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7. Plant Growth & Mineral Nutrition.

Plant Growth :

- characteristics feactures of living beings
- Plant show indeterminate growth is due to meristimatic cells.
- 1] quantitative growth → Increasing length, Volume, weight, No. of cells.
  2] qualitative growth → leaf Colour, flowers, Colour, Shiff from vegetative phase to reproductive phase.

• Types of merestematic cell :

1] Apical meristem :

- Location ⇒ tip's of root & shoot
- responsible for increase in length
- Contribute to primary Growth [length ↑]

2] Intercalary meristem :

- location ⇒ at node or base of internode
- responsible for increase in length
- Contribute to primary growth
- formation of leaf primodia & lateral bud.

3] Lateral meristem :

- location ⇒ lateral axis of plant (Dicots, Gymnosperm
- Absence in Monocots
- Responsible for increasing girth
- Contribute to secondary growth

e.g., Vascular Cambium = strip in between xylem & phloem of dicote stem

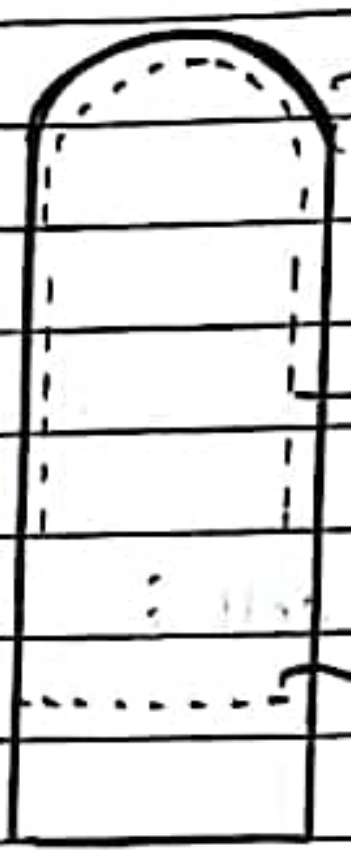

Fig., Shoot system

Phases of Growth :

INP A] Phase of cell division / formation :

- Thin walled, Non-vacuolated
- Prominant Nucleus & Granular cytoplasm
- permanant cell ⇒ Do not divide, undergoes elongation & maturation
- Growth Rate : Slow

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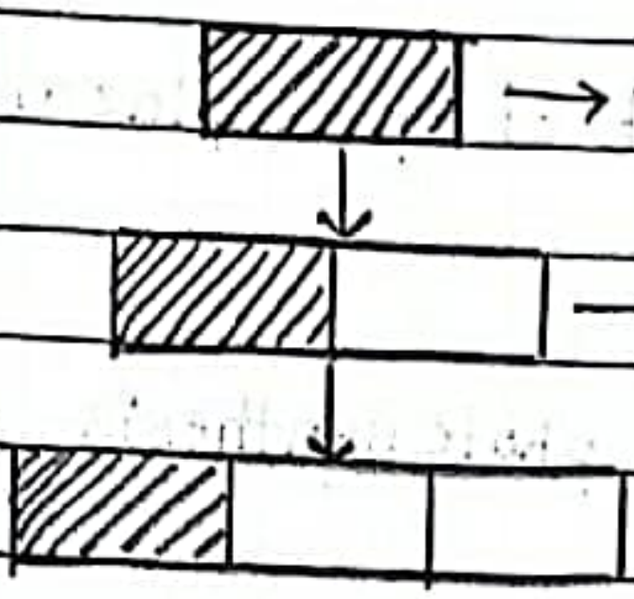
8] Phase of cell enlargement /elongation :



8] Phase of cell enlargement / elongation : (in permanent cell)

IMP

- Vaculated , Turgid due to absorption of water
- Turgidity result in elongation of cell (l, b)
- New cell wall material synthesized to Cope up with cell elongation.
- Growth Rate : Accelerated (fast)

c] Phase of cell maturation / differntiation :

- enlarge cell now become specilized to perform specific function
- Cell attain maturity, morphologically , physiologically
- Growth Rate : stationary / steady (slowdown)

Condition for Growth :

1] Water ⇒ It is a part of protoplazm and it maintai tergidity

2] light ⇒ essential for photo synthesis and seed germina

3] Nutrients ⇒ Micro & macro nutrient

4] Temperature ⇒ Optimum temp. 25°C - 35°C

5] Oxygen ⇒ Respiration and energy

6] Gravitational force ⇒ Provide direction for growth of shoot and root

MCQ • Growth Rate :

- Increased growth per unit ~~cell~~ time
- Also called as efficiency index
- In maize, root apical meristem from 17,500 cells/hr.
- Growth is measurable :

1] Direct method

2] Horizontal method

3] Auxanometer : [Arc (used to measure linear growth
[Pfeffer's

4] Crescograph = measure primary growth
- discovered by J.C. Bose [Jagdish chandra Bose]

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- Types of Growth Rate:

1] Absolute growth rate:

Ratio of no. of cells added over time

$$AGR = \frac{dn}{dt} = \frac{\text{No. of cells added}}{\text{Time}}$$

Q. Initially cell in culture are 500 after 5 hrs. it will be 600. AGR?

→ $\frac{100}{5}$ = 20 cells/hr.

