Experiment suggest that after digesting DNA with DNase

Transformation inhibit.

∴ They concluded that DNA is hereditary / transforming material.

⑩ Unequivocal proof / Experimental varification → 100% confirm

In 1952

↓

2 scientist (Hershey & Chase) HC

↓

2 material (DNA / Protein)

↓

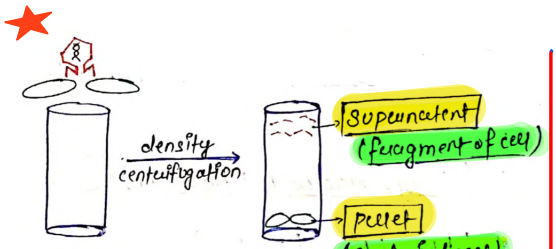
2 Radioactive substance * (P^{32} (DNA) & S^{35} (protein))

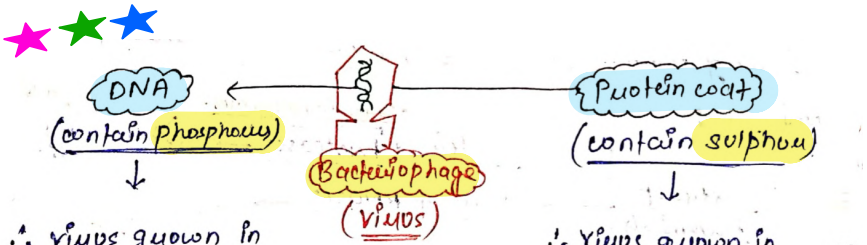
↓

Unequivocal proof that DNA is genetic Material.

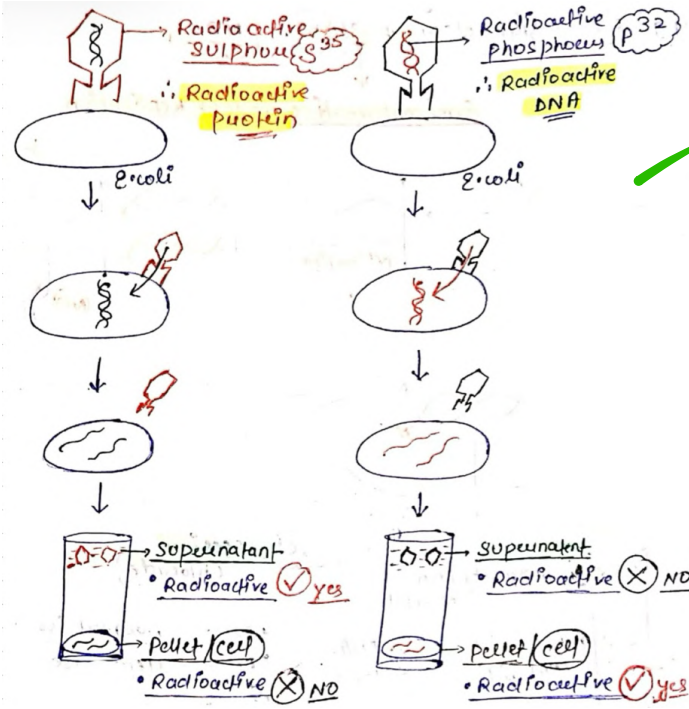
↓

They worked with Bacteriophages (Virus) (infect bacteria)





Experiment



① Infection (Radioactive material attach to bacteria E.coli)

↓

② Blending (Removal of viral coat)

↓

③ centrifugation (seperation of viral particle)

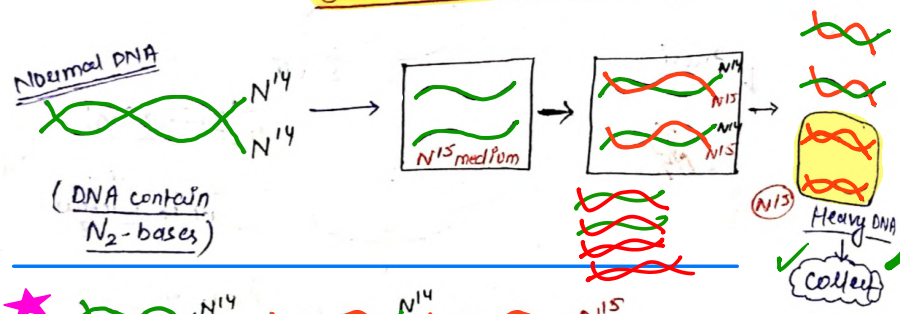
* If DNA is Radioactive, then bacterial cell Radioactive
that means, DNA is genetic material that pass from virus to bacteria

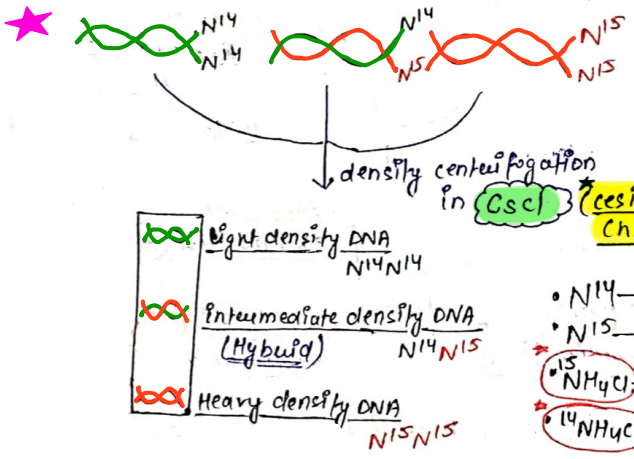
* If protein is Radioactive, then bacterial cell non-Radioactive
that means, protein not pass from virus to bacteria

(11) Density centrifugation

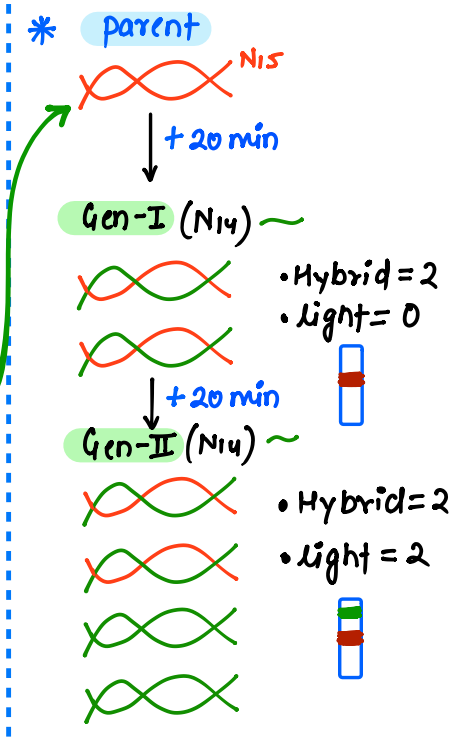
In 1958 → Meselson & Stahl

→ Semi conservative mode of Replication





- N^{14} → normal isotope.
- N^{15} → Heavy isotope.
- $^{15}NH_4Cl$ → N^{15} medium
- $^{14}NH_4Cl$ → N^{14} medium



- Hybrid DNA = 2
- Total DNA = 2^{Gen}
- Light DNA = $2^{Gen} - 2$

Meselson & Stahl grew *E.coli* in N^{15} ($^{15}NH_4Cl$) medium

↓

N^{15} incorporated into newly synthesised DNA

↓

Heavy DNA distinguished from normal DNA by density centrifugation in (CsCl), Heavy DNA collected.

↓

They transfer Heavy DNA (N^{15}) into N^{14} medium & took sample at various time intervals.

↓ after 20 min

- Gen-I : Had only hybrid or intermediate density (0 : 2)

↓ +20 (after 40 min)

- Gen-II : Had "light DNA" & "Hybrid DNA" in equal amount (2 : 2) (Light, Hybrid)

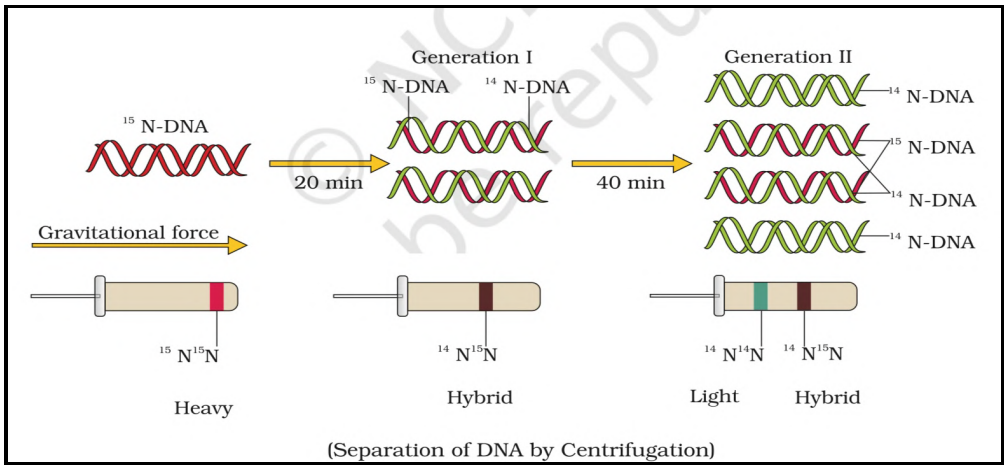
↓ +20 (after 60 min)

- Gen-III : Had light DNA more than Hybrid DNA ($N^{14}N^{14}$, $N^{15}N^{14}$) (6 : 2) (Light, Hybrid)

↓ +20 (after 80 min)

- Gen-IV : Light : Hybrid = 14 : 2

* *E.coli* divides in each 20 min
∴ Generation change in each 20 min



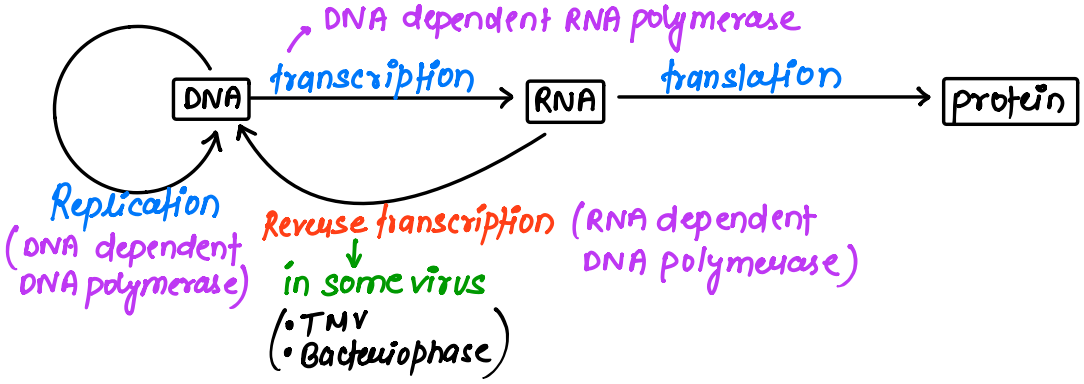
(Separation of DNA by Centrifugation)

Q: *If E. coli was allowed to grow for 80 minutes then what would be the proportions of light and hybrid densities DNA molecule?*

(12) Faba beans experiment

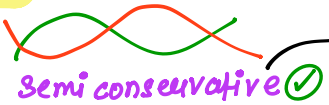
- Similar experiment as previous
- by Taylor & colleagues (in 1958)
- using Radioactive Thymidine
- on vicia Faba (Faba bean)

(13) Central dogma → by Francis Crick



(14) DNA Replication


conservative



semi conservative ✓

Requirements:

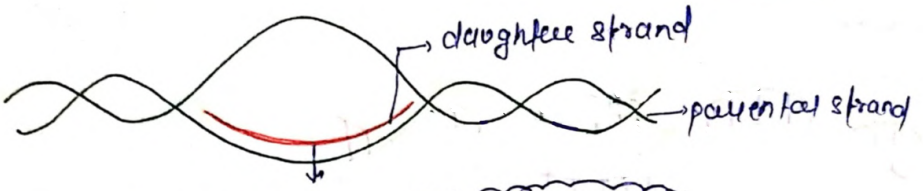
- Helicase
- SSBP
- Topoisomerase
- RNA primer
- primase (RNA polymerase)
- DNA polymerase (main enzyme)
- DNA ligase

- dNTPs (deoxynucleotide triphosphate)
  - dual function
    1. substrate
    2. provide energy for polymn
       {terminal phosphate of dNTPs are High energy (like ATP)}

* DNA polymerase (or) RNA polymerase

- Read parental strand: 3'→5'
- polymerisation of daughter strand: 5'–3'

Our objective



Cell needs to form New DNA strand

↓

Need DNA dependent DNA polymerase (main enzyme)

- only work on single strand
- but starting point should be double stranded

★ DNA being stable molecule so it need RNA primer to initiate Replication

Polymerisation of Deoxynucleotides

↓

Highly efficient enzyme (Polymerize large number of nucleotide in very short time)

eg: In E.coli → Replication within 18 min → 2000 BP/sec

∴ Polymerisation

↓

- Fast
- Highly Accurate

* E.coli
  → divides: 20 min
  → Replicate: 18 min

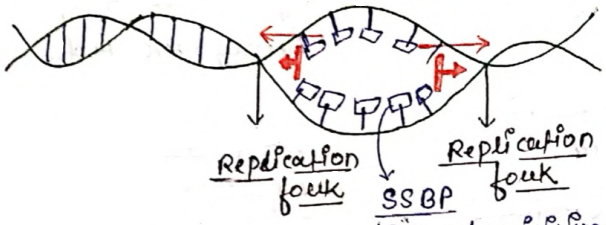
Replication process

"A-T" rich area

ORI (origin of replication)

identify by DNA-A-protein

↓



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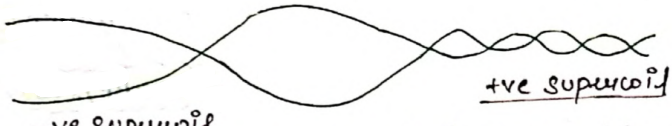


- Supercoil is produced by Helicase
- Supercoil stops the activity of Helicase

To correct this supercoil → Topoisomerase

Helicase

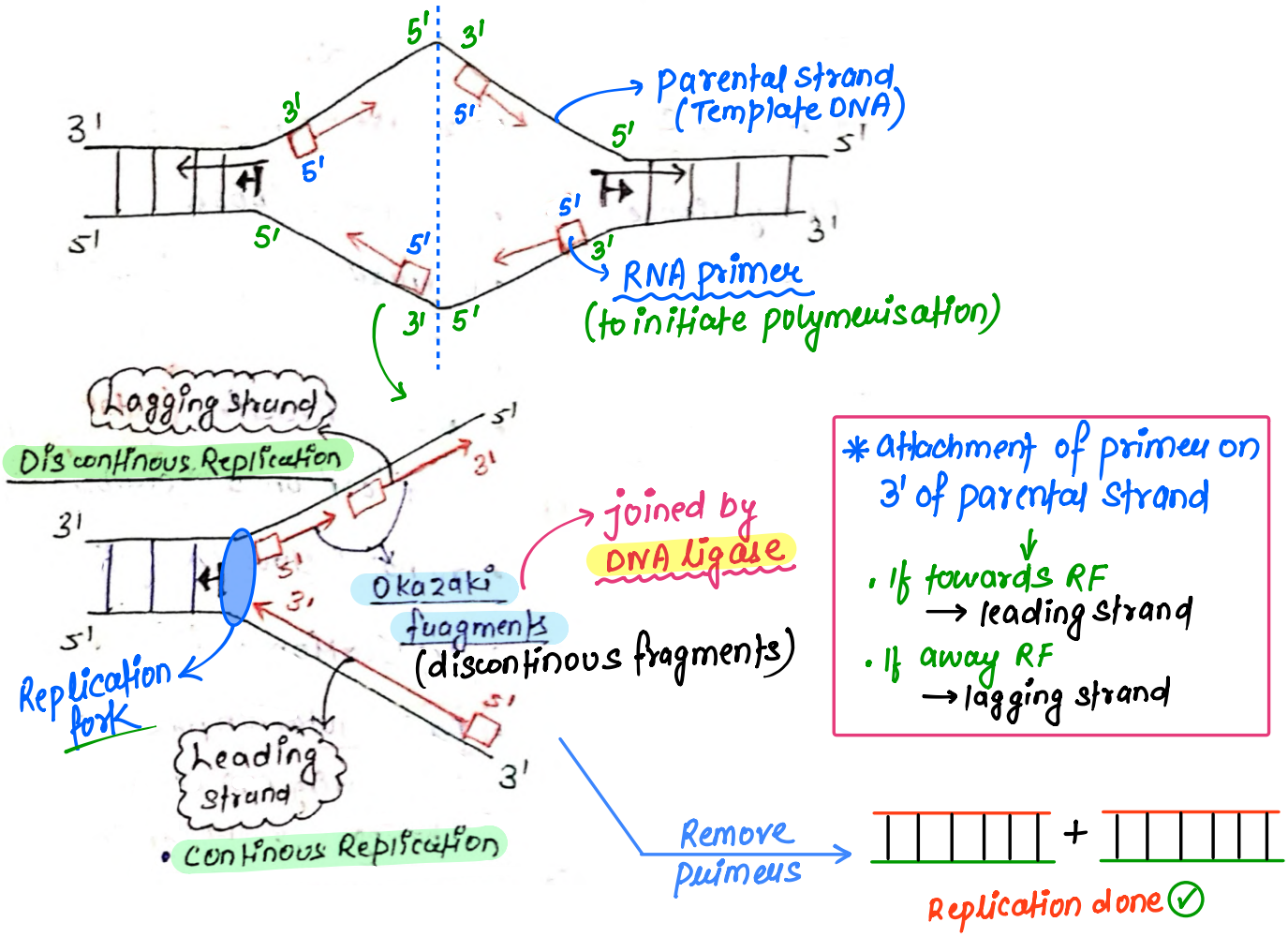
- H-bond cutter
- ATP driven enzyme
- 2000 RPM in DNA
- induce supercoil.

* For long DNA molecules ∵ two strands of DNA can't be separated in its entire length (due to High energy req)

∴ Replication occur at with a small opening

↓

Replication fork



DNA

- N_2-base : A T G C
- Sugar : Deoxyribose
- Generally double std
- More stable
- less reactive
- Free 'OH' on 2nd carbon ⊗
- Chargoff's rule ✓
- Replication ✓
- slow mutation/changes
- DNA ⟶ RNA ⟶ Protein

∴ DNA depend on RNA for protein synthesis

- DNA is prefered for **storage** of **genetic** material
- DNA as Genetic material
  - better
  - predominant

RNA

- N_2-base : A U G C
- Sugar : Ribose
- Generally single std
- less stable
- More reactive (catalytic activity)
- Free 'OH' on 2nd carbon ✓
- Chargoff's rule ⊗
- Replication ✓
- Fast mutation/changes → virus having RNA → • shorter life • mutate & evolve faster
- RNA ⟶ Protein

∴ RNA directly synthesis protein hance it easily express characters

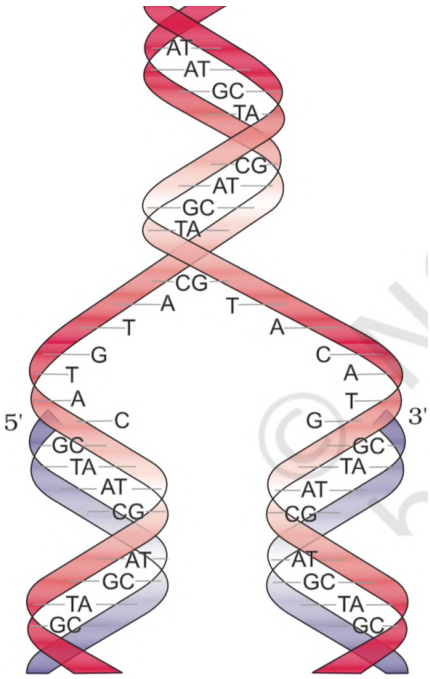
- RNA is prefered for **transmission** of **genetic** information
- RNA as Genetic material
  - • TMV, Bacteriophase
  - • Dynamic fn → messenger, adapter

★ Criteria for Genetic material:

- Replication ability
- chemically & structurally stable
- slow changes/mutation
- express Mendelian characters

(15) RNA World

RNA was the first genetic material. There is now enough evidence to suggest that essential life processes (such as metabolism, translation, splicing, etc.), evolved around RNA. RNA used to act as a genetic material as well as a catalyst (there are some important biochemical reactions in living systems that are catalysed by RNA catalysts and not by protein enzymes). But, RNA being a catalyst was reactive and hence unstable. Therefore, DNA has evolved from RNA with chemical modifications that make it more stable. DNA being double stranded and having complementary strand further resists changes by evolving a process of repair.



Semiconservative DNA Replication

1953 — Watson & Crick

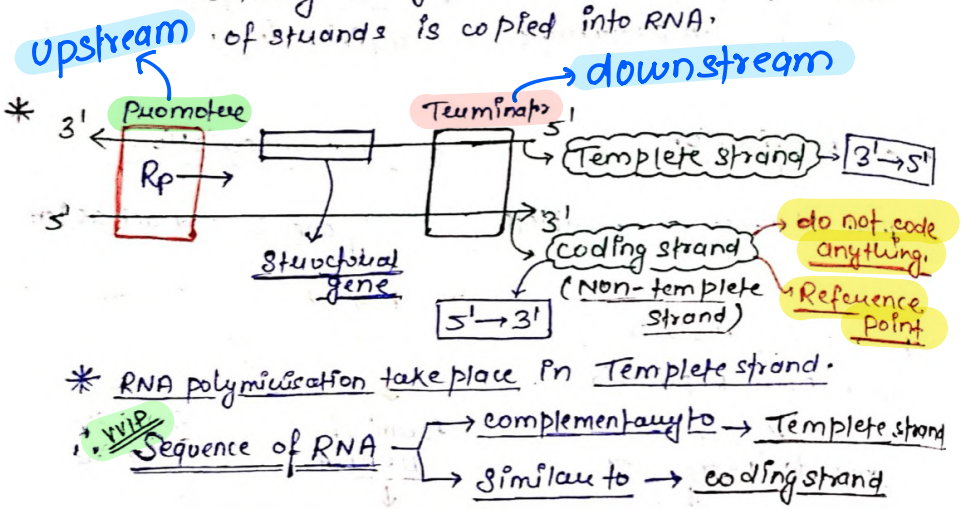
(16) Transcription

* Single enzyme (RNA polymerase) perform all functions

* For few genes lower strand act as template & few it is upper

↓

But only a segment of DNA and only one of strands is copied into RNA.



* RNA polymerisation take place in Template strand.

* Sequence of RNA (5'→3') → complementary to → Template strand
  → similar to → coding strand

*** Transcription unit**

- promotere
- Structural gene
- Terminator

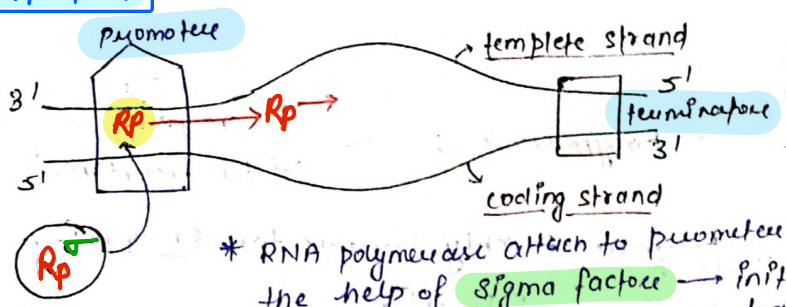
*** In RNA, in place of Thymine, uracil is present**

eg: DNA: • Template strand: 3'-ATGCATGCATGC-5' → RNA: 5'-UACGUACGUACG-3'
• coding strand: 5'-TACGTACGTACG-3'

★ Transcription

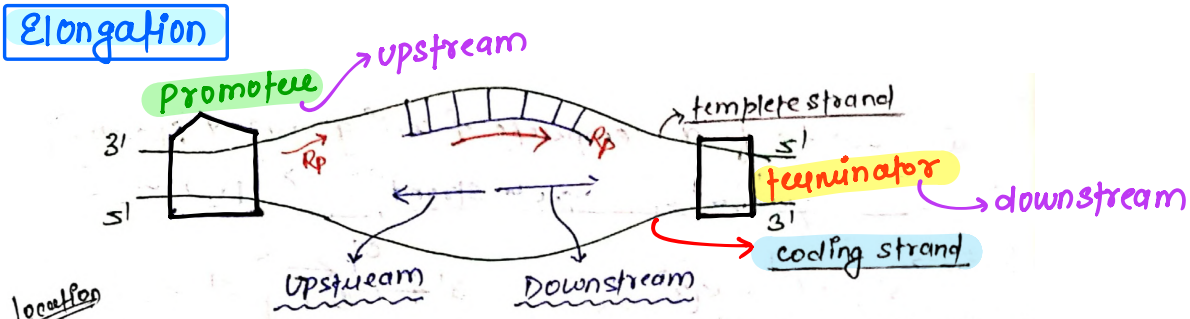
- **Initiation** → RNA polymerase (σ) → Sigma factor (or) Initiation factor → Start transcription
- **Elongation** or **polymerisation** → RNA polymerase
- **Termination** → RNA polymerase (ρ) → Rho factor (or) Termination factor → Stop transcription

Initiation



* RNA polymerase attach to promoter box by the help of sigma factor → initiate transcription.

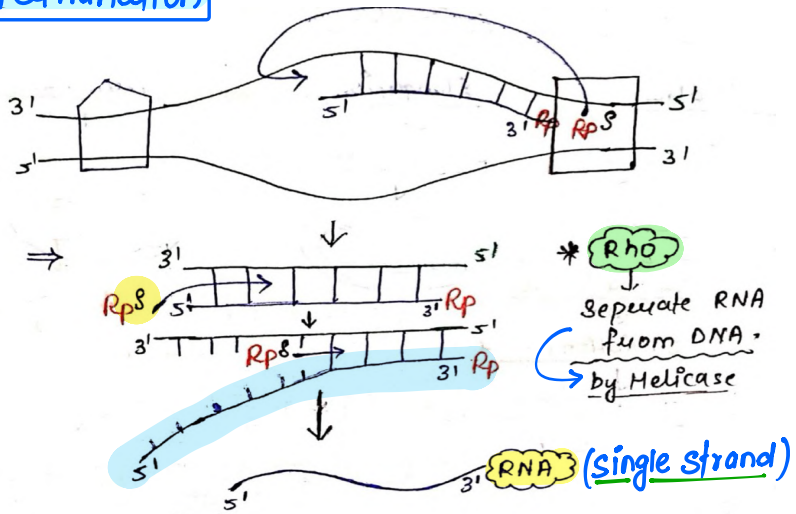
Elongation



location

* Promoter box located towards 5' end (upstream) of coding strand.
* Terminator box located towards 3' end (downstream) of coding strand.

Termination



* Rho → Separate RNA from DNA. → by Helicase

Replication

DNA → (Replication) → DNA

↓

by DNA polymerase

Ⓐ In case of Replication chances of error are less.

Ⓡ Presence of proof Reading Activity in DNA polymerase

★ In Replication

↓

Both strand act as template

* Failure in cell division after DNA Replication

↓

leads to Polyploidy (chromosomal anomaly)

B/C DNA Replication & cell division are highly coordinated.

Transcription

DNA → (Transcription) → RNA

↓

by RNA polymerase

Ⓐ In case of transcription chances of error are more

Ⓡ Absence of proof Reading activity in RNA polymerase.

★ In transcription

↓

only one strand act as template

*if both strand act as template in transcription then:

- Form of DsRNA → Degradation → No protein synthesis
- Same segment code for two different protein → This will complicate central dogma.

★ Types of RNA

rRNA

Ribosomal RNA

↓

Rampant

↓

maximum quantity

- RNA associated with Ribosome
- Structural & catalytic role during translation

m-RNA

messenger RNA

↓

massive

↓

Biggest RNA

- contain message for protein synthesis

↓

In the form of codon

t-RNA

transfer RNA

↓

tiny

↓

smallest RNA

↓

72-90 nucleotide long

- transfer Amino Acid
- Reads Genetic code

snRNA

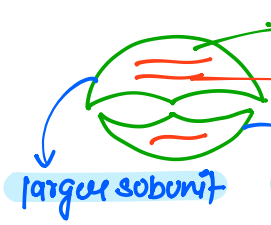
Small nuclear RNA

↓

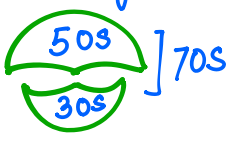
Small RNA present inside nucleus

- only present in Eukaryotes.

