ZOO501 – DEVELOPMENTAL BIOLOGY

MID TERM MOST IMPORTANT QUESTIONS

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GROUP LINK: https://chat.whatsapp.com/BjC6W0jZx8o9yaC2ISh1Gu

1. Explain metamorphosis in frog.

Metamorphosis in Frogs refers to the biological process through which a larval frog (tadpole) transforms into an adult frog. This transformation involves a series of morphological, physiological, and biochemical changes driven by hormonal regulation, primarily under the influence of thyroid hormones (thyroxine and triiodothyronine). The process can be summarized in three stages:

- ***Egg Stage:*** Frogs lay fertilized eggs in water, which hatch into tadpoles.
- ***Larval Stage (Tadpole):*** Tadpoles are aquatic, possessing gills for respiration, a tail for swimming, and an herbivorous digestive system adapted for algae consumption. During this stage, the body grows while the internal systems prepare for metamorphosis.
- ***Metamorphic Transition:*** Initiated by thyroid hormones, specific changes occur, including:
  - ***Resorption of the tail:*** The tail is broken down and reabsorbed to provide energy.
  - ***Development of limbs:*** Hindlimbs appear first, followed by forelimbs.
  - ***Lung development:*** The respiratory system transitions from gills to lungs for terrestrial breathing.
  - ***Digestive system remodelling:*** The herbivorous gut shortens to accommodate a carnivorous diet.
  - ***Changes in the circulatory system:*** The single-loop circulation of tadpoles shifts to a double-loop system in adults.
- ***Adult Stage:*** The adult frog is terrestrial or semi-aquatic, possessing lungs for respiration, limbs for movement, and a carnivorous diet.

2. Write 5 steps of interaction of sperm in egg.

Here are the 5 key steps involved in the interaction of sperm with an egg during fertilization:

1. Sperm Binding to the Egg's Zona Pellucida

- The sperm recognizes and binds to specific glycoprotein receptors on the egg's zona pellucida (a protective glycoprotein layer surrounding the oocyte). In humans, this is primarily mediated by the ZP3 protein.

2. Acrosome Reaction

- Upon binding, the sperm undergoes the acrosome reaction, where enzymes (like hyaluronidase and acrosin) are released from the acrosome (a cap-like structure in the sperm head). These enzymes digest the zona pellucida, allowing the sperm to penetrate through it.

3. Sperm Penetration

- The sperm moves through the zona pellucida toward the perivitelline space (the space between the zona pellucida and the egg plasma membrane) using its motility and enzymatic activity.

4. Fusion of Sperm and Egg Membranes

- The plasma membranes of the sperm and egg fuse at the point of contact, facilitated by specific proteins like Izumo1 on the sperm and Juno and CD9 on the egg. This fusion allows the sperm nucleus and other contents (e.g., centrosome) to enter the egg cytoplasm.

5. Cortical Reaction and Block to Polyspermy

- After sperm entry, the egg undergoes a cortical reaction where cortical granules release enzymes that modify the zona pellucida, preventing additional sperm from binding (block to polyspermy). This ensures monospermic fertilization.

3. What controls the rate of cleavage?

The rate of cleavage in early embryonic development is controlled by several factors, primarily influenced by the following mechanisms:

1. Maternal mRNA and Proteins

During cleavage, the embryo relies on maternal mRNA and proteins that were deposited in the oocyte during oogenesis. These molecules regulate early cell cycle events and drive rapid mitotic divisions.

2. Cyclins and Cyclin-Dependent Kinases (CDKs)

The rapid cell divisions during cleavage are controlled by the oscillation of cyclin levels and their interaction with CDKs. These proteins regulate the progression through the M phase and S phase of the cell cycle, bypassing G1 and G2 phases to speed up division.

3. Cytoplasmic Volume

The cytoplasmic volume inherited from the oocyte limits the number of cleavage divisions. During cleavage, cells divide without growth, meaning that the cytoplasmic volume is progressively partitioned among smaller blastomeres. The rate slows as these divisions near the point where cells require additional resources.

4. Energy Supply (ATP)

Cleavage is an energy-intensive process, requiring large amounts of ATP. The availability of ATP, derived from yolk nutrients or external resources, influences the rate of cell division.

