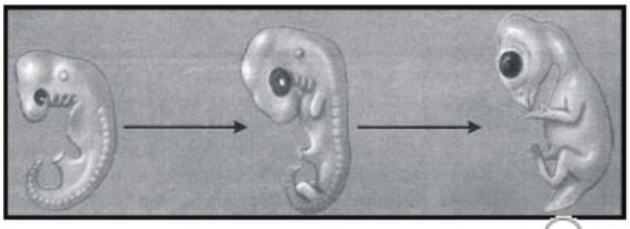

Chapter 19

Growth and Development

19.0 INTRODUCTION

In the course of its life cycle, an organism changes from a fertilized egg into an adult. As development proceeds, all sorts of the changes take place.

Growth

Growth is the permanent and irreversible increase in size that occurs as an organism mature.

Embryonic Development

The progressive changes which are undergone before an organism acquires its adult form constitute **embryonic development.**

The most obvious change is growth.

19.1 GROWTH AND DEVELOPEMNT IN PLANTS

In plants growth and development involve cell division, elongation and differentiation of cells into tissues and then organs.

Growth is an irreversible increase in size and development is a programmed series of stages from a simpler to more complex form.

As development proceeds, cellular differentiation of structure and function takes place.

Open Growth in Plants

A plant has a growth pattern called open growth. In this growth pattern, plants add new organs such as branches, leaves and roots enlarging from the tips of roots and shoot but the rate of growth is not uniform throughout the plant body.

- At the beginning growth is slow.
- Gradually it becomes rapid attains a maximum state.
- After attaining maximum state, the process then gradually slows down.

19.1.1 Meristems and Growth

Meristems are young tissues or groups of cells. Growth occurs through the activity of meristems.

- In lower plants the entire plant body is capable of growing.
- In higher plants, entire plant body is not capable of growing but growth is limited to certain regions known as growing points. In this case, these points are called meristems due to presence of group of cells which are capable of division.

Types of Meristems

Meristematic cells are located at the stem and root and are divided into three types.

1) Apical Meristems

i) These are found at the tips of roots and shoot

ii) These are responsible for increase in number of cells at the tips of roots and stem.

iii) They cause extension of plant body and this plays important role in primary growth.

2) Intercalary Meristems

i) These are part of apical meristem which get separated from apex by permanent tissue.

ii) These are situated at the bases of internodes in many plants.

iii) They are of temporary nature and play important role in production of leaves and flower.

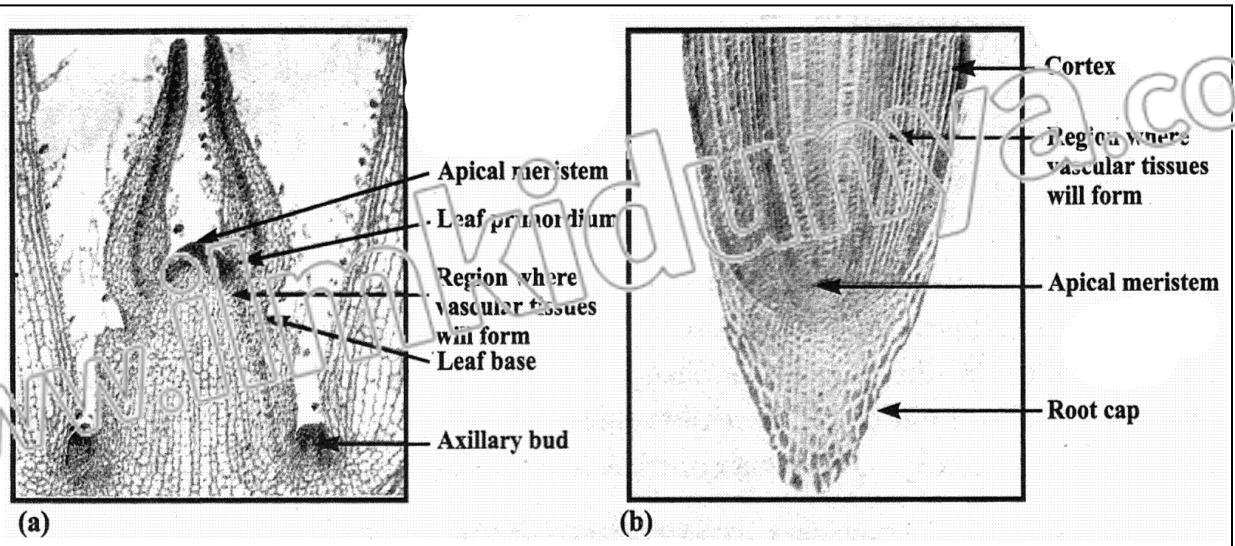

Fig. 19.1 ***Photomicrographs of the apex of a shoot (a) and a root (b).***

3) Lateral Meristems

i) They are present in gymnosperms and dicots

ii) They play important role in increasing diameter of stem and root and thus in secondary growth and determinate.

iii) Vascular and cork cambium are examples.

GROWTH PATTERNS

There are two growth patterns.

1) Determinate

When structures grow to certain size and then stop, it is called determinate growth as in leaves, flowers and fruits.

2) Indeterminate

In it, there is continuous growth in which meristems replenish themselves remaining youthful as in vegetative root and stem.

QUESTIONS RELATED TO ABOVE ARTICLE

Describe the types of meristems. (DGK 2019, LHR 2021)

19.1.2 Types of Growth

Growth is of two types

1) Primary Growth

Primary tissue is added by the apical meristem or it is elongation of plant body caused by apical meristem. The tissues formed in the primary growth are called as primary tissues.

2) Secondary Growth

Secondary tissue is added by intercalary or vascular cambium leading to increase in thickness or it is increase in thickness caused by secondary tissue i.e. intercalary or vascular cambium.

PHASES OF GROWTH

Growth of multicellular plant is divided into four phases or zones.

1- Zone of cell division

2- Zone of cell elongation

3- Zone of cell maturation

4- Zone of cell differentiation

1) Zone of Cell Division

During this number of cells increases by mitosis.

i) It occurs at the tip of roots and shoot.

ii) Cells are small, non-vacuolated with spherical nuclei lying in center of cytoplasm.