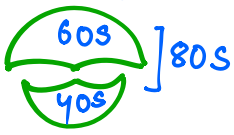
Ribosomes



★ Prokaryotes v/s Eukaryotes



rRNA
- 23S
- 16S
- 5S



rRNA
- 28S
- 18S
- 5.8S
- 5S

* 5S rRNA present in both that Represent common ancestory

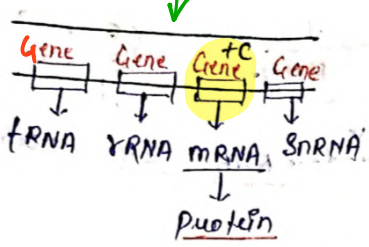
RNA polymerase

Prokaryotes (Bacteria) v/s Eukaryotes

Prokaryotes → Single DNA dependent RNA polymerase synthesise all type of RNA.

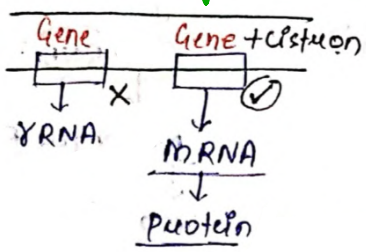
★ Eukaryotes → 3 RNA polymerase
- Rp-I : 28S, 18S, 5.8S (rRNA)
- Rp-II : hnRNA ⟶ mRNA
- Rp-III : tRNA, SnRNA, 5S rRNA

(17) **Gene**



⇒ Segment of DNA which Synthesise any type of RNA.

Cistron



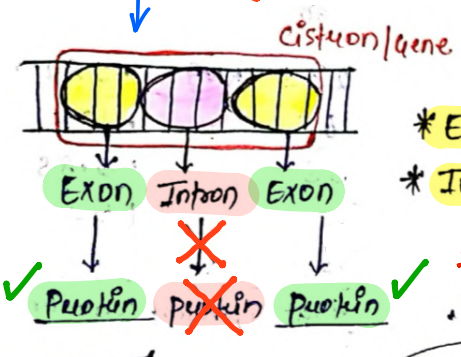
⇒ Segment of DNA which only synthesize mRNA then polypeptide ⟶ Cistron

⇒ All Cistron are gene
All Gene are not Cistron.

✓ **monocistronic Gene**
- code single protein
- in Eukaryotes

polycistronic Gene
- code many protein
- in prokaryotes

(18) Monocistronic gene

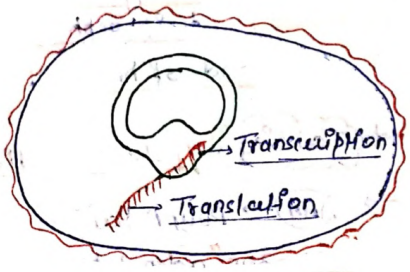


* Exon → expressing part
* Intron → Intervening / interfering segment

* Introns were removed by the process of splicing.

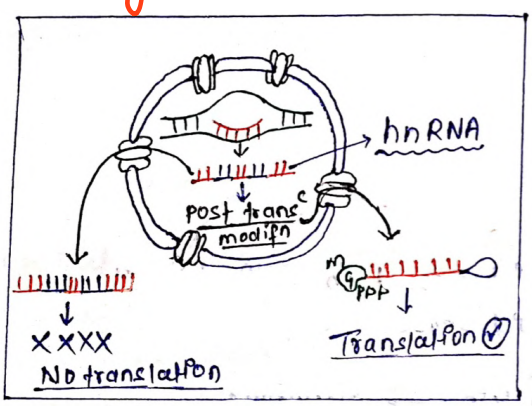
∴ Split-gene arrangment
Presence of Introns b/w exon.
Ancient feature of Genome
Presence of Intron is Reminiscent of Antiquity
Splicing represents dominance of RNA world.

(19) Prokaryotes



* mRNA does not Require any processing to be active
* Transcription & translation occur in same compartment
  ↓
  as there is no seperation cytosol & nucleus
* Thus many times translation begin much before transcription
  ↓
  Coupled transcription

(20) Eukaryotes

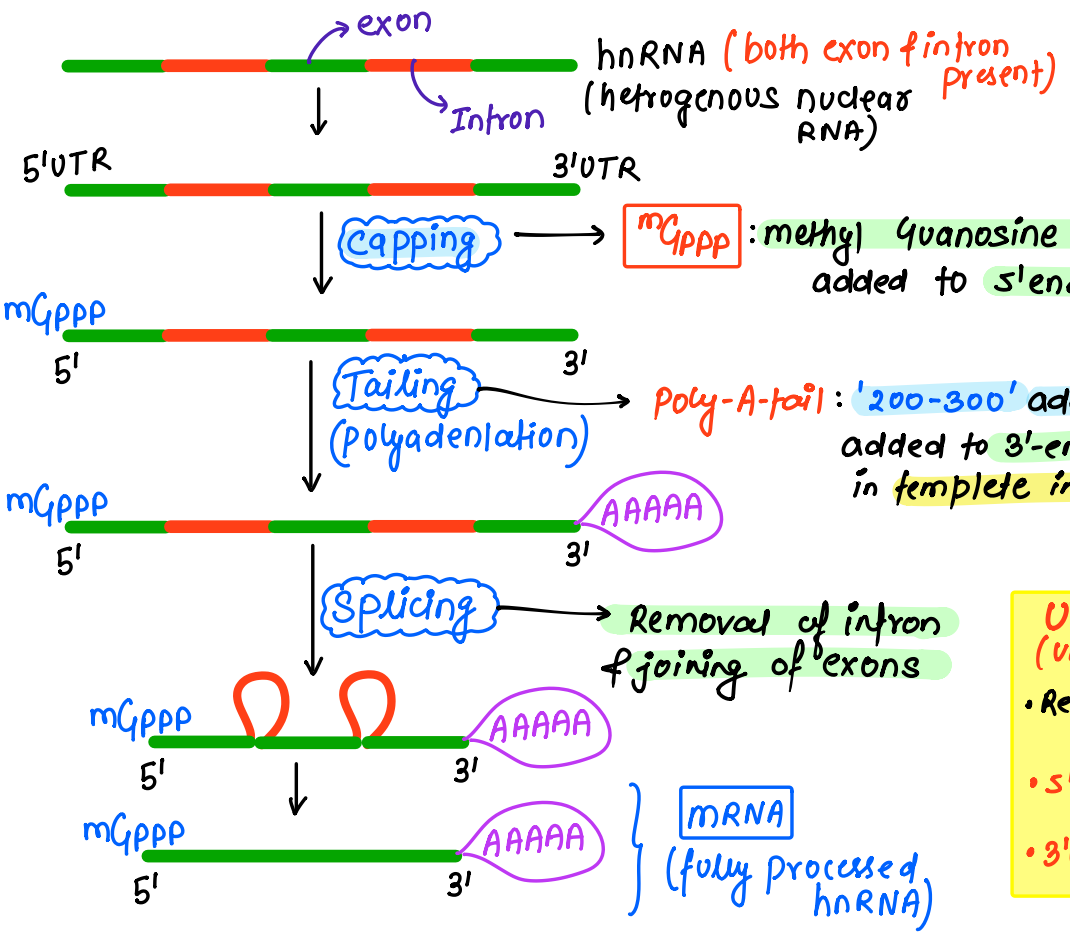


- Transcription → inside nucleus
- Translation → In cytoplasm

★ hnRNA → precusor of mRNA
  heterogenous nuclear RNA
  Exon & Intron both ⊕

★ mRNA → fully processed hnRNA
  only Exon ⊕

Post transcriptional modification



UTR
(untranslated region)

- Req. for efficient translation
- 5'UTR: before start codon
- 3'UTR: after stop codon

(21) Genetic code

- Sequence of nucleotide present in RNA which decides amino acid sequence in protein
- DNA → RNA → protein → structure

(Require 20 amino acid)

∴ we have 4 bases [AUCG]

Few more than 20 AA.

Codon sequence must be greather than 20.

Hence codon is [triplet] [XYZ]

B/c

$4^1 = 4$ ✗

$4^2 = 16$ ✗

$4^3 = 64$ ✓

64 sequences easily code 20 amino acids

George Gamow

* Genetic code is triplet → George Gamow (physicist)

* Experimental proof that genetic code is triplet

- Nirenberg Matthaei
  - O → outside cell
  - P → protein synthesis
  - ↓
  - cell-free system for protein synthesis.
- Har Gobind Khorana
  - Homo-polymer: UUUUUU
  - co-polymer: CUCUCUCU
  - * Synthesize RNA with defined combination of bases
- Severo Ochoa
  - ↓
  - Synthesize enzyme
  - ↓
  - severo ochoa enzyme
  - * (polynucleotide phosphorylase)
  - ↓
  - Enzymatic synthetic of RNA

↙

Synthesis of RNA with defined sequence in template independent manner.

(22) Salient features of Genetic code

(a) codon is triplet XYZ

- Total 64 → codon
  - 61 codon → code for amino acid
  - 3 codon → stop codon (do not code)
    - UAA
    - UGA
    - UAG

(b) Universal

- From bacteria to Humans (Prokaryotes) (Eukaryotes)

⇒ UUU: code for phe (phenylalanine)

* exception:
  - → mitochondrial codons
  - → protozoans codons

(c) Specific / unAmbiguous

- one codon code for only one amino acid.

(d) Degenerate

- Same amino acid are coded by more than one codon
  - AAA → lysine
  - AAG → lysine

exception:

- Methionine (coded by only AUG)
- Tryptophan (coded by only UGG)

(e) No-punctuation (commaless)

↓

Read in a contigous fashion

(f) AUG → dual function

- code for Methionine
- act as initiator/start codon

The Codons for the Various Amino Acids

First position	Second position U	Second position C	Second position A	Second position G	Third position
U	UUU Phe	UCU Ser	UAU Tyr	UGU Cys	U
	UUC Phe	UCC Ser	UAC Tyr	UGC Cys	C
	UUA Leu	UCA Ser	UAA Stop	UGA Stop	A
	UUG Leu	UCG Ser	UAG Stop	UGG Trp	G
C	CUU Leu	CCU Pro	CAU His	CGU Arg	U
	CUC Leu	CCC Pro	CAC His	CGC Arg	C
	CUA Leu	CCA Pro	CAA Gln	CGA Arg	A
	CUG Leu	CCG Pro	CAG Gln	CGG Arg	G
A	AUU Ile	ACU Thr	AAU Asn	AGU Ser	U
	AUC Ile	ACC Thr	AAC Asn	AGC Ser	C
	AUA Ile	ACA Thr	AAA Lys	AGA Arg	A
	AUG Met	ACG Thr	AAG Lys	AGG Arg	G
G	GUU Val	GCU Ala	GAU Asp	GGU Gly	U
	GUC Val	GCC Ala	GAC Asp	GGC Gly	C
	GUA Val	GCA Ala	GAA Glu	GGA Gly	A
	GUG Val	GCG Ala	GAG Glu	GGG Gly	G

(23) T-RNA

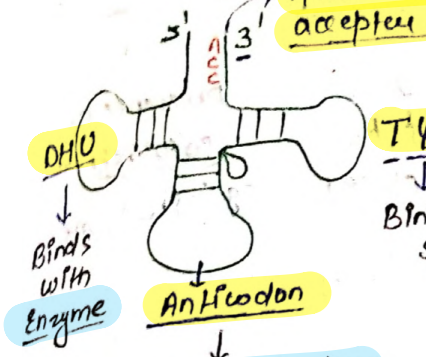
- Transfer RNA → B/c it transfer amino acid during translation.
- tiny RNA → Smallest RNA
- Adapter molecule → • one hand Read the code • other hand bind to specific amino acid
- Soluble RNA → sRNA

* Some points:
  - tRNA has Anticodon loop, Amino acid acceptor end
  - tRNA specific for each Amino acid.
  - NO tRNA for stop codons
  - for initiation → Initiator tRNA

(24) Structure of T-RNA

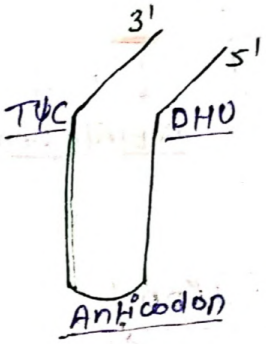
2-D structure (secondary)

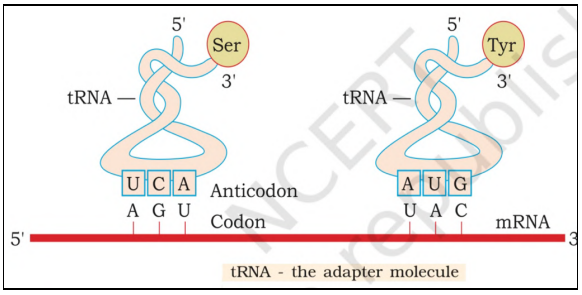
- Clover-leaf-like
- Amino Acid acceptor end
- DHU → Binds with Enzyme
- TψC → Binds with larger subunit of Ribosome
- Anticodon → complementary to mRNA code. → ∴ binds with codon of mRNA



3-D str (actual str)

- Inverted L-shape

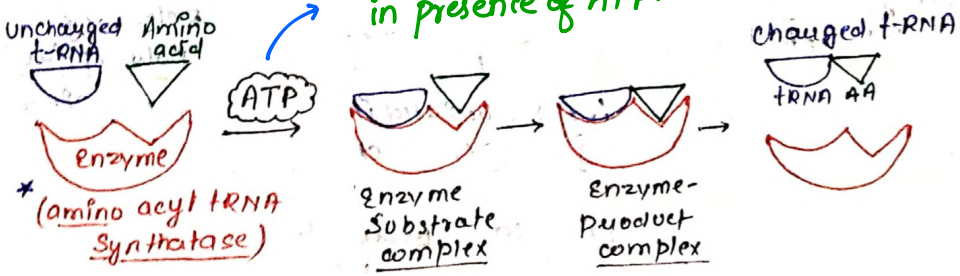




First phase

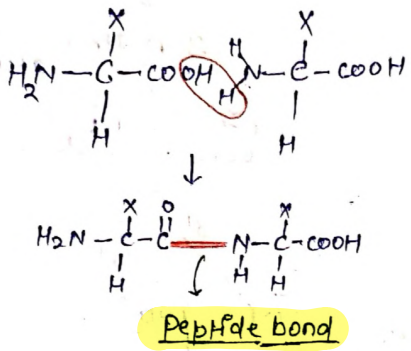
Charging of t-RNA (or) Amino-acylation of t-RNA

amino-acid activated in presence of ATP.



* (amino acyl tRNA Synthetase)

Amino Acid



Peptide bond

* Amino acid joined by peptide bond & its formn req energy.

* Peptide bond formn enhanched by:

- when two charged t-RNA brought close.
- Presence of catalyst. eg: Ribozyme

25 Translation

Initiation

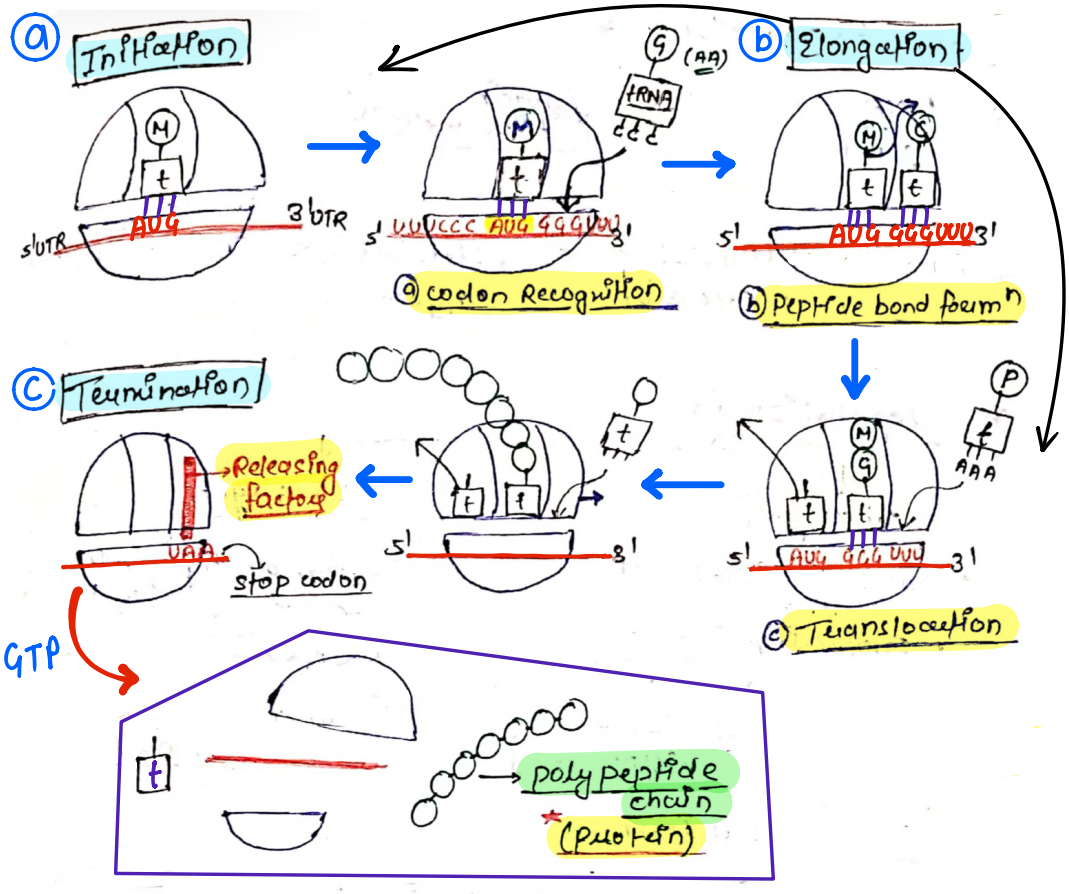
- Small subunit of Ribosome encounters an mRNA. (at start codon AUG)
- Recognised by Initiator tRNA ✓

Elongation

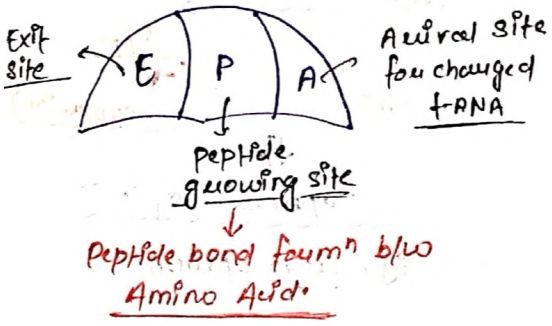
- "Amino acid-linked-t-RNA" binds to mRNA.
- Ribosome moves from codon to codon along mRNA &
- Amino acid added one by one.
- ∴ AA translated into Polypeptide chain
  - Dictated by → DNA
  - Represented by → mRNA

Termination

- Release factors binds to the Stop codon ✓
- Translation terminate.
- Releasing polypeptide chain from Ribosome.

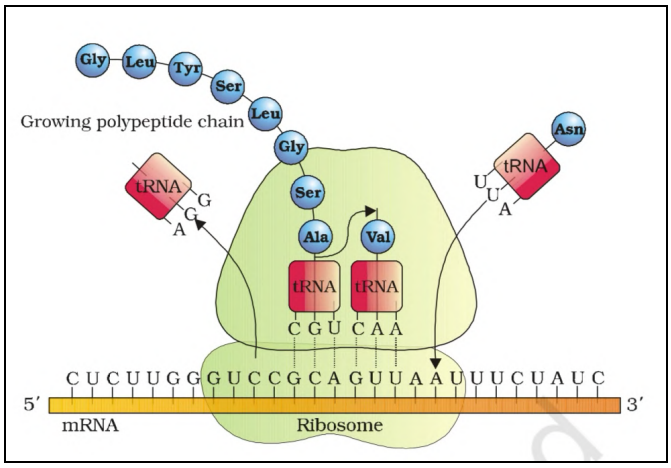


Largeu subunit of Ribosome



* Act as catylest (enzyme) → Ribozyme

- In Bacteeia (prokaryote) → 23S-rRNA act as enzyme ⇒ Ribozyme
- In Eukaryote → 28S-rRNA, act as Ribozyme



26 Gene Expression

* DNA (gene) → RNA → Protein (Structure)

* Factees that regulate gene expression → Metabolism, Environmental, Physiological conditions

* Regulation in
  - Eukaryote
    - Transcriptional level
    - Processing level (Splicing)
    - transport of mRNA [nucleus → cytoplasm]
    - translational level.
  - Prokaryote → only Transcription level
    - Regulation by OPERON
      - Given by Jacob & monad

(27) OPERON

Inducer

Gene off → Gene ON

(+ve Regulation)

↓

Inducer operon

Repressor

Gene ON → Gene off

(-ve Regulation)

↓

Repressor operon

eg: • Lac operon • Trp operon

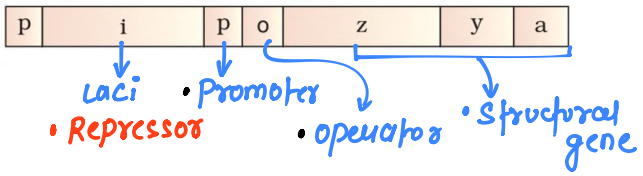
Operon
- ara operon
- his operon
- val operon

★ O P E R O N

Operator Promoter Regulator ON/OFF

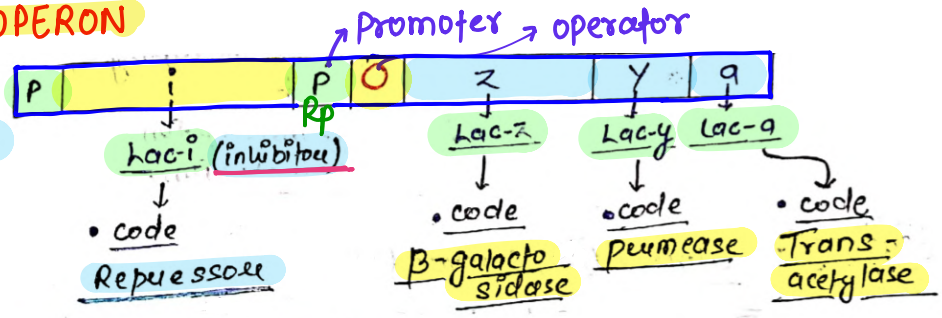
→ linear arrangement of operator, promoter, regulator & structural gene

→ each operon has specific operator & specific Repressor.



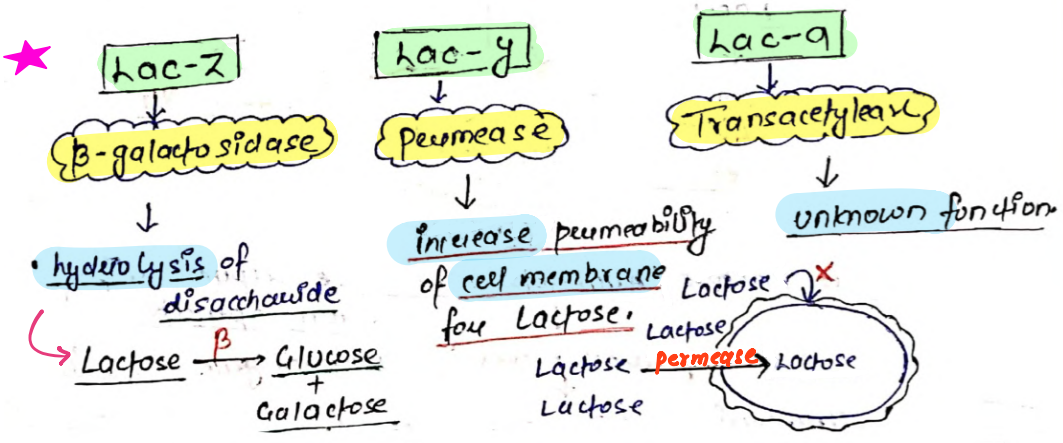
(28) LAC OPERON

(inducer operon)

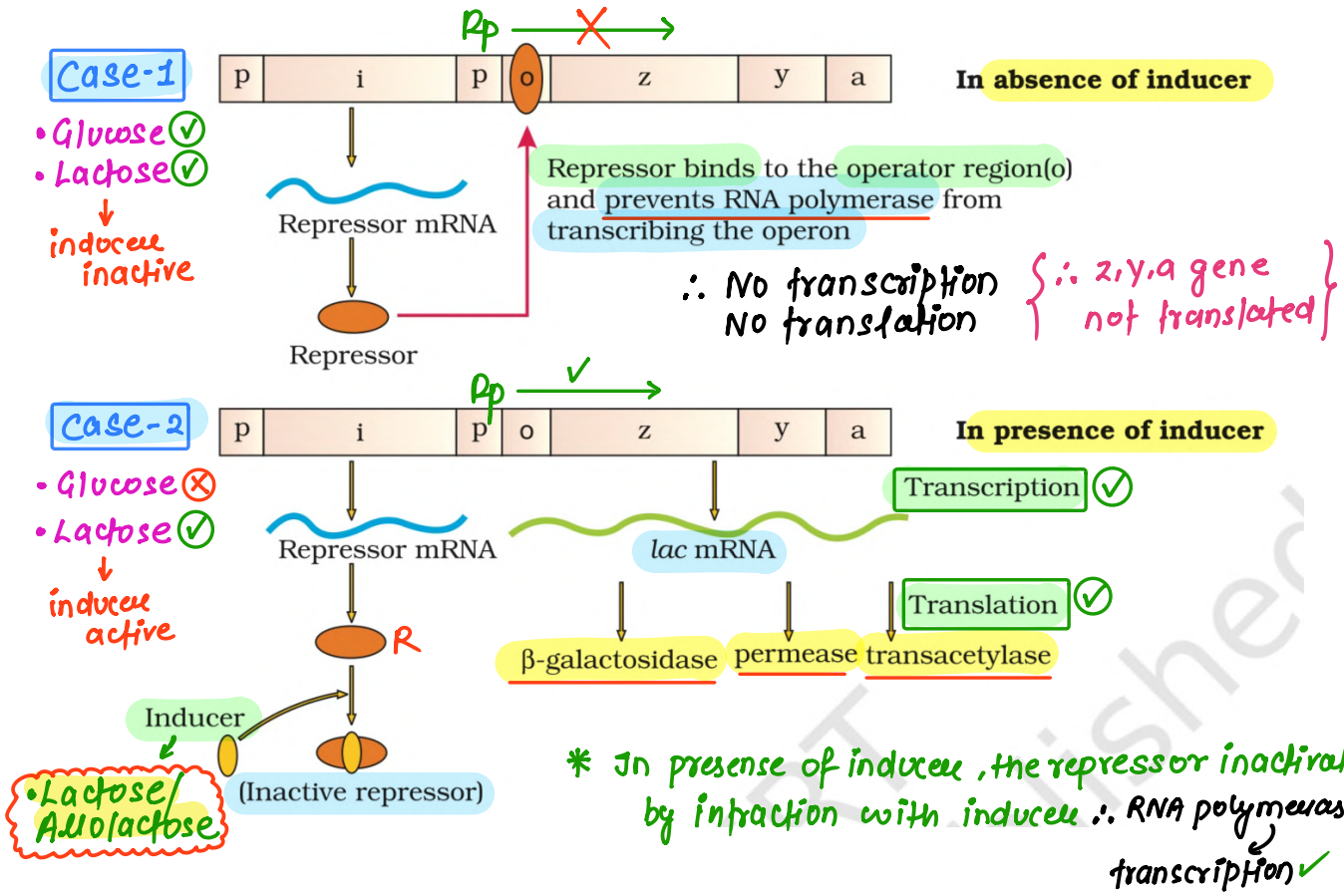


- Lac-i → Regulator gene (1)
- Lac-z, Lac-y, Lac-a → Structural gene (3)

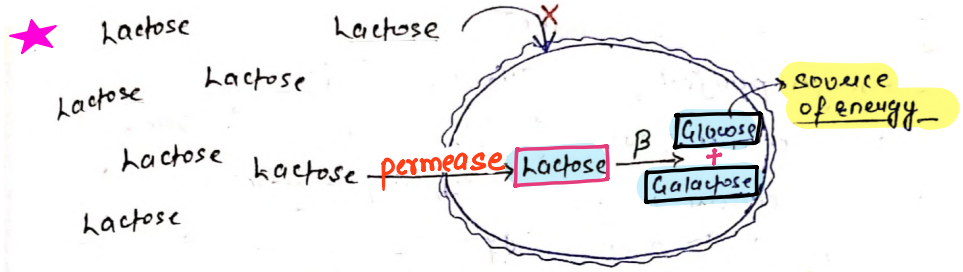
★



(29) Regulation of lac operon



(30) Important point



* Regulation of lac operon by repressor called -ve Regulation but lac operon is under +ve Regulation as well

⇒ Lactose transported into cell by permease

⇒ Lactose is substrate of β-gal which regulate ON/OFF operon.

A/R ↳ ∴ Lactose is inducer.

* Leaky Expression

VIP ⇒ very low level of Expression of Lac-operon is always present otherwise → lactose can not enter the cells.

