GROWTH AND DEVELOPMENT

The growth in size of a single cell is limited by the distance which the nucleus can exert its control. When single called organisms reach a maximum size, they divide to give two separate individuals. In order to attain greater size, organisms become multi cellular.

Definition

Growth is the permanent (irresistible) increase in size and dry weight of an organism. Growth is usually accompanied by development.

Development: it refers to change in shape, format degree of complexity that accompany growth. Development involves differentiation whereby unspecified structures become modified to perform specific functions.

N.B: Mere increase in size is not growth e.g a cell mass absorb water by osmosis, but this is reversible, change in volume alone is not growth. Yet the increase in number of cells as a ziggote undergoes cleavage without any increase in size crolm or mass of cytoplasm) is a case of growth.

Growth and development often go hand in hand and one collectively referred to as morphogenesis'. The origin of form growth in a multi cellular organism can be brought about by three distinct process.

(i) Cell division (mitosis) / hyper plasis. This is increase in number of cells as a result of mitotic cell division and cytokinesis.

(ii) Cell expansion:- whereby the cells increase in size. This follows the synthesis of new structures / protoplasm from raw materials absorbed from their surroundings so absorption of water. The synthesis of new protoplasm from the raw materials / nutrients in the surrounding of the cells is assimilation.

(iii) Cell differentiation: the cells change in both size and form structures to perform specific forms such cells usually do not divide any more.

Each of these processes may occur at different points inturn for growth to occur anabolism must exceed catabolism.

Growth is usually accompanied by an increase in the complexity of the organism by the form of new tissues of organs i.e growth accompanied by development.

NB:- In case of single celled organisms of bacteria, cell division results in reproduction of the individual and eventually growth of the population as a whole. It does not result in growth of the individual.

- The process of proteins synthesis forms the basis of growth. There are two levels of growth:-

i) Growth of an individuals (for multi cellular organisms)

ii) Growth of a population (for both multi cellular and unicellular organisms)

MEASUREMENT OF GROWTH (IN PLANTS AND ANIMALS)

Growth can be measured at various levels of biological organization such as

- growth of a cell
- growth of a population

At the level of individual organism there are a variety of parameters / variable that reflect growth which may be measurement.

a) Change in height or length

To determine the change in height / length the following methods can be used:-

- By using a measuring tape, the change in height of the whole organism or part of an organism in a certain period is taken **(illustrate with table.)**

- By using time lapse photographs of an organism are taken per unit time, regularly.

- By the use of slowly revolving kymograph which record on a graph, changes in height with time.

ADVANTAGES OF HEIGHT / LENGTH

- It can be used for most organisms (plants and animals)
- Easy to measure

DISADVANTAGES

- It does not take into account growth occurring in other dimensions e.g highly branding plants.
- In case of plasts, it does not take into account for the growth
- Does not consider growth in organs. i.e parts of the organisms may grow at different rates from that of the whole organism.

b) CHANGE IN WEIGHT / MASS

Two aspects of an organisms weight can be measured. Fresh weight is dry weight.

Fresh weight

This is the weight of an organism taken its natural onstition i.e when alive. The organism is weighed on a scale or balance at set time intervals **(illustrate)**

ADVANTAGES

- It is a quick and easy way of determining growth
- The same organism can be studied continuously to give a continued indication of growth sicne the method does not harm the organism (one specimen used many times)

DISADVANTAGES

- It includes the water content of the organisms body fluctuates is environmental conditions such as temperature e.g on a hot day a plant may lose a lot of water.
- Method can only be used for small organs (eg plants) whose weight can easily be measured.

- In case of plants, many specimens are required since it involves uprooting the plant.

Dry night (mass after all moisture has been driven off)

This is the weight after all the water has been dried (evaporated) from the issue of the organism i.e weight of protoplasm presence without the water content. The organism is heated in an oven at around 100^{o}C till all the H2O has evaporated. This is determined when a constant weight is attained. Weight is determined using a weighing scale or balance.

ADVANTAGES

- It measures the exact new protoplasm laid down due to growth. Therefore, it is more reliable than fresh weight.

DISADVANTAGES

- It involves billing of the organism. Many are needed for the expectation. They have to be the same species, age and size, growing in similar conditions.
- It may not be possible to use the method on some organisms. E.g man, domestic animals.
- Does not recognize the fact that different parts grow at different rates.

c) CHANGE IN AREA / SURFACE AREA

Surface Are is more commonly used. It is useful in measuring growth of plant organisms e.g leaves whose surface area changes greatly as they grow.

The heat is placed on a graph paper and its outline is drawn.

The number of complete squares enclosed in the outline is counted.

It is added to half the total number of incomplete square.

Advantages

- Increase in size is prominent and can be measured at short time intervals.
- Easy to use it is a useful method of determining growth of structure that grow in two dimensions i.e length and width e.g leaves.

Disadvantages:

- -Leaves grow faster and drop off before the rest of the plant is mature and doesn't account for total growth.

- -It is not suitable for young plants that show a reason because increase in leaf surface area.
- Different plant organs (leaves) may have different areas so an average of few leaves is used. This makes it less accurate.
- It is difficult to apply to a whole organ. Only growth or parts/organs can be determined.

d) Changes in volume/girth (diameter)

- Increase in diameter e.g. a tree can be determined using a tape measure.
- Change in volume can be determined by dropping/immersing the organ in a known volume of water. The changes in volume of water is determined.

Advantages.

- It is easy and quick
- Useful in plants where secondary growth occurs.

Disadvantages

- Volume may fluctuate according to fluid content of the organ's body making the method less accurate.
- Not easy to determine volume of some organs.

NB: The parameter /method used depends on the organ whose growth is to be measured. No single method seems most suitable to a particular organ or situation. For more reliable results, more than one method can be used.

Qn: How would you determine the growth of the following?

(a) Growth of a root?

-Use germinating seeds with straight radicals'

(b) Growth of a stem?

-Internodes length

-Increase in length of the whole stem.

(c) Growth of a leaf –leaf area

(d) Growth of a population of bacteria?

-Volume count colony- using microscope?

(e) Tree-Circumference of stem, height, leaf area.

(f)Crop plant-fresh weight.

INTEPRETATION OF GROWTH MEASUREMENTS.

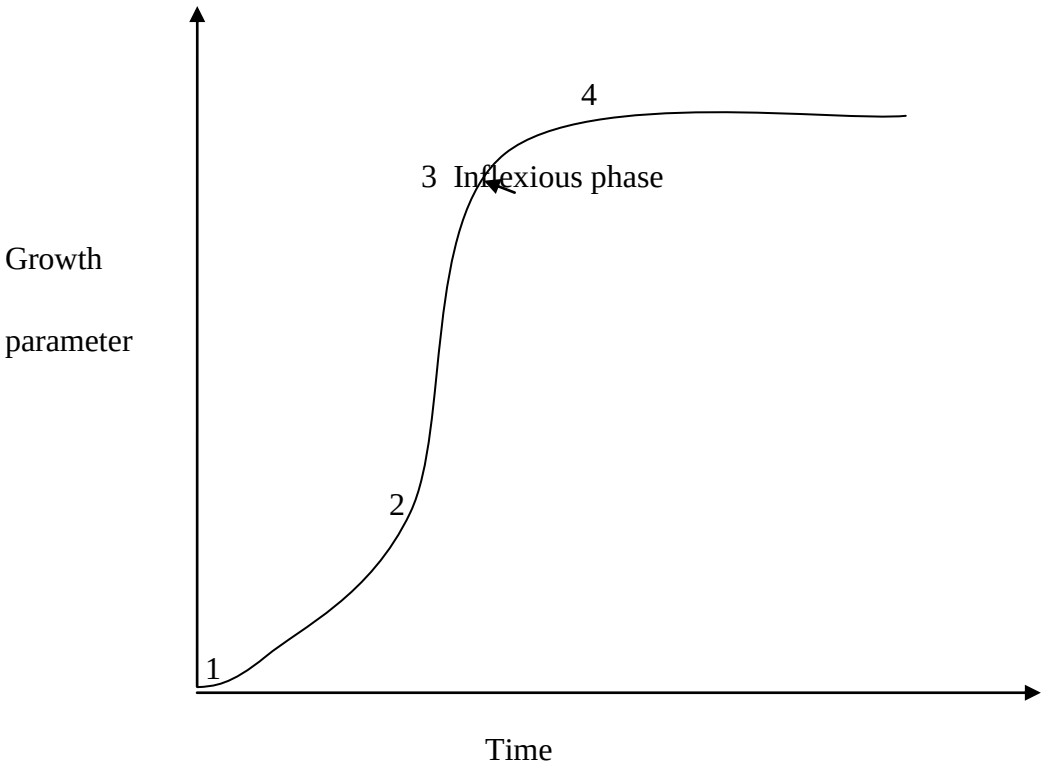
(Types of growth curves)

Growth can be estimated by measuring some aspects of the organ such as height, weight volume, etc over a specific period of time. The measurements so obtained, if plotted over time result into a growth curve know as the absolute/actual growth curve.

1 Absolute/actual growth curve.

The organ measured of e.g. height, weight are plotted against time

The growth curve shows the overall growth pattern and extent of growth. The general pattern turns out to be the same for most organs (popns/organs) ie the sigmoid curve.(s-shaped curve). It has distinct phases.



Lag phase: slow grow occurs because

- There is no or slow cell division occurring.
- The numbers of organs/cells dividing are few
- The organs are adapting to surrounding environmental factors.

2. The Logarithmic phase (log phase, exponential phase)it is the phase of rapid/exponential growth. The rate of growth is …… to the material/organs present. With time, the exponential increase declines, and the rate of growth begins to decrease. The point at which this occurs is known as the inflexion point.

3. Decelerating phase/self retarding phase.

Growth becomes limited as a result of the effect of:

- Internal or external factors or both
- Most cells have differentiated so fewer are dividing.

4. The stationary/plateau phase.

It marks the period where overall growth ceased and the parameter under consideration remains constant.

The nature of the curve at the stationary phase may very depending on the spp ,the parameter used and internal factors.

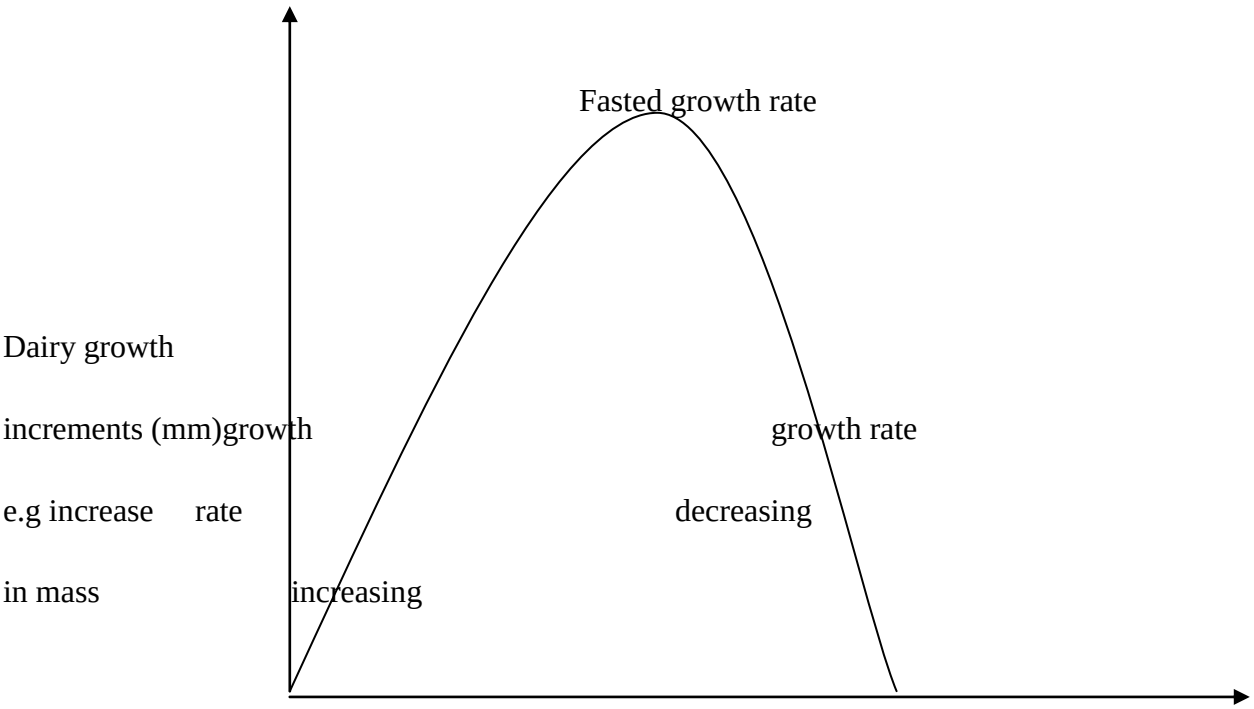
- In some cases it may continue to rise slightly, until the organ dues e.g. monocot leaves, fish, some reptiles (they show unlimited growth).

-In coelenterates the curve flattens out indicating no changes in growth.

Other growth curves tail off indicating a period of negative growth e.g. in mammals. This is a sign of physical senescence associated with increase in age (old age)

2. Growth rate curve (rate of growth)

It is obtained by finding the increments (increase change in parameter) are plotting the increase against time i.e. growth increments are plotted against time. The most organs the growth rate increases steadily until it reads a maximum and it gradually falls.pg 413 Rbts 760 Bsc



3. Absolute growth rate curve (percentage growth)

This is a measure of the efficiency of growth. The increase in growth over a period of time is expressed as a percentage of growth that has already occurred and then plotted against time. Existing size is taken into account by using the following calculation.

$$\frac{absolute\ growth\ rate}{original\ measurement}\ \text{or}\ \frac{growth\ in\ given\ time\ period}{measurement\ at\ start\ of\ time\ period}$$

E.g. A five year old and a ten year old both grew 10cm in one year .Their absolute growth rates would be:

5 year old and $\frac{10}{orginal\ heights} \times 100$

10 year old

Example 2

Between the age of one and 2 years the baby's mass may increase from 10 to 12 kgs Absolute increase is 2kg

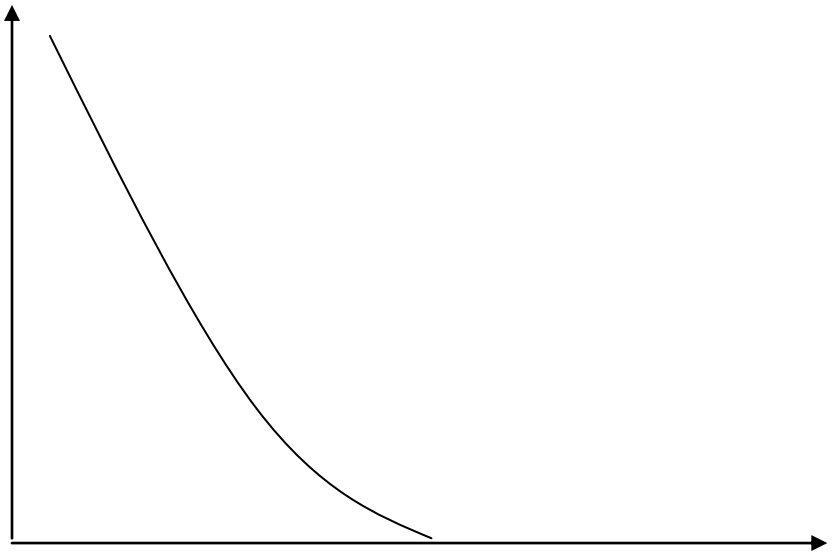
%age increase is $^{2}/_{10} \times 100 = 20\%$

In the same period (two years) the mass of a teenager may go up from 50 to 55kgs Absolute increase is 5kg

%age increase is $^{5}/_{50} \times 100 = 10\%$

-The babe has a higher rate of percentage growth

Relative growth rate curve shows the rate of growth relative to the size of the organ.

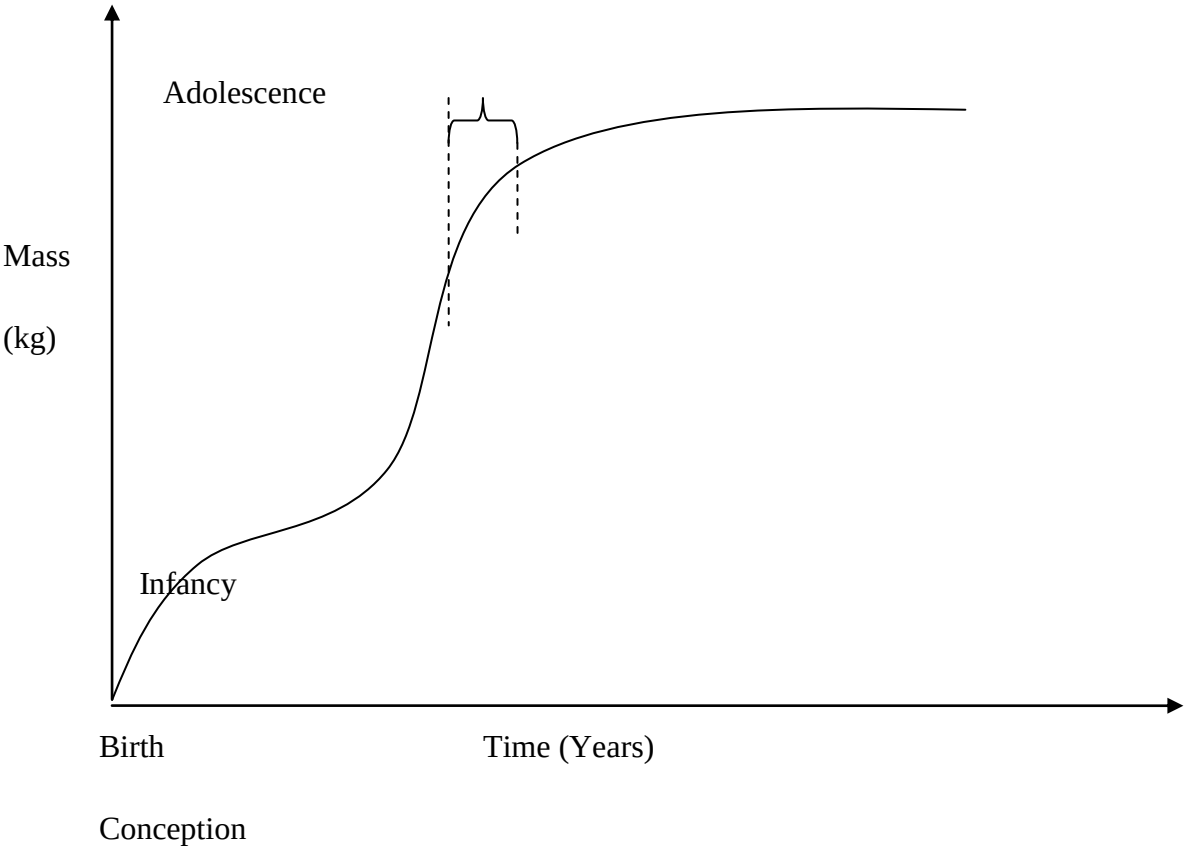


The rationale (importance) of plotting a relative growth rate curve is an internal process, largely dependent upon the growth that has already been achieved. Growth rate is maximum at the beginning and gradually decreases with time.

