Ist Internal Portion

CLASS : II M.Sc ZOOLOGY PAPER - DVOLOPMENTAL BIOLOGY and IMMUNOLOGY Sub Code: 18KP3Z10

UNIT :I

Basic concepts of Development

- **Developmental biology** is the study of the process by which organisms grow and develop.
- Modern **developmental biology** studies the genetic control of cell growth, differentiation and "morphogenesis," which is the process that gives rise to tissues, organs and anatomy.
- The development of an embryo from the fertilized egg is known as **Embryogenesis**
- All multicellular organisms arise by a slow process of progressive change called development. Development is a process by which a multicellular organism arises, initially from a single cell (the zygote).
- The gradual developmental strategy is known as epigenesis. Cell growth and cell division not only contribute to the size but to the shape and pattern as well of the developing organism. It involves 5 major overlapping processes:

1. **Growth = increase in size**
2. **Cell division= increase in number**
3. **Differentiation = diversification of cell types**
4. **Pattern formation = organization**
5. **Morphogenesis = generation of shapes and structure**

Potency

- Cell **potency** is a cell's ability to differentiate into other cell types. The more cell types a cell can differentiate into, the greater its **potency**.
- The number of different cell types in the embryo increases as **development** proceeds.
- The **potency** of a cell is an intrinsic property and is greater than or equal to its fate. The fate of a cell depends on its **potency** + its environment (e.g. its contact with other cells in the embryo).

- **Cell potency** refers to the varying ability of stem **cells** to differentiate into specialized **cell** types. **Cells** with the greatest **potency** can generate more **cells** types than those with lower **potency.**

Zygote considered a Totipotent cell

- The **zygote** from that fusion of an egg **cell** and a **sperm cell** then begins **cell** divisions that are capable of forming the entire human body. It is these **cells** that are **totipotent**, so **called** because their potential is 'total.'

Types of Potency

- **i)Totipotency ii) Pluripotency iii) Multipotency iv) Oligopotency v) Unipotentency**

- **Totipotency** ("ability for all [things]") is the ability of a single cell to divide and produce all of the differentiated cells in an organism. Spores and zygotes are examples of totipotent cells
- **pluripotency** ,*(* "ability for many [things]") refers to a stem cell that has the potential to differentiate into any of the three germ layers: endoderm (interior stomach lining, gastrointestinal tract, the lungs), mesoderm (muscle, bone, blood, urogenital), or ectoderm (epidermal tissues and nervous system). However, cell pluripotency is a continuum, ranging from the completely pluripotent cell that can form every cell of the embryo proper,
- This ability to become any type of cell **in the** body is called **pluripotent**. The **difference between totipotent** and **pluripotent** cells is only that **totipotent** cells can give rise to both the placenta and the embryo. As the embryo grows these **pluripotent** cells develop into specialized, **multipotent** stem cells.
- **Multipotency** describes progenitor cells which have the gene activation potential to differentiate into discrete cell types. For example, a multipotent blood stem cell and this cell type can differentiate itself into several types of blood cell like lymphocytes, monocytes, neutrophils, etc.,

- **Oligopotency** is the ability of progenitor cells to differentiate into a few cell types. It is a degree of potency. Examples of oligopotent stem cells are the lymphoid or myeloid stem cells
- **Unipotentency** cell is the concept that one stem cell has the capacity to differentiate into only one cell type. It is currently unclear if true unipotent stem cells exist.

Commitment

- **Definition**: The **commitment** of **cells** to specific **cell** fates and their capacity to differentiate into particular kinds of **cells**.
- Positional information is established through protein signals that emanate from a localized source within a **cell** (the initial one-**cell**zygote)
- The fate of a cell depends on its potency + its environment (e.g. its contact with other cells in the embryo). ... As cell fate becomes restricted following each decision in the **developmental** hierarchy, cells are said to be **committed** to a certain fate.

