GROWTH PHYSIOLOGY

INTRODUCTION :

- Growth is a characteristic feature of all living organisms.
- Growth is a vital process, whcih brings about **permanent** and **irreversible change** in any plant or its part.
- Growth in plants means increase in shape, size, weight and volume of a plant or plant part.
- Grwoth lead to increase in fresh wight, dry weight, lenght, area, volumke and cell number. All these are controlled externally (by environmental factors) and internally (by Gnetics)
- Growht is **diffused in animals,** but in **plants growth is localised & irregular** (nail in plant stem, occupies same height till several years of growth)
- Seeds germinatin is the first step of plant growth. Almost all the plants face a period of suspended growth.
- If the suspension of growth is due to **exogenously controlled factros** (environmental factors) then it is called **quiescence.**
- When the suspension of grwoth is due to the **endogenously controlled factors** (hormonal, genetic) then it is termed as **dormany.**
- Weight increased during growth but exceptions are **potato** & **seed germination,** where weight decrease.

CHARACTERISTICS OF PLANT GROWTH

Differenttiatioin : Cells derived from ctive meristem tissue, become mture to perform specific function.
Development : Sum of morphogenesis and differentiation activies in livings is called as development.
Defifferentiation : dIn plans the living differentiated cell which lost the capacity of cell division, regain the capcity of cell division under certain conditions called dedifferentiation.
Ex. Formation of meristems intrafascicular cambium & cork from differentiated parenchyma cells.
Redifferentiation : The regain of differentiation by losing the capacity of cell division for performing specific function by a didifferentiated cells.
Determinate/Limited growth : Growth activites in some plants limited from specific period of season called as determinate/limited growth.
Ex. Annuals & beinnials

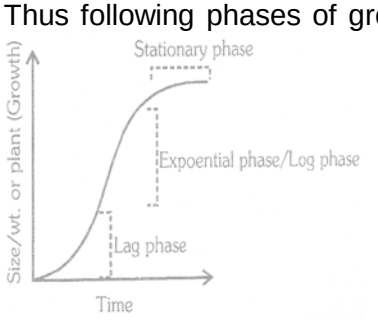
PHASES OF GROWTH

(1) **Phase of cell division or cell formation :** Number of cells is increases by cell division.
(2) **Phase of cell enlargement or cell elongatiion :** Size of cells increases due to **vacuolization** & TP (turgo pressure).
(3) **Cell maturation or differentiation phase :** (Also called as **morphogenetic, organogenic** phase) Development or qualitative change is important feature of this phase.

Pattern or course of plant growth : (growth curve)

- The pioneering work on growth was done by **Von Sachs.**
  The plotted a growth curvee between time & growth, which is knowns as **sigmoid curve** or **S-curve** or GP (Gran period)-curve.
- Growth pattern of cell, organisms is uniform under favourable conditions. Thus following phases of growth are recognised.

(1) **Lag phase :** In lag period the growth is slow.
(2) **Log phase :** Also called as exponential phase. During this phase growth is maximum & most rapid.
(3) **Steady** or **stationary phase :**
   - Time taken in growth phases (mainly log phase) is called as **"grand period of growth".**



Measurement of growth :

(1) By direct obersation
(2) By horizontal microscope
(3) By **Crecograph** (J.C. Bose) : It magnifies growth as 10,000 tiems
(4) By **Auzanometers :**
  (i) Arc - auzanometer
  (ii) Pfeffer's auxanometer/pully auxnometer (permanent graph on smoke paper)
  (iii) Micrometer screw-auxanometer

- **Efficiency index (E.I.) :**

Growth can be measured by an increase **in size** or **area of an organ** of the plant (leaf, flowr, fruits etc.) in a unit time is called as **efficiency idex.** E.I. may be same or different in species to species and organ to organ.

Factors affecting plant growth :

(1) **Light :** Light involves in photosynthesis and determine the direction of shoot and root growth. Light controlled morphogenesis of plant is called **photomorphogenesis.**

- Light is not essential during th einitial stage of growth or seed germination. In absence of light p lant exhibit etionlation.

(2) **Temperature :** Optimum temperature for growth is 20 - 35^0C. temperature above 45^0C damages the protoplasm and growth can be retarded.
Effect of low temperature of flowering is called vernalization.

(3) **Water :** Water maintains the turgidity of cell, which is essential for growth. (TP is important for growth). in order to cell to grow Ψ_ω must not be allowed to reach zero.

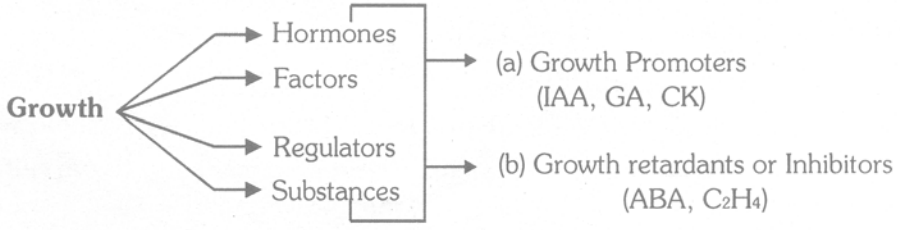
- Water is essential for the enzyme activity is protoplasm.