2] Relative Growth Rate:

- It is ratio of AGR to the initial growth rate

$$\therefore RGR = \frac{AGR}{n}$$

n = initial growth

e.g., AGR = 20 cells/hr.

n = 500 cells.

$$RGR = \frac{20}{500} = \frac{2}{50} = 0.04$$

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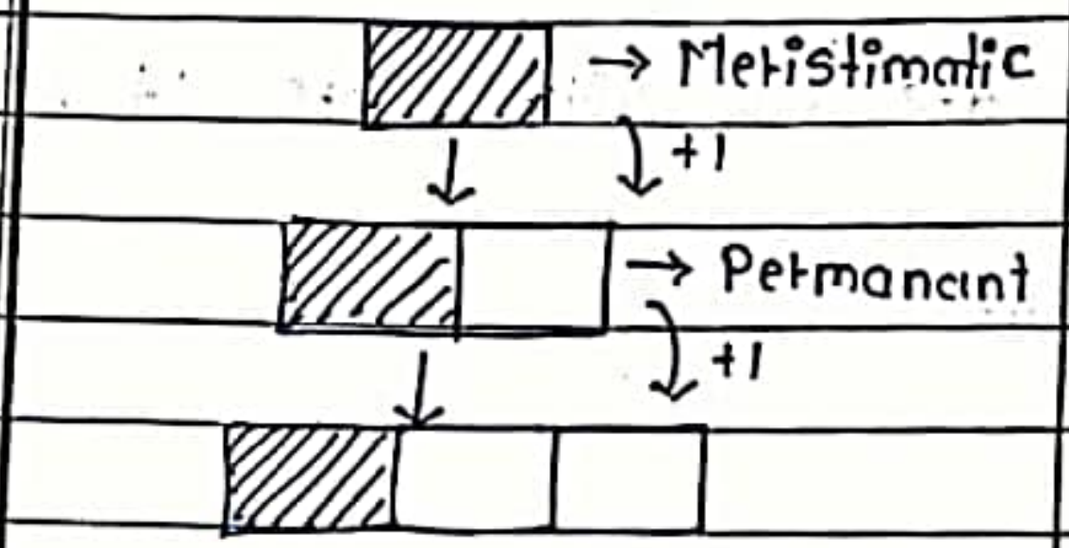
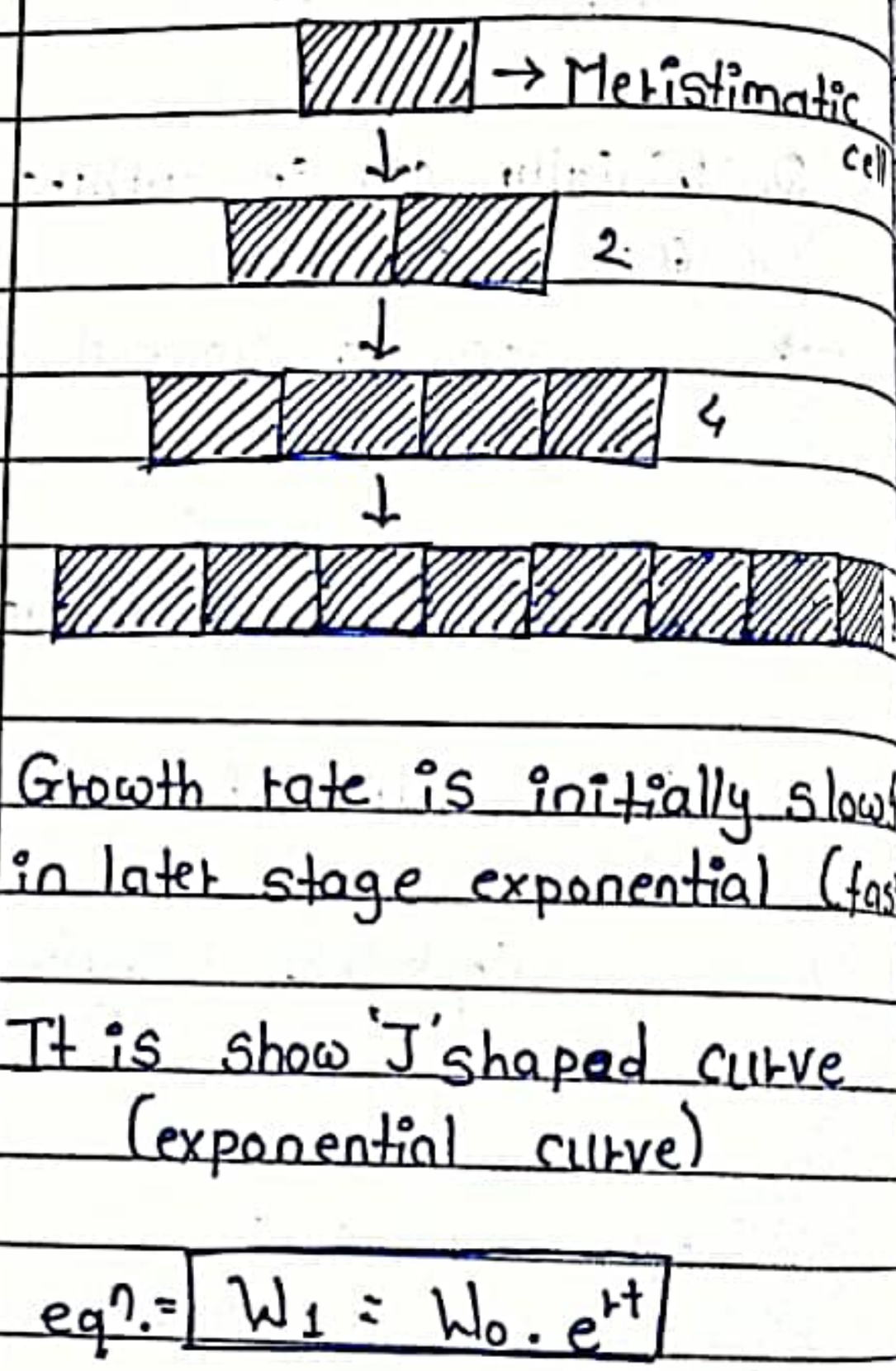
• Types of Growth :

