* Plant Growth and Development *

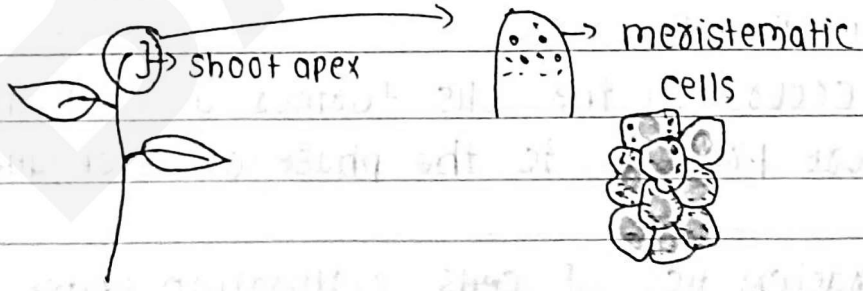
Growth is an irreversible permanent increase in size of an organ or its parts or an individual cell.

It involves metabolic processes that consume energy.

Growth is Measurable.
→ Cell number - A maize root apical meristem can produce more than 17,500 new cells per hour.
→ Cell size - Cells in a watermelon may increase in size by upto 3,50,000 times.
→ Length - Growth of a pollen tube.
→ Surface area - Growth in a dorsiventral leaf.

* Phases of Growth

1) Meristematic phase
It occurs in the meristems of the root apex and the shoot apex



→ Characteristics of ~~cells~~ Meristematic phase
Small, isodiametric, thin cell wall
No intercellular spaces, dense cytoplasm,
Prominent nucleus, Abundant plasmodesmata

2) Elongation Phase

It occurs in cells proximal (just next, away from the tip) to meristematic zone

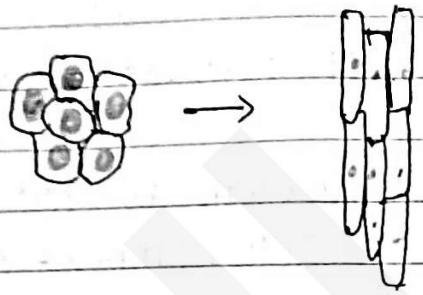
→ Protoplasm increase

↓

Increase in cell wall

↓

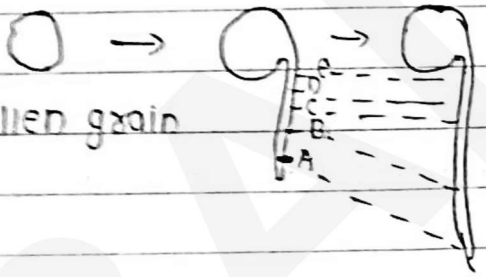
Cell enlarges



Characteristics of ~~Cells~~ Elongation phase

→ Increased size, secondary wall, Increased vacuolation

* Parallel line Technique



Pollen grain

Detect the zone of Elongation

3) Maturation Phase..

It occurs in the cells further away from the apex (more proximal to the phase of Elongation)

Characteristics of ~~Cells~~ Maturation phase.

→ Cells attain maximum size

→ Protoplasmic modification (eg- xylem vessels lose their protoplasm)

→ wall thickening → xylem walls are lignified

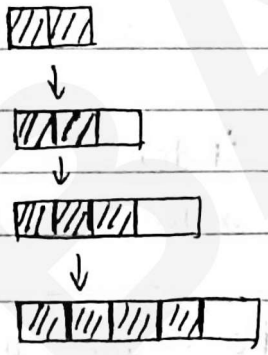
* Plant Growth is indeterminate
→ continues throughout life ; Because of meristematic cells (Dividing cells) ; new cells are added

* Growth in plants *

Primary	Secondary
→ Increase in length	→ Increase in diameter
→ Occurs due to	→ Occurs due to
• Root Apical Meristem (RAM)	• Lateral meristem.
• Shoot Apical Meristem (SAM)	• Vascular cambium.
	• Cork Cambium.