(4) **Oxygen :** Necesory for cell respiration.
(5) **Mineral nutrients :** All esential elements are compulsory for growth and metabolism.
(6) **Genetic factors :** Genotype & Phenotype.

PLANT HORMONES

- First of all idea of plant hormones was given by **Von Sachs "organ forming substance"**
- Ist Plant hormone discoverred by **F.W.Went** was **auxin** but term **hormone** was given by **Starling** & **phytohormone** by **Thieman.**
- Chemicals, which act as natural phytohormones are called as **synthetic growth hormones. Synthetic auxins -** α & CC-NA, 2, 4-D, 2,4,5-T, IPA, PAA, IBA Maleic hydrazide (MH).

NA - Napthelaene acetic acid.
2, 4-D - 2,4-Dichlorophyenoxy acetic acid
2,45-T - 2,4,5-Trichloro phenoxy acetic acid.
IPA Indole Propeonic/Pyruvic acid
PAA - Phenyl/phenoxy acetic acid



AUXINS

HISTORY -

- First of all **Charles Darwin** & **F. Darwin** (1880) was studying phototropism. They observed coleoptile bending in Canary grass **(Phalaris).** Wrote, Book **"Powr of movements in plants"** term - **"Stimulus"** By Darwing
- **Boysen & Jensen 1910 :** Experiments on oat **(Avena sativa)** Plant.
  In the first experiment, he removed the coleoptile tip and then replaced it on stump. On providing unilateral light the coleoptile tip gave positive curvature.
  They observed, tht if gelating inserted between the tip & cut stump, then coleoptile bends towards the unilateral light. if mica inserted then coleoptile **fail to show phtotropism. Maerial substance** term for growth hormone was given by him.
- **Paal :** Demontated that, when the cut tip was replaced on cut end (stump) exccentrically (asymmetrically) it cuased bending even in dark.
  If **coca butter** or platinum foil inserted-threre is no curvature obserbed.
  Idea of **unezual distribution fo growth substance** given by Paal. lare amount of substane found on shaded side.
- **F.W. Went (1928):** Went isolated the growint tip of Avena sativa on agar plate & performed **Agar-block experiment.**
- He give name **"auxin"** to growth substance, thus credit of auxin discovery goes to **F.W. Went**
- He also found tdhat the curvature (bending) in **Avena** celoptile is proportional, with in limits to the amount of auxin in Agr-block. This test was named as **Avena curvature - test** (Biossay of Auxin).
- Went found that 27% auxin present on illuminated side & 57% on the dark side. (About 16% auxin lost on illumiated side & rest transferred to base)
- Transport of natural auxin is **basipetal** & **polar type.** (Synthetic $\rightarrow$ auxin = apolar transport)
- **Kogl** & **hagen Smit (1931:** Isolated an active substance from **rine** f pellagra patient, which was called as **auxin - A** or chemicall7 **auxenotriolic acid** ($C_{18}H_{32}O_5$)
  Later a similar substance was isolated from **corn grain oil** and was named as **auxin-B** or **auxenolonic acid.** ($C_{18}H_{30}O_4$)
- Again **Kogl, Erxleben** & **Haagen Smit 1937 -** Isolated another substance from human urine and named as **heteroauxin** (IAA –$C_{10}H_9O_2N$) by **Thimann**
- Auxin from **Rhizopus** was obtained by **Thimann.**
- Auxin biosynthesis occurs by **tryptophan amino acid** in the presence of Zn^{++} ion.
- Degradtion or oxidation of auxin
  - Enxymatic (by IAA oxidate)
  - Phtoxidation
- Now IBA (Indole butyric acid) has been also isolated from plants (natural auxin) but IAA, is most widely found auxin in plants.
- The compounds, which can be converted into auxin ae called as **auxin precursor,** whereas the compound, which inhibit the activity of auxin are called as **antiauxins.**
- The auxin, which can be easily extracted in agar are called **free auxins,** while auxins, which are not easily extracted practivally are called **bound auxins.** A dynamix equilibrium is exists between these two forms (**free and bound auxins**).

Physiological effects and applications of auxin

(1) Apical dominance : (**Characteristic function of auxin**) The phenomenon, in which apical bud dominates over the growth of lateral buds is called **apical dominance.** Prunning in gardens promotes densing of hedge.

(2) Cell division & cell enlargement/Callus formation : Auxin is important in **tissue culture** & **Grafting.** It stimulates division of intrafascicular cambium. Also in **healing of wounds.**

(3) **Shortening of internodes :** α-NAA induces the formation of dwarf shoot or spurs in apple, pear etc., thus number of fruits increases.