5. Species-Specific Genetic Programs

The rate of cleavage is also genetically programmed and varies among species. For example, organisms with large yolky eggs (e.g., birds) have slower cleavage in yolk-rich regions, while those with less yolk (e.g., mammals) exhibit more uniform and rapid divisions.

4. Define blastomere and germ layer.

Blastomere:

A blastomere is a single cell formed during the early stages of embryonic cleavage. It results from the division of the zygote and contributes to the formation of the blastula.

Germ Layer:

A germ layer is a group of cells in the early embryo that gives rise to specific tissues and organs. The three primary germ layers are ectoderm**,** mesoderm**,** and endoderm**.**

5. How cleaved cell is trapped?

A cleaved cell (blastomere) becomes trapped within the developing embryo due to the constraints of the zona pellucida, a protective glycoprotein layer surrounding the zygote. During cleavage, the cells divide but do not grow in size, as the zona pellucida remains intact, preventing expansion. This restriction ensures that the embryo maintains its overall size while the number of cells increases, leading to the formation of smaller blastomeres within the confined space. The trapping within the zona pellucida persists until the blastocyst stage, when the embryo "hatches" out of the zona pellucida to implant into the uterine wall.

6. Write composition of yolk.

The composition of yolk varies between species but generally includes the following components:

- ***Proteins (15-20%):*** Yolk proteins, primarily vitellogenin, serve as a major nutrient source. Other proteins include enzymes and structural proteins essential for embryonic development.
- ***Lipids (20-35%):*** Lipids are the primary energy source, comprising triglycerides, phospholipids, and cholesterol.
- ***Carbohydrates (1-5%):*** Small amounts of carbohydrates, such as glycogen, provide additional energy.
- ***Water (50-70%):*** Acts as a medium for biochemical reactions and nutrient transport.
- ***Vitamins and Minerals:*** Includes vitamins (A, D, E, and K) and minerals like phosphorus, calcium, magnesium, and iron, essential for growth and development.
- ***Pigments:*** Carotenoids and other pigments may be present, influencing yolk colour and protecting the embryo from oxidative damage.

7. Write role of progesterone and estrogen.

Role of Progesterone:

- ***Maintaining Pregnancy:*** Supports the growth and maintenance of the uterine lining (endometrium) for implantation of the fertilized egg. Prevents uterine contractions, reducing the risk of miscarriage.
- ***Regulating Menstrual Cycle:*** Works in the luteal phase to prepare the endometrium for potential pregnancy. If pregnancy does not occur, progesterone levels drop, triggering menstruation.
- ***Breast Development:*** Promotes the development of mammary glands during pregnancy to prepare for lactation.
- ***Immune Modulation in Pregnancy:*** Helps suppress maternal immune responses to prevent rejection of the foetus.

Role of Estrogen:

- ***Regulating Menstrual Cycle:*** Stimulates the growth of the uterine lining during the follicular phase of the menstrual cycle. Triggers the release of luteinizing hormone (LH), leading to ovulation.
- ***Development of Secondary Sexual Characteristics:*** Responsible for the development of female characteristics, such as breast growth, fat distribution, and reproductive organ maturation.
- ***Bone Health:*** Promotes bone density by reducing bone resorption and maintaining skeletal strength.
- ***Cardiovascular Protection:*** Improves blood flow and supports vascular health by regulating cholesterol levels and reducing the risk of atherosclerosis.
- ***Pregnancy Support:*** Works with progesterone to maintain the uterine environment and promote fetal development.

8. Write role of calcium in cortical reaction.

Calcium plays a critical role in the cortical reaction, which is a key process during fertilization to prevent polyspermy (entry of multiple sperm into the egg). Its role can be summarized as follows:

- **Initiation of Cortical Reaction:** Upon sperm fusion with the egg membrane, there is a sudden and localized release of calcium ions (Ca^{2+}) from the egg's endoplasmic reticulum. This calcium release spreads as a **calcium wave** throughout the egg cytoplasm, triggering the cortical reaction.
- **Exocytosis of Cortical Granules:** The rise in intracellular calcium concentration causes cortical granules (vesicles located just beneath the egg membrane) to fuse with the plasma membrane. These granules release their contents, such as proteases and enzymes, into the perivitelline space.