2) Zone of Cell Elongation

During this cell increase their size.

i- It lies a little distance from apex of root and shoot.

ii- It is few millimeters in length.

iii- Cell volume increases upto 150 folds due to uptake of water.

iv- Plasticity of cell wall increases, and wall pressure is reduced.

v- Synthesis of new cytoplasm and cell wall material proceeds on

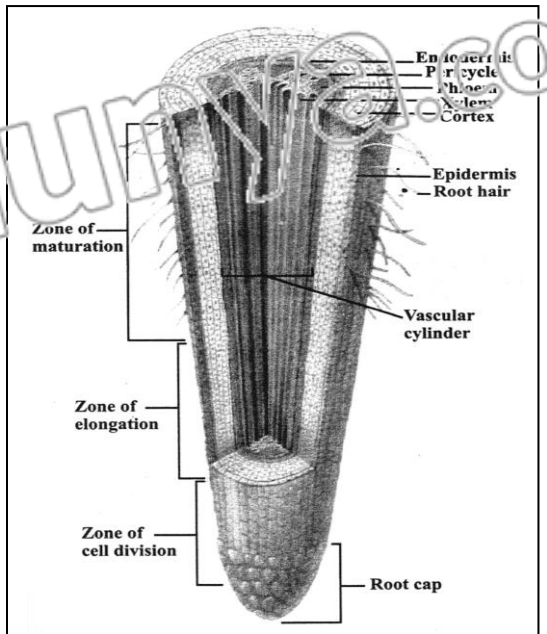

Fig. 19.2 The root tip is divided into four zones.

3) Zone of Maturation

During this cell become mature

i) Cells attain full size

ii) Some cells develop into pith cortex and certain other tissue do not elongate further along the axis.

iii) Cells like fibers and tracheids elongate lengthwise more than in other direction.

4) Zone of Differentiation

During it, cells are differentiated to perform their functions.

i) Walls of cells become thicker and of many cells and tissues become pitted.

ii) Various thickening appears on walls of xylem vessels and cells of various tissues differ in the spatial dimensions and many new structural features appear.

QUESTIONS RELATED TO ABOVE ARTICLE

What is growth? Discuss different phases and conditions of growth.

(Exercise Question iv)

What is growth? Discuss different phases of growth. (DGK 2019)

19.1.3 Conditions of Growth

Growth rate is influenced by number of factors both external and internal. All of these temperature and light are most important.

A) External Factors

Important external factors are temperature, light, oxygen and carbon dioxide.

1) Temperature

Temperature influences the rate of growth within a certain range (0-35˚C)

- For maximum growth, optimum temperature is 25-30˚C and it is least at 5-10˚C.
- Normally rate of growth increases with rise of temperature and decrease with decrease in temperature.
- At very high temperature (35-40˚C) rate of growth stops and the plant may die.

2) Light

Light plays very important role in growth of plants. Light influences growth in three ways; intensity, quality and duration.

a. Intensity

Increase in intensity of light increases the number of cell divisions.

b. Quality

- Red light favours elongation of cells.
- Blue light enhances cell division but retards cell enlargement.
- Ultraviolet rays also retard cell elongation.

c. Duration

- It affects growth of vegetative and reproductive structures.
- It plays role in inducing or suppressing flowering through photoperiodism.

3) Oxygen

- For successful growth, regular supply of oxygen is necessary.
- Without oxygen, no metabolic activity is possible, and no growth takes place.
- A very high supply of oxygen also inhibits growth.

4) Carbon dioxide

- Carbon dioxide is essential for carrying out photosynthesis.
- Low CO_2 retards growth.
- Very high concentration of CO_2 also retards growth.

B) Internal Factors

Important internal factors are hormones, water, nutrition and vitamins.

1) Hormones

Plants hormones (Auxins, Gibberellins, and Cytokinins) influence growth e.g. IAA causes elongation of cells.

2) Water

Elongation of cells is possible due to absorption of water. Plant growth ceases in absence of water.

3) Nutrition

Nutrients supply energy to growing parts.

- Increase in nutrition increases growth.
- Decrease in nutrition retards growth.

4) Vitamins

Vitamins are organic compounds formed within the plant body in presence of light.

If plants are grown in dark, the vitamin deficiencies are induced and growth of plant body ceases.

QUESTIONS RELATED TO ABOVE ARTICLE

Explain how the growth rate is influenced by external factors.

19.1.4 Differentiation

Once a seed has germinated, the plant's further development depends on the activities of the meristematic tissues and we know that shoot and root apical meristems give rise to all cells of the adult plant.

Differentiation is the formation of specialized tissues. Process of differentiation in plants is divided into five stages.

Stage-1 It represents formation of embryo.

Stage-2 It represents formation of apical meristems of shoot and root.

Stage-3 It represents formation of cambium for secondary growth.

Stage-4 During this stage, there is formation of leaf primordial. Root primordial develops from root cambium called pericycle. Leaf and shoot primordial develop directly from apical meristematic cells.

Stage-5 Fully differentiated tissues and structures are formed including xylem, phloem, leaves, shoots and roots.

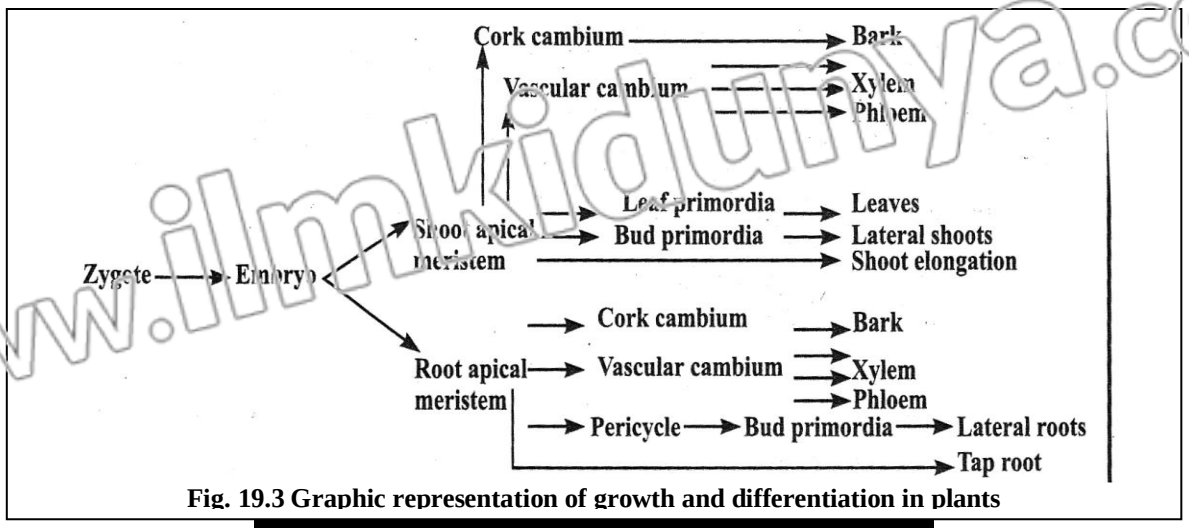

Fig. 19.3 Graphic representation of growth and differentiation in plants

QUESTIONS RELATED TO ABOVE ARTICLE

Describe differentiation in detail.