Q. In an E. Coli strain i gene gets mutated and its product can not bind the inducer molecule. If growth medium is provided with lactose, what will be the outcome?

[NEET 2022]

(31) HUMAN GENOME PROJECT

→ mega project, Ambitious project

→ launched in year → 1990 & completed in 2003

→ HGP closely associated with Rapid development of new area of biology → Bioinformatics

→ HGP was (13) year project, ★ (9 billion$ cost) Total (3×10^9 bp x 3$/bp)

→ By U.S department of Energy & National institute of Health.

→ Solving challanges in → Health care, agriculture, Energy production, environmental.

→ Also sequenced many non-human model

★ A → Arabidopsis (plant); B → Bacteria; C → Caenorhabditis elegans (free-living non pathogenic-nematode); D → Drosophila (fruit fly); R → Rice (plant); Y → yeast

★★ Methodologies of HGP

* ESTs (Express sequence tags) → identify all gene that expressed as RNA.

* Sequence Annotation → Blind approach of simply sequencing the whole set of genome.

* For sequencing → Recombinant DNA tech^n used

* Hosts: → yeast & Bacteria

* Vectors: → BAC & YAC → & pBR322

★ Goles of HGP

- Identify all genes (25K-30K)
- Determine entire DNA sequence (3×10^9 Bp)
- collect & store this infom^n.
- Improve tools for data analysis
- Transfer related technologies
- Address → ELSI → issue (ethical, legal, social)

★ Frederick Sangee

→ Automated DNA sequence principle

→ Determination of Amino acid Sequence in protein.

★ ∵ Sequencing Not possible Humanly
∴ Special computer programs developed.

→ Chromosome -1 → Sequence completed in May 2006.

→ last chromosome sequence in HGP.

→ has most genes (2968)

★ Assigning Genetic & Physical map on genome

→ By polymorphism of Restriction endonuclease

→ By microsatellites (Repetitive DNA seq^n)

32 Salient Features of Human Genome

(i) The human genome contains 3164.7 million bp. (3 billion)

(ii) The average gene consists of 3000 bases, but sizes vary greatly, with the largest known human gene being dystrophin at 2.4 million bases.

(iii) The total number of genes is estimated at 30,000–much lower than previous estimates of 80,000 to 1,40,000 genes. Almost all (99.9 per cent) nucleotide bases are exactly the same in all people.

(iv) The functions are unknown for over 50 per cent of the discovered genes.

(v) Less than 2 per cent of the genome codes for proteins.

(vi) Repeated sequences make up very large portion of the human genome.

(vii) Repetitive sequences are stretches of DNA sequences that are repeated many times, sometimes hundred to thousand times. They are thought to have no direct coding functions, but they shed light on chromosome structure, dynamics and evolution.

(viii) Chromosome 1 has most genes (2968), and the Y has the fewest (231).

(ix) Scientists have identified about 1.4 million locations where single-base DNA differences (**SNPs** – **single nucleotide polymorphism**, pronounced as 'snips') occur in humans. This information promises to revolutionise the processes of finding chromosomal locations for disease-associated sequences and tracing human history.

33 DNA Fingerprinting

- By Alec Jeffreys [he used satellite DNA as probe]
- very quick way to compare DNA seqⁿ of any individual
- "Identification of specific parts of DNA" named Repetitive DNA.
  - B/c in these seqⁿ small stretch of DNA repeated many times.
- During density centrifugation of DNA → minor peak ⇒ Satellite DNA
  - major peak → BULK DNA

34 Satellite DNA

- occup minor peak in density centrifugation
- 0.1% of DNA
- specific/different in every individual (except: monozygotic twins)
- Do not code for any protein, but form large portion of Human genome
- contain large number of Repetitive unit
- show high degree of polymorphism & form basis of of DNA fingerprinting

★ Classification of satellite DNA on basis of → Base composition (A:T rich / G:C rich), length of segment, number of Repetitive units

- Microsatellite → • STR
- Minisatellite → • VNTR (variable number tandem Repeat) → 0.1–20 Kb (High degree of polymorphism)

AIR
Ⓐ DNA fingerprinting useful in forensic application
Ⓡ DNA from every tissue of an individual, show same degree of polymorphism.

Ⓐ DNA fingerprinting useful in paternity testing
Ⓡ DNA polymorphism are inheritable from parents to offspring.

35 Polymorphism
- variation at genetic level
- arise due to mutation
- Mutation arise either in → Somatic cells / germ cells (gametes) → If germ cell mutation not harm ability to have offspring, then it spread to other generation (via sexual Reproduction)

* DNA Polymorphism —Basis→ • Genetic mapping of Genome • DNA fingerprinting

* Some important points about DNA polymorphism

★★★

Allelic sequence variation has traditionally been described as a DNA polymorphism if more than one variant (allele) at a locus occurs in human population with a frequency greater than 0.01. In simple terms, if an **inheritable mutation** is observed in a population at high frequency, it is referred to as **DNA polymorphism**. The probability of such variation to be observed in non-coding DNA sequence would be higher as mutations in these sequences may not have any immediate effect/impact in an individual's reproductive ability. These mutations keep on accumulating generation after generation, and form one of the basis of variability/polymorphism. There is a variety of different types of polymorphisms ranging from single nucleotide change to very large scale changes. For evolution and speciation, such polymorphisms play very important role

36 Steps of DNA fingerprinting

The technique of DNA Fingerprinting was initially developed by Alec Jeffreys. He used a satellite DNA as probe that shows very high degree of polymorphism. It was called as **Variable Number of Tandem Repeats** (VNTR). The technique, as used earlier, involved Southern blot hybridisation using radiolabelled VNTR as a probe. It included

(i) isolation of DNA,

(ii) digestion of DNA by restriction endonucleases,

(iii) separation of DNA fragments by electrophoresis,

(iv) transferring (blotting) of separated DNA fragments to synthetic membranes, such as nitrocellulose or nylon,

(v) hybridisation using labelled VNTR probe, and

(vi) detection of hybridised DNA fragments by autoradiography

*last step

37 AutoRadiogram

Gives many bands of different size

↓

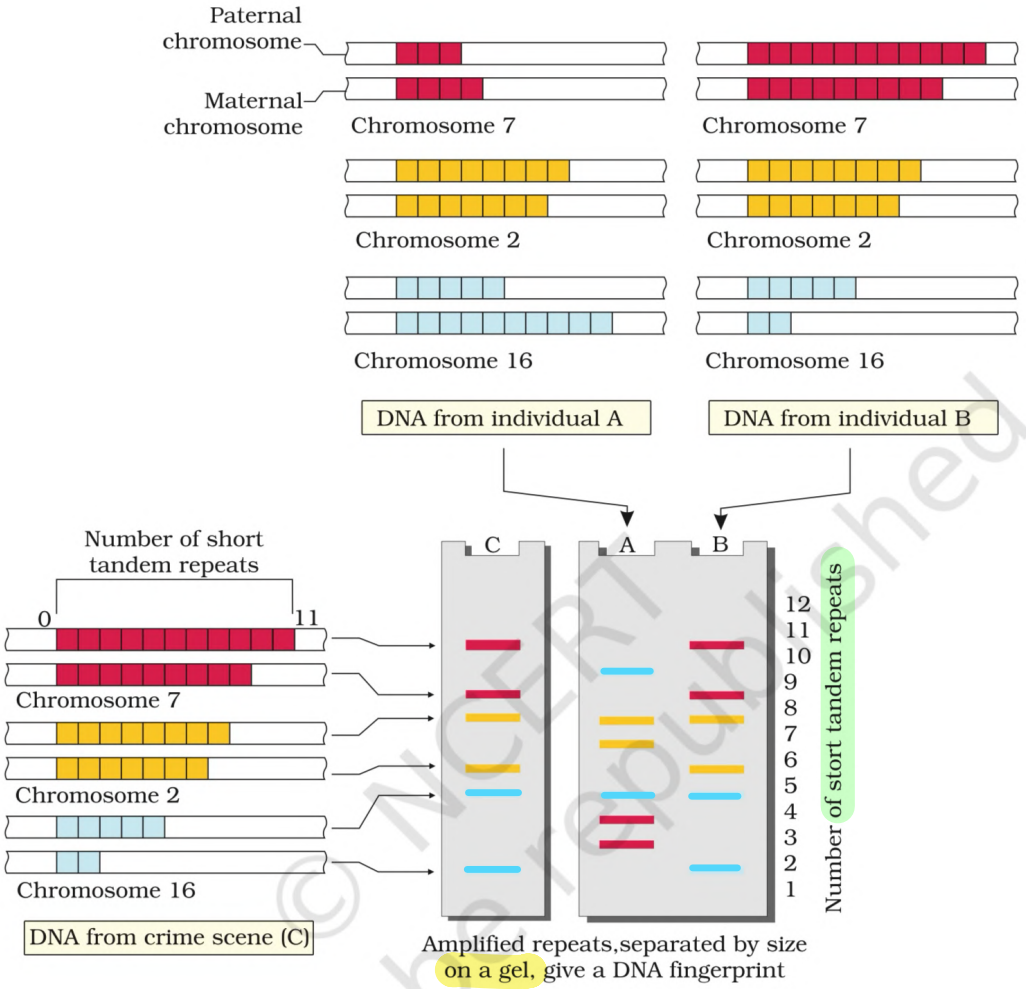
These bands differs from individual to individual

• except: monozygotic twins.

→ Sensitivity of Fingerprinting → increased by PCR.

→ DNA of single cell enough to perform → DNA fingerprinting.

→ Useful in → forensic science, determining population, genetic diversity identify.



EVOLUTION

① Big Bang → origin of universe (20 billion ya) → clusters of Galaxies → Stars + clouds + gas + dust

- Singular Huge-explosion

* Universe → Temp° ↓ → Hydrogen & Helium formed cond° → Galaxies → Solar System

* milkey way galaxy → our solar system → Earth (Formed 4.5 billion yrs back) → NO atmosphere of early earth

* Early earth → molten mass → H_2O (vapour), CH_4, CO_2, NH_3

- $H_2O(g)$ —UV ray from sun→ O_2 + $H_2\uparrow$ (escaped)
- CH_4 —O_2→ CO_2 + H_2O
- NH_3 —O_2→ N_2 + H_2O

clouds (H_2O) → depressions → water fall as rain → filled depressions → ocean formation

- Ozone layer formed

* Life appeared
↓
4-billion years ago
(or)
500 million years after earth formation

ⓐ Theory of panspermia

- Early greek thinkers → unit of life → spores
- other planet —spore→ Earth
- panspermia still favourite idea for some astronomers

ⓑ Theory of spontaneous generation (A-biogenesis)

- life come from dead, decaying & Rotting matter (straw, mud)

ⓒ Theory of Biogenesis
↓
By Louis pasteur : life only come from pre-existing life
↓
Experiment: • Steriliised flask → Killed yeast → life ✗
→ Killed yeast + open air → life ✓

ⓓ Chemical evolution (abiogenesis)

- Oparin (Russia) & Haldene (England) → • life come from pre-existing non-living organic molecule (RNA, protein)

{inorganic molecule → organic molecule}

(e) S.L. Miller expt (1953) : American

* Early earth → Temp(↑), volcanic storms, Reducing atmosphere of CH_4, NH_3 ↓

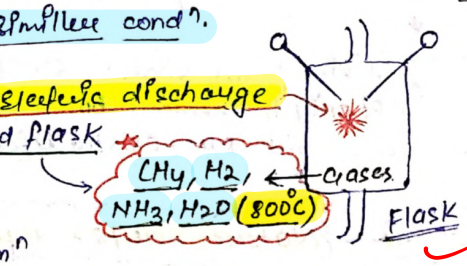
Miller created similar cond^n.

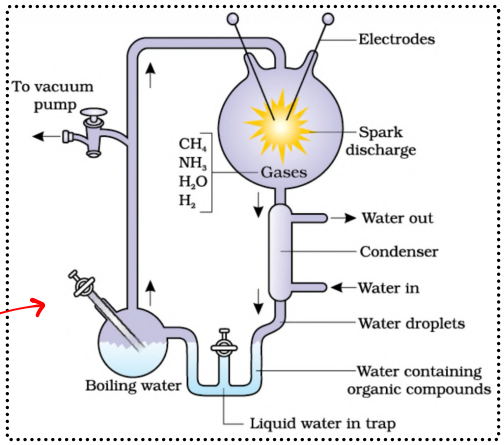
↓

He created electric discharge in closed flask

↓

Observed form^n of amino acids





* Life formed : 4 billion yrs ago
  - 1st non-cellular life: 3-billion yrs ago (giant molecule: RNA, protein, polysaccharide) (Protobionts)
  - 1st cellular life: 2-billion yrs ago

⟹ all life formed in water only

(f) Theory of special creation

- All living organism created as such
- Diversity is same since creation
- Earth was 4000 yrs old

} Discarded in (19th) century

(2) Natural selection

↓

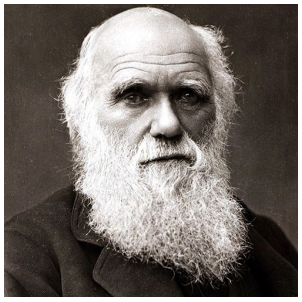
Charles Darwin

* His observation during sea tour on H.M.S Beagle ship

↓

- existing living form share similarity not only in themself but also with pre-existed lifes

* Darwin → Nature selects for fitness → Reproductive fitness ↓ make more progeny



↓

Key concept of Darwin

↓

- Natural selection
- Branching desent

eg: Pop^n A of Bacteria growing in given mdm.

Now, Medium changed → only Pop^n B were left & rest die

∴ Fitness of "B" better than "A" in new medium.

* Alfred Wallace (Naturalist) → work in Malay Archipelago region → similar conclusion as other

* Lamark → use & disuse of organs (eg: Giraffs necks)

* Thomas Malthus → He influenced Darwin
  - → Natural resources are limited
  - → population are stable in size (except seasonal)
  - → population member vary in character
  - → Most variation are inherited

③ Hugo de-vries

mutation theory
↓
⇒ large diff arising suddenly in population

* Mutation caused speciation
  - ↓
  - e/g Saltation {single step large mutation}

Mutation

By Darwin	By Hugo-de-vris
→ cause minor variations	→ cause ↑ evolution
→ Small	→ large
→ Directional	→ Directionless
→ Gradual	→ Random
→ Multistep	→ Single step
→ Slow	→ Sudden

④ Embryological support

* In all vertebrates (Human) certain feature during embryo stage is common
  - ↓
  - but absent in adult.

• proposed by: Ernst Heckel
• disapproved by: Karl Ernst von Baer

eg: All vertebrates embryo → ★ Raw of vestigial present
- → only functional in adult fish
- → Not found in other adult vertebrates

⑤ Evidence for evolution

ⓐ Paleontological Evidence

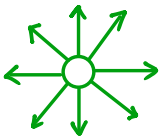
Study of fossils
↓
remaining Hard part of life found on Rocks

- using sedimentary rocks to collect fossils
- Different aged rocks sediments contain fossils of different life form.
- we can find age of rocks/fossils by Radioactive dating technique

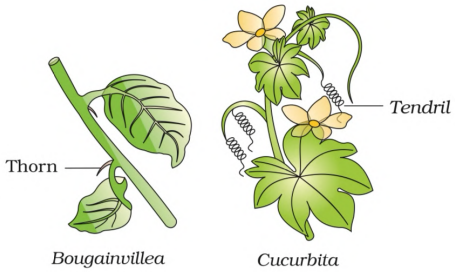
(b) Anatomy & morphology Evidence

Divergent evolution

- Similar anatomical str
- Different in function
- Homologous strs (Homology indicate common ancestry)

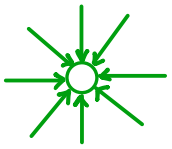


eg: → Forelimbs of all mammals (whales, bats, Cheetah, Human)
→ Hearts/Brain of vertebrates
→ Thorn & tendrils of Boogainvillea & cucurbita



Convergent evolution

- different anatomical str
- Similar in function
- Analogous strs



eg: → wings of butterfly & birds
→ Eye of octopus & mammals
→ Flippers of penguins & Dolphins
→ Sweet potato & potato
(root modt) (Stem modt)

Biochemical evidance

- Similar structure
- Similar Function
- Similar ancestory

eg: Similarities in proteins & Genes

(6) Industrial Melanism : Moths (England) → Natural selection

Before industrialization (1850)
↓
white wing moth ↑
Dark wing moth ↓
↓
B/c: Less pollution so, light tree trunk
↓
∴ white moth camouflage & Dark moth picked by Predators.

After industrialization (1920)
↓
white wing moth ↓
Dark wing moth ↑
↓
B/c: more pollution so, dark tree trunk
↓
∴ Dark/Melanised moth camoflage & white moth picked by Predators


unpollutated area


pollutated area

* ∴ In mixed population those who can better adapt →
- They survive
- Increase their popn

→ No varients are completely wiped out

(7) Anthropogenic Action

- Human made evolution (Artificial evolution)

eg:
- Excess use of herbicides/pesticides → selection of only resistant varieties (in less time)
- Antibiotics/drug against eukryotes
- Man created crops & animal breed (Dogs)

★ This tells evolution is not directed process
↓
it is stochastic process
↓
Chance event/mutation

⑧ Adaptive Radiation

- Darwin went to galapagos islands → small black birds : Darwin's finches
- Finches orginally seed eating birds → evolved & altered their beaks → become insectivorus finches / become vagetarian finches

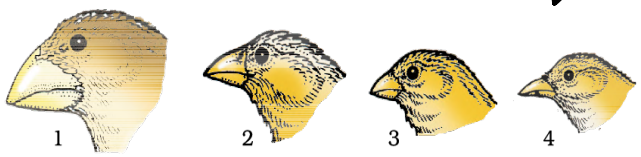
Adaptive Radiation → evolution of different species → in Given Area starting from point → Radiating to other area

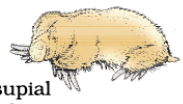
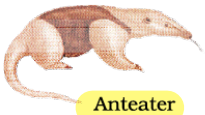
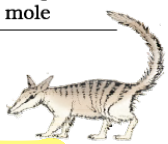
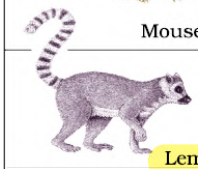
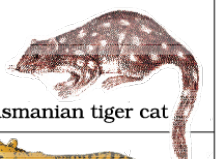
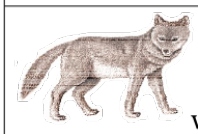
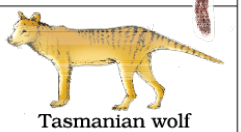
Eg:
- Darwin's finches
- Australian marsupials
- Placental mammals

★ More than one adaptive Radiation in isolated Area → convergent evolution

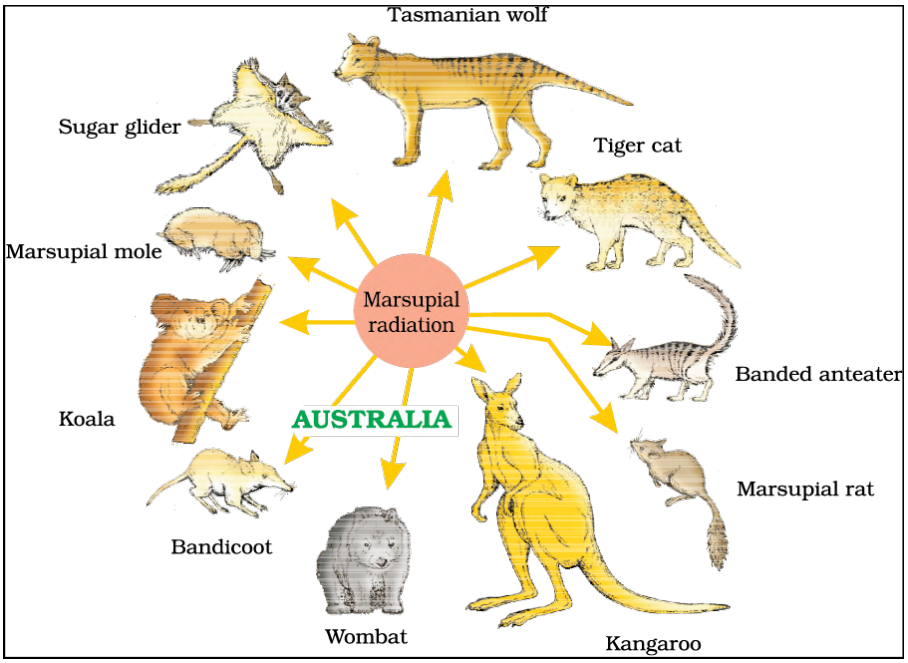
Placental mammals	Australian marsupials
• Mole	• Marsupial Mole
• Anteater	• Numbat
• Mouse	• Marsupial Mouse
• Lemur	• Spotted cuscus
• Flying squirrel	• Flying phalanger
• Bobcat	• Tasmanian tiger cat
• Wolf	• Tasmanian wolf

* Darwin finches (Adaptive radiation)



Placental mammals	Australian marsupials
 Mole	 Marsupial mole
 Anteater	 Numbat (anteater)
 Mouse	 Marsupial mouse
 Lemur	 Spotted cuscus
 Flying squirrel	 Flying phalanger
 Bobcat	 Tasmanian tiger cat
 Wolf	 Tasmanian wolf

★ Adaptive radiation of Australian Marsupial



⑨ Hardy-weinberg principle

- Allele frequency in popⁿ are stable & constant from generation to generation

* Genetic eqᵐ / Hardy-weinberg eqᵐ ⟶ Gene pool remain constant (Gene + Allele in popⁿ) : • Sum of all Allelic freqⁿ = 1 ($p+q=1$)
  - p → freqⁿ of allele A
  - q → freqⁿ of allele a

→ • $p+q=1$

∴ $(p+q)^2=1$

↳ $p^2+q^2+2pq=1$

(p^2 = AA, q^2 = aa, $2pq$ = Aa)

- AA → Homozygous dominant
- aa → Homozygous recessive
- Aa → Heterozygous

* $p = AA + \frac{1}{2}Aa$

$q = aa + \frac{1}{2}Aa$

Q: Assuming Hardy Weinberg's Principle, in a certain population, the frequencies of three genotype are as follows: 2024

Genotypes	AA	Aa	aa
Frequency	22%	62%	16%

What is the likely frequency of 'A' and 'a' alleles?

Q: A gene locus has two alleles A, a. If the frequency of dominant allele A is 0.4, then what will be the frequency of homozygous dominant, heterozygous and homozygous recessive individuals in the population? 2019

⑩ Factors affecting Genetic eqᵐ

- Gene migration / Gene flow
- Genetic drift
- Mutation
- Genetic recombination
- Natural selection

* Distrbance in Genetic eqᵐ ↓ freqⁿ of allele change ↓ caused evolution

ⓐ Gene migration

* New Genes added in new popⁿ
  lost from old popⁿ
  ↓
  ∴ Gene freqⁿ change in both new & old popⁿ

* multiple gene migration → Gene flow

ⓒ Mutation (Microbial expt)

- pre-existing advantageous mutation ↓ New phenotype ↓ Speciation

ⓑ Genetic drift

↳ Change in gene frequency by chance (i.e. Random / Non-directional) in small population

** cause founder effect ↓

- Change in allele frequency is different in New population

∴ old drifted popⁿ become founders

(d) **Genetic recombination**

↓

Variation in recombination due to gametogenesis → Genes/allele freq^{n} change in next generation (progeny)

(e) **Natural selection**

↓

Heritable variation → better survival

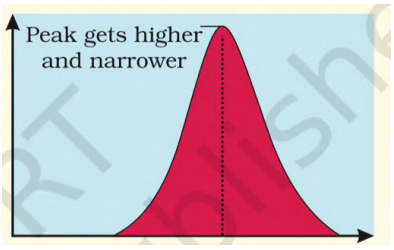
→ better reproduction → more no. of progeny

(11) **Natural selection leads to**

Stabilisation

↓

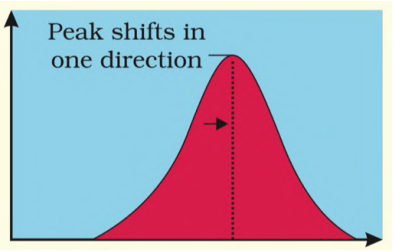
more individual aquire mean value



Directional change

↓

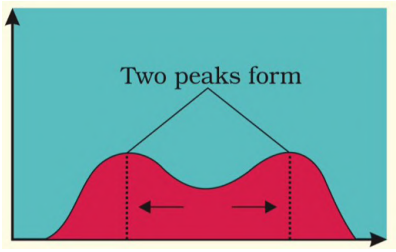
more individual aquire value other than mean



Disruption

↓

more individual aquire peripheral value



(12) **Brief Account of evolution**

1st A-cellular : 3 Bya

↓

1st cellular : 2 bya (2000 mya)

↓

Invertebrates : 500 mya

↓

Jawless fish : 350 mya

↓

* Coelacanth : 350 mya (lobefins)

↓

1st Amphibians (ancestor of frog & salamanders) (live in both water & land)

↓

Reptiles (lay thick shelled egg)

↓

200 mya

back to water → Fish like reptile → Ichthyosaurus

Land Reptiles → Dianosaurus

* 1st organism invaded land are plants

↓

Sec weeds & few plants ⇒ 320 mya

* Coelacanth fish (Lobefins)

↓

Stout & strong fin fish

↓

move on land, go back to water

* Dianosaurs : (Dominated Jurassic period) (150 mya)