- **Modification of the Zona Pellucida:** The enzymes released degrade sperm-binding receptors (e.g., ZP3 glycoprotein) and harden the zona pellucida. This creates a block to polyspermy, ensuring that only one sperm fertilizes the egg.
- **Regulation of Egg Activation:** The calcium wave also activates the egg's metabolism and cell cycle machinery, leading to resumption of meiosis and subsequent embryonic development.

9. What are protostomes and its classification?

Protostomes are a group of animals characterized by their embryonic development, particularly the fate of the blastopore (the first opening formed during gastrulation). In protostomes, the blastopore develops into the mouth, while the anus forms later from a secondary opening. Protostomes also exhibit spiral cleavage, where cells divide in a spiral pattern, and determinate cleavage, meaning the fate of cells is predetermined early in development.

Classification of Protostomes:

Protostomes are broadly classified into two major groups based on their developmental features and evolutionary relationships:

- ***Lophotrochozoa:*** Named after two key features: the lophophor**e** (a feeding structure with tentacles) and the trochophore (a type of larva with a distinct band of cilia).
- **Key phyla:**
  - **Annelida** (segmented worms)
  - **Mollusca** (e.g., snails, clams, octopuses)
  - **Platyhelminthes** (flatworms)
  - **Bryozoa** (moss animals)
  - **Brachiopoda** (lamp shells)
- ***Ecdysozoa:*** Distinguished by the process of ecdysis, or moulting, where they shed their exoskeleton to grow.
- **Key phyla:**
  - **Arthropoda** (e.g., insects, arachnids, crustaceans)
  - **Nematoda** (roundworms)
  - **Onychophora** (velvet worms)
  - **Tardigrada** (water bears)

10. Write difference between karyokinesis and cytokinesis.

Karyokinesis refers to the division of the nucleus, during which the chromosomes are equally distributed between two daughter nuclei. This process takes place during mitosis or meiosis and involves the stages of chromosomal condensation, alignment at the metaphase plate, and their separation into opposite poles of the cell. The result of karyokinesis is two genetically identical or genetically diverse nuclei, depending on the type of cell division.

Cytokinesis is the final step of cell division, where the cytoplasm and other cellular components are divided between the two daughter cells. It typically occurs after karyokinesis and involves the physical separation of the cell, either through the formation of a cleavage furrow in animal cells or a cell plate in plant cells. The end result of cytokinesis is the formation of two separate daughter cells, each with its own nucleus and cytoplasm. Thus, while karyokinesis focuses on the division of genetic material, cytokinesis ensures the physical division of the entire cell.

11. What is animal hemisphere and vegetal hemisphere?

In the context of embryology, animal hemisphere and vegetal hemisphere refer to the two regions of an egg that differ in their content and developmental roles:

1. **Animal Hemisphere:**

The animal hemisphere is the upper, lighter region of the egg, which is typically rich in cytoplasmic contents, such as proteins, RNA, and mitochondria, necessary for early development. This region is where the nucleus is often located and is the area that will give rise to the embryo's head and anterior structures. In many animals, especially in eggs with unequal yolk distribution (like in amphibians), the animal hemisphere undergoes more rapid cleavage during early embryonic development.

2. **Vegetal Hemisphere:**

The vegetal hemisphere is the lower, denser region of the egg, typically where the yolk is concentrated. The yolk provides nutrients for the developing embryo and supports cell division and growth during the early stages of development. This region typically gives rise to the posterior structures of the embryo, such as the tail in some species.