What is differentiation? Explain its phenomenon in the formation of different structure of the body. **(SWL 2022)**

19.2 Growth Correlations

The development of a plant is usually correlated with its growth and different organs growing at different rates in different directions and the development of different parts takes place. Such reciprocal relationship is known as **correlation**.

Correlative effect

The most important correlative effect in plants is apical dominance.

Apical Dominance

"Influence exerted by terminal bud in suppressing the growth of lateral buds is called as apical dominance."

In many plants, only apical bud grows while growth is suppressed in lower axillary buds. In an experiment, when apical bud was removed, the growth in the lower buds was inhibited. So active shoot apex controls the development of lateral buds. Thus, the auxin of the terminal bud is responsible for inhibiting the growth of lateral buds by a phenomenon known as **apical dominance.** (Fig 19.4)

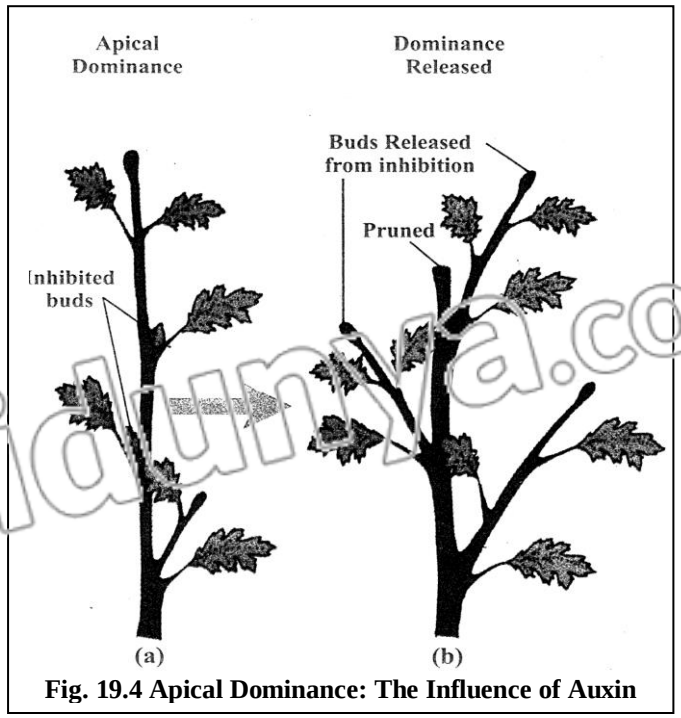

Fig. 19.4 Apical Dominance: The Influence of Auxin

Work of Thimann and Skoog

Thimann and Skoog in 1934 performed experiments and showed that apical dominance was caused **auxin** diffusing from the apical bud which inhibited the growth of lateral shoots is called **inhibitory effect**.

- The removal of apex releases the lateral buds from apical dominance. It is called **compensatory effect**.

Research has also indicated that not only auxin causes apical dominance, cytokinins also play important role in apical dominance.

If cytokinins are applied directly on the inhibited bud, it allows lateral buds to be released from apical dominance. It is also seen that those plants that have dense growth of lateral branches, have very little apical dominance.

Practical Application of Apical Dominance

As far as practical application of apical dominance is concerned, it plays an important role in

(i) Tap root development.

(ii) The inhibition of sprouting of lateral buds (eyes) in potato tuber by applying synthetic auxin. In this case, the sprouting of eyes is prevented and storing period is increased from one to three years.

QUESTIONS RELATED TO ABOVE ARTICLE

Describe apical dominance in detail.

Define and explain growth correlations.

(GRW 2017, LHR 2018, MTN 2019, FSD 2019, GRW 2021, MTN 2021, BWP 2021, , BWP 2022)

Define growth correlations. Describe apical dominance in detail. (FSD 2022)

19.3 GROWTH AND DEVELOPMENT IN ANIMALS

Embryology

It is the study of growth and differentiation undergone by an organism in the course of its development from a single fertilized egg into a highly complex and an independent living being like his parents.

Development

It is an ordered sequence of irreversible steps, with each step setting up the necessary conditions for the next step.

Developmental stages

Since all animals are some how related through the process of evolution, there are some similarities in their various forms of development.

Here, we will see a broad outline of the early stages of development.

Gamete formation	Sperm and egg formation.
↓	
Fertilization	Egg and sperm fuse to form zygote.
↓	
Cleavage	Zygote divides, blastomeres are formed.
↓	
Gastrulation	Germ layers are formed.
↓	
Organogenesis	Body organs formed, cells interact and differentiate.
↓	
Growth	Organs increase in size, adult body form attained.

9.3.1 Development of Chick

The development of chick has been taken as a basic scheme of development. It will provide basis for understanding the early differentiation of the organ systems and the fundamental process of body formation, which is common to all vertebrates.

FERTILIZATION AND INCUBATION

Fertilization

Chick egg (yolk) is surrounded by various accessory covering secreted by female reproductive tract.

- Fertilization is internal and normally takes place just as ovum entering in oviduct.
- Shell is secreted as the egg passes through the shell gland (uterus)

Incubation

After egg laying, development ceases unless the temperature of egg is kept nearly upto body temperature of mother.

In incubating eggs artificially, the incubators are usually regulated at temperature between 36-38˚C. At this temperature chicks completes development and is hatched on 21st day.

DEVELOPMENTAL STAGES

1) Cleavage

"Series of mitotic divisions after fertilization constitute cleavage."

In bird's egg, process of cell division is confined to small disc of protoplasm lying on surface of yolk at the animal pole. This type of cleavage is called discoidal cleavage.

- Cleavage furrows start in clear cytoplasmic region.
- First and second cleavages planes are vertical.
- Third cleavage runs horizontally and parallel to the surface thus cuts underneath the cytoplasm and separates it from the yolk.
- The successive cleavages become irregular and number of cells increases.
- Each cell formed after division is called blastomere.