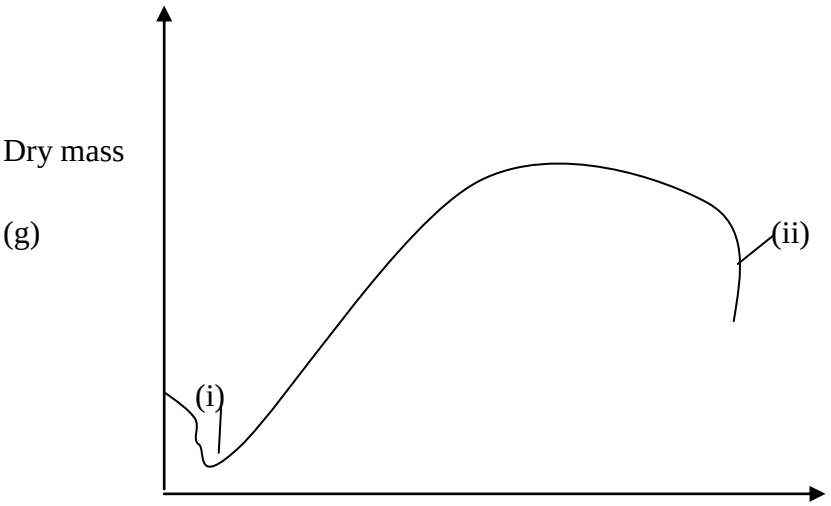
MODIFICATION OF THE SIGMOID CURVE.

While the sigmoid curve forms the basis of most growth curve it may be modified certain circumstances e.g.

(a) In humans: There are 2 phases of rapid growth: one during the early years of life(infancy) and the other during adolescence. In between the two phases, there is period of relatively slow growth .The growth curve resembles two sigmoid curves, oneoh top of the other



(b) In annual plants (If mass is used).With other parameter. It is truly sigmoid.



The growth curve is typically sigmoid expect that there is an initial increase during the early stages of germination (i) This is due to respiration of stored food reserves in order to produce roots and leaves . Once the leaves begin to photosynthesis, growth proceeds in sigmoid fashion.

At majority, there is a final decrease in weight due to dispersal of seeds and fruits.

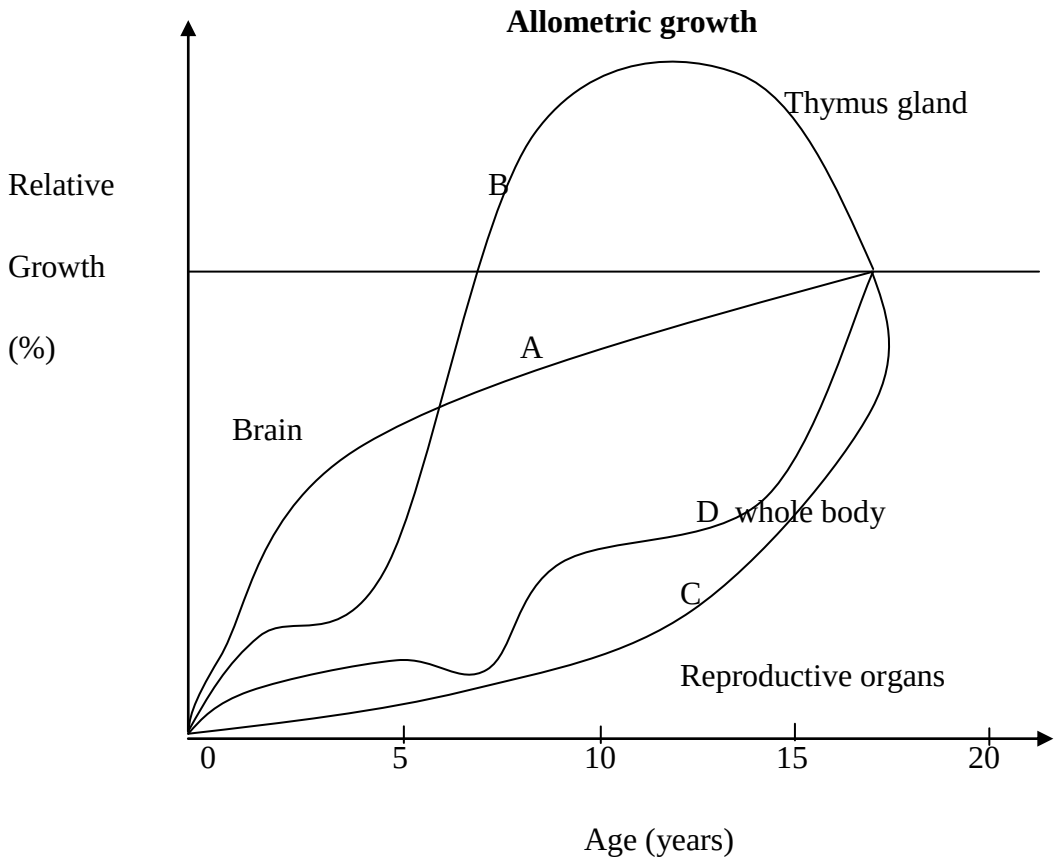
PATTERNS OF GROWTH.

Isomeric and allometric growth.

Isometric growth occurs when an organ grows at the same mean rate as the body. Change in mass of the organ is not accompanist by a change in shape or external form e.g. leaves of plants, in fish, locusts (with exception of…….)

Allometric growth occurs when an organ grow at a different rate from the rest of the body. A change in size is accompanied by a change in shape of the organ. It is a characteristic of mammals. It illustrates relationship between growth and developments. F In all animals (mammals inclusive) the last organs to develop and differentiate are the reproductive organs. In man lymph tissue is usually the first to develop. Why?

Relative growth rates of the brain, thymus gland and rep.organs of humans.



Account for the different growth rates.

Thymph tissue (thymus gland) which produces white blood cells to fight infection grows rapidly in early life (infancy) when the risk of diseases …… as immunity has not yet been acquired. By adult life, rel. growth declines.

The reproductive organs grow very slowly in early life but develop rapidly at puberty.

The brain grows very rapidly in infancy and rate declines by ten years. It's the first to attain maximum size.

Brain responsible for the most process of life e.g. irritability, walking, co-ordination.

LIMITED AND UNLIMITED GROWTH

The duration of growth in plants and animals shows two basis patterns.

(a) Limited (definite or determine) growth. This is illustrated by growth in annual plants and their parts e.g. leaves After the plant matures and reproduces, growth remains constant and then followed by a period of negative (senescence) before the death of the plant.(as shown by annual plants)

Several plant organs show limited growth e.g. fruits, seeds, internodes, dicot leaves, etc

N.B doesn't undergo a period of negative growth. some animals show limited growth e.g. birds, mammals, insects.

(b) Unlimited growth :(Indefinite, Indeterminate)

Some organs grow continuously throughout their lives. Their growth curve never flattens out. Eg woody perennial plants, their growth curve is accumulative series of sigmoid curve each of …….. re /

1`presents one year's growth (i.e. growing season) other examples are fungi, algae (lower plants) invertebrates fish, reptiles e.g. tortoise, monocot leaves, corals, sponges. Perennials add to their mass or weight during each growing season.

QUESTIONS

Plant species A and B grow naturally in different habitants. In an expt the exchange of carbon dioxide between the atmosphere and species A and B was determined over a range of light intensities from darknesses to the equivalent of mean …… sunlight. A constant dioxide absorbed or released was determined by measuring the carbon dioxide canon in a stream of air before and after it had passed over the plants. The data obtained are given below.

Light intensity % mean noon sunlight	**Net CO2 absorption arbitrary units**	
	Species A	**Species B**
0	-0.1	-0.8
10	+3.0	+0.5
20	+5.3	+2.5
30	+6.5	+7.0
40	+6.6	+9.3
50	+6.7	+11.5
60	+6.8	+13.2
70	+7.0	+15.0
80	+6.5	+17.0
90	+6.8	+18.0
100	+6.7	+19.0

(a) Plot these data on a single set of axes {5}

(b) Discuss the extent to which species A and B might be able to grow in the same habitant{4}

(c) (i)What is meant by the team compensation point? {1}

(ii) Clearly indicate on your graph the compensation point for species B {1]

(d) What is meant by the term 'limiting factor' ?{1}

(e) From your knowledge of photosynthetic path ways, explain precisely how and named factor can be limited in photosynthesis {6}

(f) Distinguish between C3 and C4 plants {2]

13(a) Draw a well labeled diagram of a chloroplast as seen with the election microscope. Show clearly, on the diagram where the chlorophyll is found within the chloroplast {7]

(b)(i) Name the metallic element that occurs in chlorophyll a and b

(ii) Name two other pigments that occur in association with chlorophyll a and b in higher plants {2}

©Give 2 advantages of chlorophyll occurring in chloroplasts rather than being diffuse in the cytoplasm {2}

(d)Explain briefly how you would demonstrate the presence of the photosynthetic pigments in plant material {4]

QUSTIONS

What are?

(a) Explain what each of the following means:
    (i) High Hybrid Vigor (ii) Pure breeding (iii) Lethal gene
(b) Give an account of Johannes's expts and explain their relevance to understanding of in heritage

2(a) Compare the skeletal system of mammals, herbaceous plants and trees to show how:

(I)The organ is supported (ii) growth occurs (iii) the type of skeleton is adapted to the way of life of the organ

3(a) what do you understand by the term evolution?

(b)Name the b/d pigments which have been used as evidence for evolution

(c)Outline the process of the theory of evolution?

4 (a) Define the term homeostasis?

(c) How is blood sugar regulated in mammal
(d) What would be the object of defective …… of largerhans?

5(a) Discuss the principle involvement of hormones in the lifecycle of a flowering plants under the following heading

(I)Dormancy (ii) Growth (iii) Response to stimuli (iv) fruit formation

(b) Explain how hormones are involved in photoperiodic behavior in plants

© Discuss the different kinds of photoperiodic behavior in animals

6(a) Explain how the mammalian kidney eliminates metabolic waste productions from the body.

(b)Discuss how the different terrestrial mammals conserve water.

7(a) Define evolution

(b) Variation can be due to continued or genetic factors. Describe how both factors can contribute to speciation and evolution.

(c) How has man applied the knowledge of variation and evolution to his benefit?

(d) Using well illustrated diagrams explain how meiosis brings about genetic variation.

(e) State the significance of this variation.

8(a) Describe the structure of the skeletal muscle

(c) Describe the sequence of events involved in the stimulation and contraction of the skeletal muscle fibre.

(d) What are the function of muscle

9(a) what do you understand by the following terms

(i) Sex linkage

(ii) Mutation

(iii) Polyploidy

(iv) Crossing over

(v) Industrial melanism

(b) Mutations are normally harmful when they are in the homozygous necessitate condition and yet they sometimes do most disappear from a populations in few generation, why is this so?

10 (a) what is the biological significance of homeostasis

b) With examples, state the major homeostatic processes of heir functioning in animals.

11(a) Explain the term organic evolution

b) Differentiate between each pan of these concepts

i) Genes / Alleles frequency and genal typical frequency

ii) Genetic pool and genetic equilibrium

iii) Natural selection and demonstration

c) Give four specific examples that demonstrate that evolution I still taking place.

d) State Damon's theory of evolution and use it to account for any two of the galapages islands fauna.

12 (a) Explain the term pollution

b) How is the water hyacinth adapted to it's made of life

c) Outline the ecological effects of water hyacinth on animals and plant life in aquatic habitants.

d) Suggest ways of eradicating water hyacinth giving possible adv. and disadva.

(e)Discuss the sliding filament hypothesis in muscular mov't

13. With the help of examples, example how points survive condn of waterstress.

14(a) Distinguish between lamarlasm and dalumish

(b.To what extent can the embryonic dev;t of man be regarded as an example of ontogeny y recapitulate phylogeny.

©Give 4 example demonstrating that evolution is still taking place to the present time

15. Yeast is a unicellular fungus. The table below shows the no of yeast cells counted thru a microscope after several hours of establishment of a yeast culture.

Hours	0	4	8	12	16	20	24	28	32	36	40	44	46
No of yeast cells	2	5	18	15	29	52	86	116	134	142	143	142	130

Assuming divides by binary fission once every 4 hrs construct a table similar to that above to show the theoretically popn curve over period of 36 hrs starting with one cell at zero hrs.

(b)Draw graphs on a single set of axes to show the actual detain the table above and the theoretic data in your table.

© Compare the actual and theoretical growth curves up to 36 hrs. Explain the difference between them

(d)How do you explain the slope of the actual growth curve after 36 hrs?

(e)Predict and draw the growth curve for the following;

(I)A bacterial pon in a fixed nutrient medium.

(ii)The human population if no birth control measures are taken.

16(a) with an example in each case distinguish between homologous and analogous organs.

(b)What is meant by pent dactyl limb system?

©How has this system been modified in the following animals to suit their function

(I)Monkey (ii) Rat

(d) What is the evolution significant of these modified organs?

17(a) Describe four theories to describe the origin of life

(b)How does Darwin's theory explain the mechanism of evolution?

18(a) what is meant by (I) analogous structure (ii) Homologous structure (iii) Vestigial structure.

(b) Give example f each

(c) How can these structures be used as evidence of the process of organic evolution

(d) Outline the theories for the origin of life

(e) Define the terms (I)Converged evolution (ii) Genetics load (iii) Founder effect (iv) Reproductive isolation

20 (a) Giving an example in each case, name 3 types of involuntary responses in animals

(b) What is the ecological value to an animal of the following?

(I) Insight learning (ii) Territorial behavior (iii) Associative behavior

21. Describe how the human ear functions as an organ of balance

(a)How are excretion and osmoregulation carried out in the amoeba?

(b)Suggest why plants do not require excretory organs

22. Distinguish btn tropism and nastic movement

(b)Compare the actions of auxins and gibberellins in higher plants

23(a) Explain the following process involved in the transmission of impulse along a neuron.

(i) The formation of arresting potential

(ii) The formation and transmission of an action potential.

(b) How do retina cells traduce light energy into nerve impulse?

24(a) what is the correct order of structure thru which light passes before striking the retina in a mammalian eye?

(b)Explain why ;(I)Retinal convergence increases the sensitivity of the eye?

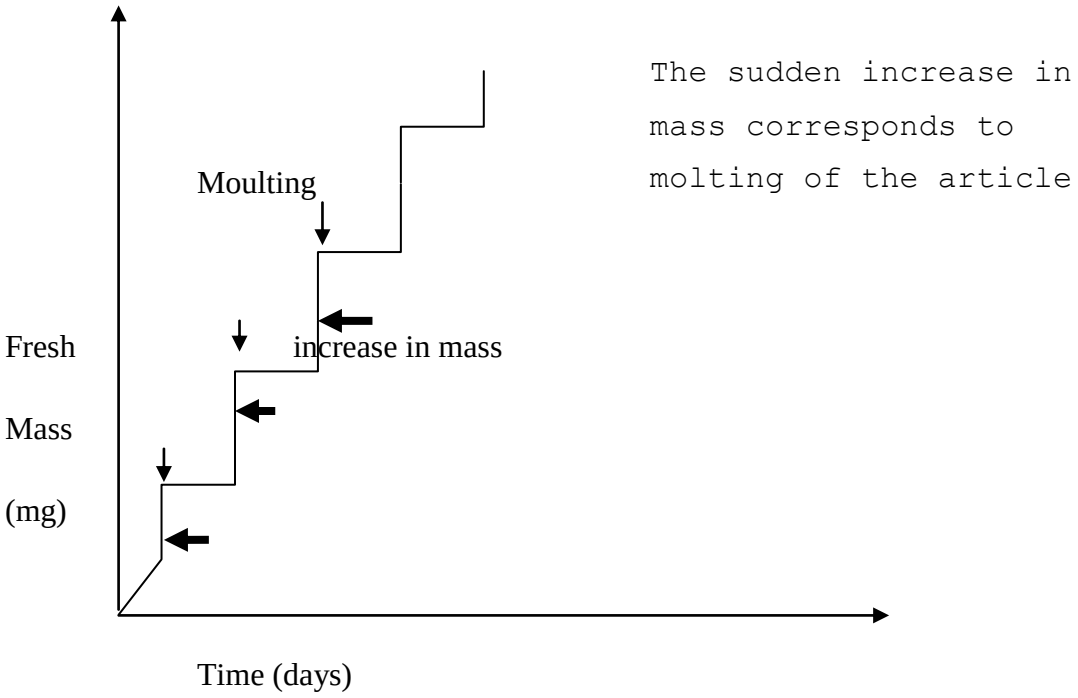
(ii) While trying to see an object clearly at night, it is best not look directly at it, but rather slightly to one side.

GROWTH IN ARTHROPODS

e.g Crustacea, insects

They show intemintent growth. The hard inflexible exoskeleton interferes with smooth growth rate. As consequences, arthropods must move periodically during growth. They appear to growth in spurts discontinuous growth.

Before a new exoskeleton has fully hardened, it is capable of some expansion. Rapid expansion is achieved by the insect by swallowing air or water. Distension of the gut pushes the soft intermittent outwards. The new cuticle then hardens there is still some room for growth. Measuring flesh weight gives the intermittent growth curve (discontinuous).



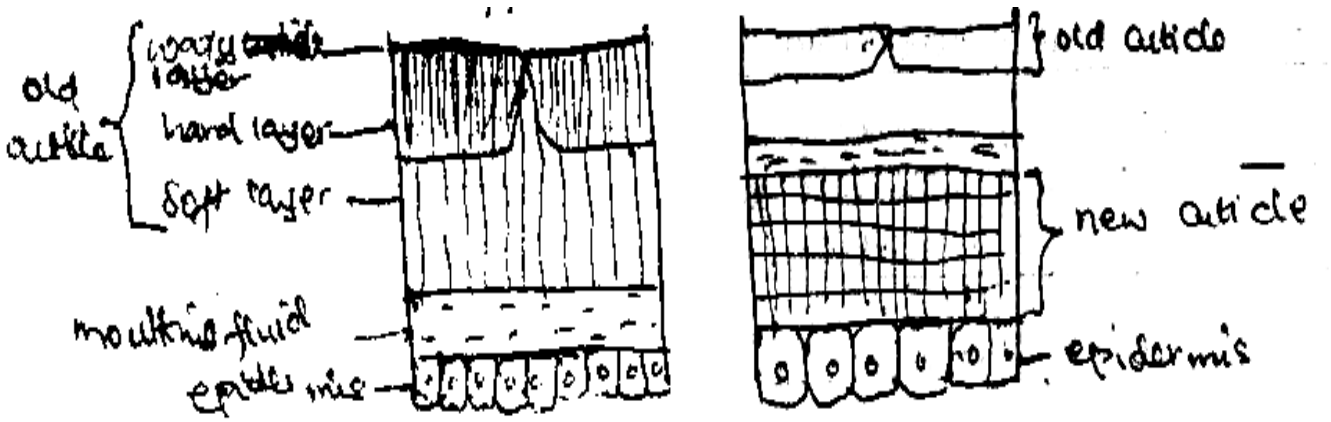
Moulting (ecadysis) takes place by secretion of molting fluid immediately beneath the old cuticle. It dissolves the soft inner part of the cuticle leaving only the hand outer part.

A new cuticle is secreted by the epidermis. The new cuticle is protected from the enzyme action of the moulting fluid by its protective surface. The cuticle is composed of chitiri. It is hardened by deposition of hardened proteins. It is made water proof by deposition of athim layer of the surface.