Levels of developmental commitment

- As cell fate becomes restricted following each decision in the developmental hierarchy, cells become committed to a certain fate. An uncommitted cell can be described as naïve, meaning that it has received no instructions directing it along a particular developmental pathway.
- Fate of a cell is said to be specified if the cell is directed to follow a certain developmental pathway and does so when placed in isolation, which should provide a neutral environment. Commitment at this stage is reversible as it may be specified if placed in different environment.
- The fate of a cell is said to be determined if it cannot be changed, regardless of cell's environment. Commitment at this stage becomes irreversible. Stages of developmental commitment Determination to follow one developmental pathway coincides with loss of competence to follow alternative pathways.
- Mechanisms of developmental commitment There appear to be two major strategies for establishing commitment and hence initiating the series of events that result in cell

differentiation. The inheritance of cytoplasmic determinants: Cytoplasmic determinants are the molecules in cytoplasm that can help to determine cell fate.

- The asymmetric distribution of cytoplasmic determinants indicates that the mechanism of differentiation is entirely intrinsic. For example, if a mother cell contains cytoplasmic determinants that is localized to one pole as the cell under goes division, that determinant will be inherited by only one of the daughters.
- The perception of external inductive signals: The process where one cell or group of cells changes developmental fate of another is termed induction. It is extrinsic process that depends on the position of a cell in the embryo. Two identical cells can follow alternative fates if one is exposed to an external signal (often secreted by a different cell).

Specification and **Determination**

- During the differentiation process, **cells** gradually become committed towards developing into a given **cell** type. Here, the state of commitment may be described as "**specification**" representing a reversible type of commitment **or** "**determination**" representing irreversible commitment.
- Specification Mechanism by which the cells acquire the proper identity in space and time, and instruct genetically identical cells to express distinct sets of gene.
- Two general mode of development resulting in differential gene expression are Mosaic development or Autonomous specification If development was controlled entirely by cytoplasmic determinants, the fate of every cell would depend on its lineage,
- while its position in embryo would be irrelevant. Then embryo is made up of independent, self-differentiating parts that, if removed from embryos, would still differentiate into their normal fate.
- **Autonomous** cell fate **specification** is a form of embryonic **specification** in which a developing cell is able to differentiate (become a cell carrying out a specialised function) without receiving external signals.
- **Autonomous specification**, the development of **reversible** cell fate without external influence. New cells are created by cleavage division of the zygote, called

blastomeres, and during **autonomous specification** they start to become distinct types of cells based on the composition of the zygotic cell.

- **Mosaic specification** development occurs when cytoplasmic determinants (Certain proteins or mRNAs), are regionally localized within the unfertilized egg. Following fertilization, these determinants are apportioned to the different cells as embryo divides. These cytoplasmic determinants specify cell type by regulating expression of different sets of genes.
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- **Cell differentiation** is how generic embryonic **cells** become specialized **cells**. This occurs through a **process** called gene expression. ... Gene expression occurs because of certain signals in your body, both inside and outside of your **cells**. **Cell differentiation** occurs during multiple stages of development.
- **cell determination**, in which initially identical **cells** become committed to different pathways of development. A fundamental part of **cell determination** is the ability of **cells** to detect different chemicals within different regions of the embryo.
- **Environmental factors** can also influence gene expression and **cell differentiation**. For **example**, available nutrients, **salinity**, and **temperature** are all factors that can influence gene expression in **organisms**. In Himalayan rabbits, genes that code for fur **color** are turned on and off depending on **temperature**.
- **Cellular differentiation** is the process where a **cell** changes from one **cell** type to another. Usually, the **cell** changes to a more specialized type. **Differentiation** continues in adulthood as adult stem **cells** divide and create fully **differentiated** daughter **cells** during tissue repair and during normal **cell** turnover.
- Humans have many different types of **cells** with different jobs, such as blood **cells** that carry oxygen and nerve **cells** that transmit signals to all parts of the body. **Cell differentiation** is the process by which **cells** become specialized in order to perform different functions.

Morphogenetic gradients

Introduction

- A **morphogen gradient** is an important concept in developmental biology, because it describes a mechanism by which the emission of a signal from one part of an embryo can determine the location, differentiation and fate of many surrounding cells.
- However, most **morphogens are** secreted proteins that signal between cells.