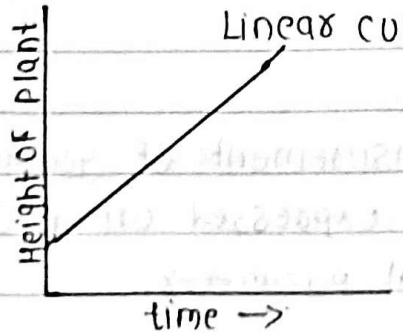
* Growth Rates (Increase in growth / Time)

1) Arithmetic Growth



→ Only one daughter cell continues to divide other becomes permanent (it will not divide
→ eg - Growth of root

Graph:

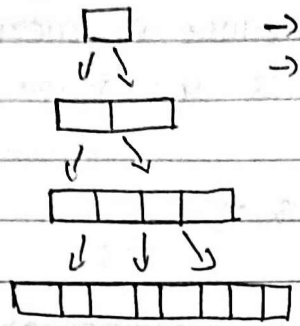


Mathematically, it is expressed as

$L_t = L_o + \gamma t$

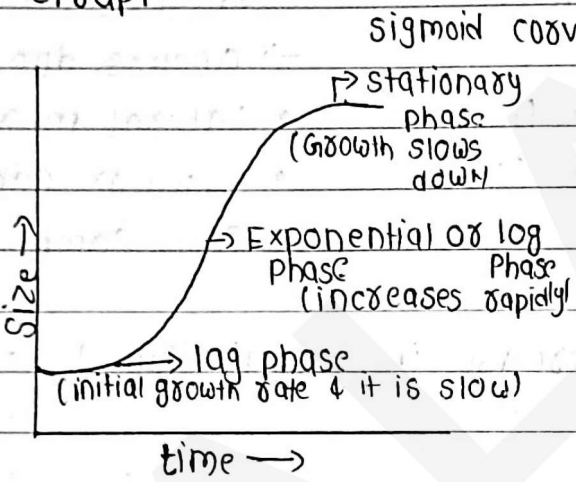
L_t = Length at time 't'
L_o = Length at time 'zero'
γ = growth rate / elongation per unit time

2) Geometrical Growth:



→ Both daughter cells divide
→ This type of Growth occurs in natural environment

Graph



The exponential Growth can be expressed as $W_1 = W_0 e^{rt}$

W_1 = final size (weight, height, number etc)

W_0 = initial size at the begining of growth rate

t = time of growth.

e = base of natural logarithms

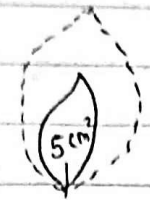
Relative Growth Rate (Efficiency index)

Ability of plants to produce new plant material

Quantitative comparison between the growth can also be made in 2 ways

i) Absolute Growth rate - Measurement and comparison of total growth per unit time.

ii) Relative Growth rate - Measurement of growth of the given system per unit time expressed on a common basis, e.g. - per unit initial parameter

eg 

(A)

(B)

Absolute Growth rate
A → 5 (10-5)
B → 5 (55-50)
measurement and comparison of total Growth per unit time

Relative Growth Rate.
A → 100 %. $\frac{10-5}{5} \times 100 = 100$
B → 10 %. $\frac{55-50}{50} \times 100 = 10\%$
Measurement of Growth / time expressed on a common basis

* Condition for Growth.
→ Water → Cell enlargement → Turgidity → Enzymatic activity.
→ Oxygen → For ATP synthesis
→ Nutrients → Macro & Micro
→ Temperature - Proper Enzymatic Activity
→ Light & Gravity → Affects certain Phases of Growth
↳ Photosynthesis, photoperiodism

* Differentiation -
It is a process → meristematic cell (RAM, SAM) (cambium)
↓ mature
Change in Structure.
↓
Starts performing Specific function
(Permanent - Stop dividing)

* Dedifferentiation

Some permanent cells
↓ under certain condn
Start dividing.

eg- formation of Interfascicular cambium & Cork Cambium.
(Ray parenchyma) (Cortex cells)