↓ Biggest

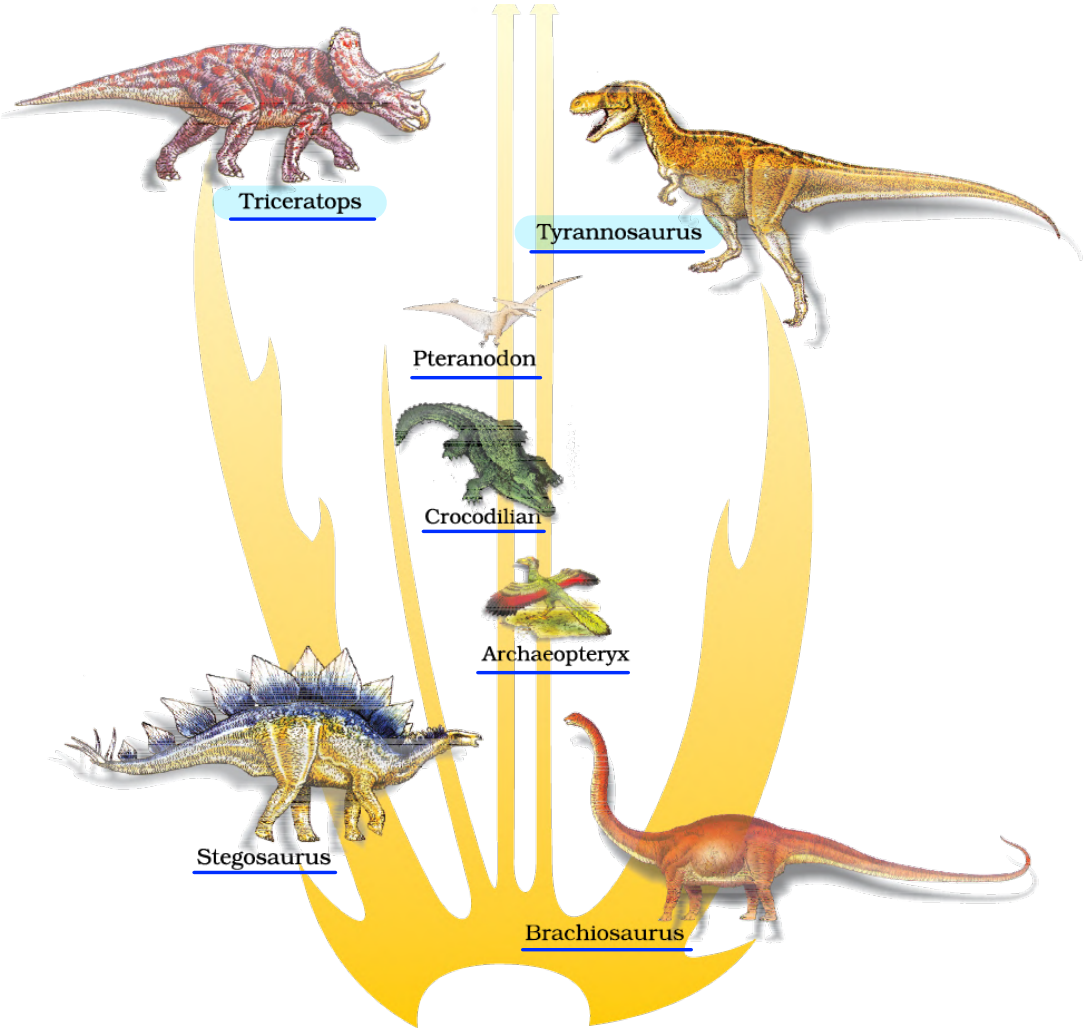
T-Rex

↳ 20 feet

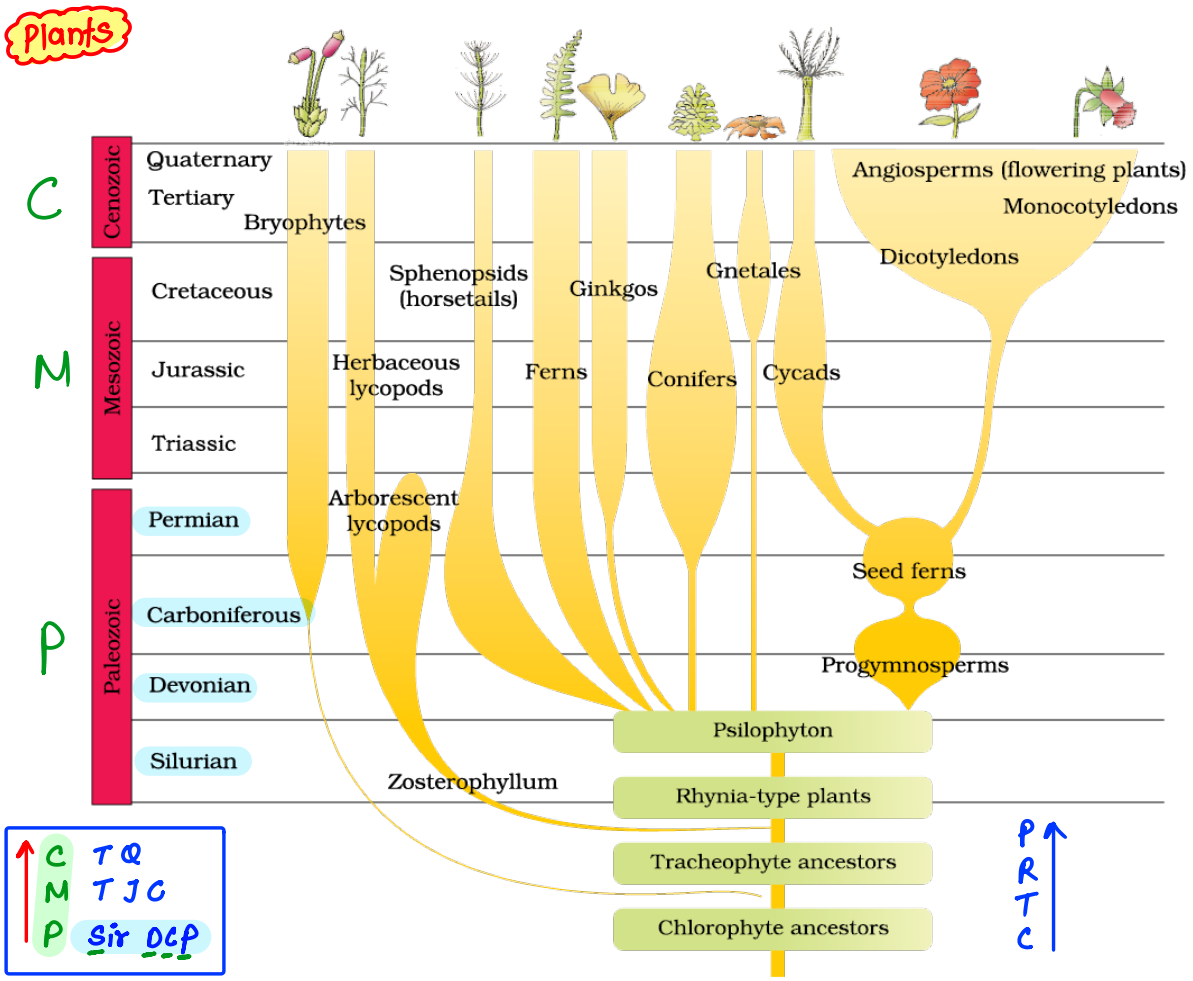
↳ dagger teeth

* Dianosaur extinct : 65 mya

Family tree of Dinosaurs

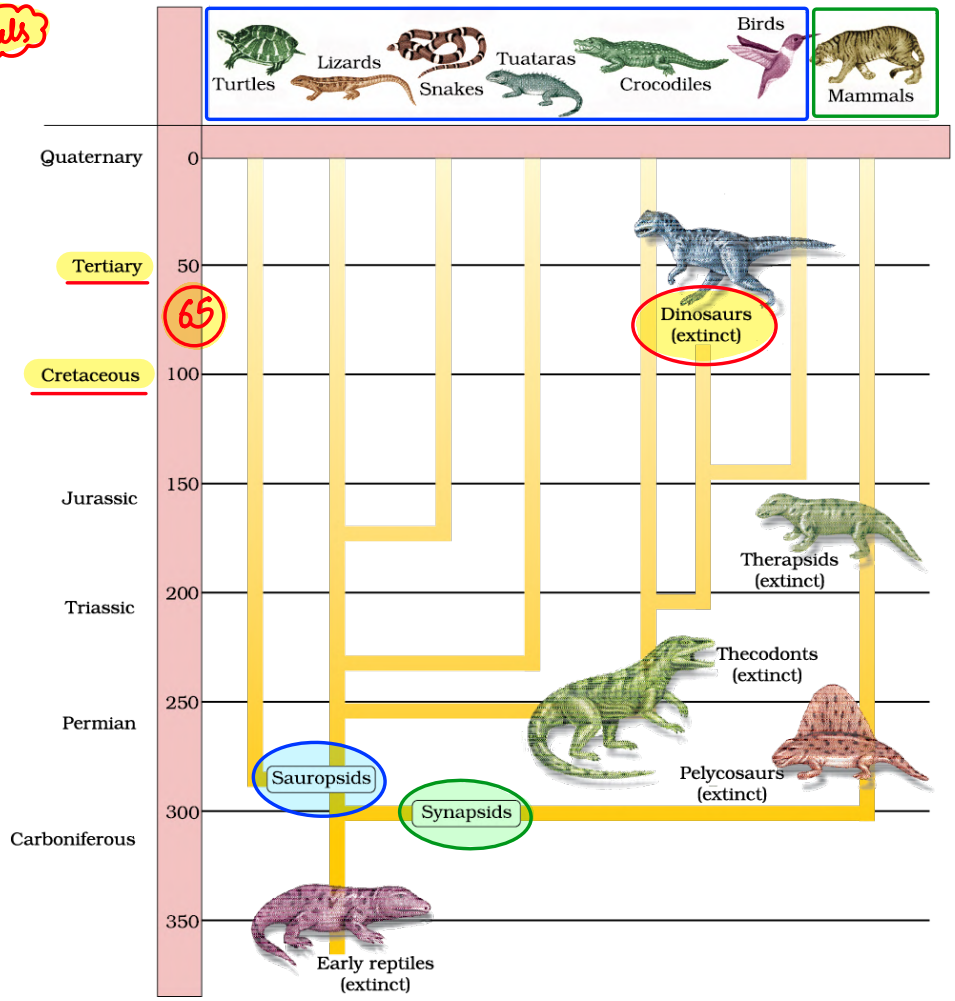


Plants



C TQ
M TJC
P Sir DCP

Animals



Q. Match List I with List II:

	List I		List II
A.	Mesozoic Era	I.	Lower invertebrates
B.	Proterozoic Era	II.	Fish & Amphibia
C.	Cenozoic Era	III.	Birds & Reptiles
D.	Paleozoic Era	IV.	Mammals

Choose the correct answer from the options given below: Neet-2024

1. A-III, B-I, C-II, D-IV
2. A-I, B-II, C-IV, D-III
3. A-III, B-I, C-IV, D-II
4. A-II, B-I, C-III, D-IV

Q. What is the correct order (old to recent) of periods in Paleozoic era? Re-Neet-2024

1. Silurian, Devonian, Permian, Carboniferous
2. Silurian, Devonian, Carboniferous, Permian
3. Permian, Devonian, Silurian, Carboniferous
4. Silurian, Carboniferous, Permian, Devonian

★ Some imp points:

- Jurassic period: Dinosaurus
- Cretaceous period: • Birds, Angiosperms, Mammals → Viviparous, intelligent
  → 1st mammal: Shrews

* Due to continental drift:
  - → South America joined to North America → ∴ South American mammals overridden by North American fauna
  - → Australian pouched mammals survived → B/c of lack of competition by other mammals

(13) Evolution of Man

* Primates (15mya)
  - Dryopithecus: Ape like
  - Ramapithecus: man like
  - → • Hairy • walked like Gorillas + chimpanzee
- (2mya) Australopithecus (East Africa): • Hunted with stone weapons • ate fruits
- (2mya) Homo Habilis: • 1st Human-like Hominid • 650-800cc, do not ate meat
- (1.5mya) Homo erectus: • 900cc • ate meat
- Homo sapiens (Africa)
  - (1,00,000-40,000 ya) Neanderthal man: • 1400 cc, • protect their body • Buried their dead
  - (75,000-10,000 ya) Modern man (Modern HS)

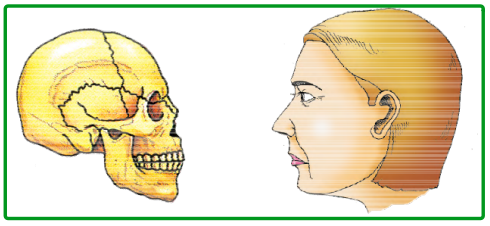
Ice age

D R A HH HE HS

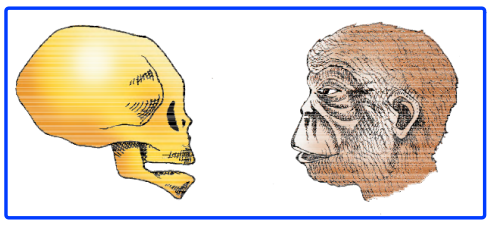
★ Some imp points:

- Man like bone found in: Ethiopia, Tanzania
- Man like primates: Ramapithecus
  - walked in east Africa
  - walked up-right
  - not taller than 4-feet
- Homo sapians in Africa → moved across continents
- pre-Historic cave art: 18,000 ya
- Agriculture: 10,000 ya

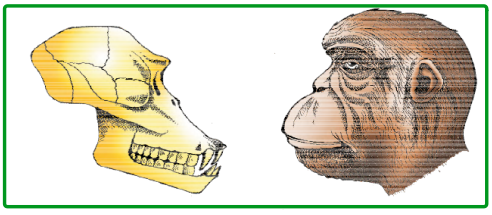
* Skull of baby chimpanzee
  - → more like adult Human skull
  - → less like adult chimpanzee skull



adult Human



baby chimpanzee



adult chimpanzee

HUMAN HEALTH AND DISEASE

① Health

- Affected by: • Genetic disorder, Infection, life style (food, water)

* William Harvey: • discovery of blood circulation
• disproved the good humor hypothesis → by Greeks like Hippocrates & Indian ayurveda

- Health does not simply mean 'absence of disease' or 'physical fitness'.
- It could be defined as a state of complete physical, mental and social well-being.
- Balanced diet, personal hygiene and regular exercise are very important

② Common Diseases

Genetic disorders (congenital)

Aquired Disorder
- Infectious (communicable) — by pathogen
  - Bacterial Diseases
  - Viral Diseases
  - Helminths Diseases
  - Fungal Diseases
  - Protozoan Disease
  - AIDS
- Non-infectious (Non-communicable)
  - Cancer
  - Allergy
  - Drugs & Alcohol Abuse
  - Diabetes
  - Deficiency Disorder

a. Bacterial Disease

	pathogen	Details
Typhoid → widal test	Salmonella Typhi	Infect: Intestinal perforation Symptoms: • weakness, • High fever (39-40°C) • Stomach pain, etc. Spread via: contaminated food & water
Pneumonia	Streptococcus pneumoniae & Haemophilus influenzae	Infect: Alveoli Symptoms: lips & nails turn grey to blue Spread via: inhaling droplets released by infected person. (Air-borne)

Other bacterial diseases
- Dysentery
- Plague
- Diphtheria

(b) Viral Disease

* common cold (Most infectious)

pathogen

Rhino-virus (group of virus)

Details

infect: nose & Respiratory passage
* {But not lungs}

Symptoms: nasal congestion, sore throat {for 3-4 days}

Spread via: cough/sneezes of infected person. (Air-borne)

(c) Fungal Disease

Ringworm (most common in males)

pathogen

- Microsporum
- Trichophyton
- Epidermophyton

Details

infect: thrives in skin folds (groin/b/w toes)

Symptoms: dry skin, dry nails

Spread via: Intense itching, Heat, moisture. (Fungus grow)

(d) Helminthic Disease

* Ascariasis

pathogen

Ascaris (Roundworm) → intestinal parasite

Details

infect: block Intestinal passage

Symptoms: Internal bleeding, muscular pain etc

Spread via: contaminated food & water.

* (parasite egg: excreted through faeces of infected person.)

* Elephantiasis (or) Filariasis

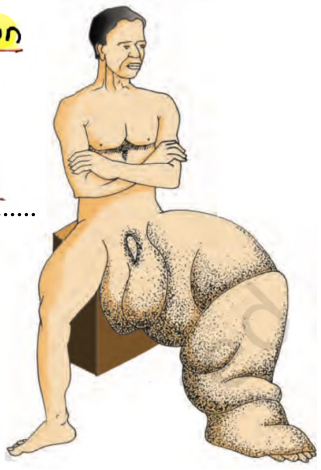
pathogen

Wuchereria (Filarial worm)

Details

infect: chronic inflammation on lymphatic vessels.

Spread via: female mosquito vector (Culex)



(e) Protozoans Disease

Amoebiasis → Amoebic dysentery

pathogen

- Entamoeba histolytica → parasite in Large Intestine

Details

Symptoms: constipation, cramps, blood clots.

Spread via: contaminated food & water

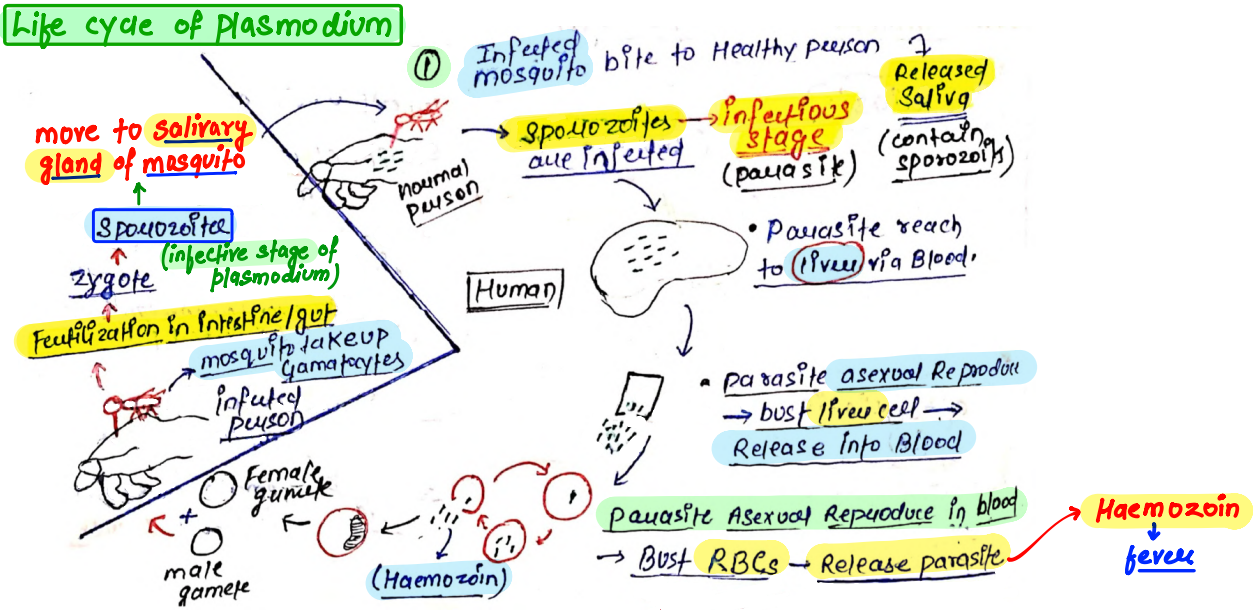
{Houseflies act as carrier}

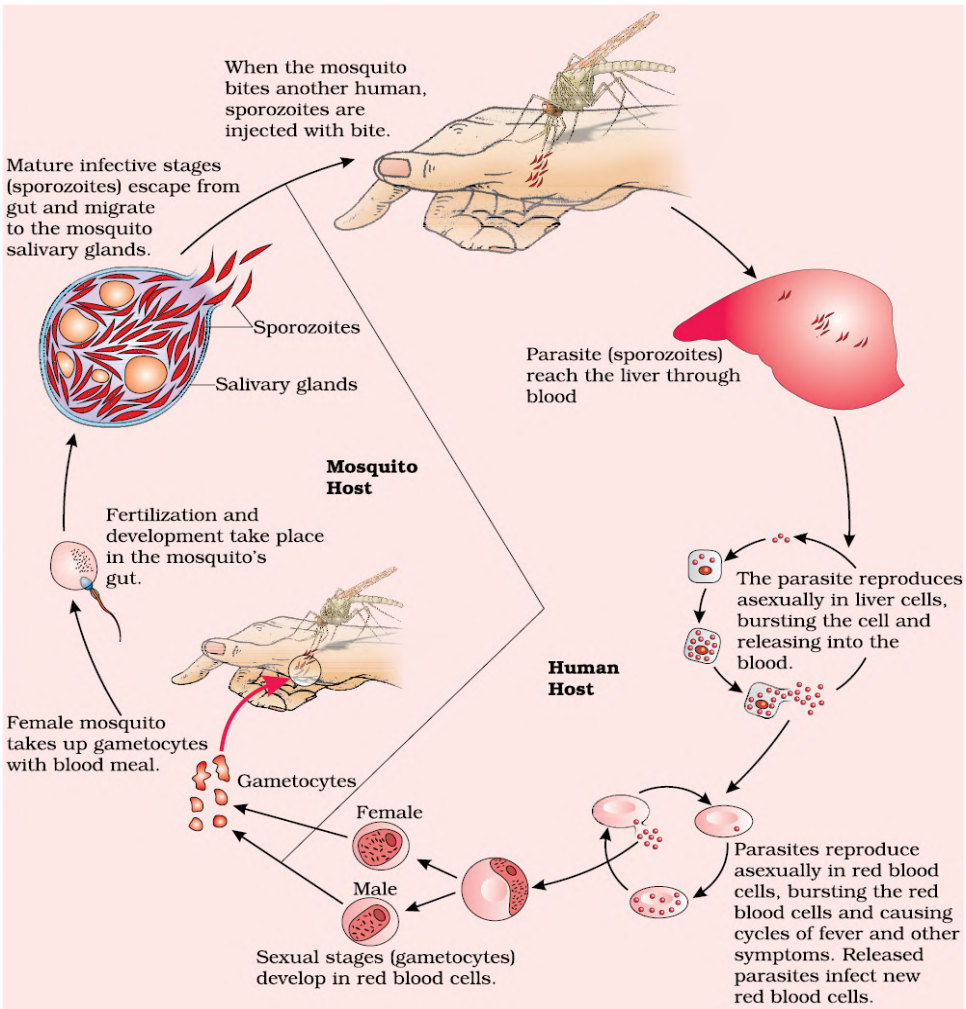
Protozoans Disease

Malaria

- Plasmodium
  - P-vivax
  - P-malaria
  - P-falciparum → malignant malaria (dangerous)
- In plasmodium life-cycle → Two host
  - Primary Host → female Anopheles mosquito (also act as vector)
  - Secondary Host → Human

★ Life cycle of plasmodium





③ Immunity (ability of host to fight disease)

ⓐ Innate immunity (non-specific, present at time of birth)

External (1st line of defence)

- **Physical barrier** ↓
  - Skin
  - Mucus
- **Physiological Barrier** ↓
  - Stomach acid (HCl)
  - Saliva
  - Tears

Internal (2nd line of defence)

- **Cellular Barrier** ↓
  - PMNL neutrophils
  - Monocytes
  - Natural killer cell

  (WBC)
  - Macrophages (phagocytatic)
- **Cytokiwin Barrier** ↓
  - Interferons (protein)
    - → secreted by virus infected cells
    - → protect non-infected cell from infection

Aquired immunity (Aquired with time)

- pathogen specific & memory based

Primary Response ↓

- 1st encounter by pathogen
- Low intensity

Secondary Response ↓

- 2nd encounter by same pathogen
- High intensity
- also called Anamnestic Response

* Primary & secondary Response carried by special lymphocytes
→ β-lymphocytes & T-lymphocytes

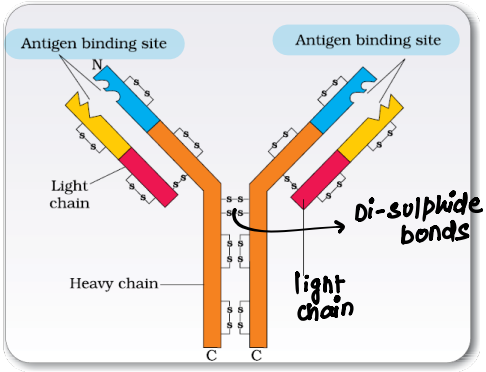
④ β-lymphocytes

- Antibody mediated immunity
- Humoral immunity (B/C Antibody found in blood)

* Produce army of proteins ↓ **Antibodies** ↓

eg: IgA, IgM, IgE, IgG

- IgE → Allergies
- IgA → mother 1st milk (colostrom)
- IgG → placenta to foetus



→ H_2L_2 { 2 Heavy chain, 2 light chain }

T-lymphocytes

- Cell mediated immunity (CMI)
  - → for organ Transplantation
  - → Also responsible for Graft rejection

* T-cells do not produce antibody, but help β-cell to produce antibody

⑤ Aquired immunity types

Active immunity (direct)

- Antibody produced by Host
- Memmory cell ✓
- Slow response

* Natural → Injection
* Artificial → vaccination

passive immunity (indirect)

- Ready made antibody provided to Host → Preformed
- Memmory cell ⊗
- Fast Response (Quick)

* Natural
  - IgA: in mother's 1st milk (colostrum) → yellowish
  - IgG: placenta to foetus during pregnancy

* Artificial
  - Anti-venom → in case of snake
  - Anti-Tetanus serum → for tetanus (ATS)

⑥ vaccination

- Based on Memmory cells (BfT cells) ⟶ Recognise pathogen Quickly
- Vaccine (inactivated/weakened pathogen)

* In vaccination ⟶ preparation of antigenic proteins
  → vacine introduced into body (to nutrilize pathogen action)

* RDT also used to make vaccine in large scale
  {eg: Hepatitis-B-vaccine → produced from yeast (Host)}

⑦ Allergies

- Exaggerated Response of immune system for Allergens. → Dust, pollens, animal donder
- IgE antibody produced
- Allergy due to chemials: Histamine, serotowin (from mast cells)
- Symptoms: Sneezing, running nose, teaus, breathing difficult ...
- Treatment: use of drugs → Anti-histamine, adeunaline, steroids

⑧ Auto immunity

- Memory-Based (Aquired Immunity)
- In Higher vertebrates → Differentate foreign molecule from self cells.

* Auto-immune Disease → Body attaks self cells
  → Due to genetic/unknown reason.
  eg: • Rheumatoid Authritis
  • Myasthenia Gravis

Immune system of body
↓
Lymphoid organ, tissue, cells
↓ Lymphocyte Ka Antibody.
Differentation ↓ Maturation ↓ proliferation } Primary LO, Sec. LO

* MALT (Mucosa-associated lymphoid tissue)
  → lymphoid tissue within lining of major duct (RT, DT, UGT)
  → contain 50% of lymphoid tissue

⑨ Primary Lymphoid organ v/s Sec. Lymphoid organ

immature lymphocyte → (differentiate) → Antigen sensitive lymphocyte → (mature) → mature lymphocyte + Antigens → (Proliferation) → Effector cells

eg: Bone marrow, Thymus → Both provide • micro-envt for maturation of T-cells

Bone marrow
- main lymphoid organ
- all blood cells produced

Thymus
- Lobed organ
- near Heart
- beneth breast bone
- *Reducing with age
  - Breath: large
  - Puberty: Small

* VIP
- Sec LO: provide site for interaction of lymphocyte with Antigen.

eg: Spleen, Lymph node, tonsils, Peyer's patches, appendix. } ⑤

Spleen
- large Bean shaped
- have lymphocyte & phagocyte
- Blood filter { trap blood-borne micro-organism }
- Large Reservoir of erythrocytes

Lymph node:
- Small solid str
- trap micro organism (or) Antigens
- trapped antigen
- Activate lymphocyte
- immune Response

⑩ AIDS (Acquired immunodeficiency syndrome)

- caused by HIV (grp of Retrovirus)
- 1st Reported in 1981

* HIV/AIDS only spread via body fluids (∴ Not spread by physical contact)

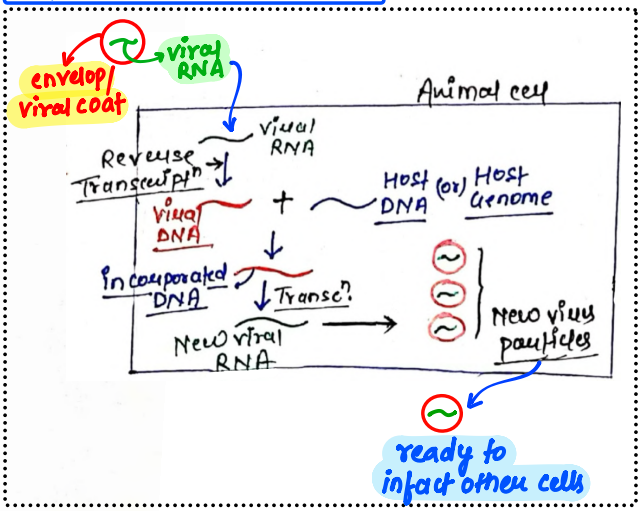
(Human immuno deficiency virus)

* Timelag b/w AIDS symptoms → few month to years (5-10 yrs)

* Transmition by → Saxual contact, Blood transfer, Infected needles, Infected mother to child.

* High Risk for AIDS → multiple sexual partners, Drug addits, Repeted Blood transfer, Child Born from HIV mothers

★ Replication of Retrovirus

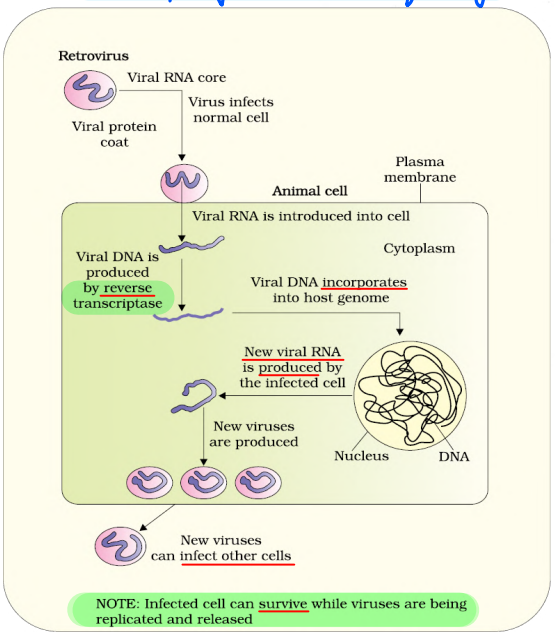


(11) HIV (Retrovirus after enter into body)

Virus enter into **macrophages**

- Viral RNA —RT→ Viral DNA + Host DNA } virus particles

∴ Macrophage act as HIV factory



Virus/HIV enter into **T-Helper cells (TH)**

HIV → Phagocytic virus

Released into Blood

attack TH-lymphocyte

∴ * TH-cells number ↓

{fever, weightloss, dPneumonia}

Immune system of patient → low ↓

∴ patient start suffering from infection

- Bacterial (Mycobacterium)
- Fungal
- viral
- parasitic (Toxoplasma)

VIPS

AIDS Diagonastic Test

→ ELISA

Treatment

→ Anti-retroviral drug (partially effective, b/c AIDS has no cure)

Preventions:

- ∵ AIDS has no cure ∴ preventions is the only options
- Do not ignore/Hasitate

*In India organisation that educate people about AIDS: NACO & NGOs (National AIDS control organisation)

(12) Cancer:

- most dreaded disease
- major cause death

* development of Cancer cells from Normal cell: onchogenic /neoplasmic transformation

Normal cell	v/s	Cancer cell
• cell growth: controlled		• cell growth: uncontrolled
• contact inhibition ✓ (on contact with normal cell → inhibit uncontrolled growth)		• contact inhibition ✗

∴ cancer cells continue to divide to form mass of cells → **Tumor**

(a) Types of Tumors

Benign tumors

- Remain to their location
- Do not spread
- little damage

malignant tumors

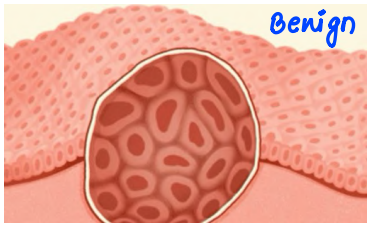
- mass of proliferating cells
- Neoplastic/tumor cells
- Grow very Rapidely

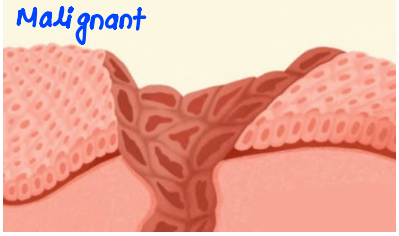
Great damage to tissue.