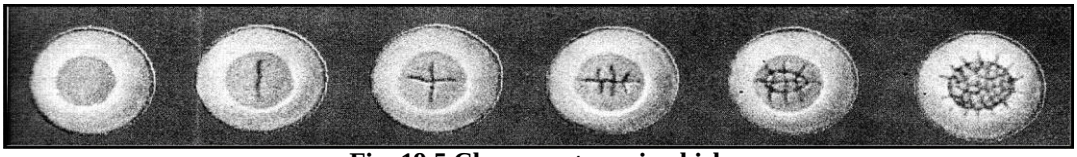

Fig. 19.5 Cleavage stages in chick

2) Morula

Formation of a rounded closely packed mass of blastomeres is called morula. It is short lived and soon changes into blastula.

- It consists of a disc shaped mass of cells **(blastomeres).**
- It lies close to the yolk.
- It is two or more layered thick. These layers are called blastoderm.
- In the center of blastoderm, the cells are smaller and completely defined while those at periphery are flattened and large.

3) Blastula

It is characterized by the presence of s segmentation cavity or **blastocoel.**

- Discoidal cap of cells above the blastocoel is called **blastoderm.**
- Marginal area of blastoderm in which cells remain undetached from the yolk and closely adherent to it and is called **zone of junction.**

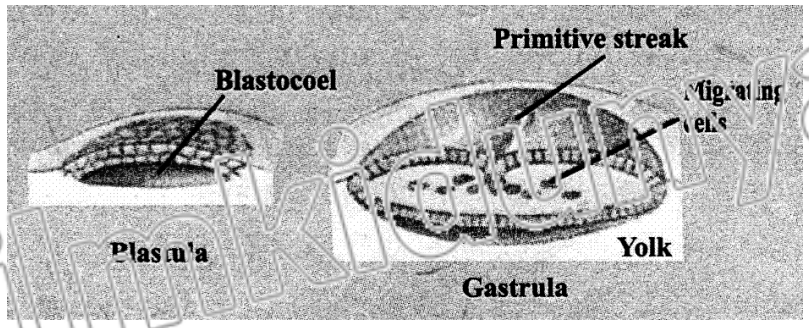

Fig. 19.6 Blastula and gastrula stages in embryo of chick

4) Gastrula

It is the stage during which there is movement and rearrangement of cells in embryo.

- Blastoderm splits into two layers an upper layer of cell called epiblast and lower layer of cells called hypoblast.
- **Epiblast** is mainly presumptive ectoderm and mesoderm
- **Hypoblast** is mainly presumptive endoderm because hypoblast cells first grow outward over the surface of yolk and then downward around it to form endodermal lining of yolk sac.
- Then central cells of blastoderm (hypoblast) are separated from yolk.
- Under central cells a pool of fluid develops which raises central cells off the yolk and gives a translucent appearance **area pellucida.**
- At peripheral part of blastoderm where cell lie un-separated from the yolk and constitute an area called **area opaca.** It is white area that transmits light.

5) Notochord and Mesoderm Formation

A) Formation of Primitive Streak

i) Mesodermal cells migrate medially and caudally from both sides and create a mid line thickening called primitive streak. In amphibians, mesodermal cells do not invaginate.

ii) Primitive streak grows rapidly in length as more and more presumptive mesodermal cells continue to aggregate in middle.

iii) Due to these changes, blastoderm changes from circular to pear shaped.

iv) Anterior end of primitive streak is occupied by an aggregation the primitive node or notochordal cells while rest of cells are mesodermal cells.

v) Now primitive streak represents dorsal and both lateral lips of blastopore.

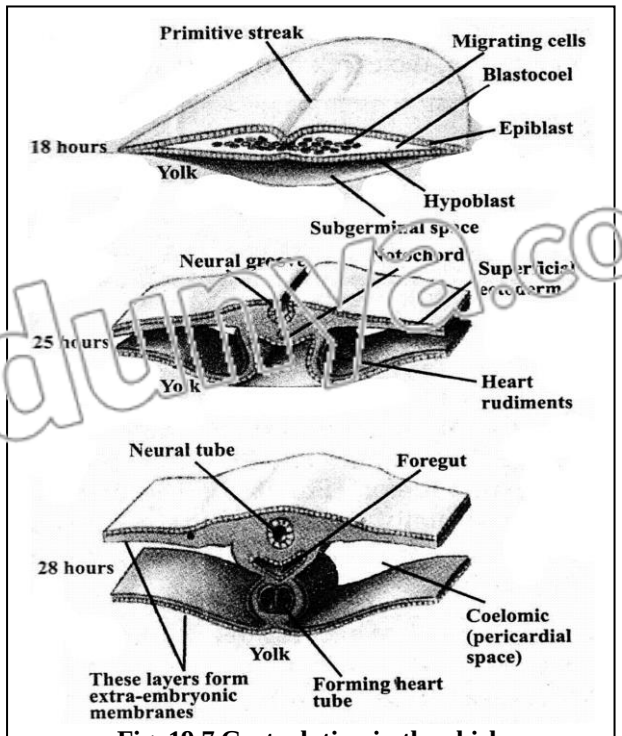

Fig. 19.7 Gastrulation in the chick

B) Formation of Primitive Groove and Hensen's Node

i) Continuous migration of cells takes place between epiblast and hypoblast results in formation of groove along the whole length of primitive streak. It is called **primitive groove.**

ii) Thickened margins present on either side of primitive groove are called **primitive ridges.**

iii) At the cephalic end of primitive streak, closely packed cells form a local thickening known as **Hensen's node**. It represents special type of invagination.

C) Formation of Notochord, Ectoderm and Endoderm

i) Cells from Hensen's node begin to move in to form notochord (rod like structure) in mid line beneath ectoderm. Notochord is prominent structural feature of 18-hour chick embryo.

ii) After 18-20 hours of incubation, ectoderm is spread and become organized into a coherent layer of cells merging peripherally with the yolk.

iii) Marginal area where expanding germ layers merge with underlying yolk is known as **germ wall.**

iv) Endodermal cells also move inward and form endoderm. A cavity appears between endoderm and yolk which first called **gastrocoel** and then **primitive gut.**

D) Formation of Mesoderm and Coelom

From Hensen's node

i) Dorsal mesoderm is formed and organized into somites.

ii) Lateral plate mesoderm is split into two sheet-like layers i.e. somatic mesoderm and splanchnic mesoderm. The cavity between somatic and splanchnic mesoderm is **coelom.**

iii) Somites are seen in 25-26 hour embryo these are complete cell masses lying immediately lateral to neural folds.