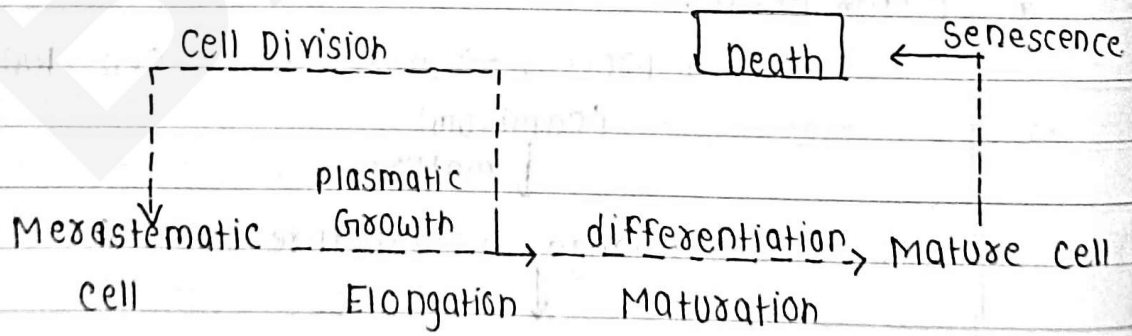
* Redifferentiation

Interfascicular Cambium → 2° xylem, 2° Phloem
Cork Cambium → Cork

↓
Do not divide Redifferentiation

Dedifferentiated cells → new cells
↓ Again lose capacity to divide
mature / permanent

* Development → Growth + Differentiation.



* Plasticity

Change in form / structure in response to change in environment / phases of life.

eg - Heterophylly → formation of 2 diff type of leaves in single plant.

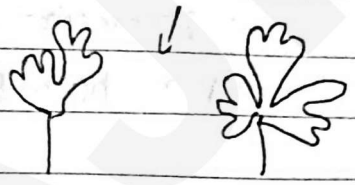
External Heterophylly

↓

Buttercup

Internal heterophylly

eg - cotton, coriander, larkspur



Factors controlling Development

* Intrinsic
→ Genetic
→ Plant Growth Regulator

* Extrinsic
→ Light, water, oxygen, nutrients, temp.

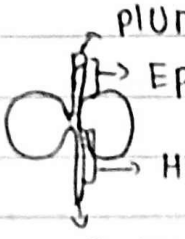
* Seed Germination and Dormancy

→ The first step in the process of plant growth is seed germination.

→ The seed germinates when favourable conditions for growth exist in the environment.

→ In absence of such favourable conditions the seeds do not germinate and goes into a period of suspended growth or rest called dormancy

→



Steps of seed germination

→ Imbibition of water → Enzyme active
→ Entry of O_2
Breakdown of complex substance → simple form.

What causes seed Dormancy.

* Internal
→ PGR - Plant Growth Regulator
  ↳ ABA (Abscissic Acid)
→ Para ascorbic Acid
→ Phenolic Acid
→ Immature embryo
→ very hard seed coat

* External
→ Light
→ Temp.
→ water
→ O_2

* Methods to Overcome Seed Dormancy.

→ Natural
- Sunlight, water, Temp.
- Seed ——→ Seed coat
  Digestive tract of animal. Soft + Enzyme Active

→ Artificial.
1) Stratification → Cold and moist condition
2) Scarification → Nicking seed coat with sharp knife.
3) Vigrous shaking.
4) Rubbing with sand paper.
5) Running water treatment.
6) Nitrates (Soft seed coat)
7) Growth hormone.

* Plant Growth Regulators

These are small, simple molecules that Regulate plant growth. Based on functions, PGR are 2 types.