	Atithmetic Growth	Geometric Growth
1.	Only one daughter cell continue to divide and other cells takes part in maturation 	two daughter cell continue to divide. 
2.	Growth Rate is constant	Growth rate is initially slow in later stage exponential (fast
3.	It shows linear curve	It is show 'J' shaped curve (exponential curve)
4.	eqn. = $l_t = l_o + rt$	eqn. = $W_1 = W_o \cdot e^{rt}$
	l_t = final size l_o = Initial size r = Growth rate t = time	W_1 = final size W_o = Initial size e = Natural log r = Growth rate t = time

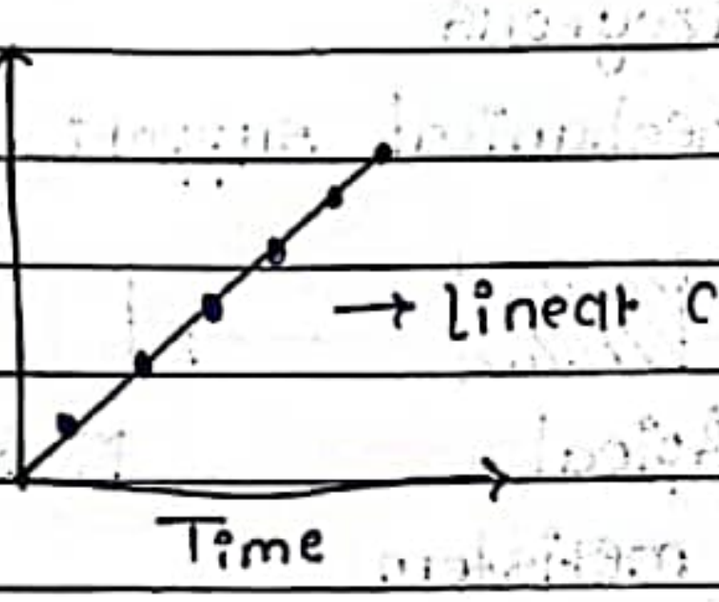
Arithmatic Growth ⇒ Root & shoot tip's

Geometric Growth ⇒ Zygote & embryo stage

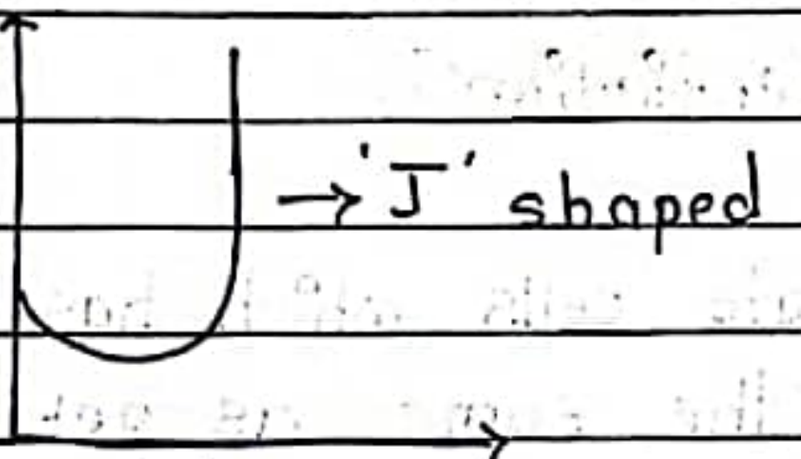
- **Growth Curve :**

It is graphical representation of growth.

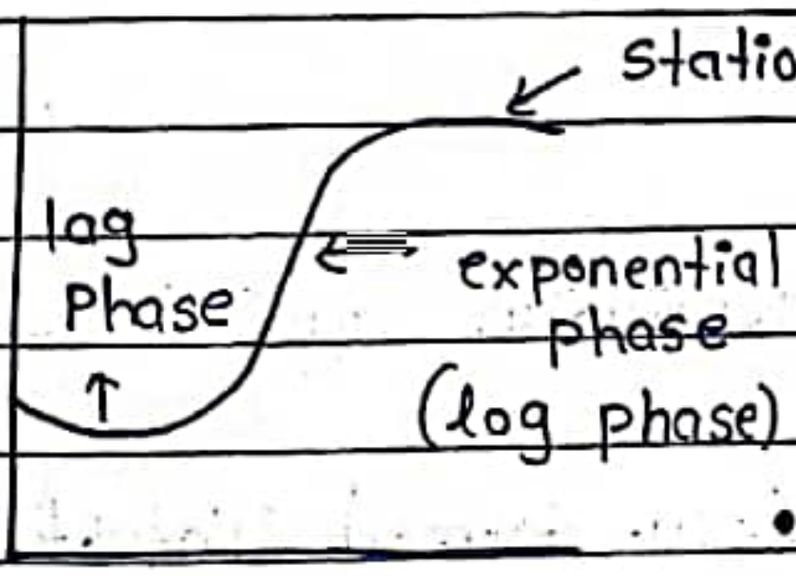
1] Arithmatic growth :



2] Geometric Growth :



3] In natural condition :



- log phase ⇒ Growth rate is slow