- A **morphogen** is a substance whose non-uniform distribution governs the pattern of tissue development in the process of morphogenesis or pattern formation, one of the core processes of developmental biology, establishing positions of the various specialized cell types within a tissue.
- Morphogens are signaling molecules that emanate from a restricted region of a tissue and spread away from their source to form a concentration gradient.
- The term morphogen is used rigorously to describe a particular type of signaling molecule that acts on cells directly to induce distinct cellular responses in a concentration-dependent manner.

Examples

- As the fate of each cell in the field depends on the concentration of the morphogen signal, the gradient prefigures the pattern of development.
- Although there is abundant evidence for concentration-dependent activity of secreted signaling molecules, evidence for their direct action on cells has been lacking in many cases and, so far, only a few such molecules fulfill the criteria of morphogens.
- Nevertheless, the roles of morphogens during the development of ***Drosophila*** appendages have been extensively studied, and a few examples of morphogens have recently been identified in vertebrate development.

Genes and signals

- A morphogen spreads from a localized source and forms a concentration gradient across a developing tissue.

- In developmental biology, 'morphogen' is rigorously used to mean a signalling molecule that acts directly on cells (not through serial induction) to produce specific cellular responses that depend on morphogen concentration.
- This definition concerns the mechanism, not any specific chemical formula, so simple compounds such as retinoic acid (the active metabolite of retinol or vitamin A) may also act as morphogens.
- Morphogens act as graded positional cues that control cell fate specification in many developing tissues. This concept, in which a signalling gradient regulates differential gene expression in a concentration-dependent manner, provides a basis for understanding many patterning processes.
- It also raises several mechanistic issues, such as how responding cells perceive and interpret the concentration-dependent information provided by a morphogen to generate precise patterns of gene expression and cell differentiation in developing tissues.
- More specifically, a morphogen is a signaling molecule that acts directly on cells to produce specific cellular responses depending on its local concentration.
- Typically, morphogens are produced by source cells and diffuse through surrounding tissues in an embryo during early development, such that concentration gradients are set up.
- These gradients drive the process of differentiation of unspecialized stem cells into different cell types, ultimately forming all the tissues and organs of the body.

Mechanism of Morphogenic Gradients

- **During the course of development, cells of many tissues differentiate according to the positional information that is set by the concentration gradients of morphogens.**

- During early development, morphogen gradients result in the differentiation of specific cell types in a distinct spatial order.
- The morphogen provides spatial information by forming a concentration gradient that subdivides a field of cells by inducing or maintaining the expression of different target genes at distinct concentration thresholds.
- Thus, cells far from the source of the morphogen will receive low levels of morphogen and express only low-threshold target genes. In contrast, cells close to the

source of morphogen will receive high levels of morphogen and will express both low- and high-threshold target genes.

- Distinct cell types emerge as a consequence of the different combination of target gene expression.
- In this way, the field of cells is subdivided into different types according to their position relative to the source of the morphogen.
- In such a way a general mechanism by which cell type diversity can be generated in embryonic development in animals.

The control of morphogenesis is a central element in evolutionary developmental biology.

- **Several intracellular** signaling pathways **have been identified, some of which are activated** in **response to secreted** growth **factors.**
- **Examples include the i) Sonic hedgehog (SHH),ii) Wingless (WNT), iii) Retinoic acid (RA), iv) Bone morphogenetic protein (BMP),** and **v) Fibroblast** growth **factor (FGF)** pathways**.**

Morphogens are secreted growth factors.

- Morphogens are secreted growth factors that direct cell fate decisions during embryonic development. Components of
- Many morphogen signaling cascades continue to be expressed in the postnatal brain, indicating that they may govern additional developmental processes after the completion of cell fate specification.
- For example, fibroblast growth factors(FGFs) exhibit important, previously unanticipated signaling functions in axon guidance and synapse formation—essentially being "recycled" for morphogenetic programs in a different developmental context during postnatal development.

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Cell fate

Introduction

- Within the field of developmental biology, one goal is to understand how a particular cell develops into a final cell type, known as **fate determination.**
- Within an embryo, several processes play out at the cellular and tissue level to create an organism.
- These processes include **cell proliferation, differentiation**, **cellular movement and programmed cell death.**
- The fate of a cell describes what it will become in the course of normal development. The fate of a particular cell can be discovered by labelling that cell and observing what structures it becomes a part of.
- When the fate of all cells of an embryo has been discovered, we can build a **fate map, fate map**

  which is a diagram of that organism at an early stage of development that indicates

  the fate of each cell or region at a later stage of development**.**
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Definition

- The **fate** of a **cell** describes its future identity, or the identity of its daughter **cells**, before it **is** actually phenotypically detectable through differentiation or division.