∵ they actively divide & grow,
∴ kill normal cell by competing for Nutrition.

* They show **Metastasis** (spreading via blood)

* Tumor reaches to different sites via blood → start new tumors





(b) Cause of cancer

By cancer causing agent: Carcinogens

- **Physical agent**
  - Ionising Radiation → X-ray, γ-ray
  - Non-Ionising Radn → UV-ray (DNA Damage)
- **Chemical agent**
  - Tobacco smoke → lung cancer
- **Biological agent**
  - oncogenic viruses → viral-oncogens (cancer causing)
  - Normal cells → cellular-oncogens, proto-oncogens → activated under certain condition

(c) Cancer Dection

- Biopsy & Histopathological studies → piece of tissue cut & examined in microscope
- Blood & Bone marrow test → For Leukemias (Blood cancer)
- Radiography (X-ray used)
- CT [computed Tomography] → (X-ray used → 3D image)
- MRI → (Strong Magnetic field non-Ionising Radn used.) (safest)

(CT, MRI) detect cancer in internal organ.

- Antibodies against cancer-specific Antigen
- Molecular Biology

(MRI)

(d) Treatment of cancer

- **Surgery**
- **Radio-therapy** → tumor cell are ir-radiated lethally (or) Vigorously
- **Chemo-therapy** → Chemotherapeutic Drug used → Side effect
  - hair loss
  - Anemia

Most of cancer treatment by these combination

- **Immuno-therapy** → Immune system unable to kill cancer cell → α-interferon (Biological response modifier) → Activate Immune system to kill tumors.

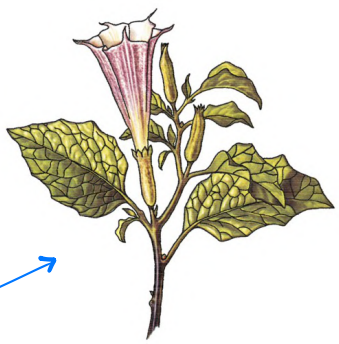
(13) Drugs

Mood altering

- opoids
- Tranquilizer
- Cocaine
- Tobacco

Hallucinogenic (AB C D)

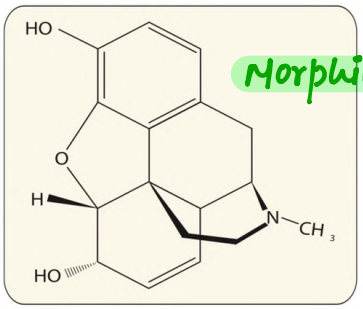
- Atropa belladona
- cannabinoids
- Cocaine (excess dose)
- Datura



(a) Opiods

- Binds with receptors of CNS & GIT → CNS/GIT
- extracted from opium poppy (latex): {papaver somniferum}
- Derivatives
  - Morphine
    - sedative
    - painkiller
    - ↓ Useful in Surgery.
    - methylation → codein → methyl morphine
    - Acetylation → Heroine / smack
      - ↓ depressant
      - slow body function
      - diacetylmorphine: white, odourless, bitter, crystalline
      - injection / snorting

opium poppoy



Morphine

(b) Tranquillisers

- used as medicine
- Help in → mental illness, depression (depressent), insomia
  - Barbiturates
  - Benzodiazepine
  - Amphetamines

(c) Cannabinoids

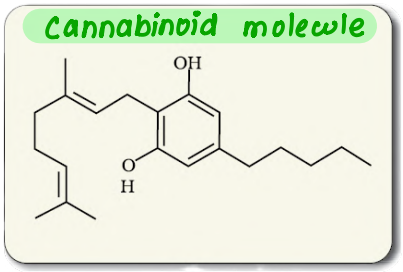
↳ Bind with cannabinoids receptors in brain

* Obtained from: Cannabis sativa (plant)

* Plant (cannabis) → flowers, leaves, Resin →
  - marijuana
  - Hashish
  - charas
  - Ganja
  - Bhang

→ by inhalation & oral ingestion → Cardiovascular system affect

Cannabinoid molecule

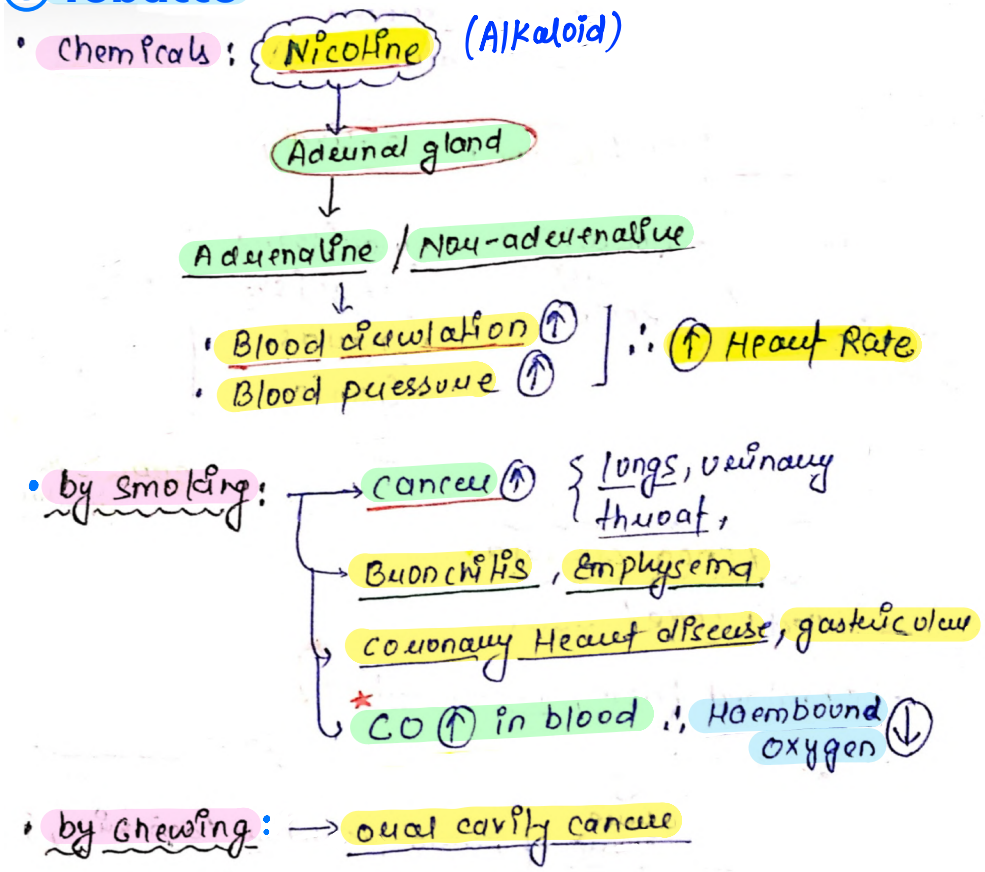


(d) Cocaine/Coca alkaloids

- called: coke / crack
- obtained from: coca plant → Erythroxylum coca (south america)
- by snorting

effect (VIP)
- ↓ transport of neuro-transmitter (dopamine)
- ↓ Central Nervous System (CNS)
- Sense of Euphoria
- Increased energy

Tobacco



(14) Adolescence and Drug/Alcohol Abuse

Adolescence means both 'a period' and 'a process' during which a child becomes mature in terms of his/her attitudes and beliefs for effective participation in society. The period between 12-18 years of age may be thought of as adolescence period. In other words, adolescence is a bridge linking childhood and adulthood. Adolescence is accompanied by several biological and behavioural changes. Adolescence, thus is a very vulnerable phase of mental and psychological development of an individual.

Curiosity, need for adventure and excitement, and experimentation, constitute common causes, which motivate youngsters towards drug and alcohol use. A child's natural curiosity motivates him/her to experiment. This is complicated further by effects that might be perceived as benefits, of alcohol or drug use. Thus, the first use of drugs or alcohol may be out of curiosity or experimentation, but later the child starts using these to escape facing problems. Of late, stress, from pressures to excel in academics or examinations, has played a significant role in persuading the youngsters to try alcohol and drugs. The perception among youth that it is 'cool' or progressive to smoke, use drugs or alcohol, is also in a way a major cause for youth to start these habits. Television, movies, newspapers, internet also help to promote this perception. Other factors that have been seen to be associated with drug and alcohol abuse among adolescents are unstable or unsupportive family structures and peer pressure.

15 Addiction and Dependence

Because of the perceived benefits, drugs are frequently used repeatedly. The most important thing, which one fails to realise, is the inherent addictive nature of alcohol and drugs. Addiction is a psychological attachment to certain effects – such as euphoria and a temporary feeling of well-being – associated with drugs and alcohol. These drive people to take them even when these are not needed, or even when their use becomes self-destructive. With repeated use of drugs, the tolerance level of the receptors present in our body increases. Consequently the receptors respond only to higher doses of drugs or alcohol leading to greater intake and addiction. However, it should be clearly borne in mind that use of these drugs even once, can be a fore-runner to addiction. Thus, the addictive potential of drugs and alcohol, pull the user into a vicious circle leading to their regular use (abuse) from which he/she may not be able to get out. In the absence of any guidance or counselling, the person gets addicted and becomes dependent on their use.

* Dependence is the tendency of the body to manifest a characteristic and unpleasant **withdrawal syndrome** if regular dose of drugs/alcohol is abruptly discontinued. This is characterised by anxiety, shakiness, nausea and sweating, which may be relieved when use is resumed again. In some cases, withdrawal symptoms can be severe and even life threatening and the person may need medical supervision.

Dependence leads the patient to ignore all social norms in order to get sufficient funds to satiate his/her needs. These result in many social adjustment problems.

16 Effects of Drug/Alcohol Abuse

The immediate adverse effects of drugs and alcohol abuse are manifested in the form of reckless behaviour, vandalism and violence. Excessive doses of drugs may lead to coma and death due to respiratory failure, heart failure or cerebral hemorrhage. A combination of drugs or their intake along with alcohol generally results in overdosing and even deaths. The most common warning signs of drug and alcohol abuse among youth include drop in academic performance, unexplained absence from school/college, lack of interest in personal hygiene, withdrawal, isolation, depression, fatigue, aggressive and rebellious behaviour, deteriorating relationships with family and friends, loss of interest in hobbies, change in sleeping and eating habits, fluctuations in weight, appetite, etc.

There may even be some far-reaching implications of drug/alcohol abuse. If an abuser is unable to get money to buy drugs/alcohol he/she may turn to stealing. The adverse effects are just not restricted to the person who is using drugs or alcohol. At times, a drug/alcohol addict becomes the cause of mental and financial distress to his/her entire family and friends.

Those who take drugs intravenously (direct injection into the vein using a needle and syringe), are much more likely to acquire serious infections like AIDS and Hepatitis B. The viruses, which are responsible for these diseases, are transferred from one person to another by sharing of infected needles and syringes. Both AIDS and Hepatitis B infections are chronic infections and ultimately fatal. Both can be transmitted through sexual contact or infected blood.

The use of alcohol during adolescence may also have long-term effects. It could lead to heavy drinking in adulthood. The chronic use of drugs and alcohol damages nervous system and liver **(cirrhosis)**. The use of drugs and alcohol during pregnancy is also known to adversely affect the foetus.

Another misuse of drugs is what certain sportspersons do to enhance their performance. They (mis)use narcotic analgesics, anabolic steroids, diuretics and certain hormones in sports to increase muscle strength and bulk and to promote aggressiveness and as a result increase athletic performance. The side-effects of the use of anabolic steroids in females include masculinisation (features like males), increased aggressiveness, mood swings, depression, abnormal menstrual cycles, excessive hair growth on the face and body, enlargement of clitoris, deepening of voice. In males it includes acne, increased aggressiveness, mood swings, depression, reduction of size of the testicles, decreased sperm production, potential for kidney and liver dysfunction, breast enlargement, premature baldness, enlargement of the prostate gland. These effects may be permanent with prolonged use. In the adolescent male or female, severe facial and body acne, and premature closure of the growth centres of the long bones may result in stunted growth.

(17) Prevention & control

- Avoid undue peer pressure
- Education & counselling
- Seeking help from parents & peers
- Looking for danger signs
- Seeking professional & medical help

MICROBES IN HUMAN WELFARE

Bacteria, cyanobacteria, protozoa, fungi (yeast), virus

① House hold product

Curd

Milk —LAB→ curd

LAB: Lactic acid bacteria / Lactobacillus

- LAB produce Acid that coagulate & partially digest Milk proteins
- curd has more nutritional value due to presence of Vit-B_{12}
- LAB play benificial role in checking disease

Idli-dosa

Blackgram + Rice → Fermentation → Idli/dosa

(Puffed appearence due to production of CO_2 gas)

Cheese

oldest food item

eg: Swiss cheese
- large holes due to production of CO_2 by bacteria
  - Propionibacterium Sharmani

eg: Roquefort cheese
- Ripened by fungi
- give perticular flavour

Toddy

Traditional South Indian drink (Fermenting sap from palm)

* Microbes are used as food
- Ferment fish
- Soyabean
- bamboo shoots

② Industrial products

Anti-biotics (anti: agoist; biotics: life)
- For disease: Against life
- For Human: pro life

* produced by microbes & kill/retard growth of disease causing microbes

eg: penicillin (1st antibiotic discovered by chance event)

Alexander fleming → working on staphylococci Bacteria → He found mould growing in his unwashed plates

mould: penicillium notatum (∴ He named Antibiotic → penicillin) → used during WW-II to treat American soldiers

* Full potential of Antiboitic by Ernest Chain & Howard Florey

∴ Fleming, chain & Florey → Nobel price in 1945

* Antibiotics treats
- Plague
- whooping cough — Kali Khansi
- Diphtheria — gal ghotu
- Leprosy — Kusht rog

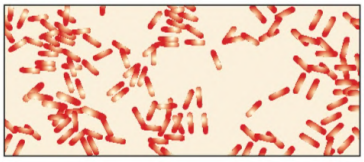
Fermented

yeast (saccharomyces cerevisiae)

- Beer making → Brewer's yeast
- Bread making → Baker's yeast

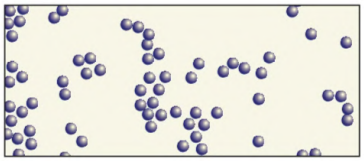
depend on type of raw material & processing, diff type of alcohol obtained

with distillation	without distillation
• whisky	• wine
• Brandy	• Beer
• Rum	



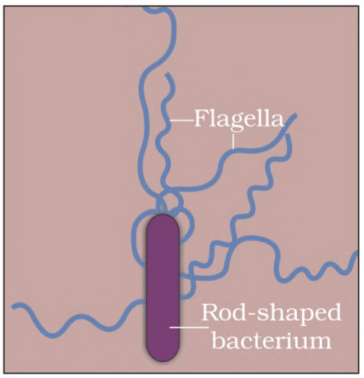
Rod (1500X)

(a)



Spherical (1500X)

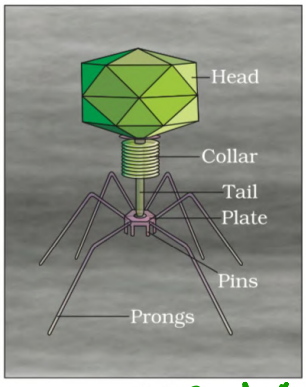
(b)



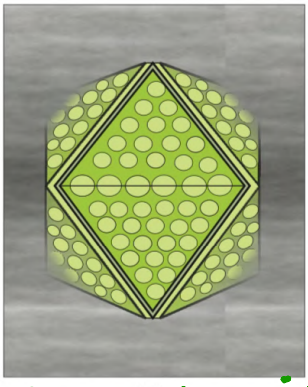
Rod + flagella (50,000X)

(c)

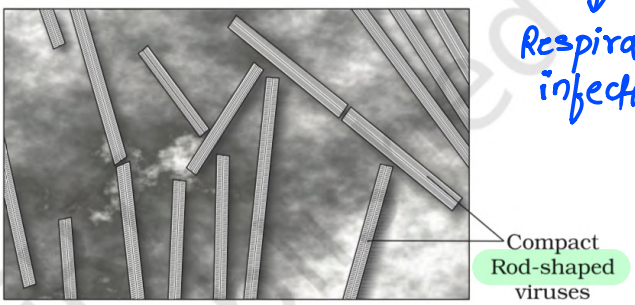
Bacteria: (a) Rod-shaped, magnified 1500X; (b) Spherical shaped, magnified 1500X; (c) A rod-shaped bacterium showing flagella, magnified 50,000X



(a) Bacteriophage

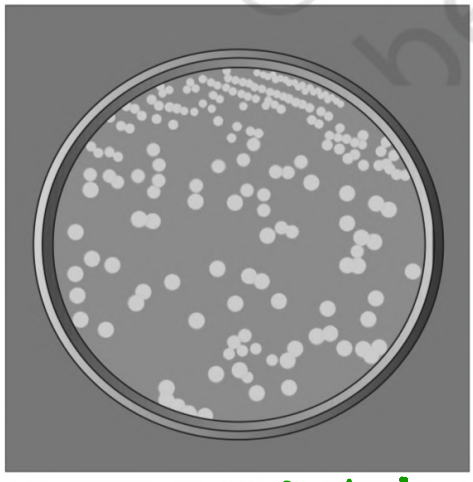


(b) Adenovirus → Respiratory infection

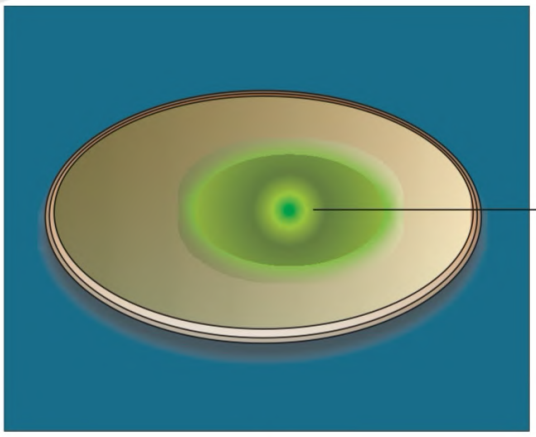


(c) TMV

Viruses: (a) A bacteriophage; (b) Adenovirus which causes respiratory infections; (c) Rod-shaped Tobacco Mosaic Virus (TMV). Magnified about 1,00,000–1,50,000X



(a) Bacteria



(b) Fungi

(a) Colonies of bacteria growing in a petri dish; (b) Fungal colony growing in a petri dish

③ Acids

- by Bacteria
  - Acetobacter Aceti → Acetic Acid
  - Clostridium Butylicum → Butyric Acid
  - Lacto-Bacillus → Lactic Acid
- by Fungus
  - Aspergillus niger → citric Acid

④ Enzymes

- **Lipase**
  - Detergent formulation → removing oily stains
- **protease & pectinase**
  - clear bottle juices
- **Streptokinase**
  - Genetically modified from Streptococcus
  - used as clot buster → Remove clots from Blood vessels
  - ∴ treat Myocardial infaction

⑤ Bioactive molecule

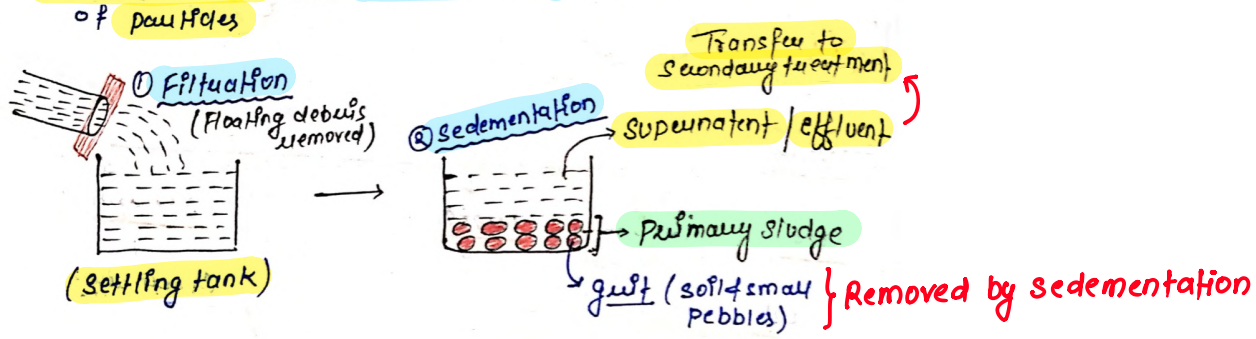
- **cyclosporin-A**
  - immunosuppressive agent (∵ used in organ transplantation)
  - produced by Fungus → Trichoderma polysporum
- **Statin**
  - Blood cholesterol lowering agent
  - * Statin competitively inhibit enzyme for cholestrol formation
  - produced by yeast → Monascus purpureus

⑥ Sewage Treatment

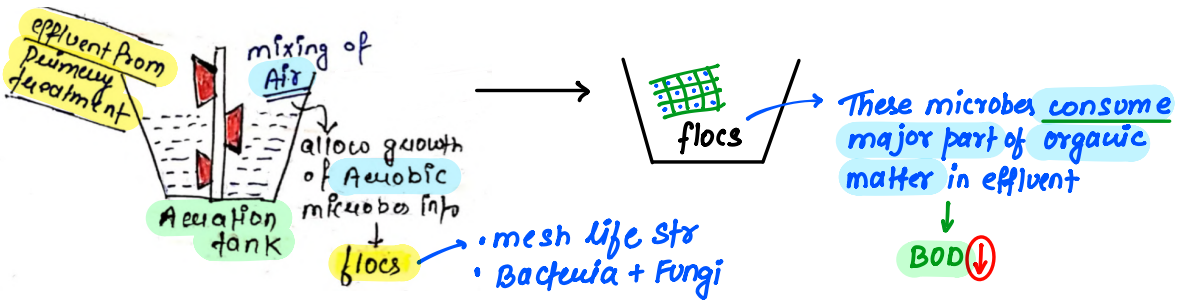
- Before disposal sewage treated with Sewage treatment plants (STPs)
- Treatment of sewage by Heterotroplic microbes

ⓐ primary treatment

→ Physical Removal of particles by Filtration & sedimentation



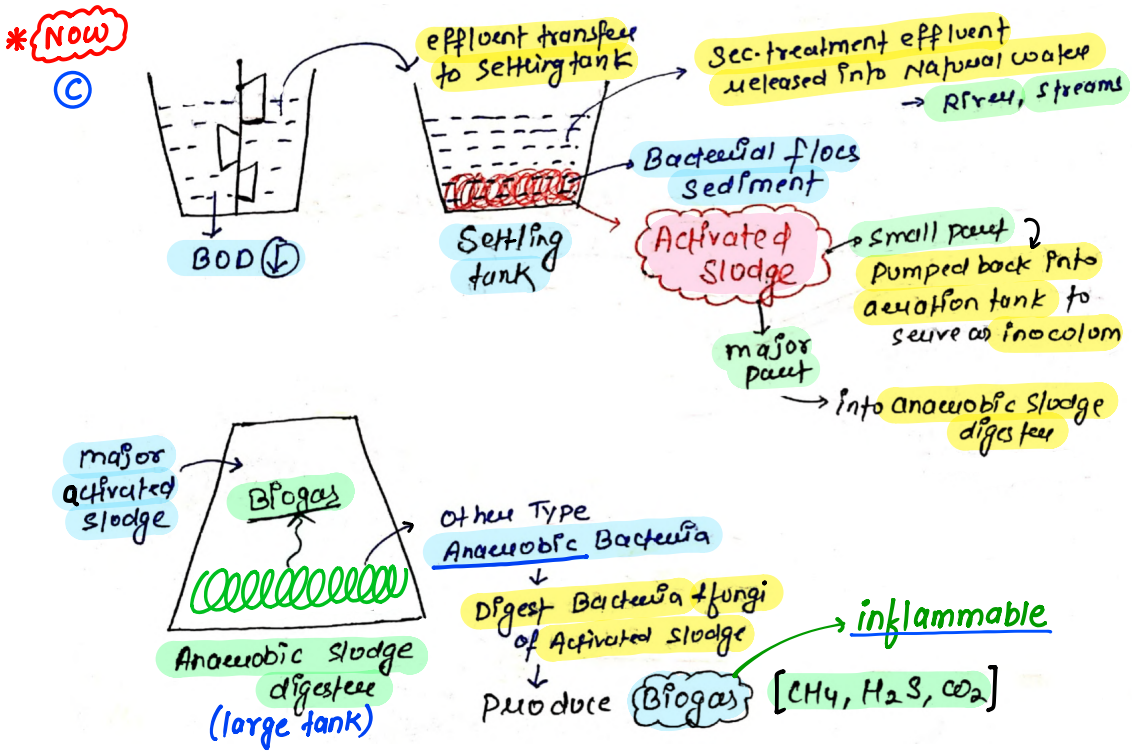
ⓑ Secondary treatment / Biological treatment → using aerobic bacterial & fungi



* **BOD:** (Biochemical oxygen demand)
  ↳ amount of O_2 req by bacteria to consume all organic matter in 1 liter of water

BOD ∝ amt of organic matter ∝ polluting potential

∴ sewage water is treated till BOD reduced



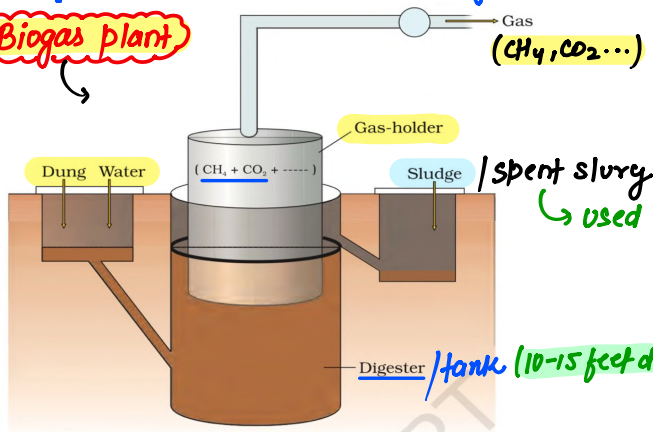
* Depelop large no. of **sewage plant** to dec ↓ pollution in river
  → By Ministry of Environment & forests → Ganga Action plan
  → yamuna Action plan

⑦ **Production of Biogas** → predominatly methane

* **Methanogens** → grow anaerobically on cellulosic material
  ↓ → produce: CH_4, CO_2, H_2
  Found on
  - Anaerobic sludge
  - Rumen of cattle → These bacteria breakdown cellulose & play imp role in Nutrition.

* Dung (gobar) can also used to generate **Biogas / Gobar gas**

Biogas plant



* **Biogas production**
  - **IARI:** Indian agriculture Research institute
  - **KVIC:** Khadi & village industrial commesion

⑧ Biocontrol Agents

↳ control plant disease & pests

* Biological control of pest & disease → • Relay on Natural predation
• Reduce dependence on toxic chemical

* **Types of Biocontrol Agents**

Insects

- Lady bird (Beetle with Red & Black marking) ↓ kill aphids
- Dragonflies ↓ kill mosquitoes

Bacteria

- Bt-toxin ↓ control butterfly caterpillers (insects)

* Bt sparyed on vulnerable plants ↳ Brassica, fruit tree

* Bt-toxin kill caterpillers, but leave other insects (due to genetic engineered)

Fungi

- Trichoderma (Free living fungi) ↓ common in Root Ecosystem ↓ control Plant/Root pathogen

Virus

- Baculovirus ↓ control insect & arthropods

* Genus: NPV (Nucleopolyhedro virus)

* • species-specific
• Narrow spectrum
• No negative impact
↓
∴ Beneficial in
→ insect managment program
→ ecologically sensitive area treatment

⑨ Bio-fertilizers (organic farming) → increase ↑ Nutrient Quality of soil

Bacteria

- Rhizobium (Root of legumes)
- Azospirillum
- Azobacter

↓ fix atmospheric Nitrogen ↓ ↑ N_2 in soil

- Cyanobacteria / Blue-green-Algae (Biofertilizers in paddy fields)
  - Anabaena
  - Nostoc
  - Oscillatoria

↓ fix atmospheric N_2 ↓ ↑ fertility of soil

* **Fungi** ↓ + Root
Mycorrhiza *(Genus: Glomus) ↓

- ↑ absorption of Phosphorus
- Provide resistance to
  - Root borne pathogen
  - Salinity & drought

BIOTECHNOLOGY PRINCIPLES AND PROCESSES

① Definations

* **Old Biotech** → • Using live organism/enzyme to produce products & process useful to humans
  • making curd, bread, wine (microbe mediated process)

* **Latest Biotech** → • Test tube baby (in vitro fertilization)
  • Gene synthesis & using it
  • DNA vaccine (to correct defective gene)

* **EFB** (European Federation of Biotech) → Integration of Natural science & organism, cells, parts there of & molecular analogues for product & service.