- exponential / log phase ⇒ Growth rate is faster & reaches it's maximum
- Stationary phase ⇒ Growth rate gradually slow down.

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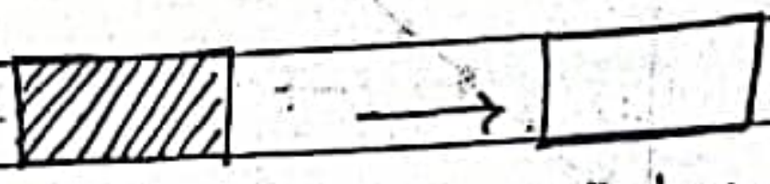
1] Differentiation :

- Maturation of cell derived from apical meristem
- Permanant changes occure in cell
- cell denote divide further
- e.g., Parenchyma cells in hydrophytes forming large Schizogeous
- Gives mechanical support & biyoyancy to plant.



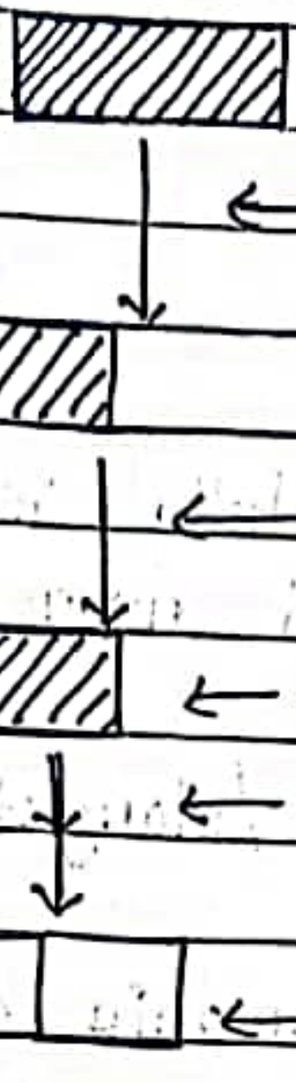
Apical meristem → Mature / differentiate Permanent cell

2] Dedifferentiation :

- Differentiate cells which has lost the ability to divide regain the same as pet need.
- becomes meristematic
- e.g., Interfacicular combium come from parenchymatic cells between vascular bundles

3] Redifferentiation :

- Cells produce & form dedifferentiation again lose ability to devide
- e.g., Secondary xylem & phloem formed Interfacicular combium.