(4) **Prevention of lodging :** Auxin spray prevents lodging of crops, immature leaves & fruits.

(5) **Root initiation :** Tooring on stem cutting is promoted by IBA & NAA (**Root growth inhibited by auxin**)

(6) **Potato dormancy :** mH (Maleic-Hydrazide), α-NAA, induces **dormancy of lateral buds in potatto tubers** & potato can stored for long duration.

(7) **Preventin of abscission :** IAA, NAA **prevent premature abcission of plant organs.**

(8) **Flower initition :** Auxin is inhibitor of flowring but it promotes **uniform flowring in pine apple & litchi** plants.

(9) **Parthenocary : Seed less fruits** can be produced by spray of IAA. (By Gusteffson)

(10)Selective weed killer : Dicot broad leave weeds can be eradicated by - 2, 4-D & 2,4-5-T

Agend orange

Agent orange is used i biowar. It was used by USA against Vietnam (1966-70)

(11) **Femaenes :** Ferminising effect is some plants

(12) **Flowre & fruit thinging :** Certain trees like mango form less number of fruits in alternate years. But auxins can produced normal fruit crips every year. This is known as **fruit thinging.**

(13) When **antiauxin (TIBA-Tri-Iodo Benzoic Acid)** are sprayed on mature coton firled then cotton balls ca picked easily

Bio-assay

Biossay means the testing of substance for it's activity in causing a growth response in a living plant or it's parts.

(i) Avena curvature test

(ii) Root growth inhibition test, are biossays for examining **auxin** acitivity.

GIBBERRELLINGS

- First of all Japanese farmers observed peculiar symptoms in rice seedings & called the **bakanae disease (foolish seedling disease)**
- Rice plants become **thin, tall** & **pale** due to infection of **Gibberella** (Acomycetes) or **Fuxarium** (Duteromycetes) confirmed by **Kurosawa & Swada.**
- **Yabuta** and **Sumiki** 1938 were the first to extract a crystaline substance from th e **Gibberella** fungus, which they named as **Gibberelling.**
- Gibberlling, is an acidiv & posses a **gibben ring srucutre**, are able to **overcome genetic dwarfism in plants.**
- 100 type of Gibberllins (GA_1, GA_2 $\boxed{GA_3}$ ..... GA_{100}) are known**.** **GA_3** [$C_{19}H_{26}O_6$] is **representative of all gibberellins.** First discovered gibberellings from higher plants was GA_1 (GA_1 & GA_{20} are common $GA^{'s}$ of higher plants).
- GA found in all groups of plants (algae, to angiosperms, but as a flowering hormone acts only in angiosperms.
- Biosynthesis of gibberelling takes place by **mevalonic acid pathway** (Kaurene $\rightarrow$ GA)

Physiological effects and applications

(1) **Stem/internode elongation (characteristic function of gibberllings) :** GA induces internode elongation, leaf expansion & used in sugarcane cultivtion. Gibberllings induce stem elongation in **rosette plants (Cabbage)** this phenomenon known as **bolting effect**. (Elimination of rossete habit in some plants by gibberellins action is bolting)

(2) **Elongation of genetic dwarf plant :** When gibberellin are applied to dawr maize, **Pisum** & **Vicia faba**, then they become tall. The rosset plant of sugarbeet indicate and extreme dwarfism, this habit can be eliminate by GA.

(3) **Flowring in LDP, in short light duration :** (Shorting of life cycle)
(4) **Parthenocarpy :** Like auxin, exogenous use of GA also induces the formatioin of seedles fruits.
(5) **Substitution of cold treatment or vernalisation :** The biennials plants from their vegetative body in the Ist year. Then they pass thrugh a winter season & produce flower & fruits in IInd year. GA induces flower in first year.
(6) **Breaking of dormancy :** GA breaks the dormancy of seeds, buds and tubers
(7) **Seed germination :** Gibberellin induce the synthesis of hydrolysing enzymes like α **-amylse, lipases, & proteases**
(8) **Sex expression :** GA induces **maleness** in **Cucumis, Cannabis.**
(9) **Germination of photoblastic seeds :** Gibberelling treated light sensitive seeds can germinates in ddrk. Ex. **Lettuce, Tobacco.**
(10) **Fruit & flower enlarger :** Size of grape fruits & bunch & **Geranium** flowrs increased by GA **Pomalin** $\Rightarrow$ GA (GA_4 & GA_7) + CK (6-Benzyladenine) - acts as an apple enlarger.
(11) **In fermentatioin :** More growth of yeast cells by GA.
(12) **Increase height of Sugarcene plant :** (More sugar contents by IAA)

- **Bio-assay:-** (1) α **-amlase activity test in Barley endosperm**
  (2) **Dwarf Pea & Maize test**

CYTOKININS (CK)