E) Neurulation

Process during which formation of nervous system occurs is called neurulation.

Different steps occurring during this process are;

i) Presumptive neural ectoderm is present in form of a band on dorsal surface of gastrula over the notochord.

ii) During elongation of gastrula the band thickness to form a neural plate. In chicks of 18 hours, neural plate can be seen as a flat, thickened area of ectoderm.

iii) In embryos of 21-22 hours, longitudinal folding occurs forming neural groove in mid-dorsal line with neural folds on either side. In 24 hour embryo folding is clearly visible. The embryo is now termed as neurula.

iv) Neural folds grow towards one another meet in the mid dorsal line and convert neural groove into neural tube.

v) At each end of neural tube, a small opening called anterior and posterior neuro-pores are also seen openings which close later on.

vi) Anterior end of neural tube is wide and forms the future brain and rest of position is future spinal cord.

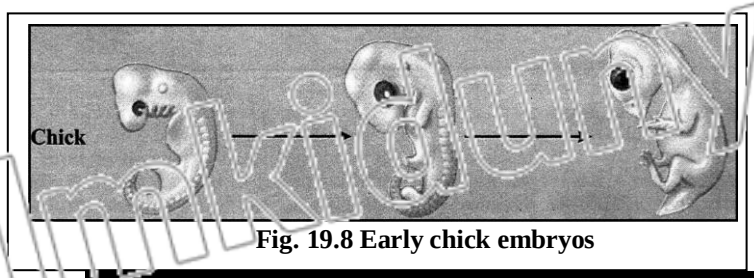

Fig. 19.8 Early chick embryos

QUESTIONS RELATED TO ABOVE ARTICLE

Write a note on the development of chick up to gastrulation stage. (RWP 2019)
Write a note on Neurulation in Chick Embryo. (BWP 2019, MTN 2021)
Discuss the Notochord and Mesoderm formation in chick embryo. (FSD 2021)
Write a note on the development of chick up to gastrulation stage. (SGD 2021)
Explain the mechanism of development of chick up to neurulation.Describe in detail the developmental process of chick. (Exercise Question iii)
What is development? Describe the principles of development in detail. (Exercise Question v)

19.3.2 Mechanisms of Development

We know that from a single celled zygote, multicellular individual is formed and zygote contains complete information in the form of genome which has come in the form of chromosomes from the eggs and sperms.

During cleavage zygote divides into many cells. Each cell has full set of chromosomes and gets complete instructions from the parents. During differentiation however some genes remain active, while others switch off. The importance of nucleus and cytoplasm during development is revealed from the following experiments.

Experiment of Hans Driesch

He took sea urchin's egg at two cell stage, shook it apart and separated it into two cells.

Later on it was seen that both these cells developed into normal larvae.

Driesch concluded that both these cells contained all the genetic information of original zygote.

Experiments of Spemann

Experiment-1

Spemann took salamander zygote and with help of minute ligature of human hair divided the zygote into two equal halves. The nucleus was present in one half, but the other half had no nucleus.

Observation

During developmental process, it was seen that cleavage was completed in the half containing nucleus but the anucleated half was not seen dividing.

Eventually, when nucleated side had reached a 16-cell stage, one of the cleavage nuclei crossed the narrow cytoplasmic bridge to the anucleate side. Immediately this side started dividing.

Experiment-2

In another experiment, he separated two halves of embryo both of them contained nuclei

Observation

Both these halves developed into complete embryos.

Experiment-3

He removed a single cell from 16-celled embryo.

Observation

He observed that this single cell is converted into complete embryo because it contained complete genetic information.

Experiment-4

During experiments he also observed that sometime nucleated half can develop into abnormal ball of cells. Later studies revealed that development depends on position of gray crescent.

Gray crescent is the pigment free area that appears at the time of fertilization.

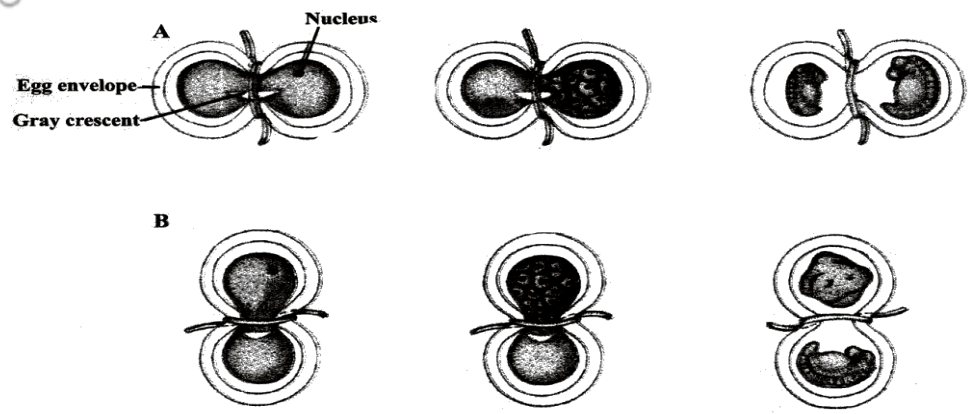

Fig 19.9 Spemann's delayed nucleation experiments.

Two kinds of experiments were performed. A, Hair ligature was used to constrict and uncleaved fertilized newt egg. Both sides contained part of the gray crescent. The nucleate side alone cleaved until a descendant nucleus crossed over the cytoplasmic bridge. Then both sides completed cleavage and formed two complete embryos. B, Hair ligature was placed so that the nucleus and gray crescent were completely separated. The side lacking the gray crescent became an unorganized piece of belly tissue; the other side developed normally.

Conclusion

On the basis of above experiments, Spemann made two conclusions.

(i) All cells contain the same nuclear information.

(ii) In the gray crescent area, cytoplasm contains information essential for development.

It is noteworthy that if all the cells contain same nuclear material, what causes the cells to differentiate. There are two ways by which cells undergo differentiation and become a specific structure to perform a particular function.

(i) During cleavage, cytoplasmic separation of determinative molecules takes place.

(ii) Induction or interaction with the neighboring cells takes place.

19.3.3 Role of Cytoplasm in Development

Different cytoplasmic components contain different morphogenetic determinants that are responsible for cell differentiation. These determinants are present in blastomeres.

The fertilized egg of an Ascidian contains cytoplasm of four different colours that is segregated into different blastomeres.

1. Clear cytoplasm:

It produces larval epidermis.

2. Yellow cytoplasm:

It gives rise to muscle cells.