* Development :

Seed germination → meristem → divide → plasmatic growth

Death ← agying ← plant ← maturation ← elongation

Senscens mature

Plasticity :

- It is capacity of being moulded (adjust)
- In plants the ability to form different kind of structures in responce to different enviotment.
- Heterophilly - plants in Tavenile & mature stage show differentiation from of leaves
- e.g., Cotton, Cariander lovkspr.
  Ranunwls flubellosis

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Growth Hormones :

A] Auxin :

- F.W went in 1931 succesfully isolated form (oles) ← Avena coleoptile tips, & named as Auxin.

★ - Function : Cell enlargement /elongation

★ - Precursor : Tryptophan (Ammonia acid)

★ - Site of synthesis : shoot apices / tips

★ - Natural form of Auxin : IAA [Indole - 3 - acetic acid]

- Transport : Polar / Basipetal (tips → Base)

★ - Also isolated form human urine suffering form pellagra disease

★ - Synthetic Auxin = 1] NAA [Napthalene acetic acid]

2] IBA [Indole - 3 - butyric acid]

3] 2,4 : D [2,4 Diphenoxy acetic acid] (Pichloro)

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- Physiological effect :

* 1] Apical Dominance :
Growing apical buds inbibit growth of lateral buds is Called d apical dominance.

* 2] Stimulate growth of root & shoot's

3] stimulate formation of lateral & Advantitious root

4] Seedless fruit formation.

* 5] 2,4,D used as herbiside and kill dicot weeds

6] It increase rate of respiratation.

* 7] Promote rooting in low concentation & shooting in high concentation.

8] Break dormancy in seed

9] Prevent Pre-mature fruit drop

8] Gibberellins :

* - Discovery :
- Scientist kurosawa first isolate this hormone from fungus 'Gibberella fujikuroi' which infect rice plant causing 'bakane disease'

- Site of synthesis = Root tips & developing seeds

★ - Preursor = Mevalonic acid

★ - Common form : GA3

Physiological effect :

★ 1] Breaking of seed dormancy.

2] It promote seed germination in cereals by synthesizing hydrolytic enzyme Amilase to produce sugar.

★ 3] Causes steam elongation.

★ 4] Promote bolting ⇒
i.e., elongation of internode before flowering in rossete habbit
e.g., Cabage, beat.

5] Increase fruit size and bunch length in grapes.

6] Production of male flowers on female plants

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c] Cytokinin :

- Discovery :

Skoog & Miller → Tobacco culture → Provided coconutmilk → Increased cell division

- Function : cell division
- Nature plant source ⇒ Unripe maize ⇒ Zeatin
  isolated
- Natural animal ⇒ Herring sperm ⇒ Kinetin
  Source DNA
- Synthetic cytokinin ⇒ 6 - benzyl adenine

- Physiological effect :

1] It promote growth of lateral buds and control apical dominance.
2] Delay in senescence / aging
3] It also break dormancy
4]
High $\frac{\text{Auxin}}{\text{cytokinin}}$ ratio promot Rooting

High $\frac{\text{cytokinin}}{\text{Auxin}}$ ratio promot shooting

5] formation of inter facicular combium.

d] Ethylene : [Inhibiting hormone]

- Discovery :

- only gaseous hormone present in plant
- function - Fruit ripening
- Source of ethylene - ethephon
- Site of synthesis - ripening fruit, roots, shoot, apical meristem

- Physiological effect :

1] Pramot ripening of fruit

2] Also break Dormancy.

3] Accelerates abscission in leaves, fruit & flower

4] Inhibit growth of lateral bud and cause apical dominance

5] Pramot Epinasty (drooping) → कोमजणे

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e] Abscissic Acid :

- called as stress harmone

- Discovery : Adicote ⟹ Cotton balls ⟹ Abssisin - I/II

Wearing ⟹ Acet ⟹ Dormin

- Commonly called Abseissic Acid

- Precursor = Mevalonic Acid

- Natural Source = 15 - C compound - Sesquiterpenoid

- Physiological effect :

1] Pramot ~~abs~~ adssision in leaves

2] Induced dormancy in seed

3] Accelerate senescence.

4] Delay in cell division and elongation.