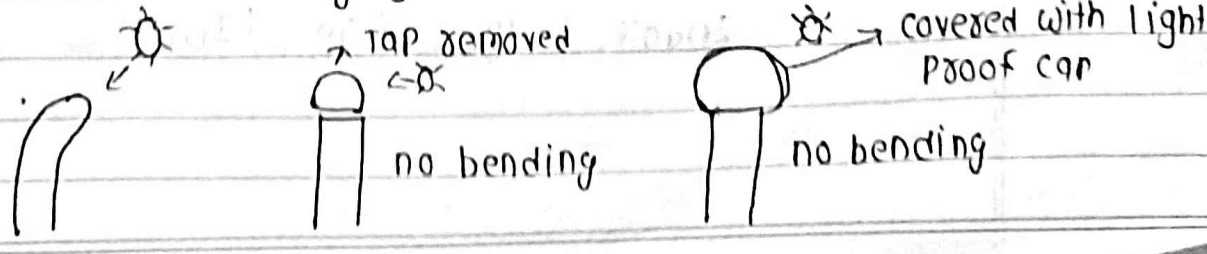
1) Plant growth promoters - For growth promoting activities like cell division and enlargement, tropic growth, pattern formation, flowering, fruiting and seed formn
eg - Auxins, Gibberellins and cytokinins.

2) Plant growth inhibitors - For growth inhibiting activities like dormancy and abscission. Respond to wounds & stresses of biotic and abiotic origin.
eg. abscisic acid & Ethylene.

** Ethylene fits either of the groups, but it is largely a Growth inhibitor.

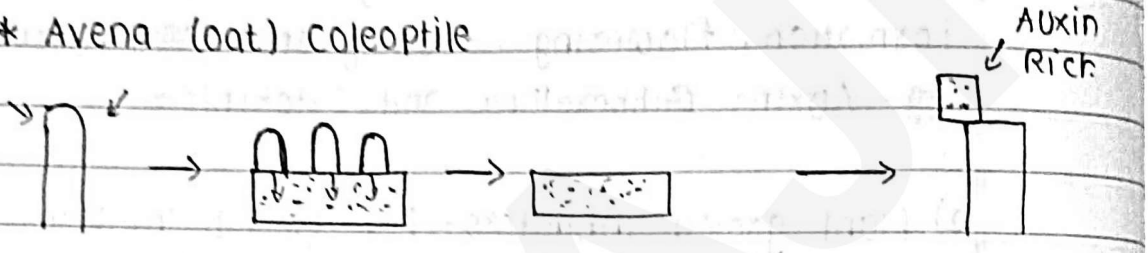
* Senescence & Abscission
↓ ↓
Final stage of Plant development — Shedding of various parts of a plant.

* Auxins (Auxien → to grow Greek)
Bioassay for Auxin: Avena curvature test
History - Charles Darwin & Francis Darwin (son)
↳ Canary grass coleoptile



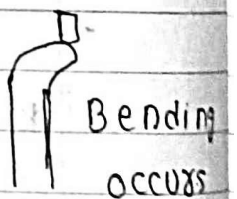
Conclusion :- Something is synthesized in the tip of coleoptile which is transmitted downwards and cause Growth and bending.
They exposed coleoptile to unilateral leaf.

→ F. W. Went (1928)
* Avena (oat) coleoptile



Coleoptile tips on Agar | Tips removed agar cut into blocks | Coleoptile tips cut and agar block placed at one side

Conclusion - Some substance synthesised at the tip causes the coleoptile to bend
→ Shade → more auxin → more growth → Bending



→ Isolated Auxin.
→ Named this substance Auxin
→ Auxin was isolated from urine of Human

Serotonin $\xrightarrow[\text{liver}]{\text{Breakdown in}}$ by product Auxin

- Tryptophan (Precursor) ⟶ Auxin

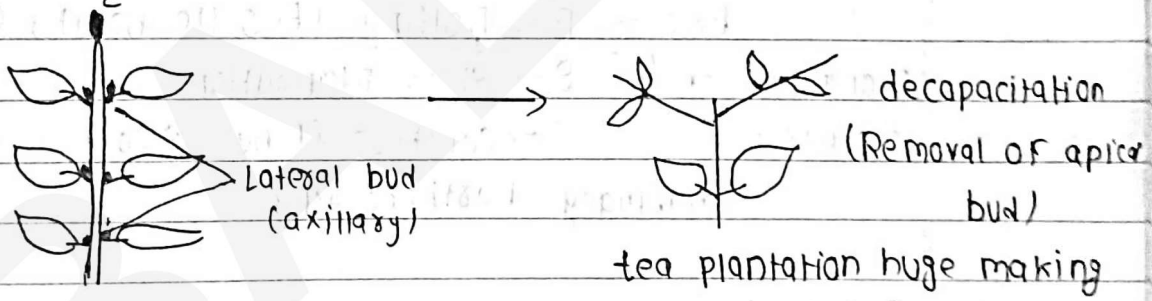
- Natural- Indole-3-acetic Acid (IAA)
  Indole butyric Acid (IBA)