② Process of Biotechnology

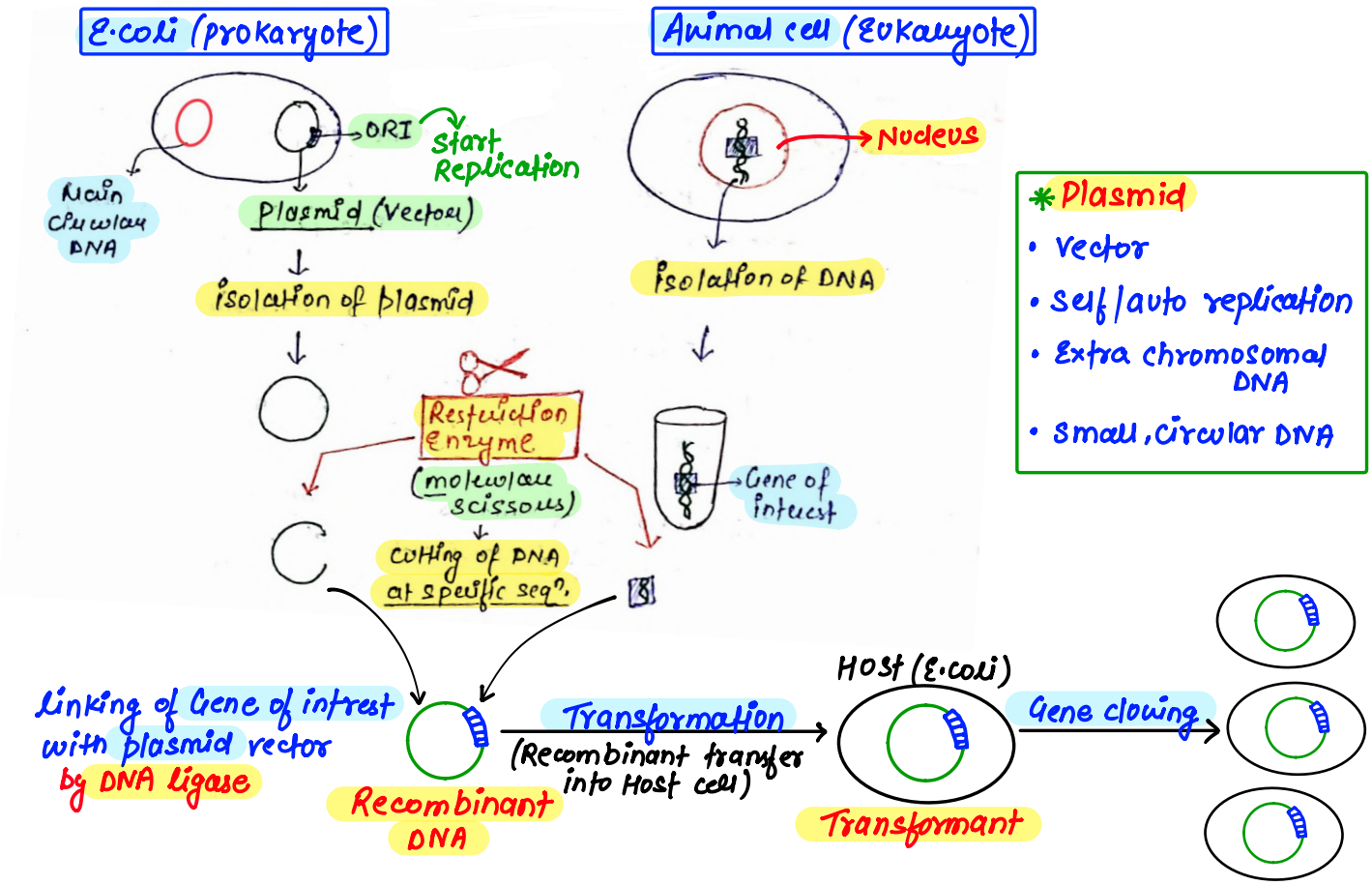
Genetic engineering V/S **Bioprocess engineering**

- Alter the chemistry of Genetic material (DNA & RNA)
- ↓ Introduce into host
- ↓ Change phenotype of host

★ This technique include:
→ creation of Recombinant DNA
→ use of gene cloning
→ Gene transfer
→ Introduce only desirable gene into target host.

- Chemical engineering
- ↓ Maintanance of sterile / microbial free medium
- ↓ To enable growth of only desired microbe/eukaryotic cell.
- make products like: antibiotics, vaccines, enzymes.

③ Gene cloning



* Plasmid
- Vector
- self/auto replication
- Extra chromosomal DNA
- small, circular DNA

④ 1st Recombinant DNA

- 1972 by Stanley cohen & Herbert boyer

↓

By linking Antibiotic Resistance gene + plasmid of Salmonella Typhimurium (GOI)

* Simple E.coli converted into drug/Antibotic Resistance E.coli

* VIP

Do you know the likely fate of a piece of DNA, which is somehow transferred into an alien organism? Most likely, this piece of DNA would not be able to multiply itself in the progeny cells of the organism. But, when it gets integrated into the genome of the recipient, it may multiply and be inherited along with the host DNA. This is because the alien piece of DNA has become part of a chromosome, which has the ability to replicate. In a chromosome there is a specific DNA sequence called the **origin of replication**, which is responsible for initiating replication. Therefore, for the multiplication of any alien piece of DNA in an organism it needs to be a part of a chromosome(s) which has a specific sequence known as 'origin of replication'. Thus, an alien DNA is linked with the origin of replication, so that, this alien piece of DNA can replicate and multiply itself in the host organism. This can also be called as **cloning** or making multiple identical copies of any template DNA.

PYQ

⑤ Steps of Genetically modifying an organism

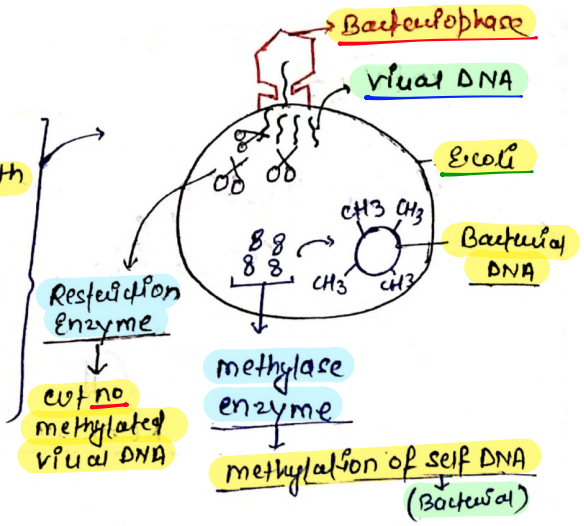
(i) identification of DNA with desirable genes;
(ii) introduction of the identified DNA into the host;
(iii) maintenance of introduced DNA in the host and transfer of the DNA to its progeny.

★ Tools for Recombinant DNA Technology

- Restriction enzyme (molecular scissor), polymerase enzyme, DNA ligase (molecular glue), vector, Host organism

⑥ Restriction Enzyme

* postulated in 1963
↓
* Two enzyme Restrict growth of Bacteriophage in E.coli
  - one: add methyl grp to DNA
  - other: cut viral DNA → called Restriction endonuclease.



⑦ Types of Restriction enzyme (class: Nuclease)

Endonuclease
- Hind II
- EcoRI
- cut DNA at specific position within the DNA.

Exonuclease
- cut nucleotide from ends of DNA

★ Steps (of working)
ⓐ inspecting the length of DNA sequence
↓
ⓑ finds specific Recognition sequence
↓
ⓒ Binds to DNA
↓
ⓓ Cut each of two strand of double helix at specific point in their sugar-phosphate backbone.

★ Palindromic sequences

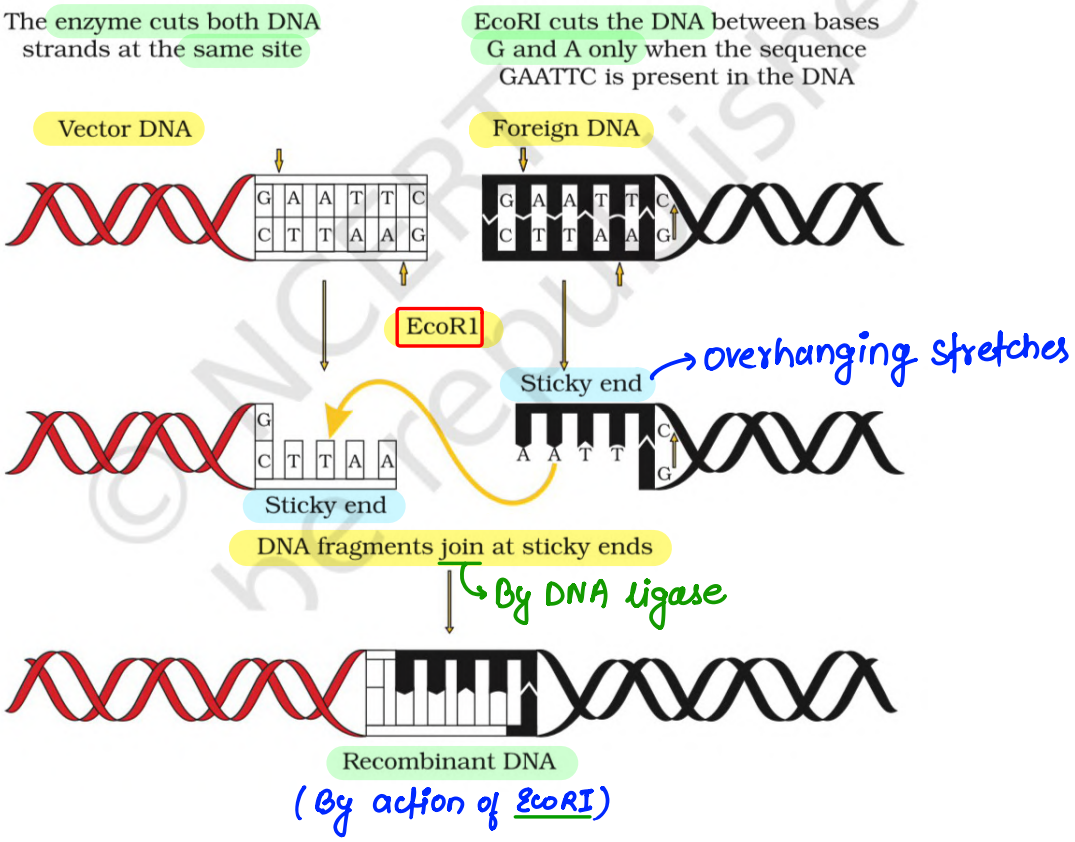
→ Sequences same when reads either forward / backward

eg: sticky end
5'–GAATTC–3'
3'–CTTAAG–5'

* cut the DNA b/w G & A only of: GAATTC

For EcoRI Restriction enzyme

⑧ Action of Restriction Enzyme



⑨ VIPS

* Each Restriction endonuclease recognises a specific palindromic nucleotide sequences in DNA
* Restriction enzyme cut strands of DNA little away from centre of palindrome sites b/w same two bases (like G & A by EcoRI) on opposite strands.
* Cutting this way creates overhanging stretches (or) sticky ends on each strand
* Sticky ends named b/c → they form hydrogen bond with their complementary cut part
* These stickness facilitates action of DNA ligase
* Restriction enzyme are used in genetic engineering

⑩ Naming

* 1st Restriction endonuclease
  - Hind-II
    - 1st discovered
    - 2nd isolated
  - cut DNA at particular point by recognising specific sequence of six base pair called Recognition sequence for Hind II.

★ Nomenclature
- 1st letter → Genus
- 2nd two letter → species of prokaryotic cell
- Next letter → name of strain
- Roman number → order of isolation

* EcoRI → 1st isolated
  - Escherichia (Genus)
  - coli (species)
  - RY13 (strain)
* Hind II → 2nd isolated
  - Haemophilus (genus)
  - influenzae (species)
  - strain

* There are more than 900 Restriction enzymes that isolated from 230 strains of bacteria.
  eg: Hind II, EcoRI, etc...

⑪ Cloning vectors

eg: Plasmids & bacteriophage

ability to replicate within bacterial cells independently

* copy number varies from plasmid to plasmid

Ⓐ Bacteriophage have very high copy number of genome within bacterial cell

Ⓡ B/c Bacteriophage present in high number per cell

* Features of cloning vectors

ⓐ ORI (Origin of Replication)
- Responsible for initating Replication
- This sequence also responsible for controlling copy number

* no. of copies of traget DNA ∝ high copy number supporting ORI

ⓑ Selectable Marker
- Promote growth of transfoument
- Identify & Eliminate non-transfoument

eg:
- Antibiotic resistance gene (Ex E. coli)
  → ampicillin, tetracycline, kanamycin, chloramphenicol
- Lac Z gene (For β-galactosidase enzyme)

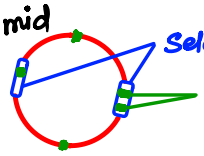
© Cloning sites

* Recognition sites for Restriction enzymes ∴ K/A Restriction sites
* useful when present within selectable Marker gene

↓

* Note: → Presence of more than one recognition site within vector will generate several fragments complicate the gene cloning process

★ plasmid

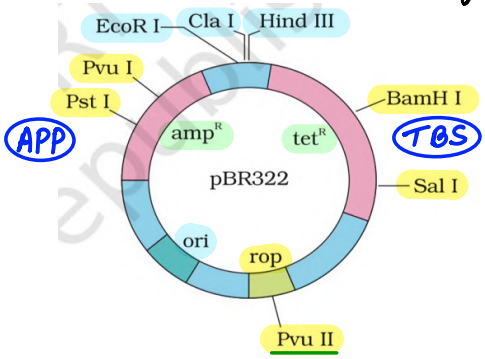


Selectable Marker

Cloning sites / Restriction site (can present outside / inside selectable Marker)

★ PBR322 : plasmid vector for E.coli

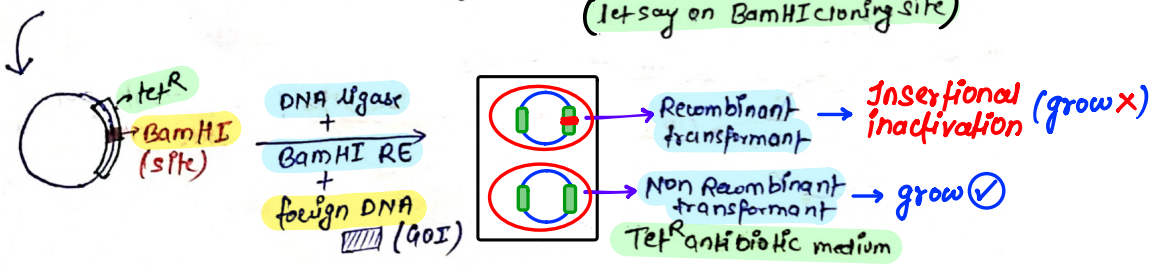
* Rop: • codes for protein that involve in Replication of plasmid



- Selectible Markers → Amp^R & tet^R (Antibiotic resistance)
- Cloning sites → (Restriction sites) Total 8
  - PstI, BamHI, PvuI, SalI → 4 within SM
  - EcoRI, ClaI, HindIII, PvuII → 4 outside SM

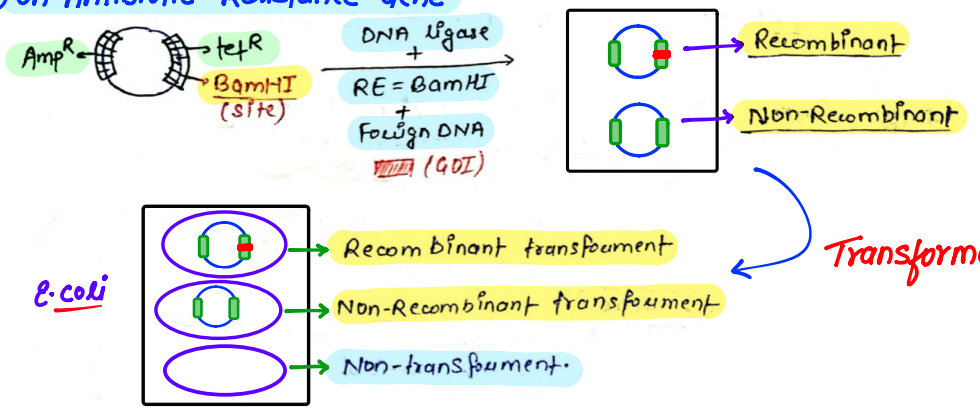
(12) Insertional inactivation

- Inactivation of particular selectible marker Gene due to insertion of foreign DNA on that selectible marker
- Recombinant plasmid lose tet^R Resistance ability due to insertion of foreign DNA on tet^R selectible marker (let say on BamHI cloning site)

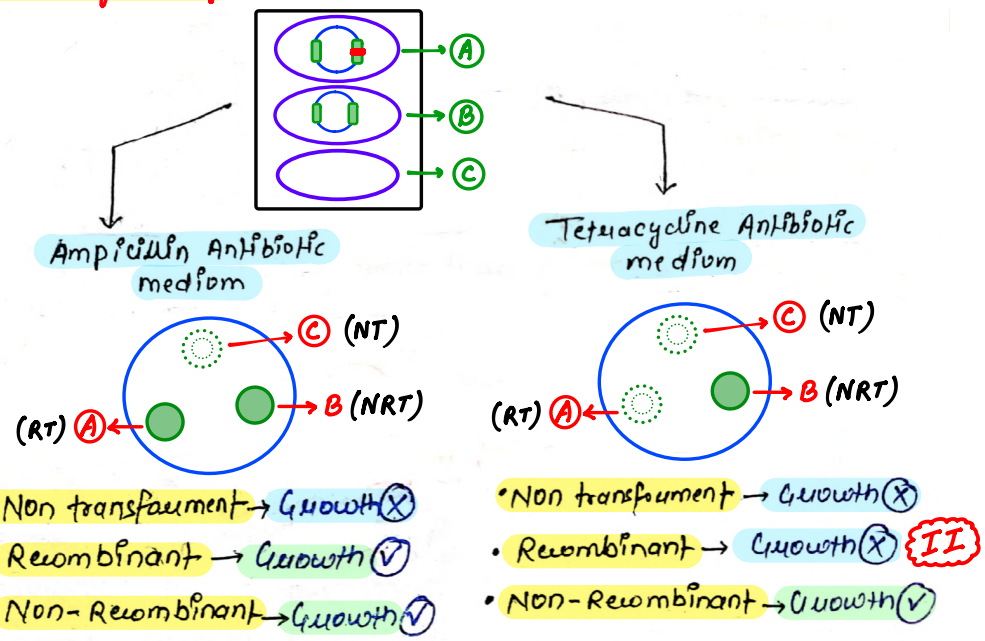


(13) Application of insertional inactivation

(a) On Antibiotic Resistance Gene



★ How to find out?



(A) Grow on Amp^R medium, but do not grow on tet^R medium
∴ A is Recombinant transformant (B/C on ter^R medium it get Insertional inactivated)

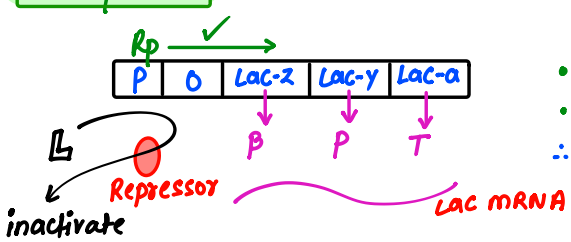
(B) Grow on Both Amp^R & tet^R medium ∴ B is non-Recombinant transformant

(C) Do not grow on both medium ∴ C is non-transformant

(b) Lac-z-gene

Inactivation of Antibiotic is cumbersome process, thats why differentiation on the basis of colour introduced (by chromogenic substance)

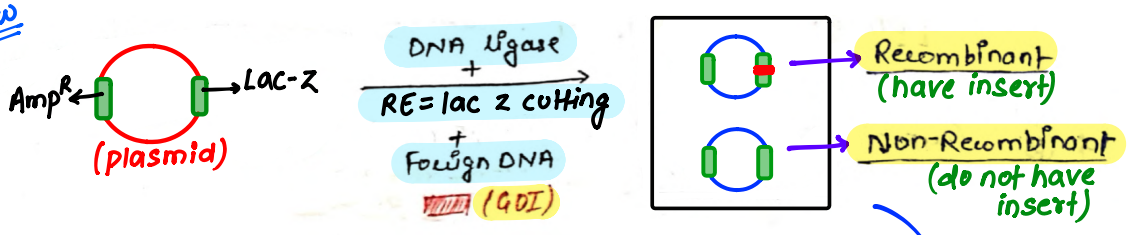
Lac-operon:

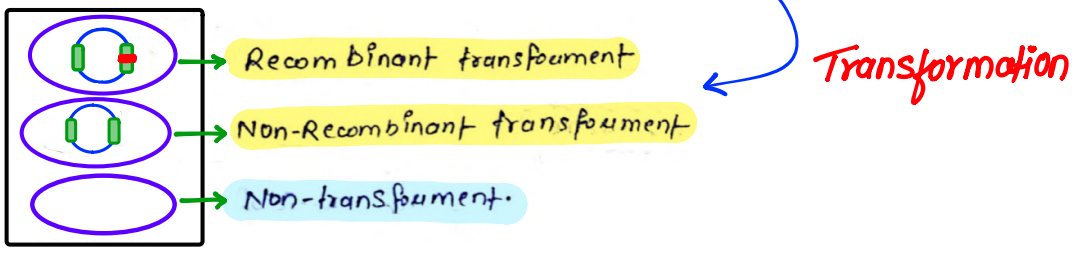


• Lactose ✓
• Glucose ✗
∴ +ve (ON)

* Lactose $\xrightarrow{\beta\text{-gal}}$ Glucose + Galactose
& In presence of chromogenic substance it give Blue colour

Now





* Hence we conclude insertional inactivation helps in : Selection of Recombinants

(14) Vectors for plants & animals

plants

Plasmid from Agrobacterium tumifaciens

* Ti-plasmid { Tumor inducing plasmid }

modified into

Cloning vector

No more pathogen

able to deliver gene of interest into plant cell

* Pathogen of Dicot plants

Normal plant cell —T-DNA→ Tumor

(Convert Normal plant cell into Tumor by deliver T-DNA in it)

Animals (Human)

- Retrovirous → disarmed → vector (deliver GOI into animal cells)

* Retrovirous → virus that has ability to transform Normal cell into cancerous cell

(15) Competent Host (method for transformation)

Bacterial cell

- Heat shock method: ICE ⇌ Heat at 42°C
- Using Ca^{2+} → increase efficiency of transformation

Animal cell

Micro-injection → γDNA directly inject into nucleus

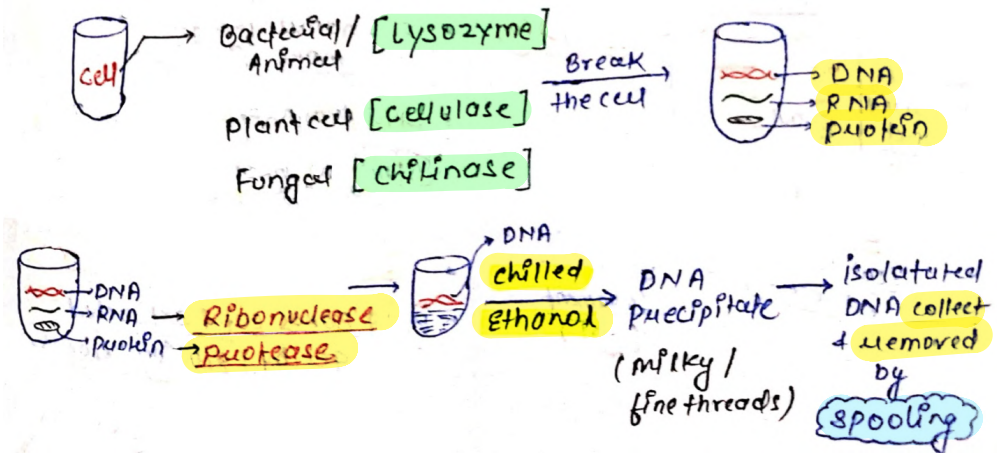
plant cell

Biolistics / Gene Gun → micro particles of Gold / tungsten

(16) Process of Recombinant DNA Technology

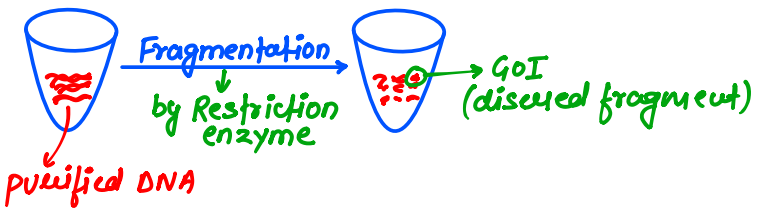
(a) Isolation of Genetic material (DNA)
↓
(b) Fragmentation / cutting of DNA (by Restriction enzyme)
↓
(c) Isolation (or) separation of desired DNA fragment (by Gel electrophoresis)
↓
(d) Amplification of DNA fragment (by PCR)
↓
(e) Ligation of DNA fragment into vector (by DNA ligase)
↓
(f) Transfer the Recombinant DNA into host
↓
(g) Culturing host cells in large scale (Bioreactors)
↓
(h) Extraction of desired product
↓
(i) Downstream processing (Separation + purification + preservation)

(a) Isolation of Genetic material (DNA)



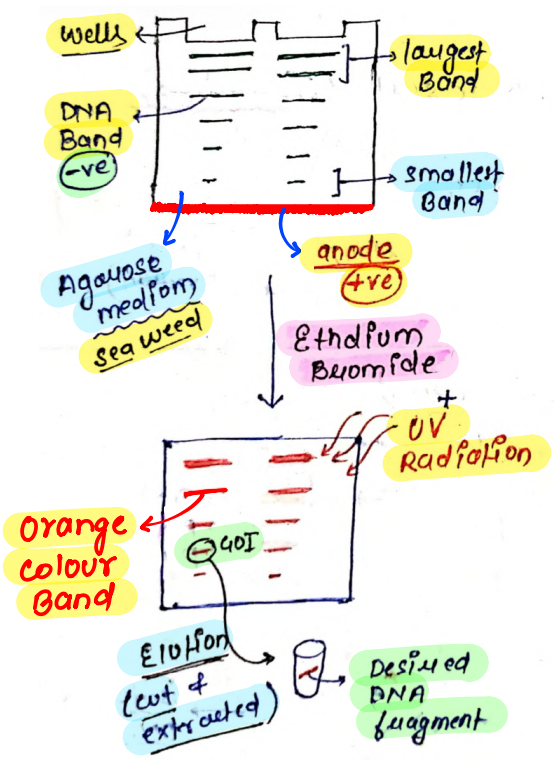
DNA that separates out can be removed by spooling

(b) Fragmentation / cutting of DNA

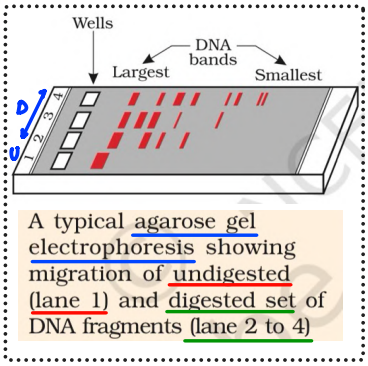


* RE digation by incubating purified DNA with RE
→ at optimal condition for that specific enzyme