5] Cause closing of stomata

6] LDP = long day plant ⟹ Inhibit flowering

7] SDP = short day plant ⟹ Induced flowering

- Bioassay for plant hormones :

1] Auxin = Avena curvature test

2] Gibberelins = α - amylase bioassay

3] Cytokinin = chlorophyll retention test

4] ethylene = Triple response pea test

5] Abscissic acid = Inhibit of α - amylase test.

Photoperiodism :

- Photoperiodism :

It is the responce of plant to the duration of light & dark period ~~affeting~~ affecting flowering and reproductive growth.

- Discover by garner and allard

- 2 key factors for transition to reproductive phase

1] light ⇒ Photoperiodism

2] temperature ⇒ Vernalization.

- Rate of light in plants = 1] Germination
2] Flowering
3] Photosynthesis

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- Aspects of light:

1] Quality : Blue wavelength light

2] Intensity

3] Duration of light

- Organ for Photoperiodism: leaf

Defoliated plant cannot flower even with proper light duration.

- Photochemical receptor : Phytochrome
  located in cell membrane
- Sensitive to blue light
- flowering hormone : florigen
- Singnel travelled via phloem.
- Based on duration of light plant classified into long day plant , short day plant & Day neutral plant.

1] long Day plant:

- flowering occure when day length is longer than critical photoperiod

- Also called as short night plant.
- flowering can occure if dark period interapted by brif light flash.
- e.g., 1] Pea plant 2] raddish 3] Sugar 4] Cabbage
5] Spinatch 6] Wheet 7] poppy

2] Short Day Plant:

- flowering occure when day length is shorted than critical photo period
- flowers during winter and late summer.
- It required long unintarupted dark period.
- flash of light during dark period inhibit flowering
- e.g., 1] Dahila, Aster
2] Tobacco
3] chrysanthemum
4] Soyabean (Glycine max)
5] Cocklebur (xanthium)

3] Day Neutral Plant:

- flowering is independent of photo period
- They flower throughout the year.

- e.g.. 1] Cucumber [cucumis Satives]
2] tomato
3] Cotton
4] Sunflower
5] maize
6] balsam (गौरीची फुले)

• Vernalization : (Yarovization)

- It is acceleration of the ability to the flower by chilling treatment called as vernalization.
- Term coined by T. D. lysenko
- Vernalization stimulus is a chemical stimulus called as Varnalin.
- It can be transport through grafting
- Ex., 1] Cereals
2] Crucifers
- Site of Vernalization : Shoot Apical Meristem

Devernalization :

Reversal of vernalization by high temperature treatment is called as devernalization

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Phytochrome :

Pr 660 — red light → / ← far red light — Pfr 730 wavelength

↓ Induce flowering in SDP

↓ Induce flowering in LDP

Pr = Phytochrome red (absorb red light)
Pfr = Phytochrome far red (absorb far red light)

During day time red light is more in atmosphere which is absorbed by Pr and Pr gets converted into Pfr
So, during day time Pfr form is more in leaves = Induced flowering in LDP.

During night time far red light is more in atmosphere which is absorbed by Pfr and Pfr gets converted into Pr.
So, during night time Pr form is more in leaves = Induced flowering in SDP.

& essential = गरजेचे

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* Mineral Nutrition :

- Plant absorbs minerals from soil, air and water.
- Minerals commonly occuring solid, inorganic substances from earth crust.

C → atmos; atmospheric CO_2
H → from water
O → CO_2 & H_2O

Classification of Minerals :

	essential	Non-essential
1.	Indispensable for plant life cycle	Not required for plant servials
2.	Deficiency causes major symptons	No deficiency symptons
3.	e.g., C, H, O, N, P	

This classification is not accepted

* Criteria for Essentiality : (Arnon & stout)

- Must be ~~nessa~~ necessary for normal growth & reproduction
- not replaceable by another element
- advance classification :- 1] Macronutrient
  2] Micronutrient

1] Macronutrient : It is required in large quantity
e.g., C, H, O, P, Mg, N, K, S. etc

2] Micronutrient :
needed in small quantity.
e.g., Zn, Cu, Al, Si. etc.

* Mineral deficiency sympton in plants :

- Mineral is considered deficient if it's amount is below the critical conc. in plant tissue.

- A visible change from normal structure and function of plant called as sympton / hunger sign.

• stunting :
Growth is slowed, stem short & compact.

• chlorosis :
Yellowing of leaves due to chlorophyll loss.

• Necrosis :
Localized death of tissue.

• Mottling :
Patchy green & non-green areas.

• Abscission :
Early dropping of leaves, fruits & flowers.