- Cytokinin was discovered by **Miller** when he was working (in lab. of prog. Skoog) on **tobacco with culture.** He added the contents of an old DNA-bottle (**Herring fish sperms DNA**) to the culture medium & observed that the tobacco pitch callus could grow for longer period.
- **Miller** isolated an active substance from **autoclaved DNA** from **Herring sperm,** which stimulated cell division. He named this substance as **kinetin**
- **Term cytokinin** By **Letham, Phytokinin** by **Osborne and Kinin by Skoog.**
  The **First natural ctytokinin** was indentified & crystalized from **imamture corn grains** by **Latham** & named as **Zeatin.**
- The most common cytokinin in plants are zeatin and isopentenyl adenine.
- **BAP** (Benzylamino purine), diphenylurea and thidiazuron are synthetic cytokinins.
- Cytokinin is a derivative of **adenine base.**
- **Root tips** are major site of synthesis of CK (by **mevalonic acid pathway)**
- Movement of ctykinin is **polar** & **basipetal.**
- **Coconut milk factor** also performed activity like cytokinin, thus used in **tissue culture.**
- **Zachau** obtained **cytokinins** from serine-t-RNA of yeast.

Physiological effects and applications

(1) **Cell division (Characterstic function fo cytokinin) & Cell enlargement :** One of the most important biological effect of **CK (cytokinin)** on plants in induction of cell division. In tissue culure also.
(2) **Formation of interfacicular cambium** and induce secondadry grwoth.
(3) **Morphogenesis :** Morphogenetic changes induced by CK in presence of IAA.
High auxin + **low CK** - Root formation

$$\left(\frac{\text{Low CK}}{\text{Hight Auxin}}\text{Ratio} \rightarrow \text{root}\right)\left(\frac{\text{Hight CK}}{\text{Low Auxin}}\text{Ratio} \rightarrow \text{shoot differentiation}\right)$$

(4) **Counteraction of apical dominance :** promotes growth of lateral buds.
(5) **Breakingthe dormancy of seeds :** Like GA the dormancy of certain seeds can be broken by CK.
(6) **Seed germination :** Seeds of parasite plant (Striga) can germinate in teh absence of host by CK treatment.
(7) **Delay in senescence : (Richmond Lang Effect)** The ageining process of leaves usually accompanies with lost of chlorophyll & rapid catabolism. This is called as **sensecence.** senescence postpned by CK. (increase short life of plant parts)
(8) **Lignin biosynthesis**
(9) **Larthenocarpy in some fruits.**
(10) **Pro-plastids modification**
(11) **Phloem conduction (nutruents mobilisation)**
(12) **Femaleness.**
(13) **Flowring in SDP (also in long days)**
(14) **Induce stomatal opening :**

- **Bio - assay :-**
  (1) **Tobacco pith cell division test**
  (2) **Chlorophyll preservation (retension) test (delay in senesecence test)**
  (3) **Soyabean and Radish cotyledon cell division test.**

Abscisic Acid (ABA $C_{15}H_{20}O_4$)

- First indicaion of growth inhibitors was given by **Osborne.**
- **Frst growth inhibitor** was identified by Bennet-Clark and Keffort (1953) from dormant potato tuber and called if β-inhibitor.
- **Addicott & Okhuma** (1963) obtained from mature **cotton fruits** and named as **Abscisin** II.($C_{15}H_{20}O_4$)
- **Waring** & **Robison** - Isolated a growth inhibitor for **old Betula leaves** & called as **dormin.**
- Leter estabilised that β-inhibitor, Abscisin-II and dormin are same and called as Abscisic acid.
- ABA is the msot wide spead growth inhibitor in plants.
- ABA synthesized by **Mevalonic acid pathway** & **oxidation of carotenes in chloroplasts.**
- **ABA** also known as **stres hormone,** because it protect plants from adverse conditions like water stress. ABA increases tolerance of plants to vrious type of stresses.

Physiological effects nd applications

(1) **Induce abscisioin -** ABA causes ageing and abscissioin of leaves & fruits (antiauxin) (cellulase & pectinase genes induced by ABA)
(2) **Induce bud & seed dormancy** -ABA regulates (anti-GA) bud & seed dormancy. ABA plays a major role in seed maturation enabling seeds to become dormant.
(3) **Induce senescence -** ABA accelerates senescence of leaves.
(4) **Inhibition of cell division & cell elongation - anti CK.**
(5) **Stomatal closing** -ABA causing the stomatal cloing under the water stress conditions. Increases resistance to frosty injury. (**anti transpiratnt** & **stress hormone**)
(6) **Delaying of flowering in LDP..**
(7) **Tuberisation in potato.**
(8) **Inhibitor of α-amylase synthesis -** Inhibition of seeds germination.
(9) **Geotropism in roots.**
(10) **Growth inhibition in duckweed (Lemna).**

ETHYLENE

- H.H. Cousin first suggested, tht ripened organges are responsible for ripening of unripen bananas.
- Ethylene is a gaseous pollutant **hydrycarbon** but **Burg** reported it as a **fruit ripening hormone.**
- **Pratt Goeschl -** Rocognized ethylene as a natural plant growth regulator.
- Biosynthesis of ethylene takes place by **methionine** amino acid. Ethlene is synthesized in large quantity by repening frutis and senescent o rgans.
- Ethylene also formed in roots in water logged conditin.