© Separation / isolation of DNA fragment : Gel electrophoresis



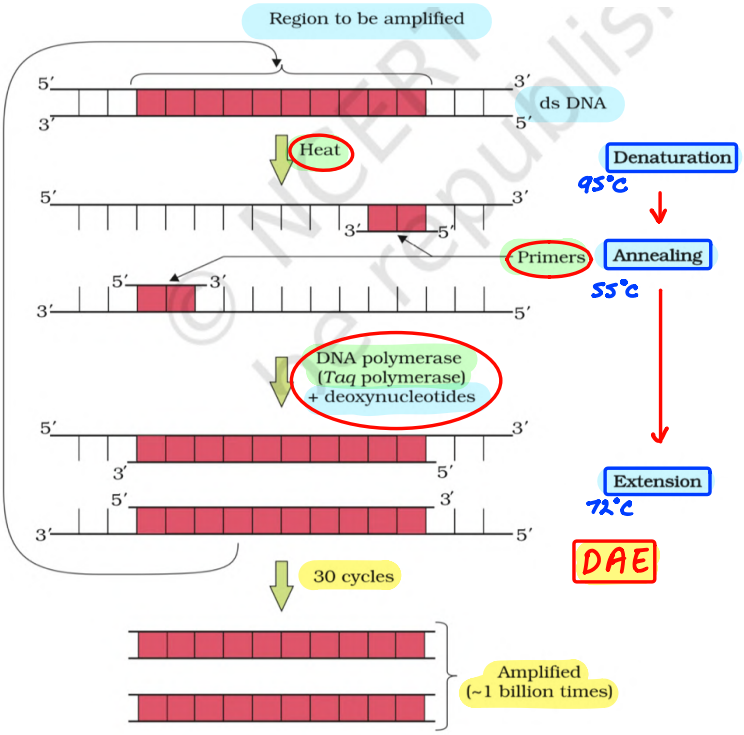
* DNA fragment (-ve) move to Anode (+ve) (under electric field & medium)
* Medium : Agarose gel
  * Natural polymer of : sea weeds
* DNA fragment separate according to size (sieving effect)
  ∴ Smaller fragment move farther
* DNA fragment visualised only by Ethidium Bromide staining & UV light exposure
  ↓
  Orange colour Band of DNA
* DNA Bands cut & extracted from gel by elution process
* DNA fragment Ready



A typical agarose gel electrophoresis showing migration of undigested (lane 1) and digested set of DNA fragments (lane 2 to 4)

ⓓ Amplification of GOI by PCR

* PCR : polymerase chain reaction
* Synthesised in vitro
  - 2 sets of primers (oligonucleotides) → complementary to DNA
  - Thermostable DNA polymerase → (Taq polymerase)
    - isolated from Thermus aquatics Bacteria
    - Remain active during High Temp^{r}
    - Denature ds DNA
  - Genomic DNA
  - dNTPs + Mg^{2+} → deoxy Nucleotide Triphosphate



* Total copies = 2^{n} → no of cycle
  ($2^{30} \approx 1B$)

ⓔ Ligation of DNA fragment into vector

→ By DNA ligase

ⓕ Insertion of rDNA in Host

→ using suitable vector

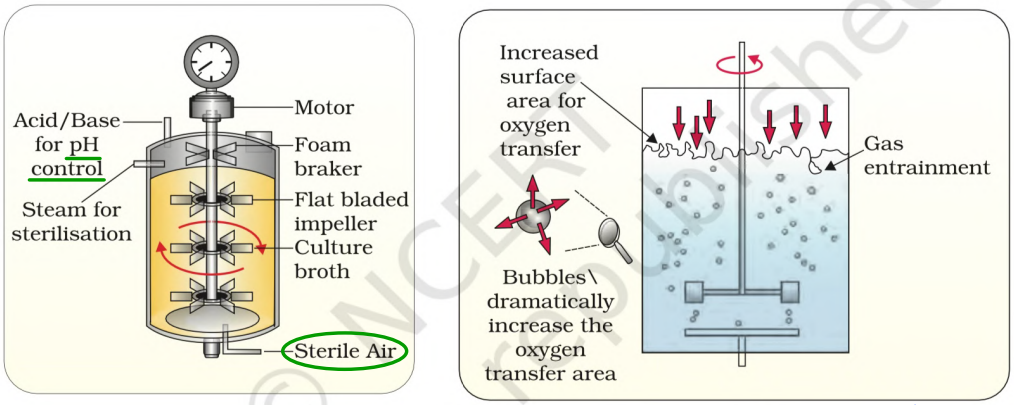
(g) obtaining foreign gene product

* large scale production → To make more profit from rDNA
* protein encoding gene expressed in Heterologous host → Recombinant protein
* small volm culture can't yield good quantity
* For large scale production → Bioreactors
  - 100-1000 litre
  - Raw material → product enzyme
    ↓ using microbe/plant/animal/Human cells
  - provide optimum growth conditions
    ↓ Temp, pH, substrate, salts, vitamins, oxygen

Systems
- Agitator system
- oxygen delivery system
- pH control system
- sampling system → for withdrawal

* Most common bio-reactor → stirring type
* Stirred tank bioreactor → simple / sparged
  - Cylindrical & curved base
  - Mix reactor contents
  - Stirrer: Even mixing & oxygen availability throughout Bioreactor
  - Sterile Air bubbled in reactor

★ Reactors



(a) simple (b) sparged

(a) Simple stirred-tank bioreactor; (b) Sparged stirred-tank bioreactor through which sterile air bubbles are sparged

(h) Downstream process

- Series of process (for market ready)
  ↓
  Separation + purification + preservation
  ↓
  Clinical trials (for drugs)
  ↓
  Quality control testing

* Downstreaming & Quality control
  ↓
  Vary from product to product

BIOTECHNOLOGY AND IT'S APPLICATIONS

① Biotech application in agriculture

- Agro chemical based (fungicides, Herbisides etc)
- Organic agriculture (Bio control, Biofertilizers etc)
- Genetically engineered crop

***Green Revolution**

- Tripling food supply, but not enough
- Increase yield by → improved crop varieties
  → Better managment
  → Agro-chemicals

***Limitation**

∵ Agro-chemicals are too expensive

∴ further increase in yield not possible

② Tissue culture

→ Whole plant can be regenerated from explant under sterile condition in Nutrient medium

Carbon source

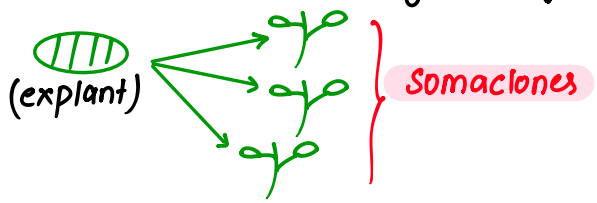
- Sucrose, inorganic salt
- vitamins, Amino acids
- Growth Regulator → Auxin, cytokinin, etc

* → cut → (explant) → → →

explant: any part of plant taken out

ⓐ **Totipotency:** capacity to generate whole plant from ex-plant/any cell

ⓑ **Somaclones:** New plant that genetically identical to the original plant



ⓒ Application of tissue culture

* Micro-propagation → producing thousands of plants in very short time by tissue culture

→ eg → tomato, banana, apple etc

* Meristem culture → Recovery of Healthy plant from diseased plant.

→ even plant infected with virus, but their Meristem free from virus

→ ∴ By Removing Meristem & growing in-vitro → we get virus free plant

eg → Banana, Sugarcane, potato etc

ⓓ Somatic Hybridisation

Tomato protoplast + potato protoplast → Fused → pomato (Hybrid protoplast/ somatic Hybrid)

failed concept

* protoplast = cell − cell wall (∵ surrounded by plasma membrane)

* two diff variety of proto plast fused

③ Genetically modified organisms (GMOs)

- organisms whose gene has been altered

Use
- made crop tolerant to stress (abiotic)
- dec. ↓ dependency on chemical pesticide (pest resistant plant)
- post harvest loss ↓
- efficiency of minerals ↑ (∵ prevent early exhaustion)
- Nutritional value of food ↑ → **Golden Rice** (Rich in vitamin-A)
  (use gene from Daffodil plant)

④ Pest Resistance plant → • Insect resistant plant : Bt-toxin
• Nematode resistant plant : RNAi

ⓐ Bt-cotton (Bt-toxin)

- Produced by Bacteria : *Bacillus thuringinusis*
- resistant to Insect

Working:

Bt. → Release inactive protoxins (crystals) → insecticidal protein → insect → Protoxin enter in midgut of insect → due to alkaline pH in midgut → inactive protoxin converted into Active → Active toxin bind to epithelial cell of midgut → create pores in gut → cell swell & lysis → Death of insect

* **Bt-cotton**: (Kill certain insectes)

Kill : • Lapidopterens : Tobacco budworm, armyworm
• coleopterens : beetles
• Dipterens : flies, mosquitoes

L C D
TA B FM

Ⓐ choice of bt-toxin gene (Cry gene) depend on crop & pest.

Ⓡ B/C many bt-toxin are insect grp specific
→ Cry I AB : —Kill→ corn borer
→ Cry I AC, Cry II AB : —Kill→ cotton bollworm

ⓑ RNAi (RNA interference)

- used for Resistance to nematode

eg: *Melodegyne incognitio* (nematode) → infect Root of tobacco plant → tobacco yield ↓ ∴ we have to use RNAi

RNAi → • silencing of specific mRNA due to complementary dsRNA → Stop translation of mRNA
• In all Eukaryotes as cellular defence
dsRNA source: • infected virus • transposons (mobile genetic element)

★ **Method**

- Agrobacterium vector + nematode specific gene (GOI) → Recombinant DNA

dsDNA → sense + dsRNA + antisense → antisense → Nematode → RNAi ✓ (Silincing of mRNA)

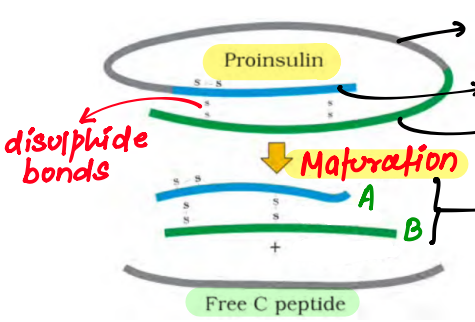
Tobacco plant

* Antisense: non-coding/templete strand
* Sense: coding strand

(5) Biotech application in medicine

- Recombinant therapeutin for human use → world: 30, India: 12

* **Insulin** • Earlier: used for diabetes & extracted from pancrea of cattle & pigs
  • In mammels (Human): pro insulin ⟶ mature insulin



connected by di-sulphide bridge

Mature insulin/ insulin

* Mature insulin do not have C-peptide
* B/C C-peptide removed during maturation

* **1983**: Eli-Lily (American company)
  - prepared two DNA sequence similar to A & B chain of Human Insulin
  - Introduced them into plasmid of E.coli ⟶ to get new insulin
    ↓
    Genetically engineered insulin

(6) Gene Therapy

- Insertion of Gene into cells/tissue to treat Hereditary disease
- It is collection of methods ⟶ correction in defective gene ⟶ in child/embryo
- Replace defective gene with functional by gene amplification

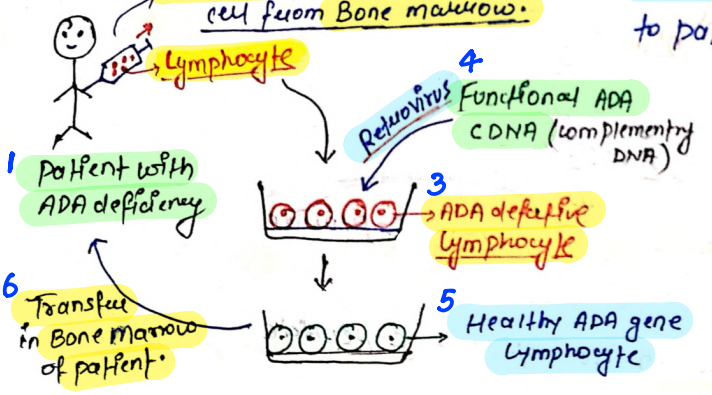
★ **1st gene therapy** **1990**
↓
- To 4-year girl having ADA deficiency (due to deletion of ADA gene)

* ADA (enzyme): ⟶ • Adenosine Deaminase
  • Crutial for immune system

* ADA deficiency can be cured by

- Bone marrow transplantation
- Enzyme replacement therapy

Both are not completely curable



- Functional ADA given to patient by injection

* patient required periodic infusion of such Genetically modified lymphocyte
* B/C these cells are Not immortal
* Gene Tharapy → Embryonic state → parmanent cure
  → After birth → Temperary cure

⑦ Molecular diagnosis

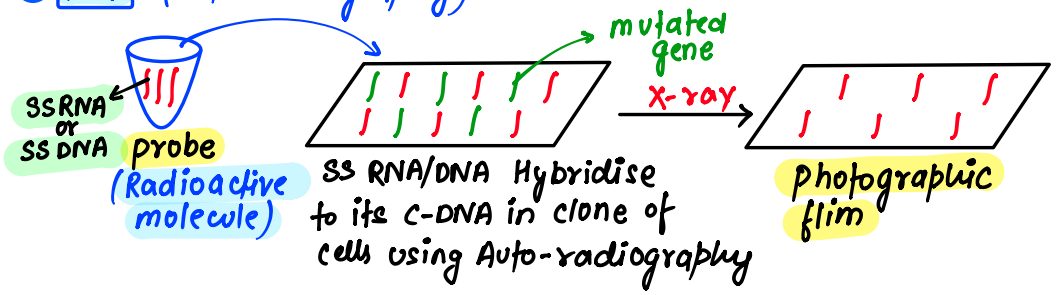
- conventional method: serum & urine analysis → early diagnosis ⊗
- New Techniques: PCR, rDNA (RDT), ELISA → early diagnosis ✓

ⓐ PCR (powerful technique to identify many genetic disorder)

- Detect → HIV in AIDS patients
  → Mutation of gene in cancer patients

* even very low conc^n of Bacteria or virus can be detected by PCR

ⓑ RDT (Auto-radiography)



* Clone having mutated gene Not appear in Photographic film
* B/C probe not complementary with mutated gene

ⓒ ELISA (enzyme linked immunosorbent assay)

- Based on Antigen-Antibody intraction
- Infaction by pathogen detected by: → presence of antigen (proteins, Glycoproteins)
  → Antibodies synthesised against pathogen

⑧ Transgenic Animals

- Animals that DNA manipulated to express extra foreign gene
- Transgenic animals: Rats (95%), Rabbit, Sheep, cows, fish

* Reason for making Transgenic animals

ⓐ ***Normal physiology and development:*** Transgenic animals can be specifically designed to allow the study of how genes are regulated, and how they affect the normal functions of the body and its development, e.g., study of complex factors involved in growth such as insulin-like growth factor. By introducing genes from other species that alter the formation of this factor and studying the biological effects that result, information is obtained about the biological role of the factor in the body.

ⓑ ***Study of disease:*** Many transgenic animals are designed to increase our understanding of how genes contribute to the development of disease. These are specially made to serve as models for human diseases so that investigation of new treatments for diseases is made possible. Today transgenic models exist for many human diseases such as cancer, cystic fibrosis, rheumatoid arthritis and Alzheimer's.

ⓒ ***Biological products:*** Medicines required to treat certain human diseases can contain biological products, but such products are often expensive to make. Transgenic animals that produce useful biological products can be created by the introduction of the portion of DNA (or genes) which codes for a particular product

- Human protein: α-1-antitrypsin → treat emphysema
- Some other protein: treat PKU & cystic fibrosis
- 1st transgenic cow: Rosie → Milk → Human α-lactalbumium (Human protein) 2·4g/l (1997)
  - more balanced product for Human body

ⓓ ***Vaccine safety:*** Transgenic mice are being developed for use in testing the safety of vaccines before they are used on humans. Transgenic mice are being used to test the safety of the polio vaccine. If successful and found to be reliable, they could replace the use of monkeys to test the safety of batches of the vaccine.

ⓔ ***Chemical safety testing:*** This is known as toxicity/safety testing. The procedure is the same as that used for testing toxicity of drugs. Transgenic animals are made that carry genes which make them more sensitive to toxic substances than non-transgenic animals. They are then exposed to the toxic substances and the effects studied. Toxicity testing in such animals will allow us to obtain results in less time.

⑨ Ethical issues

* Indian Government organisation for GM Research → GEAC {Genetic Engineering Approval committee}
* Rice Varieties in India : 200,000 (2 lakh) varieties → Richest diversity in world
* Basmati Rice → 27 varieties → unique Aroma & flavour
* Genetically different rice varieties (in India) : 50,000 varieties
* New variety of Basmati actually derived from India
* 1997 : America company got patent on Basmati Rice
* Several attempts also made patent for Turmeric, neem

★ **Biopiracy** is the term used to refer to the use of bio-resources by multinational companies and other organisations without proper authorisation from the countries and people concerned without compensatory payment.

★ Patent (exclusive right)

- Criteria
  - Novelty
  - non obviousness
  - Utility
- For
  - Invention, improvement
  - Create product
  - concept/design

* Indian parliament recently cleared Second amendant for Indian patent Bill

ORGANISM AND POPULATION

① population interaction

Population Interactions

Species A	Species B	Name of Interaction
+	+	*Mutualism*
–	–	*Competition*
+	–	*Predation*
+	–	*Parasitism*
+	0	*Commensalism*
–	0	*Amensalism*

* ⊕ : benificial / profit
  ⊖ : detrimental / loss
  ⊙ : Neutral / No effect

② Amensalism (-, 0)

(i) Penicillium (fungi) secrete penicillin (chemical) → inhibit growth of other micro-organism

(ii) Streptomyces secrete streptomycin → inhibit growth of bacteria

(iii) Root of black walnut secrete toxin → inhibit growth of soil born pathogens & other plants

③ Mutualism (+, +)

(i) Rhizobium (Bacteria) & Roots
Rhizobium → provide N_2 compound
Roots → provide food

(ii) Orchid & Bumble bee
Orchid → pseudo-copulation (sexual deceit)
Bumble bee → pollinating agent

(iii) Mycorrhizae: Fungi & Roots
Fungi → Phosphorus & water absorption
Roots → provide food

(iv) Lichens: fungi & cyano bacteria / Green algae
fungi → provide attachment to soil
cyano bacteria / Green algae → provide food

(v) Figs & wasp
Figs → provide safe-place for laying egg
wasp → pollination

(vi) Yucca & moth
Yucca → safe-place for laying egg
moth → pollination

④ Proto cooperation (non-obligatory Mutualism / coevolution)

(i) Oxpeckers & Rhino
- Oxpeckers → • eat ticks • warn Rhino from danger; Rhino → provide food (flies)

(ii) Plovers & Crocodile
- Plovers → Relief from leaches; Crocodile → provide food

(iii)* Sea Anemone & Crab
- Sea Anemone → provide protection; Crab → provide movement

⑤ Commensalism (+,0)

	+ (benifited)		0 (Neutral)
O	• Orchids	&	Mango (provide shelter)
B	• Barnacles	&	Whale (provide shelter & food)
C	• Clown fish	&	Sea Anemone (have tentacles that provide protection)
C	• cattle guazing bird (egret)	&	Cattles (provide food)

⑥ Predation (+,-)

- Natures way of transfering energy from lower tropic level to higher tropic level
- Control & Regulate prey population
- Maintain species diversity "by reducing intensity of competition among prey"

eg:-
- In Australia → population of prickly pear cactus → control by → Cactus feeding moth
- In Rocky industrial community → America specific coast → Starfish disaster removed (which is imp predator) → Results more than 10 species of invertebrates extinct within year → Due to inter-specific competition.

★ Predators are too efficient thus it might lead to extention of its prey.

↓

But they never over exploit its prey

↓

if they do so, predators also become extinct due to lack of food

↓

Thus, predators are prudent (समझदार)

★ Prey species develops some mechanism to avoid predation.

- some are poisonous
- Frog & Insect → cryptically coloured → Camouflaged
- Monarch butterfly highly distasteful to its predators bcz of chemical in body → They aquire this chemical during caterpillar stage

★ AIR

(A) Herbivorous are predators for plants, i.e, plants are affected by predation

(R) Plants are non-motile

* 25% of all insects are phytophagous → "feeding on plant"

★ Defence Mechanism of plants

- Morphological → Thorns & spines (In Acacia, cactus)

- ★ chemical
  - positives cardiac glycoside present in calotropis
  - Nicotine, caffine, quinine, Strychnine, opium.

⑦ Competition (-,-)

Intraction of organism for same resources in same area

Fitnes of one species is lowes in presence of another species

★ Types

Intra-specific competition

- b/w same species
- b/c their requirement same

Inter-specific competition

- b/w different species

* Darwin belive interspecific competition is potent source of organic evolution

★ NICHE

- When Competition ✕ : Fundamental niche
- When Competition ✓ : Realistic niche

↳ when home is habitat, the profession is niche

Denotes:
- Functional role in community
- Utilization of Resources
- Range of condition that organism can tolerate.

★ Generally, closely related species compete for limiting resources

but!

① Unrelated species also compete for same resources
eg → in south americal lake : Flamingoes & fishes compete for same food (zooplankton)

② Resources need not to be limiting: (unlimited)
→ Interference competition
→ presence of one affect → affinity of others
eg: lion & leapord competing for deer.

★ Competition occurs:
- B/w closly related species: (interspecific)
- B/w unrelated species: (interspecific)
- When Resources are limited:
- When Resources are unlimited: (Interference)

★ Evidence of competition :-
- "Competition Release" → Removal of superior species
- "Interference competition"

⑧ Competitive exclusion

↓

Gause's competitive exclusion

↓

two **closely related** species competing for **same** Resources **can't** co-exist indefinitely

↓

inferior species eliminated by superior.

eg:-

Ⓑ

Barnacles **Balanus**

↓ Eliminates

Barnacles **Chathamalus**

*[connell's elegant field expt]

Ⓖ

Goat

↓ Eliminates

Abingdon tortoise

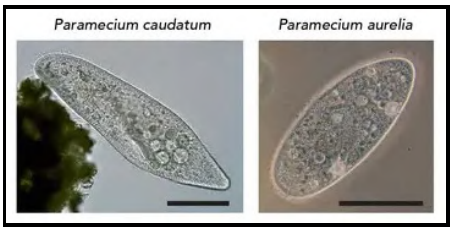
- due to high grazing power of goat
- in galapagos islands

Ⓟ

Paramecium **Aurelia**

↓ Eliminate

paramecium **caudatum**



⑨ Co-existance

★ Recent studies → Reject competitive exclusion
→ support co-existance

★ To avoid competition for same Resources

↓

Resource partitioning

- different feeding time
- different foraging patterns.

eg:- *mac Arthur expt

→ 5 closely related warblers co-exist together due to **different foraging** patterns

(10) parasitism (+,-) {+: parasite, -: Host}

★ Special adaptation of parasite
- loss of unnecessary sence organ
- ⊕ of adhesive organs / suckers
- loss of digestive system
- high regeneration capicity

eg:
- Human liver fluke (trematode) → need two intermidiate host → snail & fish
- Malarial parasite (plasmodium) → need vector → mosquito.

★ impact of parasite on Host :-
- Reduce survival, growth, Reproduction, population density
- make host more vulnerable to predation by making physically weak

(11)

Ectoparasite
feed on external surface of host

eg:
- lice on human
- flies on dogs
- copepods on marine fish
- cuscuta on hedge plant

Endoparasite
* live inside host (in liver, kidney lungs, RBC etc)
★ • more complex life cycle
↓
due to extreme specilization
- Simplified morpho & anatomical features
- Great Reproductive potential

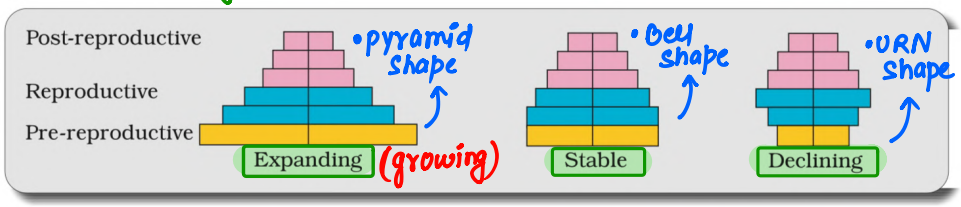
Brood parasitism
in birds
↓
parasitic bird lay egg in nest of its host
↓
parasite bird egg similar to host bird egg
↓
eg: cukoo (koel) → parasite bird
and crow. → Host bird

(12) Population

→ Population ecology is important area of Biology, Bic it links ecology to population genetics & evolution

* **Population attributes**
  - Birth/Death rates
  - Sex ratio
  - Age distribution

★ Population age pyramids



Representation of age pyramids for human population

★ Measuring population size/density (N)

Total number (size)
- < 10 → Siberian Cranes
- Millions → chlamydomonas

% Biomass / % cover
- when compare large & small species
- Banyan tree & parthenium (carrot grass)

Population Density
- Fish caught per trap
- Bacteria in petridish

Indirect count
- VIP: pugmark & fecal pellets
- Tiger censes
- Tiger Reserves

(13) Population growth (Not a static parameter, Keep changing with)

→ time
→ Food availability
→ predation pressure
→ adverse weather

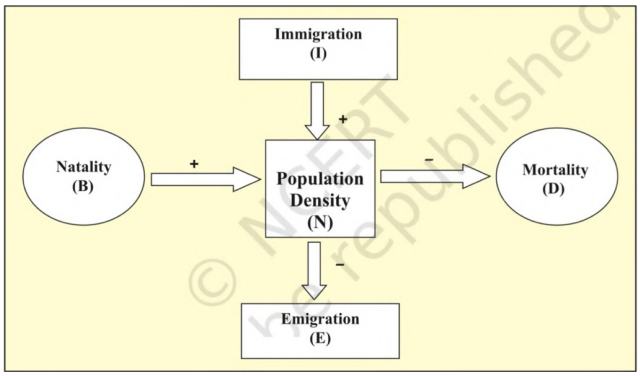
* Density of population fluctuates due to 4 basic process

(i) ***Natality*** refers to the number of births during a given period in the population that are added to the initial density.

(ii) ***Mortality*** is the number of deaths in the population during a given period.

(iii) ***Immigration*** is the number of individuals of the same species that have come into the habitat from elsewhere during the time period under consideration.

(iv) ***Emigration*** is the number of individuals of the population who left the habitat and gone elsewhere during the time period under consideration.



★

* Under normal cond?
  - Birth & death are most important factor
* If new habitat being colonised
  - Immigration may more significant factor

$N_t = N_0 + (B+I-D-E)$

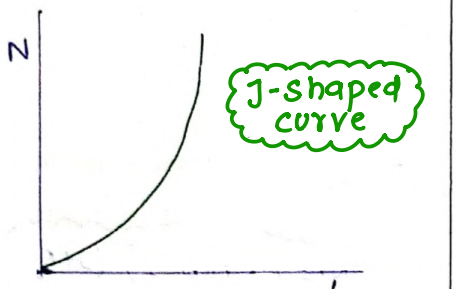
N_t: final population at time 't'.
N_0: initial population.

* birth: $b = B/N$ rate
* death: $d = D/N$ rate

$b - d = r$ → Biotic potential
→ intrinsic rate of Natural increase.
→ Imp parameter to check impact on biotic / abiotic factor.