Molecule determines the fate of each cell

- The **cell**-intrinsic properties arise from **a** cleavage of **a cell** with asymmetrically expressed maternal cytoplasmic determinants (proteins, small regulatory RNAs and mRNA). Thus, the **fate** of the **cell** depends on factors secreted into its cytoplasm during cleavage.
- Each cell in an embryo receives molecular signals from neighboring cells in the form of proteins, RNAs and even surface interactions.
- external long-distance signals such as morphogens and hormones.
- Almost all animals undergo a similar sequence of events during very early development, a conserved process known as embryogenesis.
- During embryogenesis, cells exist in three germ layers, and undergo gastrulation.
- While embryogenesis has been studied for more than a century, it was only recently (the past 25 years or so) that scientists discovered that a basic set of the same proteins and mRNAs are involved in embryogenesis.
- Evolutionary conservation is one of the reasons that model systems such as the fly (Drosophila *melanogaster*), the mouse (Mus *musculus*), and other organisms are used as models to study embryogenesis and developmental biology.

- Studying model organisms provides information relevant to other animals, including humans.
- New discoveries and investigations include in how RNAs and proteins are expressed differentially between cells types, temporally and spatially; and how they are responsible for cell fate determination contributing to the vast diversity of organisms.

Totipotency and Cell fate

- The zygote and its very early descendents are totipotent - these cells have the potential to develop into a complete organism.
- Totipotency is common in plants, but is uncommon in animals after the 2-4 cell stage.
- As development proceeds, the developmental potential of individual cells decreases until their fate is determined.

There are three general ways a cell can become specified for a particular fate;

- Autonomous specification. -The fate of a **cell** or a tissue is said to be **specified** when it is capable of differentiating autonomously
- when placed in a neutral environment such as a petri dish or test tube. (The environment is neutral with respect to the developmental pathway.)
- Autonomous cell fate specification is a form of embryonic specification in which a developing cell is able to differentiate (become a cell carrying out a specialised function) without receiving external signals.
- This property is enabled by cytoplasmic determinants (cytoplasmic regulatory factors necessary for specification) that are deposited in different regions of the ovum during oogenesis.
- These cytoplasmic determinants are partitioned into individual cells during embryonic cleavage, and thus endow these cells with the ability to form specific cell types.

Conditional specification.

Conditional specification. **(A)** What a **cell** becomes depends upon its position in the embryo. Its **fate** is determined by interactions with neighboring **cells**.

(B) If **cells** are removed from the embryo, the remaining **cells** can regulate and compensate for the (more...)

Syncytial specification

This type of a **specification** is a hybrid of the autonomous and conditional that occurs in insects.

As there are no **cell** boundaries in the **syncytium**, these morphogens can influence nuclei in a concentration-dependent manner.

Pattern formation

- How do organs develop in their proper positions? How do cells "know" where they are within a developing organism? Pattern formation concerns the processes by which cells acquire positional information.
- There are two general models for how patterns form: use of a **morphogen gradient**, and **sequential induction**.

Cell lineage

Introduction

- **Cell lineage** denotes the **developmental** history of a tissue or organ from the fertilized embryo.
- This is based on the tracking of an organism's **cellular** ancestry due to the **cell** divisions and relocation as time progresses, this starts with the originator **cells** and finishing with a mature **cell** that can no longer divide.
- That cell lineage is capable of causing cell fate is indicated by the finding that in some types of embryos changes in cell lineage patterns also lead to changes in cell fate.
- Such changes in the cell chromosomes, that is, need not correspond to genes

History of Cell Lineage

- Cell lineage studies aim to define the developmental history of a particular cell type from its precursors through their fully differentiated state.