Physiological effects and applications

(1) **Post harvest ripening of fruits** - Citrus, oranges, banana, apple, tomato, today **ethephon**/CEPA(Chloroethyl Phosphonic acid) used at commercial level.

(2) **Stimulatio of senescence & abscission of leaves.** Ethylene is synthesized in large quantity by ripening fruits and senescent organs.

(3) **Flowering in pineapple.**

(4) **Triple response on stem :**
- (i) Inhibition of stem elongation
- (ii) Stimulation of readial swelling of stem
- (iii) Horizontl growth of stem (ageotropism)

(5) **Inhibits root growth :** Enthylene is inhibitor of root growth but stimulates the formation of root hairs.

(6) **Epinasty of leaves.**

(7) **Femaleness (Feminising effect) Pineapple (Bromeliaceae).**

(8) **Tightening of hooks of epicotyl and hypocotyl.**

(9) **Inhibits he polar movement of auxin.**

Other growth regulating substances

⇒ **Wound hormone Traumatic Acid :** Induce callus formation on injured parts (healing of wounds) Chemically traumatins are auxin like substance.

⇒ **Calines** (Formative hormones)

(1) **Rhizocalines :** Produced by leaves & induce formation of roots.

(2) **Caulocalines :** Produced by roots & induce formation of stem.

(3) **Phyllocalines :** (Self forming hormone) produced cotyledons & leaves, induce division of leaf mesophylls.

- **Morphactins or (HFCA)** These are, synthetic growth inhibitors, which are polyvalent (wide range) in action (**Antiauxin propery**)
  - (i) Inhibition of internode elongation
  - (ii) Reduction of apical dominance & promotio of laterl branching
  - (iii) Reduces the laminar rea of leaf
  - (iv) Abolition of phototropism
- **Chlormequant (CCC or Cycocel) :** Growth inhibitor, which is **used in bonsai.**
- **Alar - 85 B-(Nine) :** in floriculture
- **Agent organe : Mixure of 2,4-D & 2,4,5-T** used in bio-war (Used by U.S.A. in Vieatnam war)
- **Amo - 16818 :** in biowar.
- **Phosphon-D, Cycocel, Amo-16818, Alar-85 Ancymidol (A-REST) are antigibberellins** and cause inhibition to stem growth.

PHOTOPERIODISM

- The relative lenght of day of night is called as **photoperiod**
- The response of plant to the photoperiod, expressed in the form of flowering is called as **photoperiodism** "Effect or requirement of relative lenght of day (**photoperiod**) & night (**dark phase**) on flowering of plants is called as **photoperiodism.**

- The phenomenon of photoperiodism was firt discovered by **Garner** & **Allard** or **Maryland mammoth** (a mutatnt variety of tobacco) and biloxy soyabean.
- **Garner** & **Allard** classified the plants is following groups.

(1) **SDP (Short Day Plants) :** "These plants give flowers on exposure to photoperiod equal or **shorter than their critical day lenght**"

- They need a continuous (uninterrupted) dark period for flowering. Thus SDP also called as LNP **(Long Night Plants)**

- Ex. of SDP : **Tobacoo, soyabean, Viola, Xanthium (Cocklebur), Chrysanthemum, Cannabis, Coleus, Chenopodium, Mustard, Dahlia, Sugarcane, Strawberry, Cosomos, Rice etc.**
- In SDP the **dark period is critical** and **must be continuous.** If this dark period is breaks by a breif exposure to red light, the SDP will not flowers.
- Maximum inhibition of flowering with red light occur at about the middle of critical dark period.
- Prologation of teh continuous dark period, initiates early & good flowering in SDP.

(2) **LDP (Long Day Plants) :** These plants flowers only when they exposed to critical photoperiod or photoperiod longer than their ctirical day lenght."
The **light period is critical for LDP**
Ex : **Henbane** (Hyscyamus) **Spinach, Sugarbeet, Radish, Carrot, Wheat, Larkspur, Barley, Avena, Potato.**

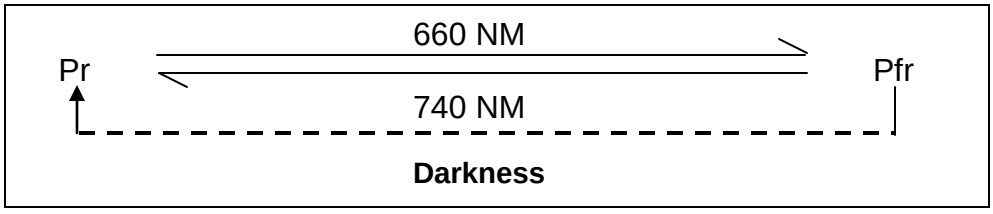
- A brief exposure in the dark period stimulates flowering in LDP