Vertical section of insects cuticle to show stages in the moulting process

Vertical section of insects cuticle to show stages in the moulting process

A **B**



N.B: if a growth curve is plothed for the same insect (large sample are drawn from a uniform population

Using dry mass, a normal sigmoid curve is obtained. It shows that true growth is not interrupted by ecadysis (moulting). It demonstrates that true growth as represented by increase in protoplasm is continuous.

Fresh weight shows – discontinuous pattern

Dry weight is continuous patterns

FACTORS AFFECTING GROWTH IN PLANTS AND ANIMALS

Environmental factors

1. Nutrient availability

   Deficiency of one or more nutrients in any organism may result in cessation by growth even death of the organism. Living organism need nutrients and energy from which to obtain the necessary materials for growth. Green products are able to manufacture their

own food but depend on mineral supply from the soil. Other organisms obtain nutrients by feeding heterophrophically.

2. **Accumulation of excretions**

   Presence of excretions may inhibit growth because they are toxic. However, most PHs and animals can convert these substances to less toxic excretions.

   N.B: Yeast a bacteria (micro organisms) are affected by accumulation of alcohol resulting from fermentation and decay process.

3. **Temperature**

   When temperature rises from a minimum value at which no growth occurs up to optimum values for the organism, growth it accelerated. It is retanded by temperatures beyond optimum. This is partly due to the effect on the enzyme controlled rxus of metabolism.

4. **Light**

   Animals, most fungi and bacteria can grow in the dark but green pits depend on light to build new tissues.

5. **PH**

   Micro organs and lower animals are affected most by PH and will only show fast growth in a given range of PH. The aquatic habitat, growth may cease if PH is altered beyond certain limits. PH changes in soil affect the growth and functioning of plant roots e.g mineral salts, absorption.

   6otehrs CO_2, O_2, water, mineral salts availability.

INTERNAL FACTORS

Hormones

In higher animals, hormones e.g growth hormone, thyroxime are essential for the control of growth. In insects, it is the moulting hormone.

In plants, auxms and other growth substances control growth mainly from their effect on cell expansion.

Genetic factors (hemeditary)

Other factors being favourable, the final size an organism attains and HS characteristics are controlled by the genes it contains.

GROWTH AND DEVELOPMENT IN FLOWERING PLANTS

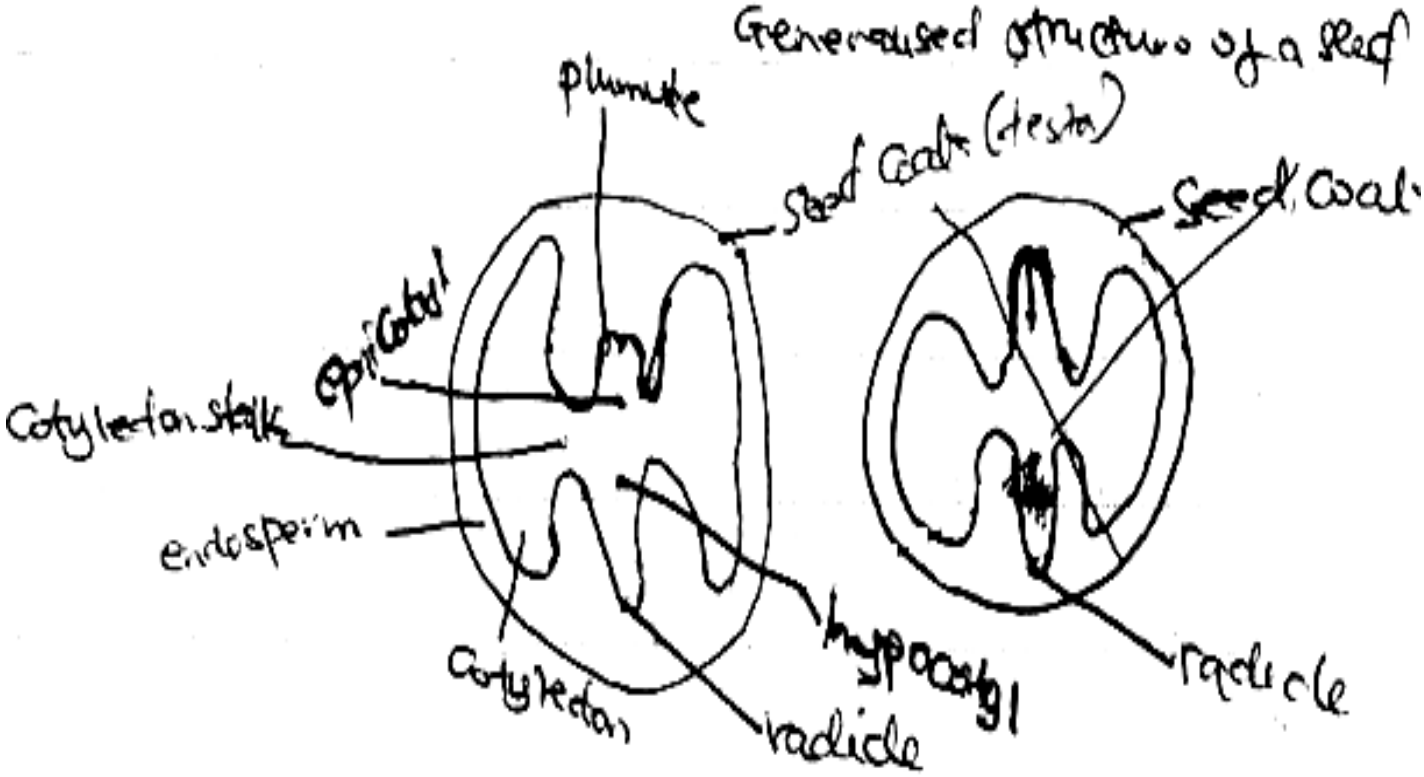
Seed structure

The seed develops from a fertilized ovule. It contains an embryonic plant together with its food store. The embryo consist of an embryonic shoot the plumule, an embryonic root the radical and one or two seed leaves / cotyledons. The base of the plumule is the epicotyls. It is above the attachment of cotyledons. The base of the radical is the hypecotyl. The food store is either the cotyledons or the endosperm.

With endosperm e.g maize, rice, barley, e.t.c.

The seed is enclosed and protected by the testa.

DRAW MONOCOT AND DICOT SEED P.G 423 RBTS.



GERMINATION

Growth of a seedling from the embryo of a seed, usually after a period of dormancy. Growth of seed embryo into seedling.

TYPES OF GERMINATION

Hypogeal

It takes place by elongation of the epicotyls base of the plumula. The plumula is thrust upwards out of the soil, leaving the cotyledons below the ground. Seeds germinating this way have much stored in the cotyledons.

Advantage

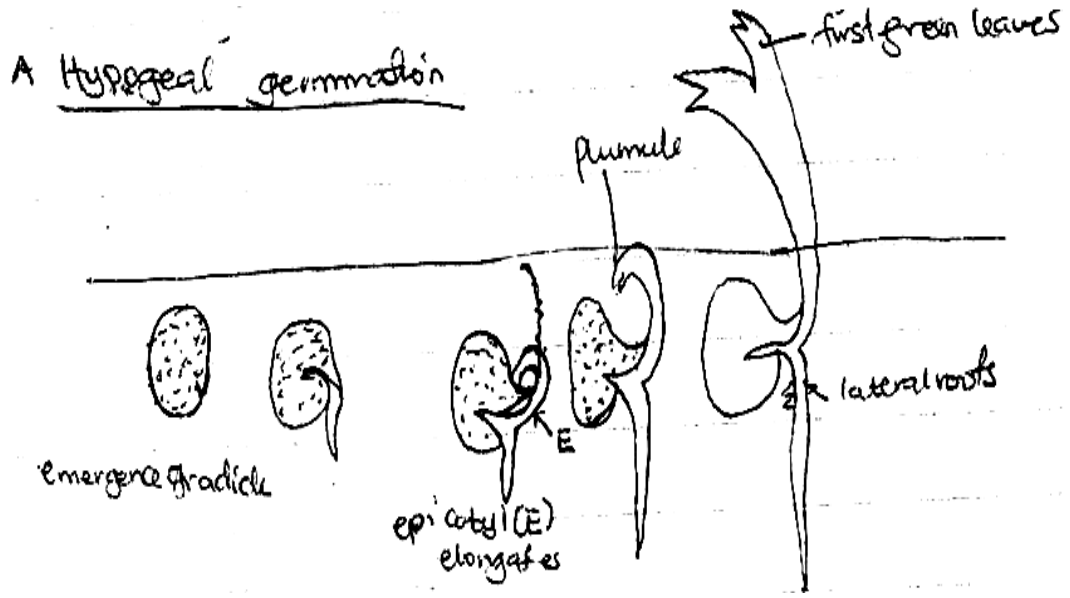
This provides the growing embryo which nourishment until the first leaves develop.

Epigeal

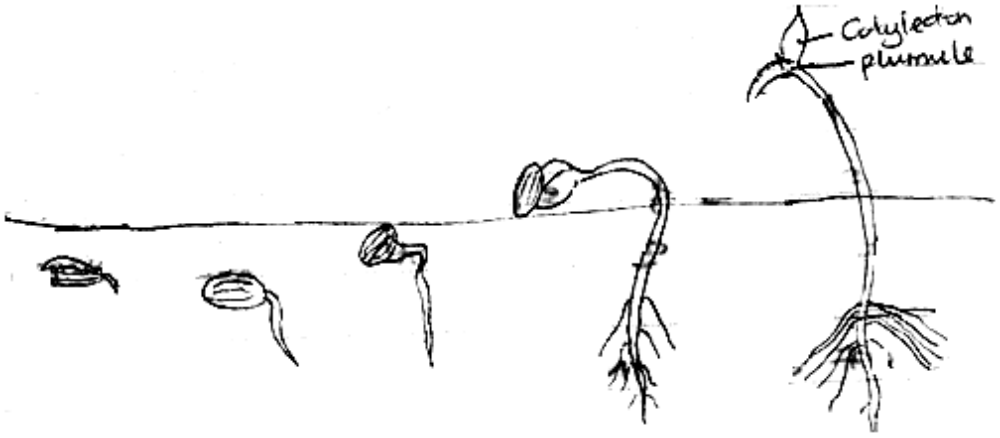
The hypogeal elongates faster such that the plumule and cotyledon are thrust out of the soil. Such seeds have small cotyledons; once exposed to light, the cotyledons develop chlorophyll and begin to photosynthesize.

NB:

Radical forms the primary root and plumule the primary shoot.



Hypogeal germination



Hypogeal (CH) elongates

External (Environmental) conditions necessary for germination

1. **Water:** the initial uptake of water by a seed is by a process called inhibition (i.e attraction between water molecules, and hydrophilic colloids e.g proteins, starch, cell wall materials). The swellings of these materials leads to strong forces of inhibition i.e builds up a hydrastatic pressure. Water enters the seed through the micropyle. It then moves from cell to cell by osmosis.

   During germination, water is required for:

- swelling of seed raptures i.e testa allowing plumule to radical to emerge.
- Activation of the enzymes which control metabolic reaction e.g hydrolysis of stored complex food with simple soluble form needed for germination.
- Acts as the medium of transport of the dissolved food from the storage tissues to growing points of the embryo (radical plumule).
- Vaculation of the cells.

2. Oxygen: This is required for respiration to provide energy. Syrthosis of new cellular material at the plumule and radical require energy which is produced most efficiently on presence of O_2.

   NB- Some seeds have impermeable testa and ca respire enactrobically.

- The respiratory quotient RQ at varleous stages of germination gives an indication of the type of substance oxidized and whether it is anaerobic or aerobic respiration.

3. Suitable temperature: each product has an optimum temperature at which its seeds germinate most. If other factors are favorable metabolic changes which take place in germination are catalysed by enzymes. Temperature affects enzyme activity. The optimum temperature range is recased to the natural / normal environment of the plant.

   N.B: Seeds of some plants e.g apples only germinate if they have been exposed to periods of low temperature after water absorption (between 0 – 5t) for a few days.

   Seeds need a period of drilling to reduce the level of abscisic acid a growth inhibitor and produce gibberellins (growth promoters)

   Chilling reduces the abscusic acid content of the seed coat and enables it to make giberrelic acid.

   In nature, winter provides the chilling requirement.

4. Lights: Some seeds can only germinate if exposed to light. They are positive photoblastic seeds. The time of exposure varies from seconds to days. Light is only effective after H2O absorption germination of some seeds is inhibited by light. They are negative photoblastic seeds and many light dependent seeds tend to be small in size germinate on soil surface. Neutral seeds are not affected by light or darkness.

5. Micro soil organisms e.g fungi and bacteria. They may cause seed mortality. Some promote germination by breaking dominancy that may be caused by a hard seed coat. They eat it a way making it permeable to air and H_2O.

Internal factors

- **Viability of the seed**
  Only a viable seed will germinate even if all condrisave favourable.

- Bio deterioration of seeds in storage: if mostly seeds are stored in bulk at room temperature, they may star fecto germinate.
- As food reserves are respired, waste heat is produced. It accumulate and causes temperature to rise. Enzymes are denatured and embryo dies self heating.

This affects germination since their food store is lost is embryo dies cell proteins are denatured.

PHYSIOLOGY OF GERMINATION

Germination starts with a rapid uptake of water by the seed through micopyle and testa. The initial absorption is by inhibition (attraction) between hydraphillic colloids in seed and the H_20 molecules in the tissues in solution increases H2O moves from cell to cell by Osmosis. It is also taken up by Osmosis. The resulting swelling of the seed reptures the testa and the radical emerges then later the plumule. The absorbed H20 has the following uses:-

- It activates enzymes necessary for biochemical reaction of germination.
- It allows hydrolysis of stored food to soluble materials e.g carbohydrates to glucose, proteins to amino acids e.t.c.
- It allows the soluble products to be adopted to the growing products of the embryo.
- Water is essential for vacuolation of growing cells.

Glucose and fatty acids provide respiratory substrates from which energy is released. Glucose is also used to form new enzymes and structural proteins in the new cells. Food mobilization leads to increase in dry mass of seed and an increase in the embryo tissue.

Read about mobilization of food reserves in barley (a monocot)

Pg 441, Clegg 442 Simpkins

Study Graphs 765 Bsc

SEED DORMANCY

It is a state in which growth and development cease and metabolic rate feeds to a minimum, only sufficient to keep cells and alive though the seed is viable, it will not germinate, even when all conditions are favourable.

CAUSES OF SEED DORMANCY (and how they are broken)

1. Immaturity of embryo (causes primary dormancy). The seed may mature but the embryo is either dormant or just immature. Such a seed is unable to synthesize globerellic acid (GA), a growth promoter. This implies that hydrolytic enzymes needed to hydrolyse food reserves are not produced.

   Dominancy is broken by allowing the embryo time to maturity i.e give a period of after ripening.

   A growth promoter such as GA can be applied o activate embryo.

2. **Hard and impermeable testa. (2^o dormancy)**

   Some seeds have hard seed coats which are impermeable to H2O or air and may prevent emerging of the embryo.

   Dormancy may be broken by:-

- Microbial attack by fungi and bacteria in the soil.
- Cracking due to exposure to alternate heat and cold
- Artificial means such as removing the testa, dissolving testa in alcohol or sulphuric acid, as seeds pass through machines (harvesters) during harvest, e.t.c. passing through the gut of animals, physical damage to the testa (scarification); action of fire

3. **Lack of light**

   Some seeds require light of particular wave length before they can germinate.

   It is broken by providing required wavelength. It is phytochrome controlled reaction associated with risk in gibberellic level in the seed.

4. **Temperature:**

   Some seeds require a period of cold treatment (preaching / cereals, rose family (Rosacea) such as apple, plant. This period is associated which rise in gibberellic acid level or reduction of growth inhibitors e.g abscisic acid.

   Dormancy broken by cold treatment / prechilling / stratification.

5. **Presence of germination inhibitors**

   Many fruits or seeds contain chemical growth inhibitors which prevent germination e.g abscisic acid in tomatoes and pawpaws. Such seed cannot germinate until remove from the fruit.

   Dormancy may be broken by.

   Soaking the seeds in H2O (reduces canon of inhibitors)

   Treatment with germination promotes e.g gibberellic acid.

USES OF DORMANCY

- It allows a seed to germinate only during favourable conditions i.e is a means of surviving unfavourable conditions e.g temperature seeds in autumn may delay germination until the following spring.
- Gives the seed greater chance to be dispersed away from parent plant.
- Allows seeds to germinate only when embryo is mature.
- Enables seeds to remain viable for a long time. Thios is important in preservation and storage of seeds by man.
- Prevents seeds from germinating inside the fruits.

GROWTH OF THE PRIMARY PLANT

MERISTEMS

Growth in PHs is confided to certain regions casted meristems.

A meristem is a group of cell which retains the ability to divide mitotically producing cells which grow and form the rest of the plant body.

There are 3 types of meristems.

A. Apical meristems

Found at root and shoot apex (trips of roots and shoots). They are responsible for 1o growth of the PH and lead to the increase in its length.

B. Lateral meristem (the carribium)

Laterally situated in old parts of the PH i.e form a cylinder towards the outside of roots and stems e.g the cord carribium (phellagen) and vascular carribium. They are responsible for 2o growth leading to increase in girth (thickness of the stem).

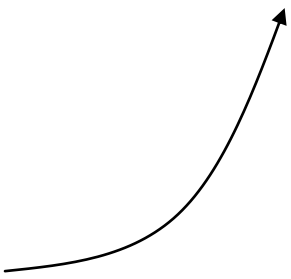
C. Intercalont meristems

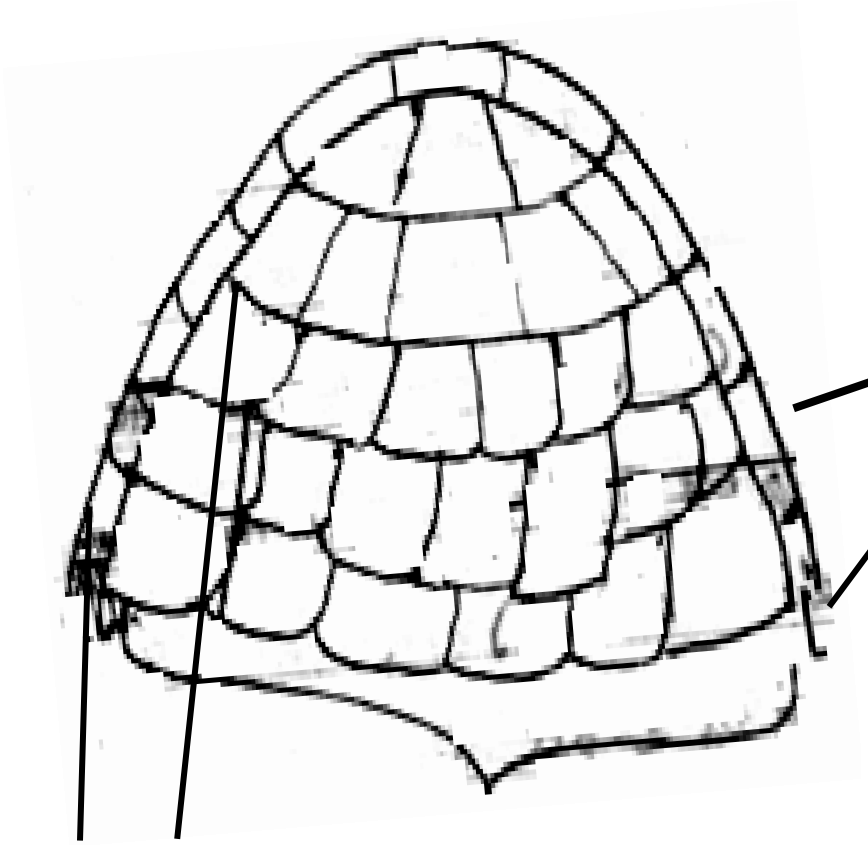
Found at modes of monocotyledonous plants. They allow growth to occur in regions other than the tips. This is useful as the tips are susceptible to destruction e.g by herbivores.