12. Write significance of fertilization.

Fertilization is a critical process in sexual reproduction with several significant roles in the formation of a new organism:

1. ***Restoration of Diploidy:*** Fertilization restores the diploid number of chromosomes in the zygote. The egg and sperm each contribute half of the genetic material (haploid sets of chromosomes), and their fusion ensures the resulting zygote has a full set of chromosomes (diploid), which is essential for normal development.
2. ***Genetic Variation:*** Fertilization introduces genetic diversity by combining the genetic material of two parents. This results in offspring with a unique combination of alleles, contributing to variation in the population, which is crucial for evolution and adaptation to changing environments.
3. ***Activation of Development:*** The entry of the sperm triggers a series of molecular and cellular events that activate the egg and initiate embryonic development. This includes the resumption of the cell cycle and the start of processes like cleavage, gastrulation, and organogenesis.
4. ***Sexual Reproduction and Continuity of Species:*** Fertilization is essential for the continuation of sexually reproducing species. It ensures that genetic information from both parents is passed on to the next generation, maintaining the species' characteristics while allowing for genetic diversity.
5. ***Determination of Sex:*** In many species, the combination of sex chromosomes from the sperm and egg (e.g., X and Y in mammals) determines the sex of the offspring. This is an important aspect of sexual reproduction and species reproduction patterns.

13.What did Laurent Chabry demonstrate about autonomous specification?

Autonomous specification refers to a type of developmental mechanism in which cells or regions of the embryo "know" their fate and can develop into specific structures or tissues without reliance on signals from neighbouring cells. Through his experiments, he showed that:

1. ***Cell Fate Determination:*** Chabry showed that cells in specific regions of the developing embryo, such as the vegetal pole, could autonomously express certain genes and differentiate into particular cell types without external signalling. This indicated that their fate was determined early in development and did not require influence from neighbouring cells.

2. ***Organ Formation:*** By isolating parts of the embryo at early stages and observing their development in isolation, he demonstrated that some tissues, like mesodermal structures, could form without the need for inductive signalling from adjacent tissues, supporting the idea of autonomous specification.

14.Define mucopolysaccharides?

Mucopolysaccharides are a group of complex carbohydrates (polysaccharides) that contain amino sugars and are often sulphated. They are found in connective tissues and play a key role in the structure and function of the extracellular matrix. Examples include glycosaminoglycans such as chondroitin sulphate,

heparin**,** and hyaluronic acid. They are important for maintaining tissue hydration, elasticity, and lubrication.

15.Explain transcription domain.

A transcription domain refers to a specific region of a gene or chromatin that is involved in the regulation and initiation of transcription. It contains sequences and structures that allow the binding of transcription factors, RNA polymerase, and other regulatory proteins to control gene expression. These domains can be located in the promoter, enhancers, or specific regions of the gene body and are essential for the precise regulation of transcription in response to cellular signals.

16.What are deuterostomes? Also give example.

Deuterostomes are a group of animals characterized by their embryonic development, specifically the way the blastopore (the first opening formed during gastrulation) develops. In deuterostomes, the blastopore develops into the anus, while the mouth forms later from a secondary opening. This is in contrast to protostomes, where the blastopore becomes the mouth. Key characteristics of deuterostomes include:

- ***Radial cleavage****:* Cells divide in a radial pattern.
- ***Indeterminate cleavage****:* Early cell division is not predetermined, meaning cells can still develop into complete organisms if isolated.
- ***Coelom formation****:* Deuterostomes form their coelom (body cavity) through enterocoely, where the coelom develops from pouches of the archenteron (the primitive gut).

Examples of deuterostomes include:

- ***Chordates****:* Such as vertebrates (e.g., mammals, birds, fish).
- ***Echinoderms****:* Such as starfish, sea urchins, and sea cucumbers.

17.Explain early stage of egg of Sea Urchin.

The early stages of egg development in sea urchins, like many marine invertebrates, follow a series of well-defined steps after fertilization. Here's an overview of the main events:

1. **Fertilization:** The sea urchin egg is fertilized when a sperm cell penetrates the egg's outer layer, known as the vitelline layer, which triggers the cortical reaction. This reaction leads to the formation of a fertilization envelope, preventing additional sperm from entering the egg (a process known as polyspermy prevention).

2. **Egg Activation:** After sperm entry, the egg undergoes activation, including a rise in intracellular calcium levels, which initiates metabolic changes in the egg, such as resumption of the cell cycle and activation of transcription and translation.