(3) **DNP (Day Neutral Plants**) or **Intermediate plants :** These plants do not \need specific light period for the flowering.
Ex. **Zea, Cotton, Tomato, Sunflower, Cucumber**

- **L-SDP :** These are SDP but must be exposed to long day during early stage of their growth. Ex. Bryophyllum
- **S-LDP :** These are LDP but must be exposed to short photoperiod during early stage of growth. Ex. **Wheat** & **Rye** sps.
- **Cajlachjan :** Reported that stimulation of critical photoperiod is percepted by leaves.
- **Chailakhyan :** Discovered **"Florigen"** it has been not isolated, thus called as **hypothetical hormone**

PHYTOCHROME

- **Borthwick & Hendricks:** Discovered a light sensitive pigment responsible for flowering
- **Butler :** Give Term **"phytochrome"** for this pigment & isolated it.
- Pigment phytochrome is a chromophore billiprotein,w hich is as open tetrapyroolic related to phycoilin.
- Phytochrome mainly located on cell membrane of all type of plans.
- Phytochrome : exists in two different forms
  Pr (Phytochrome red) - Red light absorbing form, induce flowering in SDP.
- **Absorption range** - 630-670 nm. absorption peak -667 nm.
  Pfr (Phytochrome far red)- This is far-red light absorbing form, induce floweing in LDP.
  Absorption range - 720 - 740 nm. absorptio peak-735 nm.
- Both forms of phytochromes are photobiochemically inter -convertible into each other.
- The **Pfr** (Yellowwish) form, gradually changed in to **Pr** (bluish) form in dark.



- During the day the Pfr form is accumulated in the plants, which is inhibited to flowering in SDP but stimulates in LDP.

- Phytochrome - **Pfr (P_{730}) is active form,** which controls may phtophysiological processes in plants
- Control of morphogeneisis by light & phytochrome is called **photomorphogenesis**
- now phytochrome is considered as universal distribution is plant kingdom.

Photomorphogenesis in higher plants appear to be under control of one of three photoreceptors.
(a) **Phytochrome -** Which absorbs red and far red region of light
(b) **Cryptochrome -** Which absorbs blue and UV-A (380 nm) light.
(c) **UV-B-REceptors -** Which absorb UV-B (290 nm) light.

VERNALISATION OR YAROVIZATION

- Effect of low temperatuer on the initiation and development of flower, was first realised by **Klippart** 1857 (Exp. on winter & Spring wheat)
- Detail study and term - **"Vernalisation"** by **Lysenko** (Credit of discovery).
- **Chourad** defined as **"acceleratioin of ability to produce flowr by chilling treatment is called vernalisation"**
- Mainly **embryo tip, shoot apex & leave perceps** induction of low temperature of plants.
- Concept of hormone **'vernalin'** in vernalisation was given by **Melcher et. al.** This a **hypothetical plant hormone,** because not has been isolated till today.
- Vernalisation of **seeds or plant propagule** in laboratory can be induced at 1^0C to 10^0C in presence of O_2 & H_2O.
- If vernalized plant prapagules are kept in high temperature, just after the low temp. treatment then effect of vernalisation is reverse, this effect is called as **devernalization.**

Significance :
(i) Better & early flowering
(ii) Vernalisation increases the resistance to fungal diseases

PALNT SENESCENCE

- Period form complete maturity to degredative chagnes during the death of an organ or plant is known as **senecence.**
- Dring senescence a gradual destruction occurs in protoplasm, cell , tissue, organ or plant and functioning of the plant and plant parts.
- During the senescence, higher rate of catabolism starts, under the control of growth hormones like **ABA. ethylene.** Senescene occurs as a result of ageing and leads to death of plant parts or whole planat. (Senescence and ageing studied in **phyto-geronology**)
- Senescence may be of following types :
  (a) **Whole plant senescence :** ex. Tomato, Wheat, Mustard, Rice, Beans.
  (b) **Organ senescence :** When plant part above ground dies (shoot) each year and root & rhizome system alive. Ex. Alfa-alfa, Sugarcane, Banna, Ginger.
  (c) **Sequential or progresive senescence :** Everygreen perennials show progresive or sequential senence of older leaves, lateral organs, branches, flowers, fruits and shoot. Ex. Eucalyptus, Mango.
  (d) **Simultaneous or Synchronous leaf senescence :** In perennial deciduus plants, all the the leaves undergo sennescence and abscission sp.
  Ex. **Dalbergia sisso, Azadirachta indica, Ficus religeosa.**

ABSCISSION

- Detachment of senescent or mature plant organs like leaves, fruits, flowers due to change in hormonal activity.
- There is separation layer (**abscision layer**) is formed within the regioin of attachment of these parts. Cell wall layers and middle lamella are dissolbed by the activity of **cellulse** and **pectinases** (Polysaccharide hydrolyising enzyes) during the **abscisioin.**
- Hormone **ABA is main controllar** of abscission process.