- One of the first studies of cell lineages took place in the 1870s by Whitman who studied cleavage patterns in leeches and small invertebrates.
- He found that some groups, such as nematode worms and ascidians form a pattern of cell division which is identical between individuals and invariable.
- This high correlation between cell lineage and cell fate was thought to be determined by segregating factors within the dividing cells. Other organisms had stereotyped patterns of cell division and produced sub lineages which were the progeny of particular precursor cells.
- These more variable cell fates are thought to be due to the cells' interaction with the environment.
- Due to new breakthroughs in tracking cells with greater accuracy, this aided the biological community since a variety of colors are now used in showing the original cells and able to track easily.
- These colors are fluorescent and marked on the proteins by administering injections to trace such cells.

Method of Cell lineage Determination

- Cell lineage can be determined by two methods, either through direct observation or through clonal analysis.
- During the early 19th century direct observation was used however it was highly limiting as only small transparent samples could be studied.
- With the invention of the confocal microscope this allowed larger more complicated organisms to be studied.
- Perhaps the most popular method of cell fate mapping in the genetic era is through site-specific recombination mediated by the Cre-Lox or FLP-FRT systems.
- By utilizing the Cre-Lox or FLP-FRT recombination systems, a reporter gene (usually encoding a fluorescent protein) is activated and permanently labels the cell of interest and its offspring cells, thus the name cell lineage tracing.
- Since then, multiple techniques have been developed to follow the fate of cells, including injections of vital dyes or radioactive molecules in cells of different organisms, introduction of reporter genes by transfection or viral infection, and transplantation of embryonic cells and tissues.
- More recently, generation of genetically modified mice expressing reporter genes have provided major advantages for tracing different cell lineages.

Role of Cell lineage

- Cell lineage can be inferred to have a causative role in developmental cell fate in embryos in which induced changes in cell division pattern lead to changes in cell fate.
- Such a causative role of cell lineage is suggested also by cases where homologous cell types characteristic of symmetrical and longitudinally metameric body plan arise via homologous cell lineages.

- Thus the early embryo came to be regarded as a regulative system, meaning that each cell has the capacity to restore the tissues normally produced by the missing cells when portions of the embryo are removed.

- That cell lineage is capable of causing cell fate is indicated by the finding that in some types of embryos changes in cell lineage patterns also lead to changes in cell fate.
- Such changes in the cell chromosomes, that is, need not correspond to genes

- Comparative cell lineage studies carried out under normal and abnormal developmental conditions have shown that in some cases cell lineage plays its determinative role in cell commitment by bringing about the orderly, unequal partitioning of intracellular determinants over daughter cells in successive cell divisions

GENOMIC EQUIVALENCE

- It is the concept that each cell in the body has the same genetic material and therefore all the information necessary to create a complete organism.
- Based on the embryological evidence for genomic equivalence (and on bacterial models of gene regulation), a consensus emerged in the 1960s that cells differentiate through differential gene expression.

The three postulates of differential gene expression are as follows:

- 1. Every cell nucleus contains the complete genome established in the fertilized egg. In molecular terms, the DNAs of all differentiated cells are identical. 19
- 2. The unused genes in differentiated cells are not destroyed or mutated, and they retain the potential for being expressed.
- 3. Only a small percentage of the genome is expressed in each cell, and a portion of the RNA synthesized in the cell is specific for that cell type.

The theory that all cells of an organism contain an equivalent complement of genetic information.

- Genomic equivalence has been confirmed for most cells, but exceptions occur in some animal cells where loss, gain, or rearrangement of nuclear DNA has been observed
- The idea that the genes of chromosomes were differentially expressed in different cell types was confirmed using DNA-RNA hybridization.

CYTOPLASMIC DETERMINANTS

- A cell can divide to produce 2 daughter cells committed to different fates. This can be achieved through the asymmetric distribution of cytoplasmic factors (e.g. proteins and RNAs) that can influence the fate of the daughter cells.
- Cytoplasmic determinants are found in many developmental systems: this strategy is used frequently in early development, when maternal gene products, localized to particular egg regions, are asymmetrically distributed to different blastomeres during cleavage.
- **Cytoplasmic determinants** are special molecules which play a very **important** role during oocyte maturation, in the female's ovary.
- During this period of time, some regions of the **cytoplasm** accumulate some of these **Cytoplasmic determinants**, whose distribution is thus very heterogenic.