A typical meristematic cell has a simple structure. (it is undifferentiated which thin cellulose cell wall and dense cytoplasm.) The cells are constantly dividing which means that there is much metabolic activity and thus the nucleus is large and cytoplasmdense. Cells are packed tightly together which no air space in between. The cells have few small vacuoles. The cells are called initials.

PRIMARY GROWTH IN THE SHOOT

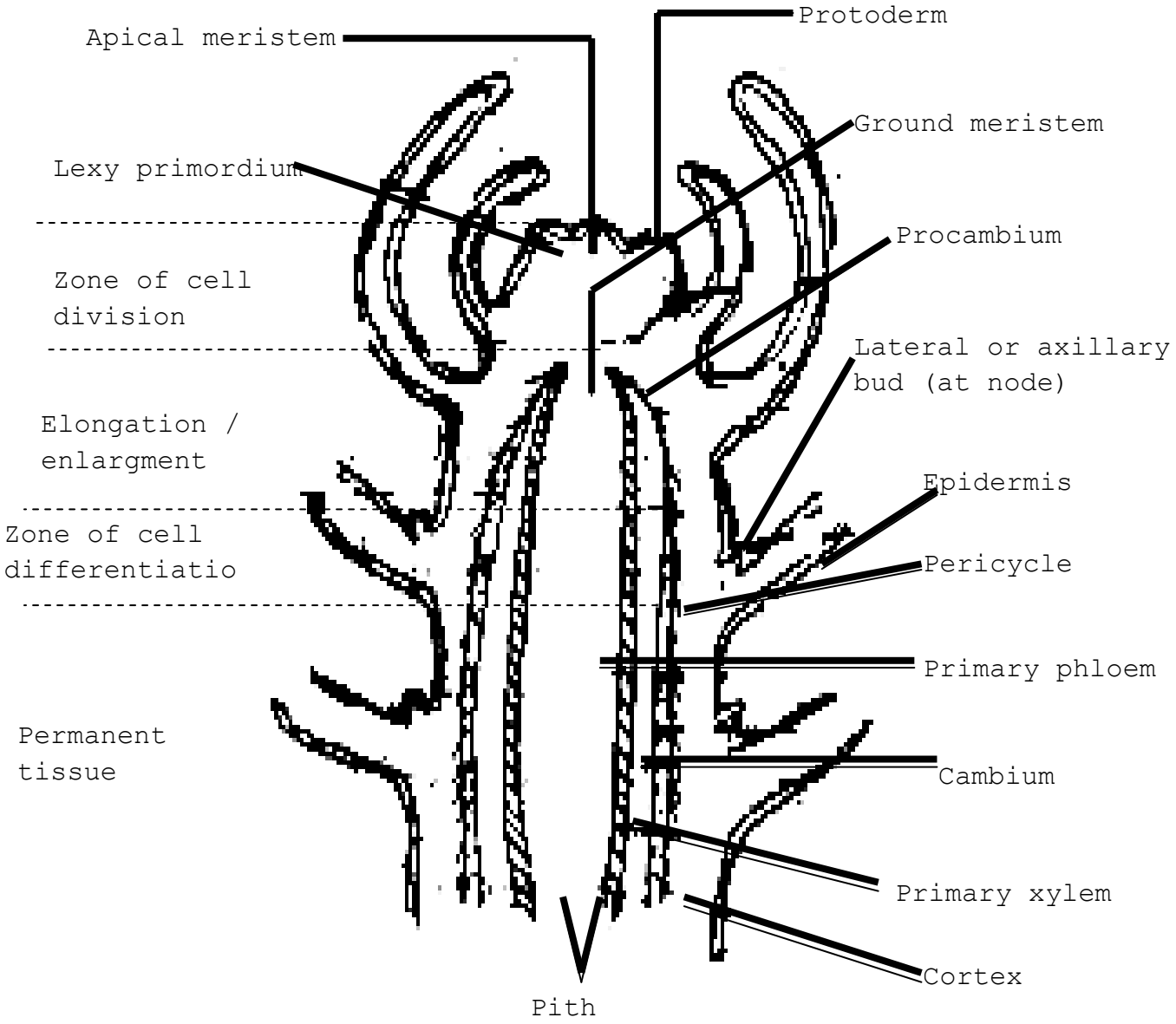
Primary growth is the first growth to take place in a PH and mainly leads to increase in length. (cell division of apical menstem of at the apex of the stem (shoot tip), there is a zone of cell division. It is a composed of an outer layer called tunica (coat) which consists of neatly arranged cells. Beneath the tunica, the cells are less organized charphocandy arranged. This region is the corpus (body) of meristem





Cell division of the tunica results on growth of the epidermis while that in the corpus results in growth of the internal tissues. Tunica cells only divide in place A. in the corpus, cell division in place B lengthens the apex where as divisions in plane C broaden it. Other cells differentiate into procabium (procambial strands) and retain ability to divide.

SHOOT TIP OF A DICOT STEM



Divisions of the menytomotic cells (initials) in the apex produces 3 types of meristematic tissues.

Protoderm which gives rise to the epidemis.

Procambium which gives rise to the vascular tissues including the pericycle, proto phloem and protoxylem (1o xylem and puloem) and vascular cambium.

Ground meristem: gives rise to ground parendlyma tissue which in dicots are the contex and pith.

CELL ENLARGEMENT (expansion, elongation)

As new cells are formed of the meristem, the older cells are placed further back. They expand / elongate by osmotic uptake of water leading to form of vacuoles in the cytoplasm. Several small vacuoles are formed, these then coalesce (join) to form one layer sap vacuole.

Water flows into the vacuole by osmosis pushing the thin, elastical wall outwards thus the cell expands.

The 1o cell wall also grides and stretches. Growth is by breakdown of hemicelluloses, stretching of microfibrils, deposition of more cellulose hemicelluloses. The final shape of the cell is determined by the direction in which the cellulose microfibers are laid down.

As cell expansion is completed, the cells develop additional thickening of cellulose or ligrim depending on the tissue being formed increase in length is achieved by cell elongation.

DIFFERENTIATION

There is no sharp distinction between the zones of elongation of differentiation.

The cells begin to differentiate while still elongation / expanding.

The cells of the procambium differentiate into protoxylem to the inside and protophloem to the outer side. The protozylem has only annular and samal thickening of lignin on the trecheids. This allows for further extension of cells. Proxylem and protophloem later die and their function is taken over the xylem and phloem.

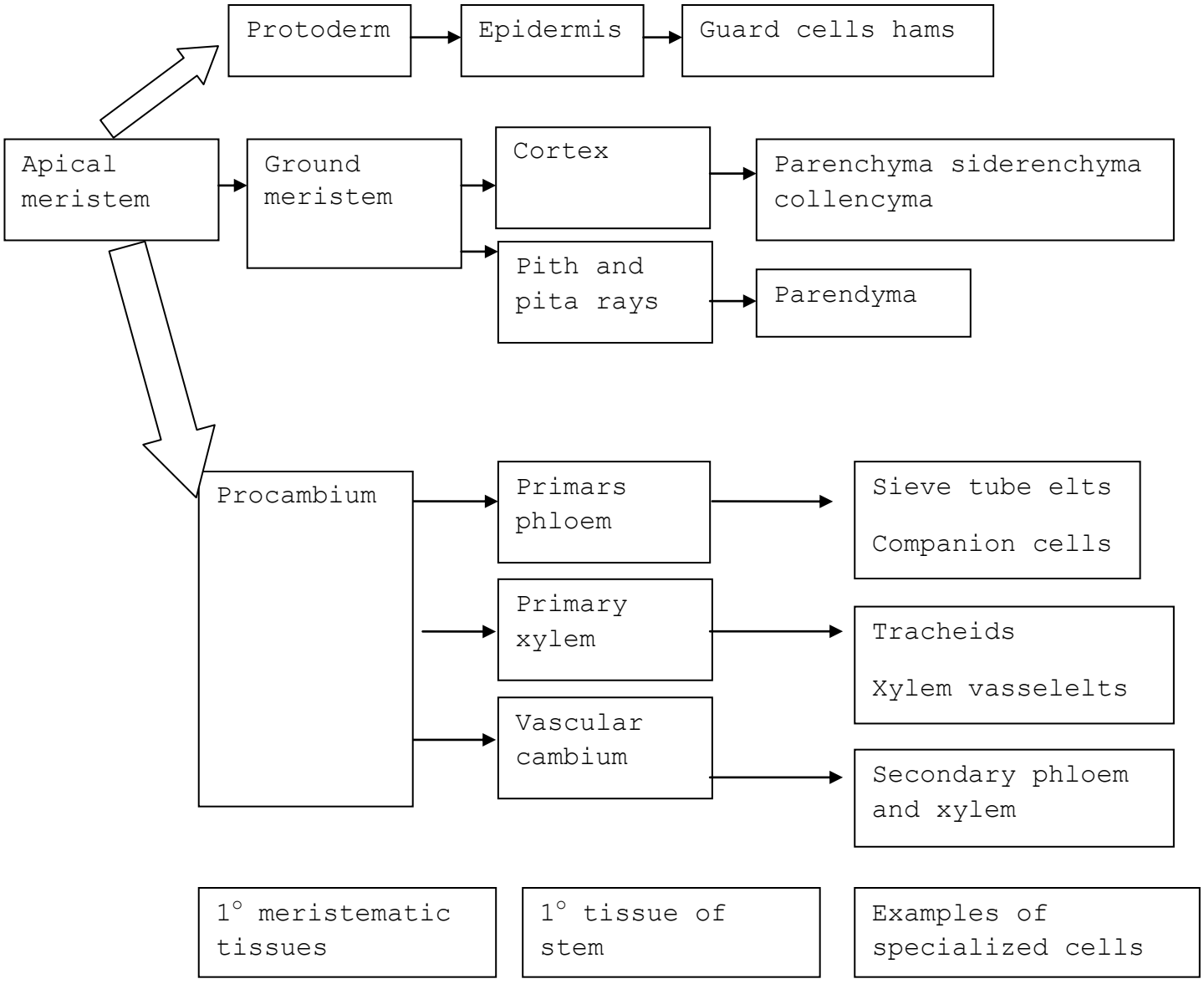
In the zone of differentiation, the procambium differentiates into xylm elements, phloem sieve tubes and comparispnm cells and sclerenchyma. Xylem acts and sclerendyma bimes lignyied. Between the xylem and phloem, some cells retame ability to divide and become the vascular cambium.

The apical meristem gives rise to leaf primedial which later develop into leaves. The leaf primordial group and enclose the apex forming the terminal / apical bud. The primordial protects the apical meristems. Axillary buds are formed in the angle between the leaves and m aristem.

They may form side exanches or flowers.

N.B: Side branches arise from cambium near the tip of the axillary buds. Their formation is exogenous.

ORIGIN OF PRIMARY TISSUES AND SPECIALIZED CELLS IN THE STEM



PRIMARY GROWTH OF THE ROOT

The epical meristem of the root is a mass of irregularly arranged cells which divide and cutoff new cells in cell directions.

At the centre of the apical meristem there is a region of cells known as the quiescent centre. It gives rise to the other meristemetic cells (initials) of the apex. The cells of this quiescent centre divide very slowly and appear to regulate root growth by limiting the number of initials (other meristematic cells that divide rapidly).

The apical meristems of the root gives rise to cells of the root cap (mass of undifferentiated cells) the root cap protects the apical meristem of the root and the cells are continuously replaced to replace those lost as the root pushes the soil. The cells develop gelatinous walls which lubricate the apex.

NB. Some roots have an additional layer of meristamatic cells which gives rise to the root cap. It is calyptrogens.

L.S OF APICAL MERISTEM OF THE ROOT TIP

There are three types of meristematic tissues in roots

Protoderm:- A single layer of cells which gives rise to the epidemis. In the zone of differentiation some epidermal cells become modified into roots hairs. Cells lack cuticle (why) water transport through absorption (osmosis).

Ground meristem:- It gives rise to a relatively thick layer the cortex.

It is made up of large parenchyma cells. The inner most cells of the cortex form the endordermis. It is a sylinder of cells surrounding the central vascular tissue. The lateral (radial) walls of the endodermis become thickened with sliberin forming the casparian strip.

The procambium gives rise to the central cylinder of mascular tissue (also referred to as the stele). Review T.S of root.

Cells of the procambium divide to give rise to the protoxylem on the inner side. The outer most procambial cells do not differentiate into phloem, and retain their ability to divide. They become the pericycle which later produces lateral roots.

LATERAL ROOT FORMATION

They arise some distance from the root apex. They originate from within the root tissue from the perecycle. Their formation is endogenous.

The pericycle cells divide by mitosis to form lateral root primodial (bulges). These force their way through the root cortex (helped by enzyme action) and emerge through the ruptured epidermis.

By this time, a procambial strand was differentiated in each lateral root. The vascular tissues of the lateral root become joined to that of the main root.

Qn: How is the structure of the primary stem related to its function?

SECONDARY GROWTH

Secondary growth is that growth which occur as a result of the activity of the lateral meristems (occurs after 1^{o} growth). It takes place in woody perrennlas (tress and shrubs). Does not occur in herbacerus annuals and biannuals.

It leads to increase in girth (diameter). Takes place in roots and stems. It results from the large amount of 2^{o} xylem (wood) formed and an external cort layer (bart).

Secondary growth is brought about by cell division of lateral meristems namely:- vascular cambium.

Cork cambium (phallegen).

THE VASCULAR CAMBIUM

The vascular cambium is at the first confined to the vascular bandles secondary growth commences when the parenchyma cells between the vascular bundles become meristematic. As a result the cambium in the vascular bundles is inter fascicular cambium.

There are two types of cells on the vascular cambium:- viz flusiform initials and ray initials.

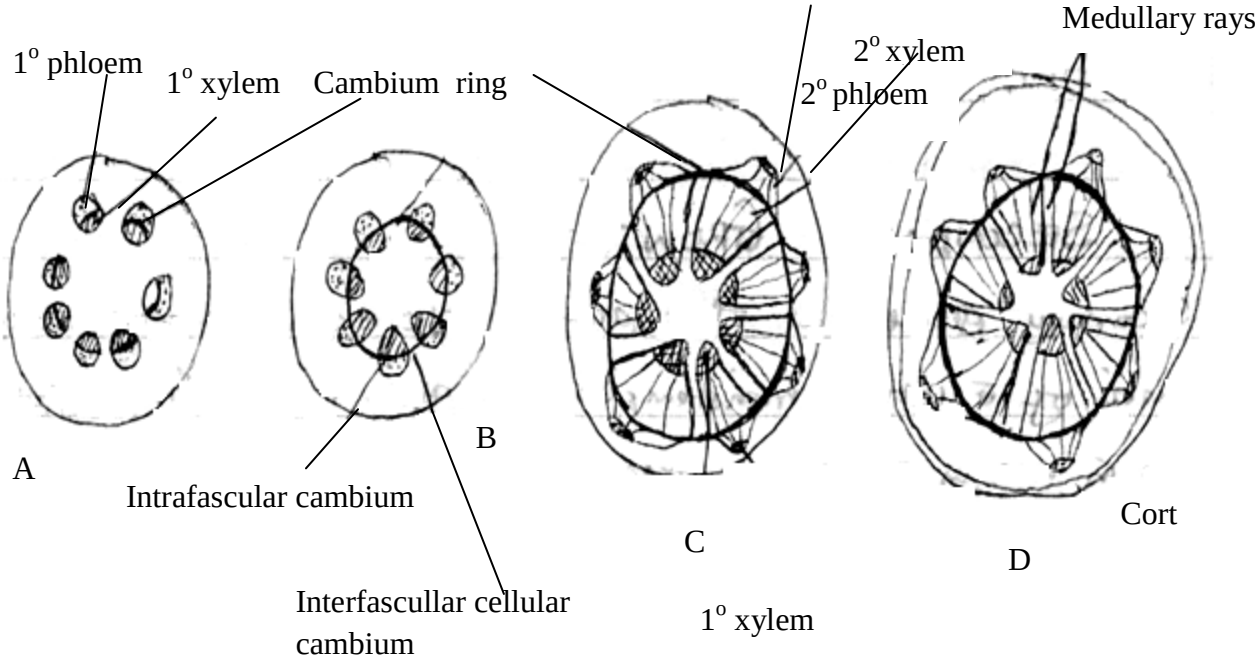
The fusiform initials divide by mitosis to form 2^o phloem to the outside and secondary xylem to the inside. In this way, a cylinder of 2^o xylem and 2^o phloem forms on either side of the cambium.

The amount of xylem produced normally exceeds the amount of phloem.

Meanwhile the ray initials have produced rays of parenchyma (medullary rays). Primary medullary rays run from the pith to the cortex, 2^o mrays do not.

The 2^o xylem develops thick lignified walls (various types of lignite cation.) and persis from year to year. The phloem cells are less rigid and the old ones get crushed out in time by the 2^o xylem.

A STEM



ROLE OF RAY INITIALS

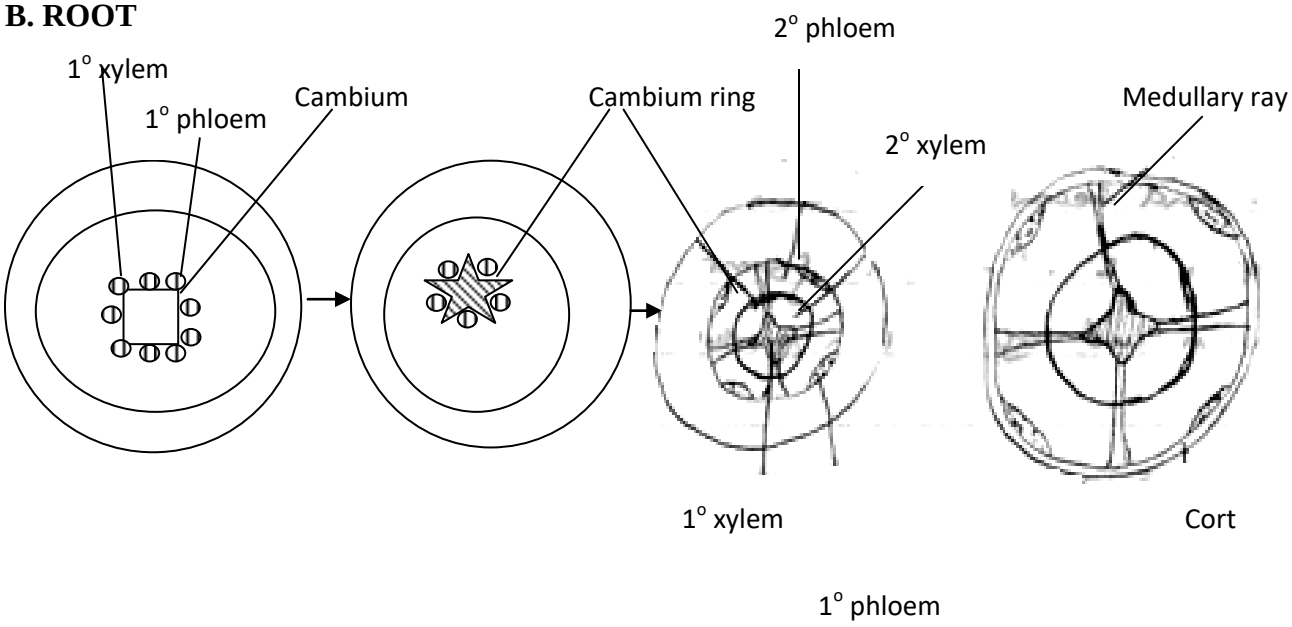
Give rise to medullary rays which connect the cortex and the pith.