3. **Cleavage:** Sea urchin eggs exhibit radial cleavage, where the division of the zygote occurs symmetrically along the vertical axis. This cleavage is holoblastic, meaning the entire egg divides. The first cleavage occurs along the animal-vegetal axis, dividing the egg into two cells: the animal hemisphere (where the sperm entered) and the vegetal hemisphere (where the yolk is concentrated). Cleavage proceeds rapidly and results in the formation of a blastula, a hollow ball of cells, which is an early stage of embryonic development.

4. **Formation of Blastula:** The blastula consists of blastomeres (cells formed after cleavage) surrounding a fluid-filled cavity called the blastocoel. The cells in the animal hemisphere are smaller and more numerous than those in the vegetal hemisphere because the animal hemisphere has less yolk.

5. **Gastrulation:** During gastrulation, cells begin to migrate and invaginate (fold inward) at the vegetal pole, forming the archenteron (the early gut). This marks the beginning of the differentiation of the three primary germ layers: the ectoderm, mesoderm, and endoderm.

18.Explain third stage cleavage in sea urchin.

In the third stage of cleavage in sea urchin embryos, the process continues after the first two rounds of radial cleavage and results in the formation of a blastula. Here's a brief overview:

1. ***Orientation****:* By the third cleavage, the embryo is still undergoing holoblastic cleavage (complete division of the egg). The third cleavage is typically equatorial, dividing the cells along the equator of the embryo.

2. ***Formation of Blastomeres****:* The third cleavage divides the cells of the animal hemisphere further, producing smaller cells called micromeres in the animal pole and larger cells called macromeres in the vegetal pole.

3. ***Blastula Stage****:* As cleavage continues, the embryo develops into a blastula, which is a hollow sphere with a fluid-filled cavity called the blastocoel. The blastomeres in the animal hemisphere remain smaller and more numerous than those in the vegetal hemisphere, where most of the yolk is concentrated.

19. Write steps of egg activation.

Egg activation is a crucial process that occurs immediately after fertilization, initiating the metabolic changes needed for embryonic development. Here are the key steps involved in egg activation:

i. ***Sperm Entry:*** The sperm penetrates the egg membrane, triggering the activation process.

ii. ***Cortical Reaction:*** The entry of the sperm causes a release of calcium ions from the egg's endoplasmic reticulum, leading to the cortical reaction. This reaction involves the fusion of cortical granules with the egg membrane, forming a fertilization envelope to prevent polyspermy (entry of multiple sperm).

iii. ***Increase in Intracellular Calcium:*** The sperm entry stimulates a calcium wave that spreads across the egg. This wave of calcium ions activates various signalling pathways, which are essential for egg activation.

iv. ***Resumption of Meiosis:*** The rise in calcium levels causes the egg to resume meiosis, completing the second meiotic division and producing a mature egg or ovum with a haploid set of chromosomes.

v. ***Metabolic Changes:*** The activation of the egg triggers an increase in metabolic activity, including the activation of RNA and protein synthesis, which are required for the early stages of development.

vi. ***Protein and RNA Synthesis:*** The egg begins to translate maternal mRNA and activate stored proteins needed for the initiation of cell division and further development.

vii. ***DNA Replication and Cell Cycle Progression:*** The egg starts to prepare for cleavage by replicating its DNA and entering the mitotic cell cycle, setting the stage for early embryonic development.

20. What is Mosaic and regulating development?

Mosaic development and regulative development are two different mechanisms of embryonic development that govern how cells in the early embryo differentiate. In mosaic development, cell fate is largely predetermined by maternal factors and inherited determinants distributed unevenly within the egg. This means that each cell in the early embryo has a fixed fate based on the molecules it inherits, and if a cell is removed or damaged early in development, it cannot be replaced or compensated by neighbouring cells. This type of development is seen in many protostomes, such as some invertebrates.

Regulative development is characterized by flexibility, where the fate of cells is not pre-determined but instead is influenced by interactions with neighbouring cells. In this system, if part of the embryo is lost or damaged, the remaining cells can adjust and compensate, often forming the missing structures. This type of development is seen in deuterostomes, including vertebrates like humans. The key difference is that mosaic development is more rigid and deterministic, while regulative development allows for greater adaptability and recovery in the face of damage.