3. Gray vegetal cytoplasm:
It gives rise to gut.

4. Grey equatorial cytoplasm:
It produces notochord and neural tube.

QUESTIONS RELATED TO ABOVE ARTICLE

Explain role of "Cytoplasm in development".
Discuss mechanism of development in Animals with refine to Spemann's experiments. **(DGK 2022)**

19.3.4 Role of Nucleus in Development

The zygote nucleus has complete genetic information to form a complete individual.

(i) Most gene controlled substances are found in the cytoplasm, and are probably produced in it.

(ii) The production of developmentally active substances by the nucleus itself or its immediate neighborhood, is, however available in some cases.

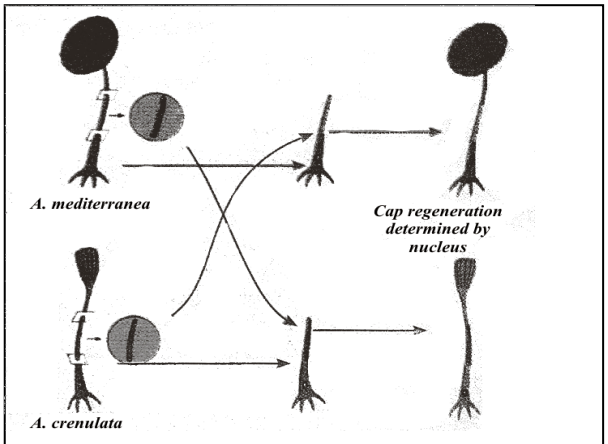

Fig 19.10 Nuclear control of cap structures in two species of *Acetabularia*

Explanation by Example of *Acetabularia*

Acetabularia is unicellular alga. It has following features

- Rhizoid attached to ground.
- Single nucleus, which may be several centimeters or more in size.
- A long stalk
- Umbrella shaped cap at top.

On basis of structural cap, two species of *Acetabularia* have been identified.

i. *Acetabularia mediterranea* containing regular shaped cap.

ii. *Acetabularia crenulata* having irregular shaped cap.

Work of Haemmerling

Haemmerling showed that if the cap is removed a new one is regenerated.
He cut off the nucleus containing rhizome from algae of one species *A. mediterrana* and grafted a similar piece containing nucleus of *A. crenulata*.
After removal of cap stalk of A. mediterranea regenerated cap of A. crenulata

Results of the Experiment

Experiment shows that nucleus lying at the base of the alga and not the stalk to which the regenerate was attached determined the structure of cap. It means that irrespective of the cytoplasm genes expressed themselves according to nucleus.

Conclusion

From all these experiments, it was concluded that both gene end cytoplasm play important role in development.

(i) Nucleus contains all the genes which determine the characteristic of the individual.

(ii) Cytoplasm plays the role of selection of genes.

QUESTIONS RELATED TO ABOVE ARTICLE

Describe the role of nucleus in development. **(LHR 2017, MTN 2019)**
Explain role of nucleus in development by given example of Acetabularia. **(SGD 2022)**

19.3.5 Concept of Differentiation

Presentation

Spemann performed a series of experiments on amphibian embryo to explain process of differentiation.

Basic Principle

A fertilized egg contains cytoplasmic components that are unequally distributed within the egg. These different cytoplasmic components are believed to have morphogenetic determinants that control the functioning of a cell type. This is now called differentiation.

Experiment-1

He took out piece of ectoderm from frogs' embryo and grew it in a separate dish.

- The embryo from which the piece of ectoderm was removed was unable to form normal nervous system but had a defective nervous system.
- Isolated piece did not develop any structure even though it was active and healthy.

Experiment-2

In another experiment, he separated the mesoderm underlying ectoderm and folded the flap of ectoderm to its original piece. The frog did not develop any nervous system.

Conclusion

From the experiments, it was proved that mesoderm had some effect on the ectoderm to stimulate ectodermal cells to form nervous system.

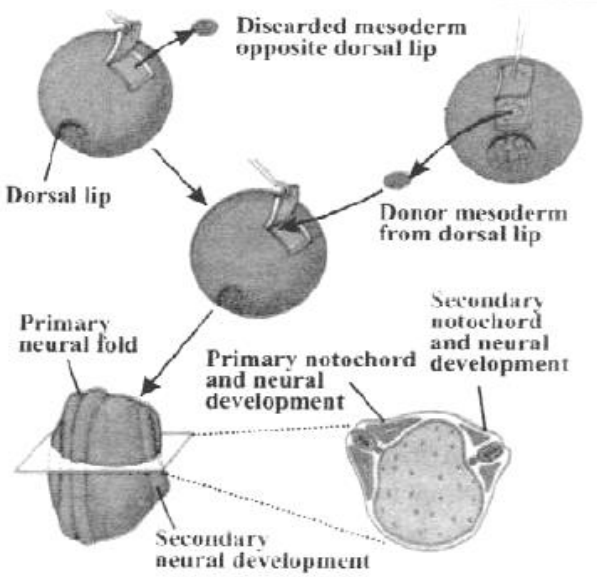

Fig. 19.11 The Spemann primary organizer experiment

19.3.6 Embryonic Induction

Definition

Process by which some cells influence other cells and evoke developmental process is called embryonic induction.

Presentation

Work on embryonic induction was reported by Hans Spemann and Hilde Mangold in 1924.

Experiment

They took two embryos of salamander at gastrula stage and performed following steps on them.

i) They removed a piece of dorsal blastopore lip from one embryo and transplanted it into a ventral or lateral position of another salamander gastrula.

ii) It invaginated and developed a notochord and somites.

iii) It also induced second embryo to form neural tube and complete nervous system.

Conclusion

It was concluded that only cells from the dorsal lip of blastopore were capable of inducing a complete embryo. This area corresponds to the presumptive areas of notochord, somites and prechordal plate.

Spemann designated the dorsal lip area the ***primary organizer*** because it was the only tissue capable of inducing development of secondary embryo in the host. This was called **primary induction.**

QUESTIONS RELATED TO ABOVE ARTICLE

Describe embryonic induction.

(GRW 2018, SGD 2021, LHR 2022, GRW 2022, RWP 2022)

19.4 AGING

Definition

It is an inevitable process comprising negative physiological changes in our body.