• Synthetic - NAA → Napthalene Acetic Acid
2,4-D → (2,4 - Dichlorophenoxy acetic acid)
Weedicide / Herbicide
It kills dicot weed, does not affect monocot

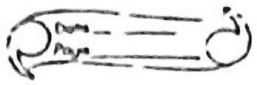
→ Auxin is formed in RAM & SAM

Effects (~~toict~~)
→ cell division ; xylem differentiation ; 2,4-D (Dicots) ; Rooting hormones , Apical dominance ; Flowering in Pineapple ; Parthenocarpy ; Abscission (Mature Part)

* Apical dominance



* Gibberellins.
→ These are acidic PGR.
→ E. Kurosawa treated the sterile filtrates of Gibberella fujikuroi (a fungus that causes 'bakanae' disease or foolish seedling in Rice) to healthy rice seedlings
→ As a result, it showed the symptoms of bakanae disease Later the active substances were identified as gibberellic acid



→ There are more than 100 gibberellins (GA1, GA2, GA3, etc) in fungi and higher plants.

→ Gibberellic acid (GA3 or Terpenes) is one of the first discovered and most intensively studied gibberellins

→ Sugarcane stores sugar in stems. Spraying sugarcane crop with Gibberellins increases the length of the stem. It increases the yield by as much as 20 tones per acre.

→ Spraying juvenile conifers with GAs hastens the maturity period. It leads to early seed production

Functions

Trick - Malti - Malting in Brewing Industry.

Das - Delayed Senescence (Ageing)

Applied for - Apple Growth

BSc — B → Bolting (Rosette habit, eg - Beet, Cabbage)

Elongation of internodes ← S → Stem Elongation

C → Conifers (Pine) early seed set

Pharmacy - Parthenocarpy.

* Cytokinin.

Discover → Skoog & Miller

Work on Plant → Nicotiana tabacum (Tobacco)

Used - Yeast extract,

Coconut milk,

Extract of vascular tissue

Sample of DNA.

(Herring fish sperm)

↳ kinetin.

→ Cytokinins were discovered as kinetin (N6 - furfurylamino purine an Adenine derivative) from the autoclaved herring Sperm DNA.

→ Kinetin does not occur naturally in Plants

Coconut milk + DNA ⟶ Rapid cell division.

* First natural cytokinin → Maize grain (zea mays)
↳ zeatin.

Functions- Trick

Tissue colduse is → Tissue Culture
Advance ⟶ Apical dominance remove (Antagonastic to auxin)
Science ⟶ Senescence Delay → Richmond Lang effect
Said ⟶ Shoot bud initiate
Chief ⟶ Cell division
Colour ⟶ Chloroplast.
officer ⟶ Organogenesis → formn of new organs shoot

* Ethylene

→ Cousins confirmed the release of a volatile substance from ripened oranges that hastened the ripening of stored bananas. Later this substance was identified as Ethylene.

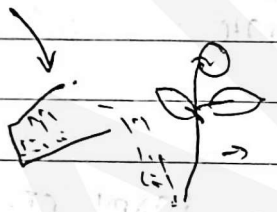
→ Ethylene is a simple gaseous PGR.

→ It is synthesised in large amounts by tissues under going senescence and ripening fruits

Trick -
Apply - Apical hook in dicots
Some - Senescence promote.
~~Peanut~~ Raw - Ripening.
Peanut - peanut germination
Butter on - Bud initiate / dormancy overcome
Potato - Potato Tuber sprout.