The medullary rays

- They allow for horizontal transports of H2O, mineral salts and food substances in the thickened stem.
- Are for gaseous exchange by diffusion through the intercellular spaces.
- May be used for food storage especially during periods of dormancy.

Question. Outline differences between ray initials and fusion form initials

B. ROOT



2o growth in both a dicot stem and root. In both cases the cambium tissue (shown in dark throughout) forms a complete ring which proliferates internally to form 2^o xylem and externally 2^o phloem.

The vascular cambium is seasonal in its activity. It is dormant under unfavorable condition e.g drought, winter.

A cylinder of 2o xylem (annual ring) is added each year to the existing PH body. Xylem vessels produced early in the growing season are wide and thin walled. Those arising later (when conditions are less favourable). Are narrower and thick walled.

- The age of the tree can be estimated by counting the number of annual rings of 2^o xylem in a cross section of the main stem.
- Past climate can be studied using the nature of the annual rings i.e their width. (Ref Pg 464 Simpkins)

As a tree ages, the wood (2^o xylem) at the centres may become blocked with stored wastes e.g tamins. It ceases to serve a conducting function. It is called heart wood.

The outer wetter conducting xylem (wood) is called sap wood.

Question: What is the difference between proxylem and metaxylem?

1) Outline the changes that lead to formation of mature sieve tube and xylm vessels.
2) What is the significance of 2^o growth in plants?

Early stages in secondary thickening of stem.

Pg 770 Bs, 428 Rbts, 291 Toole.

The 2^o growth of roots is similar to that of stems. Vascular cambium develops from cells of the procambium which have remained meristem. It grows to form a complete ring.

Cells of the pericycle outside the xylem arm also become meristematid.

The cambium produces 2^o xylem to the inside and 2^o phloem externally. Growth of 2^o xylem starts earlier and is more rapid between arms of the xylem. The cambium thus becomes circular rather than wavy in outline. As growth continues, the increasing girth tears the endodermis, cortex and epidermis and these are sloughed off.

A cort cambium develop from the pericycle (beriearth the endochermis) and gives rise to the periderm.

NB. Development of the 2^{o} xylem and phloem, medullary rays and similar to that of stem.

THE CORK CAMBIUM (PHELLOGEN)

2o thickening (of stem or root) causes the epidermis to split. It is then replaced by bark (periderm). The periderm is a result of the activity of the cork cambium (phellogen).

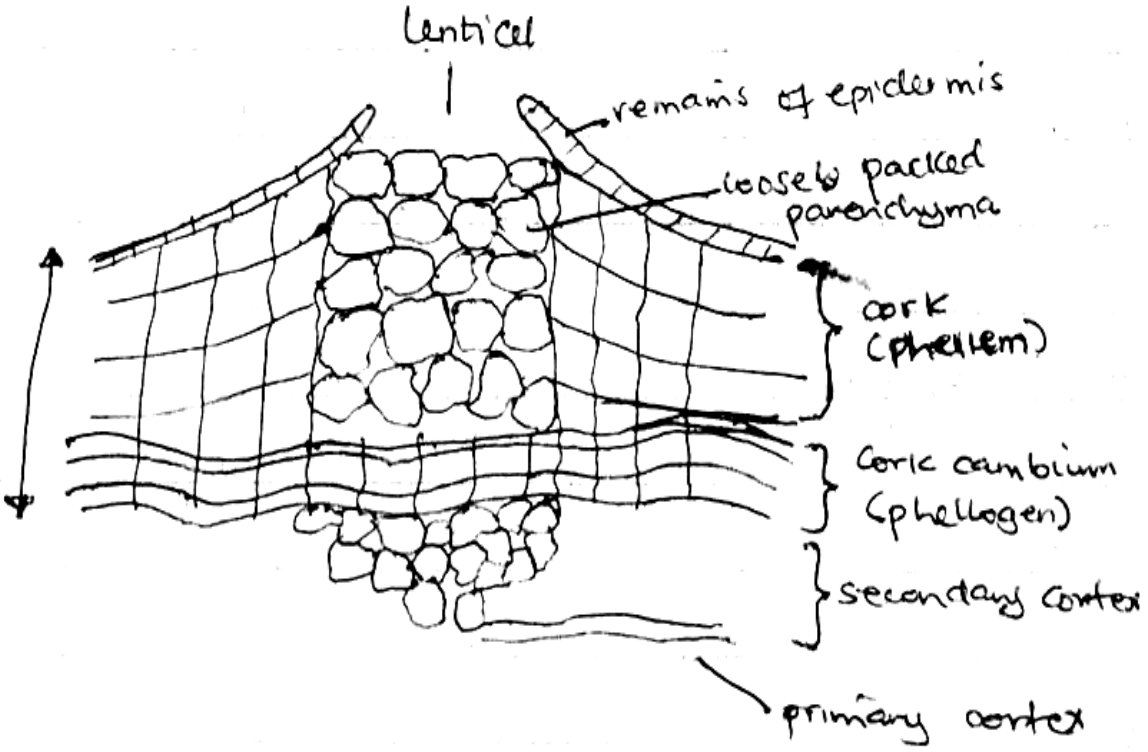
The cork cambium is formed by division of parenchyma cells become of epidermis. Mitotic divisions of the cork cambium give rise to cells of the inner side which form secondary corterx. Those to the outside form as layer of corky cells. The walls of these cells become impregnated with suberin which makes themampermable to water and respiratory gases. Their protoplast dies (they die). They form a water proof barrier which protects the inner tissues.

At random intervals the cork cells are loosely arranged forming lenticels for gaseous exchange between inner tissues and atmospheres.

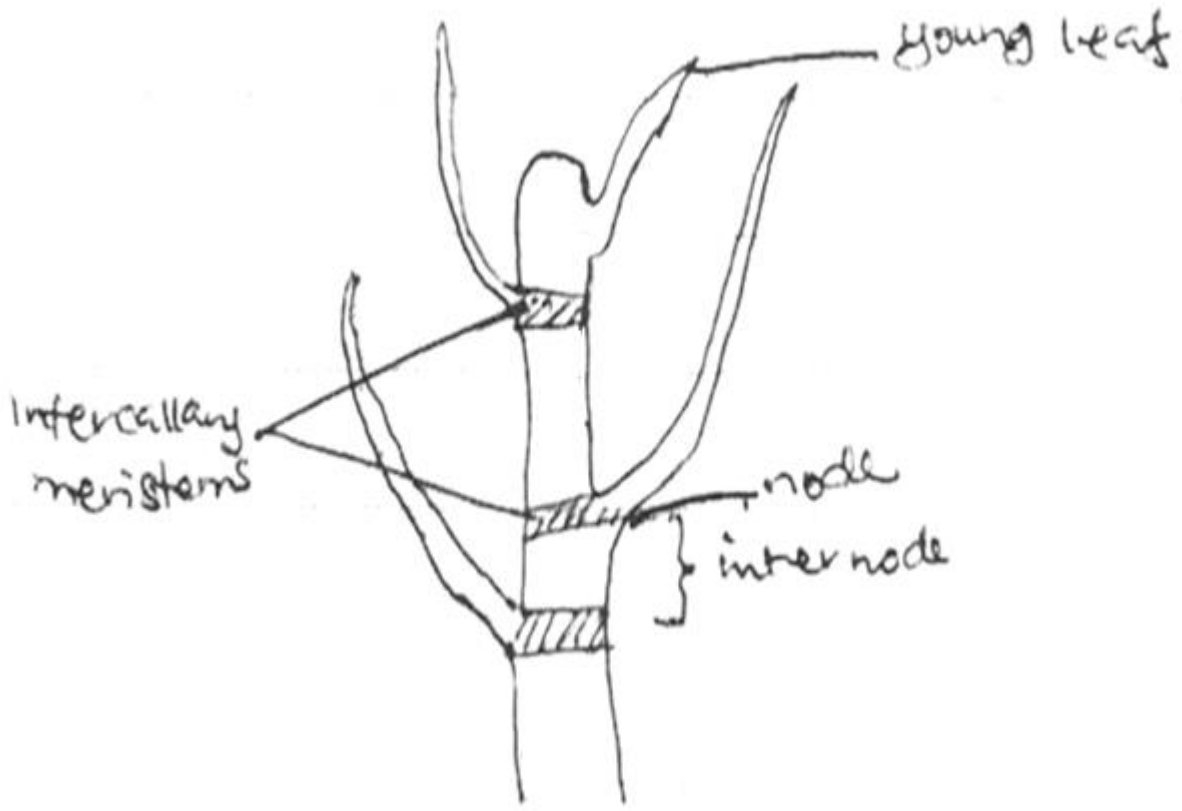
Cork cells at the lenticels are thin walled and lack suberim and are dead.

N.B: The cells immediately above the cambium layer are the youngest have cellulose walls are and alive. The ones near the surface are older, thickened with suberin and are dead.

VERTICAL SECTION OF A LENTICEL



NB: fens monocots undergo secondary growth. In grass family the tissues at the base of the intermodes remain. Meristematic form internallary meristem. It enables gross shoots to regulared rapidly after being out e.g by moving, grazing animals, destruch by fire e.t.c.



GROWTH AND DEVELOPMENT IN ANIMALS

Many multi cellular organisms develop from a fertilized egg (zygote). In the early stages of development an embryo is formed development at the embryo stage involves cell division, maturation and specialization of cells. In animals it also involves movement and repositioning of certain groups of cells.

- Cell division
- Maturation (expansion and elongation)
- Specialization (differentiation)
- Movement and repositioning of tissues (groups of cells)

DEVELOPMENT IN VERTEBRATES

Development which follows fertilization in animals can be divided into 3 groups

1. Cleavage:- mitotic division of the zygote to form a ball of identical cell
2. Gastulation – the arrangement of cells into definite layers.
3. Organageny (organogenesis) – differentiation of cells to form organs and organ systems.

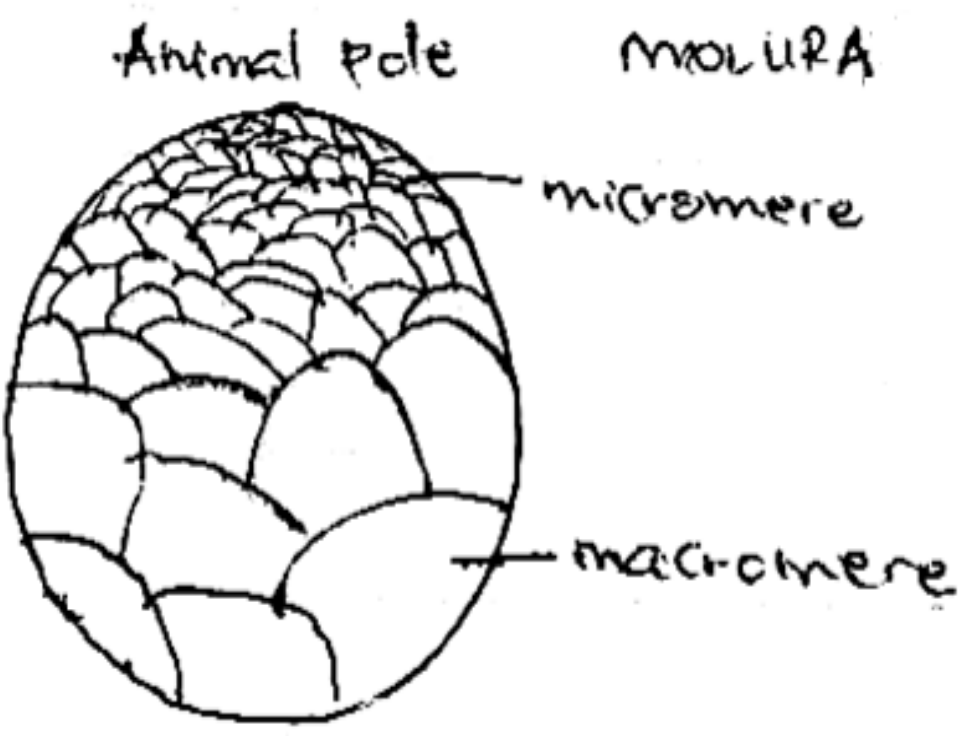
A) CLEAVAGE

After fertilization the nucleus of the zygote divests by mitosis followed by cleavage of the cytoplasm. Repeated division produce a series of small cells called blastomeres. They form a spherical mass of cells called a merula. There is no increase in size at this stage.

The cells then form a hallow sphere the blastula. It has a fluid filled cavity at the centre called the blastocock.

The extent and speed of cleavage depends on how much yolk is present in the egg; as the yolk inhibits cleavage. With little yolk, the cleavage involves the whole cell and the resulting cells called blastomeres are small and equal in size. When much yolk is present e.g in frog, the yolk is normally concentrated at the vegetal pole and to less at the animal pole.

BLASTULA

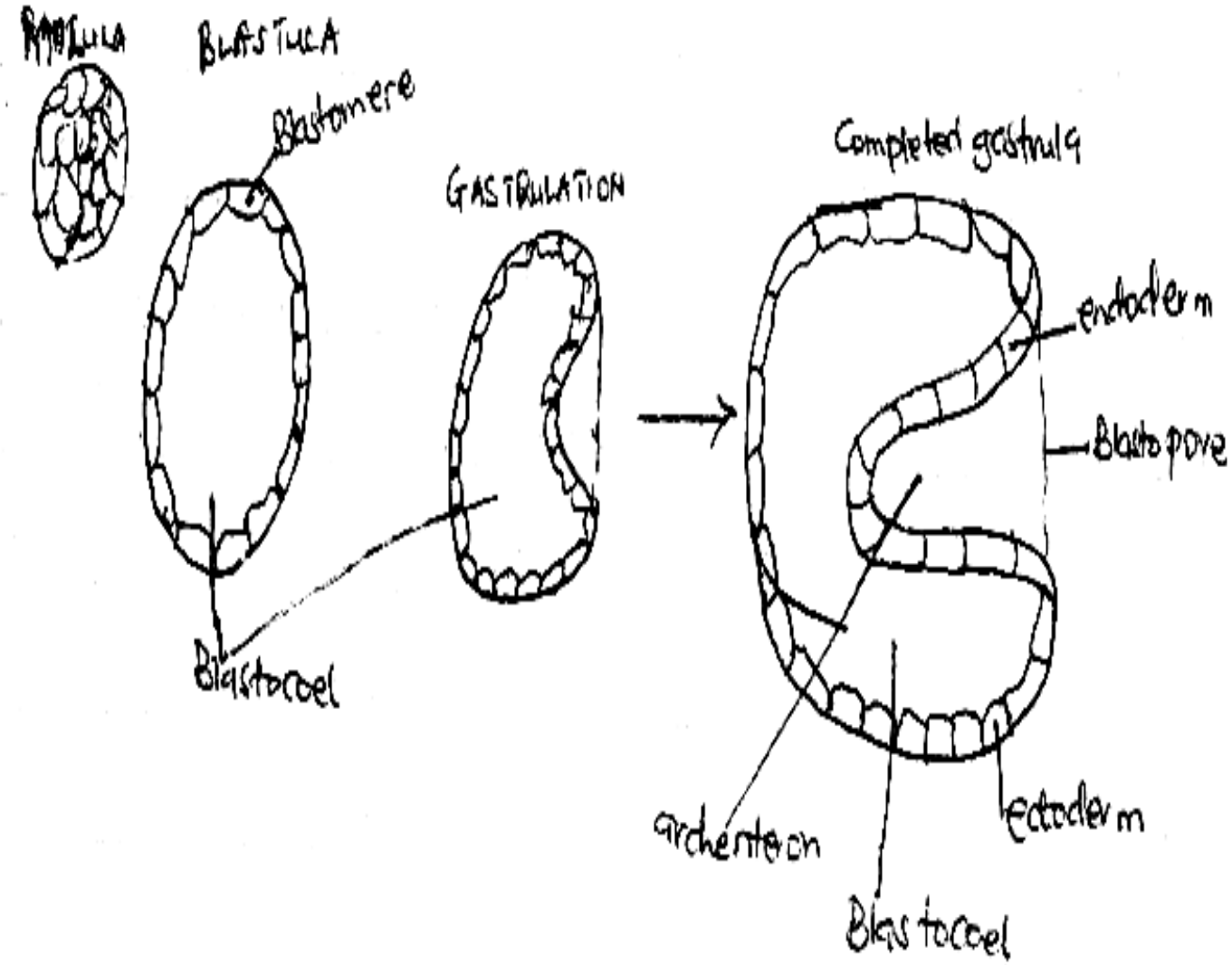


Cleavage is minimal at the vegetal pole and large cells called macromeres result. Cleavage occurs rapidly at the animal pole producing many small cells called micromeres.

NB: In the birds egg, there is so much yolk that cleavage is restricted to the animal pole only.

B) GATRULATION

It involves in pushing of one side of the ball of cells (blastula) to produce a cavity called the archenteron. It later forms the gut.



The structure as a whole is called the gastrula. At this stage the cells have the final fate determined. During gastrulation the cells continued to divide and blocks of cells move to their correct positions i.e where they will form the appropriate structure. The enlarge embryo elongates and becomes tubular. The blastocoels disappears and the cells of the gastrula become arranged into 3 germ layers. This condition is known as triploblastic. The layers are:- endoderm (innermost) mesoderm (central) – ectoderm (outermost).

C) DIFFERENTIATION

Cell differentiation commences and the cells develop into tissues and organs of the embryo. Ectoderm form a neural plate which eventually forms the neutral tube. The interior part of the neural tube forms the brain and cranial nerves and the rest forms the spiral cord and peripheral nerves. Part of the ectoderm gives rise to the epidermis of the skin and associated structures e.g nails, hair.

Mesoderm:- is subordinated into 3 blocks Viz

i) Semite mesoderm
ii) Lateral plate mesoderm
iii) Nephrogenic mesoderm.

Semite and nephrogenic mesoderm form a series of blocks along the length of the embryo. This is known mesmeric segmentation. (a series of identical units rearing along the length of the body).

Nephrogenic mesoderm also forms the kidney

Semite mesoderm gives rise to dermis of the skin, skeleton muscles vertebra and body wall muscles.

Lateral plate mesoderm forms smooth muscles of the gut, the peritoneum, blood and blood vessels, connective tissue e.t.c.

Endoderm forms the lining of the alimentary canal.

GROWTH AND DEVELOPMENT IN NON VERTEBRATES (INVERTEBRATES)

Growth of invertebrates from fertilized egg to adult normally involves one or more intermediate stages known as larva e.g insects have caterpillar, maggot or nymph larva, trocophone larva of annelids and mollusos, planula larva of coelendrates, hadpole of frog (vertebrate).

Though varied in structure, all have these basic features in common.

- They are markedly different in structure from the adult.
- They can lead an independent life from the adult and feed differently from it.
- They are not capable of sexual reproduction.