21. What is species specific fertilization?

Species-specific fertilization refers to the process in which fertilization can only occur between gametes (sperm and egg) of the same species. This specificity is often mediated by molecules on the surface of the egg and sperm that recognize each other, ensuring that sperm from one species cannot fertilize eggs of a different species. These molecular signals prevent hybridization and ensure that fertilization occurs only within the same species.

22. Write components of egg with function.

The main components of an egg and their functions are:

1. ***Yolk:*** Provides nutrients for the developing embryo, especially in eggs with high yolk content (like in birds and amphibians).
2. ***Cytoplasm:*** Contains the cell's organelles and macromolecules, supporting cellular processes and early development.
3. ***Egg Membranes:***
   - ***Plasma Membrane:*** Encloses the egg, protecting the contents and controlling the entry of substances.
   - ***Vitelline Membrane:*** A layer outside the plasma membrane, involved in protecting the egg and facilitating sperm entry during fertilization.
4. ***Nucleus:*** Contains the genetic material (DNA) and is involved in the early division of the zygote after fertilization.
5. ***Cortical Granules:*** Stored in the egg's cortex, they release enzymes during fertilization to prevent polyspermy by modifying the egg's surface.
6. ***Mitochondria:*** Provide energy for cellular processes during early development.

23. Write causes of MpF.

The activation of Maturation-promoting Factor (MPF), which regulates the progression of the cell cycle, particularly during mitosis and meiosis, is caused by the following factors:

- ***Cyclin Binding:*** MPF is formed when a cyclin binds to the Cyclin-dependent kinase (Cdk). The cyclin-Cdk complex is essential for MPF activity.
- ***Phosphorylation/Dephosphorylation:*** MPF activity is regulated by the phosphorylation status of Cdk. It is activated when the Cdk is dephosphorylated by Cdc25 phosphatase and inactivated when it is phosphorylated by Wee1 kinase.
- ***Accumulation of Cyclin:*** Cyclin levels rise during the cell cycle, reaching a threshold at the end of the G2 phase, which activates MPF.

- ***Positive Feedback:*** Once activated, MPF can stimulate the activity of Cdc25, which in turn further dephosphorylates and activates Cdk, creating a positive feedback loop.
- ***Environmental Signals:*** External factors such as nutrient availability, cell size, and signals from other cells can also influence MPF activation to ensure proper cell cycle progression.

24.Write role of zP3 in gene regulation.

ZP3 (Zonadhesin 3) is a glycoprotein component of the zona pellucida (the extracellular matrix surrounding the egg) and plays a significant role in fertilization. Although ZP3 is not directly involved in gene regulation in the traditional sense (like transcription factors or epigenetic modifiers), it does influence fertilization events that can affect gene expression at the beginning of embryonic development. Here's its role related to gene regulation:

- ***Sperm-Egg Recognition:*** ZP3 acts as a sperm receptor on the egg surface, specifically binding to sperm, which is crucial for species-specific fertilization.
- ***Acrosome Reaction Induction:*** ZP3 triggers the acrosome reaction in sperm, enabling them to penetrate the egg's zona pellucida and fuse with the egg membrane.
- ***Regulation of Early Embryonic Development:*** After fertilization, the interaction between sperm and ZP3 indirectly influences gene regulation in the zygote by initiating a cascade of signaling events that activate the egg's cell cycle and transcriptional machinery, essential for embryonic gene activation.
- ***Control of Polyspermy:*** By mediating sperm binding and initiating cortical reactions, ZP3 prevents polyspermy, which ensures proper fertilization and gene expression in the zygote.

25.Differentiate between monospermy and polyspermy.

Monospermy is the ideal condition in fertilization, where only one sperm successfully fuses with the egg. This ensures that the egg receives the correct number of chromosomes, maintaining the proper diploid state in the zygote, which is essential for normal development. The egg has mechanisms to prevent additional sperm from entering, such as changes in the egg's membrane potential and the release of cortical granules to form the fertilization envelope, which blocks other sperm from fusing with the egg.

Polyspermy occurs when more than one sperm enters the egg, which leads to an abnormal number of chromosomes (polyploidy), disrupting normal development and often resulting in inviability. While some species have evolved mechanisms to block polyspermy, such as the cortical reaction in mammals or the formation of a fertilization membrane in other animals, polyspermy is usually harmful and is strictly prevented in most species.