Signs of Old Age

Process of aging can be identified by following signs (all of these signs need not be present) of old age. e.g.

i) Loss of hair pigment.
ii) Development of small pigmented areas in the skin of face and arms.
iii) Dryness and wrinkling on skin.
iv) Loss of agility.
v) Increased weight due to fats.
vi) Poor vision.
vii) Forgetfulness.
viii) General weakness.
ix) Decreased body immunity.
x) Degeneration of organs and tissues may also take place e.g.

- In joints, arthritis arises from the degeneration of cartilage
- Degeneration and disappearance of the elastic tissues in the tunica media of the blood vessel results in arteriosclerosis which can cause blood clotting in the coronary arteries.

Mechanism of Aging

Exact mechanism is unknown, following points are worth consideration.

I) Finite Number of Mitotic Divisions

Cells of tissues have only a finite number of mitotic divisions and after reaching finite number, tissue or organ is fully-grown.

In case of nervous system mental activity and memory deteriorate and there are fewer nerve cells in old age.

II) Changes in Intracellular Substances

These changes occur during aging.

For example;

- Collagen acquires increased cross linkages in its protein molecules.
- Elastic tissues lose their elasticity with the passage of time.
- There is hardening and loss of resilience in dense connective tissue and cartilage.

III) Spontaneous Mutation

It may result in loss of cells and degeneration of tissues.

Gerontology and Its Data

Study of aging is called gerontology. The number of older individuals are expected to rise.

In the next half century.

- The number of people over age 75 will rise from present 8 million to 14.5 million.
- The number over age 80 will rise from 5 million to 12 million.
- Human life span is judged to be maximum of 120-125 years.

The present goal of gerontology is not necessarily to increase life span but to increase health span.

Prevention of Aging

The process of aging can be slowed down by better nutrition and improved living conditions e.g.

- Regular meals
- Regular exercise
- Adequate sleep
- Abstinence from smoking
- Maintaining ideal weight

➢ These conditions can prolong life by an average of 11 years.

QUESTIONS RELATED TO ABOVE ARTICLE

Describe the process of aging.

What is aging? Describe its causes and symptoms. (LHR 2018)

Write a comprehensive note on aging. (LHR 2019)

What is aging? How will you explain this process? (LHR 2017, RWP 2021)

What is aging? How will you explain this process? (Exercise Question i)

19.5 REGENERATION

Definition

The ability to regain or recover the lost or injured part of the body is called regeneration.

Examples

1) Sponges

They have greater power of regeneration due to simple organization. They not only regenerate their lost parts, but their small pieces can grow into a complete sponge.

2) Lobster

A lobster can regenerate its pincer claw.

3) Starfish

If starfish breaks off portions of its arms into pieces till the central disc completely devoid of arm is left. Then the central disc in almost all cases and arms in some cases are capable of developing into new separate individuals.

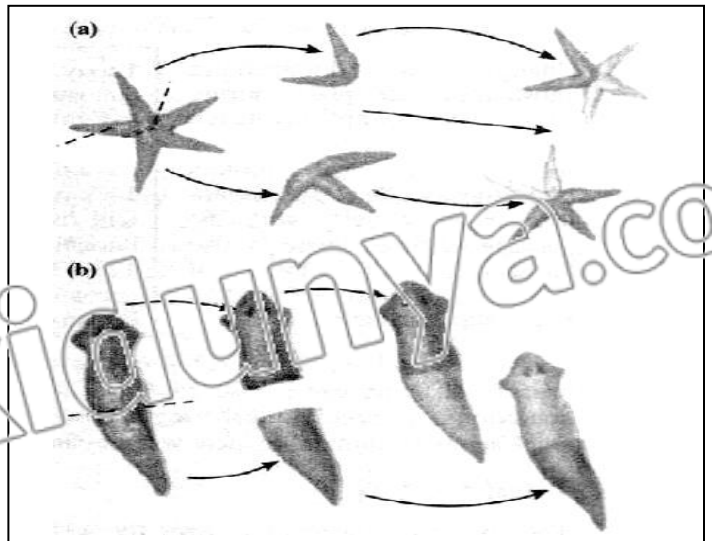

Fig. 19.12 Regeneration in (a) star fish (b) Planaria

4) Earthworm

If head of earthworm is removed, a new head regenerate.

5) Salamanders

Salamander can regenerate its limbs. Other amphibians can regenerate limbs rapidly during metamorphosis.

6) Lizard

Lizard can easily discard its tail, but tail can be regenerated by special features of its fail.

7) Mammals

Healing of fracture and repair of skin wound are some examples of regeneration.

8) Plants

Regeneration is the basis of plant propagation. Any part or a very small fragment of plant e.g. piece of stem or leaf or even single tissue or cell may develop into a full plant.

A part of stem with a few leaves may be taken from many kinds of plants and when planted in soil form a complete plant.

MECHANISM OF REGENERATION

In Invertebrates

- It is considered that during formation of missing organs same embryological process is repeated as was in embryo i.e. the relation of undifferentiated cells and differentiation of cells.
- During regeneration many cells at injured site show differentiation.
- In invertebrates e.g. earthworm and planaria, unspecialized cells called **neoblasts** have been found in the body of adult during regeneration, they are mobilized and migrate to the site of amputation where they differentiate into specialized cell types.

In Vertebrates

In vertebrates like salamanders and newts some of the specialized tissue cell types in the stump of an amputated limb apparently de-differentiate (become les specialized) and then proceed to differentiate into the same and probably different types of cells.

QUESTIONS RELATED TO ABOVE ARTICLE

Write a note on regeneration. (LHR 2019, FSD 2021)

What is "Regeneration"? Discuss it in various animals. (GRW 2019, SWL 2021)

Define regeneration. Describe the mechanism of regeneration in planarian and salamander. (GRW 2021)

What is Regeneration? Discuss at least four examples. (MTN 2022)

What is regeneration? Why it is so effective in some animals and missing in others? (Exercise Question ii)

19.6 ABNORMAL DEVELOPMENT

Teratology and Abnormal Development

Teratology is branch of biology, which deals with these abnormal developments and its causes. Abnormal development usually occurs under unfavorable conditions.

Factors for Abnormal Development

Any thing which interferes with the normal process of development is the factor causing abnormalities.

Important factors are:

i) Abnormalities inherited from parents through abnormal or defective gene (s).
ii) Abnormalities due to chromosomes or genes
iii) Environmental factors
iv) Metabolic defects

(i) Abnormalities Inherited from Parents

These abnormalities are inherited from parents through abnormal or defective genes (s). Abnormality of development is also related to the presence of defective gene (s) on sex chromosomes. e.g. in haemophilia only males suffer from this disease. It again depends whether the gene is dominant or recessive, homozygous or heterozygous.