** Promotes Female Flowers → Cucumber
Promotes Root & Root hair
Promotes Internode elongation in Rice

Ethephon → Source of Ethylene



→ Releases ethylene slowly

→ Thinning of cotton, walnut and cherry
→ Respiratory climactic
Fruit ripening ——→ Respiratory climactic
Rate of Respn ↑

* Abscisic Acid (ABA)

→ During mid 1960s, it was reported 3 kinds of inhibitors: inhibitor-B, abscisin II & dormin
→ They were chemically identical and now known as abscisic acid

→ ABA is the derivatives of carotenoids
→ It regulates abscision and dormancy

Functions -
→ Inhibitor of plant growth, metabolism and seed germination
→ Closure of stomata in the Epidermis
→ Stress hormone.
→ Seed dormancy by ABA helps to withstand desiccation & other factors unfavourable for growth

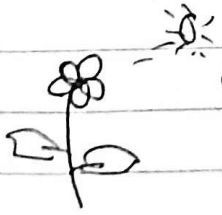
Interactions of PGR.

Alone ↑ | ↱ work together to produce more effect. (cytokinin + Auxin)

→ PGRs play individualistic or synergistic role. Such roles may be complementary or antagonistic
→ PGRs interact to affect dormancy in seeds / buds, abscission, flowering, senescence, vernalisation, apical dominance, Seed germination, plant movements etc.
→ In most cases, ABA acts as an antagonist to GAs

ABA ↓ Induce dormancy
GAs ↓ Remove dormancy

* Photoperiodism.
It is the response of plants to produce of day / night
some plants require light to induce flowering



8 hours } Photoperiodism

→ Critical day length is the specific length of daylight that is required to initiate the flowering response in the long day plants or to inhibit the flowering response in the short day plants.

→ The critical day length is specific for each species of plants.

PQ PYQ corner

→ Term photoperiodism given by Garner & Allard

→ Working on Soyabean.

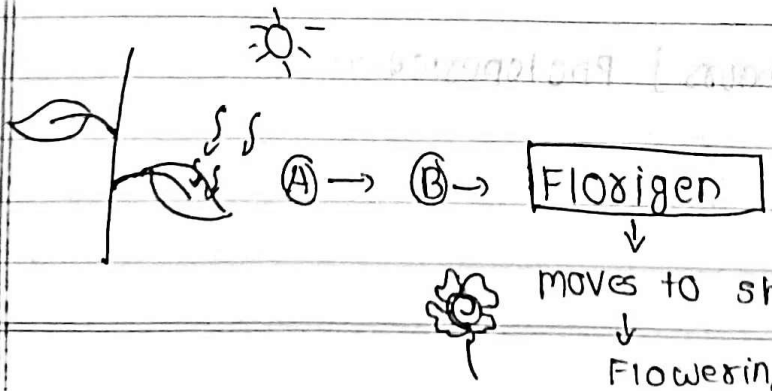
Mexyland mamoth variety of tobacco

→ Short day plants - Light less than Critical photoperiodism
Ex- Tobacco, Soyabean.

→ Long day plants - More light than Critical photoperiodism
Wheat, Pea, Cabbage, Radish

→ Day Neutral plants - Independent of duration of light
Ex- Cucumber, maize, Tomato, cotton

* Site of perception
Leaf is the site of perception



* Phytochrome
↳ Pigment Proteins
→ Present in leaves → percieve light
↓
Florigen → Flower

$Pr_{(red)} \underset{730\ nm\ (far\ red)}{\overset{660\ nm\ (red)}{\rightleftharpoons}} Pfr\ (far\ red)$

* Vernalisation (Yarovization)
Low temp. → Vernalin
Seed / Seedling ↓
Flower

Advantage -
→ Crops can be produced earlier
→ It prevents precocious reproductive development late in the growing season

→ Biennial plants $\xrightarrow{\text{vernalization}}$ Annual
1 year → Veg. growth
2 year → Reproductive growth
Monocarpy flower only once.

Wheat, barley, rye

Spring
Planted in spring & flower produce grain before the end of growing season

Winter
if planted in spring ↓ do not produce flower