Role of Cytoplasmic determinants

- They play a major role in the development of the embryo's organs. Each type of cell is determined by a particular determinant or group of determinants.
- Thus, all the organs of the future embryo are distributed and operating well thanks to the right position of the cytoplasmic determinants.
- The action of the determinants on the blastomeres is one of the most important ones. During the segmentation, cytoplasmic determinants are distributed among the blastomeres, at different times depending on the species and on the type of determinant. Therefore, the daughter cells resulting from the first divisions are totipotent :

- They can, independently, lead to a complete individual. That is not possible after the cytoplasmic determinants have been distributed in the differentiated blastomeres.

Cytoplasmic determinants and Cell divitions

- During the mosaic development, the future embryo contains all the distinct cytoplasmic determinants that are distributed in distinct cells.
- Regions of the organism differentiate very quickly if each cell contains specific cytoplasmic determinants since the first divisions : then the cell divides to give all the other cell of its type, and the same process happens in all types of cells in the organism.
- As a result, in the case of the mosaic development, cell totipotence disappears very quickly during segmentation. Indeed, each new created cell determines a new region of the future organism, and it is independent from the other ones : thus development is independent from interaction between cells.
- It is most of all known in certain animals as nematodes C. elegans, or ascidians (marine animals).

Imprinting Mutants and Trangenics in analysis of Development

- Mammals inherit two sets of chromosomes, one from each parent, and therefore possess two copies of each gene. For the majority of these genes, both alleles are expressed or repressed, depending upon the cell type.
- However, a small number of genes, designated imprinted genes, are monoallelically expressed in a parent-of-origin-specific manner. The murine genome contains ~150 such imprinted genes, although this number is likely to increase as more tissue-specific imprinting is described.
- Importantly, imprinting is well-conserved across mammals, with many, but not all, imprinted genes and imprinting mechanisms being conserved between mouse and human
- This conservation has greatly facilitated the study of imprinting, as researchers have used both experimental mouse models and human genetic disorders to expand our knowledge of imprinting.
- A significant consequence of imprinting is that mammalian development requires genetic contributions from both a mother and a father. Moreover, a number of rare congenital disorders are caused by parental-allele-specific mutation or misregulation of one or more imprinted genes
- Genes that are subject to genomic imprinting in mammals are preferentially expressed from a single parental allele.
- This imprinted expression of a small number of genes is crucial for normal development, as these genes often directly regulate fetal growth
- The possibility of expressing foreign genes in mammals and plants by gene transfer has opened new dimensions in the genetic manipulation of these organisms.
- **Transgenesis** refers to the process of introducing an exogenous or modified gene (transgene) into a recipient organism of the same or different species from which the gene is derived.
- **Transgenics** describes the process of introducing foreign deoxyribonucleic acid (DNA) into a host organism's genome. The foreign DNA, or "**transgene**," that is transferred to the recipient can be from other individuals of the same species or even from unrelated species.

- The three principal **methods used** for the creation of **transgenic animals** are DNA microinjection, embryonic stem cell-mediated gene transfer and retrovirus-mediated gene transfer.

- The use of transgenic animals as an experimental system for the study of gene regulation, genetic modeling of diseases, and testing of novel therapies or as a way to produce important bioactive drugs has provided great advances in agriculture and medicine.
- Transgenic technology has been used successfully to generate animals exhibiting features associated with human diseases or genetic disorders such as hemoglobinopathies, diabetes, cystic fibrosis (CF), Huntington's and Alzheimer's diseases providing significant advances in understanding the development and pathophysiological aspects of these diseases.

UNIT: II

Organogenesis

Organogenesis is the process by which the three germ tissue layers of the embryo, which are the ectoderm, endoderm, and mesoderm, develop into the internal organs of the organism. This must occur many times as a zygote becomes a fully-developed organism.