* Mobile elements :

e.g., N, Mg, K.

deficiency symptons appear 1st in older plant parts

* Immobile elements :

e.g., B, Ca.

deficiency symptons appear 1st in younger plant

- Boron = deficiency → Brown heart disease
- Copper = deficiency → dig-back of shoot
  Progressive death of plant

Role of Minerals :

- It is compount of protoplasm and cell wall
  e.g., C, H, O, N, P, S.
- Maintaining osmatic potential of cell
  e.g., fe, cu, Zn, Mg, Mn, Cl
- Helps in catalytic fuctions and acts in cgtalist in various enzyme reaction.
- Helps in permeability of membrane.
- They are components of energy related chemical compounents
  e.g., Phosphotas in ATP & Mg in chlorophyll.

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Mineral Absorption :

1] Passive absorption :

- Occurs by diffusion from high concentration to low concentration
- Non energy is used

Modes of passive absorption :

1] Direct ion exchange
2] Indirect ion exchange
3] Mass flow
4] Donnan equilibrium

2] Donnan equilibrium

- Negatively charged ion in the cell become fixed and can not move out of cell
- To maintain electrical balence Cations from outside intet the cell agains their concentration gradient.

3] Active absorption :

- Occurs against concentration gradient requite ener.
- require energy (ATP)
- If respiration is inhibited active absorption decreases

atmosphere → Soil → atganisms → atmosphere

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Nitrogen Cycle:

- It is a natiral process through which nitrogen moves from atmosphere to soil, soil to living atganisms and back to atmosphere

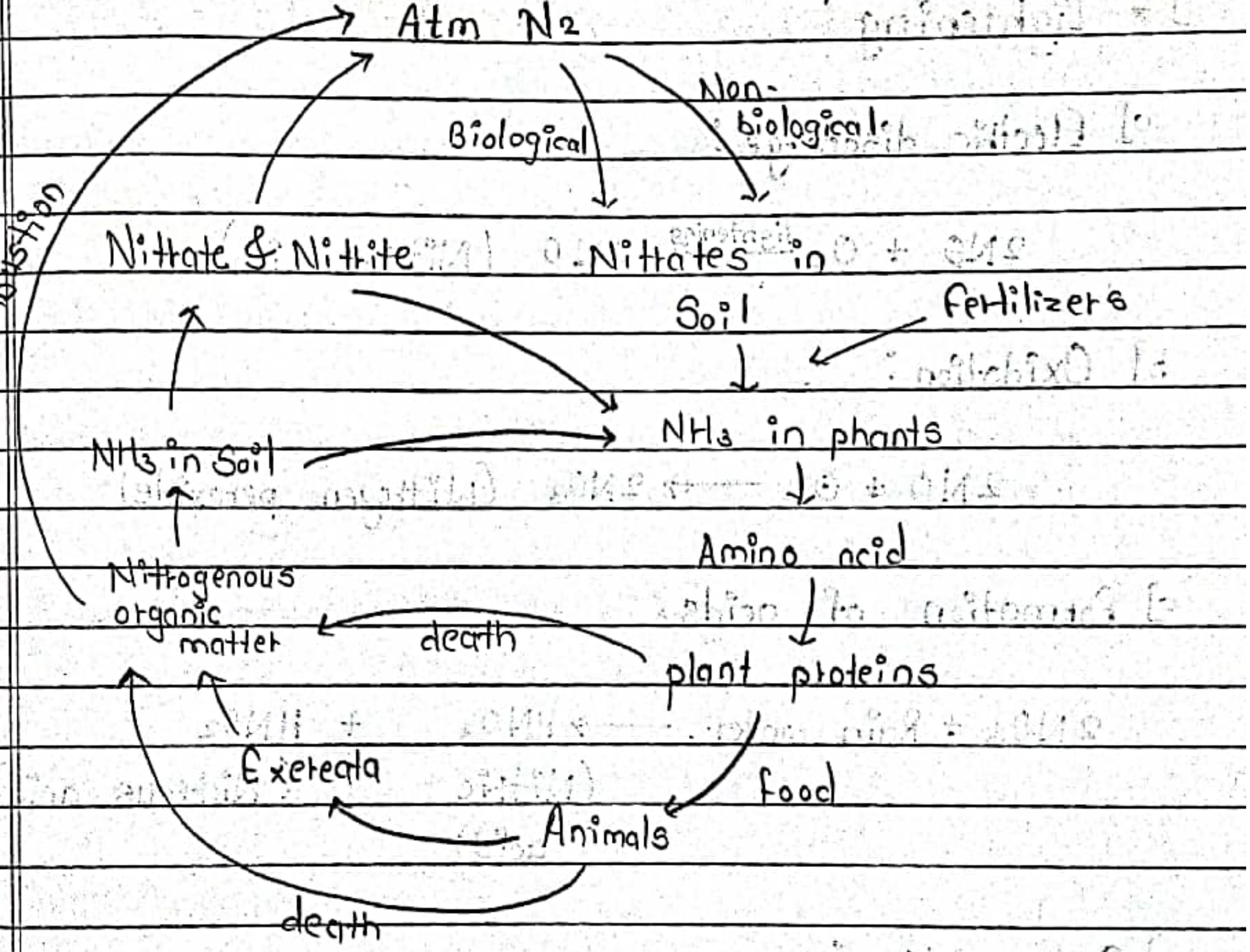

Fig., Nitrogen Cycle

- Nitrogen fixation:

The process of conversion of atmospheric nitrogen into nitrogenes compound like Nitrate, Nitrite & Ammonic

1] Biological fixation = Bacteria
2] Physical fixation = lightening / Industrial

Physical Nitrogen fixation:

1] * lightening:

a] Electric discharge:

$$2N_2 + O_2 \xrightarrow{\text{lightening}} 2NO \quad \text{(Nitric acid)}$$

b] Oxidation:

$$2NO + O_2 \longrightarrow 2NO_3 \quad \text{(Nitrogen peroxide)}$$

c] formation of acids:

$$2NO_3 + \text{Rain water} \longrightarrow HNO_3 \text{ (Nitric acid)} + HNO_2 \text{ (Nitrous acid)}$$

d] Soil reaction:

$$HNO_2 + Ca/K \text{ salts} \longrightarrow Ca/K \text{ nitrates} \rightarrow \text{absorbed by plants}$$

P_i → (inorganic phosphate)

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2] * Industrial Method :

$$N_2 + 3H_2 \xrightarrow[200\ atm]{450^\circ C} 2NH_3 \text{ (Ammonia} \rightarrow \text{Toxic)}$$

↓

Converted to urea
(less toxic form)

- Method called as Haber Bosch process.

Biological Nitrogen Fixation :

- Carried out by prokaryotes called as nitrogen fixers OR diazotrophs

- 70% of nitrogen fixation

- Nitrogen fixers can be ① symbiotic = e.g., Rhizobium
② Free-living = e.g., Azotobacter, Clostridium

- Symb Cynobacteria fixed nitrogen in heterocysts.
It is energy intensive process 16 ATP

$$N_2 + 8H^+ + 8e^- + 16\,ATP \longrightarrow 2NH_3 + H_2 + 16\,ADP + 16\,P_i$$

- Nitrification :

Conversion of ammonia to nitrate by soil bacteria
(Nitrifying bacteria)

Ammonio $\xrightarrow[\text{Nitrosococcus}]{\text{Nitrosomonas}}$ Nitrite (NO_2^-)

Nitrite $\xrightarrow{\text{Nitrobacter}}$ Nitrate (NO_3^-)

- This autotropes.
- This bacteria are chemoautotrophs

* Symbiotic N_2 fixation:

- e.g., Rhizobium
- forms nodule in members of fabacece like gram, beans, groundnut etc.

* Ammonification:

- decomposers convert organic nitrogen into ammino acid and then to ammonia.

Proteins $\xrightarrow{\text{decomposers}}$ amino acid

Amino acid $\longrightarrow$ $NH_3 + ROH$

- Nitrogen Assimilation:

- Absorb nitrogen converted to nitrogenous organic compound like amino acid, DNA and proteins

- Nitrate are 1st converted to ammonia but ammonia is highly toxic so immediately converted to amino acid

- Amino acid synthesis :

1] Reductive amination :

- Ammonia react with α - Ketoglutaric acid to form Glutamate acid

Ammonia + α - ketoglutaric acid ⟶ Glutamate acid

2] Transamination :

- Amino group of one amino acid transfered to keto position of other carboxylic acid

Glutamic acid + Oxalacetic acid ⟶ Aspartic acid

3] Amidation :

- Amids are the amino acid having 2 amino groups

- Need ATP to attach extra amine group to acidic group

- Glutamic acid + NH_4 + ATP ⟶ Glutamine

- Aspartic acid + NH_4 + ATP ⟶ Asparine

- **Denitrification:**

- Conversion of soil nitrates back into nitrogen gas with the help of anaerobic bacteria (Denitrifying bacteria)

e.g.,

IMP Denitrifying bacteria : 1) Bacillus species
2) Paracoccus species
3) Pseudomonas species

Nitrate (NO_3^-) → Nitrite (NO_2^-) → Nitric axid (NO) → Atm N_2 (N_2)

- **Sedimentation:**

- Nitrates of the soil are washed away to the sea or leached deep into the earth along with percolating water.