Example

Hemophilia, which is common in male.

(ii) Chromosomal Abnormalities

These result when one sex chromosome is missing, or extra sex chromosome is present. These abnormalities arise during the formation of gametes when these abnormal gametes fuse with normal, resulted zygote also becomes abnormal.

Example

i) Klinefelter's syndrome (XXY) is an example of trisomy of sex chromosomes.

ii) Turner's syndrome (XO) is condition in which one sex chromosome is missing.

iii) XYY leads to tallness, aggressiveness, mental defect and antisocial behaviour.

(iii) Environmental Factors

Environmental factors causing or contributing to abnormal development are grouped together as **teratogens.** These defects may be through ionizing radiations e.g X-rays or nutritional deficiencies or use of drugs.

- ***Ionizing radiations*** have their effect on the developing ovum or spermatozoa.
- ***Nutritional deficiencies*** result from absence of certain substances e.g vitamins and trace elements.

***Toxins and drugs*, even ingested by mother, also affect the differentiation of energy tissues in foetus. If such deficiency is high, a cell may cause death of foetus.**

(iv) Metabolic Defects

These lead to structural deviation from normal during organogenesis. Missing or repeated part of organ results in abnormal development and malformed individual.

Example

i) Microcephaly; individuals are born with small skull.

ii) Cleft palate; individual with folded upper lip or harelip.

iii) Microdacatyl; less than five fingers.

iv) Polydactyl; more than five fingers.

QUESTIONS RELATED TO ABOVE ARTICLE

Write a note on abnormal development.

Define teratology. Discuss various types of abnormalities in development.

(SWL 2019)

KEY POINTS

Difference between growth and development:-

The development includes all types of changes occur from zygote to adult (mature) organism. The growth includes increase in size of an adult (mature) organism.

Types of cleavage

There are two types of cleavage:

1. Holoblastic cleavage

In this case entire zygote takes part in cleavage. This type of cleavage occurs in the animals in which a small amount of yolk is present. For example frog.

2. Meroblastic cleavage

In this case only a part of zygote takes part in cleavage. In occur in animals which have a large amount of stored yolk. In case of birds like chicken, the cleavage occurs in a small disc like part of the zygote. So it is called Discoidal cleavage. **Discoidal cleavage is actually Meroblastic cleavage.**

Primitive streak

The cells of blastula moves inward. They form groove like structure above the blastoderm. This groove is called primitive streak. As it is formed at very early stage of development, so it is called primitive streak.

Role of nucleus and cytoplasm in differentiation

The nucleus has all the information in form of genes on chromosome. But these genes cannot express on their own. They need certain switch to be turned on. This switch is cytoplasm. It selectively turns the genes in different parts of the body. So different type of proteins are formed in different organs.

Morphogenetic determinants

The cytoplasm of the embryonic cells have certain chemicals called morphogenetic determinants. These chemicals determine which cells have to form which organ.

Relationship between regeneration and embryonic development

The regenerating cells repeat the stage of embryonic development during development. So regeneration has a close link with the embryonic development.

EXERCISE

Q 1 Fill in the blanks.

i) The influence of notochordal cells on the ectodermal cells to become nervous system was called _____.

ii) _____ is a condition in which individuals have small skull.

iii) Growth is accompanied by two factors;
(a) by increase in _____
(b) increase in _____

iv) _____ are the regions where growth is initiated by the proliferation of cells.

i) Induction ii) Microcephaly
iii) Number of cells,size
iv) Meristem

Q 2 Write whether the statement is true or false and write the correct statement if false.

i) Primary growth leads to increase in length, while secondary growth leads to increase in width. **(True)**

ii) The plants in which flowering is not at all effected by the day length are called day neutral plants. **(True)**

iii) The somatic mesoderm soon splits in the middle to form two layers **(a)** outer parietal layer **(b)** inner visceral layer **(True)**

iv) In the clear cytoplasmic area, cytoplasm contains information essential for development. **(True)**

v) The phase of cell movement and rearrangement is called cleavage. **(False)**

The phase of cell movement and rearrangement is called gastrulation.

Q 3 Each question has four options. Encircle the correct answer from the multiple choices.

i) Growth rate is influenced by:
(a) Hormones
(b) Water
(c) Vitamins
(d) All a, b, c

ii) Neurula is the stage in which embryo has:
(a) Blastocoel
(b) Neural tube
(c) The germ layers
(d) Archenteron

iii) The mesodermal cells do not invaginate but migrate medially and caudally from both sides and create a midline thickening called:
(a) Hensen's node
(b) Primitive streak
(c) Epiblast
(d) Hypoblast

iv) The negative physiological changes in our body are called:
(a) Degeneration
(b) Abnormalities
(c) Aging
(d) Regeneration

Answer key

i	**d**
ii	**b**
iii	**b**
iv	**c**

Q 4 Short Questions.

i) What is organizer and inducer substance?

Ans:

- It is the tissue in embryo which is capable of inducing development in embryo. Actually it is notochord (dorsal lip of blastopore).
- Chemical substances which induce development of embryo i.e. because primary induction are called inducer substances.

ii) What is differentiation?

Ans. Differentiation is the formation of specialized tissue. During this growth phase the walls of cells become thicker, the walls of many kinds of cells and tissues become pitted: thickening appear on the walls of xylem vessels, cells of various tissues differ in spatial dimensions and many new structural features develop.

iii) Define embryonic induction.

Ans. Development of embryo induced and organized by notochord is called primary or embryonic induction.

iv) Differentiate between growth and development.

Ans

Growth	Development
It is the permanent and irreversible increase in size that occurs as an organism matures.	It is ordered sequence of steps involving cell division and differentiation from a single fertilized egg up to the formation of complex and independent organism.
Only the size of already formed organs increases.	New organs develop to form entire body of individual i.e. organogenesis.

v) What is meristem?

Ans. Growing points in plants consisting of group of cells which are capable of division are called meristem.

Q 5 Extensive Questions.

i) What is aging? How will you explain this process?

Ans (see article 19.4)

ii) What is regeneration? Why it is so effective n some animals and missing inothers?

Ans (see article 19.5)

iii) Describe in detail the developmental process of chick.

Ans (see article 19.3.1)

iv) What is growth? Discuss different phases and conditions of growth.

Ans (see article 19.1.3 & 19.1.2)

v) What is development? Describe the principles of development in detail.

Ans (see article 19.3)