NB: larva of many parasites reproduce a sexually.

SIGNIFICANCE OF LARVAL FORMS

1. For dispersal especially of slow moving or sessile organism e.g alliated planula larva enables spread of sessle coelenterates such as the sea anemone, alliated miracidium larva enables the parasitic fukes to get from host to host.

2. They are responsible for feeding. They may have well developed feeding devices which are absent in the adult.

   They also exploit different food sources from the adult e.g butterflies and moth larva.

3. They may have resistant forms which are useful in overcoming adverse conditions e.g cold, drought e.g greatly increasing the number of offspring e.g in the liver filuke (fascidal hepatices) the intermediate heart has several larva stages, each responsible for producing large number of new larva by internal propagation.

N.B: Occassionary larva develop sexual organs to attain sexual maturity the process is neoteny.

Major final difference between larva and adult is absence of reproductive organs thus larvas are sexually immature (reproductively).

GROWTH AND DEVELOPMENT IN INSECTS

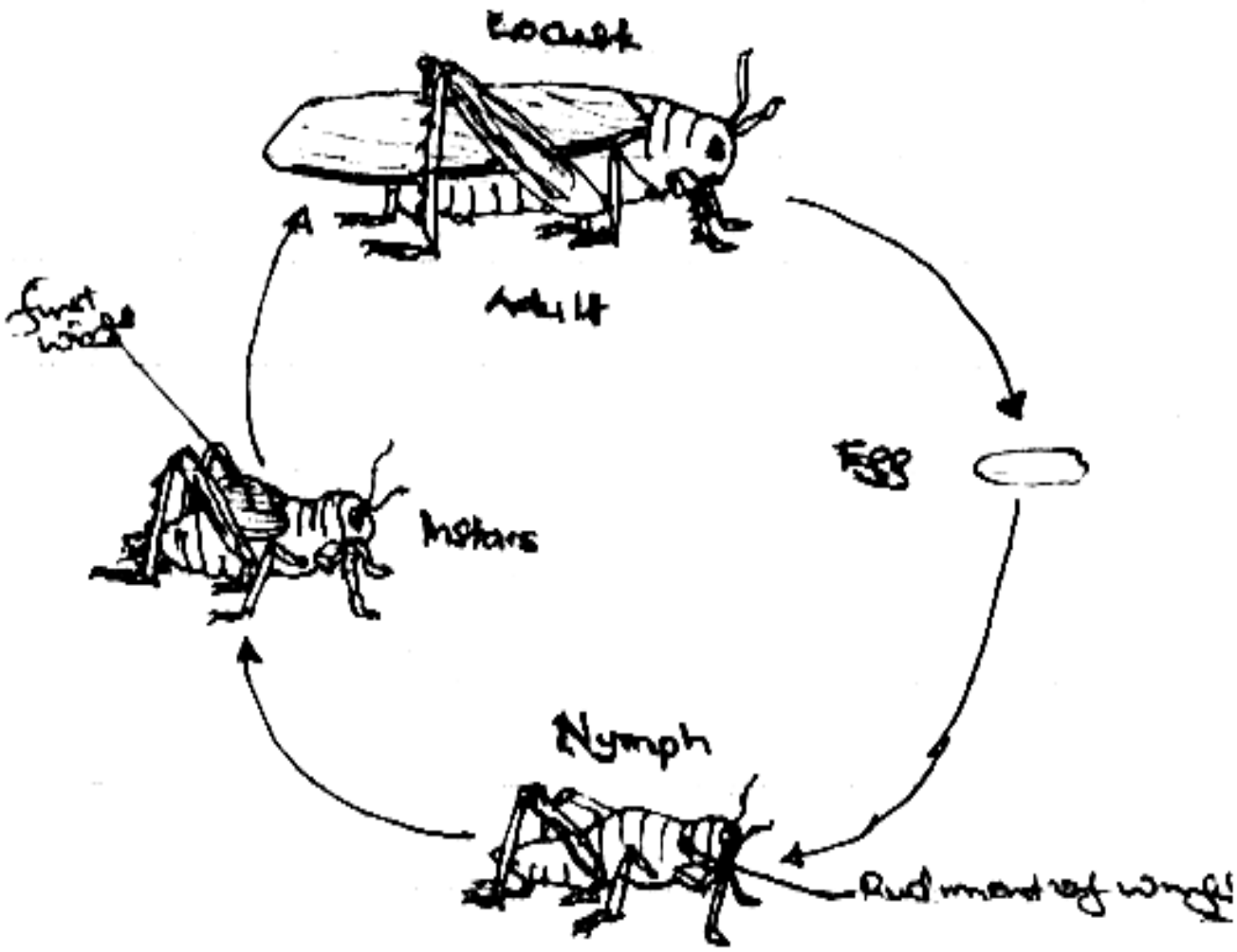
Insects and other arthropods show intermittent growth. They moult periodically during growth. The process is ecdysis. Larva change into adult by a process of metamorphosis.

METAMORPHOSIS

This is the change from larva to adult. It involves reorganization of the body and breakdown of larval tissues. There are two types of life cycles.

a) Hemi metabolous insects. E.g locusts, cockroach grasshoppers, termites. They show incomplete metamorphosis. The egg develops into adult via a series of hymphs i.e (they are like immature adults, lacking wings). Moulting and grant take place between each mymphal stage. Nymphs are similar to adult but are
   - Smaller
   - Sexually immature
   - Lack wings.

Describe life cycle of one the above examples in details



The embryo of an insect such as grasshopper, cockroach or locust undergoes incomplete metamorphosis. It develops into a nymph which closely resembles the adult form, but which hasamemebrs of adaptive features that enables it to live in a different habitant and eat different food from the adult in order to grow, the nymph moults several times and goes through a number of developmental stages called in stars. The final instant emerges as an adult, with all the adult organs.

METAMORPHOSIS

Tadpoles	**Insects**
- Metamorphosis is controlled by	- Controlled by juvenile hormone and

thyroxine	moulting hormone
- No moulting	- Moulting occurs
- No dormant stage	- Dormant stage present (pupa)

D) HOLOMETABOLOUS

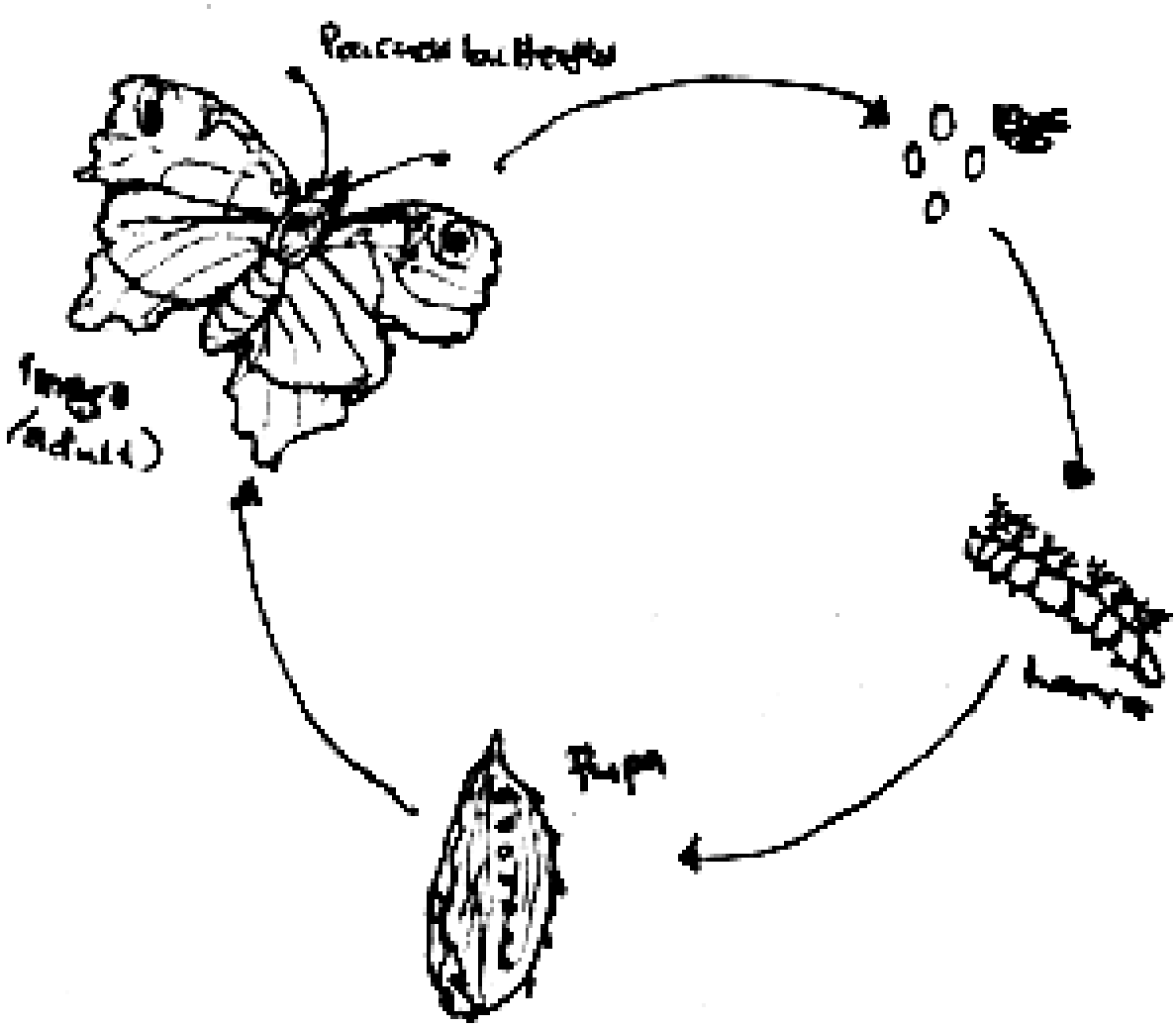
These show complete metamorphosis e.g Butterfly, bettles, math, housefly, e.t.c. their eggs develop into larva which is different from adult. Egg larva pupa adult.

The larva actively feeds and grows with several moults.

Then it enters the dormant pupa stage where there is reorganization of tissues. The larval organs are broken down to a fluid mass (except the central nervous system and small groups of cells called imaginal buds). From these, adult organs are formed, nourishment is from the dissolved larval tissue. When an audlt body is complet, pupa batches into adult (imago).

N.B: Study the life cycle of one insects in details.

How does metamorphosis is tadpoles differ from that in insects?



The embryo of an insect (for example, a moth, butterfly, beetle or fly) which undergoes complete metamorphosis develops into organs form called a larva which appears very different from the adult. Larva often lack many structures of the adult. Butterfly larval have no wings and lack compound eyes and jointed legs, they have become little more than feuting machines whose primary is to find and consume food. Once it has reached a certain size, the larva stops feeding and becomes a pupa by enclosing itself into a protein case. Within the case tissues are broken down and reorganized so that they undergo remarkable information to the adult from the image. Once the adult has emerged from the case, with fully developed wings. It can no-longer moult. This restricts growth.

HORMONAL CONTROL OF INSECT METAMORPHOSIS

Metamorphosis of insects involves two main hormones.

- Moulting hormone (ecdysone) – produced by the prothorocic gland (in the 1st thoracic segment)
- Juvenile hormone (neotonin – produced by the corpus allantum a region behind the brain).

Production of both hormones is controlled by neurosecretory cells in the brain.

Distension of the gut after a meal causes neurosecretory cells to produce a hormone "brain hormone". It may also be triggered by external factors e.g light, temperature. It causes the prothorocic gland to secrete moulting hormone. This causes shedding of the old cuticle and growth.

Juvenile hormone inhibits metarmophosis and causes retention of larval character during the early moults. It suppresses the genes responsible for producing adult structures. In conclusion, juvenile hormone, the larva moults to pupa. During the final stage only moulting hormone is released and pupa moults to adult.

Once the adult form has been attained, the prothoracic glands degenerate and further moulting is prevented.

GROWTH IN ANIMALS

(ROLE OF THE PITUITARY IN REGULATING GROWTH)

Growth is regulated by hormones. Most directly involved is the growth hormone secreted by the anterior because of the pituitary gland.

It is transported to the bones and other tissue of the body effects. It increases metabolic rate, it extra energy being diverted to cell division and protein synthesis.

Stimulates fat breakdown is the synthesis of glucose for energy other hormones influencing growth are;

Thyronaine (from thyroid gland): it increases breakdown of carbohydrates and causes an increase in basal metabolic rate.

Two much growth hormone causes an abnormally large individual gigantism in children.

Too little causes dwarfism

Too much causes acromegaly in adults

Read about repair and regeneration

N.B: Growth hormone promotes growth by stimulating synthesis of proteins and absorption of vital nutrients of amino acids. It also activates genes which control growth.

Synthesis of growth hormone diminishes after the growing period but continues throughout life.

DORMANCY IN ANIMALS

It is a period when growth ceases and metabolic activity is reduced to a minimum. Animals show 3 forms of dormancy.

a) DIA PAUSE

This is a period when growth and developmenta re arrested / cease. It can occur at any stage in the life cycle. Most common in insects. Normal growth promoting hormone is not produced in adequate quantities.

The main factor inducing diapauses is day length (photo period) when hours of day light fall below a certain critical level diapauses sets in. Other factors such as food availability temperature and moisture may be influential. Insects' life cycles are adapted to produce off springs at times when food is in plenty for the lava and nymphyl stages.

Significance of diapauses

It is a means of coordinating production of offsprings and availability of resources (food) ie prevents production of offsprings in adverse conditions. Development can be arrested at any

stage in the life cycle e.g egg larva, pupa or adult. For any SPP, the stage is determinant genetically.

In order for diapauses to be effective, the factor inducing it must act in advance of unfavorable (adverse) conditions. e.g diapauses in the egg stage of the silk worm is a result of photoperiod experienced by the female during egg development.

Diapauses at adult stage is a result of light conditions experienced during early larval stages.
The light stimulus is perceived by the brain which influences activity of neuro secretory cells. The adverse conditions themselves which diapauses avoid act as the stimulus to the break of dormancy.
Whether or not diapauses will occur is determined by a hormone.

Diapauses hormone

Some insects always undergo a period of diapauses. This is obligatory diapauses (genetical - must). It is a must in a life cycle.
Other insects enter diapauses only if conditions become unfavorable.
This is referred to as facultative diapauses.

b) AESTIVATION

It is a period of very low metabolic activity in responsible to hot dry conditions i.e drought. Organisms survive dehydration e.g (African) lung fish, some amphibians, they bury themselves in mud when it is still soft and undergo a period of metabolis inactivity. However, they continue to breach atmospheric air. Normal metabolic activity is restored when it rains.

c) HIBERNATION

It is a period of relatively low metabolic activity associated with low temperature.

Importance

It enables animals to reduce energy demands to a low level, when food is in short supply. This is important in homelothermrs which require a high metabolic rate to maintain body temperature.

Hibernation involves a fall in temperature to that of the environment reduction in heart rate, breathing (ventilation) rate, metabolic rate and growth development. The animals become almost poikilothemic.

Example of organisms that hibernate:- shrews, hedgehogs, ground squirrels, dormice, insectivorous bats, e.t.c. Snakes, roctidile.

The onset of hibernation is related to an increasing environmental temperature, photoperiod and accumulation of adequate supplies of stored food (lipid droplets, a diapauses tissues called brown fat).

N.B: A metabolite might be present in the blood which could trigger hibernation. Because bld taken from a hibernating squirrel induced hibernation in a non-hibernation squirrel within 48 hours.

Animals hibernate in burrows or rests to avoid freezing. Curling up the body reduces S.A and conserves heat, + burying the nose and mouth in fur.
What is meant by torpor, duinal hibernation?
Distinguish between aestivation and hibernation

THE CONTROL OF PLANT GROWTH
(Reception and response in plants)
Among internal factors that play a part in plant growth and sensitivity are substances known as plant growth hormones or plant growth substances. They accelerate, inhibit or modify growth.

Five major groups are recognized.

Auxims

Gibberelliris

Cytokinins

Abscisis acid

Ethane (ethylend)

AUXINS

This is a group of chemical substances of which indole acetic acid (IAA) is the most common. IAA is largely produced at the roots, stem apex.

It is then transported away from the tip to the other parts via the phloem or may be by active transport.

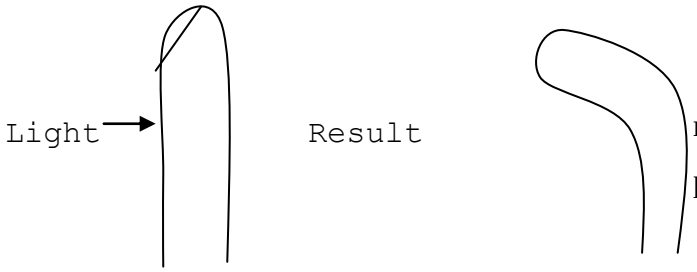
DISCOVERY OF AUXINS

A series of exports were carried out

1. **By Charles Darion:**

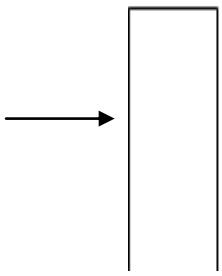
   He investigated the growth of oat coleoptiles in unilateral light

   (a) Intact coleoptiles

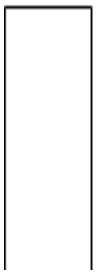


The coleoptiles grows towards light in the region of cell elongation (positive phototripusor)

   (b) With the tip cut off and discarded



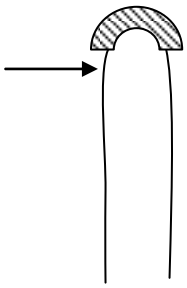
Result



There was no response i.e continues upwards

This suggests that the tip is the region of perception of the stimulus (or that damage to the tip prevents response.)

(c) With the tip covered by opaque cap



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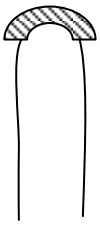
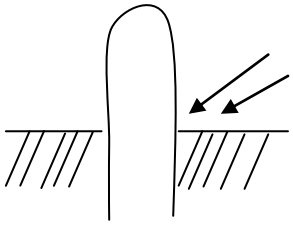


No currature

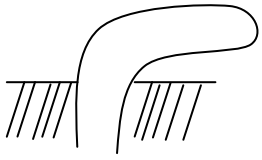
The stimulus must be perceived by the tip rather than the region of response

(d) Coleoptiles buried in sand with only tip exposed.

With only tip exposed.