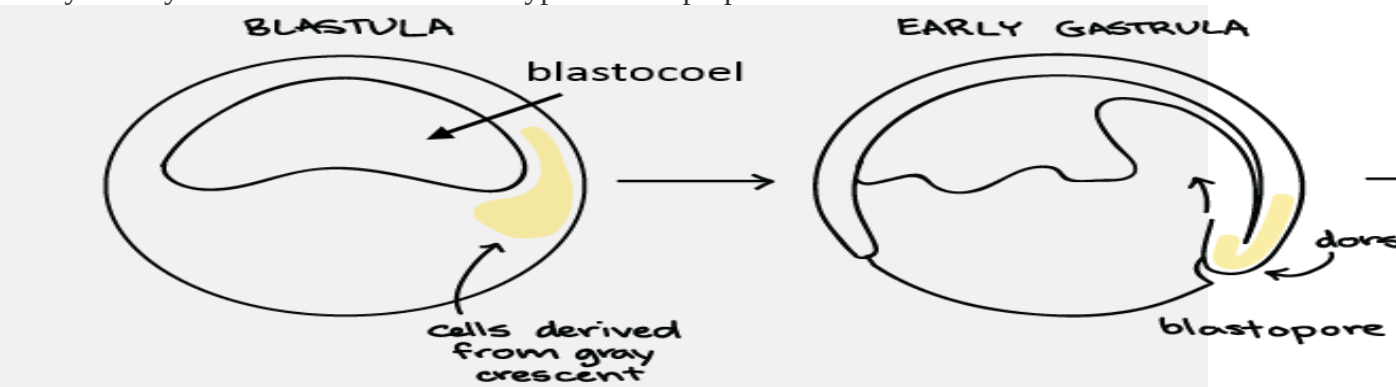
Gastrulation

At the end of cleavage, the typical blastula is a ball of cells with a hollow cavity in the middle (the blastocoel). The next stage in embryonic development is gastrulation, in which the cells in the blastula rearrange themselves to form three layers of cells and form the body plan. The embryo during this stage is called a gastrula. Gastrulation results in three important outcomes:

1. The formation of the embryonic tissues, called germ layers. The germ layers include the endoderm, ectoderm, and mesoderm. Each germ layer will later differentiate into different tissues and organ systems.
2. The formation of the embryonic gut, the archenteron.
3. The appearance of the major body axes. Recall that in some species, the information specifying the body axes was already present during cleavage as a result of cytoplasmic determinants and/or yolk polarity, but the axes actually become visible as a result of gastrulation.
4. The specific details of gastrulation are different in different animal species, but the general process includes dramatic movement of cells across and inside the embryo. In triploblasts (animals with three embryonic germ layers), one group of cells moves into the blastocoel, the interior of the embryo, through an invagination called the blastopore. These interior cells form the endoderm. Another group of cells move to completely surround the embryo, forming the ectoderm, and a third group of cells move into the locations in between the outer and inner layers of cells, to form the mesoderm. The endodermal cells continue through the interior of the embryo until they reach the other side, creating a continuous tract through the embryo; this tract is the archenteron, or

embryonic gut. In protostomes, the blastopore becomes the embryo's mouth; in deuterostomes, the blastopore becomes the embryo's anus.

5. Diploplasts (animals with only two germ layers) do not have mesodermal cells. These animals, which include jellyfish and comb jellies, have radial rather than bilateral symmetry and have far fewer tissue types than triploplasts due the lack of a mesoderm.

6. 

In developmental biology, embryonic development, also known as embryogenesis, is the development of an embryo. Embryonic development starts with the fertilization of an egg cell (ovum) by a sperm cell, (spermatozoon). Once fertilized, the ovum becomes a single diploid cell known as a zygote.

Metamorphosis:

Metamorphosis may be defined as "a rapid differentiation of adult characters after a relatively prolonged period of slow or arrested differentiation in a larva".

According to Duellman and Trueb (1986) Metamorphosis can be defined as "a radical transformation from larval life to the adult stage involving structural, physiological, biochemical and behavioural changes".

Metamorphosis in amphibians is the transformation of the larva to a miniature adult replicate, and usually from an aquatic to a terrestrial or semi-terrestrial lifestyle. Metamorphosis marks the beginning of the end of larval life.

It includes three stages: Egg, larva, and adult

The life cycle of a frog consists of three stages: **egg**, **larva**, and **adult**. As the frog grows, it moves through these stages in a process known as metamorphosis.