26.Differentiate between sex and reproduction.

Sex typically refers to the process of genetic exchange between individuals, often through the union of male and female gametes (sperm and egg) during fertilization. It involves the transfer of genetic material, leading to genetic diversity, and is a mechanism through which organisms may mate and produce offspring.

Reproduction, on the other hand, is the broader biological process by which organisms produce offspring to ensure the continuation of their species. It can occur through sexual reproduction, involving the combination of genetic material from two parents, or asexual reproduction, where offspring are produced without the need for sex, typically by processes like budding, fission, or cloning. While sex is commonly part of sexual reproduction, reproduction encompasses all methods of offspring generation, including asexual means.

27.Write relationship between gene and reproduction.

Genes play a crucial role in reproduction as they carry the genetic information passed from parents to offspring. During sexual reproduction, the combination of genetic material from both parents through gametes (sperm and egg) results in offspring with a unique set of genes. This genetic information controls the development, traits, and inheritance patterns of the offspring. In asexual reproduction, offspring are genetic clones of the parent, with the genes of the parent being directly passed on. Thus, reproduction ensures the transmission of genes to the next generation, contributing to the continuity and variation of species.

28.What is gene regulation?

Gene regulation refers to the processes by which cells control the expression of genes, determining when, where, and how much of a gene product (such as RNA or protein) is made. It ensures that genes are turned on or off at the appropriate times, allowing cells to respond to environmental signals, developmental cues, and cellular needs. Gene regulation can occur at various stages, including during transcription**,** RNA processing**,** translation, and even after protein synthesis. Key mechanisms of gene regulation include the binding of transcription factors to DNA, epigenetic modifications like DNA methylation, and the use of non-coding RNAs to influence gene expression. Proper gene regulation is critical for processes like development, differentiation, and homeostasis, and its disruption can lead to diseases such as cancer.

29.Differentiate between Blastomere and Germ layer.

Blastomeres are the individual cells produced by the division of a fertilized egg during early cleavage stages of development. As the zygote undergoes rapid mitotic divisions, it forms a cluster of cells called the blastula, composed of these smaller, undifferentiated cells. Each blastomere is capable of giving rise to various tissues, depending on its position and the signals it receives during later stages of development.

Germ layers refer to the three primary layers of cells formed during gastrulation, which is a later stage in development after the blastula forms. The three germ layers are the ectoderm, mesoderm, and endoderm. These layers give rise to all the different tissues and organs in the body. The ectoderm forms the skin and nervous system, the mesoderm forms muscles, bones, and circulatory systems, and the endoderm forms the digestive tract and internal organs. In summary, blastomeres are the early undifferentiated cells resulting from cleavage, while germ layers are the differentiated layers formed later in development that will give rise to various organ systems.

30.Explain Somite, Neural tube and tadpole.

Somite: A segmental block of mesoderm that forms along both sides of the neural tube during early embryonic development in vertebrates, contributing to the formation of the skeletal muscles, vertebrae, and dermis.

Neural Tube: A hollow structure formed during the early stages of embryonic development that eventually develops into the central nervous system, including the brain and spinal cord.

Tadpole: The larval stage of amphibians, particularly frogs, characterized by a tail, gills for respiration, and the early stages of limb and organ development before metamorphosis into the adult form.

31.Write a note on Chlamydomonas.

Chlamydomonas is a genus of single-celled green algae commonly found in freshwater environments. It has a characteristic oval shape and two anterior flagella that allow it to move towards light (phototaxis). Chlamydomonas has a simple structure, consisting of a cell wall, chloroplast, and a central nucleus. It can reproduce both sexually, through the fusion of gametes, and asexually, by binary fission. It plays a role in studying photosynthesis and cellular processes due to its simple structure and genetic makeup. Additionally, Chlamydomonas is a model organism for research in areas like genetics, cell biology, and environmental response.

32.What would happen to egg after entry of sperm?