PLANT - MOVEMENTS

(A) Movement of locomotion : When the whole plant, plant part or organs of plant move from one place to another place.

(I) **Autonomous :** (by **internal stimulus)**

(1) **Amoeboid :** Ex : Gametes of Spirogyra

(2) **Ciliary movement :** Ex : **Chlamydomonas, Euglena,** Zoospores

(3) **Cyclosis :**

(i) Rotation - Whole protoplasm moves around the one central vacuole, in one direction. Ex : **Hydrilla, Vallisneria** cells.

(ii) Circulatio : Protoplasm moves, around the different vacuoles in different directions. Ex : Stamental hairs of **Tradescantia**

(II) **Induced/paratonic/tactic movement :** (Due to **external stimulus)**

(i) **Phototactic :** Due to stimulus of light. Ex : Aglage - by (Eye spot/Stigma).

(ii) **Chemotactic :** Due to stimulus of chemicals. Ex : Male gametes of lowr plants (antherozoids). By **Chemical gradiant sensing mechanism.**

(ii) **Trermotactic :** Due to stimulus of temperature. Ex : **Chlamydomons, Euglena**

(B) Movement of curvature : Movement of plant organs only.

(I) **Autonomous : Movment of variation :** Dance movmenet by Desmodium. (India telegraph plant) due to turgor pressure change.

Epinasty & hyponasty, the growth movement in flower & leaves.

(II) **Induced/Paratonic movmenet :** (By external stimulus, but directional)

(i) Tropic movement : Definite di rectin towards stimulus.

(a) **Phototropism** — +ve ex : Stem; -ve ex : Root

☛Definite direction in relation to light

(b) **Geotropism** — +ve Ex : Root (Root cap percept stimulus); -ve Ex: stem & Mangrove plant roots.

☛Definite direction in relation to gravity, (root cap percept stimulus).

(c) **Chemotropism :** Ex. Pollen tubes & fungal hypae

☛Definite direction in relation to chemicals.

(d) **Thigmotropism (haptotropism) :** Ex : **Endrils, haustoria** of **Cuscuta.**

☛Definite direction in response to contact or supprt.

(e) **Hydrotropism :** Ex: Roots of seedlings

(ii) Nastic movment (External stimulus but diffused type or nondirectional) :

(a) **Nyctinasty :** Ex : Flowrs, leaves, stomata, daily movement (Sleep movements)

☛Due to rhythemicity of day and night.

(b) **Thigmonasty or haptonasty :** Tentacles of insectivorous plants

(c) **Chemonasty :** Ex : Tentacels of insectivorous plants

(d) **Seismonasty :** Ex: **Mimosa** (**touch me not plant**) turgor change in pulvinus leaf base **K^+ ion** also involved in this movment.

SPECIAL POINTS

☛ Many plant parts specially leaves exhibits nastic movement and involves differential growth, this type of movmenet is known as movmenet of growth. This movement, is caused due to unequal growth in plant organs.

Ex: Epinasty, hyponasty, Nutation.

- **Epinasty & hyponasty :** Ex : Leaves, flower (petal) opening & closing respiectively.
  Epinasty - More growth on upper surface of plant parts.
  Hypnasty - More growth on lower surface of plant palrts.
  Both epinasty & hyponasty are example of autonomic growth movement.
- **Natutation :** Zig zag growth of plant organ mainly shoot, it called as nutation
- **Cirumnutation :** Spiral growth of plants in tendrials
- **Protulaca** is known as **compas plant.**
- **Rhizomes** diageotropic (9^0 to gravitation force)
- **Clinostat :** used for nullifying geotropism

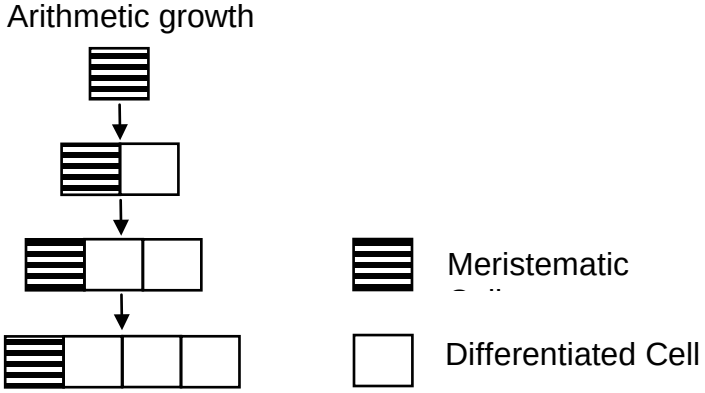
- **Hygroscopic movement** (mechanical movement)
  - **Xerochasy :** Dur to loss of water
    - **Ex :** Dehiscence of legume frutis
  - **Hydrochasy :** By excess of water
    - **Ex : -** Ruellia fruit dehiscence