Result

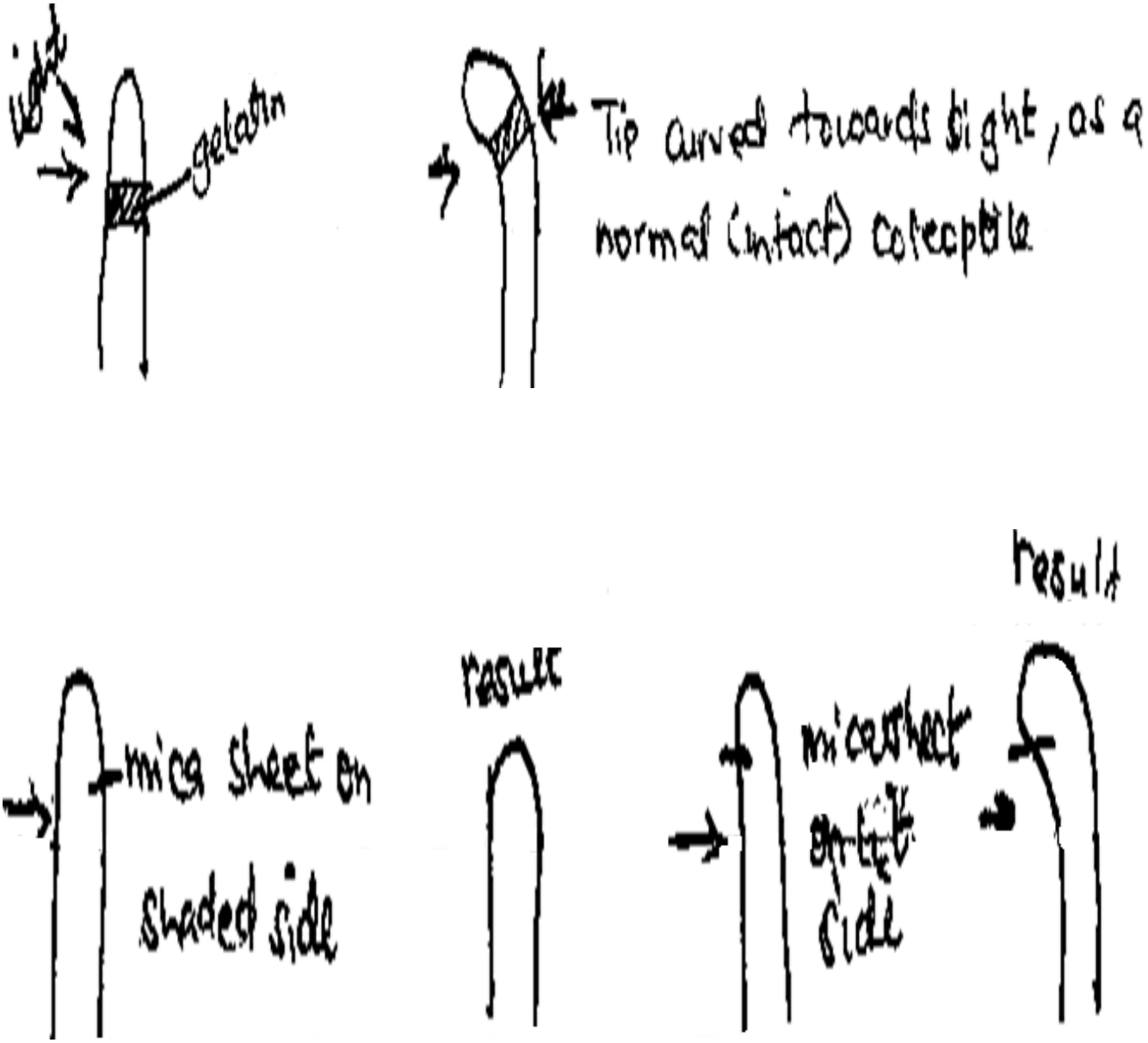


Currature occurs further confirming the above

Experiments by Boysen – Jensen

He investigated the transmission of a chemical message from the tip of coleoptiles to zone of enlargement / elongation.

(a) The tip was removed, gelatin block inserted and tip replaced.

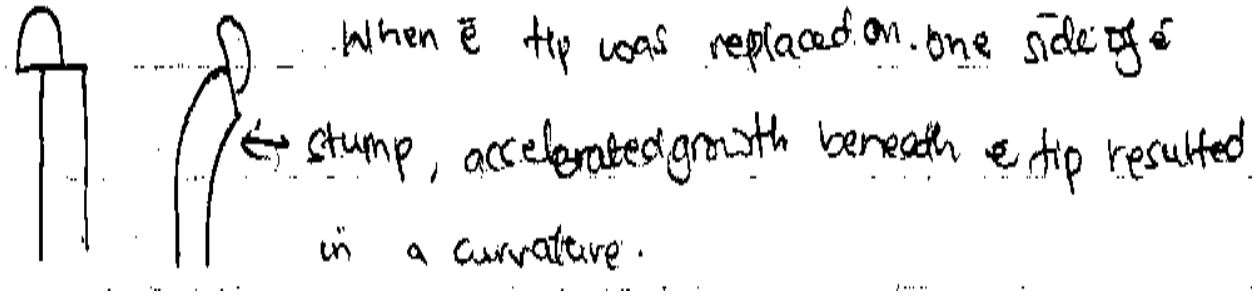


Insertion of sheet on shaded side prevented curvature in unilateral light. But with the sheet on the lit (illuminated) side the normal curvature develops.

Boysen – Jensen concluded that a chemical substance diffused down the shaded side of a unilaterally ilmica conducts electricity so it would not prevent an electrical massage possing down the tip lummated coleoptiles and caused the growth curvature. The message is chemical (i.e a hormone).

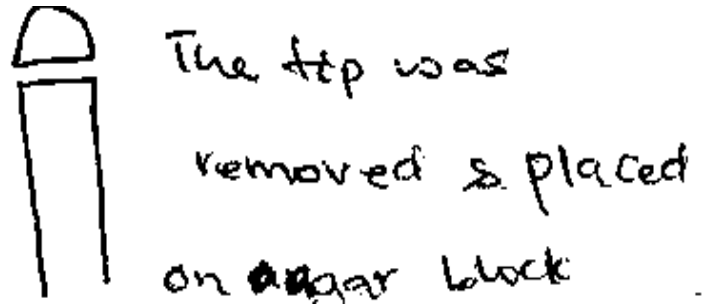
Experiments by Paal

He experimented with cut coleotile tips replaced asymmetrically one cut stump and kept in the dark.



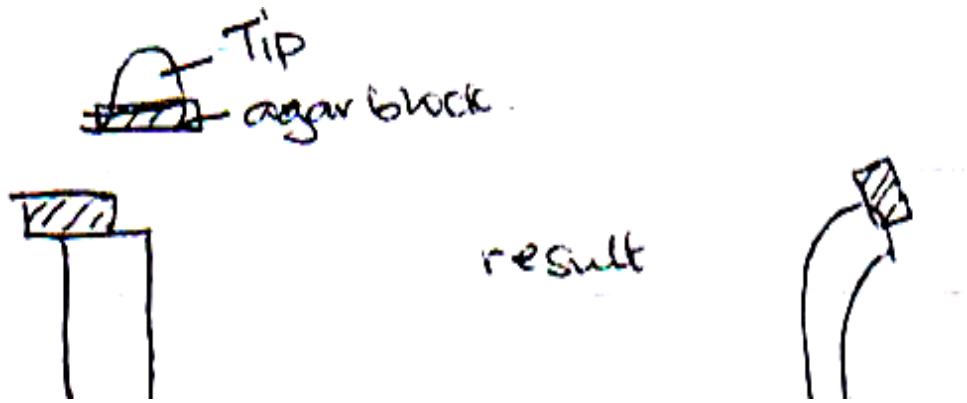
Darkness Paal concluded that a hormone had diffused from the tip and had accelerated growth on that side.

Experiments by Went



The agar block was replaced on one side of the cut coleoptiles. The coleoptiles bends towards side without the block.

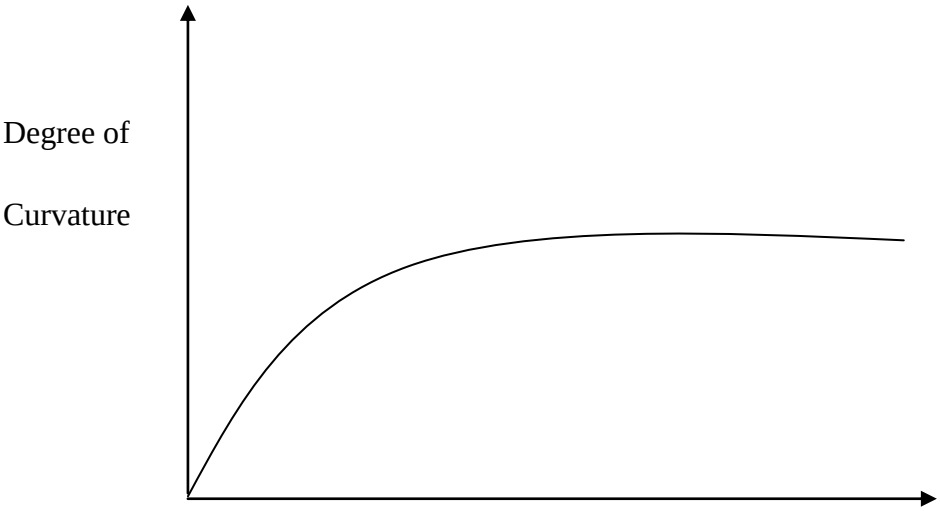
In darkness



Conclusion: The hormone from the tip diffused into the agar block. When the agar block is replaced on the side, the hormone diffuses down that side, increasing growth and causing the bend.

The degree of bending (curvature) is found to be proportional to the amount of auxim present.

Went fount that the curvature was proportional to the number of coleoptiles tips put on the agar block i.e conclusion of auxims.

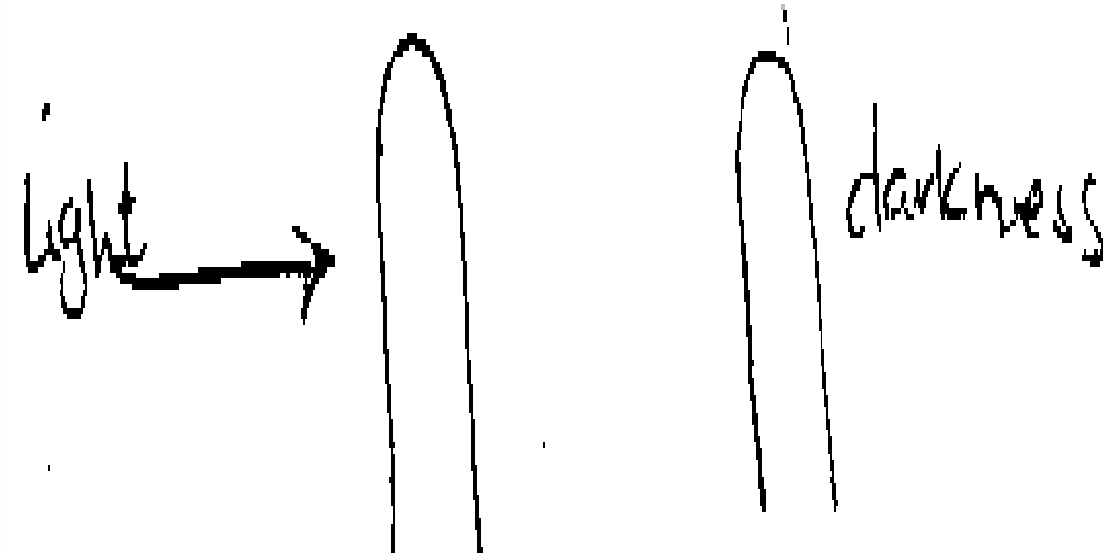


Qn. Define the term Bio assay:-

An experiment for determining conclusion of a substance by measuring the extent (degree) of its effect on a biological process.

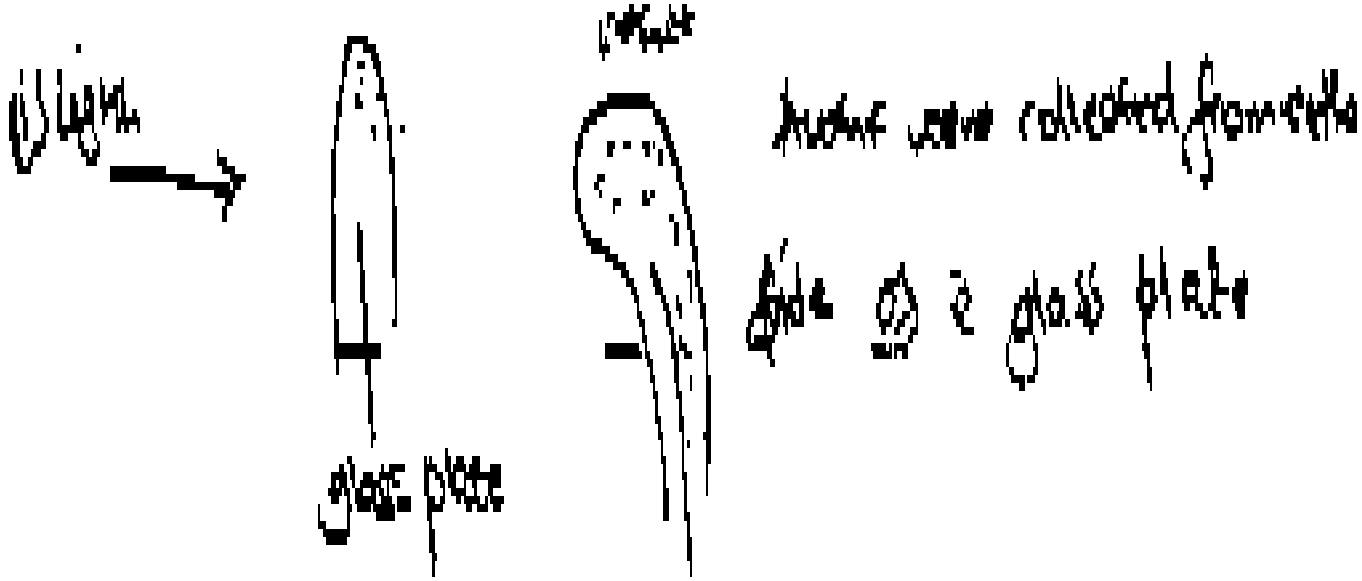
In another experiment

Is one coleoptiles was put in darkness and another in light.



Auxin was collected from both coleoptiles and the total amounts compared. The total amount of auxins collected was approx the same

Light does not inhibit auxin production nor destroy it.



30% of total auxins was collected from illummated (light side) 70% of auxim was from shaded (dark) side.

Conclusion: lateral transfer of auxims from light side to dark side occurs near the tip. More auxim passes to the dark side causing cell elongation and the coleoptiles bends.

Light causes uneven distribution of axuims.

Many growth responses are explained by presence fauxims.

RESPONSE TO LIGHT (PHOTOTROPISM)

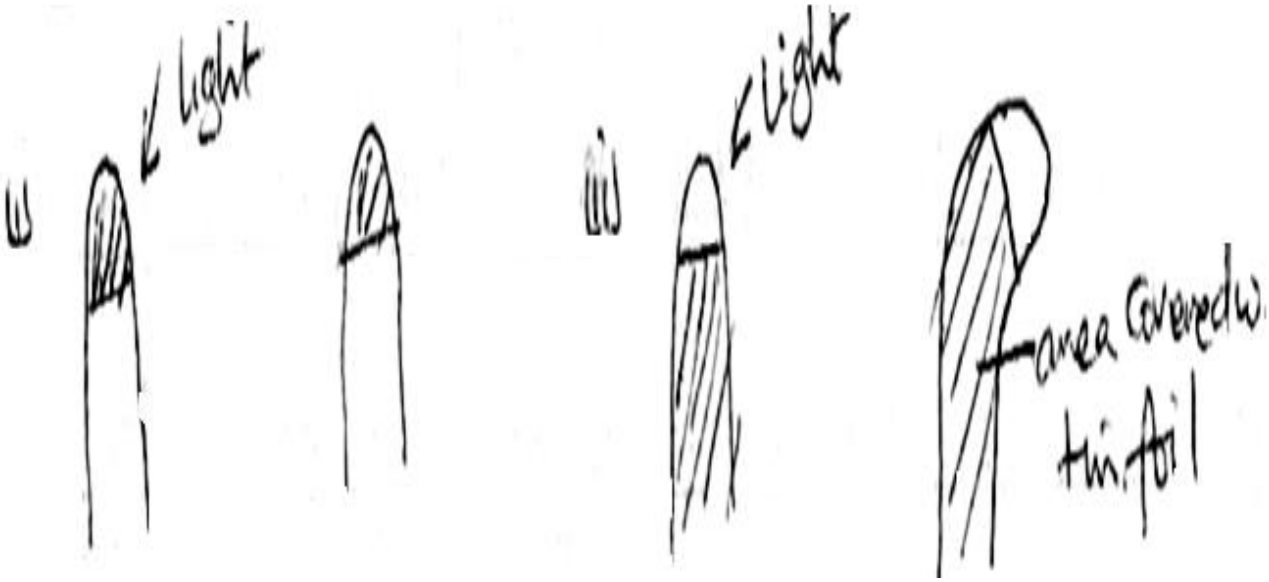
Shoots grow towards light, are positively phototropic. Roots are collect phototropic or do not respond at all. They are more sensitive to auxims, than stems. They respond to lower conclusions of axuims. As the conclusion increases, growth is inhibited.

Qn. Explain why shoot bends towards light (interns of auxims).

There are two possible hypotheses.

1) Unilateral light may cause unequal distribution of auxims in the shoot tip, more on the dark side than the light side.
2) Light may prevent the cells responsible for growth from responding to the hormone on the light side of shoot.

To establish the truth, the following is done.



This foil is placed over the shooting. Shoot does not bend towards light

This foil is placed around the shoot to cover zone of elongation. Shoot bends towards light

Cc ropic res of auxims.

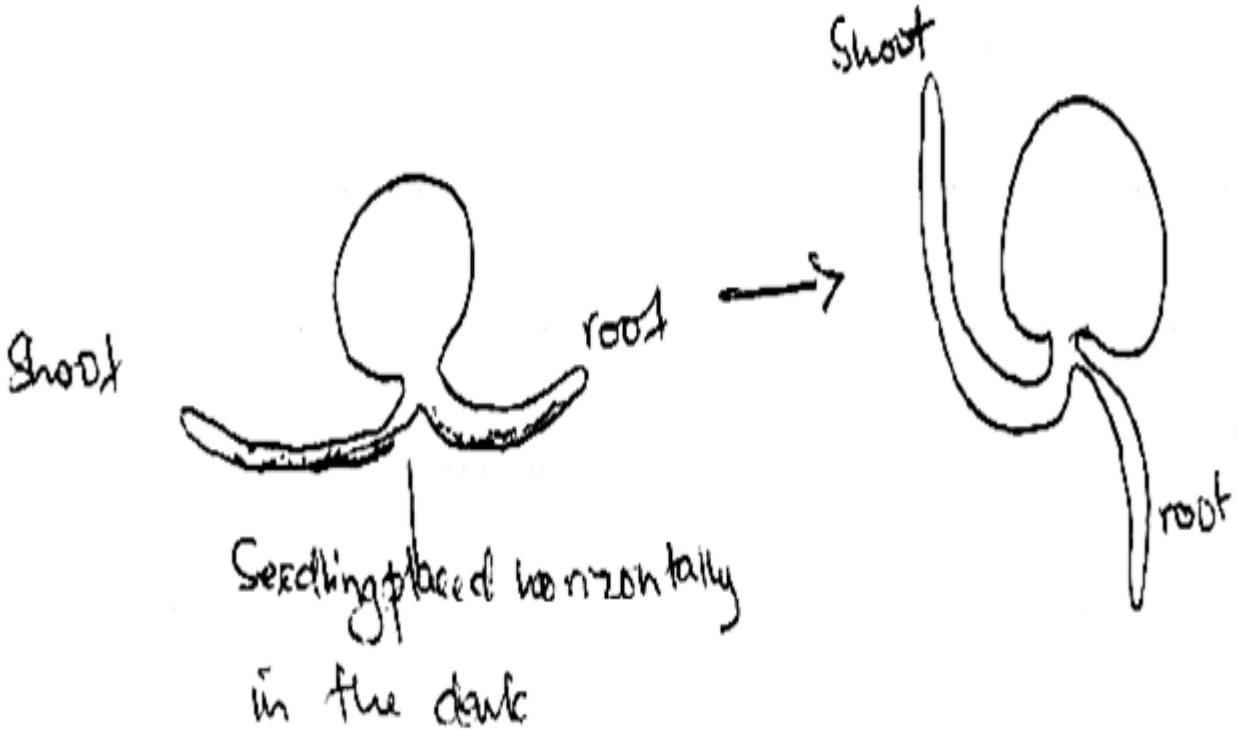
MODE OF ACTION OF AUXINS

Auxims can promote cell division as well as elongation. They enable the cell walls to be stretched move easily by osmotic forced developed in the vacuoles, allowing the cellulose micro fibrils to slide past each other.