(14) Exponential growth

- Unlimited Resources
- $\frac{dN}{dt} = rN$ → intrinsic rate
- $N_t = N_0 e^{rt}$

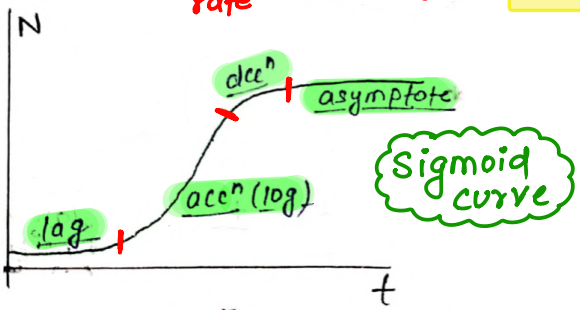


↓ exponential / Geometric*

- pop^n size ∝ r
- size = small
- pop^n density = independent
- eg = Insect, Algae

Logestic growth

- limited Resources (fittest survive & Reproduce)
- $\frac{dN}{dt} = rN\left(\frac{K-N}{K}\right)$ — r: intrinsic rate; K: carrying capacity



* Asymptote*: when pop^n density reaches carrying capacity. (N=K)

- pop^n size ∝ K
- size = Big
- pop^n density = dependent on K
- eg = Human, elephant

* $r = 0.015$: Norway Rat
  $r = 0.12$: Flour beetle
  $r: 0.0205$: Human popl^n in India (1981)

* ∵ Resource for most of animals are finite & limited
∴ logestic growth considered more realistic

(15) Life History variation

→ population evolve to maximise their reproductive fitness → Darwinian fitness (High value of 'r')

⇒ Reproductive Strategy :

- Breed only once in life → Salmon fish, bamboo
- Breed many times in life → most birds & mammals

- large number, small size offspring → oysters, pelagic fish
- small number, large size offspring → Bird, mammals

ECOSYSTEM

① Ecosystem = Biotic community + Abiotic factors (weather, sunlight, soil, water, tempr)
↳ Term given by Tansley

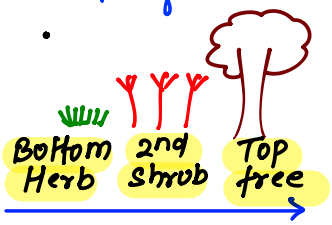
* Types of Ecosystem

Natural	Man-Made	Terrestrial	Aquatic
• Tropical Rain forest	• Aquarium	• Forest	• Pond
• coral leaf	• Crop leaf	• Grassland	• lake
• Ocean	• less diversity • lack self Regulation	• Deseart	• wetland • River • estuary

② Ecosystem structure

* Species composition
- Total no of species in given ecosystem (Plant & animals)
- Identification & Enumeration of all species

* Stratification



- vertical arrangment of different species occupy different level.
- Stratification ∝ no. of diff species
best observe in Tropical rain forest

* Function of Ecosystem
↳ Productivity, Decomposition, Energy flow, Nutrient cycling

③ Productivity

* primary production → Rate → primary productivity
- amt of biomass production by plant in unit area
- Biomass/m^2, Kg/m^2, Kcal/m^2

- Rate of biomass production
- Biomass/m^2/yr, Kg/m^2/yr, Kcal/m^2/yr
↓ organic matter

** Primary productivity v/s Secondary productivity

Primary productivity: Rate of biomass production by plants/producers.
- GPP (Gross primary productivity) → Total biomass formation by plants
- NPP (Net primary productivity) → NPP = GPP − R (R = Respiratory loss)

Secondary productivity: Rate of biomass/organic matter production by consumers

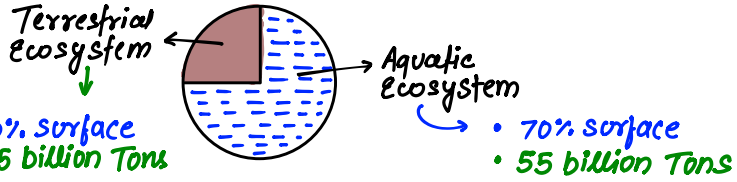
* NPP is available biomass for consumers (Heterotrophs: Herbivorous, Decomposers)

* Primary productivity Depend on **PEN**
  ↳ plant species , environmental factors , Availability of Nutrients , photosynthetic capacity

* **Highest productive ecosystem** v/s **Least productive ecosystem**

Highest productive ecosystem			Least productive ecosystem	
Tropical Rainforest (Highest productivity)	Coral leaf (N_2 fixⁿ)	Sugercane	Desert (lack water)	Ocean (limiting sunlight & Nutrient)

* **Global NPP** ⟶ 170 billion Tons



④ Decomposition

* Breakdown of complex organic matter into simple inorganic matter & loosening of soil

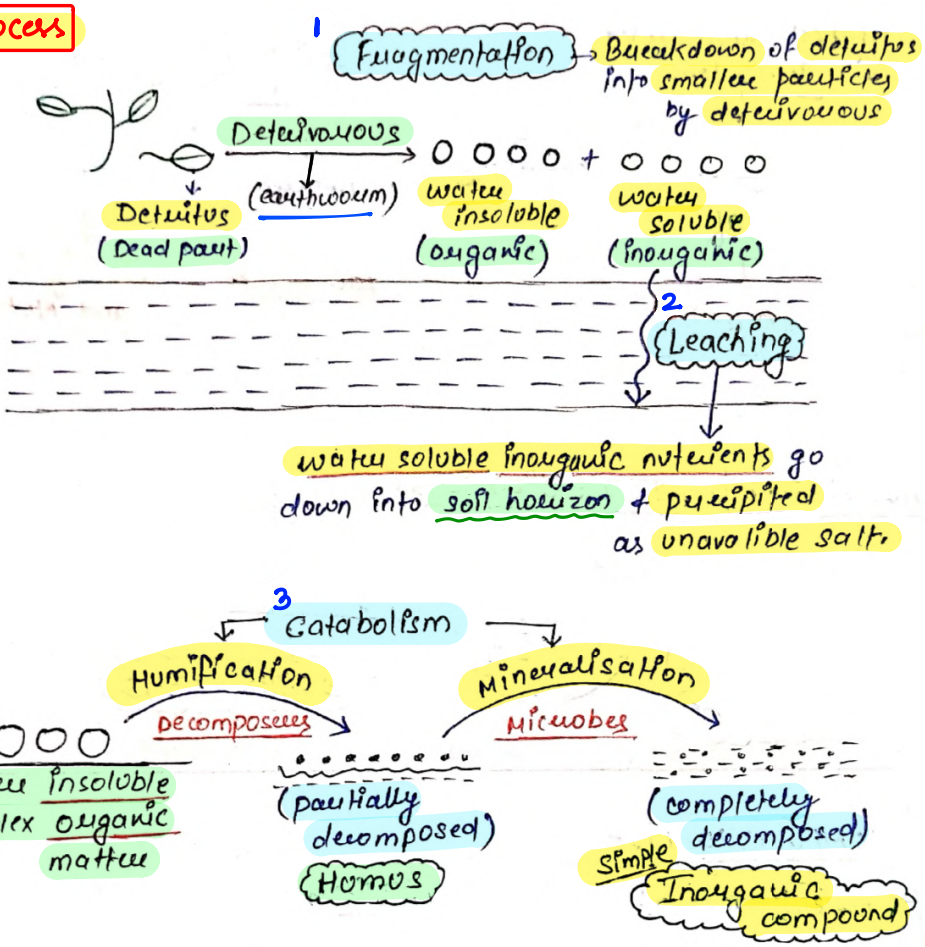
* Dead plant (leaves, flower) / Dead animals (fecal matter) → Detritus (Dead part) → Raw material for decomposition

* Dead eaters → Detritivorous → Earthworm, cockroach etc

* **Steps**
  - Fragmentation
  - Leaching
  - catabolism
  - Humification
  - Mineralisation

  (Fragmentation, Leaching, catabolism operate on detritus; Humification, Mineralisation work on decompⁿ in soil)

★ **Process**



* **Humus** (HARD)
  - A: • Acidic, Amorphus (Shape not fixed)
  - R: • Resistant to microbial action → extreme (slow) rate of decomposition
  - • Reservoir of Nutrient
  - D: • Dark colour

* During decomposition

1st organism
- Detrivorous

2nd organism
↓
Decomposers
↓
- Bacteria, Fungi, flagellates
↓
(major decomposers, B/c they grow on hot & humid envt.

Last organism
↓
Detrivorou & Decomposers

⑤ VIPS

* Favourable conditions for decomposition → High Temp, Soil Moisture, Aerobic condition
(warm & moist) (O_2 requiring process)

organic → inorganic

* unfavourable condition (inhibit decomposition) → Low Temp, Dryness, Anaerobic condition

organic → organic (accumulation)

*Rate of decomposition controlled by
- Climitic factors
  ↳ Favourable condn
  ↳ unfavourable condn
- Chemical composition
  ↳ Quality of Detritus

* Quality of Detritus also affect Rate of Decomposition

If Detritus Rich in sugar & Nitrogen compound
↓
Fast decomposition

If Detritus Rich in ligin & chitin
↓
Slow decomposition

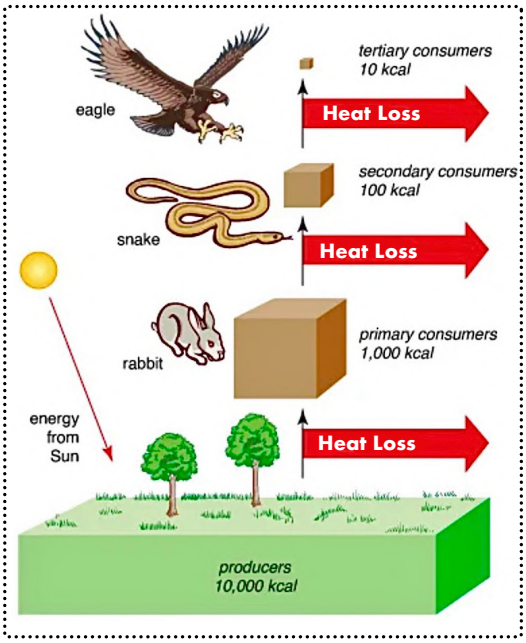
⑥ Energy flow

Sun
↓
TIR (Total incident Radiation)

★ less than 50% of TIR is suitable for plants
↓
Photosynthesis ✓

★ More than 50% for plants
↓
Photosynthesis ✗

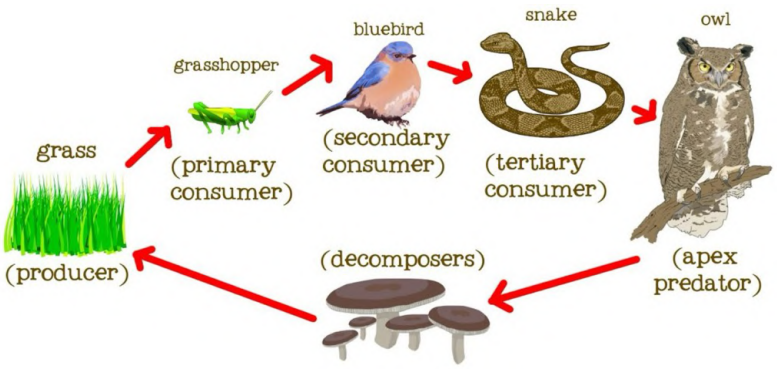
★ PAR: Photosynthetic active Radiation
↓
Plants utilised
- 2-10% of PAR
- 1-5% of TIR

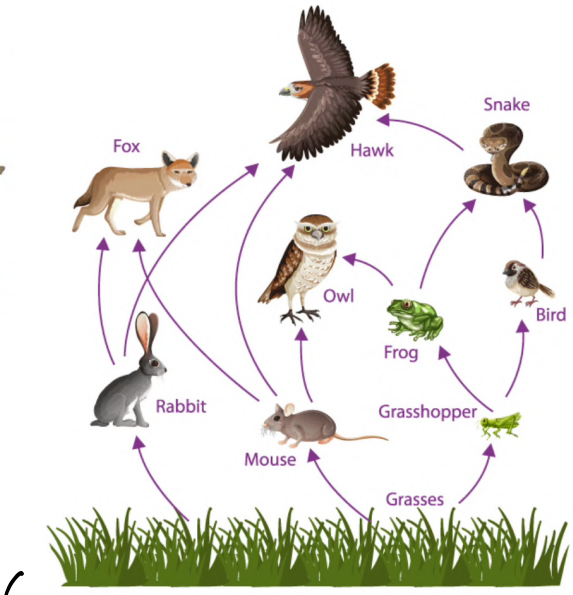


★ Sun → plants → (Energy loss) Herbivorous → (Energy loss) carnivorous

↳ Unidirectional flow of energy: 1st law of thermodynamics
↳ loss of Energy in each trophic level: 2nd law of thermodynamics
(to counter universal tendency towards increasing disorderliness)

★ **Food chain** V/S **Food web**





GFC (Grazing)
↓
- Eating chara

DFC (Detrius)
↓
- Death of orgaism is beginning

Parasatic / AFC (Auxillary)

→ Food web is formed due to their inter-dependency

⑦ Grazing food chain GFC

* Plants → Herbivorous → Carnivorous → Top carnivorous

- Producers
- Primary consumers
- Sec consumers
- Tert consumers
- Pri carnivorous
- Sec carnivorous

* **Producers**
- Terrestrial
  - Herbaceous
  - Woody plants
- Aquatic
  - Phyto-plankton
  - Algae
  - Higher plants

* **Pri. consumers (Herbivorous)**
- Terrestrial
  - Insects
  - Birds
  - Mammals
- Aquatic
  - Molluses

⑧ Detritus Food chain

- GFC —death→ DFC (begins with dead organic matter/detritus)

* mode of decomposers (Heterotrophs) → Fungi, bacteria (also called saprotrophs)

* Terrestrial ecosystem (High Temp) → DFC works properly

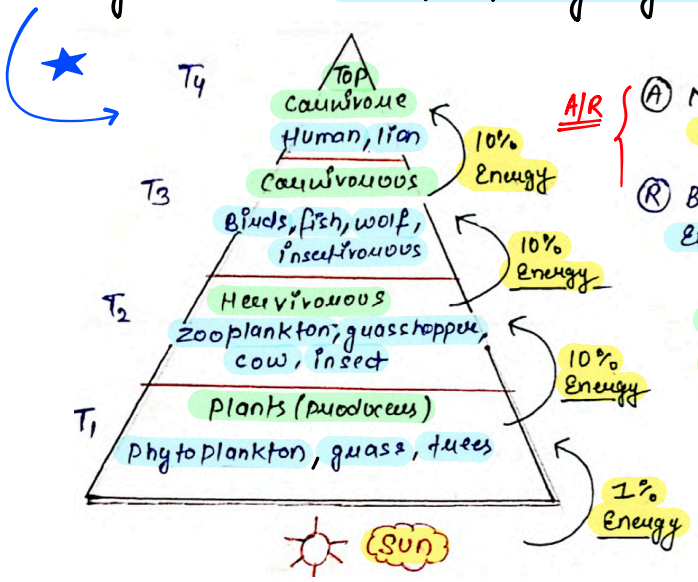
* Aquatic ecosystem (Low Temp) → GFC works properly

A/R { Decomposers meet their energy requirement by degrading dead organic matter (detritus)
They secrete digestive enzyme which convert detritus into simple inorganic substance

A/R { GFC & OFC are connected at same levels
B/c members of OFC are prey to GFC organism

⑨ Tropic level

- organism occupies special place in ecosystem according to their feeding relationship
- organism which do not eat any organism belongs to 1st to tropic level (producers)



A/R { (A) Number of tropic levels are limited
(R) B/c Reduction of Energy in each tropic level ↓ only 10% energy transfer from lower to higher Tropic level 10% law

VIPs

A/R { * NO Energy trapped by organism remain in it forever
* Energy trapped by producers either passed to consumers if not, then organism dies (consumers)

A/R { * All animals are called consumers & Heterotrophs
* All animals depend on plants (producers) → directly or indirectly for their food need

* organism at each Tropic level depend on lower tropic level for energy
* Decomposers depend on detritus/dead biomass for energy

⑩ Standing crop

↳ mass of living material at a tropic level at a particular time

→ measured as → mass of living organism (Biomass)
↳ number in unit area

→ Expressed as → in terms of fresh weight
↳ in terms of dry weight (more accurate)

(11) Ecological pyramids

Pyramid of energy

10kJ
100kJ
1000kJ

always upright

pyramid of number

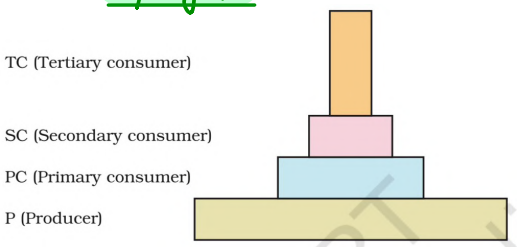
100
5000
80000

pyramid of biomass

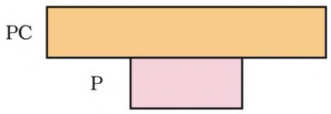
500kg
2000kg
10000kg

* **Types**

upright



Inverted



partially inverted

SC
PC
P

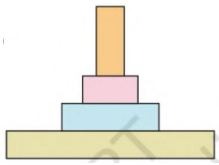
* Most of Ecological pyramid are upright

A/R { pyramid of energy always upright (Never inverted)
loss of Heat/energy in each tropic level

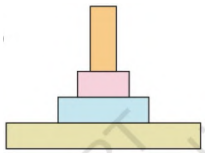
⇒ pyramid of biomass in sea → Generally inverted

* **Grassland Ecosystem**
  - 40% land area
  - grasses (Herb)

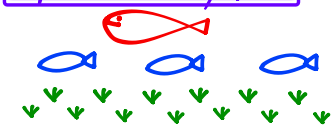
Number → upright



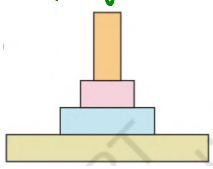
Biomass → upright



* **Aquatic Ecosystem**

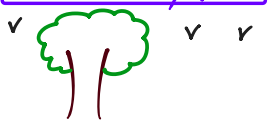


Number → upright



Biomass → Inverted

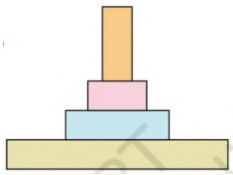
* **Tree Ecosystem**



Number → partially inverted

SC
PC
P

Biomass → upright

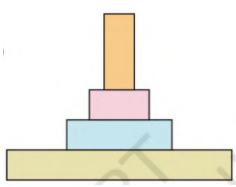


* **Forest Ecosystem**

Number → partially inverted

SC
PC
P

Biomass → upright



⑫ Limitation of Ecological pyramids

* Some species belongs to → two or more trophic level
  are not included
  ↳ eg: Sparrow
  ↳ Pri consumer : when eats seeds
  ↳ Sec consumer : when eats insects & worm
* Assume simple food chain,
  (Never exist in Nature)
* Not account food web
* Saprophytes are not included

BIODIVERSITY & CONSERVATION

① Biodiversity

Living + Heterogenicity

* Term given by → Edward wilson (sociobiologist)

* **Diversity types:**

Genetic diversity

* Single species can show high diversity at genetal level range

eg: Rauwolfia vomitoria

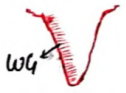
- Reserpine chemical
- grow on Himalayan ranges

* In India, genetically diff strain of:
  - Rice: 50,000
  - Mango: 1,000

Species diversity

* Diversity at species level (or) different types of species

* Western Ghats have greater Amphibian than Eastern Ghats



Ecological diversity

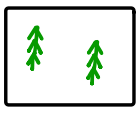
* Diversity at ecosystem level

* India has greater ecosystem diversity → than Scandinavian country (Norway)

② How much biodiversity present (Species diversity)

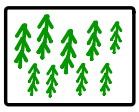
* IUCN (2004): More than 1.5 million discovered (1.7-1.8)
* Random prediction: 20-50 Million
* Robert May: 7-Million (more scientific)

* Temprate



- Species inventories complete
- B/C of less Biodiversity

Tropical



- Species inventories incomplete
- B/C of great Biodiversity

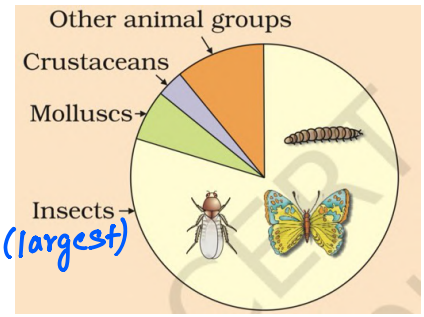
③ Biodiversity on earth

- Animals: 70% ka → 70% insect (out of every 10 animals 7 are insect) → (most species rich)
- plants: (algae, fungi, Bryo, pterido, gemno, Angio) : 22% → Fungi Highest

* prokaryotes are not included (B/c they not culturable)

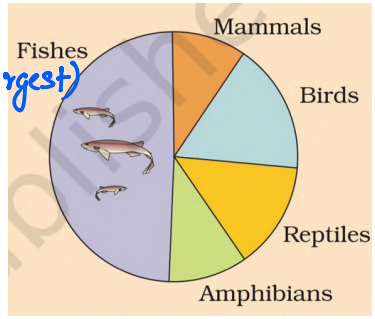
→ The problem is that conventional taxonomic methods are not suitable for identifying microbial species and many species are simply not culturable under laboratory conditions. If we accept biochemical or molecular criteria for delineating species for this group, then their diversity alone might run into millions.

④ Invertebrates



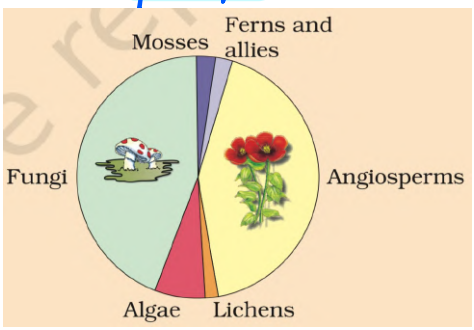
IMCO

Vertebrates



F > B > R > A > N

Plants



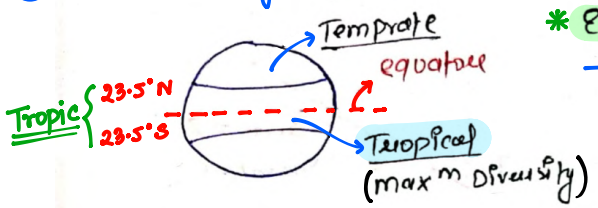
Fungi largest
(Gymno: least)

* Biodiversity in India
  - 2.4% land
  - 8.1% diversity
  - 12 Mega diversity country

* • 45,000 plants } Discovered (22%)
  • 1 lakh Animal }
  ↓ Robert May's estimation
  ∴ 1 lakh plant } yet to be discovered
  3 lakh animals }

⑤ Patterns of biodiversity

ⓐ Latitudinal gradient



* Equator → pole
  → Diversity decrease ↓

* Diversity of Birds
  - Colombia → 1400
  - India → 1200
  - Newyork → 105
  - Greenland → 56

E ↓ P

★ Amazon Rainforest (South America)
↓
Greatest Biodiversity
↓
I > P > F > B > A (=N) > R
(Invertebrate *(1.25 lakh) > Plants > Fishes > Birds > Amphibia (= Mammal) > Reptiles)

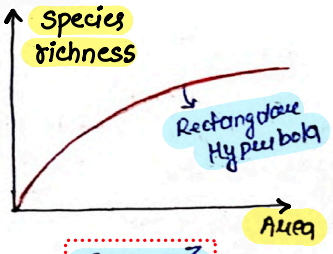
* Equador (tropical) has 10 times diversity than midwest USA (temprate)

* Equator/tropics has great biodiversity
  * B/C → Remain not disturbed by frequent glaciations → ∴ speciation / species diversification
  → Less seasonal, more constant & predictable Temp^r ∴ promote niche specialisation ↑
  → More solar energy → higher productivity → ∴ Greater diversification

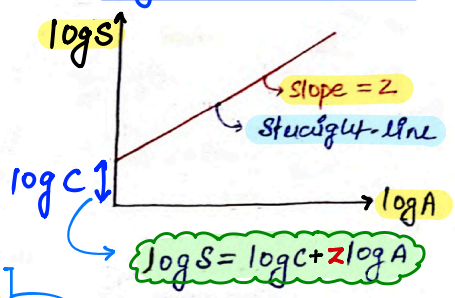
⑤ Species-Area Relationship

→ By Alexandar von Humboldt → on South America jungle (German Naturalist, Geographer)

Normal scale



Logarithemic scale



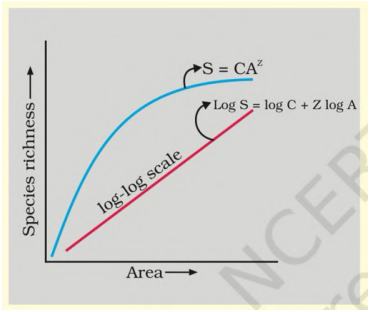
$S \propto A^Z$

$S = CA^Z$ → Regression coefficient

Species richness, intercept, Area

$\log S = \log C + Z \log A$

As area ↑, species richness ↑ but upto certain limit



* Value of Z → (Regration coefficient)

- Country (Continuity) → Z: 0.1 to 0.2 → Independent of region/taxonomic group
- Continents (large group) → Z: 0.6 to 1.2 → Greater the "Z", steeper the slope → steeper slope
  - Fungivorous Bird (Fruit eating)
  - Mammals
  - Z = 1.15
  - tropical forest of different continents

* Importance of biodiversity

↓

Stable community

↓

- Not much variation/year
- Resistant to disturbance (Natural/man-made/Alian species)
- High productivity

* David Tilman's: Biodiversity ∝ productivity

↳ using outdoor plots Experiment → Plot with more species → less variation per year

* Paul Ehrlich (Stanford ecologist)

↳ Rivet popper Hypothesis

↳ compare ecosystem with Aeroplane

- Aeroplane: Ecosystem
- Rivets: Species
- wings Rivets: Key species

↓

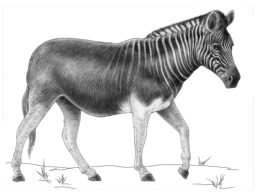
eg: Lion, tiger, fig (major role in ecosystem)

⑥ Biodiversity loss

* IUCN → Red Data book (2004) →
- 784 extint → last 500 yr
- 20 extint → last 20 yr

* Recent extinctions

- Dodo (Mauritius)
- Quagga (Africa)
- Thylacine (Australia)
- Steller's sea cow (Russia)
- Tiger
  - J: Javan
  - C: caspian
  - B: Bali



* Threat of extinctions

A > G > M > B → Birds (12%)

Gymno

Amphibian (32%) (31%) Mammals (23%)

More vulnerable

* 5 past extention : Natural
* 6th extention : Man Made (anthropogenic)
  - 100-1000 times faster

* Impact of biodiversity loss
  - Plant production ↓
  - Resistance / tolerance ↓
  - variability in ecosystem ↓

⑦ Causes of Biodiversity loss → The Evil Quartet

Habitat loss & fragmt
- most imp cause

eg: Amazon rain forest (20% O_2 : lungs of planet)
[14% → 6%]
For :- Soyaben cultivation
- Rasing beef cattle

* Fragmentation
  - Habitat broken into fragment
    - mammals & birds badly affected

Over exploitation
"Need turn into greed"
↓
Extinction
- steller's sea cow
- passenger pigeon
- Many marine fishes

Alien species invasion
Alian speies kill Native species
NEPAL
- Nileperch (lake victoria) Kill → cichlid fish
- Eicchornia (water hyacinth)
- Parthenium (carrot grass)
- Lantana
- African catfish (clarias gariepinus) Kill → indigenous catfish

(Eicchornia, Parthenium, Lantana, African catfish = weed species)

Co-extinction
extinction of one lead to extinction of other
- Predation
- Mutalism
  - eg:- Fig fwasp & yucca & moth

⑧ Biodiversity conservation :

ⓐ Why to conserve ?

Narrow utilization
* direct economic benefit
* Foods, fiuewood, fibue industeial puoduct, medicinal puoduct (moue than 25% of duog fuom plant)
* Biopuospecting
  - Explouing : molecuiaa genetic, speies diveusity foa puoduct

Broad utilization
* Amazon rain fouest → 20% of Eaeth O_2
* pollination (Bee, biuds, bats)
* Intangible benefits
  - Aesthetic pleasuue, Bulbul's song

Ethical
* otheu speies also shaue this planet
* Philosophically & spiuitually
  - they also have uight to live.

ⓑ How to conserve

In situ (on-site)

Protect whole ecosystem (we save entire forest to save tiger)

(HB News)

- Hotspot
- Biosphere reserve (14)
- National park (90)
- wildlife sanctuaries (448)
- Sacred groves

Ex-situ (off-site)

when species in endangered & urgent need to save it

↓

∴ threatened species taken out & place into protected area

eg:
- Zoological park
- Botanical garden
- wildlife safari park
- Cryopreservation (gametes)
- In-vitro fertilization (egg)
- Tissue culture (seed)
- Seed bank

⑨ **Biodiversity hotspot**

→ High species richness

→ High degree of endemism (specific species in specific area)

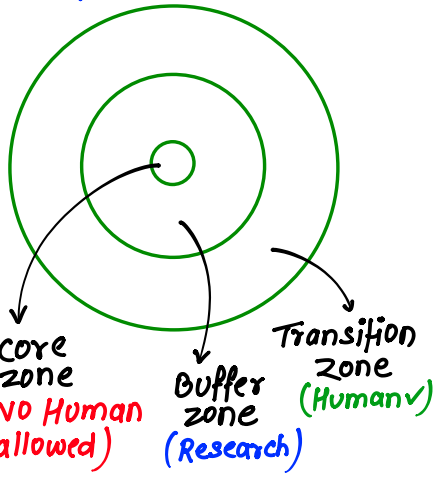
Endemic species : species confined to particular region & not found elsewere

* world : (34)
* India : (3)
  - western Ghatt & Sri-lanka
  - Indo-Burma
  - Himalaya

* Biodiversity Hotspot → less than (2%) land → High number species

* Sacred groves (Tribes)
  - Khasi & Jaintia Hills (Meghalaya)
  - Aravalli Hills (Rajasthan)
  - western Ghats (Karnataka & Maharastra)
  - Sarguja, Chanda, Bastar area (Madhya pradesh)

* Biosphere reserve (14)



⑩ Measure for conservation

ⓘ The Earth summit : Rio-de-Janeiro (Brazil) → 1992

ⓘⓘ The world summit : Johannesburg (South Africa) → 2002

'190 country' ↓ on sustainable development ↓ achieve by (2010)