- **Traumatropism :** Injury induced plant movment
- **Plageotropism :** Shown by stem & root branches growing at an angle of 45^0 form axis of plant.
- **Climact eric fruits** (Banana, Apple, Avocados) : Fruits, in which rate of respiration increases **(climacteric respiration)** during their ripening **(ethylene)**. Citrus is non climacteric fruits.
- The flower stalk of the poppy is +vely geotropic but after the opening of flower, this stalk change as negative geotropic.
- Formation of nodule is a combined activity of **cytokinin** (By bacteria) and **auxin.** (By legunimnous plant)
- **Blue light** has more effects on most of physiological and growth proceses in plants except photosynthesis and photoperiodism.
- Arabidopsis thaliana (Brassicaceae) is the most widely used plant tool for the strudies of developmental genetics and growth physiology of plants.
- **Betacynanin or Betalains :** Pigment mainly found in valcoule of **beet roots** and flower of **Bougainvellia** are differ from anthocynin due to the presence of nitrogen (N). These pigments do **not show reversibility of colour change due to p^H change.**
- **Anthocynin** in water solube **vacuolar** pigment, which does not invol ve in photosynthesis.
  Anthocyanin exhibits different colour like purple, pink, blue, scarlet etc.
  The colour of anthocynanin is sensitive to p^H change for Ex. colour of anthocyanin chnges from **Red (acidc p^H)** to **Violet (neutral p^H)** to **blue (in alkaline p^H).**
  Turgorin -a newly discovered hormone found in pulvinous leaf base regulates pressure changing movments.

Growth rate : Increased growth per unit time.

Plants growth is of two types :

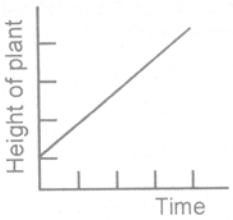
(a) **Arithmetec growth :** Form dividing cell two new cells are formed (by mitotic division) out of them one daughter cell continues to divide while other differentiate and mature (stop dividing).



Ex. Root & Shoot elongation at constant rate.
Ir is mathematically expressed as its. vorve is linaer.
$L_1 = L_0 + rt$ where L_1 - lenght at time 't'

L_0 - lenght at time 'zero'

r - growth rate / elongation per unit time.



(b) **Geoetric/Exponential growth :** From dividing cell (by mitotic division) both daughter cells retains the ability to divide and continue to do so.
Ex : All cells, tissue, organs, developing seed, germinating seeds, seasonal activites etc.
It is mathematically represented as
It's curve sigmoid

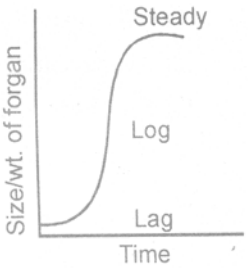
$W_1 = W_0 e^{rt}$

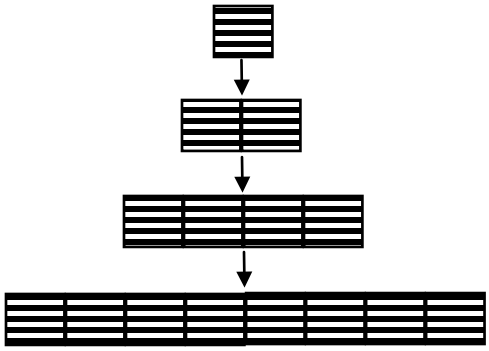
Where W_1 final size (Wight, hight, number etc.)

W_0 - initial size at the beginning of period.

r - growth rate

e - base of natural logartithms





Geometric growth - Meristematic Cells

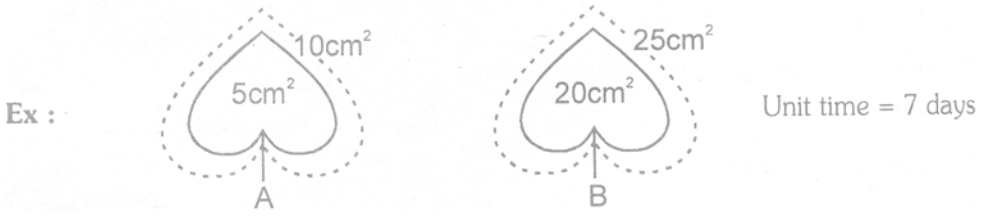
(c) **Absolute and relative growth rates :** Absolute grwoth rate : Measurement and the comparision of total growth per unit time in plant or plant parts.

or

Total growth occurs in unit time in plant or plant parts.
Relative growth Rate : The growth of the given system per unit time expressed on a common basis i.e. per unit initial parameter in plant parts.

or

Total growth occurs in u nit time in comparision ot initial growth in plant or plant parts. Relative growth rate is generally high in young developing plant parts.



Both passes same absolute growth rate i.e. 5 cm^2 in 7 days.

But high relative growth rate in leaf 'A' about 100%, while in leaf 'B' it is about 25%