Walls loosening is induced by acid condition and by auxins. Auxims stimulate H+ secretion. This lowers the pH (increase acidity). Cell wall loosening occurs possibly by an enzyme with low pH optimum.

RESPONSE TO GRAVITY (GROTROPISM)

When a seeding is placed horizontally in the dark, the steristrip grows upwards (-ve geotropism) and the root tip grows downwards (+ve geotropism).



Explanation: a higher canon of auxims occurs on the underside of horizontal roots and shoot. The high conclusion inhibits root growth and causes it to bend downwards. The same response stimulates stem growth and causes it to grow upwards.

How is the stimulus of gravity perceived?

This is explained by the stability theory. The gravity stimulus is perceived in cells containing large starch grains near the stemor root apex. The starch grains are called starch statoliths. They fall to larva side of cells and impact of lower cells and stimulate protein. They change than posh when a plant is moved from a vertical to a horizontal posh. When they fall onto ER in a different part of the cell, they bring about release of ca^{2+}, there. The increased Ca2+ canan activate a certain protein in the cells (Calmo dulin). The protein initiate the action of several enzymes which activate growth of the cells.

Starch statoliths (found in both root and shoot) perceives the gestrope stimulus.

If starch statoliths are pestroyed, the root will no longer respond to gravity if placed horizontally.

OTHER EFFECTS OF AUXINS

(other than causing cell enlargement and division in stem and root apex).

1. In increasing conclusions, auxins inhibit growth of side branches from lateral buds i.e they cause apical dominance. This is where the bud at the apex of a shoot produces auxins insufficient conclusion to inhibit growth of the lateral buds further down the shoot.

The lateral buds remain dormant unless the apical bud is removed.

Auxins cause lateral bud dormancy

Pical dominance may be of advantage to pets that have to grow tall e.g eucyptus.

N.B: When pruning is done, cutting the mainstem removes the soruce of auxin thus encouraging sprouting of side branches e.g tea plants.

2. **In stem**

   Auxins promote cell division and enlargement in the stem apex.

   Promote cell division in the lateral cambium leading to 2o, growth.

3. In leaves: They inhibit leaf abscission by preventing formation of an abscission layer. i.e they maintain the structure of cell walls such that the cells at base of stalk remain intact.

4. In fruits: Auxins promote growth of fruits without fertilization i.e pithenocarpy.

5. In roots: Auxins promote cell enlargement in the region behind the root apex in how conclusion. It inhibits cell enlargement in high conclusion. They also initiate adventitious root formation in stem cutting. This can be important on commercial faming.

Question: What is the economic importance of auxins?

- Used in preservation of stem tubers by direct spraying
- They initiate the formation of lateral roots from cutting
- Prevent premature fruit drop by inhibiting abscission
- Used as powerful weed killers.

OTHER GROWTH SUBSTANCES

2) GARBERELLINS

How they were discovered

They were first isolated from a parasitic fungus, Gibberella fusikoroi. It infected rice plants making than grow abnormally tall with weak stems and eventually they toppled over. They extract from the fungus induced abnormal growth when applied to healthy plants. It was purified and analyzed and named Gibberelli of acid. Several different forms of GA have been discovered and are collectively referred to as gibberellins rather than GA.

Synthens and distribution

They are synthesized in the chloroplasts of young leaves, in seed embryo, and in buds. The highest conclusions in fruits and seeds after synthesis, they migrate up and down the pH.

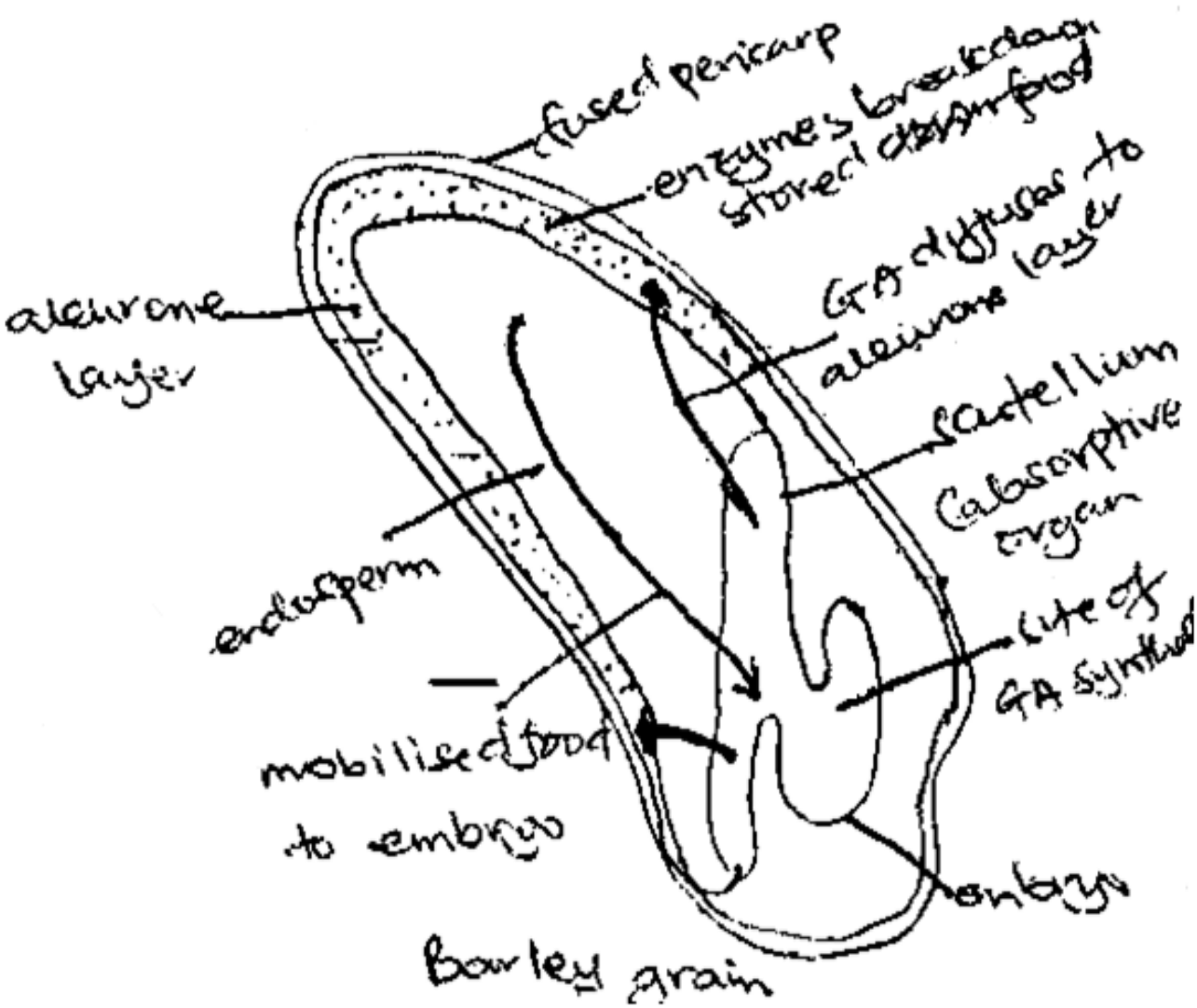
EFFECTS OF GIBBERELLINS

1. Principole effect is stem elongation by affecting cell elongation. E.g genetically dwarf varieties of peas and maize are restored to normal / growth when treated with gilberellins.

   N.B: dwarf plants cannot produce gibberellins.

2. They are involved in breaking dormancy of certain seeds especially cereals and in mobilizing food reserves in germination.

Germination is triggered by soaking, the seed in water. After inhibiting water, the embryo secretes GA which diffuses to aleurone layer. Stimulating synthesis of several enzymes. The enzymes catalyzed breakdown of food in the endosperm and the products diffuse to the



embryo where they are used in growth.

3. They stimulate growth of lateral branches from lateral bud (unlike auxims).
4. They inhibit formation of adventitious roots but not root elongation.
5. Can cause parthenocarpy in some plants and when applied they promoted fruiting. They are used to grow seedless fruits tomatoes, grapes.

   Probably act by causing initial formation of auxims.

3) CYTOKININS

They were first extracted from coconut milk which is a liquid endorsperm. Kimetim was the first cytokimin to be isolated of DNA. Zeatin was the first naturally occurring cytokimin to be identified from young maize grains.

Synthesis and distribution

They are most abundant where rapid cell division is occurring especially in fruits and seeds where they are associated with embryo growth. In mature plants they are made in the root tips and move to the shoot.

Effects of cytokinins

1. They promote cell division and differentiation but only in the presence of IAA (auxins). The interaction between cytokinins and auxins has been demonstrated by immersing un differentiated callus (tissue with undifferentiated cell) tissue in a series of solutions containing different proportion of IAA (auxins) and kinetin (a synthetic cytokinin).

The callus could be induced to:-

- Form buds or roots
- Form continue dividing into more tissue
- Or to stop growing altogether depending on the rel quality of IAA and kinetic provide.
- This illustrates the importance of interaction between different growth substances.

2. They promote leaf growth and delay the process of senescence (aging) in the leaves.
3. They promote lateral bud growth (release buds from apical dorminance).
4. They break bud dormancy and seed dormancy
5. Promote stomatal opening

Commercial application

- Delays senescence of leafy crops e.g cabbage, Lettice

- Keeps flowers fresh
- Can break dormancy in seeds.

4) ABSCISIC ACID (ABA)

It is a growth inhibitor (suppresses activity of GA, IAA and cytokinins).

It was first discovered in cotton plants and caused the fruits to fall off falling off of fruits and other plant organs e.g leaves is called abscission, so this substance was named abscisin.
Its formula is known and is now called abscisic acid.
It is formed in mature leaves and in ride fruits and seeds and root cap.

EFFECTS

- It promotes fruit and leaf fall off in pHs by stimulating form of abscission layer.
- Promotes buds and seed dormancy.
- Promotes closing of stomata order conditions of water stress (drought).
  ABA is produced in the x-plasts and reaches the guard cells. Here, it suppresses the retention of the K^+ ions by guard cells leading to stomatal closure.

Commercial application

- It can be sprayed on tree crops to regulate fruit fall thus removing this need for hand picking over long periods of time.

5) ETHANE

It exists as a gas at normal tempts. It is made by most plant organs especially the fruits.

Effects:-it is responsible for fruit ripening which occurs as a result of increase in respiration rate.

- Promotes leaf and fruit fall (abscission)

- Breaks bud and seed dormancy
- Promotes flowering in pineapple.
- Commercial applications
- The commercial …..is ethephron which breaks do write release ethane in plants.
- Induces floweing in pineapple plants.
- Speeds up ripening of fruits by tomatoes, citrus fruits bananas, e.t.c. this is important in horticulture whereby a crop is transported unripe can be ripened to coincide with a period of demand.
- Is applied to rubber plants to reduce the flow of latex.

THE INTERACTION OF PLANTS GROWTH REGULATORS

In pHs, may aspects of growth, development and response are influenced by two or more plant growth substances. Control of growth is rarely attributed to a single plant growth substance plant growth substances may interact to reinforce each others i.e effects, a process known as synergism e.g A and IAA are synergistic in stem elongation.

They may cause each other is effects – antagonism e.g cytokinins are antagonistic to IAA in maintaining apical cloud dominance.

LIGHT AND PLANT GROWTH

The stimulus with the widest influence on plant growth is light.

Importance of light

- It provides energy for photosynthesis.
- It necessary for x – phyl synthesis
- Affects plant movements (tropisms)
- Affects stem and root elongation

- Opening of stomata
- Flowering – germination of some seeds
- Growing a plant in darkness results in etiolation

ETIOLATION

Characteristics of etiolated plants

- Leaves lack chlophyll and appears white or pale yellow.
- The stem internodes are elongated and thin making the stem weak due to less rignification.
- Dicot leaves are small and unexpanded and few. In monocots they may remain rolled up.

Significance

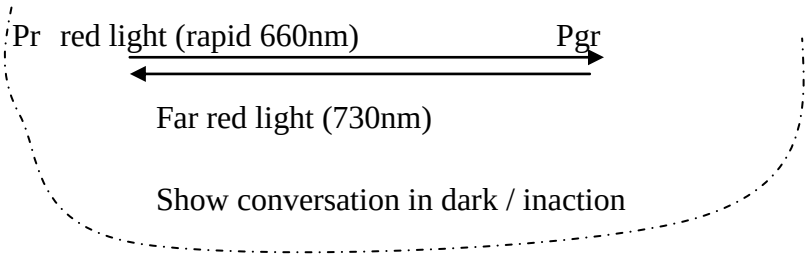
- Etiolation allows maximum growth in length with minimum use of carbon reserves which the plant can obtain in absence of light for photosynthesis.

THE PHYTOCHROME SYSTEM

In order for light to take place in any process, it must be absolute by a pigment which is photoreceptor (light receiver).

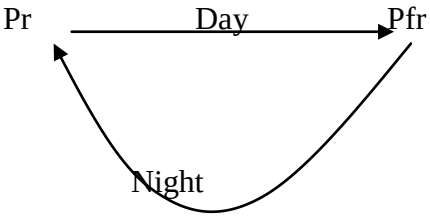
The pigment responsible for light absorption was identical and called phytochrome. It is a blue green pigment existing in two inter convertible forms. It occurs in extremely small amounts in the tips of growing shoots.

(i) Pfr or P730 – absorbs for red light. Has maximum absorption in the red part of spectrum at 660nm. Absorption of light by one form coverts i.e rapidly into another form.



In natural sun light Pr is converted into Pfr, and pfr into Pr. Sunlight contains movered than far red light so the former react with predominates i.e Pr Pfr.

(More pfr during the day). There is slow conversion of Pfr to pr in darkness. Therefore Pr predominates at night.



Pfr is biologically active possibly by initiating enzyme action, where as Pr is inactive.

N.B: Pfr does not always stimulate growth.

Discovery of phytochrome

The seeds of many pHs germinate only if exposed to light e.g lethece seeds. Sometimes only a briefly exposure is needed.

Experiments were carried out to find which wave length were effective in stimulating germination. It was discovered that red light was the most effective (in the range of 580 – 660nm) far red light (between 700 – 730nm) inhibited germination. It was noted that is a flash

of red light was immed, followed by far red, the stimulating effect of red light was called germination inhibited.

- If seeds were exposed to alternating flashes of Fr and red light, the response was determined by last flash.
- On the basis of these and other experiments. It was confirmed that light is absorbed by a substance called phytochrome.

Qn. Why does the FR light prevent germination?

Treatment with red light causes conversation of inactive Pr to active Pfr, where as treatment with far red light causes conversion of active Pfr to inactive Pr which inhibits germination.

Processes affected by the phytochrome system:

1. Stem elongation is stimulated by fr light but inhibited by red light. (as exhibited by etiolated plants)
2. Leaf expansion is stimulated by red light and inhibited by far red.
3. Growth of lateral roots is stimulated by far red light and inhibited by red.
4. Flowering depends on alternating periods of light and dark I.e light duration (photoperiod).

NB. The relative length of day and night is called the photoperiod.

The response of a plant (any organism) today length and night length is called photoperiodism i.e influence of red length of day and night on the activities of an organism.

PHOTOPERIODISM AND FLOWERING

Flowering is one of the plant processes affected by the photoperiod flowering occurs when shoot meristems. Switch from producing leaves and lateral buds to producing a flower.

On the basis of their responses of light and darkness, flowering plant can be divided into three groups.

- Long – day plants
- Short – day plants
- Day – neutral plants

1. **LONG DAY PLANTS**

   e.g Barley, grape, lettuce, spinach, radish e.t.c. They require long days and short nights. They flower only when the light period exceeds a certain critical length in each 24 hours cycle, a minimum of about 10hrs. Light treatment induces early flowering where as dark treatment delays it. They tend to inhibit temperature regions where days are long.

2. **SHORT – DAY PLANTS**

   e.g Tobacco, chrysanthemum

   they require short days and long nights. They flower only when the light period is shorter than a critical in each 24 hr cycle shorter than 14 ½ hours in some plants. i.e maximum period of light 14 ½ hrs. Such plants can be induced to flower early by giving them extra darkness. One long night may be enough in some cases tend to inhibit areas near the equator.

3. **DAY – NEUTRAL PLANTS**

   e.g tomato, cotton, coffee, cucumber, carrot, they are in different today length i.e not affected.

   It has since been shown that the critical factor influencing flowering is the length of the dark period.

   This short – day plants are long – night plants. They can be induced to flower by nights that are longer than certain critical length. If they are grown in short days, but the long night is interrupted by a light period flowering is inhibited. Long – day plants require short dark period. They will not tolerate darkness above a certain maximum. They can be induced to flower by nights that are shorter that a critical length (or in continuous light) short night plants.

MODE OF ACTION OF PHYTOCHROME

How does the phytochrome exert its control?

It has been found that red light inhibits the flowering of short day plants while far red light stimulates flowering.

Far red light reconverts Pfr to Pr. It seems a short day pH will only flower when sufficient proportion of its phytochrome is in the Pr form. The trigger (stimulus) could be a high accumulation of Pr or allow concn of Pfr. Pfr inhibits flowering, its conversion to Pr removes the inhibition.

Flowering is SD plants is promoted by the absence of Pfr rather than presence of Pr i.e Pr > Pfr.

In long day plants accumulation of Pfr promotes flowering i.e red light promotes flowering it converts Pr to Pfr.

For both short day plants and long plants, its not just the amount of Pfr or Pr which is present that matters, but also its duration (for hours long is it present) both are usually present together in varying proportions.

Which part of the plant receives the light stimulus?

The light stimulus is perceived by the leaves from the leaves the message is transmitted to the buds where flowering is initiated. The message is in form of a hormone which has been named hormone floigen but has not been isolated. Experiments have been done to prove that it's the leaves that perceive the stimulus.

i) A whole pH was covered with light proof paper except from one leaf. The leaf was subjected to light and dark treatment.

Flowering took place.

N.B: Only a small part of the leaf needs to be exposed to the correct (right) photoperiod for the pH to flower even if the rest of the plant is covered (under non – inductive conditions).

ii) A photo periodically induced plant (stem / leaf) is grafted onto a non – inducted plant and kept under unfavourable conditions for flowering => flowering takes place.

iii) The leaves of an exptal pH are removed soon after photoperiod which induction. Flowering will not occur for a period of time. Eventually the growing products receive the stimulus in sufficient quantity and flowering occurs.

SCHEME SUMMARIZING PHOTOPERIODIC CONTROL OF FLOWERING (PG 442 RBTS)