After the entry of sperm into the egg, several changes occur to ensure successful fertilization. The egg membrane undergoes a cortical reaction, releasing enzymes that form a fertilization envelope to prevent polyspermy (entry of multiple sperm). The egg's cell cycle is reactivated, and it resumes meiosis, completing the second meiotic division. The sperm's genetic material fuses with the egg's genetic material, forming a zygote with a complete set of chromosomes. This triggers embryonic development to begin, including early cell divisions and the activation of gene expression.

33.What are factors to determine embryonic cleavage?

Factors that determine embryonic cleavage include:

- ***Yolk Distribution****:* The amount and distribution of yolk in the egg affect cleavage patterns. Eggs with uneven yolk (e.g., vegetal pole with more yolk) typically undergo discoidal or meroblastic cleavage, while eggs with even yolk undergo holoblastic cleavage.
- ***Egg Size****:* Larger eggs may have slower or more irregular cleavage due to the need to divide larger volumes of cytoplasm.
- ***Species Type****:* Different species have distinct patterns of cleavage, such as radial in deuterostomes (e.g., humans) and spiral in protostomes (e.g., mollusks).
- ***Presence of Maternal Factors****:* Maternal proteins, mRNA, and other factors in the egg cytoplasm can influence how cleavage proceeds, including where cleavage planes form.
- ***Fertilization****:* The entry of sperm can trigger the onset of cleavage by activating the egg's machinery and cell cycle.
- ***Environmental Conditions****:* Factors like temperature and osmotic pressure can influence the rate and pattern of cleavage.

34.How multicellular organisms are developed from one organism?

Multicellular organisms develop from a single fertilized egg (zygote) through a process called embryonic development. After fertilization, the zygote undergoes rapid cleavage, dividing into smaller cells called blastomeres. These cells continue to divide and differentiate, forming a blastula. As development proceeds, cells undergo gastrulation, forming three primary germ layers (ectoderm, mesoderm, and endoderm), which give rise to different tissues and organs. The organism continues to grow and specialize through organogenesis, ultimately resulting in a fully formed multicellular organism.

35.Write J. Hammerling hypothesis.

J. Hammerling's hypothesis was based on his experiments with Acetabularia, a genus of green algae. In the 1930s, he proposed that the nucleus is the key factor in determining the characteristics of an organism, particularly in its development.

Hammerling's hypothesis was supported by his work on two species of Acetabularia, which have large, single-celled bodies (each with a stalk and a cap). He demonstrated that the nucleus controls the development of the entire organism, including the formation of the cap. He performed transplantation experiments by swapping the nuclei between two different species of Acetabularia. He observed that the cap formed according to the characteristics of the nucleus, not the original cytoplasm, which suggested that the nucleus carries the genetic information required for organismal development.

36.How gene and development relate?

Genes play a critical role in development by providing the instructions for creating proteins that regulate cellular processes, such as growth, differentiation, and pattern formation. These genes control when and where specific proteins are produced during development, guiding the formation of tissues, organs, and body structures. In essence, gene expression directs the developmental processes that lead to the formation of a fully developed organism from a single fertilized egg.

37.Difference between Cumulus and Corona Radiata.

CUMULUS

The cumulus is a layer of granulosa cells that surround the oocyte during the later stages of follicular development in the ovary. These cells are directly associated with the egg and provide essential nutrients and signals for its maturation. The cumulus is part of the cumulus-oocyte complex that is released during ovulation.

CORONA RADIATA

The corona radiata is a layer of granulosa cells that immediately surrounds the oocyte and is present around the egg when it is ovulated. It is the innermost layer of the oocyte's surrounding cells and plays a key role in sperm binding and facilitating the sperm's entry into the egg during fertilization. While both layers consist of granulosa cells, the cumulus is a broader structure surrounding the egg, whereas the corona radiata is a more specific, tightly associated layer directly adjacent to the egg.

38. What are three domains of transcription?

The three domains of transcription are:

- ***Initiation****:* The process where RNA polymerase binds to the promoter region and begins RNA synthesis.
- ***Elongation****:* The phase where RNA polymerase moves along the DNA, synthesizing RNA.
- ***Termination****:* The point where RNA polymerase reaches a termination signal and releases the newly formed RNA strand.